NEWSLETTER OF THE COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

CATCHWORD

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A NOTE FROM THE DIRECTOR

Professor Russell Mein

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WHAT ARE THE FUTURE ISSUES IN CATCHMENT HYDROLOGY?

All Cooperative Research Centres are required to have 'well-defined objectives that address a specific community and/or industry need'. This raises the question 'what are these needs, and determines them'. In the case of the CRC for Catchment Hydrology, the needs are those of the land and water management industry, and we determine those needs by asking people who represent it.

A scan of the Parties to the CRC will show that we have a fairly wide coverage of the industry already involved with us. A series of scoping exercises (ranging from strategic to technical) within these Parties – both users and researchers – were used to put together our Business Plan, and the core projects designed to 'deliver' it. Nevertheless, the CRC wants its successful research outcomes to be applied as widely as possible; that means our work has to be relevant to a much wider group of land and water managers.

With these wider aims in mind, we hosted a Future Issues Workshop in Canberra on 24 May 2001. The workshop objectives were to:

- hear from land and water industry, community group, and research leaders on major catchment scale issues (and approaches to deal with them)
- identify national issues for a review of the CRC's research directions
- identify opportunities for collaborative research and other linkages
- provide further opportunities for awareness/adoption of CRC research outcomes.

We were delighted to have representatives from every State and Territory, including catchment management groups, key commonwealth departments, and environmental and research bodies. Our CRC Visitor, Board members and Program Leaders also participated. Each visitor was asked to list, in advance, the five issues in catchment scale hydrology they thought most important and the approaches they saw necessary to best tackle them.

As you can imagine, there was a wide range of views, from issues of groundwater management in the Northern Territory, to the impact of the proposed Bass-link electricity grid connection, between Tasmania and Victoria, on Tasmanian rivers. For the most part, however, there was substantial common ground or overlap, showing that the majority of issues are generic across the country.

In the workshop, the issues were broadly grouped, and then ranked; each participant was given a 3, 2, and 1 vote to give to their priority groups.

The result? The clear leader was 'Catchment management – linking targets to land-use practices'. This issue picked up the difficulties in linking (say) desired improvements in river water quality with management actions on the ground. There are definite knowledge gaps in this important area.

'Environmental flows' was ranked number two. Here, the interpretation of environmental flows was "all flow in a stream "- which included return flows (and other factors) that impact on water quality.

A close third was 'Impacts of land-use change', which links closely to the first two. Interlinking is a dominant feature of catchment scale hydrology – everything is connected.

When we started the current CRC for Catchment Hydrology, users were telling us of the need for a holistic approach, and of the need to develop a capability for assessing or predicting the hydrologic impact of land use and water management at whole-of-catchment scale. It is clear from the above that these continue as major needs.

The workshop has given us many ideas for fine-tuning our current research, and communication and adoption strategies. More importantly, it will help us in the forward planning for the next round of projects to meet wider industry needs.

We are indebted to the participants for their time and contributions; their input keeps us mindful of the 'moving targets' faced by land and water managers.

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CRC PUBLICATIONS LIST

Copies of the Publications List are available on request from the Centre Office on 03 9905 2704 or can be downloaded from the CRC website at

www.catchment.crc.org.au

All prices listed include GST, postage and handling.

The Centre's products can be ordered through the Centre Office.

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PROGRAM 1

PREDICTING CATCHMENT BEHAVIOUR

Program Leader
ROB VERTESSY

Report by Rob Vertessy

Recent developments on the EMSS

Avid readers of the Program 1 segment in *Catchword* will realise that our team is building an Environmental Management Support System (EMSS) to help manage water quality in the waterways and catchments of the south east Queensland region. The EMSS predicts daily runoff, and daily loads of total suspended sediment, total nitrogen and total phosphorous from 175 different sub-catchments within the 22,670 km^2 region. The model predictions are sensitive to changes in climate, storage operations, land use and land management practices, including point- and diffuse-source loadings and treatments. The EMSS is deployed in a GIS-like environment on a PC and has been designed for use by a range of stakeholders with varying levels of computer and technical proficiency. Three separate component models underpin the EMSS, including:

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

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

Joel Rahman, Shane Seaton and Fred Watson manage all of the software engineering on this project. Sue Cuddy, Frances Marston, Leo Lymburner and Phil Scanlon are our data hounds and help with configuration and running of the models. Visiting students Mark Verbunt and Sebastien Jeannelle are writing and configuring the reservoir storage dynamics model. Francis Chiew and I (with help from Sue) try to inspire and help to keep the whole show on track.

The whole ball of wax is now coming together and we will soon be running long-term simulations for the whole region. We expect to deliver modelling results to the South East Queensland Regional Water Quality Management Strategy (SEQRWQMS) in early August, and the EMSS itself to stakeholders in early September. We aim to run a training workshop over several days in September so that we can get as many stakeholders as possible interacting with the EMSS.

Participation in consultancy

The EMSS team are working with Brisbane-based environmental consultants, WBM Oceanics on a consultancy let by the SEQRWQMS. The project is entitled 'Broad Scale Evaluation of Best Management Practices to Address the Impacts of Sediment and Nutrient Loads to Moreton Bay' and is managed by Tony McAlister at WBM Oceanics. We have just completed the first phase of the project which entailed pulling together all of the pollutant runoff data that was available for the catchment and developing a simple sediment and nutrient budget for Moreton Bay. This included point and diffuse catchment sources and atmospheric deposition of nutrients as well. Some simple spreadsheet budgeting conducted by the EMSS team compared well with some more detailed AQUALM modelling carried out by Tony. We are now circulating the draft results to local experts for comment. The second phase of the project is just beginning and will (amongst other things) entail application of the EMSS to the catchment to get a more dynamic picture of pollutant input to Moreton Bay and how this varies over time. Tony will spend some time with the EMSS team in Canberra in late July this year, and in so doing help us to get the best possible results out of the EMSS.

New project starting

As the EMSS project nears completion we are starting another project in the SEQ region. South East Queensland Water and the North Pine Shire Council, in partnership with the SEQRWQMS are co-funding a new project entitled 'A Local-Scale Environmental Management Support System for Use in Water Supply Subcatchments in Pine Rivers Shire'. This entails building a spatially-explicit, distributed-parameter runoff/water quality model that can operate on catchments of the order of 1000 km^2 in size. It will be calibrated and tested on the catchments supplying water to Lake Samsonvale and Lake Kurwongbah, but designed so that it could be applied to any catchment of similar size in the SEQ region. The local scale model will be designed so that it is embedded in the regional scale EMSS. This project will involve collaboration with Tony McAlister at WBM (who has just conducted as 'State of Catchment Report' for the area) and aquatic ecologists at Griffith University.

Tarsier workshop

Congratulations are due to Joel Rahman and Shane Seaton for running a successful two-day training workshop for aspiring Tarsier modellers in Canberra last month. Tarsier is one of the six modelling

frameworks being evaluated by the Toolkit project, and the one used in the EMSS developments described above. Joel and Shane took eleven workshop participants from the CRC for Catchment Hydrology through the details of the Tarsier system, providing guidance on how to write new models with it. About three of the workshop participants are now starting to develop new models using Tarsier; their feedback will provide the Toolkit team with invaluable insight.

European friends about to leave

Two visiting students that have been working on the EMSS project are about to leave us. Since early February 2001, the Canberra site has been hosting Mark Verbunt (from ETH, Switzerland) and Sebastien Jeannelle (from University of Toulousse, France). Both are engineering graduates who came to us for work experience. They both worked on the EMSS project, primarily on the development and parameterisation of a reservoir storages model component. It's been a pleasure and a great help having Mark and Sebastien around. I'd like to thank both students for their valuable input to our R&D effort and wish them well in their future careers. Mark is heading back to Zurich to take on a PhD at ETH, whilst Sebastien is looking for further overseas work experience (give me a ring if you have a job for him!).

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PROGRAM 2

LAND-USE IMPACTS ON RIVERS

Program Leader
PETER HAIRSINE

Report by Peter Hairsine

Overview of Program 2 – Land-Use Impacts on Rivers

Background

We are approaching the half way mark of our first round of projects for the CRC. Here I give a brief overview of the Program and the progress we are making.

The main themes of the Program are:

- changes to water yield (or stream flows) as a result of land-use change
- movement of sediment in stream networks as affecting in-stream physical habitat
- movement of sediment and nutrients in catchments as affecting water quality
- movement of salt in catchments as affecting water quality.

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.

The program has four core projects which are briefly described below. These projects are funded from the CRC for Catchment Hydrology cash and in-kind resources and are accountable to the CRC Board. All of these projects have participating staff from two or more of the CRC for Catchment Hydrology Parties. This is the case for all CRC for Catchment Hydrology core projects. The Program also has eleven associate or 'Associated/Additional' projects that are funded by external organisations. These projects complement and extend the work of the core projects. I have made some brief comments about these relationships below.

Project 2.1

Core project 2.1 is titled " Sediment movement, water quality and physical habitat in large river systems" and is led by Dr Jon Olley of CSIRO Land and Water in Canberra. Project participants are CSIRO, NSW DLWC and The University of Melbourne. The project has a close relationship with the stream restoration program and is using the focus catchments of the Murrumbidgee and the Goulburn Broken as its test bed. This projects is addressing the following questions:

- Where in catchments do sediment and nutrients have an impact on physical habitat?
- From where in the catchment is that sediment and nutrient derived?

THE THIRD AUSTRALIAN STREAM MANAGEMENT CONFERENCE - THE VALUE OF HEALTHY STREAMS

27-29 August 2001

Hilton Hotel
Elizabeth Street
Brisbane

The Third Australian Stream Management Conference will be held during 27 - 29 August 2001 in conjunction with the 2001 River Symposium (29-31 August) and associated with the Third Australian Fishways Technical Workshop (30-31 August).

In support of the 'Value of Healthy Streams' theme, the Conference is centred on four key areas:

· Ecosystem services
· Hydrological connectivity
· Bio-physical integration
· Tools and techniques

DETAILS OF CONFERENCE ACCOMMODATION AND COSTS NOW ON-LINE at www.catchment.crc.org.au/streamconference

Book your accommodation NOW to ensure a room - please quote the conference name when booking.

SALINITY DISPOSAL BASIN REPORTS NOW AVAILABLE ON-LINE

The CRC Project S2, 'On-Farm and Community Scale Salt Disposal Basins on the Riverine Plain, was a collaborative project between the CRC for Catchment Hydrology, CSIRO Land and Water and the Murray-Darling Basin Commission.

The outputs of the project include fifteen technical reports covering key issues in the siting, design and management of salt disposal basins.

Reports in this series can be downloaded (free) as pdf files from the CRC website at the address - www.catchment.crc.org.au/disposalbasins

The reports are also available in printed form for $27.50 (inc. GST) from the CRC Centre Office

- 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 is taking advantage of much of the good work done in the National Land and Water Resources Audit concerning the movement of sediment and nutrients in large catchments. The project is evaluating the predictions made by the audit and relating them to physical habitat. The local impact of synoptic movement of very large amounts of coarse sediment is being investigated in an associate project funded by AFFA and led by Dr Bill Young at CSIRO Canberra. Project 2.1's work is also being complimented by an associate project concerning evaluating sediment and nutrient budgets in the Murray-Darling Basin, funded by MDBC.

Project 2.2

Core project 2.2 is titled "Managing pollutant washoff from dryland upland catchments" and is led by Peter Hairsine of CSIRO Land and Water in Canberra. Project participants are the Queensland Department of Natural Resources and Mines, the NSW Department of Land and Water Conservation, Griffith University and CSIRO. The project is using the focus catchments of the Fitzroy and the Murrumbidgee Rivers as its test bed, as well as drawing upon the historical data from plot and small catchments in NSW. The project has two PhD students: one working on salt movement in the Murrumbidgee catchment and one working on remote sensing methodologies for assessing land-use and in-stream sediment relationships in the Fitzroy.

The questions that project 2.2 is addressing are:

- 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?

Project 2.3

Core project 2.3 is titled " Predicting the effects of land-use change on catchment water yield and stream salinity" and is led by Dr Lu Zhang of CSIRO Land and Water in Canberra. Project participants are the Victorian Department of Natural Resources and Environment, CSIRO, and the NSW Department of Land and Water Conservation. This project is focussed on providing science-based forecasts of the changes in water available in a river as a result of land-use changes. The land-use changes considered include the development of large-scale plantations on pastureland and the changes of pasture production from annual to perennial species. The project work is complemented by two associate projects that consider the impact of elevated water tables on flooding, and the impact of changes to catchment-scale water balance on in-stream salinity. The associated projects are funded by the Land and Water Australia's National Dryland Salinity Program and the MDBC respectively.

Project 2.5

Core project 2.5 is titled "Nitrogen and carbon and dynamics in riparian zones" and is led by Dr Heather Hunter of the Queensland Department of Natural Resources and Mines in Brisbane. The participating Parties are QNRM and Griffith University. This project is co-funded by the Coastal Zone CRC. This project is

PROGRAM 2 contacts:

CORE PROJECT	PROJECT LEADER	CONTACT DETAILS
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Project 2.3: Predicting the effects of land-use change on catchment water yield and stream salinity	*Dr Lu Zhang*	Tel: 02 6246 5802 Email: lu.zhang@cbr.clw.csiro.au
Project 2.5: Nitrogen and carbon dynamics in riparian zones	*Dr Heather Hunter*	Tel: 07 3877 9637 Email: heather.hunter@dnr.qld.gov.au

focussed upon getting some base line knowledge on how riparian zones moderate the inputs of carbon and nitrogen into Australian streams. This has been a major natural resource research focus in North America and Europe in the last decade. The focus catchment for this work is the Brisbane River catchment.

Project 2.5 is addressing the following questions:

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

A description of the objectives, methodology and expected outcomes of each of the core projects can be obtained on the CRC for Catchment Hydrology website at http://www.catchment.crc.org.au/programs/projects/index.html

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 I encourage you to contact myself, or the project leaders, if we can provide further details.

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PROGRAM 3

SUSTAINABLE WATER ALLOCATION

Program Leader
JOHN TISDELL

Report by Erwin Weinmann

Project 3.1: Integration of Water Balance, Climatic and Economic Models

Background

The objective of this project is to develop more comprehensive system simulation capabilities as a basis for sustainable water allocation. Considerable background knowledge exists already in the water industry, and in a number of research organisations, on the various modelling aspects that need to be integrated by this project. With these factors in mind, the first project task was a clearer identification of gaps in the current knowledge and modelling practice.

With the assistance of seconded experts from the Victorian Department of Natural Resources and Environment, Goulburn-Murray Water and the Department of Land and Water Conservation NSW, and through a workshop involving wider industry participation, the following high priority sub-projects were identified last year:

A. Modelling the effect of climatic factors on crop planting and watering behaviour

B. Modelling the effect of socio-economic factors on crop planting and watering behaviour

C. Modelling the effect of climatic and socio-economic factors on water trading behaviour

D. Developing a methodology for calculating water allocation exchange rates

E. Investigation of modelling efficiency, model sensitivity and modelling errors

F. Development of a module to calculate economic indicators from model outputs

Building up a project team

Since then we have gradually built up a research team to tackle the research tasks in each of the sub-projects. Avi Ramchurn started as an MEngSc student at Monash nearly a year ago, supervised by Erwin Weinmann and Gary Codner. As part of sub-project A, he is looking at the role played by more detailed and differentiated modelling of on-farm storage in getting more reliable model estimates of water demand and water availability.

NEW WATER ALLOCATION RESEARCH REPORTS

Two new reports from the Sustainable Water Allocation Program are now available.

IRRIGATOR AND COMMUNITY ATTITUDES TO WATER ALLOCATION AND TRADING IN THE GOULBURN BROKEN CATCHMENT

by
John Tisdell
John Ward
Tony Grudzinski
Geoff Earl

Report 01/3

IRRIGATOR AND COMMUNITY ATTITUDES TO WATER ALLOCATION AND TRADING IN THE FITZROY CATCHMENT

by
John Tisdell
John Ward
Tony Grudzinski

Report 01/2

These reports describe the results and findings of a survey of irrigator's and community members attitudes to COAG reforms in the Goulburn Broken and Fitzroy catchments respectively.

The cost of $27.50 includes postage and handling and GST in Australia.

For further information contact Virginia Verrelli on 03 9905 2704 or email virginia.verrelli@eng.monash.edu.au

WATER ALLOCATION AND TRADING VIDEO

IRRIGATORS' ATTITUDES TO WATER ALLOCATION AND TRADING IN THE GOULBURN-MURRAY CATCHMENT

Dr John Tisdell
Program Leader - Water Allocation
CRC for Catchment Hydrology
Griffith University

November 2000
CRC Video 00/6

This presentation describes the results and findings of a survey of irrigators' attitudes to COAG reforms: temporary and permanent water trading; the role of the water authority in the market; and the environmental impact of trade. The survey also elicited irrigators' attitudes to breaking the nexus between land and water, points of blockage in current water markets and possible adjustments to trading rules and procedures.

COPIES ARE AVAILABLE FOR $27.50 (INC GST, POSTAGE AND HANDLING) THROUGH THE CENTRE OFFICE.

Contact Virginia Verrelli on 03 9905 2704 or by email virginia.verrelli@eng.monash.edu.au

The questions on water trading covered in sub-project C are addressed by a CRC Associated Project undertaken by Wijedasa Hewa at the University of Melbourne, supervised by Hector Malano. Also at Melbourne and supervised by Hector, PhD student Teri Etchells has just started her research on water allocation exchange rates addressed in sub-project D.

And finally, in May, Sergei Schreider from the ANU's Centre for Integrated Catchment Assessment and Management (ICAM) started work at Monash as the project's Research Fellow.

Current and ongoing work

The parallel work undertaken in Project 3.2 to assess the socio-economic factors driving irrigator decisions will provide important inputs to sub-project B for modelling crop planting and watering behaviour. Sergei Schreider's initial task will be to define more clearly the expected nature and format of the required socio-economic inputs to support model enhancements. He will then also develop a more detailed project plan for sub-project A. In the longer term, Sergei's main involvement will be with sub-project E, looking at modelling efficiency and model sensitivity.

In all of the current work, progress depends strongly on the cooperation with our industry Parties. Their involvement in providing the following inputs is highly valued:

- understanding of important current issues in system modelling for water allocation purposes
- knowledge of model capabilities and gaps in existing modelling practices
- provision of data and calibrated models for focus catchments
- continuing involvement in the process of developing and testing model enhancements

The role of the project team in the development of model enhancements is primarily in building up the knowledge base for writing the relevant program routines. All the software development tasks will be undertaken in close cooperation with the 'Toolkit' team (Project 1.1) and the modelling experts from the industry Parties.

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PROGRAM 4
URBAN STORMWATER QUALITY

Program Leader
TONY WONG

Report by Graham Jenkins

The Effect of Vegetation on Hydraulic Efficiency in Artificial Wetlands

Introduction

Surface water wetlands play an important role in the management of urban stormwater quality. The treatment of stormwater as it flows through a wetland is the result of a complex interaction between the physical, chemical and biological processes that occur within the system. The vegetation that is a dominant feature of the shallow ephemeral and perennial water bodies that form these wetland systems, has an important function in these treatment processes.

This article describes a numerical model study that has been undertaken to investigate the effects of emergent vegetation on the hydraulic characteristics of artificial wetlands. The model study demonstrates that the poor arrangement of wetland vegetation can result in a significant reduction in the hydraulic efficiency of the wetland system.

Vegetation types

Typically artificial wetlands include a variety of vegetation types including those that are emergent, floating leaved attached, free floating and submerged. Some of the most important functions of the vegetation within the wetland are the result of physical processes such as the filtration of particles, reduction in turbulence, stabilisation of sediments, and provision of increased surface area for biofilm growth on stems, leaves, roots and rhizomes. Furthermore, these processes are controlled by the hydraulic interaction between the vegetation and the water as it flows through the system.

The spatial variation in the type and density of wetland vegetation means that the hydraulic characteristics also vary spatially throughout the system. This spatial variation produces two-dimensional flow characteristics with more water flowing through the less vegetated regions. The result is that the water flowing through an artificial wetland system will not stay together as a discrete plug, but will tend to form short-circuiting paths. Each packet of water will spend a different amount of time in the wetland, depending on the path taken as it flows through the

system. Therefore, there is no single hydraulic retention time, and in fact the hydraulic characteristics produce a hydraulic retention time distribution.

Hydraulic retention time

The concept of hydraulic retention time is an important one in the design of artificial wetland systems, as it describes the amount of time that a packet of stormwater spends within the wetland system. The treatment processes within a wetland system are unsteady, so that a longer hydraulic retention time means more advanced treatment processes. Therefore, good engineering design demands a detailed understanding of the hydraulic characteristics within an artificial wetland system. As the vegetation plays such an important role in these hydraulic characteristics, it is important to understand the relationship between the vegetation and the hydraulic characteristics.

Hydraulics of wetland vegetation

The physical, chemical and biological treatment processes that occur within an artificial wetland system rely on the flow of the water through the system to facilitate these treatment processes. Therefore, the hydraulic characteristics within the system have a significant influence on the efficiency of the wetland as a treatment device. As noted by Persson et. al., (1999), many wetland management problems can be attributed to poor hydrodynamic characteristics within the wetland system. The hydrodynamic characteristics within a wetland system are affected by features such as:

- The shape of the wetland;
- The hydraulic characteristics of the inlet and outlet structures;
- The wetland bathymetry;
- The vegetation type, density and spatial distribution; and
- Mixing.

Modelling effects of vegetation density and distribution

A numerical model study was undertaken to investigate the effects of vegetation on the distribution of flow through an hypothetical wetland. The dimensions of the rectangular model wetland were, 18 m wide, 84 m long, and 700 mm deep, with a steady flow rate of 500 L/s. This produced a nominal hydraulic retention time of (Tn) of 0.588 hours. The dimensions of the hypothetical model wetland were chosen so that the length to width ratio of 4.67:1 exceeded the minimum of 4:1 noted by Persson et. al., (1999) as essential for good hydraulic efficiency.

Mixing aspects of vegetation

One of the important functions of vegetation within the wetland is to facilitate mixing, and as noted by Kadlec (1994) dispersion tends to be stronger in wetlands than in rivers. Therefore, the MS Windows based two-dimensional flow model TDFLOW was used to study the impact of vegetation cover on the hypothetical model wetland. The model TDFLOW, developed by the first author was used to solve the two-dimensional depth averaged shallow water flow equations using an iterative Alternating Direction Implicit (ADI) scheme. The model uses a rectangular coordinate system, and is based on the model described by Jenkins (1990). The model also solves for the two-dimensional transport of a conservative contaminant using an ADI scheme based on that described by Leendertse and Gritton (1971).

The two-dimensional model was used to predict the effects of various amounts of vegetation cover on the flow characteristics of the hypothetical model wetland. Model runs were undertaken for five different vegetation cases varying from no vegetation to fully vegetated. In all cases the vegetation was arranged as fringing vegetation, symmetrically about the longitudinal centreline of the wetland. One case with banded vegetation was also modelled, in which two 10 m thick vegetation bands that crossed the entire wetland were arranged at a longitudinal chainage of 30 m and 60 m.

Conclusions

A numerical model study has been undertaken to investigate the effects of wetland vegetation on the flow characteristics within artificial wetland systems.

The study has demonstrated that the arrangement of vegetation within a wetland system has a significant impact on short-circuiting through the system. Fringing vegetation tends to decrease the hydraulic efficiency of a wetland by allowing a significant amount of the stormwater to flow through the system with a reduced retention time. Although some of the flow passes through the vegetated sections of the wetland this has only a minor effect on the overall efficiency of the system.

The numerical model study has also demonstrated that more research is required in describing the hydraulic characteristics of flexible emergent vegetation. Further research is also required in determining suitable algorithms for predicting the effects of longitudinal and transverse mixing processes within wetlands.

WATER SENSITIVE URBAN DESIGN

WATER SENSITIVE ROAD DESIGN - DESIGN OPTIONS FOR IMPROVING STORMWATER QUALITY OF ROAD RUNOFF

by

Tony Wong
Peter Breen
Sara Lloyd

Report 00/1

This joint publication with the CRC for Freshwater Ecology investigates opportunities for incorporating stormwater quality improvement measures into road design practices for protecting aquatic ecosystems.

Copies of the report are available from the Centre Office for $27.50 (includes postage and GST).

Please phone Virginia Verrelli on 03 9905 2704 or email virginia.verrelli@eng.monash.edu.au

MELBOURNE TECHNICAL SEMINAR

REVISED EVAPOTRANSPIRATION MAPS FOR AUSTRALIA

by

Dr Francis Chiew
The University of Melbourne

Thursday 5 July 2001
5.00 for 5.30pm start

Tea/Coffee on arrival

Institution of Engineers Australia
The Auditorium
21 Bedford Street
North Melbourne
Victoria

The Bureau of Meteorology and the CRC for Catchment Hydrology have collaborated to prepare and publish revised evapotranspiration maps for Australia. Francis Chiew will describe the methodology behind the new maps and their relevance.

For further information contact David Perry on 03 9905 9600

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PROGRAM 5
CLIMATE VARIABILITY

Program Leader
TOM McMAHON

Report by Bryson Bates, Neil Viney and Stephen Charles

Stochastic downscaling of climate variables

Introduction

The downscaling component of Project 5.1 "Modelling and forecasting hydroclimate variables in space and time", aims to apply a non-homogeneous hidden Markov model (NHMM) to about thirty sites in the Murrumbidgee Basin. The model will be fitted to and tested against historical data, and applied to a 1000-year simulation of the CSIRO general circulation model (CSIRO9). This will provide an ensemble of climate scenarios that can be used to drive the IQQM model for the basin developed by NSW Department of Land and Water Conservation. This will facilitate an assessment of the reliability and resilience of the basin's water supply system under multidecadal climate variability.

Why downscale?

The need for improved and realistic assessments of the regional impacts of natural climate variability and possible climate change has generated increased interest in regional climate simulation. In this context, the desire for assessments based on physical rather than purely statistical models, has led to interest in the use of general circulation models (GCMs). Although GCMs perform reasonably well in simulating climate with respect to annual or seasonal averages at sub-continental scales, they tend to over-estimate the frequency and under-estimate the intensity of daily precipitation statistics at local scales. It is also widely acknowledged that they do not provide credible simulations of precipitation at the space and time scales relevant to local and regional impact analyses. This will be especially true for a region as large as the climatically and topographically diverse Murrumbidgee Basin, where hydrological responses will vary across the catchment as a result of temporal and spatial variability in the atmospheric forcing.

To help bridge the scale gap between the GCM predictions and the hydrologic drivers of the water supply system, statistical downscaling techniques have been developed to to derive sub-grid scale weather from the coarse spatial resolution of the atmospheric data available from GCMs. Early techniques classified large-scale atmospheric circulation patterns and then modelled the

daily precipitation process through multivariate probability distributions conditional on the derived patterns. These schemes produce weather patterns that are defined independently of precipitation and have had only limited success in reproducing wet and dry spell length statistics. Other recent approaches include regressions on continuous atmospheric circulation indices, geographic location and topographic variables, and neural networks. However, the success of these methods in simulating the historical record is not always high. The downscaling method to be employed in this study uses a technique based on the NHMM to simulate the spatial distribution of precipitation occurrence and amount.

The non-homogeneous hidden Markov model (NHMM)

The NHMM relates synoptic-scale, atmospheric circulation variables through a finite number of unobserved weather states to multi-site, daily precipitation occurrence data. It finds the most distinct patterns in the daily multi-site precipitation occurrence record rather than patterns in atmospheric circulation. These patterns are then defined as conditionally dependent on a set of atmospheric predictor variables. Unlike downscaling techniques that are based on classification schemes, the weather states are not defined a priori. A first-order Markov process defines the daily transitions from one weather state to another. The process is described as nonhomogeneous since the transition probabilities are conditional on a set of atmospheric circulation predictors. These atmospheric predictors may include raw variables such as mean sea level pressure (MSLP) or derived variables such as the north-south MSLP gradient. In this way, the NHMM captures much of the spatial and temporal variability of the precipitation occurrence process.

Within the NHMM, the joint distribution of daily precipitation amounts at multiple sites is evaluated through the specification of conditional distributions for each site. The conditional distributions consist of regressions of transformed amounts at a given site on precipitation occurrence at neighbouring sites within a set radius. The optimal neighbourhood radius is determined by steadily increasing its size until further increases result in marginal improvements in the proportion of total precipitation variability explained by the precipitation occurrence at neighbouring sites.

Downscaling in the Murrumbidgee Basin

To date, downscaling experiments have focussed on the application of the NHMM to winter precipitation in the southwest of Western Australia, a region dominated by frontal rainfall. Results have been extremely encouraging. The different seasonal and synoptic patterns of the Murrumbidgee, with its mix of rainfall generating mechanisms, will provide a challenging test for the NHMM. Work is also underway on extending the NHMM to facilitate true downscaling (rather than regression modelling) of rainfall amount as well as occurrence, and of other weather variables such as temperature and humidity. Candidate atmospheric predictors have been selected and include mean sea level pressure, geopotential height, air temperature, dew point temperature and meridional and zonal wind components. These will be obtained from NCEP/NCAR Reanalysis data. Codes for extracting and processing these data have been developed and tested.

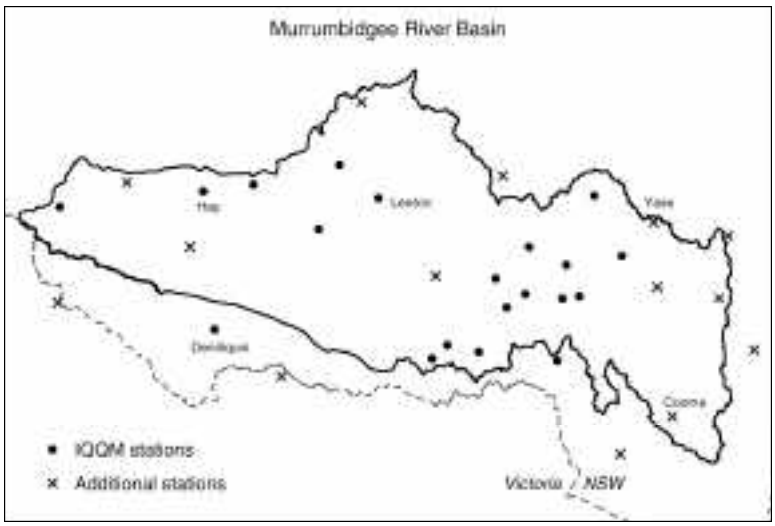

Figure 5.1 shows the location of stations used by IQQM, together with candidate complementary stations

NEW EVAPOTRANSPIRATION AND RAINFALL MAPS FOR AUSTRALIA

Where to get them!

We have had a number of queries regarding the already published Rainfall maps for Australia and the soon to be published Evapotranspiration Maps for Australia.

***** Please note**
that the Evapotranspiration Maps for Australia will be available from around mid July 2001 for around $35.00***

They can be purchased from:

1. Publications Section, 9th floor, 150 Lonsdale St Melbourne. tel: 03 9669 4000 (main switch) and ask for Publications

OR

2. Bureau Regional Offices (all capital cities) Contact details for each Regional Office are available at http://www.bom.gov.au/inside/contacts.shtml

Information about the climate atlas map sets and the digital map data sets can also be obtained from: National Climate Centre Ph: 03 669 4072 Email: webclim@bom.gov.au

Technical queries about the evapotranspiration modelling can be referred to Dr Francis Chiew at The University of Melbourne email f.chiew@civag.unimelb.edu.au

Any technical queries about the mapping should be referred to Graham de Hoedt tel 03 9669 4714 email: g.dehoedt@bom.gov.au

THIRD AUSTRALIAN STREAM MANAGEMENT CONFERENCE

All the updated details about the conference and how to register are available on-line at the Stream Management Conference home page

www.catchment.crc.org.au/streamconference

Site/station aspects

Computational considerations limit the application of the NHMM to about thirty sites. In the Murrumbidgee Basin it is desirable that wherever possible, these sites should coincide with the twenty stations being used in the IQQM model in its calibration and prediction modes. However, since IQQM models only the middle and lower sections of the basin, additional stations are required in the upper catchment. *Figure 5.1* shows the location of stations used by IQQM, together with candidate complementary stations from the Bureau of Meteorology's rainfall network.

Analysis of the IQQM rainfall data has indicated that some stations are unsuitable for inclusion in the downscaling cohort. The NHMM requires rainfall records with as little missing data or accumulated, multi-day rainfall totals as possible over a reasonably long period. In particular, stations with interpolated rainfall data are unsuitable since the interpolation process compromises the precipitation relationships among neighbouring stations. Several of the gauges used in IQQM are unable to satisfy these criteria, so alternatives have been sought from the Bureau's data set.

Work program

Work on this study commenced in January 2001. When data collation and model development and testing are completed, the model will be applied to a 1000-year CSIRO9 GCM simulation.

The resulting data set will facilitate the analysis of the effects and associated risks of long-term climate variability on water supply system management in the Murrumbidgee Basin.

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PROGRAM 6
RIVER RESTORATION
Program Leader
IAN RUTHERFURD

Report by Tony Ladson

An Australian Handbook of Stream Roughness Coefficients

Handbook Participants

The River Restoration Program of the CRC, the National Rivers Consortium, and Land and Water Australia, are now working together to produce an Australian Handbook of Stream Roughness Coefficients. This handbook is intended to become part of the toolkit of waterway managers, catchment groups and consultants when planning and designing river restoration works.

Estimating flows in ungauged catchments

Estimating discharge in ungauged catchments is a common requirement when working on stream management problems. For example, flow estimates are required for design of meander restoration, grade control structures, sediment transport rates, habitat improvement works, and stable channel size and shape. The standard method for estimating flows is to use Manning's equation (or something similar), which requires an estimate, of resistance to flow –a roughness coefficient or Manning's n.

Natural channels

Specifying an accurate roughness coefficient for a natural channel is not straightforward because of the influence of substrate characteristics, bed and bank vegetation, woody debris, and channel plan form. Resistance can also change with discharge and roughness coefficients are commonly a function of flow depth.

US, New Zealand and local work

In other countries, particularly New Zealand and the US, roughness coefficients for broad classes of streams, different types of vegetation, and specific flow conditions, have been collected and provide a firm basis for flow estimation. Hicks and Mason (1991) includes estimates of Manning's n for 78 New Zealand streams and canals and Barnes (1967) lists tabulated values of Manning's n for over 50 streams in the US. Both these books include colour photos that can be used to guide roughness estimation in There are also other monographs and journal articles that include roughness estimates in local areas (e.g. Phillips and Ingersoll, 1998) and we are now doing a literature search to locate these. Our search will also include reviewing Australian flood studies and other reports where roughness coefficients have been estimated and calibrated as part of hydraulic models. Already some unusual results

have surfaced, for example, in reaches of the Edward River, NSW, with high woody debris loadings, Mannings n values greater than 0.1 have been used in modelling studies.

Data to be collected

We are also working to enrol appropriate consultants and State and Territory government departments to help out with the project. Our plan is to prepare a list of the key measurements to be collected under field conditions and to document a protocol to ensure quality and consistency of the results. We anticipate that with minor amounts of additional data, it may be possible to build on existing stream rating work to document roughness coefficients in many Australian streams.

Publication and timing

It is important to ensure that the handbook meets the needs of its intended audience. We are assembling a small reference group to guide the project and specify the preferred content and format of the final publication. Land and Water Australia, on behalf of the National Rivers Consortium, will publish the handbook in both electronic and hardcopy formats as appropriate, and ensure that it is distributed throughout Australia.

The anticipated completion date for the first version of the handbook is mid 2003 when comments will be sought on the usefulness of the guide and ways to improve it for future editions.

If you would like more information about the project, or have any suggestions, please contact Tony Ladson.

References

Barnes, H. H. (1967). Roughness characteristics of natural channels. U.S. Geological Survey Water Supply Paper 1849. Washington D. C., USGS.

Hicks, D. M. and P. D. Mason (1991). Roughness characteristics of New Zealand Rivers. Wellington, Water Resources Survey DSIR Marine and Freshwater.

Phillips, J. and T. Ingersoll (1998). Verification of roughness coefficients for selected natural and constructed stream channels in Arizona. US Geological Survey Professional Paper No. 15844. Washington D. C., USGS.

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COMMUNICATION AND ADOPTION PROGRAM

Program Leader
DAVID PERRY

The Flow on Effect – June 2001

Upcoming Brisbane Seminar

Later this month on Friday 29 June 2001, Dr Ian Rutherfurd, Program Leader River Restoration, will present a seminar in Brisbane entitled 'Evaluating stream rehabilitation projects in rural and urban streams'. The seminar will be held in Auditorium Room 1 at the Department of Primary Industries Building, 80 Ann St, Brisbane. Brisbane City Council will be providing afternoon tea for participants from 2.45pm with the presentation commencing at 3.00pm.

The venue is diagonally opposite City Hall and as you enter the building the Auditorium rooms are located on the right hand side. For more details please see our website at www.catchment.crc.org.au/events or contact Mary-Lou Clarke on 07 3875 5394.

New Evapotranspiration Maps for Australia

Evapotranspiration is a key component of the water and energy balance of the earth's atmosphere. Estimates of evapotranspiration are required for many applications, ranging from determining irrigation crop requirements to rainfall-runoff modelling. The CRC for Catchment Hydrology and the Bureau of Meteorology are releasing a set of Evapotranspiration Maps for Australia in early July 2001, as part of the Bureau's Climatic Atlas series. The maps will be available for less than $40.00.

The new maps give mean monthly values of three evapotranspiration variables: point potential evapotranspiration, areal potential evapotranspiration, and areal actual evapotranspiration. The evapotranspiration estimates are based on Morton's complementary relationship model and are derived using climate data from over 700 locations throughout Australia. *Catchword* readers may be also interested in the corresponding set of Rainfall Maps for Australia already published by the Bureau. (They can be purchased now through the Publications Unit or Regional offices for around $20.00 - see below for details).

If you would like to obtain a copy of the Rainfall Maps now or the Evapotranspiration Maps after 2 July 2001, please contact the Publications Section of the Bureau of Meteorology in Melbourne by phoning 03 9669 4000 (main switch). Alternatively the map sets will be available through the Bureau of Meteorology's Regional Offices.

MELBOURNE TECHNICAL SEMINAR

Environmental Data Management in Europe - Good News and Bad News

by

Dr. Ralf Denzer

International Federation for Information Processing Working Group 5.11: 'Computers and Environment'

Friday 31 Aug 2001

11:45am for a 12:00 noon start

Tea/Coffee on arrival

Lecture Theatre C1
Engineering Block C
Department of Civil and Environmental Engineering
The University Of Melbourne, Parkville, Victoria

(Please note: parking is not available on university grounds)

For further information visit www.catchment.crc.org.au/events or contact David Perry on 03 9905 9600

Contact details for your nearest Regional Office are available at the web address www.bom.gov.au/inside/contacts.shtml

If you would like further technical information about the Climatic Atlas map sets or copies of the digital map data sets, please contact the National Climate Centre on 03 9669 4072 or via email webclim@bom.gov.au

Maps Seminar and Launch – Melbourne 5 July 2001

To celebrate the release of the Evapotranspiration maps, Dr Francis Chiew (The University of Melbourne) who was part of the project team, will present a seminar in Melbourne. Francis Chiew will provide an overview of the evapotranspiration maps, give a technical interpretation of how the estimates were derived, and outline the application of the various evapotranspiration variables.

As part of the 'launch' of the maps, the seminar will be introduced by Dr John Zillman AO, Director of the Bureau of Meteorology, and Prof Russell Mein, Director of the CRC for Catchment Hydrology.

The presentation will be held at the Main Auditorium, Victoria Division, Institution of Engineers, Australia, 21 Bedford Street North Melbourne on Thursday 5 July 2001. Afternoon tea will be available from 5:00pm and the presentations will commence at 5:30pm. For further information please contact David Perry on 03 9905 9600. Our thanks to the Water Engineering Branch of the Institution of Engineers, Australia for providing the venue.

A Reminder

In case you have forgotten, please book your accommodation in Brisbane for the Third Australian Stream Management Conference (Monday 27 – Wednesday 29 August 2001) as soon as possible. At the time of writing, (mid June), some people are already having difficulty finding accommodation of their choice due to the Goodwill Games, the Riverfestival and other events being held in Brisbane that week.

You can register online and obtain further information from the Conference's official website at www.catchment.crc.org.au/streamconference

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POSTGRADUATES AND THEIR PROJECTS

Our postgraduate for June is:

Clayton White

Reading over some of the 'stories' told in recent past issues of *Catchword,* to get a feel for this regular postgraduate's column before writing my own contribution, I was struck by the range and diversity of students' backgrounds. In the previous four issues we have moved from the post-industrial Rhine landscapes of Tanja's Germany, to the silt-rich waters that scour the heights of the Annapurnas and Himalayas in DD's Nepal, to the sluggish, grey Thames, Big Ben and Millennium Dome of Dominic's London, and to the clear, but often water-less skies, of Avi's Mauritius, where I imagine the sky and sea blur indeterminably at the horizon. And now, in my case, from across the "dutch" to those defenceless, watery islands to the east, as another career refugee fleeing Helengrad, New Zealand/Aotearoa.

Water is certainly a unifying element – it has bought us together to forge common goals in research. But it is also essential to our survival, and an issue of increasing importance and some urgency when you consider the following:

- Global consumption of water is doubling every 20 years, more than twice the rate of human population growth.
- According to the United Nations, more than one billion people already lack access to fresh drinking water.
- If current trends persist, by 2025 the demand for fresh water is expected to rise by 56 percent more than the amount of water that is currently available.

Coming to terms with these and many other issues related to water use, its conservation and the quality of our waterways (issues that CRC researchers are currently investigating), is going to require the diversity, range of knowledge and experiences that is mirrored in the student body of the CRC. Thankfully, the CRC is founded on a recognition of this requirement, hence its interdisciplinary focus. Solutions will require attention not only to the scientific and technical questions and answers, but also social needs of the communities that inhabit catchment areas and to the political frameworks and processes in which the management of our water and waterways occurs.

My background is in environmental education, both in training, having completed the Master of Environmental Education program at Griffith University prior to taking up a CRC scholarship, and in practice, in a national environmental non-government organisation. Professionally, and as a community activist, I have experienced frustration with the representative model of democracy popular with many governments today. Particularly with the practice of public placation commonly called "consultation" that is common. As a community organiser involved in grassroots community development I have experienced frustration with the lack of trust, the alienation of political authority, and the general erosion of the social fabric of our societies, that is wrought by economic rationalism. These issues inspire my interest in developing strong and vibrant local area democracies where people, together, are involved with making the decisions that directly affect the communities they live in, and work to improve the quality of such.

My research area is the role of communication in the management of catchment areas in Australia. Through communication, citizens acquire information about issues and problems in the community and learn of opportunities and ways to participate. Communication is also an essential and important component of citizen participation programs, but the top-down approach that is often used does not allow individuals or groups to adequately input into environmental management decisions that directly affect them. Through my research I seek to develop an understanding of communication in the participatory processes of catchment management. This approach is aimed at improving decision-making processes and environmental management outcomes, while at the same time increasing participants' satisfaction with such processes and outcomes.

Case studies of communication and citizen participation in catchment management will be used to critically ground my research in the experience of practitioners and participants. Through the synthesis of case study data with a theoretical conceptual framework for multi-way communication developed from the literature, a revised model of communication in catchment management will be proposed and made operational.

Citizen participation, and in particular the role of communication in those participatory processes, can help to increase the acceptance and uptake of scientifically-based management principles and objectives, as well as environmentally-sensitive technologies and landscape design. The development of an operational theory of communicative action for citizen participation in catchment management may enhance the dissemination of ecological information and environmental technologies developed by the CRC through creating a better understanding of scientist/environmental manager/citizen relationships.

To finish, I'd like to share this quote that appears on my computer desktop. It reminds me that improved communication and citizen participation may be a key factor in achieving important water quality objectives and environmental management outcomes.

"If we have such good grounds for our beliefs, why have we been unable to convince others?"

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CRC PROJECT SHEETS

Printed versions of the CRC project sheets (two page documents describing the key elements of research projects in CRC Programs except River Restoration and Communication and Adoption) are now available from the Centre Office.

There are 14 project sheets in total, and each gives details of research objectives, expected outcomes, target problems, key tasks, links, staff involved and contacts for that CRC project. They are an excellent way to quickly familiarise yourself with the nature and extent of our research program.

Copies are available by contacting Virginia Verrelli at the Centre Office on 03 9905 2704 or email virginia.verrelli@eng.monash.edu.au.

These sheets are also available for downloading from our website.

Look under Research 1999-2006 and follow the links for 'detailed information'

WHAT'S HAPPENING WHEN?

FIND OUT ABOUT CRC ACTIVITIES BY EMAIL

THE CRC WILL NOTIFY YOU OF AN UPCOMING CRC ACTIVITY IN YOUR AREA OF INTEREST

You can register to receive this information on line at www.catchment.crc.org.au/subscribe

or you can contact Virginia Verrelli at the Centre Office on 03 9905 2704.

CRC PROFILE

Report by Tim Fletcher

Having joined the CRC as a Research Fellow in the Urban Stormwater Quality Program around nine months ago, I guess it's about time that I explained my role, and how it came about. My interest in environmental management was created at a very young age, the product of two parents of similar mind. In Grade 5 (circa 1980…well, I can't remember!) at primary school, in Melbourne's outer eastern suburb of Montrose, I was required to write a story that 'predicted my future'. In the resulting book, (now a classic, sitting somewhere in my mother's shed), appropriately called "The Life of Tim", I wrote that I would, quite definitely, become an Environmental Scientist!

A few years later, and having undertaken work experience in the Bogong High Plains with the then Forest Commission, I enrolled in a Bachelor of Forest Science at The University of Melbourne. By the end of that degree I had established a strong interest in catchment hydrology, and management of aquatic ecosystems. This interest was contributed to, in part, by the eclectic teachings of my now good friend, Assoc Prof Leon Bren.

Upon completing my degree (1990), I received a Commonwealth Scholarship to undertake a PhD. Prior to commencing this, I worked as a statistical modeller, predicting the mortality of eucalypts in native forests (I still love UNIX!).

My PhD topic, "The cumulative effects of land and water management on the West Moorabool River, Victoria, Australia", developed approaches for analysing and modelling cumulative effects in catchments. The topic was somewhat unusual and challenging (for myself and my examiners!), spanning a broad range of issues, from legislation influencing riparian zone management, to development of Markov-Chain algorithms for predicting changes in environmental condition.

During those halcyon PhD days, I undertook a number of interesting consultancies on catchment management related issues, including assisting in setting up some of the prerequisites to the Victorian Catchment Management Authorities (didn't that come back to haunt me…read on).

Prior to completion of my thesis (I should have known better…) I responded to an advertisement by Melbourne Water for a position within their Waterways and Environment Team, and went there in 1996. Melbourne Water had a great team of people, was undertaking some great work, and taught me a lot (thanks Chris et al.). Contributing to the 'Best Practice Environmental Management Guidelines for Urban Stormwater' was the principal highlight of my time at Melbourne Water. I also finally finished my PhD.

However, in late 1997, when the Corangamite Catchment Management Authority (an organisation I had contributed to the establishment of some three years before), advertised for a Manager of their Waterways Program, I was drawn to the challenge. What a challenge it turned out to be!! With the Statewide introduction of a new ($32) Waterway Management Tariff, and the subsequent public outcry and politicisation of the debate, I, along with my colleagues, endured much public 'interest' in our work! Corangamite CMA did, however achieve great leaps forward in a region that had never before had dedicated waterway management activities, and I am proud to have been a part of that (best wishes to Bob Carraill and all at CCMA!).

I had always known, however, that it was research and development of 'new environmental technology' that interested me most. My plan had always been to get enough 'practical' and 'management' experience to ensure that my future research career met the needs of the catchment and waterway management industries.

When the opportunity to become involved in the CRC's Urban Stormwater Quality Program came along, I was therefore very excited. Without wishing to sound like I've been brainwashed, I was attracted to the quality of the research team, its approach to solving (and often preventing) environmental degradation, and its strong commitment to adoption.

I can now honestly say that, as I sit here at Monash University, examining the impacts of urbanisation on aquatic ecosystems, and developing models to predict (and improve) the performance of measures aimed at protecting these ecosystems, I have never been happier! And after all, that is how it should be.

Tim Fletcher
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WHERE ARE THEY NOW?

Report by Sharon Davis

Behind a desk in Canberra is the answer. I moved to Canberra from Melbourne more than three years ago to take up a position as a Research Manager for Rural Industries Research & Development Corporation (RIRDC). I currently work full time on the Joint Venture Agroforestry Program (JVAP). The JVAP is responsible for the coordination, management and communication of R&D into agroforestry and farm forestry system nationally.

My PhD research on soil physics and catchment hydrology gave me a sound basis to work on the range of research projects the JVAP supports. Initially I worked on a part-time basis for the JVAP and devoted the rest of my time to the completion of my PhD. As everyone warned, completing a PhD while working (initially part-time and later full-time) makes an already difficult task a bit harder. In 1999 I made the only sensible decision which was to take leave without pay and use all of my annual leave to "knock it over". I got the thesis finished and I am happy to say, as far as I am aware, I am responsible for the availability of purple thesis binding in Canberra (this took a few strategic phone calls to the binders in Canberra to put them in contact with suppliers in Melbourne).

My current position at RIRDC remains challenging and stimulating. Although I am over the worst of the incredibly steep learning curve regarding the science of farm forestry, the challenge of developing new sustainable agricultural systems incorporating trees for multiple benefits is significant. I have always enjoyed the challenge of multi-disciplinary work, possibly because of my undergraduate training as a physical geographer. A significant part of my role as a Research Manager is to ensure that research within the JVAP is well coordinated and that benefits are multiplied through the integration of a range of research activities. I am also active in ensuring that JVAP research is coordinated with activities funded by other organisations. I remain in contact with the CRC for Catchment Hydrology though a number of JVAP research projects. Our forthcoming guideline publication 'Trees, Water and Salt: an Australian guide to using trees for healthy catchments and productive farms' (Edited by Dr Richard Stirzaker, Dr Rob Vertessy and Alastaire Sarre) is one such project.

Life in Canberra is good for a former member of the CRC for Outdoor Activities (a little known sub-CRC within the CRC for Catchment Hydrology). Canberra is perfectly located for snow skiing and bushwalking and the coast is only two hours away. My fellow former CRC postgraduate students remain my "outdoor buddies" and Canberra is an excellent central location now that we are scattered around the country and overseas.

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UPDATED AWBM CATCHMENT WATER BALANCE MODEL MANUAL

The AWBM is a catchment water balance model developed by Dr Walter Boughton. The model can relate runoff to rainfall with daily or hourly data, and calculate losses from rainfall for flood hydrograph modelling.

Recently Dr Boughton and Professor Russell Mein have updated the AWBM manual to improve its readability and usefulness.

For those who would like to update their manual or learn more about the use of AWBM, the updated versions are on the CRC website at www.catchment.crc.org.au/models

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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 Land and Water Conservation, NSW
Department of Natural Resources and Environment, Vic
Goulburn-Murray Water
Griffith University
Melbourne Water
Monash University
Murray-Darling Basin Commission
Natural Resources and Mines, Qld
Southern Rural Water
The University of Melbourne
Wimmera Mallee Water

Associates: SA Water • State Forests of NSW