NEWSLETTER OF THE COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

CATCHWORD

NO 128 JUNE 2004

A NOTE FROM THE DIRECTOR

Rodger Grayson

Inside...

PLANNING FOR THE "FINAL PUSH"

We are fast approaching what might be the last twelve months of the CRC for Catchment Hydrology as an entity! Under the Commonwealth arrangements, if the application for the new eWater CRC is successful, it will begin in July 2005. The CRCs for Catchment Hydrology and Freshwater Ecology will each end in June 2005. This is one year earlier than our original arrangements, although our research projects are planned to be largely complete by December 2005. Irrespective of the outcome of the eWater CRC, a primary aim of mine is to be sure our CRC ends on a high note, maintaining its enviable reputation for delivery. To this end, the last two months has seen substantial planning activity aimed at preparing us for the "final push".

The philosophy driving our planning is based on the premise that the CRC must deliver on its core mission, even if the eWater CRC bid is successful and we have to wrap up in June 2005. This approach means we will carry solid deliverables (including products) into the new eWater CRC and the communication and adoption activities that surround them will give the new organisation some early runs on the board. If the eWater CRC is not successful, the extra time will be used to finish those tasks that were not so central to our core mission. We will also push harder on communication and adoption activities so the CRC for Catchment Hydrology finishes with a bang.

This approach also avoids complicated options that are contingent on the outcome of the eWater CRC application , thus maximising stability for our staff and Parties. This notion of "just one plan" was developed with the active involvement of all our Project teams as part of an Internal Review that took place at the end of April. This review was a chance to summarise progress on final round projects and reassess priorities for the remaining time, given the intention of "just one plan". The review team was made up of all Program leaders, Program 1 Project leaders and myself. A key outcome was an agreed set of priorities for the final phase of project activity. This was important information to take to the next step of our planning process, the Adjunct Global Review.

You may recall that last year in August, a panel of national and international experts undertook a Global Review of all our projects and programs. We were very fortunate to be able to secure all of the Australian members of that panel to reconvene in mid May to assess progress and provide advice on our plans for completion. The Panel comprised Professor Barry Hart (Panel Chair and Director of the Water Studies Centre, Monash University), Emeritus Professor Tom Chapman (University of New South Wales), Dr Chris Gippel (Fluvial Systems Australia), Dr Rory Nathan (Sinclair Knight Merz) and Dr Alistair Watson (Consultant).

The Terms of Reference for the Panel were to:

1. Assess the adequacy of response of each Program to the recommendations made in the previous review.
2. Assess progress to date and the proposed program to June 2005, in relation to the target modelling capability required for the CRC to meet its mission.

Questions to be addressed were:

- Will the work presently being undertaken, and proposed to be completed by June 2005 result in useful products that are central to the mission?
- Is the CRC on target to get its tools adopted by end-users in the land and water management
- Is there a need for any re-focusing to better achieve the mission by June 2005?

The review was held at Monash University over two days, with a dinner and overview presentation on the night before. The two days of sessions included presentations by all Program Leaders, several Project leaders and representatives from two Development Project teams. Discussion sessions were held throughout, with the afternoon of the final day devoted to drafting by the Panel of their final report, which was finalised by the end of May.

At this point it is best to let the Panel do the talking!:

'The Review Panel is confident that the CRC for Catchment Hydrology is well placed to achieve the outcomes required to satisfy their central mission by June 2005. This conclusion is based on the rate of progress and achievements over the past nine months (which is impressive), and our current understanding of the benefits to be had by capitalising on early Toolkit building blocks. The Toolkit now boasts a number of products that demonstrate that the flagship promises of the CRC are fast becoming a reality.'

COOPERATIVE RESEARCH CENTRE FOR
CATCHMENT HYDROLOGY

ANNUAL REPORT ON-LINE

The CRC for Catchment Hydrology Annual Report 2002-2003 is now available for downloading at www.catchment.crc.org.au/ publications

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In relation to our efforts to get tools adopted, the Panel concluded:

'The CRC for Catchment Hydrology has maintained its highly effective communications and adoption program. The extent of effective collaboration and involvement across different agencies, institutions and disciplines continues to be impressive. There is increasing evidence that the CRC through its communication and adoption activities will meet its objective of having a profound effect in improving understanding and changing industry practice in Australia.'

Clearly the Panel was impressed with our CRC, and in particular the major strides we have made in recent times, where the Toolkit concept has moved from "potential" to "reality". Of course after two reviews within twelve months, the Panel knows us well and provided excellent advice on areas that will be improved with some additional attention. We too are well aware that the next year or so will be incredibly challenging. What we are trying to do has not been done before - but that is what makes it so exciting!

I would like to take this opportunity to sincerely thank the Panel for their professionalism, insight and probing questions. Thanks also to the Program leaders, Project leaders and Development project teams who put so much effort into their presentations, and to John Molloy, Virginia Verrelli and Maeve O'Leary for dealing with all the logistics.

Something that was reinforced for me time and again during this recent planning process is the enthusiasm, excellence and sheer hard work of all Project teams and Program Leaders. Indeed, as the review Panel noted:

'The CRC for Catchment Hydrology has obviously attracted a highly skilled, innovative and dedicated team of researchers and project staff committed to delivering on the CRC's main objective - to produce an integrated, whole-of-catchment modelling capability for land and water managers and deliver this to them via the catchment modelling toolkit.'

The "final push" is on, and there is no doubt that we have an exceptional team to complete the transformation of vision to reality!

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PROGRAM 1

PREDICTING CATCHMENT BEHAVIOUR

Program Leader
GEOFF PODGER

Report by Joel Rahman

Update on TIME

I first wrote about TIME in the July 2002 *Catchword*, when there were four software product developers contributing to the system. Those four still form the core team and have now been joined by more than twenty new developers from around the CRC, each contributing valuable modules to the toolkit and using TIME to support their research.

It's impossible to describe everybody's contribution in this forum, but I will attempt to highlight a few of these interesting new capabilities.

Data Uncertainty

Last year (October 2003 *Catchword*) Geoff Podger described some of the ideas surrounding the visualisation of uncertainty within models. Shane Seaton and Jean-Michel Perraud have now encapsulated some of this thinking into the toolkit, with tools to store and visualise uncertainty in time series.

Instead of drawing a time series as a sharp line between points, a 'fuzzy' shaded line is drawn to represent windows of time where the value of the time series is know with greater or lesser certainty.

This new capability allows developers of future models to incorporate the representation of uncertainty. (See Figure 1.1)

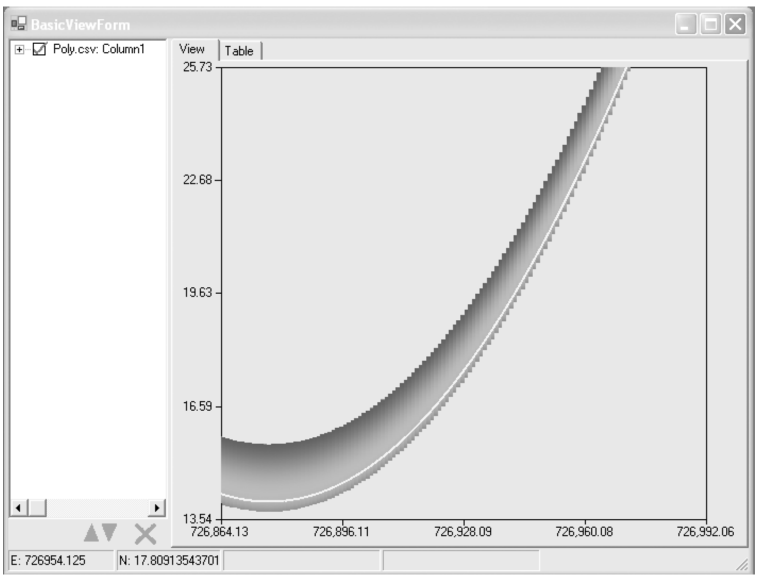

Figure 1.1 Time series with data uncertainty depicted using shading

Testing Tool

Porting an existing model from its original code base into a new system, like TIME, can be tedious and can often involve the introduction of subtle errors. Andrew Freebairn is currently porting Fred Watson's Macaque water yield model into TIME and has developed a model testing tool for streamlining porting efforts. The tool automates the comparison of the new, ported model against the original, rapidly highlighting bugs and giving the developer confidence that the new source code is working as expected.

The Testing Tool takes as input a 'trace file', which contains a time series of every input, parameter, state variable and output of the existing, legacy model. The tool then feeds the inputs and parameters into the TIME version of the model and compares values predicted for every state variable and output. If any of the state variables or outputs differ, this is highlighted in a graph containing a time series for the original model's value for the variable, as well as the TIME version and the difference between the two. This allows a model developer to quickly see what variables are wrong and often to identify 'patterns' of error that might give good hints to the location of the bug. (See Figure 1.2)

Terrain Analysis Library

Ben Leighton has been building up the terrain analysis capability within TIME, allowing more of the lengthy pre-processing associated with model running to be done within the toolkit, without resorting to a GIS. Ben has brought in numerous important tools including the D-infinity system for flow accumulation and John Gallant's Multi-Resolution Valley Bottom Flatness index (MRVBF). These tools are finding there way into various toolkit products, such as Sednet and E2. Additionally, a stand-alone package for digital terrain analysis will be released later in the year.

Distributed Computing

We currently have three, fourth-year Software Engineering students from the University of Canberra working to develop a distributed computing capability within TIME. Cheekily named DIME, the system, developed by Geoff Davis, Rob Bridgart and Trevor Stephenson, allows lengthy model runs to be split and run in parallel on multiple PCs. DIME allows a modeller to take advantage of the large amount of 'idle time' on most PCs, such as overnight or on

NEW SOFTWARE VERSION

Rainfall Runoff Library (RRL)

Version 1.0 of the Rainfall Runoff Library was released on the Catchment Modelling Toolkit web site at www.toolkit.net.au earlier this month.

The user manual and software has been updated in response to feedback from users since the Catchment Modelling School in February 2004. This version replaces the earlier beta versions available through the Toolkit web site.

There is no cost to obtain the RRL software but you must be a registered member of the Catchment Modelling Toolkit.

For further information about the RRL update please visit www.toolkit.net.au/rrl

During July 2004 additional products will be released through the Toolkit.

CATCHMENT MODELLING SOFTWARE

Further information about the Catchment Modelling Toolkit is available at www.toolkit.net.au

Visitors to the site can access a range of catchment modelling software online by registering as a Toolkit member. See www.toolkit.net.au/register

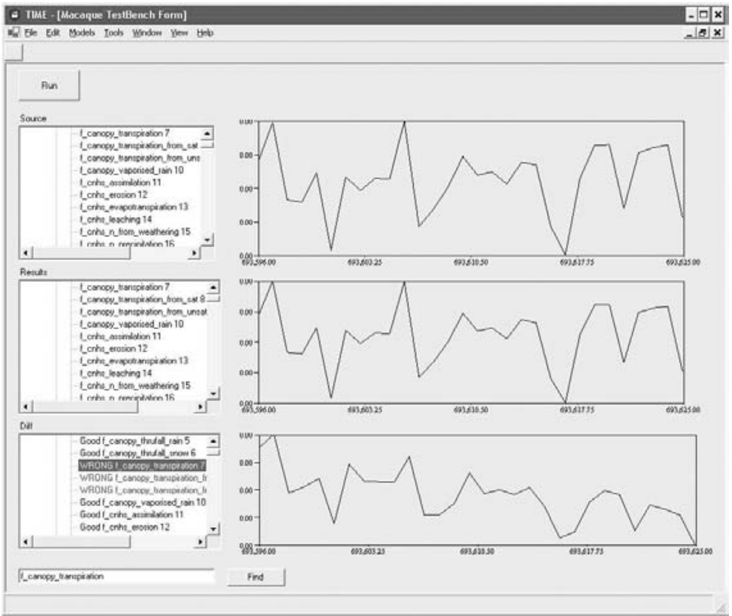

Figure 1.2 Screen shot from a testing tool showing the original, new and difference values for a given variable.

weekends. DIME will be particularly useful when a model needs to be run many times, such as for parameter optimisation or uncertainty analysis. DIME makes use of the Alchemi library for Grid computing, developed within The University of Melbourne.

Get Involved: Training and Support

These and more features are becoming progressively available to TIME developers. You can get on board by coming along to a training workshop, and by participating on the mailing list.

Nick Murray coordinates the training and induction of new TIME developers. Nick runs a two-day TIME development workshop, during which you write spatial and temporal models using the TIME system. The workshops allow you to program in Visual Basic, C# or Fortran and, while introductory, are the best way to start using TIME. An important part of the workshops involves the participants 'whiteboarding' a new model of their own devising and implementing it within TIME. Nick is running workshops in late June and in September 2004. Contact Nick on Nicholas.Murray@csiro.au for more details or to enrol.

Finally, TIME has, like all toolkit products, a vibrant email discussion group. The TIME group covers how-to questions and answers, feature requests and general model development discussion. Participants benefit from learning from each other's experience and have a very good chance of finding the right person to answer their query quickly.

I'd encourage readers who are developing models now, or expect to develop models in the near future to have a close look at the capabilities of TIME and the support services available within the CRC. Check out the TIME webpage (http://www.toolkit.net.au/TIME) for more details.

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PROGRAM 2

LAND-USE IMPACTS ON RIVERS

Program Leader
PETER WALLBRINK

Report by Mark Littleboy

Update on Project 2.21 (2C): Predicting salt movement in catchments

Background

Project 2C is developing a salt balance model that can be applied to assess the impacts of land-use change on stream flow and stream salinity at a catchment scale. The key prerequisite of the 2C model is that its data requirements must be compatible with existing sources of data across the Murray-Darling Basin.

In an operational sense, Project 2.21 (2C) is different to other CRC for Catchment Hydrology projects in many ways. The first major difference is that the activities in this project are designed to combine the best aspects of existing salt balance modelling within CSIRO and the three Industry Parties (DSE - Vic, DIPNR - NSW and NRME - Qld) to build a single model that will provide consistent and comparable results across the Murray-Darling Basin. It builds on the existing collaborative linkages and provides a platform to share skills and resources across each of the organisations.

Main modelling features

Specifically, 2C combines the following modelling features into a single predictive framework:

- Previous and current daily timestep recharge modelling in Queensland, NSW, and Victoria using a suite of pasture growth, crop growth and tree growth unsaturated zone models.
- 3 Stores groundwater model which evolved from the CSIRO Biophysical Capacity to Change (BC2C) that estimates impacts of tree planting on average annual streamflow and stream salinity.
- Groundwater flow systems concepts that evolved from the National Land and Water Resources Audit and the CSIRO led Catchment Classification Project
- Spatial apportionment of end-of-catchment stream flow and stream EC as developed in the NSW CATSALT model and Land Use Options Simulator
- Spatial connectivity of surface hydrology as applied in the Victorian CAT model
- Terrain analysis developed by CSIRO to define alluvial areas and extent of saturation in a catchment (MrVBF model).

Collaboration between agencies

Prior to the commencement of Project 2C, the modelling activities across CSIRO and the three State Agencies were generally evolving and operating independently, sometimes competitively. Project 2C has provided the platform for collaboration and we now have an excellent level of commitment across partners. For example, agreement on the model design and process specifications, agreement to provide consistency in recharge modelling across State agencies and agreement to provide consistency in salinity modelling via 2C. While these are less tangible and nonscientific outcomes, they are vital for project success.

Co-funding arrangements

The second major difference is that Project 2C is co-funded by the CRC for Catchment Hydrology and the Murray-Darling Basin Commission (MDBC). The consequence of this is that there are two major pathways for integration. Within the CRC for Catchment Hydrology, integration and adoption is focused as part of the E2 whole-of-catchment model. Within the MDBC, the focus is integration with existing State Agency tributary models (IQQM and REALM) to provide the capacity to predict the impacts of salinity management scenarios on downstream water allocations, environmental flows, and their contributions to end-of-valley salinity targets. The 2C model also has to comply with formal model accreditation requirements under the MDBC Operational Protocols. To ensure ongoing review and adoption of 2C within Industry Parties, an MDBC Project Steering Committee (PSC) has been established. The PSC has the responsibility to:

- maintain the MDBC jurisdictional interests in the direction of the project
- ensure that the model effectively serves the needs of the States and Commonwealth for the implementation of State strategies and programs
- ensure basin-wide consistency and credibility in the development and application of the 2C model.

This requires a high level of scientific rigor and objective scrutiny of the project which is achieved during external review by the PSC every three months.

Progress so far

During the first 18 months of Project 2.21 (2C), there have been five major activities and outcomes:

1. A Project Team workshop was held in May 2003 to review existing activities across project partners, document organisational expectations from the project, and achieve agreement on model components and design specifications.

RECENT TECHNICAL REPORT

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

By
Klaus Hickel
Lu Zhang

Technical Report 03/11

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

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

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2. Following this workshop, a report containing the design specifications of the model was produced. This report reviews previous salinity models across project partners, describes the relevant components of these models and how they integrate into the 2C model, the new model components being developed within Project 2C, and provides a generic description of the 2C model.

3. A Process Specifications document has also been prepared that contains a mathematical description of the functionality within the 2C model.

4. A draft report has been written by John Gallant (CSIRO) describing methods for determining the saturated area of a catchment from terrain analysis (MrVBF model) and estimated discharge from hillslope aquifers.

5. A preliminary version of the 2C model has been developed by Matt Stenson (CSIRO Brisbane) in the TIME Graphical Shell for Data Analysis and Model Testing software. Further coding is underway to integrate the spatial functionality into TIME.

Spatial units in 2C model

Conceptually, the 2C model delineates two types of spatial units within a catchment:

1. Hydrological Response Units (HRUs) represent the spatial mosaic of climate, soil type, topography and land use within a catchment. The methodology to define HRUs is based on existing State Agency unsaturated zone modelling, and provides the portal to input monthly time series of runoff, lateral flow and recharge for each HRU into the 2C model.

2. Groundwater Response Units (GRUs) are defined to represent the major groundwater units in a catchment. Each GRU is represented by a 3 store model; an unsaturated zone store, a hillslope aquifer store and an alluvial mixing store. The concept of defining GRUs evolved from BC2C model concepts. A GRU is compatible with the Functional Unit or FU within the E2 Model.

Spatial aspects of groundwater systems

GRUs are derived from terrain analysis. As such, there is the underlying assumption that the spatial extent of groundwater systems is reflected in surface terrain. While this assumption may not be credible in all landscapes, the lack of more relevant spatial data to define GRUs limits the methodology. An example of the derivation of GRUs for a catchment is presented in Figure 2.1. In this simplified example, the Kyeamba Creek catchment in the Murrumbidgee is split into five GRUs based on subcatchment delineation. The coarse definition of GRUs for Kyeamba (ie only five GRUs) was decided for code testing purposes only. In the testing and application of 2C against real data, it is expected that a catchment of the size of Kyeamba would be split into more than five GRUs.

Alluvial areas

To parameterise a 3 store model for each GRU, a crucial input is the spatial extent of alluvial areas. This is being derived using the CSIRO MrVBF terrain analysis model. The combination of GRUs and delineated alluvial areas for Kyeamba is shown in Figure 2.2. Using the groundwater attributes from the available groundwater flow systems mapping, the spatial extent, depth, volume,

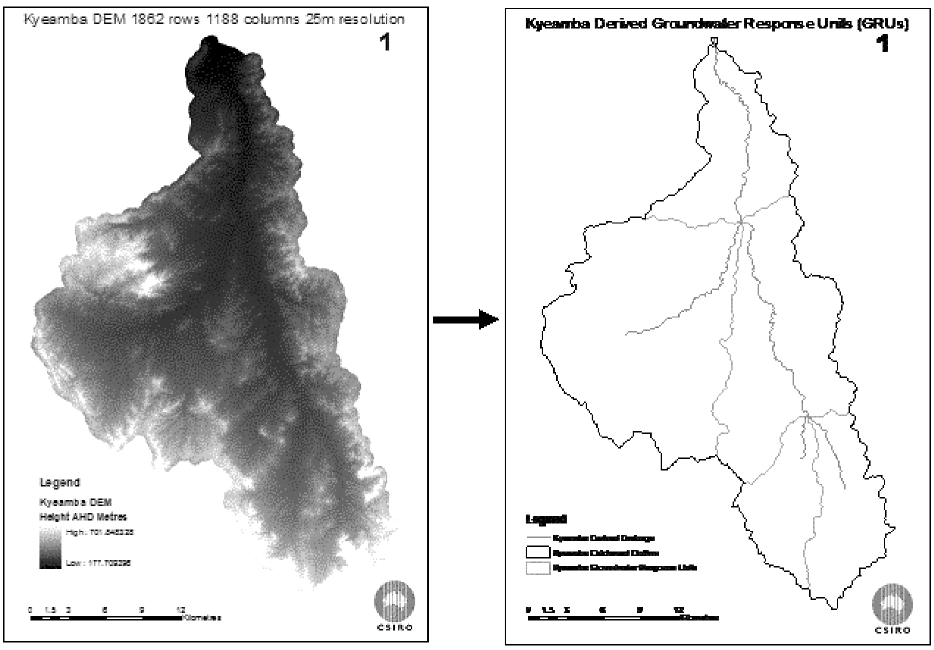

Figure 2.1. Deriving GRUs from a Digital Elevation Model for Kyeamba Creek in the Murrumbidgee

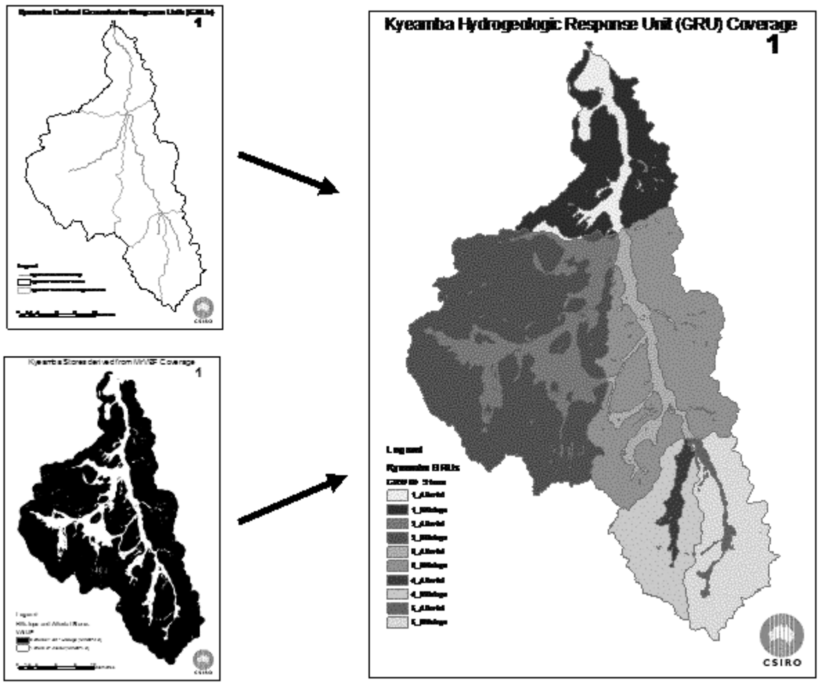

Figure 2.2. Combining GRUs with alluvial areas defined using MrVBF terrain analysis

specific yield, salinity and transmissivity of the hillslope aquifer and alluvial store in each GRU can be calculated. It can be seen from Figure 2.2 that the extent of alluvial stores varies across the Kyeamba catchment. Some GRUs have extensive alluvial areas (> 25% of area) while other GRUs are more incised streams with <10% of alluvial areas. With this procedure, we capture the relative contributions of alluvial mixing processes across a catchment, albeit in a fairly lumped way.

Water balance aspects

A conceptualisation of the 3 store model that is defined for each GRU is presented in Figure 2.3. The water balance is driven by the detailed unsaturated zone modelling for each hydrological response unit (HRU). Daily timeseries of runoff, lateral flow and recharge are accumulated to a monthly timestep and spatially averaged for all HRUs overlying the hillslope aquifer. These monthly time series provide the hydrological input for each GRU. Within each GRU, the monthly recharge signal is dampened through a hillslope aquifer and alluvial store before discharging to stream. The amount of dampening is determined from hydrogeological properties using non-linear storage-discharge relationships. A salt balance of all pathways and storages of water is maintained on a monthly timestep assuming uniform mixing of salt and water.

Predicting time series

Running a mass balance of water and salt for each GRU we can predict monthly time series of:

- Water and salt movement from runoff, lateral flow and recharge from the unsaturated zone.
- Volume, salt concentration, discharge and salt export from the hillslope aquifer.
- Volume, salt concentration, stream discharge, evaporation and salt export from the hillslope aquifer.
- Contributions to stream flow and stream salinity from surface runoff, lateral flow and stream discharge from groundwater.

Daily time series modelling

The final component of the 2C model is the spatial apportionment component that requires the input of a daily time series of stream flow and stream salinity at the catchment outlet. Sources of daily stream flow data include measured stream gauging data, the CRC for Catchment Hydrology rainfall runoff library, or Agency tributary models. Flow salinity relationships can then be used a calculate the daily time series of stream salinity data.

This daily time series is the "point of truth" of catchment stream flow and salinity under current land-use conditions. The spatial distribution of monthly output from each GRU (surface and groundwater water and salt) is then used to spatially weight the areas within a catchment that run off, discharge and export salt. In that way, the daily data at the catchment outlet is spatially apportioned or distributed throughout the catchment.

NEW TECHNICAL REPORT

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

By

Richard Silberstein

Technical Report 03/1

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

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

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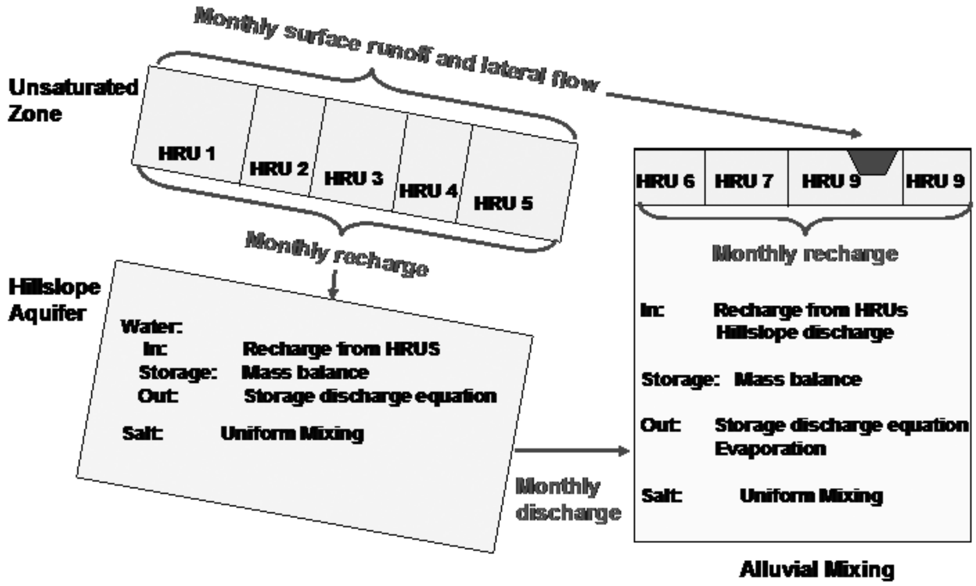

Figure 2.3. Conceptualisation of the 3 stores model for each GRU

This procedure captures the complexity of the daily time step modelling for each HRU on a simpler basis. The spatial apportionment process will incorporate the effects of spatial distributions of:

- climate, soil type, land use and topography on surface runoff to stream;
- groundwater processes (water movement, dilution or concentration of salt) in hillslope aquifers and the alluvial mixing store;
- groundwater discharge to stream.

The next phase of the project is model evaluation. Over the next six months, the 2C model will be tested against stream flow, stream EC and groundwater bore data for ten subcatchments across the entire Murray-Darling Basin.

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PROGRAM 3

SUSTAINABLE WATER ALLOCATION

Program Leader
JOHN TISDELL

Report by John Tisdell

Capacity constraints to water trading

Entitlements to extract water versus supply

Water delivery, especially in rural areas, depends on a physical network of rivers, streams and channels. Water authorities manage these physical networks, and through history have balanced the distribution of entitlements to extract with the capacity of the infrastructure to supply. In doing so, conflict over and limits to supply as a result of capacity constraints have been minimal.

Tradable water entitlements and constraints to trade

The basic premise behind the push to introduce tradable water entitlements is that water entitlements will move to their most profitable use. If this is so, water extraction should concentrate in particular locations and times where the returns to water are maximised. In some cases, the market demands to relocate extraction entitlements may exceed the capacity of the network system to supply. Over the coming months CRC Program 3, through integrated research across CRC Projects 3.08 (3A) and 3.09 (3B) will explore policy options for managing capacity constraints to trade.

Structure and management of water entitlements

The first area of research will focus on the magnitude of the problem at hand: how should such rights be structured and how the rights of existing and traded water extractors should be managed. Initial modelling using WRAM suggests that in some catchments the capacity constraints are likely to be a significant inhibitor to trade. Further modelling will provide more detailed knowledge of the matter.

Options for system capacity rights

Options for managing capacity limits include establishing separate rights to the capacity of the system. Capacity rights have become commonplace in other network-based markets for rail, gas and electricity networks, and airport landing slots. These markets use first-in-time, first-in right options, and equal or proportional rights according to pre-existing entitlements and use. These right options, among others, will be modelled and evaluated using WRAM and under laboratory conditions to assist water managers in developing water allocation rules and guidelines.

Pre-existing versus new users

Given the historic nature of water rights, one of the initial questions will be: how can the rights of existing extractive users be balanced against the rights of users trading water into a region? The literature is somewhat divided on this issue. For example, in a study of electricity capacity in California, argued that primary rights should exist for pre-existing right holders. Others argue that the rights should be auctioned in the first instance and not pre-determined. Projects 3.08 (3A) and 3.09 (3B) will jointly explore experience in other similar industries and the issue of pre-exiting rights further.

Separation of tradable rights from land and water

Having established a set of possible structures for capacity rights, the issue remains whether such rights are tradable, not just separate to land, but separate to water. The benefits of dual markets for water and capacity rights will be explored in terms of dual efficiency and transaction cost issues.

Next steps

Program 3 is now in an excellent position to provide to industry the tools necessary to fully evaluate these types of water allocation issues. The next few months of research should provide not only interesting, but vital input in the future development of water allocation and trading rules.

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NEW TECHNICAL REPORT

Nature, Preparation and Use of Water Accounts in Australia

By
Manfred Lenzen

Technical Report 04/2

This report on the nature and use of water accounts reviews major research activities and outcomes in this important area, especially the work carried out at the Australian Bureau of Statistics, CSIRO and University of Sydney in Australia. The report outlines the methodology to integrate water accounts into input-output transaction tables for water multiplier calculations, and highlights the data-intensive nature of input-output analysis and spatial issues associated with regional water accounts and input-output tables.

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PROGRAM 4

URBAN STORMWATER QUALITY

Program Leader TIM FLETCHER

Report by Margaret Greenway

Stormwater treatment devices - How effective are they in maintaining ecosystem health?

Background

In *Catchword*, March 2004, Program Leader Tim Fletcher outlined the objectives of Program 4 and the current status of activities. The overall purpose is "to develop urban stormwater management systems to better protect environmental and community values of urban aquatic ecosystems". Research at the Griffith University node has focused on monitoring the effectiveness of several stormwater treatment devices for improving water quality (*Catchword*, April 2002; *Catchword*, November 2002; Greenway *et al.*, 2002; Kasper and Jenkins, 2003) and monitoring ecosystem health.

Urban runoff as pollution source

Urban stormwater runoff is a potential pollution source to downstream waterways and aquatic ecosystems. Suspended solids increase water turbidity which reduces light penetration and photosynthesis. If there is a high proportion of organic particles, then biochemical oxygen demand (BOD) increases. These organic particles provide a food source for micro-organisms which use up oxygen in aerobic respiration, and this may lead to oxygen depletion. Nutrients are essential for plant (and animal) growth. However, excess nutrients, in particular soluble inorganic nitrogen and phosphorus, can increase the growth of unicellular algae and cyanobacteria causing algal blooms. Dense blooms can also increase turbidity and BOD, and some cyanobacteria are toxic. Other potential stormwater pollutants include heavy metals, pesticides/herbicides, oils/grease and microbial pathogens. These substances are often more localised and their impact on aquatic ecosystem health is usually not acute.

Ecosystem health

Ecosystem health can be a difficult concept to define, since it can incorporate a wide range of properties from loss of an individual species to complete ecosystem dysfunction. In our study, we have been looking at the following properties of ecosystem health: macroinvertebrate species richness, mosquito larvae abundance, aquatic plant species and abundance, and chlorophyll-a as an indicator of phytoplankton biomass.

Our research efforts have focused on two field sites in Brisbane:

(1) Golden Pond "treatment train", consisting of a sediment basin, constructed wetland, pond, two below-ground GPTs, natural riparian wetland, 600m length of natural stream channel and lagoons, at Calamvale

(2) Bridgewater Creek "wetland", consisting of a series of six interconnected ponds with fringing littoral vegetation at Coorparoo.

Study Area and Sampling Locations

<u>Golden Pond, Calamvale</u>

Five locations were sampled for macroinvertebrates:

(1) Upstream channel, a 200m concrete-lined (reno mattress stencil) channel receiving runoff from an urbanised (post-1990) residential catchment of 160ha: Periphyton cover the concrete, and the micro-undulating relief of the stencil provides numerous mini pools with coarse sediment and larger pebbles.

(2) The sediment basin, a relatively small trapezoidal concrete structure (21m x 13.5m x 1.5m): Filamentous algae covers the sides, and coarse sand forms the bottom substrate.

(3) Wetland 1, a constructed wetland (80m x 15m x 0.5-1.2 m) dominated by floating-leaved emergent species (60-90% cover) and an abundance of submerged pond weed (Elodea): The substrate grades from sand at the top to silt at the bottom.

(4) Wetland 2, a modified farm dam (52m x 20m x 0.6-1.6 m), also dominated by floating-leaved emergent species: The submerged pond weed Ceratophyllum is abundant. The substrate is silt.

(5) Downstream creek, a 600m length of the original stream channel and lagoons, with a mix of sand and silt substrates.

<u>Bridgewater Creek, Coorparoo</u>

Four locations were sampled for macroinvertebrates:

(1) Upstream channel, a 200m concrete, channelised creek bed from 0.5-1.5m width, receiving runoff from an old (pre-1950) urbanised catchment of 157ha: The deposition of larger pebbles has promoted a pool-riffle effect. Due to shading, periphyton growth is more limited.

(2) Pond 1, the sediment basin, a large (0.1ha), deep (2m), open-water pond fringed by a narrow band of Schoenoplectus: The substrate is silt overlain with a thick layer of organic detritus (deposited leaf litter).

Table 4.1. Water-quality data (mg/L) for wet weather (i.e. within 12h of a storm event).

	TSS	NH_4-N	NO_3-N	TN	PO_4-P	TP
Golden Pond, Calamvale						
Upstream concrete channel	17 ± 12	0.10 ± 0.10	0.44 ± 0.33	1.34 ± 1.00	0.06 ± 0.05	0.21 ± 0.05
Sediment basin	20 ± 8	0.09 ± 0.09	0.38 ± 0.28	1.23 ± 0.58	0.06 + 0.06	0.12± 0.05
Wetland 1	26 ± 10	0.08 ± 0.07	0.28 ± 0.18	1.12 ± 0.58	0.06 ± 0.06	0.13 ± 0.07
Wetland 2	24 ± 12	0.07 ± 0.04	0.22 ± 0.16	0.94 ± 0.51	0.05 ± 0.05	0.11 ± 0.06
Downstream natural creek	28 ± 16	0.09 ± 0.05	0.32 ± 0.27	0.98 ± 0.60	0.05 ± 0.04	0.11 ± 0.08
Bridgewater Creek, Coorparoo						
Upstream concrete channel	60 ± 25	0.14 ± 0.12	0.43 ± 0.21	4.7 ± 2.7	0.14 ± 0.16	0.70 ± 0.38
Pond 1	42 ± 38	0.13 ± 0.11	0.46 ± 0.37	2.7 ± 3.1	0.15 ± 0.21	0.21 ± 0.19
Pond 6	34 ± 33	0.13 ± 0.22	0.10 ± 0.08	0.84 ± 0.21	0.02 ± 0.02	0.12 ± 0.08

Table 4.2. Water-quality data (mg/L) for dry weather (base flow).

	TSS	NH_4-N	NO_3-N	TN	PO_4-P	TP
Golden Pond, Calamvale						
Upstream concrete channel	7 ± 8	0.03 ± 0.03	0.53 ± 0.67	0.57 ± 0.31	0.04 ± 0.04	0.08 ± 0.02
Sediment basin	6 ± 3	0.05 ± 0.05	0.56 ± 0.71	0.70 ± 0.33	0.03 ± 0.03	0.08 ± 0.01
Wetland 1	14 ± 6	0.03 ± 0.03	0.25 ± 0.49	0.63 ± 0.33	0.02 ± 0.02	0.07 ± 0.02
Wetland 2	13 ± 9	0.08 ± 0.09	0.25 ± 0.23	0.97 ± 0.50	0.05 ± 0.08	0.14 ± 0.07
Downstream natural channel	6 ± 4	0.04 ± 0.07	0.09 ± 0.11	0.60 ± 0.28	0.02 ± 0.02	0.05 ± 0.03
Bridgewater Creek, Coorparoo						
Upstream concrete channel	30 ± 30	0.58 ± 0.79	2.32 ± 0.99	2.8 ± 10	0.27 ± 0.26	0.26 ± 0.11
Pond 1	10 ± 6	0.10 ± 0.09	0.12 ± 0.24	1.28 ± 0.45	0.08 ± 0.06	0.22 ± 0.10
Pond 6	16 ± 8	0.11 ± 0.11	0.10 ± 0.14	1.04 ± 0.36	0.02 ± 0.01	0.17 ± 0.07

Note: Water Quality Objectives for Brisbane City Council are TSS 15 mg/L, TN 0.65 mg/L, NH_4-N 0.035 mg/L, NO_3-N 0.13 mg/L, TP 0.07 mg/L, PO_4-P 0.035 mg/L.

(3) Pond 6, the last of five connected ponds, about 0.06ha (0.5-1.6m deep), fringed by a narrow band of emerged macrophytes. The substrate is silt.

(4) Downstream channel, a 100m modified creek bed (1.5m width) with pools and riffles, and densely overgrown by aquatic vegetation.

Results: Water Quality

Water-quality data for the sampling sites is shown in Tables 4.1 and 4.2. Water quality was not monitored in the downstream channel at Bridgewater Creek, as this site receives its base flow from Pond 6.

Water quality of stormwater entering the treatment devices is highly variable in both wet and dry weather. Golden Pond receives a better water-quality runoff than Bridgewater Creek, with baseflow concentrations below the Water Quality Objectives. TSS, TN and TP increase in the wetlands due to the organic particulates. At Bridgewater Creek, baseflow TSS, TN and TP are reduced in the ponds, but mean values still exceed Water Quality Objectives. During storm events, mean TN and TP exceed Water Quality Objectives, but significant reductions occur, especially at Bridgewater Creek. TSS is also reduced at Bridgewater Creek, but at Golden Pond, TSS increases due to re-suspension. These comparative data indicate the benefit of the deep-water ponds to minimise re-suspension. The phytoplankton populations in Pond 1 would account for most of the removal of soluble nutrients.

URBAN STORMWATER SOFTWARE

Model for Urban Stormwater Improvement Conceptualisation (MUSIC) version 2

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

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

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

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

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

NEW TECHNICAL REPORT

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

By
André Taylor
Tony Wong

Technical Report 03/14

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

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

This report is available as an Adobe .pdf file.

Visit www.catchment.crc.org.au/publications

Results: Ecosystem Health

Phytoplankton

Table 4.3. A comparison of chlorophyll - a (µg/L) as an indicator of phytoplankton biomass.

Golden Pond	Dry	Bridgewater Creek	Dry	Wet	2004
Sediment basin	3.5 ± 0.6	Pond 1	62 ± 80	12 ± 15	24 ± 8
Wetland 1	5.5 ± 3.2	Pond 6	12 ± 10	35± 25	55 ± 30
Wetland 2	3.2 ± 0.8				

Chlorophyll-a only exceeded Brisbane City Council Water Quality Objective of 8 µg/L in the ponds at Bridgewater Creek. The higher chlorophyll-a values in Pond 6 compared to Pond 1 in our wet weather samples appears to be a flushing-out effect. In dry weather, algal blooms occurred in Pond 1. However, the series of ponds were effective in reducing phytoplankton growth, despite similar soluble inorganic nitrogen concentrations. Although the mean phosphate concentration in Pond 6 was only 0.02 mg/L compared to 0.08 mg/L in Pond 1, the N:P ratios are not limiting for phytoplankton growth. PhD student Mark Bayley is investigating phytoplankton and bacterioplankton dynamics in the pond system at Bridgewater Creek.

Light profiles are similar in Pond 1 and Pond 6, and during the first two years, DO profiles were similar. However, due to the large quantities of organic matter - mostly leaf litter that has washed into Pond 1 - it has recently become anaerobic, with surface DO of 1.2 mg/L and bottom DO of 0.2 mg/L. These conditions are now limiting phytoplankton and periphyton growth, with Pond 6 now having higher chlorophyll-a values than Pond 1 (Table 4.3 - 2004 values).

Phytoplankton species diversity changed with seasons and following rain events. Many of the genera identified are noted for their occurrence in eutrophic waters.

Macroinvertebrates

As some macroinvertebrate species are more tolerant of polluted waters than others, they are useful indicators of the water quality and ecological health of freshwater habitats. The Stream Invertebrate Grade Number - Average Level (SIGNAL) (Chessman, 1995) method takes advantage of this gradient of tolerances amongst macroinvertebrate species and can be used to give a measure of the pollution level of a water body, ranging from a "healthy habitat" to a "severely polluted" one. Therefore the monitoring of macroinvertebrate taxa upstream and downstream may give an indication of the success of a stormwater treatment device in improving water quality.

Table 4.4. Major macroinvertebrate taxa, SIGNAL-2 score and SIGNAL-2 family score.

Macroinvertebrate Taxa	Golden Pond					Bridgewater Creek			
	Upstream Channel	Sediment Basin	Wetland 1	Wetland 2	Downstream Natural Creek	Upstream Channel	Pond 1	Pond 6	Downstream Modified Creek
Annelida, Nematoda, Flatworms	3	4	5	6	6	3	9	3	5
Gastropoda (water snails)	5	5	8	8	8	4	4	2	4
Microcrustaceans,mites	3	4	5	4	4	1	6	2	4
Epiproctophora (dragonflies)	5	2	11	6	3	6	4	3	11
Zygoptera (damselflies)	1	1	3	3	5	1	2	5	4
Ephemeroptera (mayflies)	1	1	1	1	0	1	0	1	2
Hemiptera (water boatmen)	1	1	4	4	1	2	3	8	6
Diptera (flies, mosquitoes)	3	2	3	4	2	6	6	5	8
Coleoptera (water beetles)	1	0	0	0	4	3	0	8	6
Trichoptera (caddisflies)	0	0	1	1	1	0	0	2	3
TOTAL TAXA	**23**	**20**	**43**	**37**	**34**	**27**	**34**	**39**	**53**
SIGNAL-2	**2.6**	**2.8**	**2.5**	**2.7**	**2.9**	**2.8**	**2.6**	**2.7**	**2.7**
FAMILIES	**12**	**11**	**20**	**16**	**18**	**18**	**19**	**25**	**26**

From Table 4.4, it is very evident that the constructed stormwater wetlands and ponds with vegetation increased species richness compared with the channelised upstream creek bed. At Bridgewater Creek, the vegetated section of creek downstream of the wetlands had the highest species richness. The SIGNAL-2 scores fall within a very narrow range (2.5 - 2.9) and fall within the lowest score category (< 4). A score of < 4 is indicative of "probable severe pollution" (Chessman, 2001). At Bridgewater Creek, the more densely vegetated Pond 6 had a higher ranking than Pond 1, with hemipterans and coleopterans being the most diverse taxa in Pond 6.

The sediment basin at Golden Pond had the lowest number of taxa (20) and families (11), but a higher SIGNAL-2 scale (2.8) than most sites. The application of SIGNAL scores to wetlands, ponds and slow-flowing creeks must be treated with caution, since SIGNAL grades are derived from, and generally used for fast-flowing water.

Microcrustaceans (copepods, ostracods, cladocerans), insects (dragonfly and damselfly larvae, water beetles, water boatman); pond snails are a crucial component of wetland ecosystems providing invaluable food web linkages between plants, micro-organisms and other animals. Predator-prey relationships are important in the control of mosquitoes. An abundance of large cladocerans were observed in the ponds at Bridgewater Creek. As no fish were found, this could account for the large numbers and size of these zooplankton. They are also important grazers of phytoplankton.

Wetland plant diversity is important for determining macroinvertebrate associations and wildlife diversity (Knight *et al.* 2001) because of the creation of habitats and food resources. Wetzel (2001) noted that the most effective wetland ecosystems "are those that possess maximum biodiversity of higher aquatic plants and periphyton associated with the living and dead plant tissue". Wetland 1, Wetland 2 and the downstream modified creek were the most densely vegetated sites and had the most species of aquatic macrophytes and macroinvertebrates..

Mosquitoes

In aquatic ecosystems, mosquito larvae are an integral component of aquatic food webs. However, because mosquitoes can pose a risk to public health, there is often concern that constructed wetlands will encourage mosquito breeding. While most mosquitoes are opportunistic breeders, they will only deposit eggs if a suitable body of water is available. A critical and significant issue for successful mosquito breeding is larval survival and whether adult mosquitoes emerge from pupae. If constructed wetlands are designed to function as wetland ecosystems with a diversity of aquatic organisms, then it is likely that the predator/prey mix would control mosquito breeding (Greenway *et al.*, 2003).

In the wetlands at Golden Pond and Pond 6 at Bridgewater Creek, less than 5% of sampling dips over a 12-month period contained mosquito larvae, and when present, they were in very low numbers (< 10/200 mL scoop). Pond 1 recorded more larvae (14% of dips), but these occurred amongst dead vegetation, and most were only the very juvenile first and second instars. No pupae were found, indicating that the larvae did not complete their life cycle. Predation by abundant microcrustaceans and notonectids appears to be controlling mosquito larvae.

Acknowledgements

Carolyn Polson, Margaret Greenway, Graham Jenkins, Anu Datta and Mark Bayley have contributed to monitoring ecosystem health.

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UPCOMING TECHNICAL REPORT

Integrated Stormwater Treatment and Re-use Systems - Inventory of Australian Practice

By
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Ana Deletic
Tim Fletcher

Technical Report 04/1

The aim of this research was to develop an inventory of technologies for the collection, treatment, storage, and distribution of general urban stormwater runoff and, where current knowledge allows, provide interim guidance on stormwater re-use implementation.

Bound copies of this report are available from the Centre Office for $27.50 (include GST and postage and handling).

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

NEW TECHNICAL REPORT

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

By
Ratnasingham Srikanthan
Senlin Zhou

Technical Report 03/16

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

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

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

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

This report is also available as a free Adobe .pdf download from www.catchment.crc.org.au /publications

PROGRAM 5

CLIMATE VARIABILITY

Program Leader
FRANCIS CHIEW

Report by Andrew Western

Land cover and soil property data sets for modelling toolkit

Spatial data needs

Many CRC modelling tools require spatial data of one form or another. Recently two data sets have been collated and will be available via the CRC Catchment Modelling toolkit website (www.toolkit.net.au). These data sets provide information on land cover (vegetation type) and estimates of soil hydrologic properties. They are suitable for use with a variety of CRC for Catchment Hydrology Catchment Modelling Toolkit products.

Soil properties - data sources

The spatial soils data set was developed by combining Neil McKenzie's interpretations (McKenzie *et al.*, 2000) of soil properties for the Northcote soil types (principal profile forms) with a digitised version of the Atlas of Australian Soils from the Bureau of Rural Sciences. This approach provides a reconnaissance scale mapping of Australia's soil properties relevant to hydrological modelling. Qualitative reliability information is provided as part of the product. The soil maps consist of raster representations of soil landscapes with a pixel size of ~1km. An associated database provides soil properties for each soil landscape. These properties include estimates of solum depth and solum plant available water holding capacity and for each of the A and B horizons, horizon thickness, porosity, field capacity, wilting point and saturated hydraulic conductivity. As an example of the data, Figure 5.1 shows estimates of plant available water holding capacity.

Regional and local coverage

The soils data set provides a broad scale picture of soils across the continent and it is suitable for analyses covering large regions. The limitations of the data set are documented in the user guide. While there is significant uncertainty in the soil property estimates, it is the only spatially comprehensive data set for Australia. For local analyses more spatially detailed mapping is available in some areas and this should be used where

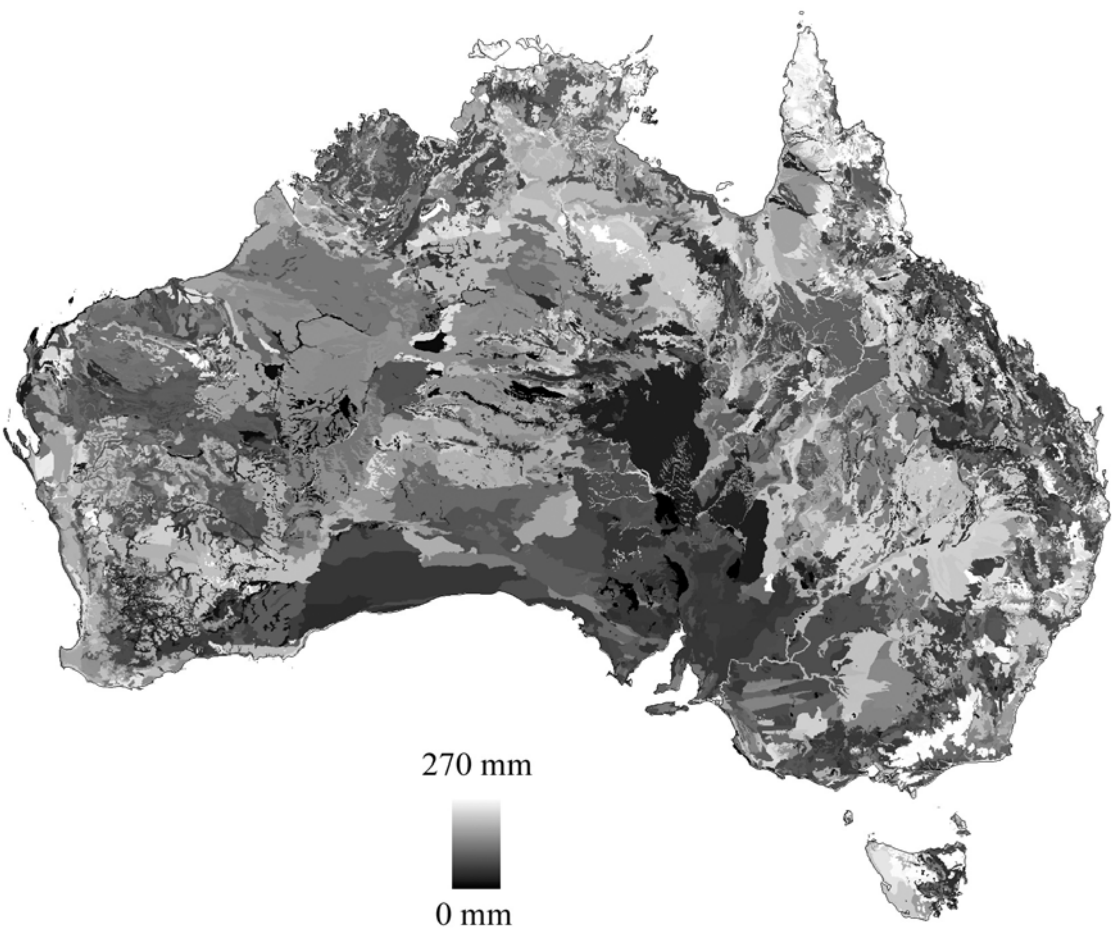

Figure 5.1: Estimates of the distribution of plant available water holding capacity across Australia.

possible. However, for many model applications it would be necessary to estimate soil properties for the soil landscapes mapped on these regional maps.

A challenge when combining these data sets is that the Atlas of Australian Soils provides delineations of soil landscapes, which are associations of a number of different soil types (as defined by specific profile characteristics). Thus, when combining the two data sets, it is necessary to make some assumptions about the relative frequency of different soil types in each soil landscape. The approach of Neil McKenzie and colleagues (McKenzie *et al.*, 2003) was followed and is outlined in more detail in the data set documentation.

Application in CRC Projects

The soil property data sets have been utilised in the CRC's Project 5.05 (5A) 'Hydrological modelling for weather forecasting' and Project 1.2: 'Scaling procedures to support process-based modelling at large scales'. In Project 1.2 we assessed the accuracy of plant available water storage estimates (Ladson *et al.*, 2002). This work identified a bias in the estimation of active soil depth such that the estimates were typically too small, especially for sites with trees. Neil McKenzie and colleagues (McKenzie *et al.*, 2003) have been working on better approaches to estimating soil depths utilising terrain analysis techniques to address this limitation.

In Project 5.05 (5A) we have used the soils data sets to set soil parameter values in the European Centre for Median Range Weather Forecasts (ECMWF) land surface scheme used in the Bureau of Meteorology's Numerical Weather Prediction models. The model results were compared with soil moisture data collected by The University of Melbourne's soil moisture monitoring network across the Murrumbidgee catchment. This work showed that there was significant uncertainty in the wilting points estimated from this data set.

Uncertainties in data sets

These analyses illustrate the uncertainties associated with these data sets and the need for improved national soils information. At present the Australian Soil Resources Information System (ASRIS) is being developed by the Australian Collaborative Land Evaluation Program following on from initial work within the National Land and Water Audit. ASRIS should lead to progressive improvement in the data available for modelling and the data will be available via a web interface in the future (2004 and 2006).

Vegetation/Land cover data

The land cover data sets are based on those developed by the Bureau of Rural Sciences Australian Land Cover Change project (Barson *et al.*, 2000). These data sets were developed by analysing Landsat imagery from 1990/91 and 1995 for the intensive use zone of Australia. Additional vegetation properties from state and federal databases were added also for the forest areas. These data sets were reprojected to map projections commonly used for hydrologic modelling (Geographic, Map Grid of Australia) and generalised, resulting in maps co-registered with the soils maps. Information relevant to hydrological modelling was extracted from the associated structural vegetation data base and put in a database that can be read by applications developed in TIME, the modelling framework used to develop the CRC models.

Applicability of land cover data sets

The land cover data sets are valid for 1990 and 1995. They include the type of land cover categorised as bare, urban, water, grassland/crop, plantation, orchard and (other) woody vegetation. Woody vegetation is defined as areas with vegetation at least 2m high and with at least 20% canopy cover. Where available, the woody vegetation has information providing canopy cover percentages (4 categories) and heights (4 categories). The Australian Greenhouse office are extending the time series of land cover estimates to cover twelve time periods from 1972 to 2002 and these data are expected to be released publicly in the future.

Figure 5.2 shows the 1995 land cover with black representing woody vegetation, dark grey representing plantations and orchards and light grey representing pasture/crop, bare, urban and water surfaces. Forest cover is an important determinant of catchment yield and this data set is ideal for determining inputs to analyses using approaches to predicting catchment yield based on climate and vegetation (Zhang *et al.*, 2001).

Spatial data set and the Catchment Modelling Toolkit

Both the spatial soils data sets and the land cover data sets will be made available from the Catchment Modelling Toolkit website and are in formats that can be read by TIME and by a range of GIS products. These data sets are being used in making regional estimate of parameters for the SIMHYD and SEDNET models. SIMHYD is one of the models in the rainfall-runoff library and used in present EMSS modelling, and SEDNET is also a Catchment Modelling Toolkit product. They provide useful information for a range of other initial analyses and large scale analyses. However more detailed and reliable local data sets, especially for soil properties, are available in some areas and these may provide a better basis for regional and small scale analyses where they area available.

RECENT TECHNICAL REPORT

Stochastic Generation of Climate Data

By

Ratnasingham Srikanthan
Senlin Zhou

Technical Report 03/12

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

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

This report is available as an Adobe .pdf file.

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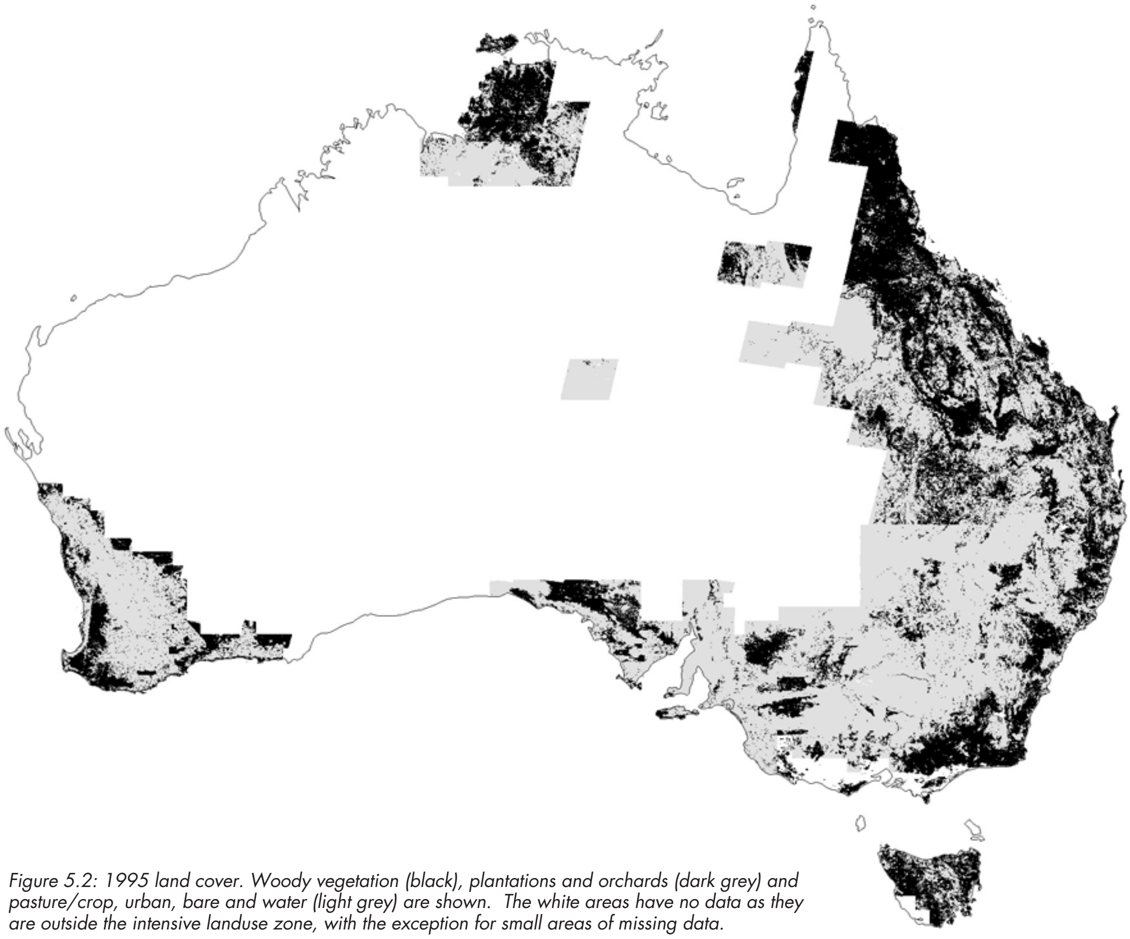

Figure 5.2: 1995 land cover. Woody vegetation (black), plantations and orchards (dark grey) and pasture/crop, urban, bare and water (light grey) are shown. The white areas have no data as they are outside the intensive landuse zone, with the exception for small areas of missing data.

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PROGRAM 6

RIVER RESTORATION

Program Leader
MIKE STEWARDSON

Report by Justin Costelloe

Project 6.14: Quantifying the health of ephemeral rivers

Introduction

There are many systems and indicators aimed at measuring the health of rivers, but most of these have been developed for perennial streams and rivers of south-eastern Australia. The applicability of indicators for measuring the health of ephemeral rivers and streams is currently the focus of a study commissioned by Land and Water Australia. The study is being carried out as a joint project involving CRC for Catchment Hydrology (as an Associated/Additional project in Program 6) and the CRC for Freshwater Ecology (CRCFE). This study is using the range of ephemeral streams and small rivers of the Mt Lofty Ranges region around Adelaide (See Figure 6.1) to evaluate the utility of a large selection of river health indicators, including measures of hydrological, geomorphological and biological health.

Work to date

Literature reviews have identified a number of indicators of river health that have been trialled on the study catchments between November 2003 and February 2004. From the initial fieldwork, a selection of these indicators has been chosen for further evaluation over two more field trials in June and November/December 2004. The effects of relatively short-term temporal variability on some of the indicators of instream biological health will also be evaluated by monthly sampling during 2004.

The river health indicators evaluated during the fieldwork are being analysed using statistical methods to determine their effectiveness in measuring river health over the wide range of sites used in the pilot study. This analysis is ongoing and the applicability of the indicators is being assessed using three possible methods:

- Performance against a 'disturbance gradient',
- Performance against a 'synthetic reference condition',
- Usefulness as a risk assessment measure.

The pros and cons of these three methods for evaluating the utility of river health indicators are briefly discussed below.

Disturbance Gradients

Definitions

A disturbance gradient is a measure of the dominant cause of 'disturbance' within a catchment that results in fundamental and widespread changes in the health of that catchment and surrounding catchments. The disturbance gradient should not be specific to a particular catchment or region, otherwise it restricts the capability of exporting the river health assessment method to ephemeral rivers in other regions. If indicators of stream health show a strong relationship with the chosen disturbance gradient then they are likely to be robust and applicable over wide areas and different regions. If they don't show a strong relationship with the disturbance gradient, then they may still be useful indicators but are not providing information of the effects of the disturbance gradient.

Limitations

Two potential problems can occur with the disturbance gradient approach. Firstly, it is assumed that changes in catchment health are due predominantly to that single gradient. If a catchment is affected by a number of problems (e.g. land clearing, urbanisation, diffuse pollution, instream storages) then it may be difficult to identify strong relationships between indicators of catchment health and the disturbance gradient (or some combination of disturbance gradients). Secondly, if the disturbance gradient coincides with a natural gradient of physical characteristics, such as mean annual rainfall, then it is difficult to know if the indicator of catchment health is responding to the disturbance gradient or to the natural gradient.

Two disturbance gradients were initially tested that considered the effects of land clearing and the effects of farm dams. A third, the effects of urbanisation, is being considered. These disturbance gradients are considered to have the most effect on the hydrology of the study sites (greater Mt Lofty Ranges) and as such are likely to have effects on the geomorphology and biology of these river systems.

Major disturbances considered - findings

- Land Clearing: the clearing of deep rooted native vegetation and its replacement with shallow rooted vegetation (e.g. pasture) results in a change in the water balance of the catchment. For instance, this study has found that the change in the water balance of the catchment from land clearing is likely to be between 32% and 218% of the mean annual runoff of the study sites.

NEW TECHNICAL REPORT

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

By

Jo Chong

Technical Report 03/2

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

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

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

This report is also available as a free Adobe .pdf download from www.catchment.crc.org.au /publications

- Farm Dams: the increase in farm dams over the past 20 years has had the opposite effect of land clearing in that it has taken water out of the river system.
- Impervious surfaces (urbanisation): data on the amount of impervious (or urban) surfaces in a catchment are currently being obtained and will be analysed in the near future.

Comparison of disturbance gradients

From initial regression analysis, we found that the disturbance gradients have significant correlations with some of the physical gradients occurring across the study reach, particularly with catchment area and mean annual rainfall. In general, the disturbance gradients have shown no strong correlations with the measures of river health that were available from the pilot field program. Standardisation of the disturbance gradients (e.g. catchment dam capacity divided by the catchment mean annual rainfall, and catchment change in annual water balance from clearing divided by mean annual runoff) reduced the correlation between the disturbance gradients and natural gradients but did not improve the correlation between disturbance gradients and catchment health indicators. Further statistical manipulation of the disturbance gradient and indicator datasets is underway using the canonical correlation approach. This method allows the correlation between a matrix of disturbance gradients and a matrix of natural gradients to be identified and the residual information from the disturbance gradient matrix can then be used to identify any significant correlations with the indicator datasets.

Synthetic Reference Condition

Another method of assessing the usefulness of an indicator in measuring river health is to use a 'reference condition' approach. Reference sites are chosen that are relatively undisturbed and considered to retain most of their natural values. The value of any given indicator at the reference site provides the benchmark for measuring if there has been a decrease in river health at other, more disturbed sites. In regions where nearly all of the catchments show signs of decreased river health due to human impacts, such as the catchments of the Mt Lofty Ranges, it can be very difficult to identify reference sites of 'natural condition'. (See Figure 6.2)

A 'synthetic reference condition' approach avoids the problem of the lack of suitable reference sites by defining the optimum, or 'natural' value of an indicator, according to an agreed scale. For example, an indicator of riparian health such as the 'percentage of native overstorey' would have a synthetic reference value of 100%. However, synthetic reference conditions are more difficult to define for many other indicators. For instance, in a region where the salinity of the stream may show significant natural fluctuations, it is difficult to define a widely applicable synthetic reference value for stream salinity.

The synthetic reference condition approach is being evaluated in conjunction with the disturbance gradient approach. It is likely that different measures of river health will require separate approaches. For instance, the initial statistical analysis of indicators of riparian health found that they did not show any significant relationship with the disturbance gradients. This group of indicators are more likely to respond to the synthetic reference approach whereas it is possible that other measures may respond more to the disturbance gradient approach.

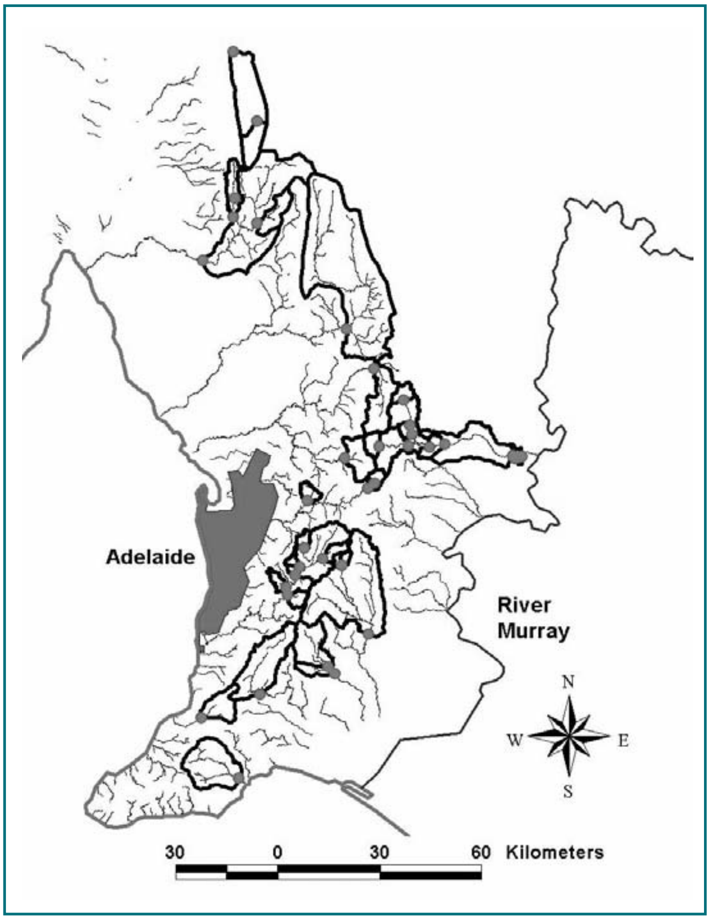

Figure 6.1. Location of study sites (dots) and study catchments within the Mount Lofty Ranges.

Risk Assessment Measures

A third approach is to devise indicators that provide some measure of risk assessment of the potential of the river health to change. Two examples of this approach are indicators of the potential for further channel incision and the use of the algal plates to identify sites susceptible to algal blooms. This moves away from a purely disturbance gradient approach as these measures do not need to be significantly correlated to a disturbance gradient to be deemed useful.

Proposed Outcomes

The project will complete the identification of suitable river health indicators during 2005 and produce a set of protocols for assessing the health of the ephemeral rivers. If the current analysis demonstrates that the disturbance gradient approach is not suitable for evaluating the effectiveness of river health indicators, then a combination of the synthetic reference condition approach and risk assessment measures will be adopted. A workshop will be held in late 2005 to demonstrate the river health assessment method for ephemeral rivers.

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Figure 6.2. Lenswood Creek of the Torrens River catchment. Note the channel incision and domination of the riparian zone by exotic vegetation.

COMMUNICATION AND ADOPTION PROGRAM

Program Leader
DAVID PERRY

The Flow on Effect - June 2004

At a glance - a summary of this article

This month's article provides brief background to the development of the CRC for Catchment Hydrology website and an overview of the updates to both the Catchment Modelling Toolkit and CRC websites at www.toolkit.net.au and www.catchment.crc.org.au respectively.

The development of the CRC's websites

Seven years ago when I first started work with the CRC for Catchment Hydrology I was very enthusiastic about updating the CRC's website to better meet the information needs of land and water management professionals. At that time the CRC site gave an overview of the CRC and its research programs, but other than information about the research we were undertaking, there was little else for the visitor. Since then I have been very fortunate to work with some highly skilled web developers who have been able to build and develop a website that presents our research team's work and activities in an easily accessible form for the land and water industry.

At the commencement of this CRC in 1999 we made a strong commitment to utilise the website as a key information vehicle to reach our target audience. However, deciding what should be (as opposed to what can be) on a website is a difficult business. Visitors to a website must be given a good reason for going there - the site must be able to offer visitors something they need and they must be able to access it quickly and easily. When we updated the CRC website's capability in 1999 we included on-line copies of *Catchword*, provided details of our new research programs and listed the outcomes from earlier research in the initial CRC. The 'News' and 'Events' pages were added to assist industry practitioners in learning about advances and activities in their area of interest and we added a 'subscription service' for visitors to join the *Catchword* mailing list or to request regular updates on publications, training and software. Most importantly, we made the commitment to make all of the publications from the new CRC available through the site as Adobe pdf files. Currently there are over 100 publications (including technical reports, industry reports, and copies of the CRC's Annual Reports) available on line.

A Sydney Harbour Bridge?

Certainly the most important lesson I have learned through my experience in contributing to the CRC website is the importance of maintaining the information on the site and the resources to do that. The actual design, construction and launching of a website is simply the start of the project. The real work is ensuring that the all of the site's information is up to date and continues to be of value to the visitor. It's a bit like painting the Sydney Harbour Bridge - as soon as you have finished, you need to start all over again. Hence my advice is to never underestimate the resources required to maintain a website, particularly when it is a vehicle for communicating knowledge. Once information on a website is no longer relevant, or has been superseded, it can very quickly become misinformation and a good reason for a visitor not to return.

You're only as good as your last update

Often the capability and responsibility to update information on the website rests solely with a web designer/web master. This works well as long as your web master never takes holidays, is available 24 hours a day and always gives the task the highest priority. Fortunately our CRC has enjoyed the skills of web masters who have appreciated this potential problem and taken steps to avoid it. Rather than code (write) the entire website's information and formatting in html - what you see if you 'view source' in your browser - our web masters have utilised web specific database software to overcome this problem. This means that the majority of the information on the website is stored in a database. The web pages do not actually exist in a formal sense but are created 'on the fly' when the visitor requests a particular page by clicking on the link to that page. The advantage is that once a user-friendly interface is created to allow modifications to the database records, then other staff (not just the web master) can update the information and it becomes live immediately. Now is a very good time to thank Virginia Verrelli and Maeve O'Leary who have updated the CRC site events, news, publications and staff contact details since 1999.

Both the CRC for Catchment Hydrology website at www.catchment.crc.org.au and the Catchment Modelling Toolkit website at www.toolkit.net.au rely heavily on this software called 'Web Objects'. The Toolkit website in fact has very little information on it that isn't stored in a database. Similarly, the CRC's 'Bushfires and Hydrology' website at www.catchment.crc.org.au /bushfire - established in response to the industry's call for information about the effects of bushfires on catchments in the wake of the January 2003 devastating fires - uses this same approach.

Development of the Catchment Modelling Toolkit

Ongoing development of the Catchment Modelling Toolkit has been the major focus of the Communication and Adoption team's efforts until very recently. A revised version of the Toolkit website has just been released with new features added to allow CRC research staff to revise and add information about Toolkit products as they evolve. The new version also allows registered Toolkit members to select the type of emails they receive from the CRC about Toolkit products (visit www.toolkit.net.au, log in with your username and password and click on 'edit my details'). The site also now has provision for data products to be downloaded by Toolkit members in addition to software products. Additional software products, and the first data product - soil properties data collated by Andrew Western at The University of Melbourne - will be available to members shortly after you receive this edition of *Catchword*.

Redesign of CRC website

Around the end of this month regular visitors to the CRC site will notice a complete re-design of the site. The existing CRC site was in need of a major overhaul to enable users to find the information they needed more easily. All of the existing capability of the CRC site remains and over the next few weeks, additional information will be added. This will include 'outcome reports' from the first round of CRC projects (1999-2002). These reports (800-1000 words) have been written specifically for industry practitioners to learn more about the outcomes from the first round of CRC projects and how they can be applied. This information will be available as Adobe pdf files presented as summaries of the research at a Program and Project level. Details of the current round of CRC projects (2003 onwards) will also be updated.

Acknowledgements - your comments appreciated

The success of the CRC and Toolkit websites are the result of consistent effort by Jake MacMullin, our web guru responsible for the construction and operation of our sites, and Susan Daly, our Graphic Designer whose input ensures a pleasant and productive experience for our website visitors. As our CRC and Toolkit sites undergo development over the next few weeks, we will be asking some of our visitors for their critique to ensure the site meets their needs. Accordingly if you have any requests or comments about our websites please send them to me via the email address below.

For more information about Web Objects contact Jake MacMullin; jake.macmullin@csiro.au

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POSTGRADUATES AND THEIR PROJECTS

Tim Capon

Environmental Economics

In the December 2003 issue of *Catchword*, I introduced myself and my research topic. Since then, I have completed by confirmation report and seminar and further developed my research questions and experiment design. So for this profile, I will write about how I became interested in environmental economics. In my Bachelor of Science degree at the University of Queensland my main subject areas were ecology and physiology, although I also studied some economics. While the areas of biology and economics might first seem to be separate and distinct, they are related in many interesting ways. Many of the same concepts, such as equilibrium or stochasticity, are important in both areas.

However, I first became interested in economics because of arguments I'd have with a friend of mine who studied economics full-time. My friend seemed to be a zealot of his subject and often attempted to apply naïvely simple economic arguments to very complex problems. For example, he would argue that the market, if left to its own devices, will lead to the best outcome for everyone. However, in my studies I had the chance to see environmental issues from a different perspective. For example, subjects in fisheries biology demonstrated the complexities of assessing sustainable fishing yields because of factors such as uncertain scientific knowledge about life-cycles or species interactions. On the other hand, the treatment of maximum sustainable yields (MSY) in elementary economics courses overlooked many of these biologically important issues and treated the MSY model as a simple problem in optimisation.

Market limitations and experimental methods

It was only during my honours studies at Griffith University in Environmental Policy and Economics that I learned how to argue effectively about environmental issues in economics. The basic theory of economics proves mathematically that market solutions result in the best outcome for everyone, given a few assumptions. In my honours project I first learned how experimental methods can be used in economics to study the impact of these assumptions. Experiments can also be used to help answer economic questions without making these same restrictive assumptions. It is the assumptions of economic theory that reveal the Achilles' heel of market

RECENT TECHNICAL REPORT

Calibrations of the AWBM for Use on Ungauged Catchments

By
Walter Boughton
Francis Chiew

Technical Report 03/15

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

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

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purists. The assumptions include the idea that all decision-makers are perfectly rational and self-interested. Unfortunately, the assumption of unbounded rationality means that engineers and economists are no longer needed since homo economicus can perform optimisation perfectly, with no modelling software required. But surely even the hardened cynic is unlikely to argue that all people are purely self-interested?

Testing assumptions in economics - Public goods experiments

Experimental economics provides methods for examining such assumptions. For example, in my honours project I used an experiment on the provision of public goods to examine policies of moral suasion. Moral suasion is the type of environmental policy that asks people nicely not to use so much during times of drought, e.g., "Don't be a Wally with water!". If people were purely self-interested this approach would never help. Rather than 'The Public Interest,' public goods are a type of economic good that has a definite economic value but are also non-excludable and non-rival. This means that other people cannot easily be prevented from enjoying the benefits of a public good (non-excludable) but this doesn't always matter as one person's use of a public good does not diminish other people's use (non-rival). Technology often fits into this category, e.g., copies can be made of computer software. Because of these properties public goods are not generally traded and their value is not measured directly by the market mechanism. Furthermore, non-excludability means that if one person provides a public good, others can benefit easily, at no cost to themselves. In a public goods experiment, individuals can either cooperate to provide a public good, thereby leaving them all better off, or they can free-ride, keeping their resources to themselves but still benefiting from the public good provided by others. In these experiments, decisions are real: test subjects make real economic decisions with real economic outcomes. Interestingly, one of the earliest experiments on cooperation in public goods dilemmas was called, "Economists free-ride, does anyone else?" (Marwell and Ames, 1981).

Externalities and public goods

One significant assumption required to argue for a market solution to environmental problems is the concept of non-attenuated property rights. Non-attenuated property rights are completely specified private property rights. If property rights are not completely specified then there are public goods or externalities. These are also referred to by economists as examples of market failure. So, the trick to arguing with a market apologist is to identify the public goods and the externalities. Because in these cases the economics texts admit that markets will not necessarily achieve the best outcome for everyone and sometimes government intervention will be required. But of course it's more complicated than that. Coase (1960) showed that it is also possible for new property rights to be defined over an externality such as pollution, making the market argument relevant again. This provides another example of how experiments can be used to test economic theory. McKelvey and Page (2000) demonstrated that when economic agents have heterogeneous risk preferences and payoffs are uncertain, Coase's solution does not guarantee an optimal outcome.

Applying experimental economics

Experimental economics provides a much needed method for examining questions in environmental and agricultural economics. Experiments have the capacity to provide insight into areas otherwise hidden from economic theory such as the details of institutional design. My current research project uses experiments to examine the consequences of alternative property rights regimes for water resources in terms of decision-making under risk and uncertainty.

"Pop quiz, Hot-shot: Your name is Keanu Rivers. You are an irrigator with an uncertain water allocation, which has just been reduced to 38% of its nominal volume. Unless it rains you won't have enough water to grow all of your crop for the rest of the season. Because of drought, the price of water has just hit $480 ML. Do you sell your water or grow your crop and pray for rain? What do you do ... what do you do?"

And what became of my zealous friend? Frank and Schulze (2000) published experimental evidence that economics students may be more corrupt than other students. You'll be pleased to hear that my friend now has a lucrative job for the federal government.

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CRC PROFILE

Our CRC Profile for June is:

Harold Hotham

Growing up for me was a little different to many of my friends, I had my first plane ride on my own at the age of four, and by the time I was eight, I was travelling between Brisbane and Canberra three to four times a year, and a few trips to Malaysia and back. If only I had joined a frequent flyer program back then! My travels were the result of my parents separating when I was too young to remember. My mother remarried and this is when my travels began, the day after the wedding we flew to Ipoh in Malaysia, where I lived for two years.

The school I attended here was a small international school that probably had less than 100 students, I was amazed to discover that when I returned to visit in 1994 that the same principal and many of my teachers were still there and remembered me (was I good or bad??). After two years (with a couple of trips home) we returned to Australia to live in Brisbane, this was my big opportunity to clock up the frequent flyer points. I travelled back to Canberra every school holidays to visit my Dad and family here.

The next big move was to Hong-Kong in 1990, this was a big change in lifestyle. We moved from a large house with a big yard to an apartment on the 15th floor. Fortunately this didn't last for too long, we moved into what for Hong-Kong was an amazingly large house, three levels, five bedrooms and 10,000 sq feet of garden. HK provided an amazing experience, the pace of life there was so fast, that anything else was crawling by comparison. It also provided the opportunity to travel, we visited Macau, China, Malaysia, England, Scotland and Wales in addition to trips home.

By 1994 I decided it was time to return to Australia to live with my Dad and finish my schooling here, because at that stage I had aspirations of joining the Air Force as a pilot. I soon decided that this wasn't for me and thus began the dive into the world of computers, when in year 11 I took up the subject.

At the end of year 12 I decided that I had had enough and deferred uni for twelve months and moved to Sydney for a year to look for work. I had a variety of jobs during the year and managed to save a bit of money. I moved back to Canberra in 1998 to begin what would be a long four years of many all-nighters, and even the odd two nights straight in front of the computers at uni. The official title of my degree is "Bachelor Of Information Technology (Software Engineering)" or BIT for short. I studied everything from distributed programming to network theory, one of my most hated assignments involved programming in binary! Imagine trying to pick the 0 that should be a 1 in a 1000 lines of the stuff. The course also covered project management and accounting, unfortunately the only thing I learned from the accounting was that I should pay someone else to do it for me.

I worked at a number of places during my time at the ANU, and I was lucky enough to get an interview for a position in ICM a few months after finishing my degree. Fortunately for me Rob, Joel and Shane must have been impressed enough with me that I was offered a job. From the outset my role has been to produce a version of SedNet that doesn't rely on Arc, but along the way I have worked on a variety of projects and developed components for the TIME modelling environment. Hopefully you will all be able to see a working version of SedNet in the very near future.

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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

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