NEWSLETTER OF THE COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

# CATCHWORD

NO 125 MARCH 2004

## A NOTE FROM THE DIRECTOR

**Professor Rob Vertessy**

**Inside...**



COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

## FAREWELL AND THANKS TO ALL

*CSIRO's Land and Water Division.*

My time in this CRC has been wonderful, enjoying as I have the comradeship of so many talented staff, students and Board members. I'm proud to have served as a Director of the CRC and greatly enjoyed my time as a Program Leader and Project Leader before being asked to lead the CRC.

I'd like to thank everyone in the CRC for their friendship, colleagueship and unswerving dedication to excellence in all they do. As one review after another has declared, we are a 'model' CRC! I want to pay special thanks to our Board Chairman John Langford who has been a fabulous mentor for me. John Molloy, David Perry and Tanya Jacobson have on so many occasions gone that extra mile or ten for me. I thank them for their support during my time as Director; I couldn't have survived without them! I could fill these pages with all the people I need to thank, but won't. I hope the rest of my colleagues appreciate how much I've valued their commitment to me and the CRC. I wish the Program Leaders and incoming Director all the very best in steering this great CRC to even greater heights.

*Towards a new CRC in 2005 and beyond*

There has been much activity behind the scenes in preparation for a CRC re-bid in the forthcoming CRC selection round. Our CRC has decided to prepare a joint bid with the CRC for Freshwater Ecology. The new joint venture we are proposing is referred to as the eWater CRC. The 'e' in this name stands for 'enterprise, environment and education'; the three main foci of the proposed CRC. The bid preparation is overseen by an 'Interim Parties Committee' (IPC), chaired by Don Blackmore (former Chief Executive of the Murray-Darling Basin Commission). The Interim Chief Executive of eWater is Gary Jones (currently CEO of the CRC for Freshwater Ecology). The IPC has now met twice and recently agreed on the broad direction of the proposed CRC and a provisional business model. The eWater CRC brings together all of the Parties currently involved in the CRC for Catchment Hydrology and the CRC for Freshwater Ecology, as well as several new ones, notably from South Australia where we have had only minor involvement to date. It is a very large and visionary bid that promises to take the science of land and water management to a whole new level. Key features of the bid include linking hydrology and ecology, linking groundwater and surface water systems, an integrated urban water systems focus, and a strong commitment to the development of advanced predictive technologies.

We have already submitted a Notification of Intent to form this new CRC and will shortly submit our Stage 1 Preliminary Business Case (due on March 31). If our Stage 1 case appeals to the Commonwealth, we will be invited to submit a Stage 2 (Final) Business Case by July 2. The Commonwealth will most likely announce application results in November or December this year. Successful bids will be required to start operations on July 1, 2005. Should the eWater bid succeed, the CRC for Catchment Hydrology and the CRC for Freshwater Ecology will both need to cease operations by this date (ie. a year earlier than expected). Both CRC's are preparing CRC termination and project completion contingency plans on the assumption that our joint bid will indeed be successful.

I'm really heartened to see the goodwill of the industry Parties and R&D providers involved in preparing the eWater bid. I've very much enjoyed participating in the early planning of this CRC proposal and believe that Gary Jones is doing a splendid job in shaping the bid. Those involved with our current CRC will surely be pleased to see such a promising proposal for a successor CRC in the making.

*Looking back on our first round of projects*

Even though we are well into our second round of projects in this CRC (spanning 2003-2006), we thought it wise to revisit what we achieved in the first round of project (spanning 1999-2002).

In this issue of *Catchword*, our Program and Project Leaders summarise our many achievements. The main reason for doing so is to alert the land and water management industry to the practical value of what we do and to encourage application of the knowledge we have generated and the tools we have developed.

Adoption is our greatest reward, so I hope and trust this special 'bumper' edition of *Catchword* will stimulate many of our readers to reach into the CRC and harness the value of what we have produced.

I'm proud of what we achieved adoption-wise so far, but firmly believe that there is a large resource of knowledge

CATCHMENT HYDROLOGY

# NEW TECHNICAL REPORT

## The Effect of Afforestation on Flow Duration Curves

By

Patrick Lane
Alice Best
Klaus Hickel
Lu Zhang

**Technical Report 03/13**

This report is part of a series that bridges the gap between the science of catchment water balances and the management of rivers for a range of outcomes by considering the impact of afforestation on flow distribution throughout the year.

**Printed and bound copies of this report are available from the Centre Office for $27.50. Contact Virginia Verrelli on 03 9905 2704 or email crcch@eng.monash.edu.au**

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and tools that remains untapped. As I've argued in previous editions of *Catchword*, the Australian land and water management industry faces some profound challenges over the next few years. A vital part of meeting those challenges is applying the best available hydrologic knowledge and tool sets. Our scientists stand ready to support the industry in applying what we have discovered through research and built into management tools.

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PROGRAM 1

# PREDICTING CATCHMENT BEHAVIOUR

Program Leader
GEOFF PODGER

## Report by Geoff Podger

*Introduction*

The first round of projects for Program 1: Predicting Catchment Behaviour was a mixture of research and model applications. The projects focused on:

- Development of a catchment modelling toolkit
- Scaling procedures to support process based models
- Development of the Environmental Management Support System (EMSS) for SE Queensland
- Modelling and estimating sediment loads in SE Queensland
- Understanding temporal and spatial distributions of soil moisture
- Integration and adoption of catchment research
- Development of a pilot local scale EMMS (LEMSS) in the Pine Rivers catchment.

This program delivers the key objective of the CRC and is structured to provide land and water managers with the tools and skills to make informed decisions on whole catchments. It involves many of Australia's leading catchment modellers and many of the tools being developed are being applied across the focus catchments.

The structure of the program is a staged approach with initial research on what is required. The program looks at the tools that are being used, how they are developed and supported, and where they have been applied. The program also looks at the gaps in knowledge that need to be addressed to be able to build a whole of catchment modelling capability. Based on this knowledge a modelling platform has been agreed upon and developed to support the connection and integration of models and research. Adoption is also important and consequently, model development is closely linked with model implementation in the focus catchments. The hard work of making this happen is the current focus of this Program.

*Key learnings from the project*

A lot was learnt from the first round of projects. The report on the Status of Catchment Modelling (Marston, *et al*) found that there was a diverse range of models available and that models were largely developed to address specific issues. The algorithms used by the models were generally well established techniques that were common to many of the models. The languages used were typically either spreadsheet based, such as Microsoft Excel or compiled languages (predominately Fortran and Visual Basic). With the exception of a few commercial products a large number of models were developed within user organisations. The level of support and documentation was poor or non-existent and largely relied upon the developer supporting the model.

The world review of existing modelling frameworks concluded that the best solution was to build a new modelling framework based on the examples set by Tarsier, ICMS and others. To facilitate the incorporation of existing models that are largely written in Fortran and Visual Basic, the .NET platform was adopted. The subsequent modelling framework developed by the CRC for Catchment Hydrology is called TIME (The Invisible Modelling Environment) (Rahman *et al*, 2002).

Lessons were also learnt from developing and implementing EMSS in SE Queensland. This work has resulted in a large number of tools to support data importing, exporting, manipulation and display. Techniques have been developed for modelling the movement of water quality in catchments. There has also been a lot of feedback from users on interface design. All of this has influenced the direction of toolkit model development and the components developed in TIME.

*Application*

The two main areas of application of Program 1 software and research are EMSS and TIME. EMSS is used to estimate daily runoff, total phosphorus loads, total nitrogen loads and suspended sediments loads. EMSS has been applied in several catchments, including:

- Yarra,
- Goulburn Broken,
- Murrumbidgee,
- Brisbane and the greater South East Queensland region, and
- Fitzroy.

TIME functionality has been growing at an exponential rate and is now at a stage where there is substantial amount of modelling capacity available. There is already a list models and applications developed in the TIME environment including:

- Rainfall Runoff Library (RRL)*
- River Analysis Package (RAP)*
- Stochastic Climate Library (SCL)*
- SedNet*
- Strategic Landscape Investments Model (SLIM)
- Land Use Options Simulator (LUOS)

* Available from the toolkit website, at http://www.toolkit.net.au.

- EMSS Yarra focus catchment

Implemented by Melbourne Water to assess the water quality at Yering Gorge. Yering Gorge is located at the lower end of the rural Yarra catchment and is where water is extracted for Melbourne's water supply. The model is used to assess the change in water quality due to changes in land use, restoration of riparian zones, point source discharges and catchment and river system hydrology.

- EMSS Goulburn Broken focus catchment

Implemented by Goulburn-Murray Water and, the Department of Sustainability and the Environment, Vic to:

- Predict sources, transport and land-use impacts of sediment, nutrients, turbidity and salinity
- Predict and manage land-use impacts on catchment yield and water quality,
- Engage catchment stakeholders, and
- Develop catchment management policy.

- EMSS Murrumbidgee focus catchment

Implemented by the Department of Infrastructure, Planning and Natural Resources, NSW to:

- Develop policy to improve suspended sediment water quality in Murrumbidgee and tributaries.
- Develop sustainable land-use policy for the catchment.
- Predict changes to water quality targets.

- EMSS Brisbane focus catchment

Implemented by WBM Oceanics, Brisbane City Council and the Department of Natural Resources, Mines and Energy, Qld to predict sediment and nutrient fluxes through the South East Queensland river network and into Moreton Bay. A more detailed Local EMSS was implemented in the Pine Rivers catchment to predict the generation of sediment and nutrients and their delivery to Lake Samsonvale and Lake Kurwongbah Reservoirs.

- EMSS Fitzroy focus catchment

Implemented by the Department of Natural Resources, Mines and Energy, Qld to help facilitate local stakeholder workshops intended to address water quality issues and to set NAP targets.

- EMSS Limitations

Although EMSS operates on a daily basis, the results are not sufficiently accurate to be used daily. However the results are reasonable on a monthly or seasonal basis. This is partly due to data issues and simplifications in the modelling approach. The modelling of water quality in reservoirs is a very simplified approach and more detailed modelling could improve

## FOREST MANAGEMENT WORKSHOP, CANBERRA

### 23-25 March 2004

The CRC for Catchment Hydrology, along with the University of New South Wales, Forest Science Centre and New South Wales State Forests presents the Forest Management Workshop on 23-25 March 2004.

The aim of the meeting is to bring together scientists and forest managers to discuss recent developments in the understanding of forest catchment behaviour and management.

Presentations will be held on the 23 and 25 March 2004 and a field excursion will be organised for the 24 March 2004. The field excursion will visit the burnt forest area at the western side of Canberra and plantation forestry sites of NSW State Forests near Tumut.

The workshop is based around four key themes:

- Forest Hydrology
- Sediment Delivery and Water Quality
- Fire Management
- Sustainable Forestry

**PLEASE NOTE:**
**The registration date has been extended to Friday 12 March 2004**

**For further information visit www.catchment.crc.org.au/news or see page 23 of this issue of Catchword.**

# NEW TECHNICAL REPORT

## The Impact of Rainfall Seasonality on Mean Annual Water Balance in Catchments with Different Land Cover

By
Klaus Hickel
Lu Zhang

**Technical Report 03/11**

Our understanding of catchment hydrology is approaching the point where we can confidently predict the partitioning of rainfall and how it changes when we change the land use. This report describes some of the research that supports this important development. By enabling the consideration of seasonality, it enables more confidence in our prediction of how catchment hydrology changes when land use changes.

**Printed and bound copies of this report are available from the Centre Office for $27.50. Contact Virginia Verrelli on 03 9905 2704 or email crcch@eng.monash.edu.au**

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this. There is also only limited capability to model river management and irrigation water use. This will be improved by linking to industry models such as IQQM.

- TIME tools

The first TIME tool to be developed was RRL. This was a good place to start as it encompassed many of the things that we wanted to achieve in the toolkit. It gave us a means of testing TIME, developing procedures and policies as well as testing out our web site. The second product was RAP. This was also released for the IE Aust conference in November 2003. Both of these products have added greatly to the core code and visualisation tools able to be used by many of the products still to come.

The next set of tools was developed for the Catchment Modelling School and includes SCL and SedNet. Both of these were built on the capability already developed for RRL and RAP and have added much more capability. SedNet is to be implemented in the all of the focus catchments.

There were also two products that were developed in TIME by industry. These are SLIM developed by CSIRO for DIPNR and LUOS developed by DIPNR. This has been a extremely beneficial exercise for both parties. TIME has gained some more functionality and industry has gained the benefit of having tools developed rapidly by using existing code. It has also given DIPNR the ability to deliver and maintain products for Catchment Management Authorities across the state.

*Further information*

- The Toolkit web site

The toolkit website is located at www.toolkit.net.au and contains information about the catchment modelling toolkit. There are contact details for members of the development team in the 'About: the team' area of the site. You can browse some of the products that have already been developed in the TIME or sign up as a member to download these products.

- Current status of Program activities

Most recently the focus of Program 1 has been getting software and documentation ready for the summer school. This has been a great success with many people in the industry becoming aware of what we have achieved, and importantly, where we are heading.

Over the next year the main areas of development will be:

- Supporting existing products (bug fixes and training)
- Developing the whole-of-catchment model
- Developing tools for visualising model uncertainty
- Developing the Toolkit assistant

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PROGRAM 2

# LAND-USE IMPACTS ON RIVERS

Program Leader
PETER WALLBRINK

## Report by Peter Hairsine and Peter Wallbrink

### Overview of Program 2 – Land-use Impacts on Rivers

*Introduction*

We are approaching the halfway stage of our second round of projects. Here we provide a retrospective overview of Program 2 and, an outline of the main outcomes of both the first round of projects and the early stages of the current round of projects.

*Program themes*

The main themes of the program are: i) changes to water yield (or stream flows) as a result of land use change, ii) the movement of sediment in stream networks as affecting in-stream physical habitat, and iii) the movement of sediment, nutrients and salt in catchments as affecting water quality. (See Figure 2.1). All of this research and development has a focus at a large catchment ('000s of $km^2$) scale, though it is informed by data at a range of spatial scales.

*First round projects*

In the first round (1999-2002), the program had four core projects that are briefly described below. All of these projects had participating staff from two or more of the CRC for Catchment Hydrology Parties. The program also had eleven Associated/Additional

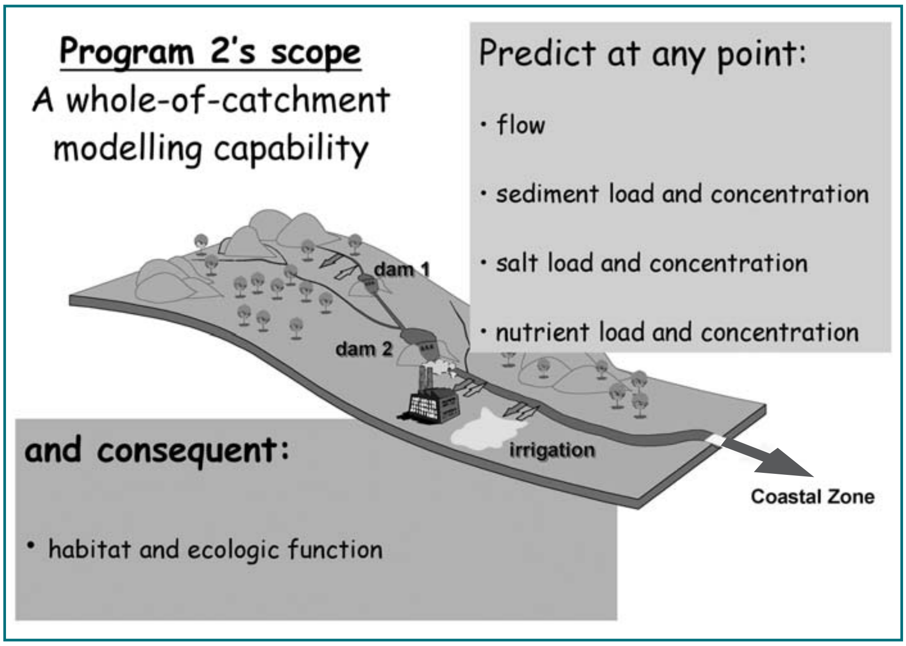


*Figure 2.1: The scope of Program 2.*

# NEW TECHNICAL REPORT

## Changes in Flood Flows, Saturated Area and Salinity Associated with Forest Clearing for Agriculture

By
Richard Silberstein

**Technical Report 03/1**

This report presents results of an investigation into the connection between stream flow and the rise of watertables following clearing, and their fall after reafforestation. The main focus is to identify as well as possible the relationship between high flows and saturated area. While there remains work to be done to completely fulfil the aims of the project, a number of key results are reported.

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# MDBC-CSIRO-CRC TECHNICAL REPORT SERIES

## Impact of Increased Recharge on Groundwater Discharge: Development and Application of a Simplified Function using Catchment Parameters.

**By**

**Mat Gilfedder**
**Chris Smitt**
**Warrick Dawes**
**Cuan Petheram**
**Mirko Stauffacher**
**Glen Walker**

**Technical Report 03/6**

This report describes the development of a simple approach towards estimating the response of groundwater systems to changes in recharge that arise from changes in land-use. The emergent properties of a groundwater system are examined using scaling arguments, by combining the effect of aquifer properties into a single dimensionless groundwater system similarity parameter (G).

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projects that were funded by external organisations. These projects compliment and extend the work of the core projects.

*Project 2.1*

Core project, Project 2.1: " Sediment movement, water quality and physical habitat in large river systems" and was led by Dr Jon Olley of CSIRO Land and Water in Canberra. Project participants included CSIRO, Department of Infrastructure Planning and Natural Resources (DIPNR - formerly NSW DLWC) and the University of Melbourne. The project had a close relationship with the River Restoration Program and was using the focus catchments of the Murrumbidgee, Goulburn Broken and Brisbane as test beds. This project addressed the following questions:

- Where in catchments do sediment and nutrients have an impact on physical habitat?
- From where in the catchment was that sediment and nutrient derived?
- Where will limited remediation efforts best improve physical habitat?
- What are, or will be, the trajectories of adjustment to historical and future changes?

Project 2.1 took advantage of much of the preliminary work done in the National Land and Water Resources Audit concerning the movement of sediment and nutrients in large catchments. The project extended and evaluated the predictions made by the audit and related them to physical habitat. Project 2.1's work was also complimented by associate projects evaluating sediment and nutrient budgets in the Murray-Darling Basin (funded by the MDBC) as well as an investigation into the local impact of synoptic movement of very large amounts of coarse sediment led by Dr Bill Young at CSIRO Canberra (funded by AFFA).

A major product of this project was the upgrade, evaluation and application of the SEDNET model to many catchments across eastern Australia. This model enables assessment of sediment and nutrient sources across very large catchments and explicitly determines the hillslope, channel bank and gully contributions of these pollutants and considers their delivery to downstream points of potential impact. SEDNET is now being integrated into the catchment modelling toolkit. The project identified the following issues as crucial for its development:

- Large-scale prediction of the hillslope sediment delivery ratio
- Improved compatibility with other models in the toolkit
- Training users in SedNet and providing support to focus catchment staff who use it

These are now being addressed by the current round project "Improved suspended sediment and nutrient modelling through river networks" led by Dr Scott Wilkinson.

*Project 2.2*

Project 2.2 was titled "Managing pollutant washoff from dryland upland catchments" and was led by Peter Hairsine of CSIRO Land and Water in Canberra. Project participants were the Queensland Department of Natural Resources, Mines and Energy (QDNRE); DIPNR, NSW; Griffith University and CSIRO. The project used the focus catchments of the Fitzroy and the Murrumbidgee as its test bed, as well as drawing upon the historical data from plot and small catchments in NSW. The project had two PhD students: one working on salt movement in the Murrumbidgee catchment, and one working on remote sensing methodologies to assess the role of riparian zones in moderating hydrological processes in the Fitzroy catchment.

The questions Project 2.2 addressed were:

- How do we represent management of pollutant sources on the hillslope at the catchment scale?
- Can we confidently provide forecasts of wash off of sediment, nutrients, and salt?

The main product of the project was the Pathways model – an automated way of designing the management measures including contour banks, grass filter strips and grassed waterways to minimise sediment and nutrient from cropping land to streams. The concepts developed in this project also addressed a key weakness of the SedNet model – the hillslope sediment delivery ratio. This work is been incorporated into SedNet by the team led by Scott Wilkinson. The two PhD projects are ongoing but will provide new methods and understanding of the salt washoff process and the role of riparian zones in large catchments.

*Project 2.3*

Project 2.3 was titled " Predicting the effects of Land-use Change on Catchment Water Yield and Stream Salinity" and was led by Dr Lu Zhang of CSIRO Land and Water. Project participants were the Victorian Department of Sustainability and Environment (DNRE), CSIRO and DIPNR. This project focussed on providing science-based forecasts of the changes in water available in rivers as a result of land use changes. The land-use changes considered include the development of large-scale tree plantations on pastureland and changing pasture production from annual to perennial species.

The work of the project was complimented by two Associated/Additional projects that considered the impact of elevated water tables on flooding and the impact of changes to catchment scale water balance on in-stream salinity. The projects were funded by the Land and Water Australia's National Dryland Salinity Program and the MDBC respectively.

Project 2.3 greatly enhanced our ability to predict the impact of land-use changes beyond mean annual water yields. The focus is now on engineering this understanding into the catchment modelling toolkit. The current CRC project "Modulating daily flow duration curves to reflect the impact of land use change" led by Lu Zhang enables predictions of changes to flow duration curves as a consequence of land use change.

*Project 2.5*

A fourth core project, Project 2.5: "Carbon and Nitrogen Dynamics in Riparian Zones" was led by Dr Heather Hunter of the Queensland Department of Natural Resources, Mines and Energy (QNRME) in Brisbane. The participating Parties have been QNRME and Griffith University. This project was co-funded by the Coastal Zone CRC. This project focussed on getting base line knowledge on how riparian zones moderate the inputs of carbon and nitrogen into Australian streams. This had been a major natural resource research focus in North America and Europe in the last decade. The focus catchment for this work was the Brisbane River catchment.

Project 2.5 addressed the following questions:

- What are the key factors influencing nitrogen and carbon transport and transformations in riparian zones?
- How can this work contribute to the revision of present guidelines for riparian management?

Project 2.5 found that denitrification of shallow groundwater does occur in Australian riparian environments and this process may be associated with flow into, out of, or parallel with the stream. The team has now turned its focus to the demanding task of modelling these processes across large catchments. The follow up CRC for Catchment Hydrology project Project 2.22 (2D): "Modelling and managing nitrogen in riparian zones to improve water quality" is led by Dr Heather Hunter with continued contributions from the associated Parties. The aim of this activity is to enable automated methods to:

- identify which riparian zones in large catchments are intercepted by shallow groundwater flows and are at risk of high N loadings
- determine which riparian zones in large catchments have all the attributes required to enable denitrification to occur, as well as
- apply in a catchment water quality model that incorporates these features in selected south east Queensland catchments to assess the potential for riparian zones to moderate N fluxes.

*Overview*

Looking back on the first round of projects in Program 2, it was clear that we did not address a major land-use impact on rivers, which was the return flows to rivers from irrigation districts. For this reason a new project entitled "Reducing the impact of irrigation and drainage on river water salinity" Project 2.19 (2A) was

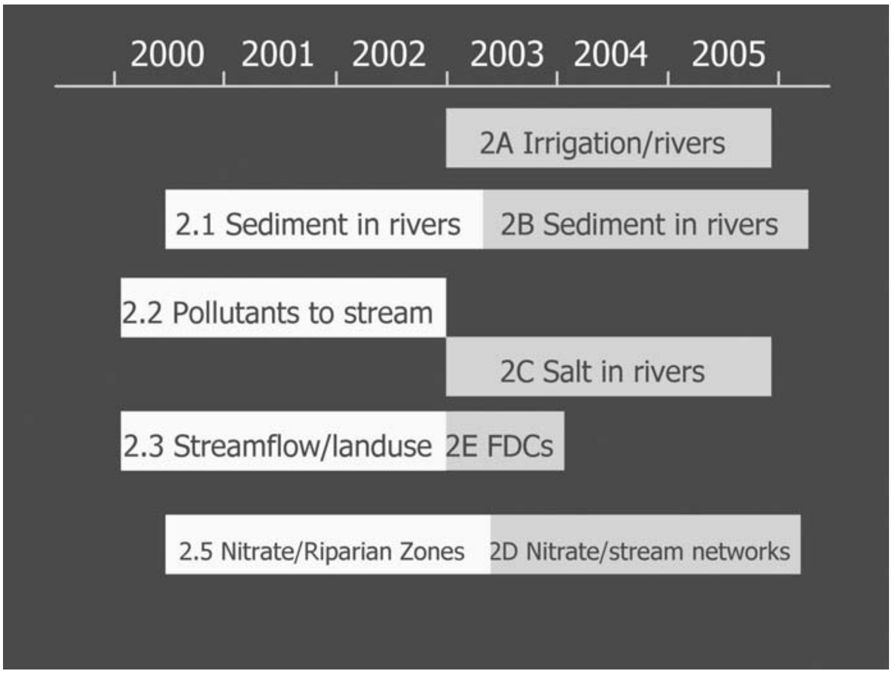


*Figure 2.2: The evolution of projects in Program 2.*

## NEW TECHNICAL REPORT

**Enhancement of the Water Market Reform Process: A Socioeconomic Analysis of Guidelines and Procedures for Trading in Mature Water Markets.**

**By**
**John Tisdell**

**Technical Report 03/10**

This report summarises the main findings of a broad survey of the literature and current government policy on water reform, an extensive survey of irrigator and community attitudes to water reform across the three rural focus catchments of the CRC for Catchment Hydrology and the development and implementation of experimental methods to water management; its auctioning and self governance.

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# MDBC-CSIRO-CRC TECHNICAL REPORT SERIES

## Testing In-Class Variability of Groundwater Systems: Local Upland Systems.

By

Cuan Petheram
Chris Smitt
Glen Walker
Mat Gilfedder

**Technical Report 03/8**

This report assesses the extent information can be transferred between hydrogeologically similar catchments, by investigating in detail one set of similar catchments.

## Assessment of Salinity Management Options for Kyeamba Creek, New South Wales: Data Analysis and Groundwater Modelling.

By

Richard Cresswell
Warrick Dawes
Greg Summerell
Geoff Beale
Narendra Tuteja
Glen Walker

**Technical Report 03/9**

This report describes a study of the hydrogeological factors influencing salinity in the Kyeamba catchment, located within the uplands of the Lachlan Fold Belt of south-eastern Australia.

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commenced by Dr Evan Christen from CSIRO's Griffith Irrigation Laboratory with participation from DSE, Vic and Goulburn-Murray water. (See Figure 2.2). This project will contribute a new module to the toolkit describing the water and salt return flows from major irrigation areas.

*Further details*

In future issues of *Catchword* the Project Leaders will report on the uptake of our projects and the relationship of our research to national catchment management issues. In the interim we encourage you to contact the Project Leaders, if you require further details.

| Core Project | Project leader | Contact details |
|---|---|---|
| Sediment movement, water quality and physical habitat in large river systems (Project 2.1) | Dr Scott Wilkinson/ Dr Jon Olley | Scott.Wilkinson@csiro.au jon.olley@csiro.au |
| Managing pollutant washoff from dryland upland catchments (Project 2.2) | Dr Scott Wilkinson/ Peter Hairsine | Scott.Wilkinson@csiro.au and peter.hairsine@ csiro.au |
| Predicting the effects of land-use change on catchment water yield and Stream Salinity (Project 2.3) | Dr Lu Zhang | lu.zhang@csiro.au |
| Carbon and nitrogen dynamics in riparian zones (Project 2.5) | Dr Heather Hunter | heather.hunter@dnr.qld.gov.au |
| Reducing the impacts of irrigation and drainage on river water quality (Project 2.19) | Dr Evan Christen | Evan.Christen@csiro.au |

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PROGRAM 3

## SUSTAINABLE WATER ALLOCATION

Program Leader
JOHN TISDELL

### Report by John Tisdell, Erwin Weinmann and Gary Codner

**Overview of First Round of Projects.**

*Introduction*

The mission for Program 3: Sustainable water allocation, is to develop principles, guidelines, and practical tools for managing water allocation and use in a sustainable and efficient manner. The management of sustainable water entitlement regimes is vital to resource managers facing the challenges of managing our limited water resources. The aims of the first round of projects in Program 3 were to:

- Assess the implications of the COAG task force recommendations on water in Australia.
- Characterise the nature of the impacts of the various sources of uncertainty in supply on the performance of surface and groundwater systems.
- Review current water entitlement regimes for surface and ground water in the focus catchments in terms of their ability to take account of climate variability and hydrological constraints on catchment yield and water supply.
- Investigate behavioural, social and economic characteristics of the focus catchments and how they may impact on the development of water allocation strategies.
- Identify appropriate management techniques to reduce the risk of change and/or to manage change.
- Outline the potential impacts of significant water entitlement movement through trade on supply systems, social structures and efficiency of water use.
- 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.
- 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.

These aims were achieved by exploring methodologies to integrate economic and hydrological models in Project 3.1: Integration of water balance, climatic and economic models, and surveying irrigator and community attitudes to water reform and development of experimental methods to evaluate principles, and guidelines for water trading in Project 3.2: 'Enhancement of the water market reform process: A socio economic analysis.'

*Key Learnings from the projects*

- Performance of water markets

The performance of water markets will, in part, depend on the attitudes and actions of farmers and community acceptance of water reform in general. The project work showed:

(a) despite legislative changes to break rights to water from land, there is resistance to trading water entitlements as a result of the traditional nexus between land and water held by farmers;

(b) trade should be open to all water users, including farmers with sleeper and dozer licenses, irrespective of the possible reductions in announced allocations for all;

(c) the water authority could take a highly interventionist approach to the market to ensure equity and environmental and social issues are adequately accounted for;

(d) trade is only likely to occur where surplus water exists and farmers are unlikely in the immediate future to explore the opportunity cost of utilising water; and finally

(e) the main blockages to trade, beyond the primary constraint of the land and water nexus, are stakeholder trepidation and misunderstanding of water market operations and the fear of losing traded entitlements.

Based on market theory, water markets have been established to redistribute water entitlements to their most efficient use. How well the market will achieve government expectations depends in part on farmers' perceptions and attitudes to water trading in general and their perceptions of the structure and conduct of the market.

- Integrated modeling challenges

The complex physical, regulatory, and socio-economic setting in which the extensive rural water supply systems in the Murray-Darling Basin operate poses a substantial challenge for integrated modelling. In the initial phase of Project 3.1, the analysis of water allocation modelling needs and capabilities in Australia concluded that, while a common model was desirable in principle, there were overwhelming reasons for the continued use and further development of the currently used models, IQQM

## NEW TECHNICAL REPORT

### Non-Structural Stormwater Quality Best Management Practices - Guidelines for Monitoring and Evaluation

By
André Taylor
Tony Wong

**Technical Report 03/14**

This report presents a new evaluation framework and guidance for measuring the effects and life-cycle costs of non-structural BMPs. This framework defines seven different styles of evaluation to suit the needs and budgets of a variety of stakeholders involved with stormwater management.

**Printed and bound copies of this report are available from the Centre Office for $27.50. Contact Virginia Verrelli on 03 9905 2704 or email crcch@eng.monash.edu.au**

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# URBAN STORMWATER SOFTWARE

## Model for Urban Stormwater Improvement Conceptualisation (MUSIC) version 2

**MUSIC** is a decision-support system. The software enables users to evaluate conceptual designs of stormwater management systems to ensure they are appropriate for their catchments. By simulating the performance of stormwater quality improvement measures, music determines if proposed systems can meet specified water quality objectives.

**MUSIC Version 2 is available as a free evalution version download from the Catchment Modelling Toolkit website at www.toolkit.net.au/music**

**The MUSIC evaluation version allows you to trial the MUSIC software for 6 weeks. During that period you are able to purchase the MUSIC software for $330. Discounts apply if you a current MUSIC version 1 user.**

**For further information visit the MUSIC web site at www.toolkit.net.au/music**

**Please note: You must be a registered Catchment Modelling Toolkit member to download the MUSIC evaluation version.**

(used predominately in NSW and QLD) and REALM (used in Victoria, SA and WA). The different modelling approaches adopted for the southern and northern water supply systems have their justification in significant differences in the physical system characteristics and water management priorities.

- Gaps in current modeling capabilities

A range of gaps in current modelling capabilities was identified in the initial project phase and followed up with scoping studies. Project 3.1 then concentrated on a number of key research areas with the following outcomes:

- The scoping studies on the effects of climate and socio-economic factors on water trading, and an Associated Additional.Project implementing a specific modelling approach informed the development of a conceptual basis for modelling temporary water trading.
- Research on potential third party impacts of water trading led to the development and testing of a system of exchange rates for water trading between different regions.
- Analysis of the sensitivity of the Murrumbidgee IQQM and Goulburn-Broken REALM models allowed the identification of the most influential model inputs and parameters for practical model applications.
- An IQQM modelling study on the impacts of farm dams in the Gwydir system provided an assessment of the potential benefits and impacts of on-farm storages and highlighted the importance of physical storage characteristics.

-Experimental methods for evaluating water management

The final aspect of the program in the first three years was to develop experimental methods to evaluate water management issues. This lead to the development of a computer software package, coined “MWater”. It provides a relatively inexpensive means of institutional analysis coupled with substantially reduced time horizons. The research examined applied economic policy, which requires more realistic simulations of economic environments that depend closely on policies developed to account for the social, economic and biophysical complexities of water as a common pool resource. To enable this complex analysis to occur, the program developed a number of methodical systems for experimental economics, including extensive survey design and analysis.

- Findings from experimental water trading

The primary hypothesis was that the level of environmental damage caused by water extraction will increase as a result of trade and decline with information, discussion and individual extraction disclosure. Statistical analysis of the environmental levies arsing from the experiments found significant differences in the levies between the trade and no trade treatments. It was assumed that providing aggregate extraction information will not significantly modify extraction levels to produce greater accordance with the environmental flow regime and allowing communication between players on extraction will allow social contracts to form to minimise the environmental externality.

In the experimental setting of the research it was found that the provision of aggregate extraction information without a formalised and appropriate forum for communication is not effective in promoting players’ coordination of their extractions to avoid environmental damage. Disclosure of individual information is also not effective in modifying people’s extractions to be more in accordance with environmental targets. The environmental damage was minimised by providing aggregate extraction information and a forum for discussion without a trading environment. Average traders’ income was maximised by providing information on aggregate extraction, environmental targets and a forum for discussion in an open call market. Providing aggregate information and a forum for discussion without trade maximised the return per unit of environmental damage.

Following from this it was also assumed that providing individual extraction information and opportunities for players to communicate will further enforce the social contract and minimise the environmental externality. The provision of information - be it market information or extraction information - should modify behaviour in an environment such as this. An open call auction, where the bids values are common knowledge, should produce greater market efficiency compared to a closed call auction. Information on extraction and in particular, on others’ individual extraction levels, should promote greater accordance with the environmental objective and minimise free riding. This research found that the provision of individual information, compared to the coarser aggregate information, was found to be counter productive. Knowing that individual extraction levels were to be public resulted in the groups setting less stringent reduction targets. The research found that even in a quite complex experimental environment, communication combined with aggregate information assisted players in coordinating their individual actions to minimise an environmental externality arising from their aggregate behaviour.

*Application*

The research is the first round of projects has provided an excellent platform for future development of integrated economic and hydrological models. This is now being followed up in the current project phase with the development of Water Reallocation Models (WRAMs) for application with IQQM and REALM.

The further development of experimental methods will explore issues surrounding permanent water trading, including how to manage capacity constraints, the development of sediment trading options, and salt markets. The survey findings, literature review on water management in Australia and findings of the laboratory experiments have provided important background information to both State and Federal agency reports and assistance for farmers interested in water trading. The experimental laboratory was recently used by DPI Victoria to pilot a series of salt trading experiments.

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## NEW TECHNICAL REPORT

### Stochastic Generation of Climate Data

**By**

**Ratnasingham Srikanthan**
**Senlin Zhou**

**Technical Report 03/12**

This report describes stochastic climate data generation models for the generation of annual, monthly and daily climate data (rainfall, potential evapotranspiration, maximum temperature and other variables) that preserves the correlation between the different variables. The performance of the models are evaluated using climate data from ten sites located in various parts of Australia.

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PROGRAM 4

# URBAN STORMWATER QUALITY

Program Leader
TIM FLETCHER

## Report by Tim Fletcher

*Introduction*

The purpose of Program 4: Urban Stormwater Quality is 'To develop urban stormwater management systems to better protect environmental and community values of urban aquatic ecosystems'. The Program 4 research team has undertaken its research with a very focussed approach to facilitating adoption of its findings (this approach, and its success, is a great legacy left by the former Program Leader, Assoc. Prof. Tony Wong). To that end, we developed the Model for Urban Stormwater Improvement Conceptualisation (MUSIC), as a part of the CRC's Catchment Modelling Toolkit.

In its first round of projects, the specific objectives of the Program were:

1. Identifying current world best practice in the management of urban stormwater for the protection of aquatic ecosystems.

2. Monitoring stormwater quality treatment facilities in the field for their pollutant removal efficiencies and understanding of the physical and biochemical factors influencing their performance as stormwater treatment facilities.

3. Determining critical pollutants and target concentration and/or load for improving or protecting aquatic ecosystems.

4. Formulating world best practice design guidelines for stormwater management techniques applicable to Australian conditions.

5. Developing predictive models for individual stormwater quality treatment techniques.

6. Integrating the process models of individual stormwater quality treatment techniques into a decision support system.

7. Developing strategies to facilitate effective adoption of research findings into practice.

*First round projects*

There were two Projects undertaken in the 'first round' of projects, (each of them containing three activities):

- Project 4.1: Stormwater Pollutant Sources, Pathways and Impacts

  This project aimed to develop a suite of models for estimating stormwater pollutant loads from different source areas, defining their impact on aquatic ecosystems, and predicting the performance of varying stormwater treatment measures. Broadly speaking this project aimed to (a) quantify the loads of pollutants coming from catchments of varying land use, and (b) predict the ecosystem impacts of changes to stormwater quality and quantity caused by urbanisation. Development of MUSIC was also undertaken within this project (although it draws from the research findings coming out of Project 4.2 (below) as well).

- Project 4.2: Stormwater Best Management Practices

  Inadequate understanding of the efficacy of many structural and non-structural management practices has been seen as an impediment to the adoption of best practice stormwater management in Australia. This project aimed to contribute to overcoming the impediment by (a) monitoring and evaluating existing stormwater quality improvement facilities, such as wetlands, swales, ponds and gross pollutant traps, (b) reviewing the effectiveness of non-structural stormwater management measures, and (c) conducting field experiments on the role of vegetations and infiltration/adsorption mechanisms in achieving stormwater quality improvement.

*Key Questions – Answered and Remaining*

- Predicting Stormwater Quality

  There have been numerous attempts around the world to model urban stormwater quality, varying in philosophy, complexity and success. Hugh Duncan undertook an extensive review of worldwide urban stormwater quality data, and characterised the statistical properties (mean and standard deviation) of these data (Duncan, 1999). We have used these data to provide estimates of pollutant loads from catchments of varying land-use. In MUSIC, for example, rainfall and runoff data are combined with the mean and standard deviation of both wet and dry weather concentrations of TSS, TP and TN, to produce a stochastic time-series of pollutant concentration and load. Brisbane City Council contributed significantly to this area of research, and derived their own similar estimates for the Brisbane area (Table 4.1).

  Whilst this approach provides an appropriate estimate of the overall water quality expected from a catchment, there are a number of significant drawbacks in such an approach. The most obvious is that this model cannot accurately predict pollutant concentration at any given point in time, because it is a purely stochastic approach. Current research, being undertaken as an Associated/Additional Project and funded by the Victorian EPA and

Table 4.1. Statistical properties of Brisbane stormwater quality data, for application to MUSIC modelling.

| Land Use | Parameter | Total Solids | Suspended ($Log_{10}$ mg/L) | Total Phosphorus ($Log_{10}$ mg/L) | | Total Nitrogen ($Log_{10}$ mg/L) | |
|---|---|---|---|---|---|---|---|
| | | Base Flow | Storm Flow | Base Flow | Storm Flow | Base Flow | Storm Flow |
| **Urban Residential** | Mean | 0.99 | 2.18 | -0.95 | -0.47 | 0.19 | 0.26 |
| | Std Deviation | 0.38 | 0.39 | 0.34 | 0.30 | 0.19 | 0.23 |
| **Commercial** | Mean | 0.82 | 2.17 | -0.66 | -0.40 | 0.35 | 0.37 |
| | Std Deviation | 0.40 | 0.39 | 0.49 | 0.35 | 0.30 | 0.33 |
| **Industrial** | Mean | 0.78 | 1.96 | -1.15 | -0.56 | 0.12 | 0.28 |
| | Std deviation | 0.44 | 0.44 | 0.44 | 0.37 | 0.19 | 0.33 |
| **Rural Residential** | Mean | 0.54 | 2.36 | -1.52 | -0.52 | -0.52 | 0.36 |
| | Std Deviation | 0.24 | 0.51 | 0.41 | 0.27 | 0.42 | 0.25 |

Melbourne Water, is attempting to use surface type, and short-duration climate data, to predict pollutant concentrations and loads.

More work is also needed to predict likely concentrations of other pollutants (e.g. heavy metals, polyaromatic hydrocarbons, etc), and their associations with sediments of varying particle size. Research findings in this area to date suggest that concentrations of many pollutants may be able to be predicted from sediment concentrations, provided that the particle size distribution is known.

- The Effectiveness of Stormwater Management Practices: Structural and Non-Structural- Non-structural measures

In the first round of projects we undertook a major review of non-structural stormwater management measures, culminating in a series of CRC for Catchment Hydrology Reports. Non-structural measures were categorised into five primary types: town planning controls, strategic planning and institutional controls, pollution prevention procedures, education and participation programs, and regulatory controls. The review showed that their application is increasing (following similar overseas trends), due to the potential benefits of reduced cost, breadth of coverage, ability to target specific pollutants, flexibility, and potential for secondary benefits. However, the review also demonstrated a general lack of attention to monitoring the effectiveness of non-structural measures; as a result the CRC has published a guideline to support their future monitoring (see Further Information for details).

Another interesting research project on non-structural measures was conducted as part of Sara Lloyd's PhD thesis on water sensitive urban design (WSUD). With support from the Urban & Regional Land Corporation, and Melbourne Water, a survey of community attitudes was undertaken, demonstrating over 90% public support for integrating WSUD into residential developments.

*Structural measures*

Extensive monitoring and testing was undertaken on structural best management practices also, with particular assistance from Brisbane City Council and Melbourne Water. Whilst there is not room to report in detail on the monitoring that has been undertaken at each site, the list includes:

- Undertaking sediment dosing experiments in a wetland, to test the influence of vegetation on sediment removal,
- Testing the performance of a wide range of gross pollutant traps (with support also from the Victorian EPA),
- Conducting field experiments on a grass swale in Brisbane, to test the influence of flow rate, inflow concentration and particle size distribution, on the removal of TSS, TP and TN.
- Field experiments on a bioretention system at Lynbrook Estate in Melbourne; testing pollutant removal (through both the swale and bioretention component), hydraulic and hydrologic performance. Not only was the bioretention system shown to be highly effective in pollutant removal, but also in reducing the frequency and amount of runoff.

*Modelling pollutant removal behaviour*

- Unified Stormwater Model

The most important thing to come from the CRC's work on structural Best Management Practices (BMPs) was the development of a Unified Stormwater Treatment Model (USTM), based around a simple first-order kinetic decay algorithm (Equation 1). The

# NEW TECHNICAL REPORT

## Calibrations of the AWBM for Use on Ungauged Catchments

**By**
**Walter Boughton**
**Francis Chiew**

**Technical Report 03/15**

This report presents an approach for using the daily rainfall-runoff model, AWBM, to estimate runoff in ungauged catchments.

The report describes computer programs that can be used to optimise three key parameters in AWBM against runoff data from gauged catchments, and provides calibrated parameter values and catchment characteristics for 221 Australian catchments. The report then recommends an approach for using the calibrated parameter values in these and other catchments to guide the choice of AWBM parameter values for use in ungauged catchments.

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# NEW TECHNICAL REPORT

## Stochastic Models for Generating Annual, Monthly and Daily Rainfall and Climate Data at a Site

**By**

**Ratnasingham Srikanthan**
**Senlin Zhou**

**Technical Report 03/16**

One of the goals of the Climate Variability Program in the Cooperative Research Centre (CRC) for Catchment Hydrology is to develop computer programs for generating stochastic data at time scales from less than one hour to one year and for point sites to large catchments.

The first phase of the program (2000-2002) has developed models to stochastically generate rainfall and climate data for a site at annual, monthly and daily time scales. Different models have been tested using data from across Australia, and the results have been reported in a series of CRC for Catchment Hydrology reports and research papers.

The purpose of this report is to provide guidance on the use of the stochastic modelling software.

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advantage of this approach has been that it has allowed a 'unified theory' for predicting the pollutant removal behaviour of a wide range of BMPs – wetlands, ponds, sedimentation basins, vegetation swales and bioretention systems (Wong et al., 2001).

$$q\frac{dC}{dx}=k(C-C^*) \qquad \text{(Eqn. 1)}$$

where q = hydraulic loading rate (m/y)
x = fraction of distance from inlet to outlet
C = concentration of the water quality parameter
$C^*$ = background concentration of the water quality parameter
k = areal decay rate constant (m/y)

The USTM forms the 'intellectual backbone' of MUSIC (it includes a Continuously Stirred Tank Reactor model to account for hydrodynamic behaviour). Despite its elegant simplicity, there are a number of limitations and assumptions of this approach, and current research within the program is aimed in part at addressing these:

- Water quality behaviour may in many cases be more complex than that described by a first-order model (Kadlec, 2000), with potential influences of flow and inflow particle size distribution. Refinements are being examined which would allow these influences to be accounted for, in a refined USTM;

- Calibration to date is based almost entirely on storm-event monitoring, with little knowledge as to how this behaviour (particularly the background concentration, C*) may behave during extended inter-event (dry weather) periods. Current monitoring at Bridgewater Creek Wetland in Brisbane and Hampton Park Wetland in Melbourne is being used to develop more rigorous inter-event calibrations. NSW EPA is currently supporting further calibration work, for wetlands in NSW and the ACT.

- Predicting Ecosystem Responses

Management of flow and water quality is ultimately just the 'means to the end', with the end being the ecosystem health of receiving waters. The general relationship between catchment urbanisation and degradation of receiving water ecosystems is well known (Booth and Jackson, 1997; Walsh *et al.*, 2000). However, there has been little success in developing predictions of ecosystem response to stormwater management scenarios. A large multi-disciplinary project is underway to develop such models, with promising results. Whilst several studies have demonstrated the impact of impervious area on aquatic ecosystems, the research undertaken in this project has highlighted the importance of the connection between the impervious area and receiving waters. The models show that the impervious area which is not connected to receiving waters has little or no impact (up to a threshold total impervious level) on, for example, macroinvertebrate community composition (Walsh and Fletcher, submitted). It is therefore effective impervious area which provides a good prediction of aquatic ecosystem health. These integrative catchment-scale

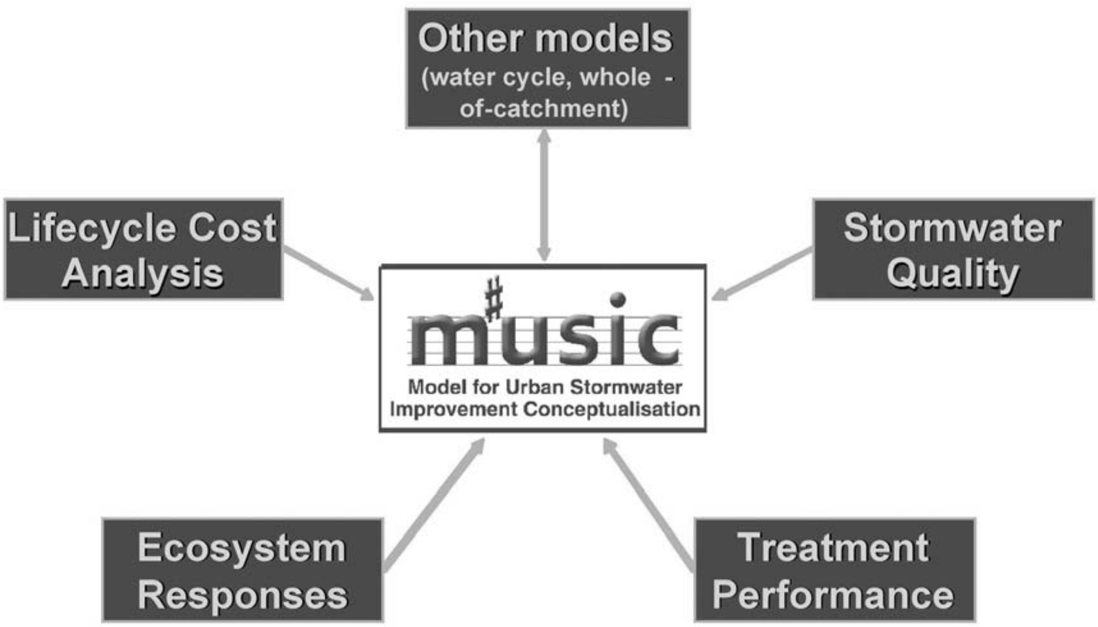


*Figure 4.1. Model for Urban Stormwater Improvement conceptualisation (MUSIC) as a focal point for research.*

models are now being refined, in an attempt to be able to describe the influence of stormwater best-management practices (which reduce the connection – both hydraulically and in pollutant transport efficiency - of impervious areas to streams) on aquatic ecosystem health. The resulting predictive algorithms will be incorporated into MUSIC.

We now propose to test these models in two moderately degraded streams, which our models suggest will show significant responses of ecological indicators to disconnection of impervious surfaces.

- MUSIC

As outlined previously, the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) was created as a user-friendly decision-support system to assist stormwater managers to predict and evaluate (a) the quality of stormwater from catchments of varying land-use and characteristics, (b) the performance of alternative stormwater management scenarios, in terms of water quality improvement, flow attenuation, and (ultimately) lifecycle costs and ecosystem responses (Figure 4.1). MUSIC Version 2 was released in December 2003, and subsequent versions will be released in 2004 and 2005, encapsulating new research findings. We will also be seeking to create effective links to whole-of-catchment models (such as EMSS) and urban water cycle models.

*Acknowledgements*

The work undertaken by the Urban Stormwater Quality Program to date has been a combined effort of a large number of people at Brisbane City Council, CSIRO Land & Water, Griffith University, Melbourne Water, Monash University and the University of Melbourne. Particular thanks go to: Tony Wong, Hugh Duncan, Ana Deletic, Tony Ladson, Chris Walsh, John Coleman, Graham Jenkins, Margaret Greenway, Lionel Siriwardena, Sara Lloyd, Tracey Walker, Justin Lewis, Peter Poelsma, Tony Weber, Graham Rooney, Lucy Peljo, Fiona Chandler, Matt Francey, Peter Breen, Jane Catford, Andrew Barton, Dale Browne, Marc Noyce, Anne Simi, Stuart Hoverman, Barry Ball and Ross Young along with a dedicated and talented group of postgraduate students, summer scholars and contributing undergraduates.

*Further Information*

Much of the research which has been produced by the Urban Stormwater Quality Program can be viewed in the Publications section of the www.catchment.crc.org.au website (look under "Urban Stormwater Quality").

A number of publications relating to MUSIC and its background science are available on the www.toolkit.net.au/music website, whilst papers from the collaborative research with the CRC for Freshwater Ecology can be obtained from http://www.wsc.monash.edu.au/urbanwater/D210/D210pubsstuds.html.

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# NEW TECHNICAL REPORT

## Analysis and Management of Unseasonal Surplus Flows in the Barmah-Millewa Forest

**By**

**Jo Chong**

**Technical Report 03/2**

This report addresses a major threat to the Barmah-Millewa Forest forest; unseasonal flooding in the summer and autumn, when the forest would normally be dry. Based on analysis of pre-regulation conditions (1908-1929) and current conditions (1980 - 2000), forest flooding has increased from 15.5% of days to 36.5% of days between December and April.

In particular, small, localized floods, which inundate less than 10% of the forest, occur at least eight times more frequently now, than before regulation. Work by others has related these hydrologic changes to tree death and changes in floristic structure in wetlands.

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PROGRAM 5

# CLIMATE VARIABILITY

Program Leader
FRANCIS CHIEW

## Report by Francis Chiew

*Background and Program Objectives*

The considerable variation of rainfall and runoff from year to year is part of the natural variability of the climate system. The management of land and water resources involves designing and operating to cope with this variability. The management challenges in Australia are compounded by Australian streamflow (and to a lesser extent climate) being much more variable than elsewhere in the world.

The mission of the CRC for Catchment Hydrology is to deliver to resource managers the capability to assess the hydrologic impact of land use and water management decisions at whole-of-catchment scale. The goal of the Climate Variability Program, Program 5, is to improve our ability to quantify climate variability, by developing tools that can be used with hydro-ecological models to quantify uncertainty in hydro-ecological systems associated with climate variability. Models developed in Program 5 have been converted into toolkit products in the CRC for Catchment Hydrology Modelling Toolkit.

There are two research projects in the Program 5. The aim of the first project is to develop and test stochastic climate data generation models, and the aim of the second project is to improve models for forecasting rainfall and streamflow for various lead times. There are essentially five research areas in the Climate Variability Program and these are described separately here. Key overview references are provided at the end of each section, from which references to detailed descriptions of research methodologies and outcomes can be found.

*Point Stochastic Rainfall and Climate Data*

Using historical climate data as inputs into hydrological models provides results that are based on only one realisation of the past climate. Stochastic data provide alternative realisations that are equally likely to occur, and can be used as inputs into hydrological models to quantify uncertainty in hydrologic systems associated with climate variability (see Figure 5.1).

In short, stochastic data are random numbers that are modified so that they have the same characteristics (in terms of mean, variance, skew, short and long term persistencies, etc...) as the historical data from which they are based. Each stochastic replicate (sequence) is different and has different characteristics compared to the historical data but the average of each characteristic from all the stochastic replicates is the same as the historical data.

In collaboration with researchers from University of Newcastle and University of New South Wales, Program 5 has developed and tested stochastic models for generating rainfall and climate data (correlated rainfall and other climate data) at a site at annual, monthly and daily time steps. The model testing indicated that, from a hydrological modelling perspective, the differences between the better stochastic models are marginal. The appropriate models are now part of Stochastic Climate Library (SCL), a CRC for Catchment Hydrology toolkit product.

The Climate Variability Program is currently developing and testing sub-daily point rainfall and spatial (multi-site) daily stochastic rainfall models. These models will also be part of Stochastic Climate Library when completed.

*Reference*

Srikanthan, R. and Chiew, F.H.S. (2003) Stochastic Models for Generating Annual, Monthly and Daily Rainfall and Climate Data at a Site. Cooperative Research Centre for Catchment Hydrology, Technical Report 03/16, 57 pp.

*Space-Time Stochastic Design Rainfall*

Program 5 has also developed a space-time rainfall model, MOTIVATE, which generates stochastic sequences (10 minutes or less) of spatial (down to 1 km) rainfall (i.e., the equivalent of radar rainfall measurements) for a given mean areal rainfall and storm duration. MOTIVATE is based on a multiplicative cascade concept, where rainfall is characterised by variability over a wide range of scales and the temporal evolution of a feature in a rain field is dependent on scale.

MOTIVATE is particularly useful for providing stochastic realisations of design storms. Melbourne Water and Sydney Water recently used 1 in 5 year stochastic space-time rainfall generated by MOTIVATE as inputs into their models to assess their sewerage network design.

The MOTIVATE software allows for the generation of stochastic space-time rainfall using default parameters (for Melbourne, Sydney, Darwin and Brisbane), as well as automatic calibration against radar rainfall data.

*References*

Seed, A.W., Srikanthan, R. and Medabde, M. (1999) A space and time model for design rainfall. J. Geophys. Res., 104: 31623-31630.

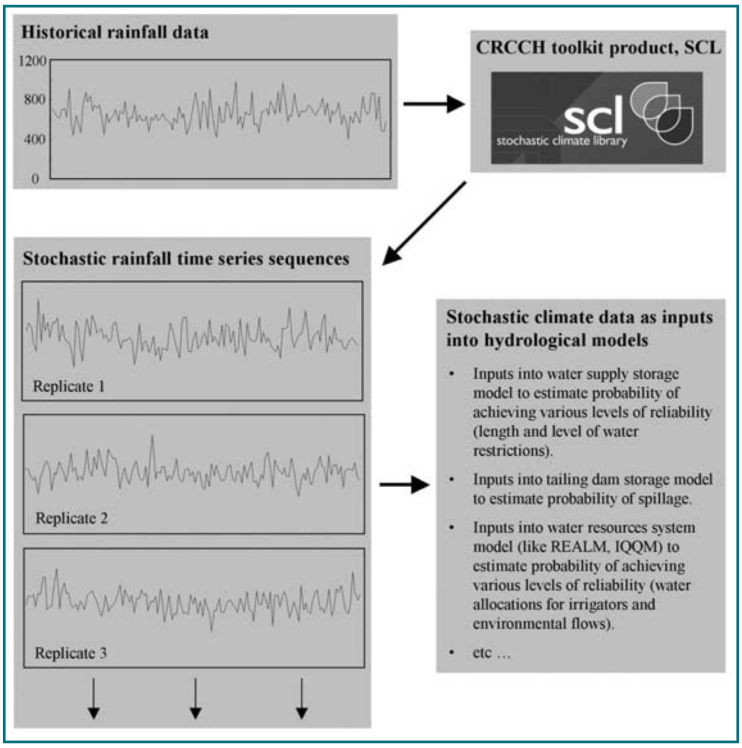


*Figure 5.1 Using stochastic climate data as imputs into hydrological models to quantify uncertainty in hydrological systems associated with climate variability*

*Rainfall Nowcasting*

Rainfall forecasts out to a lead time of six hours and more are required for a range of applications, particularly hydrological forecasting for flood warning. These applications require quantitative rainfall forecasts as well as an estimation of the error bounds surrounding the forecast so that they can be used to estimate the risk within the particular application. For example, flood warning managers require the probability that a critical threshold in a river level will be exceeded in the forecast period.

Program 5 has developed S_PROG, a stochastic nowcasting model, which can successfully forecast rainfall one or two hours ahead (see Figure 5.2). S_PROG has been tested in Australia, New Zealand, U.K. and Spain, and was the simplest and one of the best amongst similar models tested during the Sydney Olympics in 2000. The Australian Bureau of Meteorology is developing systems to use S_PROG to generate rainfall nowcasts at each of the 50 radars in the Australian radar network.

In collaboration with the U.K. Met Office, the Climate Variability Program is currently developing a joint stochastic forecasting engine that combines the stochastic nowcasting of S_PROG with deterministic rainfall forecasts from numerical weather prediction models to give stochastic rainfall forecasts with longer lead times (out to six hours or more).

*Reference*

Seed, A.W. (2003) A dynamic and spatial scale approach to advection forecasting. J. Appl. Meteorol., 42: 381-388.

*Land Surface Modelling in Numerical Weather Prediction Models*

The aims of this research are to improve the land surface modelling and the initialisation of soil moisture in numerical weather prediction (NWP) models. These improvements should lead to improved weather

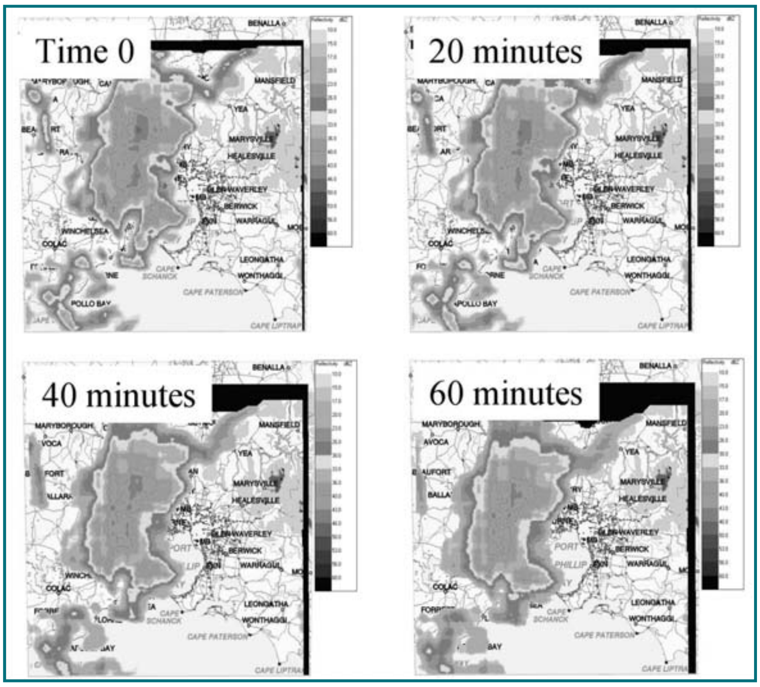


*Figure 2 Example deterministic nowcast of Melbourne rainfall (16.00 21 Apr 2001) out to 60 minutes*

# FOREST MANAGEMENT WORKSHOP, CANBERRA

## 23-25 March 2004

The CRC for Catchment Hydrology, along with the University of New South Wales, Forest Science Centre and New South Wales State Forests presents the Forest Management Workshop on 23-25 March 2004.

The aim of the meeting is to bring together scientists and forest managers to discuss recent developments in the understanding of forest catchment behaviour and management.

Presentations will be held on the 23 and 25 March 2004 and a field excursion will be organised for the 24 March 2004. The field excursion will visit the burnt forest area at the western side of Canberra and plantation forestry sites of NSW State Forests near Tumut.

The workshop is based around four key themes:

- Forest Hydrology
- Sediment Delivery and Water Quality
- Fire Management
- Sustainable Forestry

**PLEASE NOTE:**
**The registration date has been extended to Friday 12 March 2004**

**For further information visit www.catchment.crc.org.au/news or** **see page 23 of this issue of Catchword.**

## www.toolkit.net.au

The Catchment Modelling Toolkit web site continues to expand. The Toolkit web site will be used to deliver the CRC for Catchment Hydrology's modelling software and supporting documentation over the next three years.

Members of the Toolkit web site can now download the River Analysis Package (RAP) and the Rainfall Runoff Library (RRL) by logging in and visiting:
www.toolkit.net.au/rap
www.toolkit.net.au/rrl

More software products will be available to download from the Toolkit site over the coming months, so keep an eye on www.toolkit.net.au

**For further information visit www.toolkit.net.au**

**Comments and queries can be directed to**
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forecasts by the Bureau of Meteorology's NWP models out to several days.

As part of this research, an extensive soil moisture monitoring network was established across the Murrumbidgee River Basin (see Figure 5.3). This research is part of the Murray-Darling Basin Continental Scale Experiment (MBD CSE) in GEWEX (Global Energy and Water Cycle Experiment), and the data sets compiled have also been used in other international studies. The data sets include: forcing data for 10 locations at 30-minute time steps from January 2000 (rainfall, temperature, specific humidity, shortwave radiation, longwave radiation, wind speed), 30-minute soil moisture data and 6-minute soil temperature data over four depths at 18 locations from October 2001, and daily streamflow data for 20+ unimpaired catchments (these data will be made available via the web by the end of 2004); and national spatial data set of soil properties, land cover and vegetation (a toolkit product by June 2004).

Modelling studies completed in the Climate Variability Program indicate that the land surface scheme (VB95) used in the Bureau of Meteorology's NWP models can simulate the temporal fluctuations in soil moisture, and therefore the surface moisture fluxes, fairly realistically. However, the model exhibits a significant (generally wet) bias in the absolute soil moisture, and the use of the best Australia-wide soils and vegetation information did not improve VB95 simulations consistently. The soil moisture bias could be largely eliminated by using soil parameters derived directly from soil moisture observations, but such parameters are only available at very few point locations. The results also indicate that the modelling of runoff processes is important in determining long-term evapotranspiration and evapotranspiration following infiltration events, but modelling of runoff is probably the weakest component of land surface models.

Current research efforts in Program 5 are concentrating on improving the runoff modelling in VB95, improving the initialisation of soil moisture through assimilating remotely sensed near surface temperature and soil moisture, assessing NWP simulations over irrigation areas, forecasting potential evapotranspiration from NWP climate forecasts for irrigation water management, and generalisation of parameters in a simple rainfall-runoff model for runoff estimation in ungauged catchments.

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Siriwardena, L., Chiew, F.H.S., Richter, H. and Western, A.W. (2003) Preparation of a Climate Data Set for the Murrumbidgee River Catchment for Land Surface Modelling Experiments. Cooperative Research Centre for Catchment Hydrology, Working Document 03/1, 50 pp.


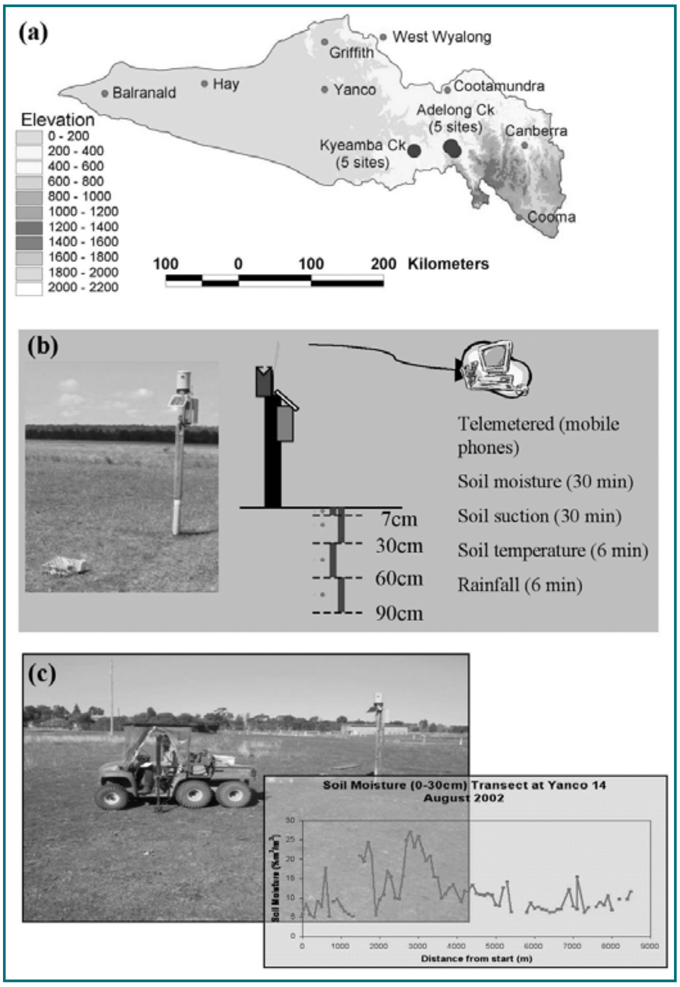


*Figure 5.3: Soil moisture monitoring in Murrumbidgee River focus catchment (a) Monitoring at 18 sites (b) Setup for monitoring rainfall, and soil moisture, temperature and suction over four depths (c) transects measurements to describe the spatial representativeness of the point soil moisture measurements*

*Seasonal Streamflow Forecasting*

The teleconnection between Australia's hydroclimate and El Niño/Southern Oscillation (ENSO) is amongst the strongest in the world. The lag streamflow-ENSO relationship and the serial correlation in streamflow can be exploited to forecast streamflow several months ahead. The use of seasonal streamflow forecast can benefit the management of land and water resources. For example, seasonal streamflow forecast could allow water managers to make more realistic decisions on water allocation for competing users, and forecast of variables like water allocation, streamflow volume and number of pumping days would help farmers make better informed risk-based decisions for farm and crop management.

The Climate Variability Program has developed and tested a non-parametric seasonal forecast model (NSFM) that forecasts continuous exceedance probabilities of streamflow (or any other variable) (see Figure 4). In the Program we are currently working with several water agencies on using seasonal inflow forecast as input into water system model to provide probabilistic indication of irrigation allocation further into the irrigation season.

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*Acknowledgements*


- Climate Variability Program: Program 5 Researchers: Andrew Frost, Tom McMahon, Graham Mills, Harald Richter, Alan Seed, Lionel Siriwardena, Sri Srikanthan, Andrew Western, Rodger Young, Senlin Zhou.

- Other Researchers and Program 5 Reviewers: Tom Chapman, Trevor Daniels, Jetse Kalma, George Kuczera, Rory Nathan, Geoff Pegram, Ashish Sharma, Mark Thyer.



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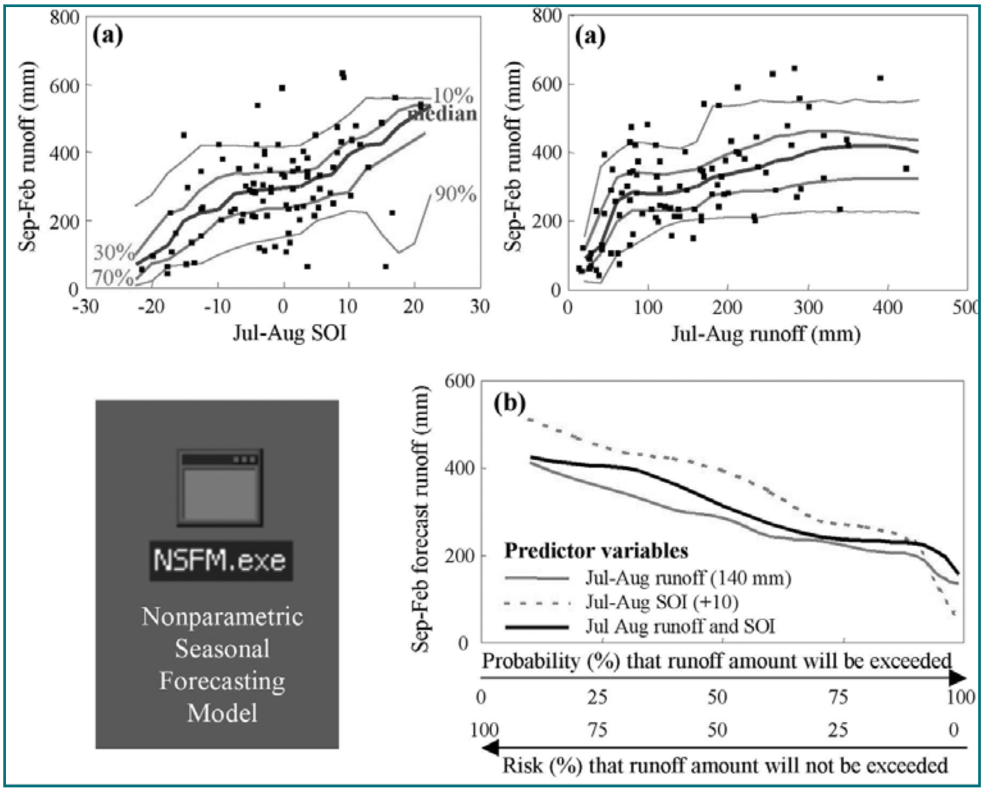


*Figure 5.4 Forecasting continuous exceedance probabilities of streamflow for use in land and water resources management (a) Sep-Feb runoff versus Jul-Aug SOI and versus Jul-Aug runoff at Nariel River catchment (south-east Australia) and NSFM 10%, 30%, 50%, 70% and 90% fits to the data (b) example forecast for Sep-Feb runoff for forecasts based on antecedent runoff alone, SOI alone and both antecedent runoff and SOI (for Jul-Aug runoff = 140 mm and Jul-Aug SOI = +10)*

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PROGRAM 6

# RIVER RESTORATION

Program Leader
MIKE STEWARDSON

## Report by Mike Stewardson and Ian Rutherfurd

### Outcomes from Round 1 Projects

*Introduction*

Unlike other projects in the CRC for Catchment Hydrology, the first round projects in the River Restoration Program concentrated on planning and process-scale issues, rather than catchment-scale modelling. This was a deliberate strategy, since many of the stream rehabilitation issues at present are still local in scale. The goal of the program was to "provide tools to stream managers to increase their confidence in stream rehabilitation". When these projects were first proposed (in 2000) it was estimated that $50m/year was spent on river restoration. Since this time, investment in river restoration has grown at least ten-fold, particularly through the provision of environmental flows, restoration of riparian zones and, to a lesser extent, the construction of fishways and re-introduction of large woody debris. Research and development activities to underpin river restoration have also expanded rapidly. Under the Program Leadership of Ian Rutherfurd, our first round projects have made an important contribution to our understanding of physical processes and planning of river restoration at the reach scale. This article is a very brief overview. The reader is directed to relevant Project Leaders, the CRC Web site, and over 80 publications listed on the relevant project summary pages of the CRC Web site.

*Key Learnings from the Round 1 Projects*

To begin, we quote from the September 2003 issue of *Catchword* (by Ian Rutherfurd):

"It is a common misconception amongst managers that good research makes management simpler. This is not always the case. Research, particularly in stream rehabilitation, often shows how we had underestimated how complex things were."

The high-degree of uncertainty regarding the physical and biological effects of river restoration is problematic for restoration practitioners. There are few design standards and even carefully planned projects are at risk of failing to achieve their goals. The demand for river restoration has raced ahead of the knowledge-base with which to predict relative merits of restoration plans. There is a need for research, but how does one research river restoration, a complex activity undertaken at a variety of temporal and spatial scales. In partnership with the CRC for Freshwater Ecology we identified three distinct research methods for expanding our knowledge-base (Stewardson *et al*, 2001). We used two of these (b) and (c) below) in our first round project.

(a) Post-Project Evaluation: Examining conditions at sites that have been subject to river restoration sometime in the past.

The most obvious opportunity to learn about river restoration is to examine how rivers have responded to restoration works undertaken in the past, but this can be problematic. A review of riparian restoration sites in north-east Victoria was undertaken to assess the feasibility of this approach (Ezzy, 2001). Riparian restoration has a relatively long-history in this region. However, it was concluded that this approach is not feasible, mainly because most historic restoration projects used techniques that are now out of favour or were undertaken at sites that are unsuitable for evaluation. Another problem with post-project evaluation is that information regarding the state of sites prior to restoration and the nature of the restoration work is often not available (Ladson, 2001). Relevant documentation and people familiar with the project are more likely to be available for more recent projects.

(b) Combining management and monitoring: Designing a monitoring and evaluation program as a part of a current river restoration project.

With the support of the agencies involved, it may be possible to transform a river restoration project into an adaptive management project in which coordinated management intervention and monitoring are designed as an experiment to improve our knowledge of restoration ecology. Such an approach has some potential for improving the knowledge-base but major challenges exist including establishing and maintaining the support of management agencies for the experimental objectives of the project in the face of other community priorities.

In our round 1 projects we planned to collaborate with the CRC for Freshwater Ecology in two management experiments, but both experiments failed to proceed. Project 6.7, a project using experimental environmental flow releases in the Campaspe River, was delayed indefinitely because of water shortages. Project 6.2, an experimental urban restoration project, was cancelled because there was insufficient knowledge to design an experiment with a high chance of successful restoration. Our troubled experience with adaptive management should caution others considering management experiments.

Ladson and Argent (2002) identified the conditions which favour successful application of adaptive management principles. Adaptive management is more likely to be successful where there are few, well defined points of intervention, early successes for experimental management, shared goals and strong political support. Where experimental policies are seen as too risky or costly, the promise of adaptive management has not been realised.

(c) Dedicated experimentation: Designing an experiment with the sole objective of improving our knowledge of river restoration.

Experiments focus on a small number of treatments, possibly limited to a restoration technique. The advantage of a dedicated experiment is the ability to make inferences based on the experimental results and that some confidence can be placed in these inferences. A limitation is that, in order to achieve reasonable statistical power, the range of site types and methods of restoration are necessarily limited.

We examined models of channel recovery from disturbance in a restoration experiment in two tributaries of the Goulburn River (Project 6.3). This joint project with CRC for Freshwater Ecology is quantifying the physical and ecological response to log structures placed in sites subject to a sand slug and control sites. The project was delayed by the absence of any flow pulses during the drought period but is now in a final reporting phase. We also conducted an experimental riparian restoration project in Echidna Creek (SE Queensland) and results are due over the coming months (Project 6.4).

In addition to these large-scale studies, a number of smaller scale studies have advanced our understanding of processes associated with river restoration. We have undertaken experimental studies of fish movement through fishways, the effect of grasses on stability of in-channel benches and the stochastic characteristics of scour at large woody debris. We have developed models of scour, the development of pool-riffle morphology, fishway hydraulics, channel and floodplain roughness and reach hydraulic geometry.

*Application*

A key product of Project 6.7 is a new analytical procedure for evaluating environmental flow requirements called The Flow Events Method (FEM). FEM has been applied in four Victorian rivers under contract to Department of Sustainability and Environment (Broken River, Loddon River, Thomson River and Goulburn River). The method proved effective in providing a defensible environmental flow assessment which was accepted by community and management groups. The method is now included as part of the Victorian statewide method. Other key products include a revised version of CHUTE and RIPRAP (Project 6.6) which assist the design of rock chutes and bank protection works. A design guide for fishways is also in preparation (Project 6.5).

In addition to these products, we have answered questions frequently asked by managers in relation to river restoration, such as the following.

- Planning project evaluation (Project 6.1 and 6.2)
  - Surely we should evaluate whether all stream rehabilitation projects have worked? Definitely not. There needs to be a clear hierarchy of evaluation methods when people alter flows, revegetate, or do other 'rehabilitation' activities. Such a hierarchy has been produced by Project 6.1 (Ian Rutherfurd, Tony Ladson, Mike Stewardson). In fact, there are many good reasons not to evaluate how effective an intervention has been.
  - By looking at revegetation projects of the past, we must be able to learn something? Unlikely. Looking at over 80 riparian revegetation projects in NE Victoria, we conclude that the projects are all so different that we can learn very little from them. Instead we have to start afresh with a properly designed riparian experiment. This experiment is coming to fruition with funding from the MDBC, and is being managed jointly by CRCFE/CH (see Gerry Quinn or Mike Stewardson for details).
- Pathways of recovery of damaged streams (Projects 6.3 and 6.4).
  - Many streams have filled with sand, if we wait long enough won't the sand all flush through and the stream recover? It depends. Using a novel space-for-time approach, Rebecca Bartley, in her PhD, looked at three sand slug systems in detail. Gravel bed streams appear to recover almost completely, whereas for many incising streams the sand simply represents a hiatus of incision.
  - Will riparian re-vegetation lead to improved water quality in small streams? Intuitively one would expect revegetation to decrease temperature and sediment load to the stream. In fact, when Nick Marsh revegetated the riparian zone of a small sub-tropical stream in Queensland, the opposite happened. The shade from the trees led to

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widening of the stream, increased sediment yield and increased temperature. When we do stream rehabilitation treatments we need to be ready for short term negative effects! If we are not, then managers are likely to lose enthusiasm.

- Improved design of rehabilitation tools (Projects 6.3, 6.5, 6.6, 6.7)
  - Does adding logs to a uniform sand bed stream lead to any recovery? Yes. Joint sampling with the CRC for Freshwater Ecology has shown that there is a strong relationship between pool-depth and fish numbers and diversity. However, this project has led us to develop a 'stochastic' model of recovery that expresses the biological effect of the log (or any intervention) in probabilistic terms.
  - Vertical slot fishways on large dams cost millions of dollars. Surely we understand the hydraulics of these structures since we are now building so many of them? We certainly understand a lot more about them after the first comprehensive hydraulic analysis carried-out by Lindsay White for his PhD (under the supervision of Bob Keller). Out of this work will come rules for optimising the design of fishway hydraulics.
  - We should build more low gradient fishways because swimming ability of Australian fish limits the success of fishways? Lindsay White's PhD thesis on fishways shows that there are numerous factors that control the success of fishways on the Murray River. Simple velocity/swimming ability is only one of them. Slower velocities in the fishway may, at some points, be less attractive to fish.
  - Rock chutes will fail at by scour at maximum flood stage. False. Rock chutes, one of the major stream rehabilitation methods, fail at floods of moderate magnitude, and by many different mechanisms. Some of the design rules are expressed in a new software package for designing rock chutes (CHUTE) developed by Bob Keller.

*Further information*

Please contact the Project leaders listed on our web-site for more information.

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# COMMUNICATION AND ADOPTION PROGRAM

Program Leader
DAVID PERRY

**by David Perry**

*Introduction*

During the first round of CRC research projects (2000-2003), the Education and Training Program comprised two key projects: Project 8.1 'Capacity Building, Education and Training' and Project 8.2 'Public Participation and Community Change'. Project 8.1 provided for the education and training needs of the CRC, in particular the supplementary training programs for our PhD students. The project aligned closely with the Communication and Adoption program objectives and supported the delivery of the research programs to users through a program of workshops, short courses, seminars and conferences.

Project 8.2 however was a research based project and was undertaken collaboratively with the CRC for Coastal Zone, Estuaries and Waterway Management. This research component of the Education and Training Program sought to identify ways in which a wide sense of community ownership and involvement in issues, and responsibility for them, could be encouraged throughout society. The key learnings and outcomes from this project are described in this article.

*Understanding stakeholder involvement*

The value of stakeholder involvement in natural resource management is recognised in both policy and legislation. However problems have emerged in practice, chiefly related to a poor understanding of the social, economic and political influences on stakeholder participation and their motives. Project 8.2 aimed to contribute to the strategic focus of the CRC through the development of a framework and practical strategies for enhancing public ownership of issues and problems in the CRC Focus catchment.

*Catchword* readers who have contributed to or orchestrated any community group will acknowledge the complex dynamics of interest, politics and actions that a group deals with in addressing a common issue. This is particularly so in the environmental management sector where groups are asked to contribute to, take responsibility for, or formally manage a wide range of large scale problems. From an environmental manager's point of view, understanding how best to engage the relevant community or stakeholders to maximise their impact (or input to a solution) is a critical aspect of management of many projects.

*Citizen Science Toolbox* - www.coastal.crc.org.au/toolbox/index.asp

One of the major achievements of the collaboration between the CRC for Catchment Hydrology and Coastal Zone CRC is the Citizen Science Toolbox. It is found at http://www.coastal.crc.org.au/toolbox/index.asp and is a free resource of principles and strategies to enhance meaningful stakeholder involvement in decision-making. In this context, stakeholders include not only communities, but also scientists and decision-makers. While the Toolbox has a focus on coastal and catchment environments, the principles and group process tools found in it can be used in many other areas for a variety of issues.

*User friendly assistance*

Using the Citizen science toolbox is very made easy. As well as a range of relevant publications and links that will assist an individual or group participatory process, there is a tool selection process. This tool process allows the user to set parameters for the process. For example, for the purpose of the consultation, budget, number of people involved, timeframe, level of participation and skills available. The tool selection provides a robust method of selecting from over 60 methodologies and processes. The web site also contains a range of case studies - as Adobe pdf files - that offer the reader an overview of an example case, an explanation as to why a particular process was used, preparations for the 'event', outcomes a review of the strengths and weaknesses of the process and further references. If you are involved in establishing, supporting or engaging groups I can recommend this site as another resource to assist you achieve your objectives.

*Additional relevant resources*

The collaborative CRC research through Program 8 also supported three postgraduate students based at Griffith University. The students and their topics were:

- Dana Thomsen – Community-based research in Integrated Catchment Management
- Margaret Gooch – Influences on voluntary activities of community groups in Integrated Catchment Management
- Clayton White – Effective communication in Integrated Catchment Management

Key papers that summarise the outcomes of Dana's and Margaret's research are available on-line as Adobe pdf files at http://www.coastal.crc.org.au/citizen_science/publications.html This page is also accessible from the Citizen Science Toolbox. There are other relevant papers by Coastal Zone CRC postgraduates also available at this site. These papers offer the reader some new insights into the motivation, attitudes and other social aspect of natural resource managements between government, communities and agencies.

*Conclusion and further information*

The research component of Program 8 was of modest size and scope, however the effective collaboration between the CRC for Catchment Hydrology and Coastal Zone CRC staff resulted in a valuable resource for practitioners working in this area. The Educational and Training Program research component has ceased for the second round of research projects in the current CRC, however the Coastal Zone CRC continues to address many important issues through its Citizen Science research Program. Further information about this ongoing work can be obtained from the Coastal Zone web site at http://www.coastal.crc.org.au/

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# WHERE ARE THEY NOW?

**Daniel Clowes**

Preparing this profile has been a pleasant distraction from the tedium of preparing one's PhD research seminar. Unfortunately, my seminar was the week following this year's Annual Workshop so I could not be available to bore you to sleep with a presentation on my progress. Instead I have prepared this short narrative on my involvement with the CRC and some personal background.

I graduated from the University of Queensland in 1998 with honours in applied science, specialising in environmental science. My honours year included the preparation of a small dissertation on the effects of urbanisation of riparian zones. From this came a keen interest in all things related to catchments and waterways. Following graduation I gained employment immediately in the local government area where I spent much of my childhood. Pine Rivers Shire, a local government authority in south east Queensland, is not unlike many rapidly urbanising areas throughout Australia and I found the streams that I remembered from my childhood were in a much poorer condition. Waterways, water quality and catchment management were topical issues in south east Queensland at the same time and this became the main focus of my work while at the Council.

The question of joining the CRC was not a difficult one. Through my work at Pine Rivers, I became involved with the South East Queensland Regional Water Quality Management Strategy. It was through this project that I met Rob Vertessy, Joel Rahman, Shane Seaton and Susan Cuddy who were at the time working on the development of the fledgling EMSS. Many cups of coffee and morning teas later, some of those involved with applying EMSS in south east Queensland decided that there was a need for a more sophisticated software model which, among other things, could model what we conceptually understood as in-stream ecosystem processes as well as being able to represent changes in catchment land use to the broader concept of ecosystem health. With the assistance of ex-pat CRC brother Fred Watson, LEMSS was born. Shortly thereafter I resigned my job at Pine Rivers to return to full-time study in the form of the PhD. I was three days away from finishing up when I received a call from Rob Vertessy who suggested that there may be some room at the CRC Inn for me, commencing in 2003. I shifted posts from UQ where I commenced my PhD candidature, to Griffith University where I have been working under the supervision of John Tisdell.

Like many eager young people, I had plans on turning around unsustainable patterns of land development which had led to the degradation of our streams and rivers. One of the cornerstones of successful catchment management is undoubtedly sound science to underpin decision-making and guide investment planning. I had felt that the science supporting catchment management was advancing rapidly with the assistance of research undertaken through organisations such as the CRC; however at the policy level there remained impediments to delivering 'on-ground' actions. How could this be? If the catchment science told us where the sediment problem was coming from in the catchment and our modelling tools could adequately predict the impacts on downstream water quality, surely then the logical solution was simply to target catchment management efforts in that area to resolve that particular problem. Surely this would deliver a cost-effective solution to the problem? I came to realise that the reality was not so simple. Much of the problem stems from institutional arrangements for water quality management in Australia. Like the recent institutional problems identified with managing water extraction and environmental flows, water pollution suffered from such problems as disparate legislation between states, inadequately-defined or enforced property rights and a lack of incentives to induce landholders to reduce pollution. Of particular interest was our almost total reliance on two policy instruments: strict regulatory approaches to water pollution control ('Comply with our legislation or else!') and voluntary approaches to water quality management ('Please do the right thing!').

The focus of my research will be to examine existing and test new institutional arrangements for nonpoint source pollution control in Australia. Non-point source pollution is characterised by stochastic events, occurs over a range of scales (temporal and spatial) and because discharge is diffuse, cannot be directly or easily quantified. Recent studies undertaken in Australia suggest pollution from non-point sources as a major source of water quality impairment and an important contributor to observed declines in ecosystem health (see for example the National Land and Water Resources Audit (2001), the Productivity Commission's report on Industries in the Great Barrier Reef Catchment and Measures to Address Declining Water Quality (2003) and others such as the South East Queensland Water Quality Management Strategy (2000)).

The output of my work to date has indicated that use of economic incentives (and appropriate institutional arrangements to support them) for managing non-point source pollution in Australia are in their infancy. In our country there currently exists a strong emphasis on regulatory and voluntary approaches. The economic and public policy literature suggests that only under special conditions will strict regulatory approaches and/or voluntary initiatives be able to deliver the desired environmental outcome. Economic incentive policies also have the advantage of providing flexibility to individual landholders and industries as to how a water quality target is achieved, taking advantage of the inherent differences in the production characteristics of firms. Properly designed economic incentives are often more cost-effective than traditional regulatory approaches and not only do they provide incentives for firms to undertake pollution abatement, but in many cases can encourage technological innovation, reduce compliance costs for firms, and promote improved social welfare. The application of economic incentives such as water pollution credit trading markets to achieving water quality targets is widely practiced overseas, particularly in the United States. Despite the increased acceptance of economic incentives for managing water extraction and allocation in Australia, their application to water quality management is in its infancy with a strong emphasis here on 'command-and-control' regulation.

In the next year of my research I aim to design and test a series of new incentive-based institutions for water quality management. The proposed research will link biophysical catchment models, such as EMSS, with economic models to support decisions about water pollution control efforts in catchments. The use of a water quality model will allow for changes in land use - including the adoption of different land management practices (under an economic incentive policy) - to be modelled and their effect on downstream water quality quantified. This step is significant in that it provides both landholders and the government with information on the predicted environmental benefits of implementing a practice.

The predictions from the catchment water quality models will then be linked with experimental economic models. This will allow landholders, industries and governments to evaluate how alternative incentive policy instruments such as credit trading markets would influence the bottom-line of their enterprise when compared with more common regulatory approaches. Experimental economics is a relatively new field within economics that provides policy-makers with a unique tool for assessing the relationship between institutions, individual incentives that derive from institutional arrangements and the outcomes (observed behaviour). Institutional design basically covers all aspects of an experiment that can significantly affect a consumer's behaviour under that institution. The application of experimental economics to natural resources policy is a new phenomenon in Australia, having been piloted successfully mainly for water trading and allocation markets.

I anticipate that the outcomes of this research will be widely applicable. Providing linkages between our flagship catchment modelling program and the design and testing of economic incentive policies will allow our industry parties and government agencies to more confidently and cost-effectively implement sustainable catchment management.

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# POSTGRADUATES AND THEIR PROJECTS

## Our CRC Profile for March is:

### Shane Seaton

*I am not a Geek!*

Kind of a defensive start to a profile, but I wanted to get the stereotype out of the way early on in the piece.

Dictionary.Com defines a geek as:

1. a. A person regarded as foolish, inept, or clumsy.

   b. A person who is single-minded or accomplished in scientific or technical pursuits but is felt to be socially inept.

2. A carnival performer whose show consists of bizarre acts, such as biting the head off a live chicken.

Okay, maybe I occasionally subscribe to 1a, but who doesn't. One wouldn't be human if they didn't pull off a foolish act every now and then. It is true that I have a sound technical background regarding computers, but that is always going to happen when you sign up to do a Computer Engineering degree from the University of Canberra. As for being single minded, or socially inept… I must disagree.

Sure, I have the propensity to bite off the odd live chicken head, but I don't do it at carnivals.

Throughout my life I have always had a passion for sports and games. It didn't matter whether it involved running around like a mad man, or using my head to outwit an opponent, so long as it incorporated a certain level of competitive behaviour, I was in.

Aside from street cricket with the neighbours, as a youngster my first competitive sports were all to do with athletics, in particular the 100m sprint. Fastest in the school, I was almost worthy of representing the ACT, but not quite. I also really enjoyed the high jump, which is kind of weird given I was a short kid. It was fun to surprise people by jumping my own height.

In about the sixth grade, my burly friend thought it would be a great idea for me to join his rugby union team, and I though "what the heck, sounds like fun, maybe I could do some damage out on the wing with my speed". But on the first day at training, I got thrown right into the deep end, the forward pack at second row. These days I am a fair bit bigger than I was back then, and for those that haven't seen me, I could still best be described as a rake. Things didn't look good for rugby, but they turned okay.

I had a few fun years with rugby, but after a while getting up at 6am in Canberra to play rugby on white frosted field just didn't do it for me anymore. Besides, I felt kind of weird playing rugby and taking piano lessons at the same time, I think it was causing a bit of an identity crisis.

Shortly after that Santa brought me a set of golf clubs, not exactly the Sega system I was after, but pretty cool anyway. After some hits down at the local oval, and a couple of lessons, I was hooked on golf for life.

Over the coming years my golf game improved and by the time I hit Uni, I was representing the ACT. Upon completion of my degree, I took a year off to see just how far my golf could take me. I had aspirations of playing with the big boys on the various tours around the world, starting in Australia and working my way from there. Unfortunately in that year off, the harder I tried, the worse my golf game became. I realise now, that I never had the game anyway. A hard thing to admit, but when I saw just how good the guys out there were, even the second string guys, I realised how tough it would have been. I guess I'll just have to settle with my life as a computer programmer with the CSIRO and CRC for Catchment Hydrology.

I don't want to talk too much about my work because I was trying to keep this piece light. The only thing I feel I must say is how much I enjoy it. This is my first degree related job out of University and I can't believe how much enjoyment I derive from what we do. I think the biggest perk of the job is that I get to work in a team full of incredibly talented people, from which I learn something new everyday. I haven't been around the traps much but I do know it's the people that make a workplace worth being around.

These days I am still playing golf, but the sports that get me excited are badminton, tennis and in particular volleyball. There is nothing quite like hovering four feet in the air while you smash a volleyball with absolutely every ounce of strength you've got. I crave that kind of physical perfection.

Oh yeah, I don't dance. My girlfriend would want me to add that. I said I like all sports and games, but this one has always eluded me. It could be the absence of competition, or it may be just a lack of talent, either way I don't like it. It is a horrible thing to not like dancing, especially with a wedding coming up… Did I mention that I'm getting married? My loving girlfriend and I are finally getting married after eight years of being together. We are really looking forward to starting a family.

So finally I ask you, after all you have read, am I geek? Is working with computers and loving absolutely every moment of it geeky? Or hosting large multiplayer computer game parties at my home on work nights? And surely just because in my free time I write the occasional golf statistics program, or create my own 3D multiplayer computer games, that doesn't make me a geek, does it?

Yes, I guess it does…Oh well, maybe I'm not a mega geek.

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## OUR MISSION

To deliver to resource managers the capability to assess the hydrologic impact of land-use and water-management decisions at whole-of-catchment scale.

## OUR RESEARCH

To achieve our mission the CRC has six multi-disciplinary research programs:

- Predicting catchment behaviour
- Land-use impacts on rivers
- Sustainable water allocation
- Urban stormwater quality
- Climate variability
- River restoration

CRC AUSTRALIA

The Cooperative Research Centre for Catchment Hydrology is a cooperative venture formed under the Commonwealth CRC Program between:

Brisbane City Council
Bureau of Meteorology
CSIRO Land and Water
Department of Infrastructure, Planning and Natural Resources
Department of Sustainability and Environment, Vic
Goulburn-Murray Water
Griffith University
Melbourne Water
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Murray-Darling Basin Commission
Natural Resources, Mines and Energy, Qld
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