

Research Program 1 Predicting Catchment Behaviour



Program Leader

Professor Rob Vertessy, CSIRO Land and Water (succeeded by Mr Geoff Podger, Department of Land and Water Conservation – NSW, from 1 August 2002)

Aim To develop a predictive capability (or Catchment Modelling Toolkit) for land and water managers to make informed decision on whole catchments.

Program Output

A Toolkit of packaged computer models – including conceptual, analytical and numerical hydrologic models, linear-programming models, Decision Support System (DSS) and simple spreadsheet models – with a common user-friendly interface.

Outcomes and Benefits

Catchment managers and the community will gain the capability to predict the likely impacts of land and water management decisions on whole catchments – leading to reduced land and water degradation, better use of catchment resources and better targeting of major works.

The research community is reaping the benefits of working cooperatively throughout the CRC's five Focus Catchments. Many of Australia's leading catchment modellers are involved in attempting to achieve scientific breakthroughs in several key areas to build a new predictive capability, including finding ways to:

- scale hydrologic processes from small areas to catchment scale
- use remote-sensing environmental data to support models
- incorporate uncertainty analyses into the models
- integrate different aspects of catchment behaviour into the models
- build bridges between scientific disciplines including socio-economics, ecology, geomorphology, meteorology and hydrology

End-Users

Primary end-users for the Toolkit include researchers, graduate students and technical planning units within urban, rural and state resource management authorities. Secondary users include catchment management authorities, community-based catchment groups, consultants, policy and extension groups at all levels of government, and undergraduates.

Program Highlights 2001-2002

- Researchers further tested and expanded three frameworks for building and linking catchment hydrology models: two existing frameworks, the ICMS (formerly known as the Integrated Catchment Management System) and TARSIER, and a new framework, TIME.

As yet, none of the frameworks are able to perform all functions required to integrate a suite of models into the Catchment Modelling Toolkit. However, each has its strengths and the team has developed them to a point where they are useful to many model-builders and users. ICMS training workshops were held in Brisbane, Tamworth and Canberra and attended by 47 researchers from Universities, CSIRO, consultancies and state agencies. The first of the TARSIER training workshops for CRC participants was held in Melbourne, on 26-27 March 2002.

ICMS This system was launched on the CRC website, allowing model-builders and users to access the technology in the public domain.

TARSIER During 2001-02, researchers expanded the TARSIER catchment modelling framework from around 30% to 60% of its expected 'maturity' (that is, its capability for use in building integrated modelling systems). Of the three frameworks under evaluation and development by Program 1, TARSIER is the most advanced.

TIME A new catchment modelling framework developed under Program 1, TIME is a manifestation of the knowledge developed through TARSIER and ICMS and, of the three, is showing the most promise as a practical framework. This will now be adopted as the main framework in the CRC's Catchment Modelling Toolkit.

- Researchers completed the EMSS, a regional water quality model, which has been applied across south-east Qld to predict sediment and nutrient fluxes through the river network and into Moreton Bay. EMSS is being used by the CRC and catchment stakeholders, including WBM Oceanics, a Brisbane-based consultancy group, as part of the Moreton Bay Catchment and Waterways Partnership.

Based on the TARSIER framework, the EMSS predicts daily runoff and daily loads of total suspended sediment, total nitrogen and total phosphorous from 180 sub-catchments within the 22,670 km² region. Its predictions are sensitive to changes in climate, storage operations, land use and land management practices, including point and diffuse source loadings and treatments. The EMSS has been designed for use by a range of stakeholders with varying levels of computer and



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*Far Left Program Leader
Prof Rob Vertessy*

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Behaviour Program group*

*Right Program Leader Geoff Podger
(succeeding Prof Vertessy)*

*Above Right Project Leader
Dr Robert Argent – Project 1.1*

technical proficiency. Three separate component models underpin the EMSS including:

- a lumped-conceptual rainfall – runoff and pollutant export model
- a flow and pollutant routing model
- a model of reservoir storage dynamics

The EMSS structure allows for component models to be easily replaced, and additional ones to be added with minimal effort.

- A pilot Local-Scale EMSS (LEMSS) was developed. A sophisticated water quality model, the LEMSS simulates the health of aquatic ecosystems. It has been applied to the Pine Rivers catchment, south-east Qld, to predict the generation of sediment and nutrients and their delivery to Lake Samsonvale and Lake Kurwongbah Reservoirs.
- A prototype version of BC2C (Biophysical Capacity To Change), a regional scale salt balance model, was built for public release next year. In building BC2C, Program 1 researchers were able to demonstrate the value of re-using software components in the TARSIER modelling framework to develop a new model quickly and in a format common to other Toolkit models. BC2C uses several interface components developed previously for the EMSS, and employs data structures that will permit integration with other models.
- A website, www.catchment.crc.org.au/toolkit, and bulletins for the Catchment Modelling Toolkit were developed, to raise awareness about the products and inform stakeholders of progress. More than 2500 bulletins were circulated to CRC stakeholders.

Development of a Catchment Modelling Toolkit

Project 1.1, Project Leader: Dr Robert Argent

Aim To select and implement a pilot framework that supports the long-term design and integration of a variety of models for the prediction of catchment behaviour, and provide a Toolkit of suitable models for practitioners.

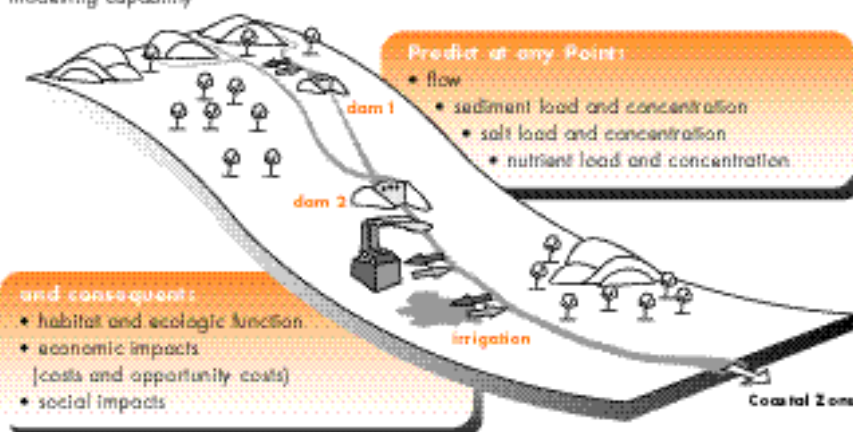
Achievements 2001-2002

- The ICMS, TARSIER and TIME catchment modelling frameworks were further developed and evaluated during the year
- Development and testing of prototype models to be incorporated within the frameworks was conducted; these included EMSS (see below), AR1 (Program 5), BC2C (Program 2) and LEMSS

- Workshops to train researchers and students in the use of TARSIER and ICMS for model-building were conducted
- Two special sessions were organised at the International Modelling and Simulation Congress (MODSIM2001), in Canberra, in December 2001
- Six team members undertook a two-week study tour of the US in July 2001, visiting various research institutes to exchange knowledge on designing and implementing catchment modelling frameworks

Our Target:

A whole-of-catchment modelling capability





Far Left (L to R) Participants at Toolkit Users' Forum, November 2001, Dugald Black (DLWC) and Ian Rutherford (Univ Melb)

Centre (L to R) Participants at Toolkit Users' Forum, November 2001, Rob Vertessy (CSIRO) and John Ruffini (NRMQ)

Left Project Leader Assoc Prof Rodger Grayson – Project 1.2

Scaling Procedures to Support Process-based Modelling at Large Scales Project 1.2, Project Leader: Associate Professor Rodger Grayson

Aim To develop generic approaches that can be used in large-scale models, but that represent the effects of small-scale variability (in space and time) of soil and landscape characteristics, and of precipitation, on various hydrological responses.

As this work focuses on improving the extent to which modelling reflects real-life situations, end-users of this research will mainly be model developers working within related CRC projects.

Achievements 2001-2002

- Two reviews were completed on the scaling of soil moisture and use of patterns in hydrological modelling
- Researchers developed and tested methods for representing the effects of high-intensity rainfall on erosion and runoff models that operate at a daily time scale
- Methods were developed for comparing observed and simulated patterns of hydrological behaviour – a vital step for building confidence in the CRC models. These are now being included in the Catchment Modelling Toolkit.
- A study with Project 2.3 was completed, on comparing observations of the dynamic range in storage of water in the soil with estimates derived from conventional approaches using soils maps. Soil water storage is a critical component of virtually all hydrological models, yet the methods for its estimation over large scales remain crude. This work has highlighted the need for information on rooting depth of different types of vegetation, which has important implications for broad-scale catchment modelling
- The team developed methods for representing space-time patterns of soil moisture at a range of scales based on influences of soils, terrain and unresolved variability. They will be included in the Toolkit.
- A range of data analysis and interpretation tools were developed to help modellers scale, aggregate and disaggregate data in preparation for use in the models. These will be included in the Toolkit.
- Project members collaborated with Project 5.1 in testing the land surface scheme used in the Bureau of Meteorology's Numerical Weather Prediction (NWP) model (for operational forecasts). This work involved the installation and commissioning of an extensive monitoring network in the Murrumbidgee River Focus Catchment, which is now part of the GEWEX (see Program 5 report).
- There was close collaboration with Project 5.1 on space-time scaling of precipitation (see Project 5.1 highlights). These will be included in the Toolkit.

Milestones Program 1

| Milestones | Progress |
|--|--|
| Years 1 and 2 | |
| Conduct a stakeholders' workshop and prepare a summary report listing the key catchment management questions being asked of models. | Three surveys conducted instead of a workshop. More than 200 catchment managers, model-users and model-developers surveyed, with 44% replying. Results compiled and disseminated to respondents. Report published in August 2001 |
| Conduct a modellers' workshop to assess the suitability of existing models to answer these questions; prepare a summary report which identifies gaps in our ability to model particular problems at particular scales. | User survey on existing models conducted. Toolkit team ran two major sessions at the International MODSIM2001 symposium in December, 2001. Two major sessions were run at the IEMSS Conference in Switzerland in June, 2002. |
| Develop specifications for new models for the Toolkit; these will take advantage of the latest environmental data products, such as rainfall radar, laser altimetry, airborne geomagnetics and hyperspectral scanners. | In progress. We have adopted ICMS, TARSIER and TIME as the three modelling frameworks for the Toolkit. Further tailoring of these products is needed to suit a wider range of modelling needs. |
| Develop a software engineering strategy for development and maintenance of the Catchment Modelling Tool kit | Technical documentation being written in preparation for forthcoming training workshops. These workshops will equip model developers with the skills to build models in a consistent fashion. |
| Develop a model documentation and training strategy . | Model documentation yet to be developed. Training program has commenced with several workshops on ICMS and TARSIER already given. We are planning a workshop on TIME, to be given around October, 2002. |
| Commence development of the Catchment Modelling Toolkit, starting with the integration of existing models. | We have implemented a small number of models in the Toolkit. These include stochastic data generation tools (Program 5), the SedNet erosion model (Program 2) and the BC2C salt loads model (Program 2). A library of conceptual rainfall-runoff models is nearing completion. |
| Years 3, 4 and 5 | |
| Adapt existing, and develop new, models of catchment function, applicable to regional scales and suited to co-evaluation of multiple issues (eg, relationship between vegetation management, water yield, salinity, erosion and sedimentation) | Excellent progress being made, evidenced by completion of the regional scale EMSS model, and pilot development of the local-scale EMSS model. The regional scale model has been applied to the entire south-east Qld region (23,000 km ²) and the LEMSS has been applied to the Pine Rivers region (500 km ²). LEMSS includes linked hydrologic, pollutant-transport, geomorphic and ecologic models. Socio-economic analysis will be incorporated into these models by the end of year 4. |
| Link hydrologic, pollutant-transport, ecologic, geomorphic, meteorologic and socio-economic models to enable holistic analyses of catchment behaviour | |
| Develop techniques to scale detailed process representation to larger scales | Good progress made in Project 1.2 through provision of spatial and temporal scaling methods for soil moisture, and rainfall modelling in Program 5. |
| Develop and incorporate an uncertainty analysis methodology into the Catchment Modelling Toolkit; this will be used to put error margins on model predictions | No progress yet; this work is planned for the next round of projects due to start in January, 2003. |
| Commence application of the Toolkit on the five Focus Catchments | Modelling initiatives have begun in the Focus Catchments, though whole-of-catchment analyses have so far only been performed in the Brisbane River Focus Catchment. Similar analyses anticipated to be conducted in the Yarra, Murrumbidgee and Goulburn-Broken Focus Catchments in 2003. |
| Conduct first public release of the Toolkit | Some models are being distributed to users. The plan is for the Toolkit model 'library' to be launched in year 4. |
| Conduct training workshops on the use of the Toolkit | Several workshops have been held to train users of ICMS, TARSIER and EMSS. |

Research Program 2 Land-Use Impacts on Rivers



Program Leader

Dr Peter Hairsine, CSIRO Land and Water

Aim To better understand the hydrological links between land use, catchment water balance and pollutant delivery to streams.

Program Outputs

Practical field knowledge and new theory to help develop and test predictive models including those incorporated into the CRC's Catchment Modelling Toolkit.

Identification of catchment 'hot spots' that contribute most to land and river degradation and strategies to treat them.

Understanding the role of pollutant stores and the way pollutants move through catchments.

Clarification of the extent to which riparian vegetation and aquifer management can reduce sediment and pollutant delivery to channels.

Outcomes and Benefits

This work will enable researchers and catchment managers to predict and interpret, at regional scale, the links between surface cover, nutrient and sediment movement, groundwater recharge, water yield and river salinity. They will be able to better understand and predict the likely effects of changes in land use (for example, from grazing to forestry) on catchment water balance and pollutant delivery to streams and river networks.

Put simply, if we know where sediment comes from and how it moves through catchments, and can predict it for different landscapes, we can better manage those landscapes to avoid erosion and water pollution.

This Program is establishing clear connections between catchment land use (current and proposed) and its ecological consequences, for example, Project 2.1 is investigating the impacts on stream habitat of big volumes of sediment ('slugs' and 'pulses') as they move through streams. In Associated/Additional Project 2.14, the consequences predicted by Project 2.1 are being considered in terms of the diversity of habitat within stream reaches and, in Project 2.5, the team is investigating the role of riparian zones in moderating the input of nutrients into streams. The results of these inter-linked investigations will promote better stream and habitat management and improve ecological health.

End-Users

Researchers, catchment managers.

Program Highlights 2001-2002

This Program is an outstanding example of the CRC's strength in bringing together researchers from many disciplines to tackle major national catchment management issues.

Last year was extremely productive in terms of Program outputs, with further development of collaborative links between researchers and stakeholders, new associate projects and major R&D activities. Highlights included:

- The Program attracted additional external funding for two Associated/Additional projects. There are now 12 Associated/Additional projects (with budgets ranging between \$100,000 and \$750,000), covering issues from catchment sediment budgets to groundwater management.
- Cross-disciplinary links continued to develop, including strong links to the Catchment Categorisation for Dryland Salinity Management (CCDSM) project led by Dr Glen Walker; R&D teams including Dr Jacky Croke's group at The University of NSW Australian Defence Force Academy (working on water quality and forestry) and the CRC for Coastal Zone Estuary and Waterway Management (modelling approaches for the Fitzroy River Catchment and its estuary). Wide-ranging interdisciplinary collaboration was initiated between ecologists, geomorphologists, climatologists, pollutant chemists and others.



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Far Left Project Leader
Dr Jon Olley – Project 2.1*

*Right Program, Project Leader
Dr Peter Hairsine – Project 2.2*

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Left Land-use Impacts on
Rivers Program group*

- This Program presented eight papers to the Third Australian Stream Management Conference in Brisbane, in August 2001, for which the CRC was a principal organiser. Topics for the papers ranged from the hydrologic impact of stock tracks to whole-of-catchment sediment budgets.
- Programs 1 and 2 researchers joined the CRC for Coastal Zone, Estuary and Waterway Management and stakeholders in developing and running an AEAM model of the Fitzroy catchment in September 2001 and May 2002 workshops. The exercise brought together the expertise of researchers from many disciplines to construct a systems view of the Fitzroy catchment and its estuary. The AEAM approach connected a series of component models, enabling researchers and catchment managers for the first time to examine the impacts of land-use change in the catchment on the estuary.
- A new association with the National Land and Water Resources Audit (NLWRA) meant Program 2 researchers were able to assess and evaluate large related datasets, enhancing their capability to predict Australian land and water resource changes.

Sediment Movement, Water Quality and Physical Habitat in Large River Systems

Project 2.1, Project Leader: Dr Jon Olley

Aim To better understand large-scale regional catchments and river processes to improve river health and develop flexible design principles for effective river restoration and riparian management.

Achievements 2001-2002

- Findings from a two-year sediment study in south-east Qld are being used to target catchment rehabilitation work in the Brisbane and Fitzroy catchments. Using a multi-faceted approach – including analysing existing data, catchment scale modelling and sediment tracing – researchers found gully and stream bank erosion was the dominant form of erosion in the catchments and that 90% of the sediment in estuaries and Moreton Bay came from only 30% of the catchment area. The study, conducted for the South East Queensland Regional Water Quality Management Strategy (SEQRWQMS) demonstrated the benefits of a combined modelling and tracing approach to determine the sources of sediment.
- The combined tracing and modelling approach (see above) was further developed on the Murrumbidgee River, where researchers mapped riverbed sediments. They are now investigating bed-load models that will accurately predict the occurrence of sand slugs in the Murrumbidgee catchment.

- Work started on improving a suspended sediment budget for the Murrumbidgee catchment using historical turbidity data, gully erosion monitoring, and modelling of the erosion and sediment transport processes. The work includes dating meander bends to assess channel erosion and migration rates in the lower river. By the end of 2002, this project will have developed one of the most complete sediment budgets on any river in the world.
- The team started developing a model to predict the form and nature of physical habitat along the Murrumbidgee River and, in early 2002, embarked on intensive fieldwork. This aims to validate part of the predictive classification for channel types and characterise the link between sand supply and physical habitat degradation. Results are being collated.

Research Program 2 Land-Use Impacts on Rivers



Far Left Project Leader
Dr Lu Zhang – Project 2.3

Centre Project Leader
Dr Heather Hunter – Project 2.5

Right Project Researcher
Dr David Rassam – Project 2.5

Managing Pollutant Delivery in Dryland Upland Catchments

Project 2.2, Project Leader: Dr Peter Hairsine

Aim To develop modules for the CRC for Catchment Hydrology Toolkit that will help make technically-sound forecasts of the impact of land-use change on the pollutants delivered to streams, at a catchment scale, for current and proposed land-uses.

Achievements 2001-2002

- Climate, soil, vegetation and topography data and observed runoff and soil loss data for three NSW sites was collected and compiled into a quality assured inventory, as part of an exercise to validate a runoff erosion prediction model for six NSW sites. Using this experience and some key data from Qld, the research developed an approach for describing the sediment delivery issue between plot and small catchment scale. The approach was explored inside the ICMS framework (see Program 1) and the published results are under internal review.
- An inventory and quality assurance exercise for climate, soil, vegetation and topography data and observed runoff and soil loss data in the Fitzroy catchment progressed through the PhD work of Leo Lymburner and the AEAM workshops in September 2001 and May 2002. Audit maps of erosion and sediment delivery were used in the AEAM workshops to provide a prototype predictive tool that describes sediment movement from paddocks to the Great Barrier Reef.

Predicting the Effects of Land-Use Changes on Catchment Water Yield and Stream Salinity

Project 2.3, Project Leader: Dr Lu Zhang

Aim To develop the ability and tools to predict the regional scale impacts of afforestation and other land-use changes on catchment water yield, groundwater recharge and stream salinity.

Achievements 2001-2002

- A forthcoming publication, the CRC for Catchment Hydrology Report, *Estimating Water Storage at Catchment Scales*, describes a new scheme for estimating catchment water storage based on terrain analysis in conjunction with conventional sources of soil information. The scheme provides more realistic estimates of catchment water storage than previously available from land resource survey data.
- Another technical report [in press] describes a study to evaluate the impact of blue gum plantation on water yield in the Goulburn-Broken catchment. The results will help catchment and resource managers develop long-term strategies to deal with land-use change and water yield reduction issues.
- Significant progress was made towards a simple method for separating the effect of rainfall variability on flow from the effect of land-use changes. Future work will focus on generalising this method for use in predicting the effect of land-use changes on flow regimes.

Riparian Zone Transport and Transformation of Nitrogen

Project 2.5, Project Leader: Dr Heather Hunter

Aims To identify key factors influencing nitrogen and carbon transport and transformations in riparian buffer zones and determine optimum riparian zone characteristics for reducing nitrate delivery to streams.

Nitrogen management in catchments impacts water quality in sensitive downstream ecosystems, for example, Moreton Bay, and Port Phillip Bay. Riparian buffer zones can intercept nitrogen in shallow groundwater and surface water flows and minimise its delivery to streams. This project involves collaboration between the CRC for Catchment Hydrology and the CRC for Coastal Zone, Estuary and Waterway Management.

Achievements 2001-2002

- Two distinct groundwater systems have been identified as a result of continuous monitoring at this project's experimental site in the riparian zone of Coochin Creek, which flows into Moreton Bay, south-east Queensland. Groundwater chemistry analyses showed a permanent water table connected to the regional groundwater table as well as a small local perched water table from the stream.
- These insights into water flows through the riparian zone revealed a component of axial flow, where some water flows from the stream channel into the riparian zone and then back to the channel further downstream. This could have important implications for how riparian zones can be managed to reduce stream nitrogen levels. The project attracted considerable community interest, in response to two newsletter articles and two field day presentations.

Milestones Program 2

| Milestones | Progress |
|--|---|
| <p>Years 1 and 2</p> <p>Compilation of the water quantity and water quality measures relevant to ecological response and delivery mechanisms for the three rural focus catchments</p> | <p>In the Murrumbidgee, Brisbane, Fitzroy and Goulburn-Broken catchments, program members have obtained data, quality assured much of it, and are using it for model evaluation.</p> <p>There are clear ecological connections in Projects 2.1 and 2.5 with the physical habitat and riparian zone research.</p> <p>The association with the NLWRA sediment and nutrient themes has enhanced the assessment and evaluation of large related datasets.</p> |
| <p>Identification and specification of technical impediments to cross-disciplinary transfer functions.</p> | <p>This Program has wide-ranging collaboration with many disciplines including ecologists, geomorphologists, climatologists and pollutant chemists.</p> <p>The Fitzroy AEAM workshop of September 2001 was a big step forward in the cross-disciplinary dialogue. This forum combined the diverse skills of this CRC (mainly Program 2) with those of the CRC for Coastal Zone, Estuary and Waterway Management.</p> |
| <p>Inter-disciplinary meeting to evaluate proposed transfer functions across a range of agro-ecological zones.</p> | <p>This Program continues to be involved in several cross-disciplinary meetings including biophysical and ecological work associated with the LEMSS in the Brisbane, physical habitat work in the Murrumbidgee and AEAM Fitzroy workshops .</p> |
| <p>Years 3, 4 and 5</p> <p>Develop methodology for predicting responses to land-use change.</p> | <p>Five products have been developed or enhanced: MAYA (water yield), SEDNET (sediment at catchment scale), ANNEX (nutrient for catchment scale), ICMS (sediment and nutrients for cropping hillslopes) and BC2C (water yield and stream salinity). SEDNET, ANNEX are NLWRA products developed by CSIRO that are being enhanced.</p> <p>(All will be incorporated into the Toolkit).</p> |
| <p>Predict the spatial distribution of pollutant sources for the three rural focus catchments.</p> | <p>The above tools predict the spatial distribution of pollutant sources and link with important data layers contributed from a range of organisations including the new Ground Water Systems map (from the Catchment Categorisation Project (CCDSM), several NLWRA layers and land-use change scenarios provided by regional planning groups.</p> |
| <p>Evaluate spatial predictions of existing land uses with a range of conventional and new remotely-sensed data.</p> | <p>The above products are being tested using a range of available data, primarily in the Focus Catchments. In the Murrumbidgee and Brisbane catchments, sediment accumulations and tracers signals are being used. Remotely-sensed data is still primarily being used for point input data interpolation. The Focus Catchments are using available in-stream measures of water quality and quantity as evaluation datasets.</p> |

Listing of Associated/Additional Projects

| Project | Start Date |
|--|---------------|
| 2.6 Predicting the combined impacts of catchment management regimes on dryland salinity (Zhang - CSIRO) | July 2000 |
| 2.7 Eucalypts and water: Managing forest plantations in China and Australia for sustained productivity and environmental benefits (Morris - NRE) | July 1999 |
| 2.8 Groundwater management - irrigation (Bethune - NRE) | July 1999 |
| 2.9 Broken and Northern Goulburn Plains study - dryland salinity (Hoxley, Daamen - SKM for NRE) | July 1999 |
| 2.10 SEQRWQMS: Sediment and nutrient sourcing (Olley - CSIRO) | August 1999 |
| 2.11 Catchment scale impacts of timber harvesting and roading (Croke - UNSW ADFA, Hairsine - CSIRO) | May 2000 |
| 2.12 Modelling flow regimes and inundation patterns of arid zone floodplain rivers (Grayson - The University of Melbourne) | November 1999 |
| 2.13 Basin-wide mapping of sediment and nutrient exports in dryland regions (Moran - CSIRO) | March 2000 |
| 2.14 Improved methods for targeting river restoration works (Young - CSIRO) | May 2000 |
| 2.15 Salinity consequences of land-use changes to water yield (Zhang - CSIRO) | February 2000 |
| 2.16 Minimising environmental impacts of grazing at a paddock to neighborhood catchment scale (Stevens - QNRM) | July 99 |
| 2.17 Minimising environmental impacts of cropping at a paddock to neighborhood catchment scale (Rohde - QNRM) | July 99 |

Research Program 3 Sustainable Water Allocation



Program Leader

Dr John Tisdell, Griffith University

Aim To develop principles, guidelines and practical tools for effectively and sustainably managing water allocation and use.

Program Outputs

Reports and information providing valuable insights into the complex social and economic drivers underpinning water reform in Australia.

Outcomes and Benefits

This Program is developing principles, guidelines and practical tools for efficient and sustainable management of water allocation and use.

Researchers are working with water authorities to encompass economic, social and hydrological factors in their modelling and planning, and link decisions concerning water management to likely social and economic consequences. A central feature is that social and economic issues surrounding catchment hydrology have been integrated with hydrological issues and addressed in a formal research program.

The challenges being tackled by this Program include:

- assessment of the implications of the Council of Australian Governments (COAG) taskforce recommendations on water in Australia
- characterising the nature of the impacts of the various sources of uncertainty in supply on the performance of surface and groundwater systems

- reviewing water entitlement regimes for surface and groundwater in the Focus Catchments in terms of their ability to take account of climate variability and hydrological constraints on catchment yield and water supply
- development of water allocation and trading frameworks that take account of economic efficiency, social interactions and equity issues, environmental flow requirements, hydrological constraints and uncertainties of supply

Project 3.1 is integrating water balance, climatic and economic models. Project 3.2 is enhancing the water market reform process by analysing guidelines and procedures for trading in mature water markets. These projects are entering their final phase.

End-Users

Water managers, policy-makers and rural communities in irrigation districts.



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Far Left (L to R) Vacation students Toby Holder, Chris Schilling with Project Researcher Dr Sergei Schreider [seated] and Project Leader Assoc Prof Gary Codner

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Above Left Irrigation – a major issue in water trading

Above Right Sustainable Water Allocation Program group

Right Project Leader Assoc Prof Gary Codner – Project 3.1

Program Highlights 2001-2002

- Stakeholder requirements from Project 3.1 were formulated during meetings throughout the project’s life. The major breakthrough has been the selection of the IQQM system as an integration platform by the Project 1.1 Catchment Modelling Toolkit team. Another Project 1.1 product, ICMS, has been chosen as a modelling tool for the socio-economic catchment evaluation within Project 3.1. Meetings with Goulburn-Murray Water and the Department of Land and Water Conservation, NSW (DLWC) enabled Project 3.1 researchers to formulate the managerial questions that must be addressed within the project framework.

Research questions addressed in Project 3.2 include:

- What are the attitudes and opinions of irrigators and rural communities to water reform in Australia?
- Can water markets be replicated under controlled conditions and used to test alternative trading scenarios?
- Are the attitudes and strategies arising from the surveys replicated in experimental water markets?

In answering these questions, the project team:

- reviewed water management in Australia, produced four CRC technical reports outlining irrigator and community attitudes to water reform in the Goulburn-Broken River, Murrumbidgee River and Fitzroy River Focus Catchments, and
- developed a water market experimental methodology, MWater, to evaluate alternative water trading rules and procedures in mature water markets.

Experiments have been conducted to simulate temporary trading scenarios with farmers in the catchments and further work is underway to explore and evaluate alternative market structures and environmental impact information on water market behaviour.

Integration of Water Balance, Climatic and Economic Models

Project 3.1, Project Leader: Associate Professor Gary Codner

Aim to provide water managers with more powerful tools to simulate seasonal water allocation scenarios and assess their performance in terms of hydrologic, economic and environmental criteria.

Achievements 2001-2002

- Sensitivity analysis of IQQM model parameters were completed and meetings held with the Department of Land and Water Conservation, NSW (DLWC) and Department of Natural Resources and Environment Vic (DNRE), regarding setting up the project and communicating results.
- An integration strategy was developed for considering how the IQQM and REALM models would be integrated with climate, economic and land-use change modules.
- A study into the modelling effect of socio-economic factors on crop planting and watering behaviour was completed and a draft report written.

Research Program 3 Sustainable Water Allocation

Left Postgraduate Marnie Griffith,
Monash Univ – Project 3.1

Right Program, Project Leader
Dr John Tisdell – Project 3.2



- Work started on determining the socio-economic indicators for assessing the impacts of different water management scenarios.
- Work began on determining the modelling effects of climatic and socio-economic factors on crop planting and watering behaviour.
- Work on the impact of farm dam storages in the Gwydir Catchment, NSW, using IQQM, neared completion.
- Researchers held meetings with stakeholders to discuss socio-economic issues related to water allocation.
- A survey of water traders in the Goulburn-Murray Irrigation Scheme analysed the drivers for water trading.
- The project team developed a modelling framework to analyse impacts of water transfers on environmental flows.
- Third-party effects arising from water trade were identified and potential solutions to mitigate them were developed.

Enhancement of the Water Reform Process: A Socio-Economic Analysis of Guidelines and Procedures for Trading in Mature Water Markets

Project 3.2, Project Leader: Dr John Tisdell

Aims To evaluate existing trading rules, market structures and procedures and their impact on regional towns and communities and, in partnership with industry and interest groups, develop scenarios and rules and procedures for trade in the Year 2010.

To assist water authorities in strategic long-term planning and development of trading rules and procedures based on principles of procedural justice and equity, within hydrological bounds and economic objectives of water reform.

Achievements 2001-2002

- Development of a working experimental methodology to evaluate alternative trading rules and procedures for mature temporary markets.
- Researchers undertook an experimental evaluation of alternative auction structures for the sale of new water entitlements arising from improvements in water management or new groundwater definitions.

- Field experiments in the Murrumbidgee River Focus Catchment involved irrigators in the research and helped them better understand closed-call water markets.
- Field experiments were conducted with irrigators in the Goulburn Broken Rivers Focus Catchment. The irrigators played an active role in refining the experimental methodology and learnt about market operations, clearance prices, effective strategies and open-call auctions.
- Presentations of this work were well-received by the international community with the Program recognised as being at the cutting edge of applied experimental work.
- Experiments were developed to address the environmental consequences of future water extraction. This research will start by exploring mechanisms to encourage self-regulation for managing environmental flows.

Milestones Program 3

| Milestones | Progress |
|---|---|
| Years 1 and 2 | |
| Assess the implications of the COAG taskforce recommendations on water in Australia. | The implications of the COAG taskforce have been included in a detailed review of the literature and commentary on water reform in Australia. |
| Characterise the nature of the impacts of the various sources of uncertainty in supply on the performance of surface and groundwater systems. | An extensive survey (leading to three reports) investigated the behavioural, social and economic characteristics of the Focus Catchments and how they may impact on the development of water allocation strategies. |
| Review current water entitlement regimes for surface and groundwater in the Focus Catchments in terms of their ability to take account of climate variability and hydrological constraints on catchment yield and water supply. | Researchers reviewed IQQM and REALM in terms of their ability to take account of climate variability and hydrological constraints on catchment yield and water supply, as well as socio-economic factors. |
| Investigate behavioural, social and economic characteristics of the Focus Catchments and how they may impact on the development of water allocation strategies. | This investigation has begun through Project 3.1. |
| Identify appropriate management techniques to reduce the risk of change and/or manage change. | Work is due to begin on developing water allocation models and institutional structures that maximise socio-economic objectives. |
| Outline the potential impacts of significant water entitlement movement through trade on supply systems, social structures and efficiency of water use. | Once these tasks are complete, work will begin to identify appropriate management techniques to reduce the risk of change and/or manage change. |
| Commence development of water allocation and trading frameworks that take account of economic efficiency, social interactions and equity issues, environmental flow requirements, hydrological constraints and uncertainties of supply. | Development of a water allocation and trading framework has begun and is continually evolving. A schematic will be reported as part of Project 3.1. Calibration of the IQQM model on the Murrumbidgee River Focus Catchment has been completed by the DLWC and has been under review by Project 3.1 researchers. |
| Commence development of water allocation models and institutional structures that maximise socio-economic objectives, given tradable water entitlements, hydrologic, climatic and other catchment behavioural characteristics. | Development of water allocation models and institutional structures has begun as part of the experimental phase of Project 3.2. Trials of the methodology have been conducted at Griffith University and with irrigators in the Murrumbidgee River Focus Catchment. Project 3.1 has rejected the use of economic optimisation models as they dis-empower industry stakeholders. |
| Years 3, 4 and 5 | |
| Develop a series of socio-economic water allocation models that integrate the climatic and catchment models derived in the other programs and take account of exchange rates and limits or constraints on trading. | Work has begun with the Integrated Catchment Assessment and Management Centre at ANU to develop economic indicators. Work is underway on methodologies to calculate exchange rates. |
| Evaluate water allocation models for methodological soundness and application to the Focus Catchments | Modules are being developed to evaluate error levels in IQQM and REALM. |
| Explore land-use practices and possible constraints to, and exchange rates for, trade in a sample of Focus Catchments | Work on methodologies to calculate exchange rates is well underway. |
| Model the impact of alternative property right regimes and constraints on trade in Focus Catchments in terms of supply systems, social structures and efficiency of water use. | This milestone will be addressed in the next round of projects. |
| Test the sensitivity of the supply system performance to modelling assumptions and to changes in physical system factors. | Researchers began a sensitivity analysis of IQQM and REALM to model parameters and data. |
| Develop improved techniques for managing flows in channel systems, and better match water diverted from rivers to predicted extractive user water needs. | This milestone will be addressed in the next round of projects. |
| Develop methods to improve efficiency in water use decision-making in order to maximise efficiency and minimise seepage and evaporation losses. | This milestone will be addressed in the next round of projects. |
| Involve stakeholders in the development of research, evaluation of the models and development of adoption strategies. | Ongoing, through meetings with stakeholders. |

Research Program 4 Urban Stormwater Quality



Program Leader

Associate Professor Tony Wong, Monash University (*Associate Professor Wong stepped down as Program Leader in April, 2002 and was succeeded by Dr Tim Fletcher, Monash University*)

Aim To develop urban stormwater management systems to better protect environmental and community values of urban aquatic systems.

Program Outputs

A Decision Support System that integrates urban stormwater management techniques into whole-of-catchment urban design encompassing urban hydrology, ecologically-sustainable land development, land-use planning, urban landscape architecture, and socio-economic issues.

World-best practice guidelines for stormwater treatment, applicable to Australian conditions.

Outcomes and Benefits

Improved quality of runoff water, together with water-sensitive design, will pave the way for ecologically-sustainable management of urban stormwater and improved urban waterway ecological health and lower infrastructure lifecycle costs for the community. Industry adoption of the techniques and tools and, ultimately, cleaner urban streams, beaches and bays, will be the measure of success for this Program.

In 2001-02, Program 4 delivered to industry the capability to develop and evaluate integrated urban stormwater management strategies at a range of typical spatial scales. This was delivered in three forms: the technical tool, the training and education necessary to underpin adoption of the tool, and demonstration of the implementation of stormwater treatment measures on the ground.

End-Users

Urban stormwater planners in cities and towns throughout Australia, land developers, water management agencies and engineers.

Program Highlights 2001-2002

- In May 2002, the Program team launched MUSIC; a new Decision Support System for integrating urban stormwater management at a range of scales, including the ability to model the effect of six key types of stormwater treatment methods. MUSIC packages the results of Program 4's research into water-sensitive urban design including operation, design and maintenance of vegetated swales, bioretention systems, constructed wetlands and ponds.

MUSIC will provide catchment managers and urban stormwater management practitioners with the capability for continuous simulations, to support a risk-based approach to target-setting and evaluating stormwater treatment measures.

About 700 urban stormwater managers participated in the launches, held at industry seminars in Canberra, Sydney, Brisbane, Melbourne and Adelaide. They were impressed with MUSIC and, as at June 2002, the CRC has received more than 200 orders for the software. An unprecedented number of registrations for the MUSIC training seminar in Sydney, Brisbane and Melbourne were also recorded.



Facing Page
Far Left Program, Project Leader
Assoc Prof Tony Wong – Project 4.1

Right Program, Project Leader
Dr Tim Fletcher – Project 4.1
(succeeding Assoc Prof Wong)

This Page
Above Hugh Duncan
demonstrating 'MUSIC' software
at Sydney seminar on Urban
Stormwater Quality Modelling

Above Right Urban Stormwater
Quality Program group



- In May 2002, the Bridgewater Creek wetland in Brisbane was launched at a community day. It was designed according to guidelines and recommendations derived from CRC Programs 4 and 5 research into water-sensitive urban design
- Demonstration sites were constructed to describe the design, construction and operation of stormwater treatment methods and provide the capacity to conduct field-scale water quality treatment experiments.
- The Program started four Associated/Additional projects funded by external bodies.

Stormwater Pollutant Sources, Pathways and Impacts

Project 4.1, Project Leader: Dr Tim Fletcher (succeeding Associate Professor Tony Wong from April 2002)

Aims To develop a Stormwater Quality Management Toolkit for predicting the performance and facilitating the design of stormwater management practices and to develop and implement Decision Support System software (DSS) that will help stormwater managers plan and design cost-effective, holistic stormwater management strategies.

Achievements 2001-2002

- The project launched MUSIC Version 1.0 to the industry, with a commitment to update the software each year for the next three years, incorporating research results as they emerge.
- Two years' data from the Brisbane City Council stormwater monitoring program have been analysed. Preliminary results provided insight into cross-correlation between pollutants. Guidance regarding on-going monitoring was provided to the Brisbane City Council. In Melbourne, a PhD project directed at analysing metal association with stormwater suspended solids is progressing well, and field monitoring at four urban catchments was completed.

- In Brisbane, researchers finished monitoring aquatic biota in Golden Pond Wetland and surveyed the ecosystem health in Bridgewater Creek, downstream of the Bridgewater Creek wetland. This data will be a baseline for subsequent evaluation of the impact of the wetland on creek ecosystem health.
- A collaborative project with the CRC for Freshwater Ecology progressed into Phase Two and a field survey of 16 urban creeks was completed. Hydraulic and water quality models are being established and will be used to characterise the creek's hydrologic conditions and the fate of urban pollutants conveyed in the creek.

Research Program 4 Urban Stormwater Quality



Far Left Water sensitive urban design wetland research site at Lynbrook Estate, Vic

Right Project Leader Assoc Prof Margaret Greenway – Project 4.2

Stormwater Best Management Practices

Project 4.2, Project Leader: Associate Professor Margaret Greenway

Aims To monitor the performance of structural stormwater management practices, review non-structural measures, and understand and quantify some commonly-used treatment processes, such as enhanced sedimentation promoted by wetland vegetation and pollutant uptake by biofilms, in stormwater quality improvement facilities.

Achievements 2001-2002

- Field experiments at Woodcrest Estate, Brisbane further refined researchers' understanding of the performance of grass swales in stormwater pollutant removal. A PhD project on porous pavements included experiments on their hydrologic properties. Research into biofilm processes began, samples of substrate from the Oxley subsurface wetland being used in laboratory experiments.
- The project team began analysing performance data of a number of stormwater quality improvement devices collected by the Brisbane City Council. The Bridgewater Creek wetland was built, and planning for monitoring – including mapping of vegetation growth – began.
- Construction of the Ruffeys Creek Wetland augmentation works was finished in Melbourne, and monitoring will begin from July 2002. Discussions were held with Melbourne Water concerning related projects for monitoring the performance of constructed wetlands around Melbourne.
- Development of a set of monitoring and evaluation protocols for non-structural stormwater management measures, and completion of a survey of consumers' responses to water-sensitive urban design in residential developments.

Milestones Program 4

| Milestones | Progress |
|---|---|
| Years 1 and 2 | |
| Establish collaborative linkages with other research organisations relevant to the objectives, of the Program, specifically the CRC for Freshwater Ecology and the CRC for Coastal Zone, Estuary and Waterway Management. | Linkages with CRC for Freshwater Ecology established with ongoing research collaboration. Linkage with CRC for Coastal Zone, Estuary and Waterway Management established, with possible joint project on ecological responses of urban estuaries to incidences of sewer overflows. |
| Collate and review information on stormwater treatment/management options and formulate the basic structures of predictive models for a range of stormwater treatment techniques. | Completed. The information was critically reviewed and used to develop the pilot DSS for urban stormwater quality management. |
| Develop conceptual models of stormwater quality treatment techniques and the framework for their integration into a decision support system. | Completed. MUSIC was released as a pilot version of the DSS in March 2001, for testing by the Brisbane City Council and Melbourne Water. |
| Establish urban stormwater quality monitoring protocols for use in evaluating pilot stormwater quality treatment facilities in the Focus Catchments. | Completed. Urban stormwater quality monitoring protocol developed after a workshop of industry practitioners and researchers, and published in June 2001. |
| Select suitable sites and establish stormwater quality monitoring systems for stormwater quality treatment facilities in the Focus Catchments. | Completed. Monitoring sites in Melbourne are being commissioned and sites in Brisbane are operational. |
| Develop technology transfer and adoption strategy. | <p>Completed. The Communication and Adoption strategy for Program 4 will use the DSS, MUSIC, as one of its main vehicles for engaging industry. Other initiatives include targeted demonstration projects, seminar lectures and collaborative projects with industry.</p> <p>The pilot version of MUSIC was evaluated by the Brisbane City Council and Melbourne Water and given wider release in 2002. Further research will focus on improving the scientific rigour in the algorithm contained in MUSIC and facilitate user-friendliness. Industry training in MUSIC's application will prepare the adoption environment for the research outputs of this Program.</p> |
| Years 3, 4 and 5 | |
| Determine critical pollutants and required pollution concentrations vs discharge relationships for the sustainability of healthy urban aquatic ecosystems. | With MUSIC's release, research activities over the next three years will focus on better defining stormwater management targets for improved urban aquatic ecosystem health. |
| Monitor and evaluate the performance of stormwater treatment facilities at pilot catchment sites in the Focus Catchments. | <p>Over the past two years, a number of stormwater treatment facilities have been designed and constructed by the Brisbane City Council and Melbourne Water. These reflect current Best Practice and form the principal group of stormwater treatment facilities where, over the next two years, the CRC will undertake field monitoring and evaluation and field experiments to improve performance prediction.</p> <p>The monitoring sites are:</p> <ul style="list-style-type: none"> • Ruffeys Creek Wetland, Melbourne • Lynbrook Estate Paired Catchment monitoring, Melbourne • Bridgewater Creek Wetland, Brisbane • Hoyland Street Bioretention System, Brisbane • An Associated/Additional project involving the construction of bioretention systems in Nerang by the Gold Coast City Council • Other Melbourne and Brisbane sites under development |
| Evaluate the life-cycle cost of stormwater treatment systems investigated. | Melbourne Water and the Brisbane City Council began collating data on capital and maintenance costs of stormwater management facilities. to incorporate into MUSIC. It will provide the capability to estimate lifecycle costs of stormwater treatment measures. |
| Commence the validation and refinement of conceptual models of stormwater quality treatment techniques. | <p>The testing and validation of the MUSIC's algorithms continues as field experiments and monitoring and evaluation of existing stormwater treatment facilities are undertaken. Over the past year, the pilot testing of MUSIC was completed, culminating in the convening of the MUSIC Pilot User's Forum on 24 October 2001.</p> <p>Field experiments were conducted to continue field validation of the algorithms describing the performance of stormwater treatment measures, including the Swale experiments in Brisbane and bioretention experiments in Melbourne</p> |
| Commence technology transfer activities to provide interim guidelines on the selection and design of stormwater quality treatment measures. | <p>A number of activities involving industry seminar, technical publications and industry training courses and field trips were undertaken, including:</p> <ul style="list-style-type: none"> • short course on Planning and Design of Stormwater Management Measures, Brisbane • Industry Seminar on Urban Stormwater Modelling (involving MUSIC), in Canberra, Sydney, Brisbane, Melbourne and Adelaide in May 2002. |

Research Program 5 Climate Variability



Program Leader

Professor Tom McMahon, The University of Melbourne (*Professor McMahon stepped down as Program Leader in April 2002, and was succeeded by Dr Francis Chiew, The University of Melbourne*)

Aim To improve the ability to quantify climatic variability and reduce hydrologic risk for water-related issues (for example, flood magnitude, drought severity, water releases from reservoirs, environmental flows), through climate forecasts.

Program Outputs

- a methodology to produce a national database of stochastic climate variables for input to hydrologic and water resource systems models
- a methodology to quantify the spatial and temporal variability of rainfall
- methods for forecasting weather, seasonal climate and streamflow from several hours to several months ahead
- tools to help catchment managers reduce hydrologic risk

Outcomes and Benefits

This Program aims to improve the ability of catchment managers and researchers to quantify climate variability. This will help reduce the hydrologic risk for a wide range of water-related issues Australia-wide. (SEE HIGHLIGHT BOX, BELOW). In 2001-02, researchers gained a clearer picture of the extreme variability in climate and streamflows throughout Australia.

End-Users

Land and water management agencies, catchment managers and scientists researching catchments Australia-wide.

Program Highlights 2001-2002

- The Murray-Darling River Basin was accepted as one of several catchment basins to be studied under the GEWEX Continental Scale Experiment. This Program's Murrumbidgee soil moisture monitoring and land surface modelling study, and the Bureau of Meteorology's numerical weather prediction modelling studies, are key components of the Murray-Darling Basin GEWEX experiment.
- The development and testing of stochastic models of point annual, monthly and daily rainfall were completed and the models are ready for incorporation into the CRC's Catchment Modelling Toolkit.
- Successful collaborations with stochastic data researchers in Australia and overseas will result in the most effective models being selected for use in the Toolkit. Non-CRC personnel developed half the point rainfall models recommended for the Toolkit, and several spatial stochastic daily rainfall and sub-daily stochastic space-time rainfall models developed outside the CRC are being tested using Focus Catchment data.
- As part of the Program's Communication and Adoption process, about 25 middle and senior managers received an overview of the CRC's capabilities in forecasting hydroclimate variables and guidance on the types of forecasts useful for water agencies at a weather forecasting workshop in Tatura, Vic, in October 2001.



*Facing Page
Far Left Program, Project Leader
Prof Tom McMahon – Project 5.2*

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Above Climate Variability
Program group*

*Centre Program, Project Leader
Dr Francis Chiew – Project 5.1
(succeeding Prof Tom McMahon
as Program Leader)*

*Above Centre Participants at
Climate Variability Research
Forum, Tatura, October 2001*

*Right Project Leader Dr Alan Seed –
Project 5.1 (succeeding Dr Chiew)*

*Above Right Project Leader
Dr Sri Srikanthan – Project 5.2
(succeeding Prof McMahon)*

Modelling and Forecasting Hydroclimate Variables in Space and Time

Project 5.1, Project Leader: Dr Francis Chiew (Dr Chiew stepped down as Project Leader in April 2002, and was succeeded by Dr Alan Seed, Bureau of Meteorology)

Aim To develop space-time rainfall models and methods for forecasting rainfall and streamflow several hours to several months ahead.

Achievements 2001-2002

- The project team completed software development of MOTIVATE, a stochastic space-time rainfall model for homogeneous areas, and S_PROG, a model that forecasts rainstorms one or two hours ahead (see BOX, right).
- Soil moisture, soil temperature and climate data monitoring began in the Murrumbidgee River Focus Catchment in September 2001. The extensive data collected from 18 sites are being used in CRC modelling studies.
- Researchers preliminarily tested a land surface model in the numerical weather prediction schemes of the Bureau of Meteorology using parameters dependent on soil and vegetation characteristics.
- A non-parametric model for forecasting exceedance probabilities (risk-based forecasts) of rainfall and runoff several months ahead has been developed and tested using Australia-wide data. It exploits the relationship between El Niño/Southern Oscillation and rainfall and runoff, and the serial correlation in runoff. Forecasts from the model will allow water resource managers to better manage irrigation and environmental flow allocations.

National Data Bank of Stochastic Climate and Streamflow Models

Project 5.2, Project Leader: Professor Tom McMahon (Professor McMahon stepped down as Project Leader in April 2002, and was succeeded by Dr Sri Srikanthan, Bureau of Meteorology)

Aim To develop robust stochastic models for generating climate and streamflow data for any location in Australia at different time scales.

Achievements 2001-2002

- The project team tested the TPMb model (Srikanthan-McMahon model with Boughton correction for annual rainfall) and the Wang-Nathan model for generating stochastic daily rainfall. The models were equally good in preserving most of the rainfall statistics, but the TPMb model was better in preserving rainfall amounts on different types of wet days.
- Testing the method of fragments, and the non-parametric model developed by Sharma for generating stochastic monthly rainfall, showed both models performed equally well in preserving key rainfall statistics.
- Testing began on the multivariate model for generating stochastic daily climate data (mainly potential evapotranspiration and maximum temperature) conditioned on daily rainfall states. The team also began testing models for generating stochastic spatial daily rainfall and sub-daily space-time rainfall.
- The above research has provided models that can generate stochastic point rainfall and climate data down to daily time scale. These models – which can be used to quantify climate variability and reduce hydrologic risk for water-related issues – will be incorporated into the CRC Toolkit.

Water authorities embrace CRC weather research

CRC for Catchment Hydrology research into climate variability has added significant value to the Bureau of Meteorology's radar network and generated spin-off benefits for Australian and overseas customers.

Radar plays a significant role in predicting and measuring storms in Australia and the CRC's remote-sensing rainfall research has:

- benefited the Bureau of Meteorology and its customers
- resulted in world-first climate prediction technology
- been applied internationally

The CRC's research into rainfall measurement has improved the Bureau of Meteorology's capability for remote sensing through its national radar network. The Bureau of Meteorology has a 50-strong network of radars around Australia for general and severe weather forecasting. Each radar can detect a raindrop as small as a millimetre in diameter at a range of 1km. They send continual pulses of radio waves into the atmosphere, record the echoes that bounce back from raindrops and convert each into a measure of rain intensity. They cycle through 15 different angles every 10 minutes, giving a three-dimensional picture of rain fields.

The CRC's work has allowed the Bureau of Meteorology to more accurately measure the amount of rain that falls during storms, providing valuable data for flood warning services and water management authorities. As a result, the CRC is developing real-time quantitative rainfall measurement to provide valuable information to water management authorities Australia-wide.

continued next page

Research Program 5 Climate Variability

"In many flood-prone areas on Australia's eastern coast, rain typically takes six hours to move through catchments and swell rivers. The ability to accurately predict rain volumes, intensity and movement between 0 – 6 hours ahead will revolutionise flood warning systems world-wide, improving the effectiveness of emergency operations. S-PROG forms a key component of the CRC for Catchment Hydrology's research program to develop accurate short-term rainfall forecasts needed for improved flood warnings."



Right (L to R) Dr Phillip Jordan, Dr Alan Seed, Dr Sri Srikanthan, Dr Harald Richter – Bureau of Meteorology researchers in Climate Variability Program



Far Right Bureau of Meteorology Radar Station

Sewerage system savings in Sydney

In 2001, Sydney Water approached the Bureau of Meteorology for rainfall information to optimise its assessment of Sydney's sewer system. Sydney Water's rain gauge data and modelling showed that during heavy rain, water was leaking into sewers, causing them to overflow and spill into local waterways. The massive cost of repairing the sewers means the work has to be carried out over several years, starting with the most deteriorated areas.

Using the new weather forecasting and modelling technology, the CRC is developing software that will enable Sydney Water to use the Bureau's radar data to better calibrate their models of the sewer system. This will allow it to better identify the worst parts of the sewer system and prioritise maintenance works, design and target costly capital works and compare the performance of sewer rehabilitation methods.

With a \$2 billion projected investment in the sewer system, the benefits of adopting CRC research are expected to save Sydney Water an estimated \$20 to \$40 million over the next 20 years.

Melbourne Water gets MOTIVATE

The CRC funded an archive of high-resolution radar data that has been used to develop MOTIVATE, a statistical rainfall model. MOTIVATE used data from the Bureau of Meteorology's Sydney and Melbourne radars to generate improved, realistic 'design storms' – virtual storms generated by computer models. These were combined with hydrological models to test the reliability of sewerage systems and stormwater networks under a range of rainfall scenarios.

MOTIVATE provides more realistic rainfall patterns than existing models and is being

enthusiastically received by industry. It allows, for the first time, accurate evaluation of the risk of system overflows. MOTIVATE also allows the industry to generate spatially realistic design storms that represent the movement of actual storms, the changing intensity of different cells within a storm, and the effects of these changes on water inflows into sewerage systems and treatment plants.

Last year MOTIVATE allowed Melbourne Water to assess the reliability of its sewer network, evaluate the risk of overflows in case of a 1-in-5-year storm, and simulate the response of the Melbourne water catchment area to different storms for the first time.

Overseas weather forecasting services adopt our nowcasting system

The third major product from the CRC's climate variability research with the Bureau of Meteorology is S-PROG – the world's first operational multi-scale nowcasting (short-term forecasting, less than three hours) system, which measures the rate at which rainfall areas of different sizes move and change in intensity across landscapes.

Following outstanding success in a trial alongside international nowcasting systems at the 2000 Olympic Games and further testing in Sydney in 2001, the Bureau of Meteorology has adopted S-PROG and is implementing the technology in all capital cities and, eventually, across rural and regional Australia.

S-PROG is based on cutting-edge developments in understanding the space-time behaviour of rainfall, incorporated into a software program. It can accurately track rainfall up to 90 minutes ahead of storms, with updates every 10 minutes,

and has immediate application wherever nowcasting is required, including:

- **Major weather-dependent sporting events**
Spectators, organisers and officials at multi-million-dollar sporting events, such as the Formula One Grand Prix, the Olympic Games, yachting, tennis and cricket, will benefit from the increased accuracy and timeliness of weather forecasting that S-PROG offers. The advance warning for imminent rainstorms will allow organisers more time to cover pitches or courts, re-schedule matches or races if needed and communicate new schedules – helping minimise disruption, inconvenience and possible danger to participants or damage to sporting surfaces.
- **Improved tracking of natural disasters**
Perhaps the most dramatic potential for S-PROG is in monitoring rainfall and storm patterns during bushfires. Using S-PROG, emergency crews will be able to accurately pinpoint where and how much rain will fall, allowing them to manage and plan firefighting, rescue and preventative management operations more effectively.
- **More efficient irrigation, urban stormwater, and water management**
Managing water resources more effectively and reducing pollution from urban storm water runoff is a priority for local, state and Commonwealth governments. Irrigators and water authorities will be better able to manage crop water requirements, coordinate irrigation for cropping, industry and recreational uses (for example, golf courses and council parks and gardens), and coordinate reservoir operations. Short-term rainfall forecasts over cities can also be used in sewer management to reduce pollution from over-loaded treatment plants.

Milestones Program 5

Milestones

Progress

Years 1 and 2

Specify through a workshop the boundaries of current data generation algorithms – the climatic and streamflow variables, time steps and spatial scales.

The workshop was held in March 2000, and the climatic variables to be generated during the Program's first three years were identified.

Identify the most appropriate methods to generate stochastically climate and related hydrologic data sequences for any point in Australia. Write and test computer programs to generate climate data. Distribute via targeted workshops to other CRC programs.

The methods were identified via an extensive literature review and tested and compared. For point rainfall, AR(1) and HSM annual models, method of fragments and non-parametric monthly models and TPMb and WN daily models were recommended for the Toolkit. For daily climate, a multivariate model conditioned on the rainfall state was recommended. For multi-site data, the Matalas multi-site annual generator with monthly fragments was recommended. Research on stochastic generation of daily spatial rainfall and sub-daily space-time rainfall is being carried out.

Conduct a stakeholders' workshop to identify key stakeholder interests and involvement in the project. Establish the project as a component of the Global Energy and Water Experiment (GEWEX) Continental Scale Experiment (CSE) by satisfying acceptance criteria.

Several workshops were conducted as part of the Communication and Adoption strategy (March, 2000, in Melbourne, July 2001, in Melbourne, August 2001, in Brisbane and June and December 2001, in Tatura). The Murray-Darling Basin was accepted as a GEWEX CSE basin in March 2002.

Adapt the land surface scheme, currently used in the Bureau's operational forecast model, to improve the NWP capability for the simulation and prediction of the surface water budget on basin and catchment scales, with a focus on the Murray-Darling Basin and Murrumbidgee Catchment.

Preliminary testing of land surface scheme in the Bureau of Meteorology's NWP model using parameters dependent on soil and vegetation characteristics was completed. Monitoring of soil moisture, soil temperature and climate data at 18 sites across the Murrumbidgee began in September 2001. The data will be used for more detailed model testing and improvements.

For climate-linked space-time modelling, determine the best way to stratify past climate (for example, wet vs dry years) in a way that makes sense from a water management perspective (that is, focusing on runoff volumes rather than rainfall).

This research is no longer a priority because approaches for forecasting seasonal rainfall and streamflow have been developed elsewhere in the Program.

Characterise and develop models for spatial and temporal rainfall patterns in terms of their statistical structure for the different climate stratifications identified within a Bayesian or other framework.

The space-time rainfall model for homogeneous areas, MOTIVATE, has been developed and calibrated against radar data from key locations across Australia. It gives stochastic realisations of design storms.

Examine existing seasonal forecasting techniques suitable for forecasting streamflow for water resources management.

A non-parametric model for forecasting exceedance probabilities of rainfall and runoff several months ahead has been developed and tested using data from across Australia. The model exploits the relationship between El Niño/Southern Oscillation and rainfall and runoff and the serial correlation in runoff.

Years 3, 4 and 5

Review the outputs and outcomes of the stochastic generation software; plan the project expansion to include the development and testing of more accurate algorithms where appropriate.

The stochastic generation methods for point rainfall and other climate data will be incorporated into the Toolkit. Their usefulness and applicability will be reviewed continuously as the software is used by industry.

Conduct research as required to develop new stochastic data generation methodologies.

The main research areas in Years 4 and 5 are on the stochastic generation of daily spatial rainfall and sub-daily space-time rainfall as well as streamflow data.

Test the new climate generation methodologies for areas within the five Focus Catchments in addition to regions in Australia recognised as having extreme variability.

The models for generating point stochastic data have been tested using data from across Australia. Promising space-time stochastic rainfall models developed in Australia and overseas are being tested using data from the Murrumbidgee and Yarra River Focus Catchments.

Develop a prototype end-to-end system, incorporating the NWP and hydrological models, to demonstrate an improved predictive capability for catchment management purposes.

Research on hydrological models and NWP models will improve weather forecasts. The use of these forecasts for water resource management will be investigated using system simulation models developed in CRC Programs 1 and 3.

Conduct a stakeholder workshop to review progress and outputs and outcomes of the project, with a particular focus on technology transfer to water managers.

Regular workshops are held as part of the Communication and Adoption strategy.

Apply, test and refine the space-time climate modelling methodology to one or more of the selected catchments/regions.

Promising stochastic space-time rainfall models are being tested using data from the Murrumbidgee and Yarra River Focus Catchments.

Package the developed space-time climate model to suit user applications and conduct workshops throughout Australia.

Workshops for these and other models will be conducted when the models are developed and incorporated into the Toolkit.

Research Program 6 River Restoration



Program Leader

Associate Professor Ian Rutherford, The University of Melbourne (succeeded by Dr Mike Stewardson from September 2002)

Aim To produce and demonstrate best-practice guidelines for carrying out stream restoration in Australia.

Program Output

Tools, information and intellectual leadership required to rehabilitate Australian streams.

Outcomes and Benefits

This Program's vision is to improve and protect the natural environment of Australian streams by equipping stream managers with effective knowledge and tools. As a result of this work, agencies will have:

- a basis for deciding whether to rebuild channels or let them degrade to a quasi-natural state
- techniques to manage sediment
- best-practice guidelines for channels to maximise environmental returns for the available flows
- an assessment of the secondary consequences of restoration works on streams, especially for flooding and erosion
- better value for money from the Natural Heritage Trust (NHT) and similar initiatives by improving the planning, design, and implementation of specific rehabilitation activities, such as re-snagging and fishway structures

End-Users

Stream managers and engineers involved in stream restoration and management works.

Program Highlights 2001-2002

- CRC researchers developed and applied the Flow Events Method to several environmental flow plans. As a result, it is being included as part of the standard methodology adopted by the Victorian government for environmental flow design.
- A major riparian revegetation experiment was developed with funding from the Murray-Darling Basin Commission (MDBC) and in association with the CRC for Freshwater Ecology.
- Project 6.3 researchers (with CRC for Freshwater Ecology) recorded a positive biological response to structures placed in sand-slugged streams in the Granite Creeks catchment, Vic, the site of Australia's biggest stream rehabilitation experiment.

- Preliminary results from experiments on the impact of riparian vegetation on stream temperature in south-east Qld streams showed a startling response: as one example, water temperature differences of up to 10°C between vegetated and unvegetated streams were recorded, with implications for stream ecology.
- Program 6 researchers helped organise the biggest river-related conference in Australia, the Third Australian Stream Management Conference in Brisbane (with more than 400 delegates), in August 2001, and published the proceedings of the conference, which included more than 130 papers. Program 6 also assisted in organising the associated Third National Fishways Workshop and published the workshop proceedings, in which they presented six papers.
- After holding a workshop on Environmental Flows (Nov 2001) (understood to be the largest such event held to date), the team published a special issue of the Australian Journal of Water Resources, on environmental flows.
- A computer model to design rock chutes for fishways and scour prevention was completed.



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Far Left Program, Project Leader Dr Mike Stewardson – Projects 6.1, 6.7 (succeeding Assoc Prof Ian Rutherford as Program Leader)

Right Project Leader Dr Tony Ladson – Project 6.2

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Left Recovery potential of streams an issue

Project Group A: Stream Restoration Procedures and Evaluation

Aims of Group A Projects:

To develop principles for evaluating restoration procedures and criteria for determining the recovery potential of streams, in collaboration with the CRC for Freshwater Ecology and evaluate large-scale stream rehabilitation projects in partnership with the Focus Catchments.

Developing Criteria and Concepts for Planning Stream Rehabilitation Planning

Project 6.1, Project Leader: Dr Mike Stewardson

Achievements 2001-2002

- Assessment of a 'space-for-time' approach to evaluating riparian effects on streams (in north-east Vic) concluded that a full before-after control intervention was probably the only evaluation design that would successfully evaluate riparian revegetation.
- Draft guidelines and principles for evaluating stream rehabilitation projects (particularly riparian revegetation) were completed for use by stream managers Australia-wide.
- The Murray-Darling Basin Commission (MDBC) funded component of this project was completed. Researchers anticipate further MDBC funding to implement a big riparian revegetation project in the Murray-Darling Basin.

Stream Restoration Planning and Execution in the Yarra Catchment

Project 6.2, Project Leader: Dr Tony Ladson

Aim To develop, implement and evaluate a major restoration project in the Yarra River Focus Catchment, in partnership with the CRC for Freshwater Ecology and Melbourne Water.

The Project is investigating the key influences on urban stream health, through an adaptive experiment to change hydrology, water quality and physical habitat and then test for improvements. Urban restoration planning procedures are also being studied.

Achievements 2001-2002

- Work was undertaken with the CRC for Catchment Hydrology on the effect of disturbance frequency on biota. Preliminary results indicated a way forward using biological data to determine whether changed hydrology or water quality was the key problem or a combination of the two.
- Preliminary modelling and analysis showed focussing on hydraulic changes produced by urbanisation would achieve little ecological benefits until water quality was improved. Researchers have now implemented a program to monitor the effect of artificial wetlands on water quality, in association with Program 4.
- Researchers tested the application of the leit built (life building) procedure in the Monbulk Creek Catchment. This procedure develops a reference condition based on 'naturalness' and lists intervention options to help move toward the natural state.

- Preliminary work highlighted two key issues for Melbourne Water in urban stream planning. A clear framework for indicators of stream condition is needed; the existing Index of Stream Condition needs to be modified to improve its suitability for urban streams. The second issue relates to priority-setting approaches. A STREAMS model needs to be tested and refined. The CRC is working with Melbourne Water to develop priorities for the remainder of this project.



Restoration Ecology in the granite Creeks Catchment, VIC

Project 6.3, Project Leader: Associate Professor Ian Rutherford

Aim To design and build artificial habitat structures in selected creeks and, in association with the CRC for Freshwater Ecology, monitor their biological and physical effects.

Achievements 2001-2002

- With the Goulburn-Broken Catchment Management Authority, more than 40 wooden structures have been placed into Creightons and Castle Creeks and the ecological and physical impacts monitored for 12 months (long-term impacts are being measured). The sampling period for Granite Creeks coincided with an unusually dry period (see Figure 1) and only modest scour around the structures has been recorded to date. Biological sampling by the CRC for Freshwater Ecology's Dr Nick Bond and Alena Glaister has shown an initial positive response to the structures by blackfish and mountain galaxiids, which increased in numbers at the treatment sites relative to controls.
- A new device – a pressure transducer plate – for measuring fluctuations in sand bed streams was trialled and deployed in Creightons Creek. There is interest in deploying the device in the Snowy River rehabilitation project.

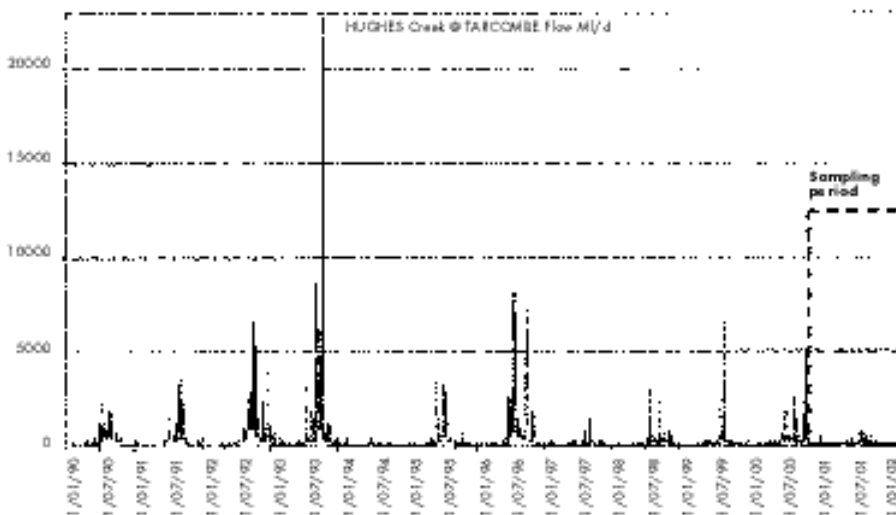


Figure 1 Granite Creek flows (ML/day) during 2001-02 monitoring period

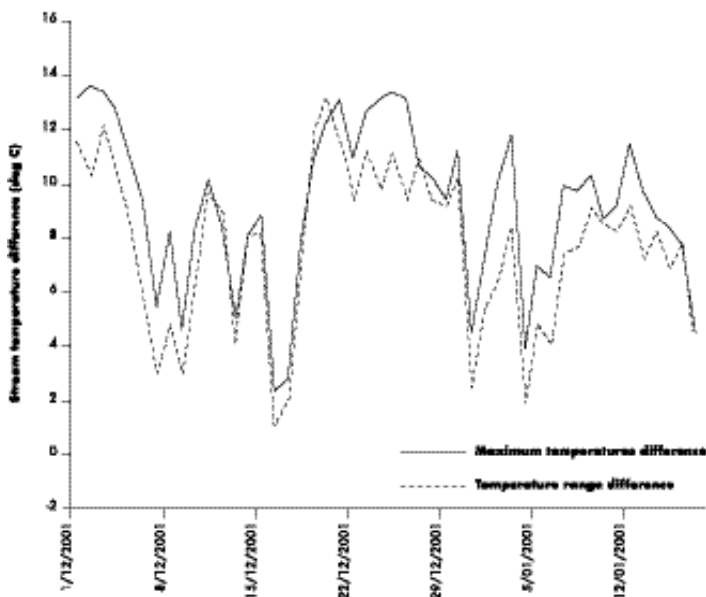


Figure 2 Water temperature differences with riparian vegetation.



Facing Page
Program, Project Leader Assoc
Prof Ian Rutherford – Project 6.3

This Page
Above River Restoration
Program group

Above Right Project Leader
Prof Stuart Bunn – Project 6.4

Evaluation of Riparian Revegetation Projects in a South-East Qld Catchment

Project 6.4, Project Leader: Professor Stuart Bunn

Aim To test the effectiveness of restoring large tracts of riparian vegetation. The focus is on evaluating a stream rehabilitation project in south-east Qld.

Achievements 2001-2002

- Stream rehabilitation works have been completed and ongoing maintenance and weed control has resulted in rapid growth of riparian vegetation.
- Equipment to continuously measure or monitor turbidity, water depth and temperature has been deployed in treatment and control reaches. The monitoring has shown a response to the revegetation strategy, especially with water temperature differences of up to 10°C between vegetated and unvegetated streams. (see Figure 2)
- A vacation scholar developed a turbidity vs. suspended solids relationship for streams in the region.

Project Group B: Improved Design of Tools for Stream Restoration

Aims of Group B Projects:

To improve the confidence with which people design and apply tools for stream restoration and develop a decision support system (DSS) to help select appropriate restoration techniques.

Hydraulics and Performance of Fishways in Australian Streams

Project 6.5, Project Leader: Associate Professor Bob Keller

Aims To recommend optimum design for fishways (structures that help fish swim past man-made barriers, such as weirs).

Vertical slot fishways are being used to restore river ecology, but they are costly and notoriously difficult to design. Detailed work by Lindsay White, Associate Professor Bob Keller and their team (Project 6.5) has led to clear relationships between many hydraulic characteristics of fishways and fish behaviour. Their work in flumes and on the Torrumbarry and Yarrawonga weirs on the Murray River, is partly-funded by Agriculture, Fisheries and Forests - Australia (AFFA). It will result in a sophisticated numerical model to optimise the design of vertical slot fishways. The Project is preparing to release an Australian Manual of Fishway Design in 2003.

Achievements 2001-2002

- A National Fishways workshop held in Brisbane in August 2001, exceeded expectations. Project 6.5 researchers presented six papers.
- The most comprehensive field assessment of fishway hydraulics ever undertaken in Australian streams was completed.
- A three-dimensional numerical model of vertical slot fishway hydraulics was developed, allowing for progress on rock ramp experiments during 2002-03 at Monash University, in association with the DLWC and the DNRE.

Left Project Leader Assoc Prof Bob Keller – Projects 6.5, 6.6



Developing Tools to Predict Scour of Rehabilitation Works in Streams

Project 6.6, Project Leader: Associate Professor Bob Keller

Aims To develop tools to predict the probability of various objects surviving in a streambed and strategies to better manage woody debris, snags and other beneficial objects in streams.

Achievements 2001-2002

- A computer model to predict rock chute failure was completed and is due for release to users for Beta testing. It will allow consultants and stream managers to design more economical rock chutes for bed stabilisation and fish passage.

Developing an Environmental Flow Methodology: A Trial on the Campaspe River

Project 6.7, Project Leader: Dr Mike Stewardson

Aim To develop a generic environmental flow methodology that integrates hydrology, geomorphology and ecology.

Dr Stewardson developed the Flow Events Method, a tested approach to designing environmental flows from dams and an invaluable tool in stream rehabilitation. It identifies ecologically-relevant flows that mimic a stream's natural variability and is the major tool adopted in designing the environmental flow strategy for the DNRE's study into environmental flows for the Loddon and Broken Rivers, Vic. It is being included as part of the standard methodology adopted by the Victorian Government in designing environmental flows.

Achievements 2001-2002

- The project led environmental flow research in south-east Australia by organising, with other groups, a major workshop on environmental flows (205 attendees) at the Melbourne Zoo in November, 2001 and publishing a special issue of the Australian Journal of Water Resources, on environmental flows. A one-day workshop on environmental flows was also organised at the 27th Hydrology and Water Resources Symposium in Melbourne, May 2002.

Milestones Program 6

| Milestones | Progress |
|---|--|
| Years 1 and 2 | |
| Formalise links with partner CRCs in joint projects | Formal links with the CRCFE in five of the eight projects. Reduced support for fishways and Yarra projects. |
| Complete evaluation of existing rehabilitation projects in Australia | <i>Milestone deleted as approved by Commonwealth 16 November 2000.</i> |
| Select catchments and sites for trial rehabilitation | All sites selected. Three projects on the Goulburn Broken River Focus Catchment, two on the Yarra River Focus Catchment, one on the Brisbane River Focus Catchment. Other two projects relate to all catchments. All experimental sites selected. |
| Trial stream rehabilitation planning procedure at target sites | This refers to a trial of the stream rehabilitation procedure described in the national stream rehabilitation manual. Trials have taken place in the Murrumbidgee and Torrens-Onkaparinga catchments. |
| Develop improved criteria for rehabilitation planning <i>Modified milestone as approved by Commonwealth 16 November 2000</i> | Strong progress in all projects. Guidelines and methodologies are well advanced for fishway design (6.5), evaluation of rehabilitation projects (6.1) and environmental flows projects flow events method (6.7). |
| Develop and calibrate hydraulic and hydrological models of rehabilitation sites and assess viability of projects | <i>Milestone deleted as approved by Commonwealth 16 November 2000</i> |
| Begin construction of works if appropriate | Where construction of structures and monitoring is contemplated (Brisbane revegetation and monitoring); Granite Creeks – structures and monitoring) all works are completed, and we have almost one year of monitoring. The exception is the detention basin experiment in the Yarra River Focus Catchment which has been proved non-viable and been replaced by an alternative trial. |
| Design associated rehabilitation experiments | Continuing experiments include: Granite Creeks structures experiment, fishways field and flume experiments, south-east Qld revegetation experiment, evaluation experiments (6.1). The scour (6.6) experiments are behind schedule because of problems with finding staff. |
| Develop a stream rehabilitation training program | We have not developed this training component but are in discussions with Land and Water Australia (L&WA) through the Rivers Consortium to develop short courses on stream restoration. |
| Years 3, 4 and 5 | |
| Complete all rehabilitation construction work | All completed |
| Deliver stream rehabilitation training program to target managers in eastern states | Negotiations continuing with CRC for Freshwater Ecology, and Land and Water Australia |
| Update rehabilitation planning procedures | Progressing well |
| Complete development of design models for rehabilitation tools | On track. Flow events method close to completion. Stochastic structural 'efficiency' developed as a new approach to restoration design. On track. |
| Complete first round of rehabilitation experiments | All experiments have already yielded strong results. |
| Incorporate modelling tools into the Toolkit of Program 1: Predicting Catchment Behaviour | On track. |

Utilisation and Application of Research Program 7 Communication and Adoption

The key goal for land and water managers and the CRC for Catchment Hydrology is to use research knowledge to link land management targets in whole catchments with their impacts on water quantity and quality in streams.



Program Leader

Mr David Perry, Monash University

Aim To meet the CRC's prime goal – adoption of its research outcomes.

This Program aims to achieve best practice in facilitating the adoption of research outputs – the CRC's prime goal.

It is adding value to the research by developing collaborative communication and delivery-focused projects with CRC Parties and Focus Catchment Coordinators (see below), and is committed to measuring its effectiveness through reviews by independent consultants in years one, three and five (the first of which was completed in May 2001, with positive results).

All research programs are implementing their Communication and Adoption (C&A) strategies, developed during 2001 based on a framework developed by Focus Catchment Coordinators and Program Leaders. During 2001-02, the research programs engaged in a range of communication activities including interactive workshops and the demonstration and application of modelling tools in Focus Catchments.

Program Highlights 2001-2002

- The Second-Year Review Panel (Stage 1) acknowledged the effectiveness of the C&A Program, stating: "The CRC has shown a good deal of innovation in this area and considered a leader in the complex business of technology transfer and adoption."
- The Second-Year Review Panel (Stage 2) was highly complimentary about the C&A Program, saying: "The CRC's communication strategy is excellent, with a highly visited website and a wide range of publications targeted carefully at appropriate community sectors. Internal communication is regarded as excellent."
- The development and application of the EMSS catchment modeling software in the Brisbane River Catchment (see Program 1)
- As reported under Program 5, the CRC's Climate Variability research made a major impact on weather forecasting agencies world-wide and Australian land and water managers (see box story right).
- As reported under Program 4, MUSIC - the urban stormwater modelling software - was launched, providing urban water managers with a Decision Support System that evaluates conceptual designs of stormwater management systems. By simulating the performance of stormwater quality improvement measures, MUSIC can assess whether the proposed measures will meet specified water quality objectives. The MUSIC software and methodology was developed in consultation with industry, making it an attractive, practical and readily useable tool. Orders for more than 200 copies of MUSIC V. 1.0 have been received from urban stormwater managers and consultants around Australia.

The future for weather nowcasting, forecasting and measurement

Because the CRC's forecasting technology was requested by industry, it has been rapidly adopted by key users of weather monitoring and prediction information, such as the Bureau of Meteorology and water management agencies. Technology has been transferred through industry meetings with key weather forecasting agencies, practical demonstrations (for example, at the Olympic Games), and scientific conferences.

Last year at a CRC workshop at Tatura, Vic, land and water managers identified a range of potential applications for the CRC's radar forecasting research outputs, which included:

- Improved flood management and flash flood warnings
- Irrigation and waterway management efficiencies
- Improved scheduling and planning of catchment management works
- Refined streamflow and water quality management plans
- Accurate hail predictions, allowing for more timely preventative measures in cropping areas
- Assistance with farm operational decisions, for example, hay-cutting, spraying, etc.



Facing Page

Far Left Program Leader David Perry

Centre Tony Weber - Focus Catchment Coordinator, Brisbane River

Right Pat Feehan - Focus Catchment Coordinator, Goulburn/Broken Rivers

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Above (L to R) Dr Graham Mills, Prof Tom McMahon, Dr Alan Seed, Dr Mike Manton - speakers at Climate Variability Research Forum, Tatura, October 2001

Centre Carolyn Young - Focus Catchment Coordinator, Murrumbidgee River

Right Graham Rooney - Focus Catchment Coordinator, Yarra River

Stakeholder and End-User Involvement

Ensuring CRC Parties are involved in the development, implementation and delivery of its research

A key strategy for involving research users in the development and demonstration of research outputs is through Focus Catchment Coordinators (FCCs) in the CRC's five Focus Catchments – the Brisbane and Fitzroy Rivers in Qld, Murrumbidgee River, NSW, and the Yarra and Goulburn/Broken Rivers, Vic. The CRC's research efforts are directed towards catchment-scale problems in the five basins, to develop and demonstrate capability to address important and practical issues. The close involvement of CRC Parties and the efforts of the FCCs appointed by the CRC Parties, has been a significant factor in the CRC's success to date.

The FCCs liaise closely with CRC researchers and land and water industry representatives to ensure the research and research products provide relevant, innovative and practical solutions to key catchment management issues.

Highlights and challenges for them during 2001-02 included:

- Mr Tony Weber, formerly Senior Waterways Program Officer – Water Quality, Brisbane City Council and FCC, Brisbane River: *"During the 2002 Annual Workshop at Ballarat, we were asked to facilitate a workshop to develop a systems view of each of the Focus Catchments. The presentations revealed a high degree of similarity between the management issues facing each Coordinator. It's encouraging that the CRC's research is addressing the majority of these issues. This has been borne out in the on-ground research being applied in the Brisbane River Focus Catchment.*

Specifically, the development of the EMSS software for the catchment - as a task for the South East Queensland Regional Water Quality Management Strategy- has shown stakeholders the potential of CRC research and the underlying science behind the development of the CRC's modelling tools.

This has also been evident in the development of the CRC's urban stormwater software, MUSIC. Through industry testing of the software, and communicating the science behind its development, a product has been developed that will see rapid adoption due to its applicability and robustness.

By focussing on continued adoption of the CRC's research outcomes, and further research to develop or enhance our knowledge, the CRC mission will be achieved within the Brisbane River Focus Catchment."

- Mr Pat Feehan, Manager, Natural Resources, Goulburn-Murray Water and FCC, Goulburn/Broken Rivers, commented: *"We're now really starting to see some research outcomes. It's much easier to convince people of the need to adopt CRC for Catchment Hydrology research outcomes with something tangible.*

The statement of the CRC's capability generated at the Woodend workshop was a major highlight. It showed what the CRC can, and will, deliver

Another highlight was a workshop held in Tatura on the effects of land-use changes on water and salinity as part of Project 2.3. We asked participants how they would use the outcomes of the research and generated a page of relevant, good ideas. It showed we are hitting the mark in terms of research outcomes – and inviting the right people to our workshops!"

- Ms Carolyn Young, Environmental Officer, Department of Land and Water Conservation, NSW (DLWC), and FCC, Murrumbidgee River, said:

"Over the past few months, one of the highlights for me has been participating in and watching the development of the second round of CRC projects. The project proposals being developed reflect the maturity of the CRC; commitments are being made towards the integration of research among the researchers and cooperation within CRC parties.

This makes my job as FCC easier; marketing CRC products that complement DLWC products and have a designated 'home'."

- Mr Graham Rooney, Manager, Water Environment Research, Melbourne Water and FCC, Yarra River:

"The highlight of the year for me was the acceptance of the MUSIC urban stormwater modelling software by Melbourne Water planners.

There are already examples where using MUSIC has made us revise down our original plans to build bigger, more costly water treatment assets, in order to treat predicted volumes of stormwater.

MUSIC user groups have been set up within Melbourne Water and across State boundaries.

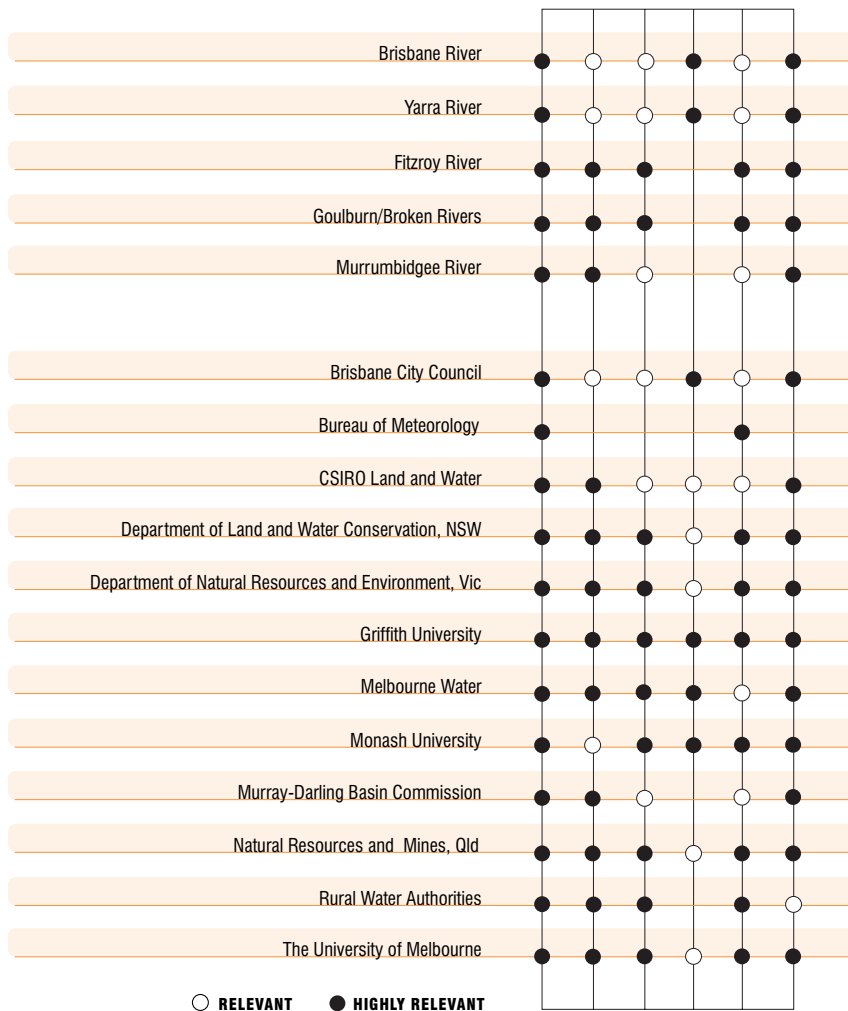
Close liaison with the Monash University node of the CRC has allowed research on a range of stormwater-treatment assets, with mutual benefit to the CRC and Melbourne Water.

A recent initiative between the two CRC Parties will lead to an enhanced knowledge of the effectiveness of big wetland systems. Stream restoration researchers at The University of Melbourne have contributed strongly to the direction of research and understanding of factors affecting biodiversity in streams flowing through urbanised catchments.

Utilisation and Application of Research Program 7 Communication and Adoption

Focus Catchment, Research Program and Party Interactions

RESEARCH PROGRAMS
 PREDICTING CATCHMENT BEHAVIOUR
 LAND-USE IMPACTS ON RIVERS
 SUSTAINABLE WATER ALLOCATION
 URBAN STORMWATER QUALITY
 CLIMATE VARIABILITY
 RIVER RESTORATION



○ RELEVANT ● HIGHLY RELEVANT

FOCUS CATCHMENTS

CENTRE PARTIES

The CRC's enhancement of the SedNet model and an EMSS-like simulation model have definite applications in the Yarra River basin. A nation-wide shift to setting nutrient targets means robust decision support systems, such as those being developed by the CRC, are required to validate planning processes."

- Mr Chris Carroll*, Natural Resources and Mines (NRM), QLD, and FCC, Fitzroy River: "Two highlights during 2001-02 stand out: the first was the Central Queensland Healthy Waterways Launch on the bank of the Fitzroy River. The launch was jointly funded by the CRC for Catchment Hydrology, the CRC for Coastal Zone, Estuary and Waterway Management and the Fitzroy Basin Association. More than 200 people attended and TV items produced for the launch have been shown at peak viewing time on WIN TV, to raise awareness about good waterway management.

"The second highlight was the AEAM workshops in Brisbane and Rockhampton, which brought together scientists from the two CRCs, government agencies and community representatives in the Fitzroy catchment and coastal region.

"The aim was to create a conceptual model of the Fitzroy, incorporating and integrating biophysical, biological and economic aspects. The workshops were a great success and have potential to lead to a customised development project for the Fitzroy River Focus Catchment in the next round of CRC projects."

* Mr Bob Noble, Principal Scientist, NRM, QLD, took over from Chris Carroll as FCC for the Fitzroy River from April to September 2002.



Facing Page
Chris Carroll - Focus Catchment
Coordinator, Fitzroy River



This Page
Above John Coleman and CRC
colleagues demonstrating 'MUSIC'
software at Sydney seminar

Above Right Communication and
Adoption Program group

Effective Communication

An encouraging result for the CRC was that on average 82% of respondents to the Communication Review in May, 2001, rated the CRC's communication product range (including *Catchword*, website, technical reports, industry reports and workshops etc) as four or more on a scale of one to six, where one was ineffective and six extremely effective.

Catchword and *CatchUp*

The CRC continued to produce its flagship stakeholder newsletter, *Catchword*, and internal newsletter, *CatchUp*, providing regular updates on forthcoming water industry events; CRC seminars; field days and workshops; technical and industry reports and videos; research progress reports; international visits and visitors; and awards and grants.

Catchword, a free publication, has about 1400 subscribers. About 950 copies are direct-mailed each month, about 450 copies are sent via electronic mail with an average of more than 1000 copies accessed from the CRC website each month. An additional 100 copies are distributed through the research nodes.

CatchUp is distributed fortnightly via email to more than 160 CRC staff throughout the 14 organisations forming the CRC.

The October, 2001 edition of *Catchword* was devoted to the issue of integration. The CRC research programs were presented from the Focus Catchment viewpoint: Program Leaders and FCCs summarised the issues in each catchment and outlined the likely impact of CRC research in providing the knowledge and tools to tackle these issues. There was also a report on the Toolkit development, describing early achievements.

Website

The CRC continued to maintain and update its website to provide information for end-users and included new features, such as the ability to access Program pages directly. Details about the CRC's website are in this report under the chapter on Public Presentations, Public Relations and Communication.

Industry Seminars, Technical Seminars and Workshops

During the year the CRC continued its seminar series. The seminars have established a reputation for providing practical information of immediate relevance to catchment managers, based on world-renowned research. They are attended primarily by researchers from many disciplines (including hydrologists, meteorologists, ecologists and engineers) interested in the CRC's projects. Industry and technical seminars providing clear, practical implications for natural resources management have attracted industry representatives.

MUSIC Industry Seminars and Sales

The initial version of the MUSIC software and methodology was launched in a series of stormwater management industry-focussed seminars during May 2002 in Brisbane, Sydney, Canberra, Melbourne and Adelaide (a Perth seminar is scheduled for 2002 – 2003). This version, a 'pre-commercial release', has a use-by date of June, 2003. It is intended to achieve widespread adoption and industry feedback before a more developed version with more options is released next year.

Almost 700 consultants, developers, research staff, local council staff, university researchers and state agency representatives attended the launch workshops. Intensive training workshops on the use of MUSIC are scheduled for early 2002 – 2003. The launch attendances showed a positive response to the industry seminars with the target audience (consultants, developers, local government and state agencies) being well represented (some 90% of the audience).

Third Australian Stream Management Conference

In August, 2001, more than 400 scientists and managers from every state and territory met at the Third Australian Stream Management Conference in Brisbane, of which the CRC was a major sponsor. CRC scientists were well represented as delegates, presenters, and as authors in the proceedings, highlighting the CRC's contribution to the industry. CRC webmaster, Daniel Figucio, developed the conference website and the CRC published the conference proceedings. Reviewing and publishing 120 papers before the conference was a great achievement and a credit to the CRC and all reviewers involved. Particular thanks go to Assoc Prof Ian Rutherford and Christine Kenyon, who coordinated the review process.

A full list of CRC workshops is provided in this report.

Publications and Videos

The CRC continued to produce high-quality and well-regarded publications and videos under its Industry Report and Technical Report series. The demand for these products is reflected in strong, consistent sales and increasing requests for electronic downloads from the website.

Utilisation and Application of Research

Program 7 Communication and Adoption



Evapotranspiration (ET) Maps For Australia

One of the projects from the initial CRC concluded in July 2001, with the publication by the Bureau of Meteorology of a book of evapotranspiration (ET) maps for Australia.

The book was launched at a joint seminar of the CRC for Catchment Hydrology and the Institution of Engineers, Australia (IEAust) in July 2001, following introductions by Dr John Zillman, Director of the Bureau of Meteorology, and CRC Director, Professor Russell Mein. The 60 attendees heard CRC researcher, Dr Francis Chiew, explain the technical basis for, and potential use of, the maps.

ET is the biggest component of the Australian water balance, after rainfall. For the Australian continent, nearly 90% of rainfall moves back to the atmosphere through ET, leaving only 10% to flow to the oceans via streamflow. Despite this importance, there is no direct way to measure ET at meaningful space or time scales and indirect methods must be used.

These indirect methods have ranged from measuring the other components of the water balance (for example, rainfall and runoff) and estimating ET from the difference of the two. More direct measurements have used evaporation pan data, with coefficients being applied to compensate for differences between evaporation from a pan and ET from a catchment. The earlier Climate Atlas of the Bureau of Meteorology included evaporation maps based on pan data.

The new maps are a considerable improvement, providing for three types of ET estimates:

- Areal actual ET – the ET that actually occurs (from an area big enough that boundary conditions, such as wind, can be ignored)

- Areal potential ET – the ET that would occur if there were an unlimited supply of water, in an area big enough to ignore boundary transfers
 - Point potential ET – the ET that would occur if there were an unlimited supply of water, but from an area small enough for the evaporated water vapour to be swept away
- The 39 maps comprise annual and monthly estimates for each ET type and are available from the Bureau's Head Office in Lonsdale St, Melbourne or through the Regional Offices.

A list of publications produced in 2001-02 is provided in this report.

Workshops, Field Tours, Demonstrations and Continuing Professional Education

The CRC maintained its program of field tours and demonstrations, which provided an opportunity for CRC researchers to meet industry practitioners, community groups and other stakeholders, share information and gain feedback about local issues, knowledge gaps and the impact of their research.

A list of workshops, field tours, demonstrations and short courses undertaken in 2001-02 is provided in this report.

Articles in Industry Journals

In 2001-02, the CRC contributed several articles to industry journals and newsletters including *Water* (Journal of the Australian Water Association) and *Australian Landcare*.

A list is included under the Communication, Public Presentations and Public Relations chapter of this report.

Advocacy

Influencing the national agenda for land and water management is a major objective for CRC communication.

With the increasing level of public and political interest in, awareness of and knowledge about catchment issues, the CRC considers it important to contribute its knowledge to the debate, to assist managers in making best-judgement management and policy decisions.

In 2001-02, the CRC Board, Executive and Program staff continued to play an advocacy role with national, state, and regional peak bodies involved in land and water management.

Examples during the reporting year include:

- Dr Rob Vertessy (Program 1) is active in international research groups as leader of the International Union of Forest Research Organisations International Task Force on Forests and Water. He also sits on the Scientific Expert Panel for the Moreton Bay Catchment and Waterways Partnership.
- Dr Heather Hunter (Program 2) has an ongoing role as part of the Scientific Expert Panel for the Moreton Bay Catchment and Waterways Partnership. Dr Hunter is also a researcher with the CRC for Coastal Zone, Estuary and Waterway Management.
- Associate Professor Ian Rutherford (Program 6) acted as scientific advisor to the DNRE's Victorian River Health Strategy.
- Dr Michael Stewardson (Program 6) served on the Scientific Reference Panel for the Snowy River Rehabilitation Project.
- Professor Stuart Bunn (Program 6) continued to play an active advisory role on several committees including the Scientific Committee



*Facing Page (L to R)
Evapotranspiration (ET) Maps team
– Dr William Wright, Graham De
Hoedt, Ross James (all BoM) and
Dr Francis Chiew (Univ Melb)*

*This Page Storm over Melbourne,
courtesy of 'The Age'*

on Water Research, the International Council of Science; SEQRWQMS, the River Symposium Advisory Committee; and the Lake Eyre Basin Scientific Advisory Panel. He is also a member of the Board of Land and Water Australia and a researcher with the CRC for Freshwater Ecology.

- Dr Peter Hairsine (Program 2) sat on four external panels, including: the Dryland Issues Working Group of the MDBC, the project steering committee of the Low Rainfall Area Alley Farming Project (MDBC), the Catchment Categorisation for Dryland Salinity Management (MDBC) project steering committee and the National Dryland Salinity Program's Hydrological Projects steering group.

- Professor Tom McMahon continued to serve as a member on the Expert Reference Panel on Environmental Flows and Water Quality Requirements for the River Murray System.

Relationships with small to medium-size enterprises (SMEs)

The CRC continued to develop a flexible and dynamic relationship with SMEs during the year. Links with SMEs were progressively strengthened, mainly through the uptake of graduates and staff by leading environmental consultancies.

The following table "Interaction with Research Users" outlines further links with enterprises including SME's.

Commercialisation and Intellectual Property Management

With mainly public sector investment and an emphasis on adoption, commercialisation for direct financial returns has not been a major priority for the CRC. However, some research outputs and products present a unique opportunity for financial return and these are assessed on a case-by-case basis.

For the management of intellectual property, the CRC:

- identifies and documents (background) intellectual property brought into the Centre
- develops a value-adding assessment procedure
- protects products with commercial potential
- negotiates agreements for commercial application and dissemination
- develops a policy for sharing royalties accruing from product sales

During 2001-02, the CRC released MUSIC Version 1.0, the Interactive Component Modelling System (ICMS) and the Environmental Management Support System (EMSS), to industry.

In each case the Centre assessed the potential financial return of the model software and sought professional legal advice to protect the intellectual property.

MUSIC Version 1.0 is a Decision Support System for managing urban stormwater quality. It enables users to evaluate conceptual designs of stormwater management systems to ensure they are appropriate for their catchments. MUSIC Version 1.0 is considered a development version and has been released to engage industry users and assess its potential. The first version is valid until June 2003, when an upgraded version will be released. All MUSIC users must complete and return a Licence Agreement, which clearly define the terms and conditions of both the software and the users manual's use. More than 200 copies of MUSIC Version 1.0 have been sold to date.

ICMS is a PC-based software product, developed to facilitate the rapid development and delivery of catchment science into models for catchment managers. It provides catchment managers with a tool to develop and investigate a range of 'what if' scenarios for a range of complex issues

important in their catchment. ICMS is available to users to download (from <http://www.cbr.clw.csiro.au/icms/>) and is protected by a Non-Commercial Software Licence Agreement. Currently more than 50 users in Australia, France, Canada, UK, Ecuador, USA, Dominican Republic and India have licences to use ICMS.

EMSS is another PC-based software product. EMSS is able to simulate runoff and pollutant movement across south-east Queensland catchments and has been demonstrated in south-east Queensland. EMSS is potentially applicable to catchments Australia-wide but requires customisation for that purpose. To date, 38 users from CRC Parties, research groups and industry have received the software on CD after accepting the terms and conditions of its use. Updates of the EMSS software are regularly sent out and support for its use is provided through the Canberra research node.

Contract Research and Consultancies

The CRC continued to actively target research contracts that strategically support the adoption of key research outcomes.

A number of key research contracts were completed this financial year, for example, Project 1.3, Development of an EMSS for catchments in south-east Qld, and Project 1.4, Modelling and estimating sediment and nutrient loads in south-east Qld.

These collaborative and highly-consultative projects resulted in the development of an EMSS able to simulate runoff and pollutant movement across south-east Qld catchments. This contract research enables the CRC to demonstrate the application of its research outputs and provide immediate benefits to the land and water management industry.

Utilisation and Application of Research Program 7 Communication and Adoption

Interaction with Research Users

| Research User Industry and other organisations | Organisation Size Small & medium sized enterprises, large firms | Basis of interaction Core participant, consultancy, grant collaboration | CRC product or service involved |
|--|---|---|---|
| Australia National University iCAM (Integrated Catchment Assessment and Management Centre) | SME | Research affiliate | <i>Interaction Component Modelling System (formerly termed Integrated Catchment Management System (ICMS))</i> Software being used to model water quality in Ben Chiefly Dam catchment (NSW). Land-use impacts on rivers |
| Australian Centre for International Agricultural Research (ACIAR) | SME | Contract research/grant collaboration | <i>Land-use impacts on rivers</i> Eucalypts and water: Managing forest plantations in China and Australia for sustained productivity and environmental benefits / Dr Jim Morris |
| Brisbane City Council | Large | Core participant | <i>Draft Stormwater Quality Monitoring Protocol</i> Brisbane City Council on stormwater and SQID monitoring to support the protocol. |
| Bureau of Meteorology | Large | Core participant | <i>Motivate Program</i> The Motivate Program was applied to a contract between the Bureau of Meteorology and Melbourne Water to determine the time-area rainfall for a one in five storm. |
| Bureau of Rural Sciences | SME | User consultant | <i>Zhang model</i> The Bureau of Rural Sciences used the Zhang model in predictions of the performance of plantations in the middle Macquarie catchment (part of a major study). |
| Coomes Consulting | SME | Industry user | <i>Model for Urban Stormwater Improvement Conceptualisation (MUSIC)</i> (Melbourne) – Cairnlea Estate, Melbourne |
| CSIRO | Large | Core participant | <i>Tarsier software environment</i> CSIRO researcher outside the CRC, applying Tarsier to model salinity in consultancy for the Water and Rivers Commission (WA) Staff at CSIRO Townsville using Tarsier for ecological modelling (stock track development) <i>Model for Urban Stormwater Improvement Conceptualisation (MUSIC)</i> Brasil Development, Brisbane application |
| Department of Land and Water Conservation (DLWC) | Large | Core Participant | <i>Sediment tracing budget methodology</i> Involvement of DLWC staff in CRC research (Guy Geeves, Christoph Zierholz and Carolyn Young), DLWC (also NSW SF and NSW EPA) reassessing impacts of relevant reforestation water quality and water quality strategies in the catchment and impacts on water availability to irrigators and Macquarie Marshes |
| DNRE | Large | Core Participant | <i>Flow events methodology (FEM)</i> DNRE commissioned an independent report to advise on integration of FEM into statewide environmental flow method. |
| Earth Tech Pty. Ltd. | SME | Consultant user | <i>Flow events methodology (FEM)</i> Report on Evaluation of Method (FEM) Earth Tech Pty. Ltd. is applying FEM in environmental study of Thomson River. |
| Ecological Engineering. | SME | Consultant user | <i>Model for Urban Stormwater Improvement Conceptualisation (MUSIC)</i> (Applications in Melbourne) – Wakerley Area Wetland & Water Sensitive Urban Design, Brisbane; Police Road Retarding Basin, Melbourne; Association of Bayside Municipalities Project, Melbourne |
| Environment Protection Authority Victoria | Large | Consultancy | <i>Urban Stormwater Quality</i> Monitoring protocols and selection guidance for primary stormwater treatment measures Monitoring and evaluation protocols and selection guidance for non-structural stormwater management measures |
| Gutteridge Haskins & Davey | Large | Consultant user | <i>Model for Urban Stormwater Improvement Conceptualisation (MUSIC)</i> (Brisbane) – Park Hill Village, Brisbane |
| Land and Water Australia | SME | Grant collaboration | <i>River Restoration</i> Riparian land management: Concepts, floods and erosion/Prof Ian Rutherford <i>Land-use impacts on rivers</i> Predicting the combined environmental impact of catchment management regimes on dryland salinity/Dr Lu Zhang <i>Sustainable water allocation</i> Enhancement of the water market reform process: A socioeconomic analysis of guidelines and procedures for trading in mature water markets (Project No:[GRU25]) / Dr John Tisdell |
| Melbourne Enterprises International | SME | Consultancy | <i>Flow events methodology (FEM)</i> Mike Stewardson led project through Melbourne Enterprises International to apply methodology to the Loddon River for the North Central CMA. |
| Melbourne Water | Large | Core Participant | <i>Motivate Program</i> The Motivate Program applied to contract between Bureau of Meteorology and Melbourne Water to determine time-area rainfall for one in five storm. <i>Draft Stormwater Quality Monitoring Protocol</i> Melbourne Water and Brisbane City Council have also adopted protocol for stormwater monitoring programs Consumer responses to residential developments incorporating Water Sensitive Urban Design (WSUD) |

| Research User Industry and other organisations | Organisation Size Small & medium sized enterprises, large firms | Basis of interaction Core participant, consultancy, grant collaboration | CRC product or service involved |
|---|---|---|---|
| Murray-Darling Basin Commission | SME | Core participant Contract research | <i>MDBC report</i> CRC Report to MDBC has highlighted strategic impact of afforestation on water yield in Murray-Darling Basin. <i>Flow events methodology</i> Report on Evaluation of Method (FEM) Final report to MDBC 'Evaluating the Effectiveness of Habitat Reconstruction' (Mike Stewardson and Ian Rutherford) <i>Land-use impacts on rivers</i> Basin-wide mapping of sediment and nutrient exports in dryland regions / Dr Chris Moran Integrated assessment of the effects of land-use changes on water yield and salt loads / Dr Lu Zhang |
| Murrumbidgee Catchment Management Board | SME | Activity by core participant DLWC | <i>SedNet and EMSS</i> Project will demonstrate the relevance and applicability of models to assist in setting end-of-valley targets |
| National Institute of Water and Atmospheric Research, New Zealand | SME | Research affiliate | <i>Climate variability</i> The National Institute of Water and Atmospheric Research, New Zealand has successfully trialled S_Prog and is investigating its use as the nowcasting component of a flash flood warning system. |
| Natural Heritage Trust, Dept of Agriculture, Fisheries and Forestry – Aust. (AFFA) | Large | Grant collaboration | <i>River restoration</i> Research to improve the effectiveness of Australian fishway design / Assoc Prof Bob Keller |
| NSW EPA | Large | Consultancy user | <i>Draft Stormwater Quality Monitoring Protocol</i> NSW EPA adopted draft protocol and now recommended procedure for monitoring stormwater treatment measures by NSW councils |
| Pine Rivers Shire Council | SME | Consultancy | <i>EMSS software</i> Development of a pilot local-scale Environmental Management Support System for use in water supply sub-catchments in Pine Rivers Shire, Qld/Prof Rob Vertessy |
| Water and Rivers Commission (WA) | SME | Consultancy-user | <i>Tarsier software environment</i> Following a Tarsier workshop in Canberra, a workshop participant at CSIRO is applying Tarsier by using it to model salinity for the Water and River Commission (WA) |
| South East Queensland Water Corporation | | Consultancy-user | <i>EMSS Software</i> Development of a pilot local-scale Environmental Management Support System for use in water supply sub-catchments in Pine Rivers Shire, Qld/Prof Rob Vertessy |
| South East Queensland Regional Water Quality Management Committee (SEQRWQMC) | SME | Consultancy | <i>SedNet - a model that predicts the sources and distribution of sediment through a river network</i> The results of the SedNet application and validation in the Brisbane River catchment have formed the basis for targeting catchment works under the SEQRWMS – this modelling work has formed the basis of the agenda for Phase 4 of the strategy <i>EMSS software</i> Development of an environmental management support system (EMSS) for catchments in south east Queensland/ Prof Rob Vertessy <i>Predicting catchment behaviour</i> Modelling and estimating sediment and nutrient loads in south east Queensland catchments – Phase 1/ Dr Francis Chiew <i>Land-use impacts on rivers</i> SEQRWQMS, Stage 3, Project Sediment and Nutrient Sourcing / Dr Jon Olley |
| State Water, an arm of DNRM | Large | Core participant | <i>Fitzroy catchment survey results – Sustainable Water Allocation</i> State Water, an arm of DNRM, used the result of the Fitzroy community and irrigator attitude survey to highlight potential issues and problems to the implementation of the Fitzroy Resource Operations Plan (ROP) |
| UK Meteorological Office | Large | International collaboration | <i>Radar forecasting</i> UK Meteorological Office has requested a MOU with BoM to apply the radar forecasting technology in the UK. |
| Urban and Regional Land Corporation | SME | User – grant collaboration | <i>Water sensitive urban design</i> Consumer responses to residential developments incorporating Water Sensitive Urban Design (WSUD) |
| WBM Oceanics | SME | Consultancy – now Industry Affiliate | <i>EMSS software</i> EMSS (Tarsier) has been delivered and being used by CRC project teams and WBM Oceanics; (consultancy) Development of a pilot local-scale Environmental Management Support System for use in water supply sub-catchments in Pine Rivers Shire, Qld/Prof Rob Vertessy <i>Model for Urban Stormwater Improvement Conceptualisation (MUSIC)</i> Used at Lenworth Lake Development, Brisbane; Forrest Lake, Brisbane; Geelong Stormwater Management Plan, Victoria; Craigieburn Bypass Water Sensitive Road Design, Victoria. |

Utilisation and Application of Research Program 7 Communication and Adoption

Contract Research Activity

CRC Associated/Additional Projects External Funding & Direct CRC Contract Research/Consulting

| 1.3 | Development of an environmental management support system (EMSS) for catchments in south east Queensland / Prof Rob Vertessy | Brisbane catchment | 263 | 151 | 112 | 43 | 0 | 110 | 41 | - | 151 | May 00 to Aug 01 | CSIRO, Univ. Melb, Monash, BCC | South East Queensland Regional Water Quality Management Committee (SEQRWQMC) | | |
|--|--|---|------|------|------|----|------------|------------|-------------|-------------|-------------|------------------|--|--|--|--|
| 1.4 | Modelling and estimating sediment and nutrient loads in south east Queensland catchments – Phase 1 / Dr Francis Chiew | Brisbane catchment | 72 | 54 | 18 | 25 | 0 | 54 | 0 | - | 54 | May 00 to Jan 01 | CSIRO, Univ. Melb, Monash, BCC | South East Queensland Regional Water Quality Management Committee (SEQRWQMC) | | |
| 1.7 | Development of a pilot local-scale Environmental Management Support System for use in water supply sub-catchments in Pine Rivers Shire Queensland / Prof Rob Vertessy | Brisbane catchment | 222 | 125 | 97 | 44 | 0 | 0 | 125 | - | 125 | May 01 to Jun 02 | CSIRO, QDNRM, BCC | Pine Rivers Shire Council, South East Queensland Water WBM Oceanics, Consultants | | |
| 2.6 | Predicting the combined environmental impact of catchment management regimes on dryland salinity / Dr Lu Zhang | Goulburn-Broken catchment, Murrumbidgee catchment | 812 | 150 | 500 | 62 | 0 | 71 | 79 | - | 150 | Jul 00 to Jun 02 | CSIRO, DNRE, DLWC-NSW, Univ. Melb | Land and Water Australia (LWRRDC) | | |
| 2.7 | Eucalypts and water: Managing forest plantations in China and Australia for sustained productivity and environmental benefits / Dr Jim Morris | Goulburn-Broken Catchment | 1621 | 821 | 300 | 19 | 223 | 205 | 195 | 198 | 821 | Jul 99 to Jun 03 | Centre for Forest Tree Technology DNRE, Univ. Melb Dept of Forestry, CSIRO | Australian Centre for International Agricultural Research (ACIAR) | | |
| 2.10 | SEQRWQMS, Stage 3, Project SS:Sediment and Nutrient Sourcing / Dr Jon Olley | Brisbane River catchment | 397 | 277 | 120 | 30 | 223 | 54 | 0 | - | 277 | Aug 99 to Jun 01 | CSIRO, DNRMQ | South East Queensland Regional Water Quality Management Committee (SEQRWQMC) | | |
| 2.13 | Basin-wide mapping of sediment and nutrient exports in dryland regions / Dr Chris Moran | Goulburn-Murray; Murrumbidgee are addressed by this study. The methodologies are of value to the other focus catchments . | 1500 | 492 | 0 | 0 | 24 | 109 | 229 | 130 | 492 | Mar 00 to Mar 03 | CSIRO, Univ. Melb, Monash Univ., MDBC | Murray-Darling Basin Commission (MDBC), Strategic Investigations and Education Program | | |
| 2.15 | Integrated assessment of the effects of land-use changes on water yield and salt loads / Dr Lu Zhang | Part of work in Murrumbidgee and Goulburn-Broken catchments. Some work in catchments in WA | 1295 | 753 | 542 | 42 | 0 | 0 | 282 | 233 | 515 | Feb 01 to Oct 03 | NRE Vic, DLWC NSW, CSIRO Land & Water | Murray-Darling Basin Commission (MDBC), Strategic Investigations and Education Program | | |
| 3.4 | Enhancement of the water market reform process: A socioeconomic analysis of guidelines and procedures for trading in mature water markets (Project No:[GRU25]) / Dr John Tisdell | Murrumbidgee catchment | 833 | 208 | 625 | 75 | 0 | 60 | 72 | 76 | 208 | Jul 00 to May 03 | Griffith Univ, DLWC-NSW, Monash Univ. | Land and Water Australia (LWRRDC) | | |
| 4.3 | Consumer responses to residential developments incorporating Water Sensitive Urban Design (WSUD) | Yarra catchment | 106 | 100 | 6 | 6 | 0 | 0 | 90 | - | 90 | Sep 01 to Jun02 | Melbourne Water, Monash Univ. | Melbourne Water, Urban and Regional Land Corporation | | |
| 4.4 | Monitoring protocols and selection guidance for primary stormwater treatment measures | Yarra catchment | 220 | 200 | 20 | 9 | 0 | 0 | 200 | 170 | 370 | Sep 01 to Jun02 | Melbourne Water, Monash Univ. | Environment Protection Authority Victoria | | |
| 4.5 | Monitoring and evaluation protocols and selection guidance for non-structural stormwater management measures | Yarra catchment | 120 | 100 | 20 | 17 | 0 | 0 | 100 | - | 100 | Sep 01 to Jul02 | Melbourne Water, Monash Univ. | Environment Protection Authority Victoria | | |
| 6.8 | Research to improve the effectiveness of Australian fishway design / Assoc Prof Bob Keller | Applies generally to Murray-Darling Basin | 672 | 362 | 310 | 46 | 18 | 134 | 210 | - | 362 | May 00 to Jun 02 | Monash Univ, Univ. of Melbourne | Natural Heritage Trust, Dept of Agriculture, Fisheries and Forestry - Aust.(AFFA) | | |
| 6.9 | Riparian land management: Concepts, floods and erosion / Assoc Prof Ian Rutherford | Feeds into Project 2.1 with focus on Murrumbidgee and Goulburn-Broken | 691 | 500 | 50 | 7 | 0 | 0 | 81 | 196 | 277 | Jul 01 to Jun 05 | Univ. of Melbourne, CSIRO | Land and Water Australia (LWRRDC) | | |
| Totals(\$000s) | | | 8824 | 4293 | 2720 | | 488 | 797 | 1704 | 1003 | 3992 | | | | | |
| Associated/Additional Projects External Funding Agency Input total (\$000s) | | | | | | | 488 | 797 | 1704 | 1003 | 3992 | | | | | |
| CRC Direct Contract Research/Consulting Income total (\$000s) | | | | | | | 32 | 152 | 30 | 50 | 264 | Note 1 | | | | |
| Total Contract Research/Consulting total (\$000s) | | | | | | | 520 | 949 | 1734 | 1053 | 4256 | | | | | |
| Commonwealth Agreement Contract Research totals (\$000s) | | | | | | | 300 | 700 | 1000 | 1400 | 3400 | | | | | |

Note 1: Actuals for 1999/2000, 2000/2001, 2001/2002 as reported in Profit and Loss Account; Budget amount for CRC Direct Consulting Income for 2002/2003.

Milestones Program 7

| Milestones | Progress |
|---|---|
| Years 1 and 2 | |
| All project agreements have a communication and adoption strategy that details the needs of end-users and a strategy for adoption of research outcomes. | The C&A program trialled the C&A framework in conjunction with Program 4 during late 2000. The Program 4 strategy has been completed and implementation begun. Program Leaders from Programs 1, 2, 3, 5 and 6 completed initial draft strategies and commenced their application. |
| Existing Centre communication and adoption activities reviewed in conjunction with existing and new parties to determine requirements and further improve the communication and adoption strategies during Years 1 and 2. | External communication review by Econnect completed April, 2001 and included an assessment of existing communication vehicles and recommendations to improve product range. Assessing the value of each product for target groups is part of the C&A Program's Planning Framework undertaken in each Program. |
| Development of a communication strategy to engage the interest and collaboration of a wide range of stakeholders in preparation for the delivery of the Centre's research outcomes. | C&A planning framework completed November, 2000. The external communication review included recommendations for improvements to developed strategies. Strategy implementation has begun |
| Communication and adoption activities benchmarked by independent consultants through review after Year 1. | Econnect successfully tendered for the communications review and completed it by May, 2001. Key communicators from other similar organisations (10), key CRC investors (25), and internal (73) and external stakeholders (175) were surveyed to benchmark CRC's communication performance. |
| Further improvement of the CRC's website to increase access to research outcomes and products | Stage 1 of CRC website redesign completed and includes improved navigation, research model downloads, technical report summaries, project information, events calendar, new pages, Catchword subscription, events notification, publications lists. Stage 2 begun. |
| Establish strategy for communication within the CRC Parties and between Focus Catchments to ensure integration with overall Communication and Adoption and research program objectives. | Initial strategy comprises FCCs as communication links via: email newsletters to target audience in catchment; scoping of AEAM project in Fitzroy; involvement of FCCs in developing C&A plans; regular FCC meetings in person and via phone. Completed December, 2001. Implementation is ongoing. |
| Level of commitment to contract research is on target set in Strategic Plan. | External projects for endorsement represent 136% of target to June, 2001: SEQRWQMS Projects 1.3, 1.4, 2.10; L&WA Projects 2.6, 3.2; NHT/AFFA Project 6.5; MDBC Project 2.13; ACIAR Project 2.7 |
| Years 3, 4 and 5 | |
| Preparation completed (Year 3) for the communication of research outcomes to targeted end-users. Individual program and project C&A strategies commenced | Each of the CRC programs are starting to deliver planned research outputs. Programs 1, 2, 3, 4 and 5 and Project 6.7 are advancing and involving key stakeholder groups representatives. |
| Communication and adoption activities measured by independent consultants (Years 3 and 5) | Year 3 communications review scheduled for February, 2003. It will build on and compare results to the 2001 first-year review. |
| Best practice communication and adoption workshop to assess and implement recommendations from independent reviews (Years 2 and 4) | The Executive Summary of the May 2001 communications review described the CRC as a 'leader in its approach to planning, implementing and evaluating communication'. The recommendations from the review did not warrant the follow-up best-practice workshop. In the short term, more effective progress will come from the proposed development projects and associated key stakeholder TAGs' to be held in each Focus Catchment. FCCs are 'brokering' appropriate development project proposals to best meet the needs of the Focus Catchments. |
| Level of commitment to contract research is on target set in Strategic Plan. | External projects underway or completed represent 160% of the target to June, 2002. SEQRWQMS Projects 1.3, 1.4, 1.7, 2.10; L&WA Projects 2.6, 3.2; NHT/AFFA Project 6.8; MDBC Projects 2.13, 2.15; ACIAR Project 2.7; URLC/Melbourne Water Project 4.3; EPA Vic Projects 4.4, 4.5. |

Research Program 8 Education and Training



Program Leader

Professor John Fien, Griffith University
(Professor Fien stepped down as Program Leader in July 2002, and was succeeded by Mr Tim Smith, Griffith University)

Aim To increase the knowledge and skills base of land and water management in Australia.

Education and training for PhD, Masters and other postgraduate students, as well as CRC stakeholders, are central to CRC activities. The CRC's whole-of-catchment approach requires novel and flexible training strategies. It involves researchers and stakeholders developing training modules to deliver research outcomes.

This Program is developing knowledge and a skills base in land and water management throughout Australia. It offers educational products developed in collaboration with participant organisations and other CRCs, with an emphasis on integrated catchment management.

Education, Training and Capacity Building

Project 8.1, Project Leader: Professor John Fien (succeeded by Mr Tim Smith from August 2002)

Key areas of this education, training and capacity-building project include:

- Postgraduate research
- Postgraduate courses, short courses, and seminars
- Capacity building via train-the-trainer activities
- Community education

Last year, CRC postgraduates participated in professional development activities including conferences, industry placement, field trips and training courses in areas as diverse as GIS, project management, thesis writing, multivariate statistics, media and oral presentation skills.

Achievements 2001-2002

- Forty-five postgraduates studied across CRC Programs, including eight students recruited during 2001-02. Areas of study ranged from riparian zone ecology, hydrological modelling and fishways to the impacts of land-use changes on catchment water yield, modelling the economics of Australian water trading and estimating extreme rainfall risk (see details in Tables A and B in this chapter).
- Ten postgraduate students graduated to industry positions with water management agencies and research organisations, or pursued further studies (details in Table C).

- Two CRC PhD students, based at The University of Melbourne, won awards. Teri Etchells won the Australian Award for Best Presentation (Student or Recent Graduate), at the 27th Hydrology and Water Resources Symposium in Melbourne, in May, 2002. Teri is investigating "A methodology for calculating water trading exchange rates in the Murray-Darling Basin". Lucy McKergow was awarded second prize in the Department of Conservation and New Zealand Limnological Society PhD Student Presentation Awards at "Just Add Water", the Joint Conference of the New Zealand Hydrological Society and New Zealand Limnological Society, Massey University, Palmerston North, New Zealand, in November 2001. Lucy is studying "Monitoring riparian lands for water quality improvement".
- PhD students Sandra Roberts and Scott Wilkinson were nominated for the Young Water Scientist of the Year Award. Sandra was selected to present at the World Water Congress, coinciding with the Enviro2002 Convention and Exhibition in Melbourne, in April 2002. Sandra's presentation, "Competing for Water: Understanding the Demands of Eucalypt Forests", received positive comments from the judges and audience.
- PhD student, Lindsay White, was nominated for the CRC Association's Showcasing Postgraduate Research competition and was invited to the finalists' presentation at the 2002 CRC Association Conference in Sydney, in May 2002.



Facing Page

Far Left Program Leader Tim Smith (succeeding Prof John Fien)

Right Education and training workshop convener James Whelan

This Page

Above (L to R) Education and Training Program postgraduates at Griffith Univ – Dana Thomsen, Clayton White and Margaret Gooch

Above Right Project management workshop for postgraduates, Ballarat, April 2002



- A paper on the contrasting perceptions and experiences of scientists, resource management professionals and community groups in community-based research by PhD student, Dana Thomsen, was accepted and presented in the main program at the Annual Conference of the International Association for Society and Natural Resources, Indiana, US, in June 2002. Dana was awarded a \$2000 postgraduate travel grant by Griffith University.
- PhD student, Margaret Gooch (with Professor John Fien and Debbie Heck), co-convended a one-day workshop on research on social learning, social capital and sustainability for the Eastern Europe Regional Environment Council, Budapest, in June 2002.
- PhD student, Clayton White, led a week-long training workshop on multimedia and environmental education at Rhodes University, South Africa, in December 2001. He was invited to a United Nations Environment Program training workshop on Information and Communication Technologies in environmental communication and education, in Kathmandu, Nepal, in July, 2002.
- A two-day postgraduate workshop on Project Management provided a major training opportunity for postgraduates in Ballarat, Vic, in April 2002 (just prior to the CRC's annual workshop).
- There was strong cooperation between the CRC's training postgraduate support program and similar programs in the CRC for Coastal Zone, Estuary and Waterway Management and the CRC for Sustainable Tourism, including joint workshop activities and teaching by staff across the CRCs. Students within the CRCs were surveyed about their postgraduate education experiences, with CRC for Catchment Hydrology students rating their experiences very highly, especially in the area of research culture of the CRC.
- The popular CRC vacation studentship scheme provided a stipend to third- and fourth-year research students to gain up to 10 weeks' professional experience with CRC research programs. Participating students affirmed the scheme's value in attracting potential future scholars and adding value to research activities. Project Officer, James Whelan, presented a paper on the comparative findings at the National Postgraduate Student Conference, Adelaide, in May 2002.
- A partnership was formed with the Australian Water Association to develop a Train-the-Trainer manual to accompany its stakeholder training package, "We All Use Water". With Peter Oliver, a PhD student in the CRC for Coastal one, Estuary and Waterway Management, Dana Thomsen facilitated two-day workshops on the "We All Use Water" program in Shepparton, Emerald and Sydney between March and May 2002. Further workshops are planned for Brisbane, Canberra and Melbourne. When completed, this workshop series will have been presented in all Focus Catchments.
- Program Leader, Professor John Fien, was the educational advisor to the biennial general conference of United Nations Educational, Scientific and Cultural Organisation (UNESCO), in Paris, in November, 2001. He was seconded half-time to UNESCO between April and September 2002 to assist with preparations for the August 2002 Earth Summit at Johannesburg, South Africa. Central to the international agency's educational program is a 100-hour multimedia teacher education program to promote student understanding of sustainable development developed by Professor Fien and PhD student, Clayton White.
- An Education and Training capability statement was published, providing workshop design, facilitation and evaluation support to CRC Program/Project leaders and Focus Catchment Coordinators.
- Project Officer, James Whelan, attended the inaugural planning workshop for the International Water Education Institute at Delft, The Netherlands, in November 2001, and with Professor Roy Rickson was invited to present lectures and workshops on Environment Education for Catchment Management in Yangon, Burma, in June 2002.



Left Program, Project Leader Prof John Fien – Projects 8.1, 8.2



Right Postgraduate and 2001-2002 Vacation Scholar, Sarah Johnson (Monash Univ)

Public Participation and Community Change

Project 8.2, Project Leader: Professor John Fien (succeeded by Mr Tim Smith from August 2002)

This research into public participation and community change complements the CRC's Education and Training activities. It identifies the needs of stakeholders in natural resource management and provides an understanding of the social, economic and political influences on stakeholder participation and the range of strategies being developed to encourage informed and appropriate participation in research, planning, policy development and decision-making.

Jointly with the CRC for Coastal Zone, Estuary and Waterway Management, this project is developing a Public Participation Toolbox – an on-line resource for agency, industry and community groups to develop understanding and expertise in innovative strategies for public participation in natural resource management.

Achievements 2001-2002

- An analysis of stakeholder perspectives on water issues is being conducted in the Upper Fitzroy catchment, as an extension of a similar CRC for Coastal Zone, Estuary and Waterway Management project in the catchment's lower parts. The outcome will be an increased understanding of stakeholder attributes and interactions and decision-making environments at a catchment and regional level. A stakeholder list for the Upper Fitzroy Catchment was developed and categorised into: researcher, investor, end-user, beneficiary and communicator.
- A catchment volunteering study included interviews with 82 people involved with community-based groups in the CRC's Qld Focus Catchments. The groups included Waterwatch, Integrated Catchment Management associations, Landcare, Coastcare, Greening Australia and Green Corps. The study generated a set of principles regarding strategies to promote and support active community involvement, Australia-wide.
- A community-based research study focused on case studies including Waterwatch Queensland and community-based groups in the Brisbane River Focus Catchment. An on-line survey was conducted to identify views and perspectives concerning community involvement in catchment research held by community members, researchers and catchment managers.
- Another study, "Citizen participation in catchment management", focussed on the 'kitchen table' approach to community engagement developed by CRC-associated Department of Natural Resources and Mines staff in central Qld, and on the CRC's communication and adoption strategy, as case studies. The project will identify strategies to enhance citizen participation, decision-making and management outcomes.
- Researchers reviewed the capacity of stakeholders in the Upper Fitzroy catchment to participate. This replicated CRC for Coastal Zone, Estuary and Waterway Management research in the Lower Fitzroy catchment and led to shared understandings and cooperation between both ends of the catchment.
- A course on "Research Design Using Case Studies" was coordinated for the CRC's social research researchers.
- Three PhD students were accepted as Associate Students into the CRC for Coastal Zone, Estuary and Waterway Management, making them part of the team developing the Public Participation Toolbox.

Table A Postgraduates – CRC Core Projects 2001-2002

| Name | University | Type of postgraduate enrolment (PhD, MEngSc etc) | Supervisor and Associate Supervisors | Funding source(s) ARC/CRC/Uni/etc | Topic (Related CRC Program/Project) |
|--------------------|---------------|--|--|--|--|
| Michele Akeroyd | Melbourne | PhD | G.R. Walker (CSIRO) G. Moore (UM) | MRS##, UMSPS† | Stable isotope dendrochronology of eucalypts: implications for riparian zone hydroecology (S3) |
| Brett Anderson | Melbourne | PhD | I.D. Rutherford (UM) A. Western (UM) | APA# | On the impact of riparian vegetation on catchment-scale flood characteristics (Program 6, 2.1) |
| Mark Bailey | Monash | PhD | L.D. Connell (University College London) R.J. Nathan (Sinclair Knight Merz) R.G. Mein (Monash) | Goulburn-Murray Water | Improved techniques for treatment of uncertainty in physically-based models of catchment water balance (A1) |
| Yinbang Bao | Melbourne | PhD | R. Argent (UM) A. Western (UM) | APA# | Scaling issues and hydrological modelling (1.1) |
| Rebecca Bartley | Monash (5) | PhD | I.D. Rutherford (UM) R.G. Mein (Monash) | MGS††, MDS* | Quantifying the geomorphic recovery of disturbed streams: using migrating sediment slugs as a model (W2) |
| Andrew Barton | Monash | MEngSc | R.J. Keller (Monash) T.H.F. Wong (Monash) | MDS (AFFA funded) | Hydraulics of the Vertical Slot Fishway (6) |
| Alice Best | Melbourne (1) | PhD | L. Zhang (CSIRO) T.A. McMahon (UM) A. Western (UM) | MRS##, UMSPS† | The impact of land-use change on seasonal water yield (2.3) |
| Margot Biggin | Monash | PhD | G. Codner (Monash) S. Schreider (Monash) M.J. Stewardson (UM) | MDS* | Investigating environmental consequences of water allocation strategies (3) and (6) |
| Dominic Blackham | Melbourne | PhD | I.D. Rutherford (UM) M. J. Stewardson (UM) | MIRS | Predicting horizontal surface development in alluvial river channels (6) |
| Kate Browning | Griffith | MPhil | M. Greenway (Griffith) I. Phillips (Griffith) | NHT Clean Seas Program (Brisbane City Council) | Effectiveness of Australian wetland native plant species in nutrient removal from a secondary treated effluent fed sub-surface flow constructed wetland(4) |
| Teri Etchells | Melbourne | PhD | H. Malano (UM) T. A. McMahon (UM) B. James (NRE) | UMSPS† | A methodology for calculating water trading exchange rates in the Murray-Darling Basin (3.1) |
| Myriam Ghali | Melbourne | PhD | I.D. Rutherford (UM) R. Grayson (UM) A. Curtis (Bureau of Resource Sciences) | IPRS, MIRS | Evaluating existing prioritisation procedures in the field of stream rehabilitation (Program 6) |
| Margaret Gooch | Griffith | PhD | J. Fien (Griffith) J. Warburton (UQ) R Rickson (Griffith) | GUPRA | Volunteers and sustainable catchment management (8) |
| Janice Green | Monash | PhD | PE. Weinmann (Monash) E.M. Laurensen (Monash) R. Nathan (Sinclair Knight Merz) | APALø | Estimation of extreme rainfall risk (D3) |
| Marnie Griffith | Monash | PhD | G. Codner (Monash) S. Schreider (Monash) | MDS* | Investigating the socio-economic impacts of water allocation policies (3) |
| Anthony Grudzinski | Griffith | PhD | J. Tisdell (Griffith) | GUPRA | An economic model of Australian water trading (3) |

- † University of Melbourne Special Postgraduate Studentship supported by CRC (1) Also located at CSIRO, Canberra
†† Monash University Graduate Scholarship (2) Also located at Goulburn-Murray Water, Tatura
* Monash University Department Scholarship supported by CRC (3) Also located at CSIRO, Adelaide
** Melbourne University Postgraduate Scholarship (4) Also located at Griffith University
Australian Postgraduate Award (5) Also located at CSIRO, Atherton
##Melbourne Research Scholarship
Melbourne International Research Scholarship (fee remission)
International Postgraduate Research Scholarship
ø Australian Postgraduate Award Industry
øø Monash Graduate Scholarship
Griffith University Postgraduate Research Award (ENS Faculty)

Research Program 8 Education and Training

Table A Postgraduates – CRC Core Projects 2001-2002

| Name | University | Type of postgraduate enrolment (PhD, MEngSc etc) | Supervisor and Associate Supervisors | Funding source(s) ARC/CRC/Uni/etc | Topic (Related CRC Program/Project) |
|----------------------------|---------------|--|---|-----------------------------------|---|
| Courtney Henderson | Griffith | PhD | M. Greenway (Griffith) I. Phillips (Griffith) | GUPRA with CRC top-up | Assessing the effect of vegetation in biofiltration devices for nutrient pollution removal from stormwater. (4.2) |
| Subhadra Jha | Melbourne | PhD | R. Grayson (UM) I.D. Rutherford (UM) | IPRS, MIRS | Modelling stream bank erosion at basin scale (6.6) |
| Sarah Johnson | Monash | PhD | T.D. Fletcher (Monash) C.J. Walsh (Monash) | MDS* | The ecological response of small streams to the input of stormwater (4) |
| Dean Judd | Monash | MEngSc | R.J. Keller (Monash) I.D. Rutherford (UM) | MDS* | The anastomosing rivers of the Riverine Plain (6) |
| Durga Kandel | Melbourne | PhD | R. Grayson (UM) A. Western (UM) H. Turrall (IWMP, Sri Lanka) | IPRS, MIRS | Temporal scaling issues in surface runoff and soil erosion modelling (1.2) |
| Peter Kolotelo | Monash | MSc | J. Baldwin (Monash) R.J. Keller (Monash) | MDS (AFFA funded) | Improving the effectiveness of Australian fishway design (6) |
| Kevin Linton | Melbourne (2) | MAppSc | H. Turrall (UM) M. Grace (Monash) | Goulburn-Murray Water | Transportation and cycling of phosphorus in the Deakin main drain (S1) |
| Sara Lloyd | Monash | PhD | T.H.F. Wong (Monash) | APA#, MDS* | Exploring impediments and opportunities of sustainable stormwater management schemes (4.2) |
| Leo Lymburner | Melbourne (1) | PhD | P.B. Hairsine (CSIRO) A. Held (CSIRO) J. Walker (UM) | UMSPS† | Describing riparian vegetation functions in the Fitzroy catchment using remote sensing and spatial analysis(2) |
| Lucy McKergow | Melbourne (1) | PhD | I. Prosser (CSIRO) R. Grayson (UM) | MRS##, UMSPS† | Monitoring riparian lands for water quality improvement (W3) |
| Nicholas Marsh | Melbourne (4) | PhD | I.D. Rutherford (UM) R. Grayson (UM) B.L. Finlayson (UM) A. Western (UM) | MRS##, UMSPS† | Large woody debris loading, distribution and scour hole formation in lowland streams (6.6) |
| Antony Motha | Melbourne (1) | PhD | P.B. Hairsine (CSIRO) R. Grayson (UM) P. Wallbrink (CSIRO) | UMSPS† | Sediment redistribution in a catchment with multiple land-uses (W1) |
| Muthukaruppan Muthukumaran | Melbourne | PhD | F.H.S. Chiew (UM) T.H.F. Wong (Monash) T. Weaver (UM) | MRS##, UMSPS† | Modelling quality and size distribution of contaminants in stormwater (4) |
| David Newton | Griffith | PhD | G.A. Jenkins (Griffith) I. Phillips (Griffith) | GUPRA | The effectiveness of modular porous pavement as a stormwater treatment device (4) |
| Cuan Petheram | Melbourne (1) | PhD | G.R. Walker (CSIRO) R. Grayson (UM) M. Stauffacher (CSIRO) | APA#, UMSPS† | Development of a regional scale salinity risk method using a catchment classification (S3) |
| Nicholas Potter | Melbourne (1) | PhD | L. Zhang (CSIRO) T. A. McMahon (UM) A. Jakeman (ANU) | UMSPS† | Statistical-dynamical modelling of catchment water balance (2.3) |
| Avijeet Ramchurn | Monash | MEngSc | PE.Weinmann (Monash) G. Codner (Monash) | IPRS, MGS ∅ | An investigation of on-farm storage modelling in the Gwydir valley(3) |
| Geoff Taylor | Monash | MEngSc | T.H.F. Wong (Monash) T. Fletcher (Monash) | MDS* | Determining the dominant phosphorus and nitrogen removal mechanisms in constructed wetlands (4.1) |
| Rachel Thomas (nee Eley) | Monash | PhD | R.J. Keller (Monash) I.D. Rutherford (UM) | APA#, MDS* | A parametric study of stream rating curves (FL3) |
| Dana Thomsen | Griffith | PhD | J. Fien (Griffith) M. Greenway (Griffith) | GUPRA | Community-based research (8.2) |

Table A Postgraduates – CRC Core Projects 2001-2002

| Name | University | Type of postgraduate enrolment (PhD, MEngSc etc) | Supervisor and Associate Supervisors | Funding source(s) ARC/CRC/Uni/etc | Topic (Related CRC Program/Project) |
|-----------------|--------------|--|---|-----------------------------------|---|
| Jai Vaze | Melbourne | PhD | F.H.S. Chiew (UM) I. O'Neill (UM) T.A. McMahon (UM) | MRS##, MIRS | Pollutant buildup and washoff in urban areas and the modelling of stormwater pollutant load (U2) (4.1) |
| Clayton White | Griffith | PhD | J. Fien (Griffith) R. Rickson (Griffith) | GUPRA | The role of communication in citizen participation in catchment management (8.2) |
| Lindsay White | Monash | PhD | R.J. Keller (Monash) I.D. Rutherford (UM) J.H. Harris (CRCFE) | APA#, MDS* | Advancements in the scientific basis of the design of fishways: with an emphasis on the Murray-Darling basin, Australia (6.5) |
| Scott Wilkinson | Monash | PhD | R.J. Keller (Monash) I.D. Rutherford (UM) | APA#, MDS* | Sediment transport processes that maintain pool riffle sequences in alluvial streams (2.1) |
| Debbie Woods | Melbourne | PhD | I.D. Rutherford (UM) M.J. Stewardson (UM) | UMSPS† | Environmental flows and connectivity of rivers with floodplains (6.7) |
| Juliette Woods | Adelaide (3) | PhD | K. Narayan (CSIRO) M. Teubner (U Adelaide) C. Simmons (Flinders Univ of SA) | APA#, CRC project support | Improving the accuracy of numerical simulations of density-dependent groundwater flow and transport (S2) |

Table B Postgraduates – CRC Additional/Associated Projects 2001-2002

| Name | University | Type of postgraduate enrolment (PhD, MEngSc etc) | Supervisor and Associate Supervisors | Funding source(s) ARC/CRC/Uni/etc | Topic (Related CRC Program/Project) |
|-----------------------------|------------|--|---|-----------------------------------|---|
| Wijedasa Hewa Alankarage | Melbourne | PhD | H.M. Malano (UM) H.N. Turrall (UM) T.A. McMahon (UM) G. Smith (G-MW) | MRS##, MIRS | Implication of water trading on system management and environmental flow: The case of Goulburn-Murray Irrigation Scheme, Victoria (3.6) |
| Josephine Brown | Melbourne | PhD | I. Simmonds (UM) | MRS## | Modelling stable water isotopes in the atmosphere and surface ocean (5.3) |
| Pandora Hope | Melbourne | PhD | I. Simmonds (UM) | MRS## | Shifts in Australia's circulation and rainfall source regions (5.3) |

- † University of Melbourne Special Postgraduate Studentship supported by CRC (1) Also located at CSIRO, Canberra
- †† Monash University Graduate Scholarship (2) Also located at Goulburn-Murray Water, Tatura
- * Monash University Department Scholarship supported by CRC (3) Also located at CSIRO, Adelaide
- ** Melbourne University Postgraduate Scholarship (4) Also located at Griffith University
- # Australian Postgraduate Award (5) Also located at CSIRO, Atherton
- ## Melbourne Research Scholarship
- Melbourne International Research Scholarship (fee remission)
- International Postgraduate Research Scholarship
- ∅ Australian Postgraduate Award Industry
- ∅∅ Monash Graduate Scholarship
- Griffith University Postgraduate Research Award (ENS Faculty)

Research Program 8 Education and Training

Table C Higher Degrees (Research) Completed and Destination of Postgraduates 2001-2002

| Name | Degree University | Supervisor(s) | Topic | Date Research Thesis Submitted | Destination |
|--------------------------|----------------------|---|---|---|---|
| Michele Akeroyd | PhD, UM | G.R. Walker (CSIRO) G. Moore (UM) | Stable isotope dendrochronology of eucalypts: implications for riparian zone hydroecology (S3) | Submitted 31 January 2002 | Murray-Darling Basin Commission (Salinity Strategy Sub-Program Officer) |
| Mark Bailey | PhD, Monash | L.D. Connell (University College London) R.J. Nathan (Sinclair Knight Merz) | Improved techniques for treatment of uncertainty in physically-based models of catchment water balance (A1) | Submitted 24 October 2001, passed 8 May 2002 | Goulburn-Murray Water (Production Engineer) |
| Rebecca Bartley | PhD, Monash | I.D. Rutherford (UM) R.G. Mein (Monash) | Quantifying the geomorphic recovery of disturbed streams: using migrating sediment slugs as a model (W2) | Submitted 18 December 2001, passed 4 July 2002 | CSIRO Tropical Forest Research Centre (Post-Doctoral Researcher) |
| Kevin Linton | MAppSc, UM | H. Turrall (UM) M. Grace (Monash) | Transportation and cycling of phosphorus in the Deakin main drain (S1) | Submitted June 2001, passed Jan 2002 | Goulburn-Murray Water (Engineer) |
| Nicholas Marsh | PhD, UM | I.D. Rutherford (UM) R. Grayson (UM) B.L. Finlayson (UM) A. Western (UM) | Large woody debris loading, distribution and scour hole formation in lowland streams (6.6) | Submitted 18 December 2001 | CRC for Catchment Hydrology, Griffith University (Researcher) |
| Antony Motha | PhD, UM | P.B. Hairsine (CSIRO) R. Grayson (UM) P. Wallbrink (CSIRO) | Sediment redistribution in a catchment with multiple land-uses (W1) | Submitted 2 January 2002, passed June 2002 | Various short term appointments |
| Cuan Petheram | PhD, UM | G.R. Walker (CSIRO) R. Grayson (UM) M. Stauffacher (CSIRO) | Development of a regional scale salinity risk method using a catchment classification (S3) | Submitted March 2002 | Various short term appointments |
| Rachel Thomas (nee Eley) | PhD, Monash | R.J. Keller (Monash) I.D. Rutherford (UM) | A parametric study of stream rating curves (FL3) | Submitted 14 September 2001, passed 6 June 2002 | DipEd, Monash University |
| Jai Vaze | PhD, UM | F.H.S. Chiew (UM) I. O'Neill (UM) T.A. McMahon (UM) | Pollutant buildup and washoff in urban areas and the modelling of stormwater pollutant load (U2) (4.1) | Submitted September 2001, passed March 2002 | Dept Land & Water Conservation, NSW (Consultant) |
| Scott Wilkinson | PhD, Monash | R.J. Keller (Monash) I.D. Rutherford (UM) | Sediment transport processes that maintain pool riffle sequences in alluvial streams (2.1) | Submitted 21 June 2002 | CSIRO Land and Water (Post-Doctoral Fellow) |

Milestones Program 8

| Milestones | Progress |
|--|---|
| Years 1 and 2 | |
| Package of courses and industry placements for PhD students in operation | <p>The CRC supports postgraduate researchers' training by organising regular events, maintaining an email bulletin to alert students to training opportunities and by organising personal and professional activities in conjunction with the postgraduate support programs of Coastal and Sustainable Tourism CRCs.</p> <p>A survey of student perceptions of their postgraduate education experiences within these three CRCs was conducted, with Catchment Hydrology CRC students rating their experiences very highly, especially in the area of research culture of the CRC.</p> <p>Annual training needs analyses are conducted among the postgraduate cohort</p> <p>Postgraduates have participated in professional development activities including conferences, industry placement, field trips and training courses in areas as diverse as GIS, thesis writing, science writing, multivariate statistics, media and oral presentation skills.</p> <p>Research skills training activities held in conjunction with the annual workshop of the CRC have addressed topics such as presentation skills, getting published, and project management.</p> <p>CRC Postgraduates have been nominated for several science competitions. In 2001 Rebecca Bartley won both the Young Water Scientist of the Year and CRC Association Showcasing Postgraduate Research Awards.</p> <p>Protocols have been developed for industry placement, mentoring and supervision. Postgraduates have undertaken placement with CRC participant agencies. Several CRC postgraduate researchers receive industry co-supervision. Similar arrangements are being actively promoted for other students.</p> |
| Selected masters coursework subjects available for participating universities to share | <p>On the basis of a review of postgraduate offerings in this field, the CRC's strategic approach to this milestone has been to negotiate with providers, rather than duplicate existing offerings.</p> <p>Discussions are underway with industry and government agencies (eg. AWA, Qld EPA, Coastal CRC) concerning the possible development of industry-related and tertiary-accredited professional development courses.</p> |
| Framework for collaborative offering of courses developed | <p>A strategic approach to course development has been achieved through regular audits and training needs analyses. A range of courses for researchers, students and stakeholders are conducted on a regular basis through appropriate collaborative arrangements. These courses have supported the adoption of research outcomes within the CRC's six research programs.</p> |
| Protocols for flexible delivery of courses in place | <p>Based on regular audits and training needs analyses, a range of appropriate course delivery mechanisms have been utilised including short courses, workshops, seminars and on-line fora.</p> |
| Training needs analysis for industry completed | <p>The training needs of industry stakeholders are identified and addressed by each research program through Communication and Adoption planning. "Train-the-Trainer" materials have been developed as an element of the "We All Use Water" curriculum package.</p> <p>CRC personnel involved in training participated in the Facilitating Community Dialogue workshop hosted by the CRC on 20 November 2001 in Brisbane.</p> |
| Action plan for community education, including schools, in catchment hydrology | <p>A partnership was formed with the Australian Water Association (AWA) to develop a "Train-the-Trainer" manual to accompany the AWA stakeholder training package, "We All Use Water". With Peter Oliver, a PhD student in the Coastal CRC, PHD student, Dana Thomsen, has facilitated two-day workshops utilising the We All Use Water program in Shepparton, Emerald, Sydney and Brisbane.</p> <p>A final workshop is planned for Melbourne. When completed, this series of workshops will have been presented in all but one of the CRC's Focus Catchments.</p> <p>James Whelan is an active member of the education committee of the Australian Water Association. This committee comprises secondary education and community and industry representatives.</p> <p>Participants include catchment agency staff, educators and community stakeholders.</p> <p>Three Project 8.2 researchers undertaking research in the area of community learning through public participation.</p> |
| Years 3, 4 and 5 | |
| Regular program of short courses and workshops for all stakeholders operating | <p>Program 8 provides support to research programs (1-6) to develop, implement and evaluate education and training activities</p> |
| Collaborative delivery of postgraduate coursework programs | <p>Uncertainty over value of postgraduate coursework masters courses. This may proceed in Years 4 and 5.</p> |
| Action plan to meet the requirements identified in the training needs analysis | <p>An Education and Training capability statement has been published, providing workshop design, facilitation and evaluation support to CRC Program and Project leaders and Focus Catchment coordinators.</p> |
| Guidelines for systems approach to catchment management teaching methodology in undergraduate programs | <p>The CRC's approach to this milestone has been to negotiate with providers, rather than duplicate existing offerings.</p> |