NEWSLETTER OF THE COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

CATCHWORD

NO 107 JULY 2002

A NOTE FROM THE DIRECTOR

Professor Rob Vertessy

Inside...

COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

PAYING HOMAGE TO DIRECTORS PAST

The CRC for Catchment Hydrology is fortunate to have had two outstanding Directors during its twelve-year history (I'm counting two years of bid preparation prior to the funding of our first CRC in 1992).

The founding Director, Emmett O'Loughlin, got us up and running in fine shape over the period 1990-1995. His role was a pioneering one, convincing the Centre participants and the Commonwealth that a CRC devoted to catchment hydrology research could add genuine value to Australia's natural resource management effort. Our Centre's sustained high level of performance has since vindicated that proposition.

Russell Mein took over after Emmett retired in 1995 and has only now retired himself. Russell managed the 'delivery phase' of the old CRC, and expertly scoped and sold the case for a second CRC which began in 1999. Over the last three years he has bedded down a very ambitious research and development portfolio and set us up for a second 'delivery phase' to be conducted over the next four years.

Emmett and Russell did an amazing job during their terms as Directors and gained the respect and affection of a great many people for their efforts. From a personal point of view I want to convey my sincerest thanks to both of them, for teaching, challenging and supporting me. I feel honored to have worked under Emmett and Russell and feel immensely privileged to have had them as dear friends too.

Thanks for your vote

It is also with a deep sense of honor that I now assume the role of Director for our Centre. I want to thank all members of the CRC's Governing Board for putting their faith in me. I'm most appreciative also to the many of you who have visited, written or rung to say well done and good luck.

It gives me a great measure of comfort to know that I am inheriting a CRC of excellent pedigree and outstanding prospects.

The road ahead

I've already mentioned that we are entering a second 'delivery phase' in our Centre. Many useful products have emerged from the first round of projects, as discussed by Russell Mein in his final *Catchword* article (June, 2002). This is despite the fact that we always saw the first three years of this new CRC as largely a 'bedding down' time during which we could re-tool and prepare for our most ambitious delivery program yet.

We are now quite advanced in the planning of our next group of three-year projects, due to start in January, 2003. Briefs for new research projects are being considered by the Board for advancement to the next stage of development: the preparation of full project agreements for tabling at the November Board meeting.

Within six months we will enter the home stretch towards delivering on the objectives articulated in our Business Plan. Although the project selection and scoping process is still underway, there are a few hallmarks of the emerging portfolio that warrant mention now.

Firstly, all of the projects are tightly integrated, so as to contribute to our overall objective of integrated (holistic) catchment prediction. Hence we have climate variability projects informing runoff and water quality prediction projects, which in turn feed into projects modelling geomorphic, hydrologic and ecological responses in rivers. Layered on these are projects focused on simulating the social and economic dynamics that take place in catchments, and determining how these dynamics are affected by land-use change and water management.

Secondly, all of the projects are structured to deliver predictive capability at the whole-of-catchment scale, and propose to demonstrate that capability via modelling case-studies on two or more of our five focus catchments (the Yarra, Brisbane, Murrumbidgee, Goulburn-Broken and Fitzroy).

Thirdly, all of the projects will aim to produce software that will be integrated in the Centre's Catchment Modelling Toolkit, our conduit to the land and water management industry and the wider natural resources management R&D sector.

Finally, the emerging portfolio is strongly tied to current industry needs and will involve greater contributions by industry participants so as to enhance our adoption effort. Dave Perry's team in the Communication and Adoption Program will play a vital role in guiding the testing and delivery of our modelling tools to our stakeholders. They will be enthusiastically supported by our research teams as we continue our Centre's tradition of converting cooperative research into practical products tailored to stakeholder needs.

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PROGRAM 1

PREDICTING CATCHMENT BEHAVIOUR

Program Leader
ROB VERTESSY

Report by Joel Rahman

Catchment modelling toolkit

What is TIME?
Other than an annoying acronym which gets in the way every *time*...there I go.

The Invisible Modelling Environment (TIME) is a system for developing and deploying environmental models, supporting multiple development languages (including Visual Basic and Fortran 95) and several deployment strategies (including Windows applications and web browser models).

Features in TIME
TIME incorporates the best features from our existing model development systems, Tarsier and ICMS, while adding new possibilities in the area of multi language development and web based delivery.

Importantly, TIME takes the flexibility of Tarsier, which allows the development of custom applications such as EMSS, and the ease of use of ICMS, which allows model developers without extensive programming experience to contribute model components. Like Tarsier, TIME allows developers to write models in a common, high level, programming language and package those models in Dynamically Linked Libraries (DLLs) which can be shared amongst peers via email. Like ICMS, TIME only requires model developers to write a small amount of code representing the core algorithm of the model. TIME shares both systems' highly visual focus, with rapid dynamic visualisation during model execution.

TIME also includes extensive support for documenting models with structured metadata, such as the numeric constraints governing a model parameter. These metadata allow us to create a range of general purpose tools for analysing and applying models, such as model parameter optimisation or automatic generation of graphical user interfaces. Importantly, these metadata will also form an important link in the development of model integration schemes in the coming years - effectively becoming 'contracts' between communicating models.

Development aspects
TIME has been developed by CRC for Catchment Hydrology researchers, using the Microsoft .NET platform (See Figure 1.1). .NET sits on top of existing Windows operating systems, and allows the integration of software written in a variety of languages. So far, we've developed simple TIME models using Visual Basic, Fortran 95 and C# (a new language, similar to Java). It should also be possible to develop models using C++, Java and Pascal.

Figure 1.1: A .NET Net

Applications
The coming months will see the development and release of several early TIME-based applications, including a web-based version of the stochastic climate generation model, AR(1), developed by the Program 5 team, and a library of rainfall runoff models, being developed by Jean-Michel Perraud at CSIRO Land and Water. These applications will have their own, stand-alone user interfaces. This leads us to the first interpretation of the 'Invisible' in the acronym. TIME is invisible because there is no visible evidence that TIME is the glue that holds these applications together.

We anticipate making TIME available to model developers later this year, supported by developer training. TIME Model Developers have access to several applications, including a graphical tool for running models, and analysing, processing and visualising data. Models can also be run from the command prompt within Windows, allowing users to script model execution in batch files, similar to shell scripts commonly used under UNIX. Models have ready access to TIME's data handling capabilities, including points, lines, polygons, grids, time series and node link networks.

Web-based rainfall generator

We are currently working on a web-based implementation of a stochastic annual rainfall generator using an autoregressive model - AR(1). The web implementation will provide stochastically generated time series of annual rainfall for any point in Australia. Users are presented with a web page showing a map of Australia and are invited to select a location, as well as the required number of rainfall series (or 'replicates') and the desired length of each series (Figure 1.2).

After selecting a location, users are presented with a number of time series graphically (Figure 1.3), with the option to download the data to a local machine.

Sitting behind the web application are TIME's graphing and data handling components, Ratnasingham Srikanthan's Fortran AR(1) model and Penelope Hancock's Australian surfaces for the AR(1) parameters of annual rainfall - mean, standard deviation, skewness and lag 1 correlation. These maps, produced during Penelope's vacation scholarship with the CSIRO Canberra laboratory, are described in a CRC for Catchment Hydrology Technical Report, due for release in the coming months.

Rainfall Runoff Library

Jean-Michel Perraud is currently developing a Rainfall Runoff Library for the Catchment Modelling Toolkit. This application brings together a number of conceptual rainfall runoff models, in a cohesive graphical user interface (Figure 1.4) that allows the selection, calibration and application of a model to a particular set of data.

The library will initially include AWBM and SimHyd, before being expanded to include other models, such as IHACRES and Sacramento. The library will also include a number of tools for calibrating models, including generic auto-calibration tools, as well as custom tools for particular models.

For more information, contact Jean-Michel on jean-michel.perraud@csiro.au

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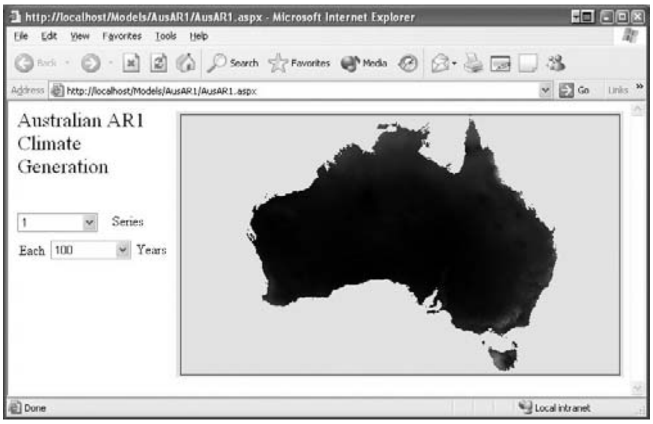

Figure 1.2: Opening Page of Web AR(1)

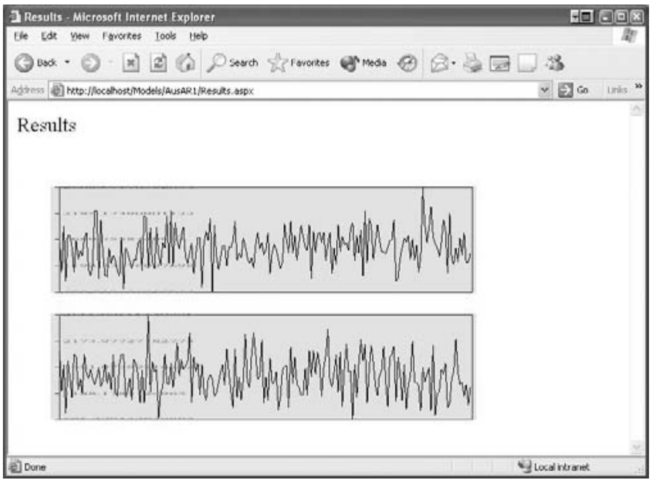

Figure 1.3: Results from Web AR(1)

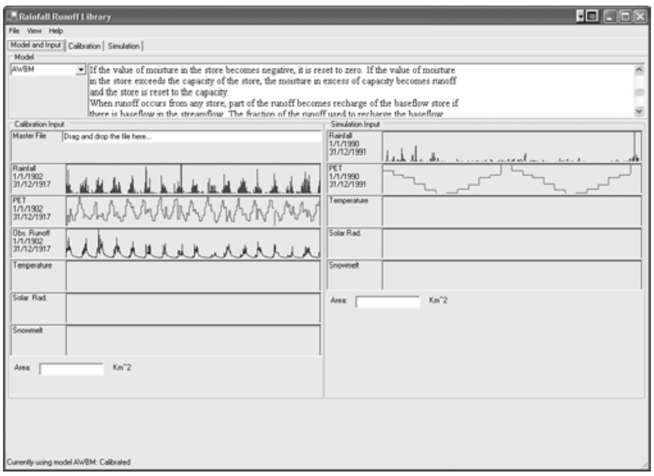

Figure 1.4: Input Screen for the Rainfall Runoff Library

RECENT TECHNICAL REPORT

CATCHMENT SCALE MODELLING OF RUNOFF, SEDIMENT AND NUTRIENT LOADS FOR THE SOUTH-EAST QUEENSLAND EMSS

by
Francis Chiew
Philip Scanlon
Rob Vertessy
Fred Watson

Report 02/1

In a jointly-funded study, the South East Queensland Regional Water Quality Management Strategy and the CRC developed an Environmental Management Support System (EMSS) to simulate runoff and pollutant movement across the South East Queensland region.

This report summarises a vital part of the research that went into the development of the EMSS. It describes the runoff and pollutant load model used in the EMSS and recommends model parameter values for use in the South East Queensland region.

Copies available through the Centre Office for $27.50.

RECENT TECHNICAL REPORT

ESTIMATION OF POLLUTANT CONCENTRATIONS FOR EMSS MODELLING OF THE SOUTH EAST QUEENSLAND REGION

by
Francis Chiew
Philip Scanlon

Report 02/2

In a jointly-funded study, the South East Queensland Regional Water Quality Management Strategy and the CRC developed an Environmental Management Support System (EMSS) to simulate runoff and pollutant movement across the South East Queensland region.

This report summarises a vital part of the research that went into the development of the EMSS. It recommends appropriate pollutant loading values for adoption in the EMSS. The work reported here is based on a very extensive data-mining exercise where the authors scoured reports and databases compiled by several organisations and scientists. In so doing, they have added significant value to work initiated by others.

Copies are available through the Centre Office for $27.50

For further information contact the Centre Office on 03 9905 2704

PROGRAM 2
LAND-USE IMPACTS ON RIVERS

Program Leader
PETER HAIRSINE

Report by Ian Prosser

Project 2.1: Sediment movement, physical habitat and water quality in large river systems

SedNet
This article gives a brief background to the *SedNet* model that is being used in Project 2.1 and associated projects funded by the Murray-Darling Basin Commission and the South East Queensland Regional Water Quality Monitoring Strategy. *SedNet* is also being included in the CRC for Catchment Hydrology modelling toolkit. Planning for the new round of CRC projects, and interest from other organizations in use of the model, has also made us focus on whether the model meets the requirements of catchment managers and what needs to be done to improve the model in that respect.

Origins
SedNet (Sediment River Network model) originated as a set of ArcInfo programs written by a team at CSIRO Land and Water as part of a project for the National Land and Water Resources Audit (NLWRA). That project assessed sediment and nutrient budgets for river basins covering about one third of Australia.

Soil and gully erosion were mapped separately across Australia and the *SedNet* programs used these maps, along with an estimate of riverbank erosion, as inputs to river basin sediment budgets. The budgets assessed the location of all major sediment sources in a catchment. The source loads were routed through the river network to estimate mean annual river loads of suspended sediment and bedload and catchment exports. Deposition and other losses are calculated along the way, providing a full account of the inputs, stores, and outputs of material in each catchment.

Nutrient Model
Much nutrient (nitrogen and phosphorus) is transported with sediment so a natural extension of the programs is into the area of river nutrient budgets. A nutrient model, ANNEX (Annual Network Nutrient Export), was thus developed, adding diffuse runoff and point sources to the sediment-attached inputs of nutrient.

The nutrient model also uses the deposition routines of the sediment budget and adds simple conceptualisations of phosphorus equilibration and in-stream denitrification to predict mean annual loads of dissolved and sediment-bound nutrients.

Australia-wide Mapping
Applying the *SedNet* models across one third of Australia was a massive task of data analysis to map all of the primary factors that control the patterns of sediment and nutrient transport at large scales. This work included mapping floodplain extent, and computing and regionalizing a set of hydrological parameters from gauging records.

The advantages of taking a budget perspective to river load modelling were outlined in the November 2001 issue of *Catchword*. Summary results, technical reports, maps and data from the NLWRA project are available from the NLWRA atlas and data library (http://www.environment.gov.au/atlas).

Regional Applications
Upon completion of the NLWRA project, people started to realise that the methods might be useful for regional planning as part of current policy initiatives such as the National Action Plan for Salinity and Water Quality, the Natural Heritage Trust, or state policies such as the Catchment Blueprints being undertaken in NSW and the Great Barrier Reef Protection Task Force in Queensland. By making explicit links between sources and downstream loads, the methods can be used to trace upstream to identify the ultimate sources of material. The methods have the potential to resolve common management problems of the link between land and water management and downstream impacts, and the highly variable link between sediment and nutrient sources and downstream loads. The model could be used to identify areas where remediation is likely to be most effective at meeting catchment targets.

National Assessment
The results of a national assessment, which was the focus of the NLWRA, do not necessarily provide the best assessment for any particular region for three reasons: data used, processes represented, and accuracy required. The NLWRA project used national databases to get coverage of all inputs across the whole study area. Many regional catchments have better local data that could be used to produce more accurate local results.

The conceptualisations in the model were chosen because they represented the primary controls at a national scale in a way that could be described at that scale. At the regional scale, other processes - supported by other data - may become more significant. For example, the recurrence interval of bankfull discharge was kept at a constant theoretical value at a national scale but local river cross-section data enable those patterns to be mapped at a regional scale.

Regional Focus
Focus on a particular region demands a higher degree of

accuracy than in a national context. For example, sediment loads of Australia's river basins range by three orders of magnitude. Thus an error of 30% in predicted load for a catchment is of minor consequence for the national perspective but is of more concern for a regional assessment and target setting. The more accurate regional data and improved process representation can help improve the prediction.

One of the most attractive features of the *SedNet* modelling is its ability to map patterns of sediment transport in a region. Once again, just because coherent and tested patterns emerged at a national scale does not mean that the same is true for finer scale regional patterns. Also, as is known from hydrological research in the CRC for Catchment Hydrology, just because the load at a point in a river network is correct, does not mean that the pattern of generation of that load is correct. There are many patterns of load generation that can produce the same total. Thus there are good reasons not to be complacent about use of the NLWRA results, but instead, to focus on improvements required for regional application, building on what has been achieved to date.

Regional Testing in Project 2.1

One of the activities in Project 2.1 has been to test *SedNet* at a regional scale. Work in both the Murrumbidgee and Brisbane River catchments has shown that the broad pattern of sediment generation that is predicted by the model using the most accurate regional data is supported by radionuclide tracers. This is true for both detecting from where in the catchment sediment is derived from and which process dominates erosion (soil erosion vs channel erosion).

Both modelling and tracing techniques require further improvement to be precise about the origins of sediment. In the Murrumbidgee River we have also shown that there is about 80% agreement between observation and prediction of historical bedload accumulation.

By the end of the project we will have examined whether such accuracy can be achieved by a more parsimonious model and evaluate what improvements would be required to improve upon bedload prediction.

Recent Developments

We have made progress in improving the model during Project 2.1, in response to its continuing use and the needs of stakeholders. Recent improvements include:

- the ability to deal with closely networked or anastomosing streams
- simple disaggregation of mean annual loads to daily loads using a daily flow series
- more automated generation of hydrological variables including regulated flows
- improved gully erosion assessment for the Murray-Darling Basin
- a prototype module to simulate future management scenarios.

Future Developments

Of course the project team and our clients still want more, and we are working toward meeting some of the needs. The current work that is incorporating the model into the toolkit will enable a seamless link between river modelling and estuarine modelling, far better scenario modelling, and a seamless link between flow modelling and sediment and nutrient loads.

Other needs that could be met in the next round of the projects include:

- improved nutrient modelling
- a bank erosion model based on Australian data
- incorporation of a wider range of future land management scenarios (farm dams for example)
- improvement to the current daily load estimates (which overestimate the probability of high loads)
- prediction of bedload trajectories into the future
- specification of particle size characteristics
- incorporation of variable channel geometry and variable delivery from gullies and hillslopes to streams.

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Report by Mat Gilfedder

Biophysical Capacity to Change

Introduction

How much difference can planting trees really make to the salt load of a stream? How long will such plantings need to take full effect? These are very important questions, given current and proposed salinity management strategies that involve broad-scale reafforestation.

Biophysical Capacity to Change is a concept that links changes in land-use to changes in stream flow and salt load. A tool has been developed from this concept that will allow priorities to be set for areas for tree planting within large catchments. The Biophysical Capacity to Change tool is aimed at helping catchment managers make rapid assessments of the gross change in salt and water balance in response to land-use change.

Future land-use and salinity

The expansion of areas of saline land and the rising salinities of river systems have increased the need for an ability to predict the likely environmental effects into the

NEW TECHNICAL REPORT

OPTICAL PROPERTIES OF LEAVES IN THE VISIBLE AND NEAR-INFRARED UNDER BEAM AND DIFFUSE RADIANCE

by
Iain Hume
Tim McVicar
Michael Roderick

Report 02/3

Land-use impacts on the water balance and regional hydrology through vegetation. Agricultural and natural resource managers therefore need to know the amount of understorey and overstorey vegetation in these woodlands. Remote sensing has a role in this assessment.

This report describes laboratory studies to determine if the remote sensing signature of tree and grass leaves differ enough to allow them to be unmixed using broad-band satellite data. Additionally, further understanding of the way understorey and overstorey leaves absorb diffuse and beam light was developed. These results provide an avenue forward for remote sensing in this difficult area.

Copies are available through the Centre Office for $27.50

For further information contact the Centre Office on 03 9905 2704 or email crcch@eng.monash.edu.au

NEW TECHNICAL REPORT

THE STATUS OF CATCHMENT MODELLING IN AUSTRALIA

by

Frances Marston
Robert Argent
Rob Vertessy
Susan Cuddy
Joel Rahman

Report 02/4

The CRC for Catchment Hydrology is developing a new generation of catchment models and modelling support tools, integrated within a system of software known as the Catchment Modelling Toolkit. The purpose of the Toolkit is to improve the standard and efficiency of catchment modelling, and to provide much-needed enhancements in predictive capability for catchment managers.

This report describes a vital element of the planning underpinning the development of the Toolkit concept. It summarises the results of three different surveys that gauged the opinions of catchment managers, model users and model developers with respect to the status of catchment modelling in Australia.

Copies are available through the Centre Office for $27.50

future. Salinity is a surface expression of hydrological change to groundwater systems. Therefore, an understanding of groundwater systems, and their responses to past, present and future land-use change, should lie at the core of any method used to predict changes in land and stream salinisation into the future. Regional or catchment scale methods must take into account the fact that features of salinity are related to the scale and type of groundwater systems, which can vary significantly both within and between catchments.

Approaches to predicting salinisation

– Landscape Components

The first step in prediction will involve the disaggregation of the landscape into smaller components that exhibit similar behaviour in terms of their hydrology and salinity processes (Gilfedder and Walker, 2001). Currently, a favoured approach in Australia is the classification of groundwater flow systems at a range of scales (local, intermediate and regional) that are also related to the topographical and hydrogeological processes leading to salinity in each system (Coram *et al.*, 2000; Stauffacher *et al.*, 2001). This classification offers a systematic and consistent landscape disaggregation, useful at a national or regional scale.

– Landscape Characteristics

The second important step is the identification and simplification of relevant landscape characteristics to predict the groundwater response to land-use change. The complexity of these methods must be limited, because of the paucity and irregularity of available data at the catchment scale. Previous research has examined relationships at a catchment scale between evapotranspiration and vegetation type with respect to rainfall (Holmes and Sinclair, 1986; Zhang *et al.*, 2001). The investigation of how this relationship might relate to groundwater recharge has also been reviewed by Petheram *et al.* (2002), who looked at possible relationships between groundwater recharge and vegetation type for a range of soil types with respect to rainfall.

– Timing of Land-use Changes

The timing of effects of a large-scale land-use change on catchment water yield, salt load and salinity will also be different for a range of groundwater systems within a catchment. This timing is extremely important, as it directly affects the physical and economic viability of possible management options, since groundwater discharge is the process that mobilises salt to the land surface and to surface water bodies. Dawes *et al.* (2001) considered relationships between catchment yield and land-use, together with a two-parameter groundwater discharge function for each groundwater flow system type, to estimate the changing groundwater response over time.

The Model Itself

The Biophysical Capacity to Change (BC2C) model is developed with adaptability and portability in mind. The adaptability is from a biophysical point of view, allowing for parameterisation flexibility to address the variability of Australian landscapes. The portability is also from a computational point of view, where it can be used on standard PC hardware (laptops).

BC2C has been implemented within the CRC for Catchment Hydrology Toolkit (Program 1) using the Tarsier environmental modelling framework. This model uses the following information layers:

- 100m digital elevation model (DEM) of the catchment,
- groundwater flow system (GFS) polygonal map, which is used to distribute hydrogeological parameters spatially.
- interpolated average annual rainfall raster dataset,
- current tree cover raster dataset.

– DEM

The DEM provides the basic information for a topographic analysis of surface water catchments based on a stream network and minimum catchment size. It is important to recognise that, while groundwater processes drive landscape salinisation, it is manifest through readily identifiable surface features, such as streams, low-lying areas, and breaks of slope. Land management is also most conveniently aimed at surface water catchments and streams rather than geological or groundwater maps.

– GFS

A GFS map is required to determine the driving groundwater gradients and flow rates within catchments. The properties within each GFS are hydraulic conductivity, porosity, aquifer thickness and groundwater salinity. Within each surface catchment defined from the DEM, the properties of each constituent GFS are spatially averaged to provide an integrated estimate of each component. Currently, this is a simple arithmetic average weighted by area.

– Rainfall

An interpolated rainfall surface is required to provide estimates of transpired and excess water. Within each catchment, the excess water can be partitioned into different pathways, which attract delays in reaching the outlet, and which have the capacity to accumulate different salt concentrations.

– Tree-cover

The current tree-cover raster dataset provides a binary map where each pixel is classified as either covered in trees or not. The proportion of tree cover of each catchment is then simply a sum of all tree pixels within the catchment divided by the catchment area. It is changes to tree coverage that drives the BC2C output since other input data are not within the domain of land management plans and practices. Tree cover also governs the partitioning of through-flow and overland flow.

Take-Home Message

BC2C brings together the available groundwater information in a transparent and spatially explicit way, within the groundwater flow systems framework. This can be used:

1) as part of a "rapid-assessment" tool to help in ranking areas with regard to the biophysical effects of possible land-use change.
2) as an interface with social and economic "capacity to change" models
3) to provide groundwater information to water management models (such as REALM and IQQM).

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PROGRAM 3

SUSTAINABLE WATER ALLOCATION

Program Leader
JOHN TISDELL

Report by Sergei Schreider and Ilan Salbe

Project 3.1: Integration of water balance, climatic and economic models

Sensitivity analysis of the IQQM parameters

Background

Part of Project 3.1: "Integration of Water Balance, Climatic and Economic Models" includes a sensitivity analysis of the IQQM water allocation model. The IQQM system was selected as a basic platform for the integration of all the modelling components considered within the Project. An investigation of modelling efficiency, model sensitivity and modelling errors was thus seen as especially important in relation to the IQQM package.

Sensitivity to major parameters

The analysis of the IQQM sensitivity has included the sensitivity analysis of all the modelling components constituting this system, and its parameters and input data. This paper reports on the analysis of the sensitivity of the IQQM package to its major parameters - parameters which play a key role in the model calibration process.

Model calibration

The sensitivity analysis has used the IQQM model calibrated for the 1999/2000 irrigation season in the Murrumbidgee River catchment - one the focus catchments of the CRC for Catchment Hydrology.

Link to catchment management scenarios

The major conceptual link between model sensitivity analysis and modelling integration is scenario formulation. System scenarios indicate the range of data, parameters and structural changes reflecting plausible future catchment management policy.

Uncertainty in evaluating catchment scenarios

The modelling integration framework allows for the socio-economic evaluation of different catchment management scenarios. An understanding of the uncertainty levels in the models is, however, a necessary part of the evaluation of a catchment system under various scenarios.

The IQQM sensitivity analysis has allowed project researchers to estimate the range of possible errors in the entire modelling integrated system under development.

NEW TECHNICAL REPORT

THE DEVELOPMENT OF WATER REFORM IN AUSTRALIA

by
John Tisdell
John Ward
Tony Grudzinski

Report 02/5

The first phase of the CRC Project 3.2 'Enhancement of the Water Market reform Process' was to gather background information on water management in Australia, and water reform and water trading in particular. Part of this important process is to gain an overview of the nature of water, a history of water management in Australia, and current literature on water reform. This report is a summary of that overview and contributes to a greater understanding of water management in Australia and its future.

This report is now available from the Centre Office for $33.00.

For further information contact the Centre Office on 03 9905 2704 or email crcch@eng.monash.edu.au

IQQM for the Murrumbidgee catchment

The IQQM is a hydrological model simulating daily time series for a set of variables associated with selected sites in the catchment considered. These selected sites in the catchment are called 'nodes'. Nodes represent structurally significant objects and links on the major river, its tributaries and irrigation channels. Nodes are classified into 12 major types, some of which are divided into sub-classes. The IQQM model calibrated for the Murrumbidgee catchment accounts more than 360 nodes of different types. The most important for the project tasks are some 60 irrigation nodes of two types: high and normal security.

Methodology

The methodology of the sensitivity analysis was based on the Monte-Carlo simulation technique. The values of selected input parameters were varied within intervals of their plausible ranges using assumed statistical distributions for the parameters. IQQM output variables were then analysed for the selected nodes in the Murrumbidgee catchment and several integral output characteristics. Statistical distributions of the output variables were estimated in response to the input variations. 'Two-sigma' intervals above and below the statistical averages were computed for each output variable.

Input parameters

The list of the model parameters selected for the analysis, the interval where these parameters were varied, and statistical distribution (uniform here) are shown in Table 3.1.

Two comments are needed about this list of IQQM parameters.

Firstly, 'adepletion' is the size of soil moisture profile related to the root depth of the crop depletion. This is actually the depth of the bucket in the CROP MODEL 2 (a crop model employed by IQQM) applied for each irrigator node.

Secondly, the 'risk function' is the coefficient (or slope) of the linear relationship between resources available and area planted. The values for these input parameters were stochastically varied for 100 replicates for each irrigation node used as an input to the IQQM model.

Output variables

The variables analysed for the output sensitivity were:

1. General security farmgate deliveries for Murrumbidgee Irrigation Association (MIA)
2. High security farmgate deliveries for MIA
3. Coleambally farmgate deliveries
4. River pumped diversions from Murrumbidgee
5. Yanco-Colombo-Billabong system diversions
6. Flow at Wagga Wagga (middle of the system)
7. Flow at Balranald (system outlet)
8. Flow at Darlot
9. Total farmgate deliveries for MIA
10. Total general security farmgate for Murrumbidgee valley
11. Total farmgate deliveries for Murrumbidgee valley

The first eight of these variables represent the local output for the selected nodal points whereas last three provide the general characteristics of water allocation in the Murrumbidgee catchment. These output variables were transformed from the daily format (the standard IQQM output structure), into long-term mean monthly values aggregated for the 20-year simulation period (1980-2000).

Results

Before presenting the output statistics for the IQQM sensitivity analysis, it is noted that perhaps the most meaningful outcome of the present work is that the approach allows stakeholders to examine the sensitivity of any IQQM output to the variations of any of the IQQM parameters including variations at selected nodes, or sets of nodes

This sensitivity analysis method can be applied to other catchments of interest where IQQM has been calibrated. This flexibility is useful for such a

Table 3.1 The IQQM input parameters selected for the sensitivity analysis

Parameter	Minimal value	Maximal value	Distribution
Adepletion (mm)	100	300	Uniform
Seepage rate (mm/d)	0.5	2.5	"
Rainfall Interception Loss (mm)	1.0	3.0	"
Crop Factor (%)	Current Value - 15	Current Value + 15	"
Risk Function (%)	0 (no risk)	10	"

complicated system as IQQM because the entire list of input and output variables is very large, hence, a comprehensive sensitivity analysis is not possible. On the other hand it is very difficult to predict what the 'important' parameters are for the different groups of stakeholders.

As an example of the analysis, Tables 3.2 and 3.3 show how sensitive the IQQM system in the Murrumbidgee catchment is to variations in 'adepletion'. The results are presented for two selected output variables taken for separate nodes (local, Table 3.2), and computed for the entire catchment (integral, Table 3.3).

Similar tables can be prepared for each combination of input/output variables. However, the results presented in Tables 3.2 and 3.3 are typical for the range of such combinations: the two-sigma interval constitutes less than 15 percent of the average monthly values for all output variables considered in the present work.

These results show that the IQQM model, for the Murrumbidgee catchment, appears to be quite robust in relation to the input parameters. [The parameter intervals reflect the expertise of researchers working with IQQM for water allocation planning in the Murrumbidgee catchment.] This robustness is considered quite important for IQQM calibration.

Further work

The next step of the IQQM sensitivity analysis requires some extension of the list of variables for which sensitivity was studied. In particular, such important integral characteristics as "percent of water allocated" must be added to the list of the output variables.

The analysis of the IQQM sensitivity to the input data will be analysed as well.

The sensitivity analysis for the REALM system in the Goulburn -Broken catchment, where a similar methodology is going to be applied, is scheduled for the next few months.

Acknowledgements

This work was undertaken with the close cooperation and assistance of researchers from the NSW Department of Land and Water Conservation, a major CRC industry Party involved in Project 3.1.

The 'batch' version of the IQQM program which allowed IQQM to run for numerous replicates of the parameter values was coded by Stephen Roberts from DLWC, Parramatta.

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Table 3.2. Model sensitivity to the 'adepletion' parameter in relation to the high security farmgate deliveries for MIA (output variable #2 - local)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average value (GL)	23.2	15.6	16.4	5.4	2.2	0.23	0	1.6	2.9	8.7	12.2	23.4
'two-sigma' as percent of average value	12	8	13	8	11	14	N/A	12	16	9	10	15

Table 3.3. Model sensitivity to the 'adepletion' parameter in relation to the total farmgate deliveries for Murrumbidgee Valley (output variable #11 - integral)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average value (GL)	331	299	240	100	30	9	1	2.	72	210	222	335
'two-sigma' as percent of average value	13	14	9	12	7	N/A	N/A	N/A	9	15	12	15

OTHER OUTLETS FOR CRC PUBLICATIONS

In addition to the Centre Office, all CRC publications are available through the Australian Water Association (AWA) Bookshop in Sydney and the NRE Information Centre in Melbourne. They also stock a wide range of other environmental publications.

AWA Bookshop (virtual)
contact Diane Wiesner
Bookshop Manager
tel: 02 9413 1288
fax: 02 9413 1047
email: bookshop@awa.asn.au
web: www.awa.asn.au/bookshop/

NRE Information Centre
8 Nicholson Street (cnr Victoria Parade)
PO Box 500
East Melbourne
Victoria 3002 Australia
publication.sales@nre.vic.gov.au
Phone: 03 9637 8325
Fax: 03 9637 8150
www.nre.vic.gov.au
Open: 8.30-5.30, Monday to Friday

NEW SOFTWARE

MODEL FOR URBAN STORMWATER IMPROVEMENT CONCEPTUALISATION (MUSIC)

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 will be available from the Centre Office in mid-June 2002 for $88.00

Individuals will need to sign a Licence Agreement (available from the Centre Office)

For further information contact the Centre Office on 03 9905 2704 or email crcch@eng.monash.edu.au

Please note: MUSIC version 1.00 is a development version and will be valid until June 2003. The CRC for Catchment Hydrology is committed to updating MUSIC annually until at least 2006. Subsequent versions of MUSIC may be charged for.

PROGRAM 4

URBAN STORMWATER QUALITY

Program Leader
TIM FLETCHER

Report by Justin Lewis

Assessing the Performance of Gross Pollutant Traps

Litter in stormwater

Urban waterways are often the receptacle for a myriad of inappropriately disposed of litter items. Research indicates that urban areas contribute between 1-3 billion litter items to stormwater each year in Melbourne (Allison, 1997).

Selecting gross pollutant traps

Many types of Gross Pollutant Traps (GPTs) are being marketed across Australia, often with very little performance data to back up vendors' claims. This makes it very difficult for Councils and waterway management agencies to select appropriate traps based on their expected performance and maintenance requirements. Consequently, price is usually the deciding factor. This has lead to a number of inappropriate GPT installations which have performed badly, have been maintained poorly, and have wasted limited resources.

GPT Monitoring Project

To address this issue, a collaborative GPT monitoring project between the CRC for Catchment Hydrology and Melbourne Water has been developed to provide selection guidance and performance assessments of stormwater litter traps. The project is being funded through the Victorian Stormwater Action Program (VSAP) (administered by EPA Victoria).

From discussions with Melbourne Water, Councils and GPT manufacturers, suitable GPT monitoring sites have been selected. Currently, six GPT designs have been selected for monitoring purposes with at least two sites per type of device being selected. The GPT manufacturers involved in the project include Rocla, CSR Humes, Ecosol, Diston, Net Tech, CDS and Baramy.

The project has several components including:

1. Developing consistent field-monitoring protocols for assessing the performance of litter traps.
2. Performing monitoring on available brands of litter traps and posting the results on a web-site.
3. Establishing a Product Register web-site for litter traps (gross pollutant traps) in conjunction with the Stormwater Industry Association Victoria. (www.siavictoria.info/products)

Monitoring approaches

Monitoring protocols have been developed on a tiered approach to match the resources available for monitoring. The lowest tier represents the minimum data set that should be collected and reported for each GPT installation. This would equate to the minimum reporting requirements that VSAP could impose on grant recipients.

Performance monitoring of GPTs is currently underway and involves monitoring flows entering GPTs, gross pollutants that bypass the GPT during high flows, and collecting water samples for analyses. In addition, information on maintenance costs, plant requirements for maintenance and amounts and types of material collected, is also being recorded.

Monitoring levels

The lowest level of monitoring (A) is being carried out on all GPT designs and sites. Level A monitoring will provide information on the hydrologic/hydraulic operation of GPTs, water quality data and construction and maintenance costs for GPTs. Level A monitoring will also include downstream monitoring of gross pollutants that escape GPTs. Downstream monitoring of GPTs involves installing temporary fine nets (approximately three mm pore size) on the end of the pipe outfalls downstream of the litter traps (refer to Figure 4.1).

Figure 4.1. End-of-pipe net for downstream monitoring of GPT performance.

The nets are checked for collected litter during routine maintenance or after significant rainfall. The quantities recovered from the monitoring nets are then compared to the loads captured in the litter traps.

Levels B&C of the monitoring protocols incorporate more advanced analysis of water quality variables. These include suspended solids, trapped sediment, nutrients, metals and hydrocarbons. Level B&C monitoring will be carried out at selected sites.

Data collected from monitoring will then be entered into a 'Stormwater Treatment Product Register' database.

Product register

The 'Stormwater Treatment Product Register' website will be administered by the Stormwater Industry Association (SIA), the peak body for stormwater treatment devices, with over 1200 stakeholders on their circulation list. The web-site will be easily accessible to the stormwater industry as well as Councils and Catchment Management Authorities (CMAs). There should also be closer links to the product suppliers - through the SIA - which should ensure up-to-date information is kept on the Register.

Project opportunities

There are many opportunities arising from this project. Some include:

- Ongoing collaboration between the CRC for Catchment Hydrology, Councils, Melbourne Water.
- The standardised collection of GPT performance data in a format that provides meaningful results for stormwater managers.
- The collection of valuable independent performance data for GPTs and dissemination of these data throughout the stormwater community via publications and the web site.
- The ability for VSAP to assess the performance of VSAP-funded GPTs with information gathered being used as a basis for future GPT funding.
- Providing selection guides for GPTs and providing current product information to enable stormwater managers choose appropriate treatments for particular applications.

References

Allison, R. A. (1997) Effective Gross Pollutant Removal from Urban Waterways. Ph.D. Thesis, University of Melbourne.

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PROGRAM 5

CLIMATE VARIABILITY

Program Leader
FRANCIS CHIEW

Report by Alan Seed

Progress in nowcasting rainfall

Introduction

One of the goals of the Climate Variability Program is to develop techniques for very short-term (0 - 2 hour) quantitative rainfall forecasting. A prototype of Spectral Prognosos (S-PROG) was developed and tested during the Sydney Olympic Games.

This article gives an update on the developments that have taken place since that trial.

S-PROG nowcasting model

The S-PROG nowcasting model is essentially an advection type nowcasting model where the motion of the rain field (a 2D grid of rainfall intensities measured by a radar) is estimated and used to predict the location of the raining areas into the future. The life-time of a storm is a function of the size of the storm; large systems live longer than small systems. S-PROG exploits this by estimating the life time of systems observed in the rain field in real-time and then systematically smoothing the forecast field as the lead time increases so as to represent the loss of information as the rain field evolves in time.

The developments since the trial of the prototype have concentrated on improving the tracking algorithm, improving the quality control of the radar data when generating the rain fields, and developing an operational system that can be used by the Regional Forecast Centres at the Bureau of Meteorology.

Improved rain field tracking

The tracking algorithm used in the prototype was the simplest possible method that could produce robust estimates of the motion of the field averaged over the entire area. This proved to be adequate in simple situations but was not able to provide good motion estimates in complex situations where the rain field rotated around a low-pressure cell that passed though the radar field of view. Rotation is more apparent in large-scale fields that result from a mosaic of data from several radars as required for longer range forecasts. A 2D motion tracking algorithm that was developed for applications in robotic vision was adapted to track the motion of every pixel in a rain field. This algorithm is significantly faster than the methods that are currently

UPCOMING CONFERENCE

SECOND NATIONAL CONFERENCE ON WATER SENSITIVE URBAN DESIGN

2-4 September 2002 Brisbane, Australia

The Second National Conference on Water Sensitive Urban Design (WSUD) will be held on 2-4 September 2002 at the Brisbane Convention and Exhibition Centre, Brisbane in Queensland. The conference has been programmed to precede the River Symposium (4-6 September 2002).

Who should attend?

- Water managers (eg. state and local government)
- Development industries
- Consulting and development engineers
- Environmental scientists
- Asset managers
- Urban planners
- Academics and researchers
- Landscape architects

Further detail and a registration form is available at www.catchment.crc.org.au/news

For further information about the program, themes or sponsorship opportunities contact the Queensland Branch of the Australian Water Association on tel: (07) 3397 5644, fax: (07) 3397 5283 or email: awaq@powerup.com.au

WORKING DOCUMENT

GENERATION OF SPATIALLY AVERAGED DAILY RAINFALLS FOR THE YARRA REGION

by

Lionel Siriwardena
Ratnasingham Srikanthan

Working Document 02/1

This document describes the data preparation and the generation of areal average rainfall for the Yarra catchment.

Two daily rainfall generation models, the Transition Probability Matrix (TPM) model and a modified Wang-Nathan Model (WNM), were used to derive spatially averaged daily rainfall sequences for a region encompassing the Yarra catchment in Victoria, one of the focus catchments in the CRC for Catchment Hydrology. The performance of the two data generation models was evaluated with respect to their ability to preserve various important rainfall characteristics at daily, monthly and annual time scales.

Copies are available through the Centre Office for $22.00.

being used for tracking rain fields. It also has been successfully tested by the Met Office (U.K.) as part of a joint Bureau-Met Office research program and is being considered for their next generation nowcasting system.

Improved quality control

Of course, any quantitative forecasting tool depends on the quality of the measurements that are used by the model.

In the case of nowcasting, the radar measurements are also required for quantitative precipitation estimation and so there was significant motivation to address data quality issues. Radar echoes from hills (and waves on the sea if the radar is close to the sea), and the partial blocking of the radar beam by topography, are major data quality issues in the Australian radar network.

Work has concentrated on developing simple, robust methods to identify and reduce these effects in real-time by considering the radar data as collected in three dimensions in conjunction with digital elevation models of the terrain and models for the propagation of radar through the atmosphere. This work has been carried out in cooperation with scientists at the Catalan Technical University in Barcelona, Spain.

Several algorithms are now ready to be tested in an operational environment.

Developing an operational nowcasting system

The current focus of the research is on the development of an operational radar data processing and nowcasting system that can be used by the Bureau in the capital cities.

The vision is to develop a web-based server that provides both quantitative rain fields and nowcasts to a variety of applications within the Bureau.

A prototype is being developed based on the Sydney, Melbourne, and Adelaide radars and is expected to be completed by the end of the year. Thereafter the system will be tested over an extended period prior to being adopted by the Bureau.

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PROGRAM 6

RIVER RESTORATION

Program Leader
IAN RUTHERFURD

Report by Tony Ladson

Project 6.2: Optimising urban stream rehabilitation planning and execution

Background

Urban streams represent a special challenge to river restorers. Often they are highly modified with numerous conflicting management demands. The past focus on using urban streams for drainage and flood control has left many in poor condition but, compared to rural streams, there are often more resources available for their care.

Stream health factors

Urban stream health can be compromised by one, or a combination of factors, such as:

- Lack of physical habitat
- Modified flow
- Poor water quality
- Lack of riparian vegetation
- Barriers to migration of fish and other biota
- Exotic plants and animals
- Channelisation, erosion and sedimentation.

Urban stream rehabilitation needs to address some or all of these factors so it is important to know which interventions will be the most effective and should therefore receive the highest priority.

Stream rehabilitation

Project 6.2 is addressing some aspects of urban stream management by looking at better ways to plan and carry out stream rehabilitation. There are two main parts to the project.

Controls on urban stream health

The first part of the project, "an adaptive experiment into controls on urban stream health", is an attempt to understand the key factors that need to be addressed to improve the ecological values of urban streams. Earlier work has show that it is not sufficient to improve physical habitat. The Cooperative Research Centre for Freshwater Ecology showed that improvements to physical habitat in the form of artificial riffles had a limited effect on stream health, as measured by macroinvertebrate community composition (Walsh and Breen, 2001). Instead, our focus is on water quality and changes to hydrology.

Retarding basin retro-filling

Originally, this study was to begin with work to improve stream hydrology by retro-fitting a flood retarding basin. Under urban conditions, floods are made more frequent and severe because runoff is increased in both volume and rate, as a result of increased impervious areas, such as roofs and roads. This increase in flood frequency is likely to adversely affect stream biota because of hydraulic forces and increased sediment transport. If the hydrology could be made more natural, i.e. more like it was before urbanisation, perhaps stream health would be improved. Retarding basins do reduce flood frequency, but are most effective for large events. Initial work suggested that it was smaller events, around six months to two years average recurrence interval, that were causing the flow stress that influenced biota. Retro-fitting a retarding basin could improve the attenuation of these smaller floods and hence improve stream health.

Other factors limiting stream health

Although the retro-fitting argument is appealing, once we investigated the specifics of designing the retro-fit experiment, we found there were some difficulties. Retro-fitting a retarding basin will certainly reduce flow stress but will only improve stream health if flow stress is the critical problem. Following a literature review and discussions with Melbourne Water and ecologists from the Cooperative Research Centre for Freshwater Ecology (CRCFE), we believe there are four reasons which suggest flow stress is not the ultimate factor limiting stream health in the urban streams we have looked at (mainly in Melbourne's east).

– Occurrence of macroinvertebrates

The first piece of evidence is that if flow stress was the only problem, we would expect to see patterns in the occurrence of macroinvertebrates. Groups or taxa that are sensitive to flow should occur in areas of the stream bed that are sheltered from turbulence, high velocities and transported sediment. These regions, known as refugia, have been shown to accumulate sensitive taxa under laboratory experiments. However, in the urban streams we have looked at, and those studied by the CRCFE, there were no sensitive taxa found in refugia.

– Types of stress on disturbance

The second line of reasoning is related to these findings. In situations of high flow stress (frequent, severe events) two types of taxa would do well, (a) those that can quickly *recover* from flow stress - their populations may be reduced by an event but they can reproduce rapidly before the next one, and (b) those that can *cope* with the stress e.g. those that prefer to live in refugia. In fact, the actual urban stream taxa are dominated by type (a) - those that can recover quickly. This suggests there is more than one type of stress - the bugs that can cope with flow stress are wiped out by water quality events (or some other stress). The only macroinvertebrates doing well are those that can recover quickly from disturbance. Reducing one source of disturbance, by retro-fitting a retarding basin, would still leave other disturbances (e.g pollution events) largely untreated.

– Elimination of sensitive macroinvertebrates

Results from the CRCFE riffle experiment provide a third reason to suggest that we need to do more than fix the flow stress. When high quality refugia are added to a stream (the CRCFE riffle experiment), some sensitive taxa appeared but were subsequently eliminated, probably by some stress other than flow, since they were living in high quality refugia.

– Comparisons of streams

The fourth reason to suggest flow stress is not the only critical factor, is that urban streams that have high quality refugia have the same taxa as streams with poor or no refugia. If flow stress was the only issue, we might expect to see some sensitive taxa where high quality refugia naturally exist.

These results suggest that urban streams are subject to multiple, frequent, and severe disturbances. The upshot of this argument is that the retro-fit experiment began to appear to be a high risk approach to testing factors critical to urban stream rehabilitation. It seemed likely that we could spend a lot of money to improve the hydrology and perhaps not see an ecological effect. Of course we could monitor hydrological effect caused by the retro-fit but that would not be sufficient justification for this experiment. We already have good models that can predict the hydrologic response of changing a retarding basin outlet.

Water quality improvements

A much more sound approach to assessing the critical factors for urban stream rehabilitation is to focus on water quality improvement first. Our emphasis now is to work with Program 4 and Melbourne Water to monitor the water quality improvement associated with some constructed wetlands. We are also developing, in cooperation with the CRCFE, a monitoring program to test for improvements in stream health by looking for changes in the population of sensitive macroinvertebrate taxa.

The wetlands we are considering do attenuate floods to some extent so we are improving both water quality and hydrology, which increases our chance of seeing a response. Even if there is no ecological improvement, the effort will be worthwhile. Firstly we will increase our

CRC INDUSTRY SEMINAR

URBAN STORMWATER QUALITY MODELLING

Wednesday 21 August 2002
CSIRO Centre for Environment and Life Sciences Underwood Avenue Floreat Park Western Australia

Following the successful Urban Stormwater Quality Modelling Industry Seminars in Adelaide, Melbourne, Canberra, Sydney, and Brisbane (involving over 700 participants), a similar presentation is scheduled for Perth.

Who should attend?
Anyone involved in protecting urban aquatic environments, planning and design of urban stormwater management measures, land development and water sensitive urban design.

Cost and registration:
The seminar costs $33 (includes GST and coffee, tea and cake for morning tea).

For further information visit www.catchment.crc.org.au/news or email your request for the Industry Seminar's details to crcch@eng.monash.edu.au

CONFERENCE PROCEEDINGS

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

27-29 August 2001

Brisbane, Queensland

Copies of the recent Stream Management Conference proceedings are now available for sale from the Centre Office.

The 700+ page, two volume set contains over 120 papers. Copies cost $110 (includes GST and postage) and can be ordered by contacting the

CRC Centre Office
tel 03 9905 2704
fax 03 9905 5033
email
virginia.verrelli@eng.monash.edu.au

Note: Limited copies of the Second Australian Stream Management Conference ($104.50 including GST and postage) are also available.

knowledge of the effectiveness of constructed wetlands in improving water quality, a key task of CRC Program 4: Urban Stormwater Quality. Secondly, we will learn that efforts to improve stream health require at least the changes to water quality and hydrology that we are proposing. This outcome could guide the next round of experiments.

Wetland monitoring
Our work on wetland monitoring is now well advanced. We have three candidate sites selected and, with Program 4, have purchased event samplers. These will now be installed, under the direction of Program 4. We are also resolving issues associated with macroinvertebrate sampling program. Although Project 6.2 will finish in mid 2003, the wetland monitoring work will continue beyond the current CRC round as part of an Associated Project with Program 4.

I hope to report on results in a future *Catchword* article.

Reference
Walsh, C. J. and Breen, P. F. (2001). A biological approach to assessing the potential success of habitat restoration in urban streams. Verhandlungen Internationale Vereinigung fur Theoretische und Angewandte Limnologie 27, 3654-3658

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PROGRAM 7

COMMUNICATION AND ADOPTION

Program Leader
DAVID PERRY

The Flow on Effect - July 2002

At a glance – a summary of this article

- **Water Reform - New Report**
- **Urban Stormwater Quality Modelling Seminar**
- **MUSIC Software and Manual Available**
- **Water Sensitive Urban Design Conference**
- **Russell Mein Seminar**

The Development of Water Reform in Australia - New Report
Australia is one of the most arid countries in the world. Like many countries, it has been reforming water management practices and policies in order to meet the needs of a maturing water economy. This phase has brought with it significant national and state government changes to water pricing, the definition of water entitlements, and the nature of water as a tradeable chattel.

The first phase of the Sustainable Water Allocation Program's Project 'Enhancement of the Water Market Reform Process' was to gather background information on water management in Australia, and water reform and water trading in particular. Part of this important process was to gain an overview of the nature of water, a history of water management in Australia, and current literature on water reform.

The recently published report entitled 'The Development of Water Reform in Australia' by John Tisdell, John Ward and Tony Grudzinski is a summary of that overview and contributes to a greater understanding of water management in Australia and its future. The report is extremely timely in providing a sound review of the nature of water, of where we have been in water management in Australia, and of current water reform debate.

The report (100pp) is available from the Centre Office for $33.00 including GST, postage and handling.

Urban Stormwater Quality Modelling Seminar - Perth
Following the successful Urban Stormwater Quality Modelling Industry Seminars in Adelaide, Melbourne, Canberra, Sydney, and Brisbane (involving over 700 participants), a similar seminar is scheduled for Perth on Wednesday 21 August 2002. The seminar will be held

at the CSIRO Centre for Environment and Life Sciences in Underwood Avenue, Floreat Park, about 20 minutes from the Perth CBD.

This Industry Seminar is aimed at professionals involved in the protection of urban aquatic environments, planning and design of urban stormwater management measures, land development, and water sensitive urban design.

The seminar will be led by Associate Professor Tony Wong and will commence with a general overview of urban stormwater quality management. He will outline the attributes of water sensitive urban design, and current complexities in assessing the benefits and opportunities for implementing a range of stormwater treatment measures.

Speakers from the CRC's Urban Stormwater Quality research program will present findings that relate to improved operation and performance of vegetated swales, bioretention systems, constructed wetlands, and ponds. A demonstration of the MUSIC software (Model for Stormwater Improvement Conceptualisation) will follow. [For further information about MUSIC please see the May 2002 *Catchword* - available on our website at www.catchment.crc.org.au/catchword]

The cost of the Perth Industry Seminar is $33.00 (includes GST, tea, coffee and cake for morning tea). Participants will need to register by completing a registration form and faxing or posting it to the CRC Centre Office.

Further details and a copy of the registration form are available at www.catchment.crc.org.au/news

For further queries regarding the seminar contact Virginia Verrelli at the Centre Office on 03 9905 2704 or email crcch@eng.monash.edu.au

MUSIC Version 1.00 released

The CRC for Catchment Hydrology has now released version 1.00 of MUSIC (Model for Urban Stormwater Improvement Conceptualisation) after three years of development and beta-testing by industry parties. MUSIC is a PC-based software program that integrates the results of many research activities undertaken by the CRC and other organisations. It is a user-friendly decision support system that enables urban catchment managers to:

- Determine the likely water quality emanating from specific catchments
- Predict the performance of specific stormwater treatment measures in protecting receiving water quality,
- Design an integrated stormwater management plan for each catchment, and
- Evaluate the success of specific treatment measures, or the entire catchment plan, against a range of water quality standards.

The CRC is committed to providing support and training for the use of MUSIC and the software will continue to be updated annually as results from the CRC's and other organisations' research become available and are incorporated into the model.

The MUSIC software is available on CD from the Centre Office for $88.00. To obtain a copy please complete an order form and sign the Software Licence Agreement, returning the signed original to the Centre Office. Order forms and further details are available from the MUSIC website at www.catchment.crc.org.au/toolkit/music

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

MUSIC manual available in hard copy

Each MUSIC software CD includes an Adobe pdf file of the MUSIC user manual as well as a help file system. To assist participants in the recent MUSIC training courses, the CRC has prepared a colour printed and bound copy of the MUSIC manual. MUSIC users who would like to obtain their own copy of the printed MUSIC manual (134pp) should contact the Centre Office. The manual costs $110.00 (includes GST, postage and handling).

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

MUSIC website

If you would like more information about the MUSIC software or copies of research papers detailing the research incorporated in MUSIC (Adobe pdf files), then please visit www.catchment.crc.org.au/toolkit/music. The MUSIC home page also provides details of upcoming activities and contact details for technical support.

Second National Water Sensitive Urban Design Conference

The Second National Conference on Water Sensitive Urban Design will be held on Monday 2 - Wednesday 4 September 2002 at the Brisbane Convention and Exhibition Centre, Brisbane. The conference has been programmed to precede the River Symposium, (Wednesday 4 - Friday 6 September 2002).

Following the huge success of the first National Conference held in Melbourne in August 2000, there has been a growing demand by professionals in various

UPDATED EVAPOTRANSPIRATION AND RAINFALL MAPS FOR AUSTRALIA

Where to get them!

The CRC for Catchment Hydrology and the Bureau of Meteorology have recently completed a project to produce national maps of evapotranspiration for Australia.

The map set is now available for $33 plus postage and packaging.

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 9669 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

WORKING DOCUMENT

GENERATION OF ANNUAL RAINFALL DATA FOR AUSTRALIAN STATIONS

by
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Tom McMahon
Geoff Pegram
George Kuczera
Mark Thyer

Working Document 02/3

The work reported here forms part of CRC Project 5.2 - National Data Bank of Stochastic Climate and Streamflow Models - of the Climate Variability Program. The literature review (CRC Technical Report 00/16) carried out as part of the project recommended an autoregressive time series model or the Hidden State Markov (HSM) model to generate annual rainfall data.

In this working document, these two models are applied to 44 stations located in various parts of Australia. The performance of the models is assessed using a number of basic and other statistics. Based on this, recommendations are made as to the appropriate model for the generation of annual data.

Copies are available through the Centre Office for $22.00.

water related fields to have access to knowledge about water sensitive urban design (WSUD) and share their experiences. This conference will meet this demand through effective forums to address some of the practical issues in implementing WSUD and the relationship with total water cycle management initiatives.

The conference targets key groups dealing with water sensitive urban design issues: Water managers (eg. state and local government), development industries, consulting and development engineers, environmental scientists, asset managers, urban planners, academics and researchers, and landscape architects.

A brochure advertising the conference program (includes a registration form) is available as an Adobe pdf download from www.catchment.crc.org.au/news For further information about the program, themes or sponsorship, contact the Queensland Branch of the Australian Water Association on tel: (07) 3397 5644; fax: (07) 3397 5283 or email awaq@powerup.com.au

Russell Mein Seminar Booklet - available on-line or in hard copy

To celebrate Professor Russell Mein's contribution to hydrologic research, practice and teaching on the occasion of his retirement, a seminar was held at Monash University in late June.

The seminar program included formal presentations by speakers who had worked with Russell over the last 30 years.

These presentations have been published in a booklet that was distributed at the seminar. An electronic version of the booklet can be obtained as an Adobe pdf download from the CRC for Catchment Hydrology website at http://www.catchment.crc.org.au/news/

Printed copies of the booklet are also available free on request from the Centre Office; contact Virginia Verrelli on 03 9905 2704 or by email crcch@eng.monash.edu.au

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POSTGRADUATES AND THEIR PROJECTS

Teri Etchells

Not just because I'm a Pisces

My interest in the water industry first developed through a cadetship with Melbourne Water. This cadetship provided a wonderful opportunity to work across a range of areas such as environmental management, operations and wastewater treatment. I worked at Melbourne Water each summer while I was studying engineering and commerce at Monash University.

Following graduation, I joined The Boston Consulting Group as a management consultant. I worked there for three exciting years, working on many different business strategy projects with a dozen clients in four countries. This was a time of huge challenge, education and diversity. However, eventually I decided to focus on a particular industry ... and, recalling those happy days at the sewage treatment plant, decided that it had to be water.

Destiny

So, about fifteen months ago, I called Hector Malano from Boston to ask about potential PhD opportunities. He asked me what my research interests were and I gave him my wish list, which was something like:

- Water-related, preferably irrigation
- Interdisciplinary: incorporating economics, engineering and management
- Something with a practical application

It seemed that I had found my PhD destiny when Hector suggested a ready-made project to develop exchange rates for water trading in the Murray-Darling Basin.

A couple of months later I had moved back to Melbourne and started my PhD at the University of Melbourne in the Department of Civil and Environmental Engineering. I am now thirteen months into my research and am very happy with my decision. I came here to learn how to think rigorously about water issues and for that I couldn't have asked for better supervisors than mine: Hector Malano, Tom McMahon and Barry James (from NRE in Victoria).

Exchange rates

My project is part of the Sustainable Water Allocation program within the CRC. The objective is to develop a methodology to calculate exchange rates for water trading in the Murray-Darling Basin. Exchange rates are conversion factors applied to the traded entitlement volume to account for the impacts caused when the water is consumed in a new location. A simple system allowing people to buy and sell water with no outside intervention does not take account of issues such as losses incurred in supplying the entitlement at the new location, changes in security level or third party impacts such as return flows and environmental degradation. Exchange rates are already used within the Murray-Darling Basin and are likely to become more widespread in the future. I hope my research will contribute to their application and design.

Through this project, I have developed a passion for water allocation as a research topic and as a pressing social issue in Australia and around the world. I am enormously appreciative of the opportunity I have to focus on this subject and to learn from the remarkable people around me.

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WORKING DOCUMENT

APPLICATION OF HIDDEN STATE MARKOV MODEL TO AUSTRALIAN ANNUAL RAINFALL DATA

by
Ratnasingham Srikanthan
Mark Thyer
George Kuczera
Tom McMahon

Working Document 02/4

In the past, the stochastic generation of annual data was performed generally with a first order autoregressive model which does not explicitly models the observed long periods of wet and dry periods in the annual data. Though geographers and geomorphologists have observed long cycles or changes in the mean level of rainfall and streamflow, it was not explicitly included in annual stochastic data models until the recent work of Thyer and Kuczera (1999, 2000). The model used is referred to as the hidden state Markov (HSM) model.

The purpose of this study is to apply the HSM model to annual rainfall data from a number of rainfall sites across Australia and identify the the sites where a two-state persistence structure was likely to exist.

Copies are available through the Centre Office for $22.00.

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CRC PROFILE

Our CRC Profile for July is:

Chris Moran

I grew up in the Northern beaches of Sydney where the majority of my spare time was spent investigating coastal issues (at the beach). I spent the rest of my recreation time on a property north of Sydney near a small town by the name of Wollombi. Some of you might recognise the name as the old Wollombi Brook has been included in a number of CRC reports. I developed a strong affinity for soil through the processes of sitting on a tractor ploughing and digging a large number of fence post holes - no this was not a labour camp although when breaking large lumps of sandstone to cut cattle tracks through the hills it sometimes felt that way.

When school finished I entered university to study agriculture (this was before vocational degrees in surfing were available) majoring in soil science and then went on to a PhD with CSIRO. I studied image processing and soil structure. During this process I became somewhat over-enamoured with computing - I couldn't believe the pleasure in having something in your head that could be converted to "reality" through a programming language. I have to admit I still find strong appeal in this outlet for creativity, but have become somewhat more circumspect about the reality part. I spent a couple of postdoc years learning about software engineering with the then CSIRO Division of Information Technology.

Over the years I gradually became attracted to spatial problems of larger and larger domains. I started with the Dalrymple Shire in Queensland (some 70,000 km2) and the vexed issue of dryland salinity, then to data mining techniques for soil mapping across the Murray-Darling Basin (about 1,100,000 km2) then, most recently, to a range of inputs into the National Land and Water Resources Audit (notably the landscape sediment and nutrient budgets and continental soil properties estimation). Surprisingly, my youth experiences at the Sydney coast and the landscapes of the Wollombi Brook have held me in good stead for many a white board dispute over processes and problem solving (maybe it was more the tenacity required to break rocks and dig through dry B-horizons combined with a sense of discomfort at cutting down the straightest and best quality trees for fence posts).

Over the last few years I have been moving inexorably towards more extensive and complex science management tasks (although somehow I am still Project Leader of a CRC for Catchment Hydrology Associated Project!). I am pretty sure that the reason for this management role is that I like people (as a generality that is - there are some I could dislike, if pushed, e.g., Queenslanders at State of Origin time). I am currently managing the initiation of one of CSIRO's new Flagship Programs - Healthy Country - and I am sure that the old fence post tenacity will be required again.

I like playing a role in the CRC for Catchment Hydrology for a number of reasons. This Centre has developed an operational style that facilitates progress and encourages resolution of CRC Party issues. There is an invigorating process for soliciting the views of participating agencies for operational directions to help set the research agenda. This is combined with effective machinery for communication of outputs and education on issues and techniques. The quality of the financial data, and their presentation, really help with high level decision making. The clarity of roles in research, focus catchments and interfaces to user agencies is a feature. Significantly, I enjoy participating in Board meetings because they are constructive and, as a group, the Board shows strong support for research and respect for its place in advancing the outcomes required to manage catchments more effectively.

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WHERE ARE THEY NOW?

Report by Rebecca Bartley

Well I'm still in the same place that I have been for the last two years, Atherton, North Queensland, however, a few things have changed. I now have an office all to myself (I'll miss those shared student offices), an official CSIRO name badge, and I'm slowly warming to XXXX beer. Most of these changes have come as a result of my new position as a geomorphologist post-doc with CSIRO Land and Water (and thanks to those from CLW Canberra for suggesting that they give me a job nearly two years ago). I'm not sure about the beer bit, I just think if you drink enough XXXX, eventually it tastes OK.

It wasn't a direct jump from PhD to post-doc though. I had six months in-between to contemplate post-thesis life. Most of this contemplation went into writing up papers for the CRC for Catchment Hydrology and working part-time as a catchment coordinator in the Herbert River Catchment, North Queensland. This was a most entertaining experience, particularly as a young vegetarian female working on cattle stations where I got to discuss tree clearing and the potential for building dams over cups of tea. Land degradation always seemed to happen in someone else's backyard, and many cane farmers thought that their cane paddocks actually did a better job at filtering water than wetlands....mmmmmm. Needless to say, when I was offered a position working back in science, I accepted. God Bless all catchment coordinators everywhere - they deserve a medal.

I've only been in my new position for six weeks and I have re-discovered the 70 hour working week and the loss of weekends! Although I'm sure this is just an initiation process...I hope! Some of the more exciting parts of my job so far have included a week out in cow paddocks in the Burdekin catchment conducting rainfall simulation experiments. I am also working on a document for the Reef Taskforce which is a summary of the evidence of land-use impacts in catchments draining the Great Barrier Reef (GBR).

The future also looks rather busy, but interesting. At least 50% of my time will be spent in the Burdekin catchment. The Burdekin is receiving a lot of attention up here as it is a NAP catchment (National Action Plan for Salinity and Water Quality), and along with the Fitzroy, it is the largest contributor of sediment and nutrients to the reef. My work here will involve more rainfall simulation experiments and some work on bank and gully erosion. The other 50% of my time is open at the moment, and I am interested in working in some of the wet tropics catchments (maybe the Daintree or Mossman rivers) to get a handle on the geomorphic and sediment transport processes in less disturbed areas. I would also like to look at some of the SedNet data to see if we find some relationships between the GBR catchments (e.g. stream power, geological characteristics etc) to see if we can predict areas that will be high contributors of sediment in the future and therefore apply appropriate land management techniques now. So I should have all have that done by next week - ha!

Although I am now thousands of kilometres from Melbourne and Canberra, I'd say that I will still have strong links back to the CRC for Catchment Hydrology, as I will still be working closely with the CSIRO staff in Project 2.1. I would also encourage anyone who has an interest in seeing some real hydrology in action (advisable to visit between November and March or during a cyclone!) or anyone who'd like a beer on the verandah (anytime of the year), to call in and say Hi. If we're not at work, you'll probably find us in the hammock down the back watching the platypus and the pelicans in the lake...

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COOPERATIVE RESEARCH CENTRE FOR

CATCHMENT HYDROLOGY

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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
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