NEWSLETTER OF THE COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

CATCHWORD

NO 113 FEBRUARY 2003

A NOTE FROM THE DIRECTOR

Professor Rob Vertessy

Inside...

IN THE WAKE OF THE BUSHFIRES

It's been a long, hot and difficult summer in Australia so far. As if the drought were not enough, we've had to endure disastrous fires also. My home city of Canberra has been severely affected an horrendous firestorm destroying over 530 homes. Much of the forest around Canberra has been destroyed, with pine forests faring particularly badly for a second year running. The Victorian high country has been severely affected, the fires there spanning an incredible 1.2 million hectares of land so far.

Our hearts go out to all of our colleagues and friends in towns and rural areas affected by the fires; some of them have lost everything they owned.

Whilst the toll this summer has been massive, there are many fires still burning and we have many hot and dry weeks ahead. The situation may thus get worse.

One of the many legacies of these fires will be a variety of catchment impacts, with significant changes to water quantity and quality likely to ensue in some areas. Right now, land and water management agencies are working overtime to assess the damage done and forecast the likely hydrologic impacts of these fires. Emergency remediation works have already begun in some catchments, though these are likely to be limited in extent until an analysis of the costs and benefits of various remediation measures are conducted. As the management agencies take stock of the situation we are experiencing a huge demand for technical input from our staff. We have been providing briefings, participating in workshops, and fielding questions from the media. The embers in Canberra's water supply catchments have barely cooled though we are already participating in a study there to assess the damage and recommend remediation strategies to limit water quality impacts. In parallel with this activity, we have launched a website entitled 'Bushfires and Catchments' which can be reached at www.catchment.crc.org.au/bushfires.

This new website presents a framework for assessing what the hydrologic impacts of fire might be in different settings, and provides advice on whether, where and how to intervene to limit those impacts. It draws on a rich Australian and international research literature which is fully referenced at the site. Also included are answers to Frequently Asked Questions (FAQ), many of which have been sent to us by staff in the land and water management agencies grappling with the fire impacts. The site is by no means an exhaustive information resource, but rather a fast-response initiative to get people started on the task of anticipating and managing the hydrologic impacts of these fires. We will run a 'news wire' at the site to keep visitors posted about what managers and researchers are doing in this area of work. To my knowledge, there is no similar resource on the internet, so I trust people will find this site useful, at least in these early weeks after the fires.

Although the site has been initially developed by staff within our CRC, we would welcome input from any contributor with wisdom to share. If you would like to share your knowledge, please contact our Communication and Adoption Leader David Perry (david.perry@eng.monash.edu.au).

I'd like to conclude by thanking the many staff who have given their time generously to deal with our CRC's response to these fires.

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Fire scorched catchment between Omeo and Anglers Rest in Victoria. Photo courtesy of John Tilleard, Earth Tech.

COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

NEW TECHNICAL REPORT

THE STATUS OF CATCHMENT MODELLING IN AUSTRALIA

by

Frances Marston
Robert Argent
Rob Vertessy
Susan Cuddy
Joel Rahman

Technical 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

PROGRAM 1

PREDICTING CATCHMENT BEHAVIOUR

Program Leader
GEOFF PODGER

Report by Joel Rahman

Project 1A - 3 related products - 1 toolkit

Main products

Project 1A: 'Implementation of the Catchment Modelling Toolkit', is tasked with 'bringing home the toolkit' by integrating existing and new research outcomes of the other research projects into a cohesive software environment for use by natural resource managers.

With the help of Project 1B: 'Methods for Integration in Catchment Prediction', the other research projects and Programs 7 and 8, we will be developing, documenting and coordinating the training for three products:

- TIME; our modelling environment,
- The Module Library that forms the building blocks of the toolkit and
- The Integrated Applications, which represent the CRC's combined knowledge in sophisticated pieces of software for end users and decision makers.

From the perspectives of different stakeholders, each of these products could be seen as the 'Catchment Modelling Toolkit'. However, all three combine form to the toolkit, with each product benefiting from work done in the other two.

TIME - Model Development

- Support for models and applications

  The Invisible Modelling Environment (TIME), discussed in the July 2002 *Catchword*, supports the rapid development of models and applications in a number of programming languages. A lot of effort has been directed into TIME development over the last 14 months and the positive reactions we're receiving from colleagues in other research programs is very encouraging. We will continue to develop TIME over the next three years to improve its support the work of the CRC researchers, as well as work internal to 1A.

  To date TIME has been used to develop models in C#, Visual Basic.NET, J#, Fortran 95 and C++. These models can make use of sophisticated data components for representing grids, time series, node link networks and point, line, polygon coverages. Data can be visualised in a number of ways, including GIS style mapping of spatial data, charting of temporal data, and a number of generic views such as scatter plots and duration curves. Generic automated optimisers can be used to calibrate new and existing models against observed data using a number of search schemes and objective functions.

- Future developments

  Future developments of TIME are planned to include:

  - A model integration 'canvas' similar to the system developed for ICMS
  - An expansion of current capabilities for the pre and post processing tools, such as statistical analysis, terrain analysis and stochastic data generation.
  - A number of re-useable components, of use to model and application developers, such as a rule engine for manipulating data according to database style queries.

  In the first incarnation of the toolkit project (Project 1.1, 2000-2002), the modelling environments were often perceived as 'the toolkit'. In 1A, we acknowledge that TIME is an important piece of infrastructure for the toolkit, but in final wash-up, it really is a means to an end.

  Before moving on, it's worth taking time to acknowledge some of the major contributors to the development of TIME.

- TIME contributors

  Shane Seaton, Jean-Michel Perraud and Harold Hotham have been part of the core team, developing much of the underlying functionality, such as data handling and visualisation, along with early examples of TIME based applications, such as the Rainfall Runoff Library. David Verrelli has joined the team, initially to TIMEify some of the pattern analysis and processing tools from Project 1.2. David is now working on the toolkit implementation of Mike Stewardson's Flow Events Method (FEM), although it is becoming hard to distinguish David from the core team, such are his contributions to the underlying functionality of TIME. Daniel Bennett has also joined Mike and David as a Vacation Scholar also working on FEM. The TIME team continues to grow with new CRC for Catchment Hydrology researchers, such as Nick Marsh, signing up, along with other researchers from CRC parties CSIRO Land and Water and DLWC.

Module Library

The module library is an ever growing collection of scientific components, including established models, as well as those emerging from the CRC's research programs.

Modules in the library are intended to be combined to form models and applications to address particular problems. The conceptual integration of these modules is the responsibility of the 1B project team, with technical support being provided by 1A. The development of the model integration canvas for TIME will streamline technical aspects of the integration process, allowing workshop participants to explore options interactively.

Some of the modules in the library will be coded by the 1A team, with many being developed within the other project teams, with the support and tools of 1A.

Although the module library is only a part of the toolkit picture, it is natural that this collection of modules, ready to be integrated to solve a problem, will be perceived by many as 'the toolkit'.

Integrated Applications

The integrated applications are software products that combine several modules from the module library, along with core components from TIME, such as visualisation and data handling, into a stand-alone system that can be deployed to stakeholders.

These are the MUSIC's, the EMSS's and the Rainfall Runoff Libraries of this world. A significant example is the Integrated River Model (currently looking for a catchy name or acronym). This model will capture the catchment, stream and storage modelling capabilities of the EMSS, the operations capabilities of established industry models, and provide 'slots' for the emerging modules from the research projects. It is anticipated that three releases of the river model will take place during the life of this CRC.

It this collection of applications, such as MUSIC and the Rainfall Runoff Library, that most users will see as 'the Catchment Modelling Toolkit'.

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PROGRAM 2

LAND-USE IMPACTS ON RIVERS

Program Leader
PETER HAIRSINE

Fires and Wash-off in Water Supply Catchments

Wash-off of pollutants

Much of the work in CRC Project 2.2 'Managing pollutant delivery in dryland upland catchments', has focussed around the wash-off of pollutants from land surfaces to the stream. We have investigated the flow of sediment, nutrients and salt from hillslopes to the stream in a range of environments and developed some tools for predicting these processes in agricultural environments.

The recent fires in south-east Australia have resulted in a frenzy of questions concerning the risk of large wash-off events carrying ash and pollutants towards our drought-affected streams in water supply catchments. While Project 2.2 has not specifically addressed the fire/wash-off relationship, a combination of published work and the principles we have developed can be applied to this problem.

Natural cycles of fire and rain

When asked for an on-the-spot comment, I start with the line "Ash, rain and sediment are the raw materials of regeneration." In making this comment I am trying to avert an alarmist response and start people approaching this question from a standpoint of observing Australia's natural cycles of fire and rain. There is much evidence to suggest that rains after fires have played a major part in shaping the spatial patterns of nutrients and vegetation in the Australian landscape.

Responses to rainfall after fires

Hydrologic studies here and overseas show a wide range of responses to rainfall following fire. Most of the Australian published work focuses on native forest environments that are common in water supply catchments. The work of O'Loughlin *et al.* (1982) and Talsma and Hallam (1982) during the 1970's and early 1980's in the Cotter Catchments of the ACT found that while water yields did change that there was very little change in the stream water quality following the fires. Also the study of Prosser* and Williams (1998) in Royal National Park following the 1994 fires in Royal National Park found that though local sediment transport did occur, the sediment that moved was deposited prior to reaching the streams. Observations by Zierholz# *et al.* (1995) concerning runoff following fires following

FOREST MANAGEMENT WORKSHOP AND FIELD DAY - CANBERRA MAY 2003

EXPRESSIONS OF INTEREST SOUGHT.

A Forest Management workshop is being arranged for May 2003 through a partnership between the University of New South Wales, NSW State Forests, the Forest Science Centre and the CRC for Catchment Hydrology.

The workshop will be held in the Canberra region over three days and will include a field trip to discuss implications for forest management. The workshop is targeting researchers and professional forest and catchment managers.

Key themes for the workshop are likely to include:

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

If you are interested in participating in this workshop please respond using the registration flyer found in this issue of Catchword before Friday 7th of March. The organisers will circulate more details on the program, dates and venue in early April 2003.

For further enquiries about the workshop please contact:
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HYDROLOGIC IMPACTS OF BUSHFIRES WEBSITE

In response to many requests for information about the hydrologic impacts of the recent bushfires, the CRC has established a website to deliver relevant information to catchment and water supply managers.

The site is a modest resource at this point and will evolve as more contributions are made. The site initially features a FAQ section designed for land and water managers, an overview of the hydrologic impacts of fire, a news page for information about related activities and reference lists that will be of particular interest.

The site can be found at www.catchment.crc.org.au/bushfires

The CRC welcomes contributions from all individuals and organisations to the site to expand its value to land and water managers.

If you can contribute to this site please contact david.perry@eng.monash.edu.au

the 1994 Royal National Park fires suggested that erosion and water quality impacts were confined to areas where tracks and roads concentrated overland flow, leading to scour and diversion of runoff directly into streamlines.

There are some studies that show a clear and persistent deterioration of water quality following fire events. The clearest example of this is the study of Brown (1972) where water quality was monitored following a major wildfire in the northern section of the Snowy Mountains. The study showed sediment concentrations were up to two orders of magnitude higher immediately following the fire and that these effects, though decaying in magnitude, persisted for three years at the catchment outlets.

Some conclusions

So, what general conclusions can be drawn about the occurrence of pollutant wash-off following fires in native forests? Firstly, the measured response is highly variable, ranging from no effect to major and persistent stream pollution. The discussion of the various papers suggests that factors increasing the risk and magnitude of pollution wash-off are: the intensity of the fires, the intensity and amount of rainfall, and the occurrence of hydrophobic behaviour of some soils. A universal comment is that areas of disturbance including roads and fire trails used in fire-fighting efforts are high priorities for remedial action.

References:

Brown, J.A.H. 1972 Hydrological effects of a bushfire in a catchment in New South Wales, Journal of Hydrology. 15 77-96.

O'Loughlin, E.M.1982. The bushrangers experiment: Hydrological response of a Eucalypt catchment to fire" pp132-138 In: E.M. O'Loughlin and L.J. Bren. Proc. Of the first National Symposium on Forest Hydrology. The Institution of Engineers, Aust. National Conference Publication 82/6.

Prosser I.P., and Williams L. 1998. The effect of wildfire on runoff and erosion in native Eucalyptus forest. Hydrologic Processes 12 (2): 251-265.

Talsma, T. and Hallam, P.M. "Stream water quality of forest catchments in the Cotter Valley ACT" pp50-59 In: O'Loughlin and L.J. Bren. Proc. of the first National Symposium on Forest Hydrology. The Institution of Engineers, Aust. National Conference Publication 82/6.

Zierholz, C., P.B. Hairsine and F. Booker. 1995. Runoff and soil erosion in bushland following the Sydney bushfires. Aust. Jnl Soil & Wat Cons. 8(5) 28-37.

*Ian Prosser is a research scientist with CSIRO Land and Water and currently leads CRC for Catchment Hydrology Project 2B.

#Chris Zierholz is a research officer with NSW Department of Land and Water Conservation and is a participant in CRC Project 2B.

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PROGRAM 3

SUSTAINABLE WATER ALLOCATION

Program Leader
JOHN TISDELL

Overcoming the environmental consequences of trade: Communication between traders

Water market experiments

As part of CRC Project 3.2: 'Enhancement of the water market reform process', a simulated water market environment was developed. That environment was used to explore, with water market experiments, the impact of providing extractors with information on the environmental consequences of water extraction and a means of communication.

This article reports the findings of that series of experiments - exploring the use of an environmental levy and release of environmental and extractive information and communication as mechanisms to address the environmental consequences of water extraction.

Participants in the experiments acted as farmers faced with monthly water demands, uncertain rainfall, possible crop loss and the possibility of trading in water entitlements.

The experimental treatments included :

(a) no information on environmental consequences of extraction

(b) the provision of monthly aggregate environmental information

(c) the provision of monthly aggregate extraction information and a forum for discussion

(d) the public provision of individual extraction information and a forum for discussion giving rise to potential verbal peer sanctions.

To account for the impact of trade, the treatments were blocked into three market types (i) no trade, (ii) open and (iii) closed call auctions. The cost to the community of altering the natural flow regime to meet extractive demand was socialised through the imposition of an environmental levy equally imposed on all players.

Results of water market experiments

This section reports the findings of the research[1]. It commences with an analysis of the level of accordance with environmental targets, measured by the environmental levy, as a result of each of the treatments. The findings are supported and supplemented by a graphical analysis of monthly extraction and environmental targets. Generally reviewed wisdom notes that the implications of laboratory findings should be interpreted cautiously beyond the specific institutional setting of the experiment.

(i) Impact of provision of information, discussion forums and sanctions on meeting environmental targets

It is expected that the level of environmental damage caused by water extraction will increase as a result of trade and decline with information, discussion and individual extraction disclosure. Table 3.1 presents the combined results of the two years of experiments.

In all cases, the level of environmental damage reflected in the value of the environmental levy is less without trade compared to open and closed call markets. Without trade, the level of environmental damage declined with the provision of aggregate extraction information from $5.48 to $5.03. Coordinating individual actions to converge with environmental targets is difficult without a means of communication. Allowing the traders to communicate improved coordination of actions resulting in a further decline in the environmental levy to $2.71. Releasing individual extraction levels compared to their agreed extraction levels was detrimental and resulted in an increase in the environmental levy from $2.71 with discussion to $3.30 with individual disclosure.

Table 3.1 The value of the environmental levy

	No Information ($)	Aggregate Information ($)	Aggregate Information and discussion ($)	Individual information and discussion ($)	Average
No-Trade	5.48	5.03	2.71	3.30	4.13
Closed Call	7.62	6.28	7.44	6.59	6.98
Open Call	5.75	8.80	4.52	4.44	5.88
Average	6.28	6.70	4.89	4.78	

[1]*These results are preliminary only and should not be quoted without permission of the Project Leader. A full statistical analysis of the results is scheduled during early 2003.*

HYDROLOGIC IMPACTS OF BUSHFIRES WEBSITE

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The site can be found at www.catchment.crc.org.au/bushfires

The CRC welcomes contributions from all individuals and organisations to the site to expand its value to land and water managers.

If you can contribute to this site please contact david.perry@eng.monash.edu.au

NEW TECHNICAL REPORT

THE DEVELOPMENT OF WATER REFORM IN AUSTRALIA

by

John Tisdell
John Ward
Tony Grudzinski

Technical 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

Introducing a closed call market produced more adverse environmental consequences. Compared to no-trade, the average levy increased from $4.13 to $6.98. The provision of aggregate information in the closed call experiments reduced the environmental levy, while allowing discussion increased the levy. Disclosure of individual information reduced the levy, but not below aggregate information levels. Closed call markets by their nature provide less market information to participants and thus should have a less adverse environmental impact than an open call market. This was found to be the case only in markets where aggregate environmental information was provided.

In contrast to the results of the no-trade market experiments, provision of individual information in the open call experiments increased accordance with environmental extraction targets and thus reduced the level of environmental damage. Without trade, the lowest environmental damage resulted from discussion between the players with aggregate extraction information. With trade, an open call with discussion and individual extraction information led to the lowest level of environmental damage.

Summary

- In these experiments the introduction of trade increased environmental damage.
- Disclosure of only the impact of aggregate extraction on riverine environments was found to be counter-productive to achieving environmental extraction targets in open call market experiments. The environmental damage was maximised with this treatment.
- Environmental damage was minimised by providing aggregate environmental information with a forum for group discussion and agreement in a no trade experimental environment.

(ii) Impact of provision of information, discussion forums and sanctions on aggregate traders' income

Traders' incomes were calibrated to ensure equal potential income and used to compare the impact of the various treatments and auction structures. Table 3.2 presents the average traders' income for each treatment/block combination. Consistently the average traders' income without trade was lower than with trade. Introducing aggregate extraction and environmental information increased average traders' income in a closed call market compared to their no-trade position, but not in the open market compared to a closed call market. A possible explanation for this may be that trade was seen as part of the cause of the environmental cost and this hampered open call trading. Once discussion was allowed, it was transparent that the level of extraction, rather than the market, was the primary determinant of the environmental levy and the stigma of the open market was removed.

Summary

- In these experiments average traders' income increased with trade in all cases.
- Introducing aggregate extraction and environmental information increased average traders' income in trade experiments compared to no trade experiments.
- Maximum average traders' income was achieved by providing information on aggregate extraction, environmental targets and a forum for discussion in an open call market.
- Disclosure of individual information compared to aggregate information with discussion led to lower average traders' income in all cases.
- Providing aggregate information and discussion produced higher average traders' income compared to no information or aggregate information alone in all cases.

(iii) Ratio of income and environmental levies

Trade-offs between maximising extractive income and riverine environmental flow regimes are common. One metric to measure those trade-offs is the income per unit of environmental damage. Table 3.3 presents that ratio for each treatment/block combination.

Table 3.2 Traders Income

	No Information ($)	Aggregate Information ($)	Aggregate Information and discussion ($)	Individual information and discussion ($)	Average ($)
No-Trade	38.10	39.55	43.20	42.88	40.94
Closed Call	40.71	44.26	47.25	46.17	44.59
Open Call	45.24	43.22	49.67	47.59	46.43
Average	41.35	42.34	46.71	45.55	43.99

Summary

- Providing aggregate information and a forum for discussion without trade maximised the return per unit of environmental damage.
- Compared to aggregate information and discussion, providing individual information provided lower returns per unit of environmental damage and therefore counter productive in all cases.

(iv) Environmental agreements and accordance

During the discussion period, participants were able to form agreements on aggregate extraction. Information on their aggregate agreement and aggregate extraction was provided. In the final series of experiments, individual agreement and extraction variations were provided.

The level of accordance reported in Table 3.5 is based on the inverse sum squared-difference between the monthly aggregate agreement and aggregate extraction. The level of accordance with the agreement was greatest in closed call, aggregate information and discussion experiments. Provision of aggregate information lead to higher levels of accordance in closed call experiments compared to open call experiments.

In contrast, open call experiments produced higher levels of accordance in experiments where individual extractions were disclosed. Disclosure of individual accordance with agreements improved the level of accordance in the no-trade and open call experiments, but not in the closed call experiments.

Summary

- The highest level of level of accordance was observed in no-trade experiments with aggregate information and discussion.
- The lowest level of level of accordance was observed in an open call environment with aggregate information and discussion.

Table 3.3 Ratios of Aggregate Income and Environmental levies

	No Information	Aggregate Information	Aggregate Information and discussion	Individual information and discussion
No-Trade	6.96	7.87	15.92	13.00
Closed Call	5.34	7.05	6.35	7.01
Open Call	7.87	4.91	11.00	10.72

Table 3.3 Ratios of Aggregate Income and Environmental levies

Treatment	Market type	Income $	Levy $	Ratio
Aggregate information and discussion	No-trade	43.20	2.71	15.92
Individual information and discussion	No-trade	42.88	3.30	13.00
Aggregate information and discussion	Open Call	49.67	4.52	11.00
Individual information and discussion	Open Call	47.59	4.44	10.72
Aggregate Information	No-trade	39.55	5.03	7.87
No information	Open Call	45.24	5.75	7.87
Aggregate Information	Closed Call	44.26	6.28	7.05
Individual information and discussion	Closed Call	46.17	6.59	7.01
No information	No-trade	38.10	5.48	6.96
Aggregate information and discussion	Closed Call	47.25	7.44	6.35
No information	Closed Call	40.71	7.62	5.34
Aggregate Information	Open Call	43.22	8.80	4.91

Table 3.5 Level of accordance with agreements[1]

	Aggregate Information and discussion	Individual information and discussion
No-Trade	0.0165	0.0241
Closed	0.0148	0.0100
Open	0.0057	0.0133

[1] $\text{Accordance measure} = \frac{1}{\sum_{t=1}^{12} (aggAgree_t - agg\ Extract_t)^2}$

NEW TECHNICAL REPORT

WATER TRADING IN THE GOULBURN-MURRAY IRRIGATION SCHEME

by

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Hector Malano
Tom McMahon
Hugh Turral
Garry Smith

Technical Report 02/9

This CRC report presents the outcomes of a study of permanent and temporary water trading in irrigation areas within the Goulburn-Murray Irrigation Scheme (GMIS). The study is based on a survey of permanent and temporary water traders in the GMIS from March to May 2001 and past water records of the GMIS. Outcomes of studies in the area based on two previous surveys conducted in 1994 and 1996 and an irrigation farm census conducted in 1997 have also been compared.

This report will be available in mid March and will cost $27.50 including GST, postage and handling. Our apologies for any inconvenience due to this delay.

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

NEW INDUSTRY REPORT

WATER SENSITIVE URBAN DESIGN: A STORMWATER MANAGEMENT PERSPECTIVE

by

Sara Lloyd
Tony Wong
Chris Chesterfield

Industry Report 02/10

In response to the need for reliable, cost-effective, environmentally-friendly, robust and aesthetically-pleasing stormwater treatment measures, the CRC for Catchment Hydrology undertook research to develop new and existing stormwater quality improvement practices. The integration of these and other water conservation practices into urban design is referred to as Water Sensitive Urban Design (WSUD) and its principles can apply to individual houses and streetscapes or to whole catchments.

Fundamental to successfully applying WSUD principles to urban development is an understanding of the performance capabilities of structural stormwater management strategies, their life cycle costs and market acceptance. This report centres on the design process, construction activities and monitoring of environmental, social and economic performance indicators associated with Lynbrook Estate's Demonstration Project.

This report is available through the Centre Office for $33.00 (includes GST, postage and handling).

Overall Conclusions

Experimental economics yields a formalised, replicable approach to rapidly assess alternate policy directives, typically expressed as market outcomes, prior to catchment-wide implementation (Dinar *et al.* 1998). The methodology provides a relatively inexpensive means of institutional analysis coupled with substantially reduced time horizons.

This research examined applied economic policy, which requires more realistic simulations of economic environments that depend closely on policies developed to account for the social, economic and biophysical complexities of water as a common pool resource. To enable this complex analysis to occur, this project has developed a number of methodical systems, inclusive of extensive survey design and analysis to experimental economics.

In the experimental setting of the research it was found that:

(a) the introduction of trade increased environmental damage

(b) environmental damage was minimised by providing aggregate environmental information with a forum for group discussion and agreement in a no-trade experimental environment

(c) maximum average traders' income was achieved by providing information on aggregate extraction, environmental targets and a forum for discussion in an open call market

(d) disclosure of individual information compared to aggregate information with discussion led to lower average traders' income in all cases;

(e) providing aggregate information and a forum for discussion without trade maximised the return per unit of environmental damage

(f) the highest level of accordance was observed in no-trade experiments with aggregate information and discussion

(g) the lowest level of accordance was observed in an open call environment with aggregate information and discussion.

Reference

Dinar, K.W. Howitt, R.E., Rassenti, S.J. and V.L. Smith (1998) Development of Water Markets Using Experimental Economics, IN: Easter, K.W., Rosegrant, M.W. and A. Dinar, Markets for Water: Potential and Performance. Kluwer Academic Publishers, London.

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PROGRAM 4

URBAN STORMWATER QUALITY

Program Leader
TIM FLETCHER

New features, new faces

New Music

Most regular readers of *Catchword* will have heard of the CRC's Model for Urban Stormwater Improvement Conceptualisation (MUSIC). A component of the CRC's Integrated Catchment Modelling Toolkit (www.catchment.crc/toolkit), MUSIC provides users with the ability to:

- predict water quality from different catchments
- predict the performance of a range of stormwater treatment measure
- evaluate and compare alternative stormwater management strategies for their catchment.

Whilst MUSIC has been very well received by the stormwater management industry (particularly councils, water authorities and consultants), the CRC is committed to updating the software on an annual basis. Updates will incorporate suggested improvements from users, and new knowledge resulting from research by the CRC and other Australian and worldwide researchers.

To this end, the CRC held two workshops in November 2002:

- the MUSIC Users Forum (an annual event)
- the first meeting of the Brisbane MUSIC Users' Group.

Both of these forums provided an opportunity for the MUSIC Development Team (led by Assoc. Prof Tony Wong from Monash University, and John Coleman from CSIRO Land and Water) to get direct feedback from users on desirable enhancements. The Users Forum was preceeded by a questionnaire, from which there was very helpful feedback.

New MUSIC Features

As a result of the workshops, a new version of MUSIC has been prepared (Version 2.00). It is due for release in mid 2003, and will feature the following improvements:

1. Improved rainfall-runoff modeling, to enhance runoff estimation, particularly under short simulation periods (ie. less than two years),
2. Improved guidance on the selection and calibration of model parameters,
3. Better summary reporting of simulation results, including the ability to provide a summary table or graph of

pollutant loads for a given stormwater management scenario,

4. The ability to provide user-defined water re-use demand, to allow more sophisticated integration of urban stormwater quality, and urban water cycle (water re-use and harvesting) objectives,

5. The ability to calculate simulation statistics for data subsets within a particular flow range (e.g mean concentration ONLY for times when flow was above baseflow),

6. Enhanced user-interface for the Generic Treatment Node,

7. Improved graphical display and output,

Future Enhancements

But wait, there's still more.

In future versions of MUSIC (in 2004 and 2005), the Urban Stormwater Quality Team will be working closely with Program 1 (Predicting Catchment Behaviour) researchers, to deliver a new version of MUSIC, written in the CRC's TIME framework.

This new version will deliver significantly enhanced integration with the Modelling Toolkit, and allow users to utilise MUSIC in conjunction with the CRC's whole-of-catchment modeling tools, such as EMSS. For example, as part of a whole-of-catchment plan, a user may wish to evaluate the relative effectiveness of revegetating 50% of riparian zones, with the implementation of stormwater treatment works in major towns within the catchment. Whilst at present this could be partially achieved by separately running each model, the Toolkit-version of MUSIC will allow this to be done in a transparent and efficient manner.

Linkages to other models

With an increasing demand for integrated urban water cycle management, the MUSIC Development Team will investigate ways to facilitate linkages between MUSIC and urban water cycle models. The team will focus on providing an efficient linkage between MUSIC and these other models, without building a behemoth, and thus sacrificing MUSIC's current user-friendliness.

New research aspects

New research being undertaken by the CRC will also be incorporated into MUSIC to:

1. Allow users to incorporate assessment of lifecycle costs in the evaluation of alternative stormwater treatment strategies,

2. Predict the consequences of alternative stormwater management scenarios on indicators of aquatic ecosystem health (e.g. macroinvertebrate composition),

3. Improve the prediction of urban stormwater quality, in relation to land use and climatic conditions, and

4. Improve the prediction of stormwater quality treatment, particularly during dry weather ('inter-event) periods.

New Roles, New Faces

It gives me great pleasure to introduce the Program's new Deputy Program Leader, Associate Professor Margaret Greenway, and to welcome two new researchers to the Program 4 Team, Dr. Tony Ladson and Dr. Ana Deletic.

Assoc. Prof. Greenway has been a key member of the Urban Stormwater Quality Program since 1999, and leads the Griffith University research team. In particular, Margaret's group (Dr. Graham Jenkins, Dr. Ian Phillips, Dr. Eloise Larsen and postgraduate students Courtney Henderson and David Newton) has been undertaking research on biofilms and their role in stormwater treatment, bioretention system behaviour, porous pavements, and the hydraulic and water quality performance of wetlands.

Towards the end of 2002, Monash University appointed Dr. Tony Ladson and Dr. Ana Deletic to the Department of Civil Engineering. Tony was previously a Research Fellow with the University of Melbourne, and has been a Project Leader in the River Restoration Program. Tony (along with Graham Jenkins from Griffith University) will be contributing to a joint research project with the CRC for Freshwater Ecology and the CRC for Catchment Hydrology, examining the relationship between urbanisation and stream ecology. In particular, the project will attempt to quantify the effect of drainage connection (the hydraulic efficiency of drainage from impervious areas) on aquatic macroinvertebrates.

Dr. Ana Deletic arrived in Australia in early January, from Aberdeen University. Ana has an impressive research record in urban stormwater, having completed her MSc on a joint research program between the University of Belgrade and Lund University in the early 90s. Her thesis developed models of suspended sediment runoff from impervious surfaces. Having moved to Aberdeen in 1995, Ana developed a major field site to monitor stormwater quality, and the performance of stormwater infiltration systems. In particular, Ana has focussed on research into clogging of infiltration systems. Ana's PhD developed a sophisticated numerical model for predicting sediment movement through non-submerged grass.

I believe that Tony and Ana will make a valuable contribution to the Urban Stormwater Quality Program; keep an eye out for their research outcomes over the next couple of years!

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NEW TECHNICAL REPORT

NON-STRUCTURAL STORMWATER QUALITY BEST MANAGEMENT PRACTICES - AN OVERVIEW OF THEIR USE, VALUE, COST AND EVALUATION

By
André Taylor
Tony Wong

Technical Report 02/11

This report presents an overview of a CRC project co-funded by EPA Victoria that investigated the use, value, life-cycle costs and evaluation of non-structural best management practices (BMPs) for improved urban stormwater quality and waterway health.

The report costs $27.50 and can be ordered through the Centre Office by contacting Virginia Verrelli on 03 9905 2704 or email crcch@eng.monash.edu.au

NEW TECHNICAL REPORT

STOCHASTIC GENERATION OF ANNUAL RAINFALL DATA

by

Ratnasingham Srikanthan
George Kuczera
Mark Thyer
Tom McMahon

Technical Report 02/6

One of the goals of the Climate Variability Program in the CRC for Catchment Hydrology is to provide catchment and river managers, and other researchers in the CRC, with computer programs to generate climate data. The need is for this at time scales from less than one hour to a year, and for point sites through to large catchments like the Murrumbidgee and the Fitzroy. Our first report (CRC Technical Report 00/16) in this series is a comprehensive literature review; in it a number of techniques are recommended for testing.

This is the first of several reports assessing stochastic data generation techniques. It includes tests of several models to generate stochastically annual rainfall data at 44 sites across Australia.

Copies of this report are available through the Centre Office for $27.50 (includes GST, postage and handling).

PROGRAM 5

CLIMATE VARIABILITY

Program Leader
FRANCIS CHIEW

Climate variability and climate change

In light of the present persistent dry conditions over large regions of south-west and south-east Australia, some of the climate variability and climate change issues and research efforts in the CRC's Climate Variability Program are discussed here.

Climate variability

The considerable variation of rainfall and runoff from year to year is part of the natural variability in the climate system. The management of land and water resources involves designing and operating to cope with this variability. The management challenges in Australia are compounded by Australian streamflow (and to a lesser extent climate) being much more variable than elsewhere in the world. For example, the inter-annual variability of river flows in temperate Australia and Southern Africa is about twice the inter-annual variability of river flows elsewhere in the world. This also means that temperate Australia is more vulnerable to river flow related droughts and floods than elsewhere in the world.

Stochastic climate data

Climate is a key driver in models developed by the CRC and others to predict and assess the hydrologic impact of land use and water management decisions. Running models with alternative sets/replicates of stochastic data provides a method for quantifying uncertainty in hydrologic systems caused by climate variability. To put it simplistically, stochastic data are random numbers that are modified so that they have the same characteristics as the historical data on which they are based.

The CRC has developed stochastic models that can generate time-series climate (rainfall, potential evapotranspiration and temperature) data at a point at annual, monthly and daily time scales, and a space-time rainfall model for design storms. Current research efforts are concentrating on developing and testing stochastic models of spatial rainfall at daily and sub-daily time scales for incorporation into the CRC's modelling toolkit.

Seasonal streamflow forecasting

Reliable rainfall and streamflow forecasts several months ahead can benefit the management of water resources systems considerably, particularly in Australia where the hydroclimate variability is high. Research studies by the CRC and others have shown that streamflow can be forecast by exploiting the lag relationship between streamflow and El Niño/Southern Oscillation (ENSO) and the serial correlation in streamflow. The streamflow-ENSO teleconnection is strongest in late spring and summer in most parts of Australia, while the streamflow serial correlation is significant for most parts of the year, particularly in south-west and south-east Australia.

The CRC has developed a nonparametric model for forecasting streamflow. The forecasts are expressed as exceedance probabilities so that they can be used to assess the operation of conservative low risk water resources systems. These forecasts can be used to help make decisions on water allocation for competing uses, and to provide a probabilistic indication of likely water allocation in the coming months.

Short term weather forecasts

The CRC has developed a model for tracking rainstorms (up to two hours ahead) that gives a longer lead-time in flood forecasting. The CRC is also working towards improving the modelling of land surface hydrology and the initialisation of surface variables in the Bureau of Meteorology's numerical weather prediction models. These studies will ultimately lead to improved weather forecasts (particularly rainfall and potential evapotranspiration) that water agencies can use for flood forecasting and operational water/irrigation management.

Climate change

The design and management considerations may be exacerbated by the threat of climate change resulting from increased concentrations of greenhouse gases. There is now strong evidence that global warming is occurring and will continue in the foreseeable future. This will lead to changes in precipitation pattern and other climate variables, which will in turn impact on the hydrological cycle. Changes in precipitation are almost always amplified in runoff. Higher temperatures increase potential evapotranspiration, which will lead to a reduction in runoff and soil moisture levels.

The historical hydroclimate data series are probably too short to confirm statistically whether or not there is a climate change trend. In addition, the data also suggest that some of the larger changes may have occurred over the last several decades. Nevertheless, the persistent dry conditions in south-west and south-east Australia are consistent with most global climate model predictions of reduced rainfall in the region in a climate-changed environment. However, there are large uncertainties in the model predictions, and it is difficult to tell

conclusively whether the dry conditions are a result of global warming or part of the natural variability in the climate system. There is ongoing research in this area, particularly by the Bureau of Meteorology and CSIRO Atmospheric Research.

The CRC is working with climate change researchers to incorporate climate change scenarios into the stochastic models, and to model the likely impact of climate change on water resources systems.

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PROGRAM 6
RIVER RESTORATION

Program Leader
MIKE STEWARDSON

Report by Dom Blackham

A fraction too much friction: grass, flow, and stream stability

Vegetation and streams

Vegetation plays an important role in controlling the geomorphological evolution of stream channels, by restricting flow velocities, shielding bed sediment from shear forces and promoting sediment deposition. Riparian vegetation is consequently an important driver of channel geometry, with implications for habitat diversity, channel stability and flood conveyance. For example, bank erosion rates are likely to be reduced by the presence of woody vegetation.

Riparian vegetation and stability

A related management issue is the use of riparian vegetation as an indicator of stream stability. Stream condition assessment methodologies commonly interpret the presence of vegetation on channel boundaries as evidence that the channel is stable. Investment in river management works and habitat enhancement programs is often based on these condition assessments, so the presence or absence of riparian vegetation can have far-reaching implications, both for natural processes and management interventions.

Riparian vegetation is an important factor in channel evolution and stability, but its interaction with a range of environmental conditions that may lead to its damage and possibly destruction is poorly understood. These conditions include:

- Scour forces imposed by flowing water
- Anoxic conditions imposed on terrestrial riparian plants by prolonged inundation

Research on riparian grasses

Research conducted as part of my PhD is underway to establish the resistance of riparian vegetation, specifically common riparian grasses, to these stresses. A number of important studies have considered the influence of hydraulics on hillslope grass destruction (eg. Prosser etc) in the context of gully initiation, but almost no data exist on the tolerance of riparian grasses, which often grow in much less cohesive substrate than terrestrial vegetation.

NEW WORKING DOCUMENT

NON-STRUCTURAL STORMWATER QUALITY BEST MANAGEMENT PRACTICES - GUIDELINES

by
André Taylor

Working Document 02/6

This working document presents a new evaluation framework for measuring the effects and life-cycle costs of non-structural BMPs. This framework defines seven different styles of evaluation to suit the needs and budgets of a variety of stakeholders involved with stormwater management. In addition, monitoring protocols and data recording sheets have been developed to support each style of evaluation.

A printed and bound copy of this report is available from the Centre Office for $22.00 including GST, postage and handling.

The report is also available as an Adobe pdf file and can be downloaded from http://www.catchment.crc.org.au/publications

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 is available from the Centre Office for $88.00

Individuals will need to sign a Licence Agreement (available from the Centre Office and website: www.catchment.crc.org.au)

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.

Two main issues make the acquisition of scour and inundation resistance data challenging:

- The difficulty in controlling experimental hydraulic conditions so that the response of grass can be observed under a range of stresses
- Acquiring grass samples with a sufficient range of vegetation morphologies and substrates to allow generalities to be drawn from the data

- Flume experiment for riparian grasses

In order to deal with the problems of acquiring useful data, work by Prosser and Dietrich (1995), Prosser and Slade (1994) and Temple (1991) has been adapted to form the basis of a design for a portable flume (Figure 6.1). The advantage of the flume approach is that scour and inundation resistance can be established for a range of grass samples by controlling the depth and velocity within the flume. In co-operation with Melbourne Water, the Cement Creek catchment was selected for the experiment, primarily because it is a closed water-supply catchment and the likelihood of vandalism of the equipment is much reduced. Under optimal conditions, the flume is capable of exerting a shear stress of up to 10,000 dyn/cm^2 (1000 N/m^2).

A key feature of the flume design used in this study is that it allows any number of vegetation samples to be tested. This flexibility allows variability in resistance between different grass species and different substrates to be examined. Vegetation samples are obtained for testing by extracting vegetated blocks from selected riparian sites, using a steel slicing and lifting mechanism. This method has been developed to minimise disturbance to the integrity of the substrate.

Figure 6.1 Flume under construction in Melbourne University workshop

Flume runs are being used to establish the resistance of various grass species to scour and inundation, and to investigate how the resistance varies with substrate and between species. Native and exotic grass species will be included so that differences in response can be examined

- Index of Stream Condition image analysis

An initial study was carried out to determine the approximate frequency of occurrence of various plant types on benches in streams in south-eastern Australia, in order to set the study in context. More than 4,500 photographs collected as part of the Victorian Department of Sustainability and Environment (DSE) Index of Stream Condition (ISC) formed the basis of this analysis. Using a standardised methodology, vegetation was classified into basic types that could be identified from the images, and an estimate of the percentage cover of each type at each site was made. Frequency of occurrence for each vegetation type was calculated at a range of spatial scales, from sub-catchment to state level (Figure 6.2). Grass is clearly the most commonly occurring vegetation type, which suggests that the outcomes from this experiment are likely to have wide applicability in south-eastern Australia and potentially beyond.

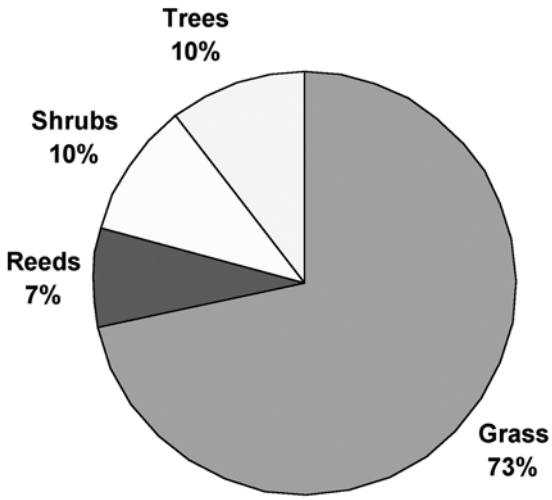

Figure 6.2 Riparian vegetation type frequency in Victoria

- Research questions

A number of possible questions can be approached will the aid of grass resistance data:

(1) Do scour and inundation play a role in controlling the structure of riparian grass communities, and if so, how important is that role?

According to (Haslam, 1978), the flow regime is the single most important factor in determining vegetation structure in riparian and aquatic environments. The data from the flume experiment provide the basis for testing the degree to which scour and inundation processes influence the distribution of riparian grasses in the riparian areas under investigation.

Using data provided by the Goulburn Broken CMA, a hydraulic model of Honeysuckle Creek in central Victoria has been developed, that allows the shear stress and inundation depth for any location in the channel to be calculated for any flow. Combining the long-term flow record, the hydraulic model and thresholds for grass scour and inundation resistance allow impacts of scour and inundation on grass response at any location in channel to be simulated for any period in the flow record (Figure 6.3).

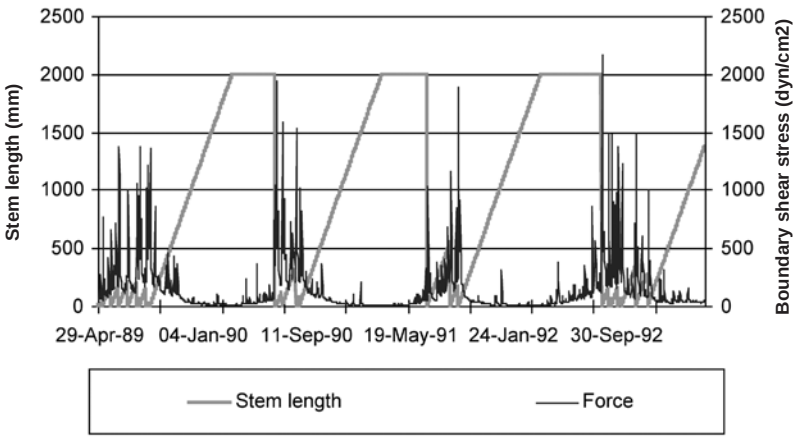

Figure 6.3 Initial grass response model for a sample location in Honeysuckle Creek

A number of assumptions are included in this initial model (eg. linear grass growth rates are used and inundation effects are not represented) but the impact of scour on grass stem length over the period April 1989 to January 1993 is illustrated. Data from the flume experiment combined with finer-scale hydraulic modelling will be used to refine the model. Output from the model will be tested by comparing the output of the model to the current distribution of grasses in the study reaches.

(2) Do riparian grasses provide sufficient resistance to scour and inundation to stabilise incised streams?

Well-established riparian vegetation is widely used as an indicator for stream stability. But does the presence of a developed grass sward on a bar or bench in an incising stream really mean that the feature has ceased to erode? In order to answer this question, scour and inundation resistance data acquired in the flume will be compared to the hydraulic and hydrological characteristics at a range of incised stream sites. A direct comparison of the resistance thresholds and maximum force and inundation duration data will show whether well-developed grass does provide protection from erosion or if the forces and/or inundation durations in a large flow event are sufficient to destroy the vegetation and remobilise the sediment.

Initial analysis of the Honeysuckle Creek site (Figure 6.4) suggests that the effectiveness of mature grass in providing protection is dependent on its location in the channel, as this influences the shear stress imposed on the sward. This preliminary finding will be refined as further flume data become available and a wider selection of study sites are included.

- Field testing

A key part of this research will be the field testing of the data acquired in the flume experiment. If you are aware of any sites that have grassed benches within the channel, are relatively close to a flow gauging station and are fenced to exclude stock, then I would be keen to hear from you. Honeysuckle Creek (Figure 6.4) is a good example of the sort of site I'm looking for. The aim is to collect field data during April and May this year.

Figure 6.4. Vegetated bench in Honeysuckle Creek, central Victoria

NEW TECHNICAL REPORT

ON THE CALIBRATION OF AUSTRALIAN WEATHER RADARS

by

Alan Seed
Lionel Siriwardena
Xudong Sun
Phillip Jordan
Jim Elliott

Technical Report 02/7

Weather radar offers an enormous potential to improve the quality of rainfall measurement. This potential can translate into benefits in many sectors of the water industry ranging from improved design information, decisions on water allocation and management, through to improved weather and flood forecasts for greater public safety.

A key step in transforming weather radar observations into accurate rainfall estimates however is the calibration of the weather radar data. This involves converting the quantity actually observed by the radar (known as reflectivity) into an estimate of rainfall intensity. The current approach used widely with Australian weather radars is to rely on a set of calibration factors that represent average, or climatological, conditions. This can lead to quite large errors in rainfall estimates.

This report describes investigations to improve the calibration process for weather radars in Melbourne, Sydney and Darwin. Rain gauge data has been used to analyse the likely errors in rainfall estimates from radar and calibration strategies to improve the quality of the radar rainfall estimates are proposed.

Copies of this report are available through the Centre Office for $27.50 (includes GST, postage and handling).

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/

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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

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PROGRAM 7

COMMUNICATION AND ADOPTION PROGRAM

Program Leader
DAVID PERRY

The Flow on Effect February 2003

At a glance - a summary of this article

Traditionally marketers have used four key aspects to decide how to deliver products into the marketplace. They are based around product, price, promotion and place. With a little interpretation this provides an excellent framework for the CRC to make similar decision about its products.

Introduction

I'm sure that many *Catchword* readers have heard of the 5 Ps rule - Prior Planning Prevents Poor Performance. I have actually heard it referred to as the 6Ps rule but the sixth P is just a coarse embellishment to emphasise how poor the performance might be if you don't plan. Regardless of which version you use, it is an excellent reminder that for just about any activity, time spent in planning is time well spent in terms of outcomes.

Coincidently, the marketing discipline has a 'Ps' based rule. While slightly more sophisticated, it is also used to plan - in this case for deciding how to deliver a product or service to market. This article describes how a modification of the '4 Ps rule' as used in commercial marketing might be of relevance to our CRC. In particular, it may be useful for researchers who are planning to bring new products to land and water management groups.

The 4 Ps

In the marketing discipline, the 4 Ps is a set of tools a business uses to pursue its marketing objectives within the group of consumers it is targeting (target market). The 4 Ps stands for product, price, promotion and place.

Product

The first P is for product and refers to the goods or service that a business is intending to deliver to market. It might be a new car, a haircut or a holiday to Europe. In creating any new product, a business must make decisions about the product in terms of its quality, design, features, brand name, packaging, sizes, warranties and associated services to meet the needs of their target market.

In a similar way, the CRC research teams make decisions about the product they intend to deliver. This P raises questions such as:

- What features can we include?
- How will it be designed and used?
- What support does it need?'

The answers should inform the final product features, advantages, and therefore benefits to the end-users.

Price

For a business whose fundamental mission is to earn profits the second P - price - can be very important. Price can be considered in terms of list price, discounts, payment periods and credit terms. The issue of price at first glance may appear less relevant to the CRC. The CRC does not exist to make a profit, however it does charge for many products in order to cover postage and handling costs. Most importantly the price we set must be at a level to encourage a level of adoption of the product - our fundamental mission.

Place

The third P stands for place - where the product is located for storage, delivery and sale. In the commercial world this is a ruthless business as manufacturers are charged for shelf space and storage by retailers and compete for the most prominent 'place' in front of the target market. For the CRC, this P is a much less brutal. Although we are not competing for shelf space at the local supermarket, we nevertheless have to make our products as accessible as possible to our end-user. Over the last few years the CRC has invested in the CRC website to meet this goal. This web-based strategy will expand to include all of our modelling products as the Catchment Modelling Toolkit becomes established on-line later this year.

Promotion

In the commercial arena, the last P - promotion - prompts decisions about sales promotion, advertising, sales people, public relations and direct marketing. It encourages companies to ask how and where they should promote their product - in *New Idea* or the *Financial Review?* - for example; perhaps on television or through a mail-out directly to potential customers. Naturally, it depends on the target market for the product. Businesses invest a lot of time and resources in finding out what we read and hear and where and how we seek information about different products.

This P is also relevant to the CRC's planning:

- Where do the people who will benefit from our product obtain their information?
- What do they read and listen to?
- Where is it most effective for us to promote a new product, given limited resources?

The 4Cs?

At first glance the 4 Ps are a worthwhile model for application in the CRC, however the 4 Ps have one key flaw. They represent the seller's viewpoint for delivering a product to the marketplace, not the consumers. Contemporary customer-focussed marketers have replaced the 4 Ps with the 4 Cs which give a greater emphasis on the consumer's perspective. It is the 4 Cs rule that has the greatest potential to assist the CRC in making decisions about delivering products.

Customer solution

Instead of product, the 4Cs have customer solution. Every product must meet a customer's needs and/or the problem that the customer wants to solve. This perspective prompts questions like 'What exactly is the problem we are offering a solution for, and how well does our solution meet the customer's needs?'. Understanding the industry perspective of a particular problem is essential to providing the most effective solution. If a product is developed without the end-user's perspective, the product developer runs the risk of delivering a product of less or no value to the user.

Customer cost

Rather than price, contemporary marketers think in terms of customer cost. Customer cost includes initial costs, running costs, maintenance and even disposal costs. What costs does the customer incur by using your product? The CRC may well produce a very capable model and make it available at a relatively low price, but there may be a substantial cost and therefore deterrent for the customer if the model requires data that is expensive to collect, or requires extended training to learn to run before a solution is available. Thinking in terms of customer costs may explain some lower than expected levels of adoption of research outputs more often than we would like.

Customer convenience

The third C is customer convenience instead of place. This reflects a desire by the manufacturer to deliver the product to the customer as conveniently as possible. If the process of obtaining the product is convenient then it is likely that greater adoption of the product will occur. As a research organisation charged with the responsibility of delivering research products we must bear in mind the customer perspective in terms of how that product is delivered.

Communication

Promotion in the 4Cs is replaced by customer communication. It emphasises the two-way communication that is required between the product developers and the end-users. How else will we (as product deliverers) understand key aspects such as:

NEW TECHNICAL REPORT

STOCHASTIC GENERATION OF MONTHLY RAINFALL DATA

by

Ratnasingham Srikanthan
Tom McMahon
Ashish Sharma

Technical Report 02/8

One of the goals of the Climate Variability Program in the CRC for Catchment Hydrology is to provide water managers and researchers with computer programs to generate stochastic climate data. The stochastic data are needed at time scales from less than one hour to a year and for point sites to large catchments like the Murrumbidgee and Fitzroy.

The first report in this series, 'Stochastic Generation of Climate Data: A Review' (CRC Technical Report 00/16), reviewed methods of stochastic generation of climate data and recommended the testing of a number of techniques. The second report, Stochastic Generation of Annual Rainfall Data' (CRC Technical Report 02/6), compared the first order autoregressive and hidden state Markov models for the generation of annual rainfall data. This third report, 'Stochastic Generation of Monthly rainfall Data', tests the method of fragments and a nonparametric model for the generation of monthly rainfall data at ten sites across Australia.

Copies of this report are available through the Centre Office for $27.50 (includes GST, postage and handling).

- Definition of the problem,
- Costs to the user,
- Required features for the product?

Communication must underpin the entire process of delivering a product.

Recently Mike Stewardson (River Restoration Program Leader) held a very rewarding forum with some potential users of the Flow Events Methodology (FEM) software. In this way Mike was able to learn how the FEM software would be used by industry and other groups, what features were important and how the software could be improved to better serve their needs. This is an excellent example of two-way communication to support the delivery of a product.

Each aspect of the 4 Cs raises questions about how to deliver the greatest benefits to the potential customer.

The 4 Cs is the marketer's version of the prior planning and performance '5P rule'. I believe the 4 Cs of:

- Customer solution
- Customer cost
- Customer convenience
- Communication

provides an excellent perspective for planning the delivery of CRC research products.

As always, any feedback about this article is welcome.

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POSTGRADUATES AND THEIR PROJECTS

Peter Kolotelo

Background

My name is Peter Kolotelo, and it is my turn to speak about my current experiences as a member of the CRC for Catchment Hydrology, and my study project topic here at Monash University.

I completed my undergraduate degree at Deakin University in Warrnambool in 1997, after having moved there from my home in Geelong back in 1995. Those years were spent studying a B.Sc. in Aquatic Science. My keen interest in water and its biological functions was a certain drawcard for me, as well as the bonus opportunities for endless surfing, diving and fishing along the west coast of Victoria. How can one resist? I then went on to do an honours year at the same institution, and looked closely into the migration patterns of freshwater fish and the implications that may be caused by barriers such as weirs. The Merri River was the stream I focussed on. This certainly opened my eyes into the environmental problems that have been brought about by man over the last century and beyond, including the decline of native fish, water quality and land degredation.

After completion of my honours year in 1999, employment was quite difficult to obtain around the area, and obviously, I had to broaden my horizons. I was fortunate to obtain a job in Hamilton with Thiess Services, as part of their hydrographic team. The skills I studied at university were certainly put into practice for this position, and what I hadn't learnt at uni, I certainly did on the job. It was an enjoyable experience, travelling around western Victoria, collecting and processing valuable environmental information such as water quality parameters, stream-gauging records and flow measurements for the many bodies of water found in this region. It was also advantageous being so close to Warrnambool.

This job was offering a great career opportunity for me, something that I certainly would be looking for. However, after about one year, a postgraduate position arose at Monash University to work on the 2001 Murray-Darling Basin Commission Fish Rehab Project (CRC Associated/Additional Project 6.8 'Research to improve the effectiveness of Australian fishway designs', looking at the biological parameters of fish undertaking migrational routes through fishways. I spent my honours year studying this very topic, so I chose to end my term with Thiess, and take up the position.

The project

I started in March 2001 having made the move from the quiet streets of Hamilton to the big smoke in Melbourne. Associate Professor Bob Keller from the Dept. of Civil Engineering at Monash took me under his wing, as did Dr. John Baldwin from the School of Biological Sciences, also at Monash.

Designing fish pass facilities has until recently relied upon engineering knowledge from previous attempts at construction. This has largely left out a very important consideration, which happens to be the biological requirements of the fish species that will use the fishway. At present, I am attempting to rectify part of this problem, and at the completion of the study, I hope to be able to supply engineers with some valuable information to assist in the design of more efficient fishways, especially for native fish in the Murray-Darling Basin.

The project entails the collection of native fish during their natural spawning migrations from the Murray River, and determining their stress responses at fishway sites. I am currently in my second collecting season for the project, corresponding to the warmer months of the year, October to April. At present, I have collected haematological data from four species of native fish (Murray cod, golden perch, silver perch and bony bream), and one exotic, namely carp. Blood is been taken from live fish after a period of extreme exercise, moderate exercise, or after a period of rest; the results of analysis should show differentiation between the three conditions. The aim is to determine the range of blood values that are obtainable from fish between resting and high velocity flows.

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NEW WORKING DOCUMENT

STOCHASTIC MODELLING OF DAILY RAINFALL

by

Senlin Zhou
Ratnasingham Srikanthan
Tom McMahon

Working Document 02/5

Stochastic generation of rainfall data offers an alternative to the use of observed records. This paper presents an evaluation of daily rainfall generation models at 21 stations across Australia. The models are the Transition Probability Matrix (TPM) method, the Daily and Monthly Mixed (DMM) algorithm, and a variation of each model.

A goal of stochastic modelling is to generate synthetic data that are representative of the statistical characteristics of the historical data. One hundred replicates of length equal to the historical data were generated using the above models. Preliminary assessment of the models suggests that overall both the TPM and DMM models preserved key statistical characteristics of the historical rainfall at the annual, monthly and daily levels. The DMM model was unable to preserve the amounts of rainfall on solitary wet days and the TPM model needed to be modified by the empirical adjustment factor to preserve the annual variability.

Copies of this report are available through the Centre Office for $22.00 (includes GST, postage and handling).

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CRC PROFILE

Our CRC Profile for February is:

Bofu Yu

I teach Hydrology and Water Resources among other courses, and coordinate postgraduate by coursework programs in the School of Environmental Engineering, Faculty of Environmental Sciences, at Griffith University, Nathan Campus in Brisbane.

As happened on several previous occasions, my research career will take yet another turn with the signing off research projects for next three years by the CRC for Catchment Hydrology Board on 18 November 2002.

For the past seven years, I have been working at the interface between hydrology and soil erosion science. I worked with stochastic generators to spin out random numbers for runoff and erosion predictions, and with surface runoff generation models to drive soil detachment equations. I was fortunate to have worked with such wonderful people as Col Rosewell of DLWC, Cyril Ciesiolka of NRM and Calvin Rose of Griffith University among many others.

Fieldwork took me to exotic places such as the east coast of Malay Peninsular, islands of the Philippines, highlands in northern Thailand, Guizhou Province in southern China, and of course to the sun-burnt country with sweeping plains around Gunnedah in NSW, and pineapple farms on extremely sandy soils around Gympie in southeast Queensland. I thoroughly enjoyed the process of doing research. Within CRC Project 2.2, a project on sediment and nutrient delivery from upland catchments, I have mostly worked on runoff and erosion model validation, algorithm implementation and software development.

For the next three years at least, I will be heavily involved in a CRC project on hydrologic and economic modelling of water allocation. What a change in the scenery! We are talking about a change from hillslopes measured in metres to mega catchments, and huge irrigation areas measured in hundreds and thousands of square kilometres. But I am convinced that the change and challenge are worthy of the effort.

Water has become the mainstream issue in the public arena. Water allocation, along with dry land salinisation and urban water management, are arguably the most relevant and urgent environmental issues of the day. I will have opportunities to report what the project is all about and what will have been achieved in *Catchword* in the near future. Suffice it to say at this stage that this project requires hydrologists and economists to work side by side to investigate some of the critical issues such as water trading, property rights, and economic impacts of changes in water management policy and policy instruments.

After all, it is climatic/hydrologic and economic conditions such as water scarcity, productivity, and commodity price that ultimately drive the interplay of demand and supply in the broad water industry.

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REPORT ON COMPLETED THESIS

Report by Rachel Thomas

Behaviour of stream rating curves

Background

The purpose of this study was to gain an improved understanding of the behaviour of stream rating curves. Of particular interest was the high end of rating curves, for which the stream flow has broken the channel banks. The thesis presented the results of research into two areas that affect the prediction of stream rating curves. Firstly, the effect of momentum transfer on stream rating curves was investigated, through both a numerical modelling study and a case study. Secondly, the characterisation of surface roughness was explored, through a case study and an experimental study.

Momentum transfer aspects

Momentum transfer is the transverse transfer of longitudinal momentum as a result of a lateral gradient in longitudinal velocity. In a compound channel this is at its greatest at the interface of the main channel and the floodplains, where transverse gradients of longitudinal velocity are steepest.

MONFLO is a two-dimensional model that was developed to calculate the flow characteristics of compound cross sections, accounting for the effect of momentum transfer. It has been implemented as a computer application.

The development of MONFLO was described in the thesis. The model as it was originally written was not suitable for the desired investigations, and several adaptations were made. It was also altered so that the model could be run both with and without the inclusion of momentum transfer.

- Numerical modelling

  A numerical study was carried out using MONFLO to investigate the effect of momentum transfer on the prediction of stream rating curves, and how this is affected by various parameters. The parameters considered were the slope of the channel, the depth and width of the cross section, and the surface roughness. MONFLO was then applied to a case site, the Yarra River at Yarra Glen. The results of this application were compared to those of HEC-RAS, an industry standard model for the prediction of water surface profiles.

- Effects of momentum transfer

  It was found that the effect of momentum transfer on the prediction of water level was minimal. The effect on flow distribution was more significant and varied depending on the cross sectional dimensions of the channel and the surface roughness. The channel slope did not affect the degree of momentum transfer.

Roughness characteristics

In the second part of this study, an investigation of the characteristics of roughness, the model HMODEL2 was described. It was applied to a field site, the Acheron River at Taggerty. For this, methods were developed for catagorising of the vegetation at the site for input to the model.

- Numerical modelling results

  It was found that HMODEL2 was not suitable for the Acheron River, due to the assumptions and simplifications of the model. The model was written assuming uniform flow, and so did not allow for any variation in the cross sectional dimensions and surface roughness characteristics in the longitudinal direction. It was also concluded that the amount of data required by HMODEL2 to describe the surface roughness model resulted in it being impractical for streams with dense or varied vegetation.

- Laboratory study findings

  A laboratory study of the influence of roughness element spacing on the surface roughness was then presented. This was carried out in a large scale laboratory flume, using a variety of both regular and random roughness element patterns, and a range of flow rates. This indicated that the density of the elements, rather than their distribution, is the dominant influence on the water level.

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- River restoration

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