PROGRAM 1 PREDICTING CATCHMENT BEHAVIOUR

PROGRAM LEADER: DR ROB VERTESSY, CSIRO LAND AND WATER

AIM: TO DEVELOP A PREDICTIVE CAPABILITY (OR MODELLING TOOLKIT) FOR LAND AND WATER MANAGERS TO MAKE INFORMED DECISIONS ON WHOLE CATCHMENTS.

PROGRAM OUTPUTS

A toolkit of packaged computer models – including conceptual, analytical and numerical hydrologic models, linear-programming models, decision support systems and simple spreadsheet models – with a common user-friendly interface.

Software modules such as an Environment Management Support System (EMSS) for assessing and managing water quality inputs.

OUTCOMES AND BENEFITS

Catchment managers and the community will gain the capability to predict the likely impacts of land and water management decisions on whole catchments – leading to reduced land and water degradation, better use of catchment resources and better targeting of major works.

The research community is reaping the benefits of working cooperatively throughout the CRC's five Focus Catchments. Many of Australia's leading catchment modellers are involved. They are attempting to achieve scientific breakthroughs in several key areas to build the optimum toolkit – including finding ways to:

- scale from small to catchment scale
- use remote-sensing environmental data
- incorporate uncertainty analyses into the models
- integrate the models
- build bridges between scientific disciplines including socio-economics, ecology, geomorphology, meteorology and hydrology.

END-USERS

Primary end-users for the toolkit include researchers, postgraduate students and technical planning units within urban, rural and state resource management authorities. Secondary users include catchment management authorities, community-based catchment groups, consultants, policy and extension groups at all levels of government.

PROGRAM HIGHLIGHTS 2000-2001

Workshops throughout the year brought a range of researchers and industry Parties together to investigate key hydrological issues (e.g. Impacts of Afforestation on Hydrology), modelling processes and development (e.g. Workshop on Regional Hydrologic Modelling), and planning for communication and adoption of the research outputs.

- An Environmental Management Support System (EMSS) was developed to predict land management impacts of water quality in south-east Queensland and a workshop for EMSS stakeholders was held in Brisbane in March. The completed software will be delivered to the South East Queensland Regional Water Quality Management Strategy (SEQRWQMS) in 2001 – 2002.

Predictive models – the way forward for catchment management

SEQRWQMS asked Program 1 team members to develop an *Environmental Management Support System* (EMSS) to manage water quality in 175 sub-catchments covering 22,670 km^2 across south-east Queensland.

The EMSS is a PC-based catchment model and software tool developed using the Tarsier modelling framework, one of six frameworks under evaluation by the project team. It predicts daily runoff and pollutant (total suspended sediment, nitrogen and phosphorous) loads from the south-east Queensland sub-catchments, which are interlinked via a river network. It is a spatial modelling system sensitive to patterns in, and changes of, climate, storage operations, land-use and land management and which can be operated by users with a range of computer proficiency.

Below Left Program Leader Dr Rob Vertessy (Centre) with research colleagues Susan Cuddy (Right), and Dr Fred Watson (Left)

Left Long-term and persistent land and water degradation an issue

Below Project Leader Dr Robert Argent – Project 1.1

- The Federal Department of Industry, Science and Resources awarded a $36,000 travel grant to the CRC's Toolkit Development Team which visited the US in June – July 2001 to exchange ideas with model development groups in a Modelling Framework Testing Workshop. A return visit is planned for 2001-2002.
- A research consortium comprising Queensland's North Pine Shire Council, South East Queensland Water and the SEQRWQMS engaged CRC researchers for the Pine Rivers Catchment Water Quality Modelling project. Work on the model began in June 2001. The aim is to build a spatially-explicit runoff and pollutant export model that can be used to improve water quality in the waterways and storages of the Pine Rivers region.
- In July 2000, CRC staff played a key role in a workshop "Plantation, Farm Forestry and Water", co-organised by the CSIRO, Rural Industries Research and Development Corporation (RIRDC) and Agriculture, Fisheries and Forestry – Australia (AFFA). As the number of plantations increases during the next 20 years, there will be implications for water quality and yield in many catchments. The workshop resulted in an RIRDC report of technical papers and a RIRDC synthesis report for managers and policy-makers.
- A workshop, Regional Hydrologic Modelling was organised in Melbourne jointly with Program 2 researchers and participants (Land-use Impacts on Rivers), in October 2000 resulting in new collaboration between groups undertaking similar modelling work. Submitted papers will be published in a special issue of the international journal *Hydrological Processes*.
- A training workshop for the Integrated Catchment Management System (ICMS) was held in Perth in November 2000. A further three are planned for 2001-2002.
- Two books co-edited by CRC researchers were published: *Trees, Water and Salt: An Australian Guide to Using Trees for Healthy Catchments and Productive Farms*, edited by Dr Richard Stirzaker, Dr Rob Vertessy and Mr Alastair Sarre and *Spatial Patterns in Catchment Hydrology: Observations and Modelling* by Associate Professor Rodger Grayson and Professor Günter Blöschl.

DEVELOPMENT OF A CATCHMENT MODELLING TOOLKIT PROJECT 1.1

PROJECT LEADER: DR ROBERT ARGENT

Aim To select and implement a pilot framework that supports the long-term design and integration of a variety of models for the prediction of catchment behaviour, and provide a toolkit of suitable models for practitioners.

ACHIEVEMENTS 2000-2001

Three user surveys on catchment models – conducted in June 2000 – were analysed and the results disseminated to project members and survey respondents in late 2000. They involved:

- senior land and water managers (to determine attitudes towards using models to predict catchment behaviour)
- model users (to discover the range and nature of hydrologic models in use)
- model designers and programmers (to identify new models and ascertain preferred hardware platforms and programming languages; and to canvass attitudes towards model training, packaging and dissemination)

More than 100 replies were received (44% of those surveyed) and the results provided invaluable information as well as input to the toolkit from a range of stakeholders. The results will be used as a benchmark to measure the level of toolkit adoption and be published in the CRC *Technical Report* series in 2001-2002.

- Project meetings in August and December 2000 updated team members on the progress on the survey results and a report on modelling requirements, and provided opportunities to discuss and review modelling framework assessment criteria and testing protocols for modelling frameworks.
- Draft review, validation and documentation protocols were compiled for testing on six selected modelling frameworks throughout 2000-2001. Tarsier and ICMS were selected for intensive testing. The others will be tested later this year.
- In November 2000, Project Leader, Dr Robert Argent, presented *A Framework for Catchment Prediction Modelling* at Hydro2000 – the Third International Hydrology and Water Resources Symposium in Perth, WA.
- A two-day workshop was held in Canberra in May 2001 to train CRC for Catchment Hydrology model-developers in applying the Tarsier framework which provides a modelling approach for catchments involving the integration and analysis of water and land issues. Organised by Mr Joel Rahman and Mr Shane Seaton, the workshop involved 11 participants from five CRC Parties, who were given hands-on experience using and applying the Tarsier framework.

Model-users at the workshop were given a draft copy of the *Principles of Good Modelling Practice Guidelines* and asked to complete a survey. Their feedback will be used to develop an effective method for delivering the guidelines to other model-users throughout the Focus Catchments.

- PhD student Yinbang Bao started work at The University of Melbourne to investigate issues relating to re-designing models into component parts for re-assembling into new models. His work will assist in developing the most appropriate models for each particular catchment issue.
- A draft Communication and Adoption Strategy outlining target audiences and communication and adoption pathways for the toolkit was developed and sent to 15 reviewers for evaluation. It is planned that the strategy will be finalised in early 2001-2002.

SCALING PROCEDURES TO SUPPORT PROCESS-BASED MODELLING AT LARGE SCALES PROJECT 1.2

PROJECT LEADER: ASSOCIATE PROFESSOR RODGER GRAYSON

Aim To develop generic approaches that can be used in large-scale models, that represent the effects of small-scale variability (in space and time) of soil and landscape characteristics, and of precipitation, on various hydrological responses.

As this work focuses on improving the extent to which modelling reflects real-life situations, end-users of this research will mainly be model developers working within related CRC for Catchment Hydrology projects.

CRC FOR CATCHMENT HYDROLOGY PROJECT LINKS: PROJECTS 5.1, 2.3, 1.1

ACHIEVEMENTS 2000-2001

- The team collated and analysed spatial soil moisture data from 13 Australian and international studies (representing almost all major studies conducted with high resolution data) to determine appropriate generic representation of key statistical properties of the data sets. A paper on this work is being prepared.
- Reviews were conducted on the scaling of soil moisture and methods for representing sub-grid variability; to be published in early 2001 – 2002.
- Project researchers developed software to illustrate a number of quantitative methods for comparing output from spatial models (i.e. spatial patterns) with measured pattern. A paper is being prepared on this work. The software will be generally available.
- The team worked with CRC for Catchment Hydrology Project 2.3 researchers on comparing field data on the dynamic range of soil moisture from sites around Australia with estimates derived from modelling studies. (When large-scale models are applied, as is being done in the CRC, soil hydraulic property estimates must be made. These estimates are usually based on modelled properties derived from soils maps, as these are the only source possessing the appropriate spatial coverage. However, the uncertainty in these estimates is unknown. This study aims to measure this uncertainty. Further work will assess the importance of this uncertainty to conclusions from modelling exercises).
- Progress was made on the representation of sub-grid variability of surface runoff. The new approach appears to overcome some problems associated with distributed modelling of runoff and a paper has been submitted.
- The team participated in PACRIM 2000 (an AirSAR mission conducted by NASA-JPL) to map soil moisture and salinity, in collaboration with the Department of Natural Resources and Environment, Vic (Tatura). Researchers will analyse and compare ground data with the AirSAR data, as this may provide some larger-scale soil moisture data sets for scaling analysis. The data from NASA has been delayed and is expected later this year.
- The team worked with Project 5.1 on developing alternative representations of land-surface hydrology to improve the performance of the Bureau of Meteorology's numerical weather prediction model, as well as on planning a field campaign to measure soil moisture and related variables over the Murrumbidgee River Focus Catchment.

Below Left Predicting Catchment Behaviour Program group.

Left Project Leader Assoc Prof Rodger Grayson (third from left), Project 1.2, and Project 2.12 – meeting with colleagues on arid zone issues.

Below University of Melbourne researchers discuss applications of statistics to project 1.2 scaling issues with Tomas Thierfelder, from Uppsala University, Sweden.

PROGRAM 1 MILESTONES

MILESTONES	PROGRESS
Years 1 and 2	
Conduct a stakeholders' workshop and prepare a summary report listing the key catchment management questions being asked of models.	Three surveys conducted instead of a workshop. More than 200 catchment managers, model-users and model developers surveyed, with 44% replying. Results compiled and disseminated to respondents. Report to be published in 2000 – 2001.
Conduct a modellers' workshop to assess the suitability of existing models to answer these questions; prepare a summary report which identifies gaps in our ability to model particular problems at particular scales.	User survey on existing models conducted and results to be published in October 2001. Two workshops held for modellers and model developers to assess suitability of, and development strategies for, catchment water quality models and to test toolkit ideas with typical end-users.
Develop specifications for new models for the modelling toolkit; these will take advantage of the latest environmental data products such as rainfall radar, laser altimetry, airborne geomagnetics, and hyperspectral scanners.	Draft *Principles of Good Modelling Practice* developed for circulation to, and feedback from, end-users. Final specifications to be delivered in 2001 – 2002.
Develop a software engineering strategy for the development and maintenance of the modelling toolkit.	Six possible modelling frameworks selected for testing throughout 2001. Final strategy to be specified in early 2002, after final framework is selected.
Develop a model documentation and training strategy.	Various model documentation approaches and examples investigated and compared. Prototype model documentation system developed as part of a process to develop an Environment Management Support System (EMSS).
Commence development of the modelling toolkit, starting with the integration of existing models.	Six modelling frameworks selected and testing begun. Tarsier and ICMS used intensively, involving integration of various models. The other frameworks will be used more intensively in the second half of 2001.

PROGRAM 2 LAND-USE IMPACTS ON RIVERS

PROGRAM LEADER: DR PETER HAIRSINE, CSIRO LAND AND WATER

AIM: TO BETTER UNDERSTAND THE HYDROLOGICAL LINKS BETWEEN LAND-USE, CATCHMENT WATER BALANCE AND POLLUTANT DELIVERY TO STREAMS

PROGRAM OUTPUTS

Practical field knowledge and new theory to help develop and test predictive models including those incorporated into the CRC's toolkit.

Identification of catchment 'hot spots' that contribute most to land and river degradation and strategies to treat them.

Understanding the role of pollutant stores and the way pollutants move through catchments.

Clarification of the extent to which riparian vegetation and aquifer management can reduce sediment and pollutant delivery to channels.

OUTCOMES AND BENEFITS

This work will give researchers and catchment managers the ability to predict and interpret, at regional scale, the links between surface cover, nutrient and sediment movement, groundwater recharge, water yield and river salinity. They will better understand and predict the likely effects of changes in land-use (e.g. from grazing to forestry) on catchment water balance and pollutant delivery to streams and river networks.

END-USERS

Researchers and catchment managers.

PROGRAM HIGHLIGHTS 2000-2001

Collaborative links were developed with researchers across a range of disciplines, major R&D activities in the Fitzroy, Murrumbidgee, Brisbane and Goulburn Broken River Focus Catchments began and a series of associate R&D projects were initiated Australia-wide. Highlights included:

- The Program attracted external funding for 10 Associated/Additional projects – ranging in size from $100,000 to $750,000 – to investigate key sediment movement issues for practical application across Australian catchments. One project, Integrated assessment of the effects of land-use changes on water yield and salt loads, attracted $750,000 in Murray-Darling Basin Commission (MDBC) funding.
- Cross-disciplinary links were developed with R&D groups, including Dr Jacky Croke's group at the University of NSW Australian Defence Force Academy (working on water quality and forestry) and the CRC for Coastal Zone Management (modelling approaches for the Fitzroy River Catchment and its estuary). Wide-ranging inter-disciplinary collaboration was initiated between ecologists, geomorphologists, climatologists, pollutant chemists and others.
- The CRC participated in several cross-disciplinary meetings including planning meetings for the Third Australian Stream Management Conference, for which it is a principal organiser. The conference with the theme The Value of Healthy Streams, will be held in Brisbane in August 2001.

Researchers from a wide range of disciplines and stakeholders will focus on issues including ecosystem services, hydrological connectivity, biophysical integration and the latest management tools and techniques.

- Data from the Murrumbidgee, Brisbane, Fitzroy and Goulburn Broken River catchments was obtained, its quality verified, and used to evaluate the models for the toolkit. Sediment movement data was collected from four Focus Catchments, for use in evaluating the models under investigation in Program 1.
- This Program has established clear connections to the ecological consequences of the physical changes investigated. In Project 2.1 the investigation includes consideration of the impacts of the passage of large volumes of sediment through stream reaches on physical habitat. In associate Project 2.14, the consequences of coarse sediment pulses predicted by Project 2.1 are being considered in terms of the diversity of habitat within stream reaches. In Project 2.5, the team is investigating the role of riparian zones in moderating the input of nutrients into streams.

Below Left Program Leader, Project Leader Dr Peter Hairsine – Project 2.2

Left The Murray River – a focus of land-use impacts

Below Project Leader Dr Jon Olley – Project 2.1

SEDIMENT MOVEMENT, WATER QUALITY AND PHYSICAL HABITAT IN LARGE RIVER SYSTEMS PROJECT 2.1 PROJECT LEADER: DR JON OLLEY

Aim To better understand large-scale regional catchments and river processes to improve river health and develop flexible design principles for effective river restoration and riparian management.

ACHIEVEMENTS 2000-2001

Achievements included:

- Project Leader, Dr Jon Olley, and Project Researcher, Dr Ian Prosser, were invited by the former Land and Water Resources R&D Corporation (now Land & Water Australia) to write a contribution on sediment as a river contaminant for a strategic plan for the National Contaminants Program.
- Project staff contributed to the effective targeting of river restoration works in the Murrumbidgee River catchment through the 'Bidgee Banks project, a $1.5 million initiative of the Department of Land and Water Conservation, NSW.
- The project team completed a prediction of sediment sources to Moreton Bay, identifying hotspots in the Lockyer Valley and Logan River, and submitted a final report to the South East Queensland Regional Water Quality Management Strategy (SEQRWQMS), which co-funded the work with the Murray-Darling Basin Commission (MDBC). Phase three will test the predictions using sediment tracing techniques and analysis of cores from the bay.
- Sediment tracing and catchment modelling techniques started in the Jugiong Creek catchment, a 2000km^2 tributary of the Murrumbidgee River catchment, to test the hypothesis that the majority of the sediment yield from the Murrumbidgee catchment comes from 10% of the catchment area. If found to be true, the information will help catchment managers better target funding for remediation works.
- A scoping workshop in March 2000 was used to identify knowledge gaps and to develop further approaches to tackle them.
- A review paper on sediment transport in Australian rivers was submitted as an invited paper to the CSIRO's Catchment Biogeochemistry Conference. The paper presented a review of past catchment sediment research, undertook new analyses to help resolve debates about patterns of sediment transport in catchments and identified the critical knowledge gaps that need to be addressed by organisations, including the CRC for Catchment Hydrology.

MANAGING POLLUTANT DELIVERY IN DRYLAND UPLAND CATCHMENTS PROJECT 2.2

PROJECT LEADER: DR PETER HAIRSINE

Aim To develop modules for the CRC for Catchment Hydrology toolkit that will help make technically sound forecasts of the impact of land-use change on the pollutants delivered to streams, at a catchment scale, for current and proposed land-uses.

ACHIEVEMENTS 2000-2001

- A model developed by the project team was tested on a data set produced by Dr Laurent Beuselink, a Postdoctoral Fellow from the Laboratory of Experimental Geomorphology, Catholic University of Leuven, Belgium. Dr Beuselink's experiments on sediment deposition were the first of their kind in the world and he delivered his data set at a CRC seminar during a visit to Australia in February 2001.
- Using the Beuselink data set, the CRC for Catchment Hydrology model performed well and four papers were prepared for submission to journals. Project Leader, Dr Hairsine, presented a summary of the papers to the International Soil Erosion Symposium (organised by the American Society of Agricultural Engineers), in Hawaii in January 2001.
- Five funding applications were prepared, in support of strategic experimental work. Two – relating to gathering new data on the effects of sealing under rainfall simulation on significant land management and surface conditions – remain pending.
- Experimental sites were selected in the Fitzroy catchment at plot and watershed scale and researchers began assembling data at each site.
- The project has begun linking models of sediment production and sediment delivery which enables representation of management measures, such as contour banks, filter strips and grassed waterways at the small catchment scale.
- A validation study of runoff erosion prediction model for six NSW sites is progressing well and a journal publication has been prepared by Dr Bofu Yu.
- Climate, soil, vegetation and topography data has been collected for input. An inventory of observed runoff and soil loss has been proposed and quality assured for three sites in NSW at the watershed scale.

PREDICTING THE EFFECTS OF LAND-USE CHANGES ON CATCHMENT WATER YIELD AND STREAM SALINITY

PROJECT 2.3 PROJECT LEADER: DR LU ZHANG

Aim To develop the ability and tools to predict the regional scale impacts of afforestation and other land-use changes on catchment water yield, groundwater recharge and stream salinity.

ACHIEVEMENTS 2000-2001

- A $750,000 MDBC grant was received for integrated assessment of the effects of land-use changes on water yield and salt loads project.
- A workshop on regional hydrologic modelling was held in Lilydale, Vic, in October 2000 to discuss issues of modelling catchment hydrological responses using a top-down approach. More than 20 people from CSIRO Land and Water, other CRC for Catchment Hydrology Parties, the National Institute of Water & Atmospheric Research (New Zealand) and the University of WA attended. Papers presented at the workshop will be published in a special issue of *Hydrological Processes*.
- A paper was published in *Water Resources Research*, arguing for a top-down approach in catchment scale modelling. The paper identified key processes responsible for mean annual water balance at catchment scale and showed how they are combined to develop a simple robust model. The study provided sound scientific basis for the mean annual water balance model developed under this project.
- A paper was published in *Water*, comparing the relationship developed by Holmes and Sinclair (1986) with the mean annual water balance model proposed by Zhang et al (1999). Both models were implemented in a Geographic Information Systems (GIS) framework to provide practical tools for predicting changes in water yield as a result of afforestation. The method was applied to the Middle and Upper Murrumbidgee catchment to evaluate the impact of afforestation on mean annual water yield. This study emphasised the importance of reduced water yield following afforestation.
- The impact of land-use changes on water yield in the Goulburn Broken catchment was studied. Researchers investigated the potential impact of a scenario involving the effects of southern blue gum plantations on the inflow to Lake Eildon. A technical report is being produced.

NITROGEN AND CARBON DYNAMICS IN RIPARIAN BUFFER ZONES PROJECT 2.5

PROJECT LEADER: DR HEATHER HUNTER

AIMS: To identify key factors influencing nitrogen and carbon transport and transformations in riparian buffer zones and to determine optimum riparian zone characteristics for reducing nitrate delivery to streams.

Nitrogen management in catchments is a little-studied but important issue in Australia, as it has impacts on water quality in sensitive downstream ecosystems, e.g. Moreton Bay and Port Phillip Bay. Riparian buffer zones can intercept nitrogen in shallow groundwater and surface water flows and minimise its delivery to streams. This is a joint collaboration between the CRC for Catchment Hydrology and the CRC for Coastal Zone Management.

ACHIEVEMENTS 2000-2001

- Pilot site established at Coochin Creek, Qld to test methodologies and gain insights into shallow groundwater flows.
- In an assessment of existing water quality data for south-east Queensland, researchers found that nitrate concentrations in many streams exceeded recommended guideline levels for protection of aquatic ecosystems, with the highest concentrations typically occurring in urban areas. Groundwaters in some parts of the region contained high levels of nitrate.
- Dr Christy Fellows presented information and preliminary data from this project to the North American Benthological Society meeting, in the USA, in June 2001.
- Dr David Rassam was appointed to Natural Resources and Mines, Qld, to work on the hydrology and modelling aspects of the project.

Below Left Land-use Impacts on Rivers Program group

Far Left Project Leader Dr Lu Zhang – Project 2.3

Left Project Leader Dr Heather Hunter – Project 2.5

Below Project review panel and contributors, Project 2.3 – (front row) Dr Lu Zhang, Dr Mat Gilfedder, (back row) Panel members – Dr Rory Nathan – SKM, Dr Glen Walker – CSIRO, Prof Russell Mein; and Program Leader Dr Peter Hairsine

LISTING OF ASSOCIATED/ADDITIONAL PROJECTS

PROJECT	START DATE
2.6 Predicting the combined impacts of catchment management regimes on dryland salinity (Zhang – CSIRO)	July 2000
2.7 Eucalypts and water: Managing forest plantations in China and Australia for sustained productivity and environmental benefits (Morris – NRE)	July 1999
2.8 Groundwater management – irrigation (Bethune – NRE)	July 1999
2.9 Broken and Northern Goulburn Plains study – dryland salinity (Collett – NRE)	July 1999
2.10 SEQRWQMS: Sediment and nutrient sourcing (Olley – CSIRO)	August 1999
2.11 Catchment scale impacts of timber harvesting and roading (Croke and Hairsine – CSIRO)	May 2000
2.12 Modelling flow regimes and inundation patterns of arid zone floodplain rivers (Grayson – The University of Melbourne)	November 1999
2.13 Basin-wide mapping of sediment and nutrient exports in dryland regions (Moran – CSIRO)	March 2000
2.14 Improved methods for targeting river restoration works (W. Young – CSIRO)	May 2000
2.15 Salinity consequences of land-uses changes to water yield (Zhang – CSIRO)	February 2000

PROGRAM 2 MILESTONES

MILESTONES	PROGRESS
Years 1 and 2	
Compilation of the water quantity and water quality measures relevant to ecological response and delivery mechanisms for the three rural Focus Catchments.	Major activities established in three rural Focus Catchments. Riparian project (2.5) and Associated/Additional projects active in the Brisbane River Focus Catchment.
Identification and specification of technical impediments to cross-disciplinary transfer functions.	Cross-disciplinary links with key R&D groups are being established. Successfully obtaining external funding for 10 Associated/Additional projects. Data gathered and quality assured for the Murrumbidgee, Brisbane, Fitzroy and Goulburn Broken River Focus Catchments and being used to evaluate model performance.
Inter-disciplinary meeting to evaluate proposed transfer functions across a range of agro-ecological zones.	Ecological connections established in Projects 2.1 and 2.5, with physical habitat and riparian zone research. Wide-ranging multi-disciplinary collaboration developed.

PROGRAM 3 SUSTAINABLE WATER ALLOCATION

PROGRAM LEADER: DR JOHN TISDELL, GRIFFITH UNIVERSITY

AIM: TO DEVELOP PRINCIPLES, GUIDELINES AND PRACTICAL TOOLS FOR MANAGING WATER ALLOCATION AND USE IN A SUSTAINABLE AND EFFICIENT MANNER.

PROGRAM OUTPUT

Reports and information providing valuable insights into the complex social and economic drivers underpinning water reform in Australia.

OUTCOMES AND BENEFITS

This Program will explore the socio-economic and modelling challenges facing water authorities, to help them encompass economic, social and hydrological factors in their modelling and planning. It will also assist authorities in linking decisions concerning water management to likely social and economic consequences. A particular initiative for this work is that socio-economic issues surrounding catchment hydrology have been integrated with hydrological issues and addressed in a formal research program.

Water reform has been partly implemented by changing institutional structures, e.g. laws governing water have been changed to allow irrigators to trade water and use water resources more efficiently. This Program is working towards assisting the various groups operating in the water market, identifying trader behaviour, and addressing social and cultural barriers to adoption of water trading practices.

END-USERS

Water managers, policy-makers and rural communities in irrigation districts.

PROGRAM HIGHLIGHTS 2000-2001

This year produced sound research outcomes with direct input to water policy development. Next year promises to produce further outputs of national and international significance.

- Researchers from The University of Melbourne and Monash University and industry modellers from the Department of Land and Water Conservation, NSW and Goulburn-Murray Water evaluated water balance models. They found further work was needed in:
  - the modelling of the effect of climatic and socio-economic factors on crop planting and watering and trading behaviour
  - development of a methodology for calculating exchange rates and economic outputs from models
  - investigation of model sensitivity to parameter and data uncertainty
  - optimisation of key parameters in water allocation models.

- The biggest and most comprehensive survey of its kind in Australia was conducted under this Program. Industry Parties and researchers at Griffith University surveyed irrigators and community members within the Focus Catchments on attitudes towards water reform and trading. The survey report, *Irrigator and Community Attitudes to Water Allocation and Trading in the Goulburn Broken Catchment*, was released as a CRC Technical Report in May 2001. It covers issues important to better understand the economic, social and cultural drivers of reform and, in particular, water markets. The survey results provided important input to the development of resource allocation plans in the Fitzroy Basin, Qld. A comprehensive review of water management literature was produced, which will become a cornerstone reference for those seeking an insight into the complex issues surrounding water management in Australia.

INTEGRATION OF WATER BALANCE, CLIMATIC AND ECONOMIC MODELS

PROJECT 3.1 PROJECT LEADER: ASSOCIATE PROFESSOR GARY CODNER

The project will link with a number of other CRC projects, in particular Project 1.1, 3.2, 5.1 and 5.2. It will do this by using climatic, land-use and economic output from other projects and integrating them to allow evaluation of water allocation outcomes.

Aim To provide water managers with more powerful tools that better reflect the various drivers of water demand in the simulation of seasonal water allocation scenarios and allow better assessment of water system performance in terms of hydrologic, economic and environmental criteria.

Below Left Program Leader, Project Leader Dr John Tisdell – Project 3.2

Left Allocation of irrigation water – a complex issue

Below Project Leader Assoc Prof Gary Codner – Project 3.1

ACHIEVEMENTS 2000-2001

Industry Parties have considerable expertise in the water allocation area. The initial phase of the project has tried to better define the capabilities and limitations of existing models to determine research needs of the water agencies related to water allocation issues.

Particular activities included:

- Researchers reviewed the capabilities of REALM and IQQM (both water resource allocation models used by industry participants) and developed a list of knowledge gaps and research needs.
- One day workshop on 27 July 2000 attended by 21 people from eight organisations including five water authorities and agencies. Briefing notes were provided from the previous activity. The workshop was held to discuss the research needs in relation to water allocation issues.
- Workshop resulted in the development of a set of seven agreed sub-projects as indicated:
  - Modelling the effect of climatic factors on crop planting and watering behaviour
  - Modelling the effect of socio-economic factors on crop planting and watering behaviour
  - Modelling the effect of climatic and socio-economic factors on trading behaviour
  - Development of a methodology for calculating water allocation exchange rates
  - Investigation of water allocation model sensitivity to parameter and data resolution and uncertainty
  - Development of a module to calculate economic indicators from hydrologic model outputs
  - Optimisation of key parameters in water allocation models
- Development of conceptual framework for integration of hydrologic, climatic, economic and land-use information with models to allow better decision making in relation to water allocation.
- A water trading database, based on survey responses, has been designed and partly completed. Questionnaires to collect data on water trading have been sent to water traders and a statistical testing method to analyse survey responses has been formulated and is in the process of being implemented.
- Work has commenced on developing a methodology for calculating exchange rates for water trading.
- Initial work has begun to better model the contribution made by on-farm storages to the total water needs of regulators.

ENHANCEMENT OF THE WATER REFORM PROCESS: A SOCIOECONOMIC ANALYSIS OF GUIDELINES AND PROCEDURES FOR TRADING IN MATURE WATER MARKETS PROJECT 3.2

PROJECT LEADER: DR JOHN TISDELL

Aims To evaluate existing trading rules, market structures and procedures and their impact on regional towns and communities and, in partnership with industry and other interest groups, develop scenarios and rules and procedures for trade in 2010.

To assist water authorities in strategic long-term planning and development of trading rules and procedures based on principles of procedural justice and equity, within hydrological bounds and economic objectives of water reform.

ACHIEVEMENTS 2000-2001

Researchers collated existing knowledge and surveyed irrigator and community attitudes to water reform and trading, in the most comprehensive survey of its kind conducted in Australia. The survey covered attitudes to water reform, temporary and permanent water trading, the role of the water authority and the impact and future of water trading across the Fitzroy, Murrumbidgee and Goulburn Broken Focus Catchments.

Overall findings included:

- Respondents in the Fitzroy and Goulburn Broken Catchments supported water reform but the community was poorly informed during the reform process. Respondents were indifferent to full-cost pricing. However, the responses differed significantly between catchments, with Fitzroy respondents less supportive of full-cost pricing than Goulburn Broken respondents.
- General agreement that the nexus between land and water should be broken and water rights traded as chattels independent of land. Setting aside water for the environment before allocating it for irrigators' use was supported, more strongly among Fitzroy than Goulburn Broken respondents. Both groups rejected licensing on-farm runoff and were indifferent to extinguishing sleeper and dozer licences.
- Irrigators believed water entitlements would be more secure and reliable following the reform process.
- Catchment communities consider social justice objectives more important than maximising aggregate farm income – a finding that appears at odds with the Council of Australian Governments' (COAG) water reform priority of maximising the return from water, measured in terms of aggregate farm income.
- There is strong support for free trade within and between sectors, including trade between irrigators, local towns and communities and local shires, but not with individuals or companies with no intention of using the water.
- Respondents agreed that, in future, water would become a chattel and be traded, but rejected the notion that a farm's water entitlement would no longer be an inherent asset in farming.
- Goulburn Broken and Fitzroy irrigators saw a surplus of water, as opposed to the opportunity value of water, as the main reason for water sales in the permanent market. This raises the question beyond redistributing surplus water, as to whether the permanent market is yet to result in real structural change including the crop mix of individual farmers.

Left Fitzroy catchment – community and irrigator views surveyed

Below Sustainable Water Allocation Program group

PROGRAM 3 MILESTONES

MILESTONES	PROGRESS
Years 1 and 2	
Assess the implications of the COAG taskforce recommendations on water in Australia.	An extensive review of the literature on the COAG taskforce recommendations on water in Australia has been conducted.
Characterise the nature of the impacts of the various sources of uncertainty in supply on the performance of surface and groundwater systems.	Sub-projects of Project 3.1 have been developed to investigate the nature of the impacts of the various sources of uncertainty in supply on the performance of surface and groundwater systems.
Review current water entitlement regimes for surface and groundwater in the Focus Catchments in terms of their ability to take account of climate variability and hydrological constraints on catchment yield and water supply.	A review of current water entitlement regimes for surface and groundwater in the Focus Catchments in terms of their ability to take account of climate variability and hydrological constraints on catchment yield and water supply is underway in Project 3.1.
Investigate behavioural, social and economic characteristics of the Focus Catchments and how they may impact on the development of water allocation strategies.	Extensive surveys of irrigators and community attitudes to water reform have been conducted. They investigated behavioural, social and economic characteristics of the Focus Catchments and how they may impact on the development of water allocation strategies.
Identify appropriate management techniques to reduce the risk of change and/or to manage change.	A sub-project in Project 3.1 has been developed to Identify appropriate management techniques to reduce the risk of change and/or to manage change.
Outline the potential impacts of significant water entitlement movement through trade on supply systems, social structures and efficiency of water use.	Research into the potential impacts of significant water entitlement movement through trade on supply systems, social structures and efficiency of water use has begun.
Commence development of water allocation and trading frameworks that take account of economic efficiency, social interactions and equity issues, environmental flow requirements, hydrological constraints and uncertainties of supply.	Development of water allocation and trading frameworks that take account of economic efficiency, social interactions and equity issues, environmental flow requirements, hydrological constraints and uncertainties of supply has begun.
Commence development of water allocation models and institutional structures that maximise socio-economic objectives, given tradeable water entitlements, hydrologic, climatic and other catchment behavioural characteristics.	Water allocation models and institutional structures that maximise socio-economic objectives, given tradeable water entitlements, hydrologic, climatic and other catchment behavioural characteristics have begun.

PROGRAM 4 URBAN STORMWATER QUALITY

PROGRAM LEADER: ASSOCIATE PROFESSOR TONY WONG, MONASH UNIVERSITY

AIM: TO DEVELOP URBAN STORMWATER MANAGEMENT SYSTEMS TO BETTER PROTECT ENVIRONMENTAL AND COMMUNITY VALUES OF URBAN AQUATIC SYSTEMS.

PROGRAM OUTPUTS

A decision support system that integrates urban stormwater management techniques into whole-of-catchment urban design encompassing urban hydrology, ecologically-sustainable land development, land-use planning, urban landscape architecture and socio-economic issues.

World Best Practice guidelines for stormwater treatment, applicable to Australian conditions.

OUTCOMES AND BENEFITS

Improved quality of runoff water, together with water-sensitive design, will pave the way for improved stream aesthetics and ecological health and lower infrastructure costs for the community. Industry adoption of the techniques and tools and, ultimately, cleaner urban streams, beaches and bays, will be the measure of success for this Program.

END-USERS

Urban stormwater planners in cities and towns throughout Australia, land developers, water management agencies and engineers.

PROGRAM HIGHLIGHTS 2000-2001

- The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) was released for testing in Brisbane City Council and Melbourne Water in March 2001. It encapsulates state-of-the-art knowledge on catchment discharge of stormwater pollutants and performance of stormwater quality improvement measures. Brisbane City Council and Melbourne Water staff and their consultants were trained to use MUSIC. Both are using the software to develop strategic stormwater management plans, for conceptual design of stormwater quality improvement measures and to evaluate urban development proposals from industry.

- Incorporating the CRC for Catchment Hydrology's research findings and design principles into its urban housing development south-east of Melbourne led to Lynbrook Estate winning the Urban Development Institute of Australia Excellence Award for innovation in urban development. The award was given to Lynbrook Estate's developers, the Urban Land Corporation, and its project consultants and collaborators including the CRC for Catchment Hydrology and Melbourne Water (see page 34).

- The Program team's work with the Lynbrook Estate and other urban developments Australia-wide led to the CRC for Catchment Hydrology winning a CRC Association Technology Transfer Award in May 2001. Effective adoption of research findings and recommendations requires collaboration with industry and government departments. This award recognised the efforts of Melbourne Water, Brisbane City Council and the Urban and Regional Land Corporation (as joint winners of the award) in creating the environment for effective adoption of research outputs. The award was for effective technology transfer based on communication of research recommendations. This communication covered the CRC's industry seminar series, publications, technical tours and face-to-face meetings with urban stormwater planners and providing the technical basis and foundation for:
  - Stormwater Management Guidelines for Vic and WA
  - new government policies on planning and land development in Brisbane City Council and in Vic
  - stormwater quality improvement measures in Lynbrook Estate
  - the design of numerous constructed wetlands undertaken by water industry consultants

- Construction has begun on the Bridgewater Creek Wetland in Brisbane, which was designed according to guidelines and recommendations based on CRC for Catchment Hydrology research. The project was awarded a Healthy Waterways 2000 Local Government Award in December 2000. The construction of the wetland is scheduled for completion in September 2001 and will demonstrate best-practice environmental management of urban stormwater in Brisbane.

Far Left Bridgewater Creek Wetlands, Brisbane – design guided by CRC research

Left Program Leader, Project Leader Assoc Prof Tony Wong – Project 4.1

Below Project Leader Dr Margaret Greenway – Project 4.2

STORMWATER POLLUTANT SOURCES, PATHWAYS AND IMPACTS PROJECT 4.1
PROJECT LEADER: ASSOCIATE PROFESSOR TONY WONG

Aims To develop a Stormwater Quality Management toolkit for predicting the performance, and facilitating the design, of stormwater management practices

To develop and implement a decision support system (DSS) that will help stormwater managers plan and design cost-effective, holistic stormwater management strategies.

ACHIEVEMENTS 2000-2001

- Development of pilot DSS (MUSIC) was completed and software released in March 2001 for testing by Brisbane City Council and Melbourne Water.
- Training of Brisbane City Council and Melbourne Water staff and consultants in the use of MUSIC has been completed.
- In Brisbane, stormwater monitoring stations were established. Monitoring, following the CRC for Catchment Hydrology protocol, has begun and past data is under review. Melbourne Water approved local research sites and monitoring equipment is being installed. Preliminary results from pollutant speciation of road sediment from two urban catchments have been reported.
- Monitoring of aquatic biota in the Golden Pond Wetland and waterway in Brisbane has begun. Similar monitoring is planned for the Bridgewater Creek Wetland.
- A field survey of an urban waterway site at Mullum Mullum Creek and a control site at McCrae in Victoria was completed and the CRC for Freshwater Ecology has started monitoring both sites for ecosystem responses to catchment urbanisation.

STORMWATER BEST MANAGEMENT PRACTICES PROJECT 4.2 PROJECT LEADER: DR MARGARET GREENWAY

Aims To monitor the performance of structural stormwater management practices, review non-structural measures, and understand and quantify some commonly-used treatment processes, in stormwater quality improvement facilities, such as enhanced sedimentation promoted by wetland vegetation and pollutant uptake by biofilms.

ACHIEVEMENTS 2000-2001

- A field experiment on the performance of grass swales at Pullenvale, Qld, was completed and the results are being analysed to determine the role of vegetation in removing suspended solids from stormwater.
- Experimental design development has begun on a PhD project into the role of biofilms in removing stormwater pollutants.
- Work has begun on hydraulic modelling of the effects of vegetation in wetlands and swales. An MSc project investigating the performance of different plants at the Oxley Creek subsurface flow wetland in Qld is progressing well.
- In Melbourne, field experiments at Lynbrook bioretention system were completed and the samples are being analysed. Preliminary results have been reported.
- The CRC for Catchment Hydrology and Brisbane City Council began the project Paired Catchment Study on the effects of Best Practice Implementation, to link with the Council's Sediment and Erosion Control Audit.
- The Urban and Regional Land Corporation and Melbourne Water provided $80,000 for a survey on community acceptance of Water Sensitive Urban Design (WSUD) in residential developments. The Environment Protection Authority in Victoria has awarded two grants totalling $300,000 to undertake research in formulating methodologies for assessing the effectiveness of structural and non-structural methods for removing pollutants.
- In Brisbane, the construction of a bioretention system has begun. Its performance will be monitored to provide valuable feedback.
- Planning for the retrofitting of a constructed wetland at Ruffeys Creek, Vic, was finished and endorsed by Melbourne Water. Design and tender drawings are being prepared and construction is scheduled for later in 2001-2002. Mapping of vegetation layout in the Ruffeys Creek wetland began with aerial photographs and ground-truthing of vegetation layout. This project is part of a monitoring program to evaluate the response of aquatic vegetation to changes in hydrologic regime following the retrospective fitting of the wetland outlet to improve its hydrology.

REVOLUTIONISING STORMWATER MANAGEMENT

Groundbreaking research by the CRC for Catchment Hydrology is helping change the face of Australian urban developments – and protect waterways and bays from stormwater pollution.

In response to the need for reliable, cost-effective, environmentally-friendly, robust and aesthetically-pleasing treatment measures, the CRC 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 be applied to individual houses, streetscapes and whole catchments.

Through its award-winning Urban Stormwater Quality research, the CRC has provided the technical basis for implementing WSUD principles on stormwater quality improvement that are being widely adopted as Best Practice and incorporated into urban planning policy and new housing developments Australia-wide.

The stormwater management practice promoted in WSUD is an integrated drainage solution that aims to minimise the impact of urbanisation on the natural water cycle and improve stormwater quality before it reaches its end collection point, such as a lake, waterway or bay.

The Urban and Regional Land Corporation's Lynbrook Estate at Lyndhurst near Cranbourne, south-east of Melbourne, is the first residential estate in Victoria to incorporate WSUD. Features include a series of linked gravel-filled, vegetated drains along wide nature strips (called bioretention systems) designed to absorb and filter stormwater, swales (shallow grass channels) and constructed wetlands. The system can remove up to 80% of phosphorus, 60% of nitrogen and 90% of suspended solids from stormwater before it enters the stormwater drainage system. The 270-lot $15 million development is complete and the CRC and Melbourne Water are using Lynbrook as a major demonstration of WSUD principles.

The project is providing an opportunity to evaluate costs and benefits and consumer responses to WSUD. It was presented with an Urban Development Institute of Australia Excellence Award for its innovation in land development. Research Program 4, through its efforts in engaging industry in the communication and adoption of its research findings and recommendation as demonstrated by the Lynbrook project, has also recently been awarded the CRC Association Technology Transfer Award.

Below Left Urban Stormwater Quality Program group

Left CRC investigations into effectiveness of Water Sensitive Urban Design approaches.

Below Hugh Duncan, Melbourne Water, demonstrates MUSIC software

PROGRAM 4 MILESTONES

MILESTONES	PROGRESS
Years 1 and 2	
Establish collaborative linkages with other research organisations relevant to the objectives of the Program, specifically the CRC for Freshwater Ecology, and the CRC for Coastal Zone, Estuary and Waterway Management.	Linkages with the CRC for Freshwater Ecology established with ongoing research collaboration. Linkage with CRC for Coastal Zone, Estuary and Waterway Management established, with possible joint project on ecological responses of urban estuaries to incidences of sewer overflows.
Collate and review information on stormwater treatment/management options and formulate the basic structures of predictive models for a range of stormwater treatment techniques.	Completed. The information was critically reviewed and used to develop the pilot DSS for urban stormwater quality management.
Develop conceptual models of stormwater quality treatment techniques and the framework for their integration into a decision support system (DSS).	Completed. MUSIC was released as a pilot version of the DSS in March 2001 for testing by Brisbane City Council and Melbourne Water.
Establish urban stormwater quality monitoring protocols for use in evaluating pilot stormwater quality treatment facilities in the Focus Catchments.	Completed. Urban stormwater quality monitoring protocol developed following a workshop of industry practitioners and researchers, and published in June 2001.
Select suitable sites and establish stormwater quality monitoring systems for stormwater quality treatment facilities in the Focus Catchments.	Completed. Monitoring sites in Melbourne are being commissioned and sites in Brisbane are operational.
Develop technology transfer and adoption strategy .	Completed. The Communication and Adoption strategy for Program 4 will use the DSS, MUSIC, as one of its main vehicles for engaging industry. Other initiatives include targeted demonstration projects, seminar lectures and collaborative projects with industry. The pilot version of MUSIC is under evaluation by Brisbane City Council and Melbourne Water and scheduled for wider release next year. During the next five years research will focus on improving the scientific rigour in the algorithm contained in MUSIC and facilitate user-friendliness. Industry training of the application of MUSIC will prepare the adoption environment for the research outputs of this Program.

PROGRAM 5 CLIMATE VARIABILITY

PROGRAM LEADER: PROFESSOR TOM MCMAHON, THE UNIVERSITY OF MELBOURNE

AIMS: TO IMPROVE THE ABILITY TO QUANTIFY CLIMATIC VARIABILITY; TO REDUCE HYDROLOGIC RISK FOR A RANGE OF WATER-RELATED ISSUES (FLOOD MAGNITUDE, DROUGHT SEVERITY, WATER RELEASES FROM RESERVOIRS, ENVIRONMENTAL FLOWS), THROUGH THE APPLICATION OF CLIMATE FORECASTS.

PROGRAM OUTPUTS

A methodology to produce a national database of stochastic climate variables for input to hydrologic and water resource systems models.

A methodology to quantify the spatial and temporal variability of rainfall.

Methods for forecasting weather, seasonal climate and streamflow from several hours to several months ahead.

Tools to help catchment managers reduce hydrologic risk.

OUTCOMES AND BENEFITS

This Program aims to improve the ability of catchment managers and researchers to quantify climate variability. This will help reduce the hydrologic risk for a wide range of water-related issues Australia-wide.

END-USERS

Land and water management agencies, catchment managers and scientists researching catchments Australia-wide.

PROGRAM HIGHLIGHTS 2000-2001

- A space-time rainfall model for homogeneous areas, *MOTIVATE*, was developed and calibrated for Melbourne. It has been used to estimate one in five-year storms to help assess the design adequacy of the Melbourne sewerage network.
- As part of the Program's Communication and Adoption process, 22 middle and senior managers (including nine from CRC Parties) attended a Stochastic Hydrology Workshop at The University of Melbourne in February 2001. They received an overview of the techniques to generate and use stochastic data in estimating risk in land and water management.
- A review of methods for generating stochastic data has been completed, and various methods were compared using data from across Australia.

Below Left Program Leader, Project Leader Prof Tom McMahon – Project 5.2

Left 'Nowcasting' model S_PROG international field demonstration at Sydney Olympics

Below Project Leader Dr Francis Chiew – Project 5.1

- New rainfall forecasting technology
  At the Sydney Olympic Games, the CRC's S_PROG rainfall forecasting (nowcasting) model and five other nowcasting systems from Canada, the US and the UK were tested as part of the World Weather Research Program Field Demonstration Project. A highlight was the interaction between scientists supporting the six nowcasting systems, which were connected to the Bureau of Meteorology network in Sydney during the Games, to demonstrate state-of-the-art forecasting of rainfall amounts. Initial evaluation of S_PROG, which forecasts rainfall one to two hours ahead, has been positive.

MODELLING AND FORECASTING HYDROCLIMATE VARIABLES IN SPACE AND TIME PROJECT 5.1

PROJECT LEADER: DR FRANCIS CHIEW

Aim To develop Australian space-time rainfall models and methods for forecasting rainfall and streamflow several hours to several months ahead.

ACHIEVEMENTS 2000-2001

- A space-time rainfall model for homogeneous areas, *MOTIVATE*, was developed and calibrated against radar data from several locations in Australia.
- The S_PROG for forecasting rainfall one to two hours ahead was tested as part of the World Weather Research Program Field Demonstration Project.
- The Bureau of Meteorology's Numerical Weather Prediction (NWP) model forecast of climate variables was assessed. Research methods to improve the land surface representation in the NWP models have been established (together with Project 1.2). This will include a monitoring program in the Murrumbidgee River Basin starting in spring 2001.
- Downscaling experiments to relate large-scale atmospheric variables and local-scale catchment data (mainly rainfall) in the Murrumbidgee River Basin were begun. Data for the study have been collated and analysed and a list of candidate atmospheric predictors developed.
- A study of the relationship between Australian rainfall and runoff and El Nino – Southern Oscillation (ENSO), and the serial correlation in rainfall and in runoff have been completed, using extended runoff data from the National Land and Water Resources Audit (NLWRA) for almost 300 sites across Australia. A non-parametric model for forecasting probabilities of exceeding seasonal rainfall and runoff was also developed.

NATIONAL DATA BANK OF STOCHASTIC CLIMATE AND STREAMFLOW MODELS

PROJECT 5.2 PROJECT LEADER: PROFESSOR TOM MCMAHON

Aim To develop a robust set of stochastic models for generating climate and streamflow data for any location in Australia at different time scales.

ACHIEVEMENTS 2000-2001

- A literature review of stochastic* generation of climate data was published as a CRC for Catchment Hydrology report and a shortened version has been accepted for publication by the *European Hydrology & Earth System Sciences Journal*.
- Researchers completed a comparison of the traditional Auto-regressive Time Series model (AR) and the Hidden State Markov (HSM) model (developed by Associate Professor George Kuczera and PhD student, Mark Thyer, of Newcastle University, NSW) for generating annual rainfall using data from 20 Victorian stations. Unlike the AR model, the HSM model identifies the long periods of above-average and below-average rainfall in a historical record. Results show in general there was no need to use the more complex HSM model.
- The HSM model was also applied to 40 Australia stations with long rainfall records to determine the regions where two-state persistence was important. This work is nearing completion and will be published as part of the CRC for Catchment Hydrology report series.
- Twenty sites were selected to generate daily rainfall data and the data were extracted and quality-checked. The Wang-Nathan model is being applied and the results will be compared with those from the Srikanthan-McMahon model. Application of the latter model is nearing completion.

**Stochastic data are random numbers modified to have the same statistical characteristics (in terms of mean, variance, etc and auto-correlation structure) as the data set on which they are based. It is a method of generating synthetic data with the same statistical properties as historical data, for use in predictive modelling. Most stochastic models have not been adequately tested with regard to characteristics at different time scales or at a number of locations with different climates.*

Left Bureau of Meteorology new weather radar at Kurnell, NSW – part of a network of data stations

Below Climate Variability Program group

PROGRAM 5 MILESTONES

MILESTONES	PROGRESS
Years 1 and 2	
Specify through a workshop the boundaries of current data generation algorithms – the climatic and streamflow variables, time steps and spatial scales.	A workshop was held in March 2000 and variables, time steps and spatial scales specified.
Identify the most appropriate methods to generate stochastically climate and related hydrologic data sequences for any point in Australia. Write and test computer programs to generate climate data. Distribute via targeted workshops for other CRC programs.	Completion of this milestone is on schedule. A literature review was completed, a CRC for Catchment Hydrology technical report written, and a paper is in press. Computer programs have been written or are available to generate rainfall data for a single site at a daily, monthly and annual level, including incorporating pseudo-cyclicity at the annual level. A workshop was held in February 2001 and others are scheduled for next year.
Conduct a stakeholders' workshop to identify key stakeholder interests and involvement in the project. Establish the project as a component of the Global Energy and Water Experiment (GEWEX) CSE by satisfying the acceptance criteria.	The March 2000 workshop was held and preliminary discussions have taken place with key stakeholders. Discussions have been held between the Bureau of Meteorology and the GEWEX Project Office regarding the inclusion of the Murray-Darling catchment as a GEWEX experimental catchment.
Develop a catchment routing scheme to link with the numerical weather prediction (NWP) model output in order to verify gridded model runoff estimates against observations of streamflow at gauging stations.	This milestone was deleted from the Commonwealth Agreement Schedule 1 as approved by the Commonwealth on November 16, 2000. The routing scheme was developed externally from the CRC and a paper has been published about the technique.
Adapt the land surface scheme, currently used in the Bureau's operational forecast model, to improve the NWP capability for the simulation and prediction of the surface water budget on basin and catchment scales, with a focus on the Murray-Darling Basin and the Murrumbidgee Catchment.	Baseline performance of the NWP model has been established and research to improve the land surface scheme in the Bureau's NWP model is underway.
For climate-linked space-time modelling, determine the best way to stratify the past climate (e.g. wet vs dry years) in a way that makes sense from a water management perspective. (i.e. focusing on runoff volumes rather than rainfall)	This research is no longer a priority because approaches for forecasting seasonal rainfall and streamflows are undertaken elsewhere in the project.
Characterise and develop models for spatial and temporal rainfall patterns in terms of their statistical structure for the different climate stratifications identified within a Bayesian or other framework.	The space-time rainfall model *MOTIVATE* has been developed and calibrated against Melbourne radar data and will be calibrated using radar data for other Australian locations.
Examine existing seasonal forecasting techniques suitable for forecasting streamflow for water resources management. (*Modified milestone as approved by Commonwealth 16 November 2000*)	A non-parametric model for forecasting probabilities of exceeding seasonal rainfall and streamflow has been developed for testing using time series data from across Australia.

PROGRAM 6 RIVER RESTORATION

PROGRAM LEADER: DR IAN RUTHERFURD, THE UNIVERSITY OF MELBOURNE

AIM: TO PRODUCE AND DEMONSTRATE BEST-PRACTICE GUIDELINES FOR CARRYING OUT STREAM RESTORATION IN AUSTRALIA.

PROGRAM OUTPUT

Tools, information and intellectual leadership required to rehabilitate Australian streams.

OUTCOMES AND BENEFITS

The vision of the River Restoration Program is to improve and protect the natural environment of Australian streams for future generations by equipping stream managers with effective knowledge and tools. As a result of this work, agencies will have:

- A basis for deciding whether to rebuild channels or let them degrade to a quasi-natural state techniques to manage sediment
- Best-practice guidelines for channels to maximise environmental returns for the available flows
- An assessment of the secondary consequences of restoration works on streams, especially for flooding and erosion
- Better value for money from the Natural Heritage Trust and similar initiatives by improving the planning, design and implementation of specific rehabilitation activities, such as re-snagging and fishway structures.

END-USERS

Stream managers and engineers involved in stream restoration and management works.

PROGRAM HIGHLIGHTS 2000-2001

- In August 2000, the CRC for Catchment Hydrology Board ratified seven projects under this Program and work began immediately, involving a range of industry Parties and two of the biggest stream restoration projects in Australia (Granite Creeks, Vic and Echidna Creek, Qld).
- Three high-calibre Research Fellows were employed (see project highlights).
- The Program team continued to develop and maintain outstanding partnerships with agencies including the CRC for Freshwater Ecology, Land & Water Australia (LWA) and agencies throughout the Focus Catchments. In particular, the Granite Creeks (Project 6.3), south-east Queensland (Project 6.4) and environmental flow (Project 6.7) projects are excellent examples of cooperation.
- LWA awarded the Program $500,000 for an associated project investigating the role of riparian vegetation in stream hydrology and erosion, which complements the work of Projects 2.1, 6.1 and 6.4. This is additional to $350,000 from Agriculture, Fisheries and Forestry – Australia for fishways research.
- An interactive CD version of the national *Stream Rehabilitation Manual* was released, building on the success of the hard-copy manual published in 1999 to widespread industry acclaim.
- Program members took on major roles organising national industry conferences to be held in August 2001- the Third Australian Stream Management Conference and the Third National Fishway Workshop.
- International researchers who collaborated with Program 6 during the year included Professor Jackie King and Dr Mandy Uys from Rhodes University, Grahamstown, South Africa. Dr Uys is working at The University of Melbourne as an Honourary Research Fellow to develop cooperative projects in stream restoration with LWA and conduct research as part of the stream restoration project with Melbourne Water.
- Three postgraduate students were welcomed to the Program (see project highlights).

Opposite Page
Left Program, Project Leader Dr Ian Rutherfurd – Project 6.3

Right Project Leader Dr Mike Stewardson – Projects 6.1, 6.7

This Page
Far Left Project Leader Dr Tony Ladson – Dandenong Ck inspection for Project 6.2

Left Brett Anderson at Creighton Ck – site for habitat restoration studies.

Below Project Leader Prof Stuart Bunn – Project 6.4

GROUP A PROJECTS

STREAM RESTORATION
PROCEDURES AND EVALUATION

Aims of Group A Projects To develop principles for evaluating restoration procedures and criteria for determining the recovery potential of streams, in collaboration with the CRC for Freshwater Ecology, and evaluate large-scale stream rehabilitation projects in partnership with the Focus Catchments.

DEVELOPING CRITERIA AND CONCEPTS FOR PLANNING STREAM REHABILITATION PLANNING

PROJECT 6.1 PROJECT LEADER: DR MICHAEL STEWARDSON

ACHIEVEMENTS 2000-2001

- Dr Michael Stewardson from The University of Melbourne was appointed Project Leader.
- The project team developed novel procedures for designing evaluation projects for stream rehabilitation.
- The project has been extended to allow trialling of methodologies to assess riparian revegetation projects in the Goulburn Broken catchment.

OPTIMISING URBAN STREAM REHABILITATION PLANNING AND EXECUTION PROJECT 6.2

PROJECT LEADER: DR TONY LADSON

Former Title: Stream restoration planning and execution in the Yarra catchment

Aim To develop, implement and evaluate a major restoration project in the Yarra River Focus Catchment in partnership with the CRC for Freshwater Ecology and Melbourne Water.

ACHIEVEMENTS 2000-2001

- Dr Tony Ladson from The University of Melbourne was appointed Project Leader.
- Designs were finalised for two sub-projects.
- Project researchers cooperated with Program 4 researchers to create efficiencies in joint research areas.

RESTORATION ECOLOGY IN THE GRANITE CREEKS, VICTORIA PROJECT 6.3

PROJECT LEADER: DR IAN RUTHERFURD

Aim To design and build artificial habitat structures in selected creeks and, in association with the CRC for Freshwater Ecology, monitor their biological and physical effects.

ACHIEVEMENTS 2000-2001

- A series of 40 habitat restoration experiments were constructed on Creighton and Castle Creeks, with the assistance of the Goulburn Broken Catchment Management Authority (CMA). Monitoring began and all sites are being surveyed in detail.
- Researchers designed a unique pressure transducer device that continuously measures bed level changes.
- Excellent cooperation with the CRC for Freshwater Ecology and the Goulburn Broken CMA in designing and constructing works.

EVALUATION OF RIPARIAN REVEGETATION IN A SOUTH-EAST QUEENSLAND CATCHMENT

PROJECT 6.4 PROJECT LEADER: PROFESSOR STUART BUNN

Aim To test the effectiveness of restoring large tracts of riparian vegetation.

ACHIEVEMENTS 2000-2001

- Following an exhaustive selection process involving community groups and the South East Queensland Regional Water Quality Management Strategy (SEQRWQMS), Echidna Creek in south-east Queensland was chosen as an experimental site. Monitoring began on control sites (grazed and ungrazed, good as well as patchy riparian vegetation). Treatment on other sites included fencing to keep out stock and revegetation. Data being collected using automated stream monitoring equipment includes water temperature, discharge and turbidity. A detailed survey of the treatment and control sites has been completed by Natural Resources and Mines, Qld (NRMQ).
- Research Fellow, Nick Marsh, was appointed to coordinate the project from the CRC for Catchment Hydrology node at Griffith University, Qld, and evaluate the effectiveness of riparian revegetation in south-east Queensland.
- Models of the expected response to revegetation and temperature to shading were completed and work begun on models of turbidity change.
- Community and landholder participation remained high and there is excellent cooperation with NRMQ, the local catchment community and the SEQRWMS.

GROUP B PROJECTS

IMPROVED DESIGN OF TOOLS FOR STREAM RESTORATION

Aims of Group B Projects To improve the confidence with which people design and apply tools for stream restoration and develop a decision support system (DSS) to help select the most appropriate restoration techniques.

HYDRAULICS AND PERFORMANCE OF FISHWAYS IN AUSTRALIAN STREAMS

PROJECT 6.5 PROJECT LEADER: ASSOCIATE PROFESSOR BOB KELLER

Aim To recommend optimum design for fishways (structures that assist fish in swimming past man-made barriers, such as weirs).

ACHIEVEMENTS 2000-2001

- Postgraduate students Peter Kolotelo and Andrew Barton were welcomed to the project.
- Planning began for the Third National Fishway Workshop, Brisbane, August 2001.
- Experiments into the effect of rock-ramp fishways on gauging rating tables were completed.
- Major experiments in vertical slot fishway hydraulics in the flume and in the field were completed. This work provided a basis for developing a hydraulic model of vertical slot fishways that allows for design optimisation.
- International collaboration was fostered by postgraduate student Lindsay White.

DEVELOPING TOOLS TO PREDICT SCOUR OF REHABILITATION WORKS IN STREAMS PROJECT 6.6

PROJECT LEADER: ASSOCIATE PROFESSOR BOB KELLER

Aims To develop tools to predict the probability of various objects surviving in a streambed and strategies to better manage woody debris, snags and other beneficial objects in streams.

ACHIEVEMENTS 2000-2001

- Researchers compiled for analysis large data sets of structures that failed in floods around Victoria. This will help develop guidelines for optimum structure design.
- Software for designing rock-chutes was developed.

DEVELOPING AN ENVIRONMENTAL FLOW METHODOLOGY: A TRIAL ON THE CAMPASPE RIVER PROJECT 6.7

PROJECT LEADER: DR MICHAEL STEWARDSON

Aim To develop a generic environmental flow methodology that integrates hydrology, geomorphology and ecology.

ACHIEVEMENTS 2000-2001

- Dr Michael Stewardson was appointed Project Leader. In the past year, there has been growing water industry acceptance of the Flow Events environmental flow methodology he developed. The CRC aims to have it accepted as Best Management Practice for determining environmental flows in Victorian streams.
- The Flow Events methodology was applied to the Broken, Snowy, Onkaparinga and Thomson Rivers in Vic.
- Six streams were surveyed to provide a unique data set to increase the efficiency of environmental flow surveys.
- UK PhD student Dominic Blackham was welcomed to the Project.

Below Left River Restoration Program group

Far Left Research to improve fish habitat – Lindsay White at Torrumbarry Weir fishway

Left Riparian zone research – Nick Marsh Project 6.4

Below Project Leader Assoc Prof Bob Keller – Projects 6.5 , 6.6

PROGRAM 6 MILESTONES

MILESTONES	PROGRESS
Years 1 and 2	
Formalise links with partner CRCs in joint projects.	Formal links established with the CRC for Freshwater Ecology in five projects.
Complete evaluation of existing rehabilitation projects in Australia. (*Milestone deleted as approved by Commonwealth 16 November 2000*)	
Select catchments and sites for trial rehabilitation.	Sites selected for all projects, with two focused on the Goulburn Broken catchment, two in the Yarra and one in Brisbane. Other two projects relate to all catchments. All experimental sites have been selected.
Trial stream rehabilitation planning procedure at target sites.	Trial well-advanced on Dandenong Creek, focusing on planning procedures, particularly evaluation design.
Develop improved criteria for rehabilitation planning. (*Modified milestone as approved by Commonwealth 16 November 2000*)	In progress in all projects. Substantial progress made in fishways, evaluation and environmental flow projects.
Develop and calibrate hydraulic and hydrological models of rehabilitation sites and assess viability of projects. (*Milestone deleted as approved by Commonwealth 16 November 2000*)	
Begin construction of works if appropriate.	All construction of structures and installation of monitoring equipment completed in south-east Queensland and Granite Creeks, Vic. Yarra structures are being designed.
Design associated rehabilitation experiments.	All but two experiments in place. Continuing experiments include: Granite Creeks structures experiment, fishways field and flume experiments, south-east Queensland revegetation experiment, and evaluation experiments (6.1). The scour (6.6) and Yarra (6.2) experiments are behind schedule because of problems finding staff.
Develop a stream rehabilitation training program.	Discussions underway with LWA through the Rivers Consortium to develop stream restoration short courses.