June 2001

WaterShed

contents

Measuring River Health

by Professor Peter Cullen

One of the questions most frequently asked of the CRC for Fresh Water Ecology is how do we measure river health? Rarely do people want to damage the rivers that they work with or that they are sustained by. However, determining when a river is healthy or when it is changing to an unhealthy state is difficult.

River health is complex, just as human health is complex. If you were to ask your doctor, "Am I healthy?", they would assess a range of indicators and make a judgement. They might look at weight and blood pressure, examine your ears or throat or they might decide on a range of blood tests or X-rays. They would then use these various indicators to determine your health and advise you of the best treatment.

Just like people, unhealthy rivers can be diagnosed by looking at some common symptoms. These are as follows:

- River banks – is the riparian vegetation intact or destroyed? Is there stock damage or signs of recent unnatural erosion? Are the banks natural or straightened? Do levees isolate the river from its floodplain?
- River bed – has excessive sand from past erosion smothered riverbed habitat, such as deep pools and riffles? Are other habitat present, such as snags?
- The look of the water – are there algal scums, dead fish, litter or other floating rubbish?

Beyond these obvious visual symptoms we, like the human doctor, might want to undertake some diagnostic tests to test our ideas on what might be wrong with a river.

The common diagnostic tests we use include:

- Water quality measurements – there are a range of chemical indicators commonly used including nutrients and salinity. With caution, we may be able to use Water Quality Guidelines to interpret these figures.

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Cooperative Research Centre for Freshwater Ecology

Cooperative Research Centre for Freshwater Ecology

The Cooperative Research Centre for Freshwater Ecology improves the condition of Australia's rivers, lakes and wetlands

CRC Australia

- Aquatic invertebrates – the levels of nutrients or pollutants in the water and/or changes in flow are significant, however it is the biological consequences of this change that may be of greater concern.

Aquatic invertebrate communities have been widely used in Australia to assess the health of rivers. Invertebrates are good indicators of the biological health of a river. Some species (such as mayflies) are known to be highly sensitive to subtle changes in their environment, while others (such as bloodworms) are very tolerant. Species recorded at a range of damaged or undamaged sites can provide an important insight into what is happening in a river or its catchment. This approach is now used as a predictive tool by river managers.

- Fish – most Australians tend to judge the health of a river by whether or not it supports a healthy population of native fish. However, in cooler mountain streams and/or sections of rivers made artificially cold by water released from dams, introduced species such as trout thrive and are welcomed by many sport fishers. Carp, however, are generally disliked by most people.

Other key elements of a healthy river are:

- The flow regime, which may be influenced by extraction and storage of water. For example, in southern Australia flows may be inverted to create peak flows in summer and low flows in winter.
- Habitat, which is made up of snags, riparian vegetation and bed condition is strongly influenced by flow regime. Adequate flow ensures connection between the river and the flood plain habitat, upstream and downstream of the river.

At the end of the day, communities must choose the level of health they want for their rivers, in a similar way that people make choices about their own health. The choices for either are not easy. With a river, our obligations to downstream users as well as to the environment have to be considered. Setting targets for flow, salinity, nutrients and riverine health is difficult because it must be done in the context of what

'acceptable change' will be a tough choice

Prof Peter Cullen, Chief Executive of the CRC for Freshwater Ecology. Photo: M Ashkanasy, courtesy of Melbourne Water

level of change is acceptable to society. This is a social choice; all science can and should do is to identify what the consequences of various decisions will be, hopefully identifying long term as well as the short-term changes.

Most people are willing to accept some change in our rivers in exchange for the benefits society gets for their use. Few people are talking about restoring all our rivers to a pristine condition - this is just not possible when we have changed so much in the catchments. We must understand that most rivers are impacted by human activity, many to a great extent. We should certainly seek to identify our few undamaged river systems and protect them.

How much change is acceptable? To answer this question we must first develop a broadly accepted measure of river health. This will ensure that we are all talking about the same thing. The National Land and Water Resources Audit and the Sustainable Rivers Audit being developed by the CRC for Freshwater Ecology for the Murray-Darling Basin address this issue. Deciding where we want a river to be on this scale of 'acceptable change' will be a tough choice for communities, but it is a choice that has to be made. In making it, people will want to know what are the limits of change beyond which a river is not likely to recover even if the stress is removed. This is a tough question and remains a challenge for science.

As we move to set targets it is important to remember they are a social choice and we may change them periodically as our views about the sort of rivers we want change and as we better understand the impacts of our decisions and actions.

Professor Gary Jones: New Director of Knowledge Exchange & Education

In January, Professor Gary Jones joined the CRC for Freshwater Ecology as the new Director of Knowledge Exchange and Education. He is also Professor of Aquatic Science at the University of Canberra.

Gary has over 20 years experience in phytoplankton ecology and aquatic chemistry, with a Ph.D. from Melbourne University and post-doctoral experience in the USA and UK. From 1989, Gary worked with CSIRO Land and Water in Griffith, NSW and then in Brisbane. He is an international authority on toxic cyanobacteria (blue-green algae) and has been involved in research and implementation of management strategies for toxic cyanobacteria in Australia, Europe, South-East Asia and South America. In recent years he has focused on developing holistic and risk-based approaches to the management of water quality, human health and recreational activities in reservoirs and lowland rivers.

Gary comes to the CRC with a vision of a philosophical and operational continuum across Knowledge Exchange and Education.

"For me, knowledge exchange includes a strong audience education component, while education can be thought of as a formally structured or institutionalised form of knowledge exchange with students, partners or the community"

Gary also has a strong commitment to outcome delivery for our partners.

"I believe it is important that the outputs or knowledge products we produce or manage are always directed at a specific outcome and target audience."

For Gary, measuring performance against specific outcomes is a major challenge for Knowledge Exchange and Education. Mind you, he is realistic about the difficulties faced in meeting this challenge.

"The Australian natural resources management environment is complex, with many players trying to influence ecologically sustainable development outcomes within government, community and the water and agricultural industries. In such a complex environment it is difficult for the CRCFE to know exactly how it may have influenced a particular audience outcome - whether it be a change in policy, a change in management systems, or a change in thinking, behaviour or actions. Nevertheless, I believe we should not shrink from the challenge of trying to understand how we have influenced the outcomes we have targeted for delivery."

I fully support the strategic approach to knowledge exchange already developed in the CRCFE. Indeed, I am looking to further strengthen interactions with our partners and the community, using our knowledge brokers as the main conduit for this exchange. Our recent appointment of a new knowledge broker in Sydney, Amanda Kotlash, will greatly enhance our ability to achieve this aim."

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Gary Jones: New Director of Knowledge Exchange and Education
Photo: CRCFE

Salinity Thresholds: Assessing the Risks

The following article is a summary of a paper written by Professor Peter Cullen, Professor Gary Jones and Dr. John Whittington for the ABARE OUTLOOK 2001 conference.

The alarming predictions of increasing salinity in many streams and rivers of the Murray-Darling Basin, and elsewhere, have prompted significant government investment, as outlined in the Prime Minister's Action Plan on Salinity and Water Quality (2000).

At present, strategies are being developed to minimise further increases in river salinity and to reduce the impacts of rising salinity on the environment. Setting salinity targets for rivers and catchments has been an important step in developing these strategies. These targets have often been guided by what might be attainable through current good management practice, rather than being based on an understanding of the ecological impacts of salinity on the biota. Is this an appropriate way to guide investment decisions aimed at protecting the environment?

information will always be imperfect

We present an alternative framework for developing salinity targets aimed at protecting riverine ecosystems from salt-induced degradation. This approach is based on a risk assessment methodology that recognises the inadequate knowledge base upon which these targets will be developed.

Understanding Salt as a Toxicant

In principle, the progressive addition of salt to a freshwater environment is no different to contamination by any other toxicant or pollutant. Plants, animals and microorganisms exposed to the toxicant (salt in this case) will show a progressive response ranging from chronic at low concentrations to acute at high concentrations.

Assessing the effect of a toxicant on a single species can be relatively simple. However, testing the response of mixed natural populations to toxicants in a natural environment is far more difficult and expensive and results of these tests are difficult to interpret. Uncontrollable environmental and climatic factors such as changes in river flow or water temperature often occur.

Consequently, guidelines on acceptable toxicity levels are often set without access to chronic exposure data.

Despite our limited knowledge base there is general agreement that the impacts of increasing salinity on aquatic ecosystems will include:

- Loss of biodiversity as susceptible species disappear and more tolerant species become dominant;
- Changes to wetland vegetation reducing habitat and food sources;
- Disruption to nutrient cycling and decomposition processes; and
- Increased risk of toxic algal blooms.

Risk Assessment: A Possible Way Forward

In arriving at exposure guidelines for humans, toxicologists are often confronted with inadequate experimental data. To cope with the uncertainty, they use a risk-based assessment methodology. We suggest that a similar approach can be used for assessing salt impacts on biota.

A key aspect of this approach is the concept of 'tolerable risk'. How much are we prepared to risk a management action, or lack of it in the case of salinity, impacting negatively on the aquatic environment? We, in this case, meaning the community as a whole, not only scientists or economists.

In this approach it is not essential to know the exact point or concentration at which environmental degradation commences. A risk-based methodology recognises that information will always be imperfect, whether for reasons of paucity or because of the highly complex nature of natural ecosystems. What is crucial is to explicitly recognise the uncertainty in the data and to compensate for this through the application of 'safety factors'.

The use of laboratory animals (such as mice and rats) to help predict the effect of toxicants on human health provides a good example of this approach and may provide a suitable framework for assessing salinity effects on aquatic biota. Currently, toxicant levels for humans are determined by assessing the LD50 concentration (the dosage required to kill 50% of the experimental animals). Safety factors of 10x10x10 ie. 1000 are imposed to arrive at a safe human guideline level.

The 'safety factors' mentioned above reflect three things: differences between humans and test animals, differences within the human population and inadequacies in the data. The latter often refers to the lack of high quality, long term chronic exposure data.

For aquatic species, the safety factor will never be reduced to zero because it is impossible to test all aquatic species, let alone all life stages of those species. Only by carrying out detailed toxicity testing on all species over a long period can the "intra-species" susceptibility factor be reduced or removed. Similarly, good long term trial data will enable the 'data inadequacy' factor to be reduced.

The process of guideline setting must be an evolutionary one. Initially, knowledge will usually be poor, clearly this is the case for salinity impacts on aquatic biota. However, good quality acute toxicity data does exist for a few species of aquatic animals and plants. By applying the appropriate safety factors to this data, economic and management projections can be made for a given scenario. Scenario assessment can be made against data for different species and with different safety factors. This will provide a spectrum of economic cost projections against which management actions and feasibilities, and socio-economic costs can be considered.

The process of guideline setting must be an evolutionary one

Risk-based assessment of salinity impacts is ideally suited to an adaptive management framework. The community will have a clear and readily definable role to play in agreeing on the levels of 'tolerable risk' of environmental degradation. The greater the desire to protect the environment the higher will be the safety factors applied to the data. Finally, scientists have an important role to play in the acquisition of toxicity data and in providing advice on appropriate safety factors.

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Dryland salinity is linked to degradation issues such as soil erosion.
Photo: B. van Aken, CSIRO

Environmental Flows: How Much is Enough?

In 1994 the Council of Australian Governments (COAG) agreed that a strategic framework for water reform was needed to address the continuing decline in the condition of Australia's inland rivers. The reforms covered all aspects of the water industry including the economic, social and environmental implications of water consumption. COAG agreed that the environment was a legitimate user of water and the environmental needs of river systems should be determined on the best available scientific information.

Extraction of water from the Murray-Darling River system has increased significantly in the last fifty years. In 1994 extraction levels were triple that of the 1950s and average annual flows from the Basin to the sea were only 21% of those that would have occurred under natural conditions. Reduced flows have affected the frequency and duration of small to medium size flood events and such drastically altered flow regimes are believed to be partly responsible for a continuing decline in river health, prompting calls for the establishment of environmental flows.

the concept of environmental flows is not new

From an environmental perspective, all water in a river ecosystem is the 'environmental flow regime'. Recently, environmental flows have been a term used by water managers to describe that component of the river flow that is managed with the aim of achieving some environmental outcome. This could be maintaining or restoring flows to key habitats such as floodplain wetlands and anabranch channels or flows to protect or enhance water quality. COAG requires that all States and Territories address river health and environmental flows when allocating water. The concept of environmental flows is not new and research relevant to this pressing water issue has been the focus of many research projects within the CRC for Freshwater Ecology.

Over eighteen projects within the CRC relate specifically to understanding the ecological, biological and geomorphological significance of environmental flows, including channel complexity, habitat availability, impacts on biodiversity, ecological processes, fish migration and fish passage.

Environmental flow requirements for the highly regulated Campaspe River in northern Victoria is a long-term project being conducted by the CRC for Freshwater Ecology. Decades of increased regulation have had a significant impact on flow regimes, reducing the amount of water available for environmental purposes outside the irrigation season. Scientists at the CRC have been monitoring the Campaspe for five years to assess the impact of highly modified flows on fish and invertebrates. Results clearly show a correlation between declining water quality and altered distribution and abundance patterns of fish and other aquatic plants and animals. The results of this research have contributed to the development of an experimental environmental flow regime that will allow some of the natural seasonality to be returned to the river.

The Campaspe is a lowland river in a temperate environment. To date, the majority of studies that attempt to explain riverine ecosystem function have originated in temperate, perennial rivers and as such, extrapolations to dryland river management can be inappropriate.

Dryland rivers are a prominent feature of the Australian landscape, comprising approximately 80% of the total length of Australian rivers. They are characterised by highly variable flows, less stable geomorphology and highly opportunistic plants and animals that have evolved with these 'boom-and-bust' cycles. Highly variable flows, a result of unpredictable rainfall and low run-off (less than 12%), underpin all ecological processes in these rivers and their floodplains and wetlands such as the transport of organisms, nutrients and other material between a river and its floodplain.

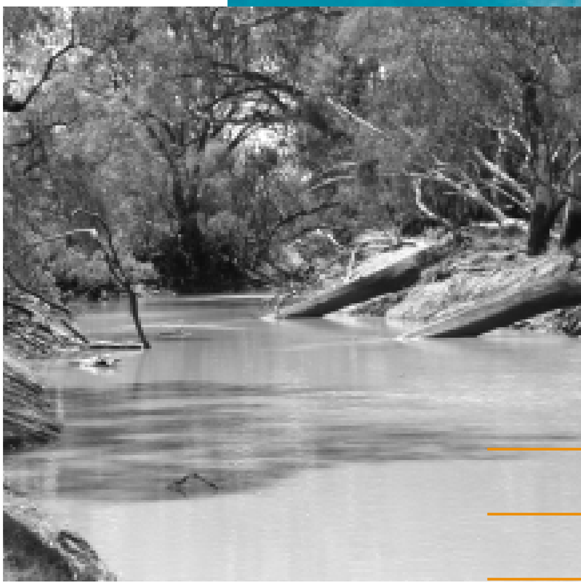
The character of Australia's dryland rivers have been altered dramatically since European settlement through large-scale floodplain development and regulation of river flows. River regulation through the construction of dams, levees and water abstraction has resulted in a loss of, or change in connectivity both along the length of rivers and between rivers and their floodplains. This has resulted in a reduction in the exchange of organic material and nutrients, and the movement of plants and animals between the floodplain and the river channel.

Ecosystem processes and environmental flow requirements in the Barwon-Darling River in northern NSW have received considerable attention from the CRC for Freshwater Ecology. Project leader Associate Professor Martin Thoms is currently studying the relationship between flow variability, habitat complexity and ecological functioning in the Barwon-Darling system. "The Barwon-Darling is a complex river channel, comprised of a series of 'benches or mini floodplains' set into the river", he said. "Each of these benches increases the habitat complexity of the river and acts as a storehouse of nutrients, or organic material which, when flooded, release carbon back into the main stream. If flooding of these benches is reduced, nutrients cannot be returned to the stream and the total supply of carbon is reduced. This is significant because carbon is one of the major food sources in rivers for bacteria, invertebrates and fish," he added.

environmental needs of rivers are recognised in policy development

River regulation has resulted in more regular 'flows' in the Barwon-Darling, and like the Campaspe, this has the effect of reducing flow variability, one of the key factors driving ecological processes in rivers.

The National Land and Water Resources Audit released by the Federal Government in April 2001 has identified environmental flows as one of the major issues that must be addressed if sustainable use of our water resources is to be achieved. The Australian Water Resources Assessment 2000 reveals that 26% of Australia's river basins are approaching or beyond sustainable extraction limits (this accounts for more than half the water used in Australia).



The Barwon Darling River near Walgett, NSW.
Photo: Martin Thoms, CRCFE

Water management policies are, by necessity, evolving rapidly and the environmental needs of rivers are recognised in policy development. However, there remains a lack of information on the relationship between environmental flow regimes and the ecological requirements of rivers.

The Campaspe and the Barwon-Darling River projects are part of a larger group of research projects within the CRC for Freshwater Ecology. Such projects are providing valuable insights into the complexities of river ecosystem function, a necessary first step before environmental flow regimes can be recommended and established.

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CRC for Freshwater Ecology – Rotary Easter Schools 2001

The Rotary Easter Schools are a collaborative effort between the CRCFE/MDFRC and Rotary. Two camps were held this year and the following articles summarise some of the highlights from each.

Lake Cullulleraine School

by Michelle Bald

The Murray Darling Freshwater Research Centre Lower Basin Laboratory and Rotary District 9520 united again this year to host the 3rd annual "Health of the River System" forum at Lake Cullulleraine (April 5th to 8th). Fifty one year 9 and 10 students from three states explored how river health affects our lives, concentrating on solutions to the problems confronting our rivers and wetlands.

The social and economic importance of river systems were explored via a 'role play' game of water allocation in a hypothetical catchment. Students inspected the irrigation systems at Tandou vineyard and visited lock 9 to investigate the benefits and impacts of locks and weirs.

Students explored the ecology of aquatic ecosystems with special reference being paid to the social and economic demands placed upon these systems. Students measured water quality, identified fish and discussed fish ecology, used macro-invertebrates to monitor river health, and identified and discussed ecological adaptations of aquatic plants.

All students were very enthusiastic, and were especially interested in learning practical ways in which they could help our rivers now and into the future. This led to some positive discussions between mentors, group leaders and students. Mentors and project leaders were recruited from MDFRC, Rotary, Lower Murray Water, Murray Wetlands Working Group, the Mallee CMA and the Coomealla Anglers Club.

The social and economic importance of rivers was explored

The Federal Member for Mallee, John Forrest, a representative from the River Murray Catchment Water Management Board and the Rotary District Governor, judged final student presentations on "What River Health Means to Me".

Given the high calibre of presentations and the enthusiasm of participants, the Easter school was declared a great success by all involved.

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Student presentations were the finale to a very successful forum. Photo: Ben Gawne, CRCFE

The Albury School

by Mike Copland

The sixth "Easter School" held at the MDFRC involved observing and sampling the Kiewa River from its source in the Bogong High Plains to its entry into the Murray. The eight groups of years 10 and 11 high school students and one Graduate Dip. Ed. student worked cooperatively to present a final report to MDFRC staff and Rotary visitors. The "report" was an attempt to bring together all the factors along the Kiewa River which the groups felt contributed to its living and non-living characteristics.

The 34 student participants came from as far afield as Cobar, Nambucca Heads, Canberra, Berri and Adelaide and the Mentors were from La Trobe University, Wodonga. Whilst all of the students were nominated by their schools as being very good scholars, some of their extra-curricular activities, especially in the field of freshwater activities, were outstanding

The deputy principal from Glossop High School, Mike Schultz and the Waterwatch coordinator from the Riverland provided valuable knowledge and expertise.

The fieldwork was carried out in perfect weather. For many participants it was their first visit to the high plains and they were most impressed by the landscapes.

The students, mentors and MDFRC staff had a great time BUT most importantly the aim of keeping these high-flying students within the science "web", seems to have been achieved, given the comments on their appraisal sheets. Advice from students who attended the first "Summer/Easter Schools" who are now at university confirms this impression.

Keeping these students in the sciences

Two items of good news announced at the final presentation were;

- The Norske Skog Newsprint Mill is to give Rotary $30,000 sponsorship for the next 5 Easter Schools, and;
- Students and Mentors from this year's School can apply to be part of an Exchange Team to visit Georgia and Tennessee in September 2001, and host a return team from the USA who will attend the 2002 Easter School at the MDFRC.

The Easter Schools continue to be a valuable link between the CRCFE/MDFRC and the schools and communities they serve. Rotary (and now Norske Skog) are prepared to put a great deal of time, energy and money into the enterprise as they both acknowledge the importance of our organisation and wish to see it continue and prosper.

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Pretty Valley in the Victorian Alps, one of sites visited during the 2001 Easter School. Photo: Mike Copland

Biofilms: The Icing on the Healthy River Cake

Simon Treadwell, PhD Student.

Simon Treadwell is completing his PhD in the Department of Biological Sciences, Monash University. His research on the importance of biofilms as a source of organic carbon in rivers is part of the CRC for Freshwater Ecology Lowland River Project.

Snags provide valuable habitat for many organisms including fish, invertebrates and biofilms. In lowland rivers, snags are often the only hard stable substrate available for colonisation by biofilms (algae,bacteria and fungi) and invertebrates. However, little is known about the ecological significance of snag biofilms to aquatic ecosystems.

The aims of this research were to determine the importance of snags as a substrate for biofilm colonisation and to measure how much of the total algal production occurring in a river is derived from algae growing on snag surfaces.

Production by biofilms growing on snag surfaces may be an important source of organic carbon entering lowland rivers. Organic carbon is a major food source in stream ecosystems for all organisms including bacteria, invertebrates and fish. Carbon can enter the stream from the floodplain in the form of leaves, twigs etc or be produced in the stream itself through algal production.

Healthy rivers need carbon from a variety of sources and different organisms are adapted to using particular carbon types. Algae, particularly diatoms – one of the most abundant algae found to be growing in biofilms – are an important source of high quality carbon for many invertebrates living in rivers.

Snags provide a variety of habitats for plants and animals. Photo: A Mostead

Simon Treadwell attaching the perspex chamber used to measure production of biofilms on snag surfaces. Photo: Ben Gawne

Research was carried out in the Murray River near Albury and Barmah and the Lower Ovens River in northern Victoria. Results show that snags are valuable sites for biofilm production.

Research, both in Australia and overseas, has shown that snag surfaces support a wide diversity of aquatic invertebrates, many of these depend on the biofilm attached to snags. Removal of snags may have had a significant impact on the diversity of organisms reliant on algal derived carbon sources.

Many resnagging projects are now being considered in an effort to restore habitat for native fish to degraded rivers. The addition of snags will also increase the surface area available for biofilm colonisation, enhancing the diversity of carbon available to aquatic organisms.

Simon is supervised by Associate Professor Ian Campbell and Dr Ralph MacNally and is the recipient of a CRC for Freshwater Ecology research scholarship.

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SideStream

Independent Review Determines Lake Free of Faecal Pollution

Ian Lawrence of the CRC for Freshwater Ecology has finalised a review, commissioned by The National Capital Authority on an incident where high faecal coliform levels were detected in Lake Burley Griffin causing closure of the lake.

The review concluded that the most probable source of the faecal coliform was 'in-lake regrowth' of *Escherichia coli* (a species of coliform bacteria). The bacteria were associated with the decomposition of plants in the lake and were not indicative of human faecal pollution, and were not considered a health hazard.

The review also concluded that the NCA's management of the situation, in consultation with ACT Health and Environment ACT, was in accordance with established procedures and that the Authority had little choice but to close the lake.

Finally, the review recommends the establishment of a risk based assessment protocol to assist management in the future.

Full copies of the report a 'Special Report - Lake Burley Griffin, Ecowise Environmental, April 2001' are available by calling the National Capital Authority on 6271 2888.

Tooma River Study Community Meeting

Members of the Tooma Landcare Group in the Upper Murray region, and staff from the Albury office of DL&WC, met on April 17 to discuss the Tooma River Study. Leader of the collaborative project, Dr John Harris, outlined the study for some 20 attendees.

The meeting considered implications of the planned experiment to mimic a rainfall event on the Deep Creek waste-rock dump, which is believed to be an episodic pollution source. People voiced concerns about the river's condition, provided local information on environmental changes, and considered the research plan. The meeting concluded on a positive note, with support for the study objectives and participants keen to be kept informed of developments. Initial results from the experiment will be available within a fortnight.

National Science Week

The CRC for Freshwater Ecology was well represented at the 2001 Australian Science Festival (May 1-6). Activities in Canberra included a live frog display as part of 'Science in the City' and PhD student Claire Sellens assisted in running the 'Rivers of Life' workshop. Approximately 350 students (8-16 year olds) participated in the workshop, which is designed to help students understand what it is that makes a river healthy and what we can do to protect rivers. Information on the Centre's research and education activities was also on display at the 'Amazing World of Science' as part of the University of Canberra display.

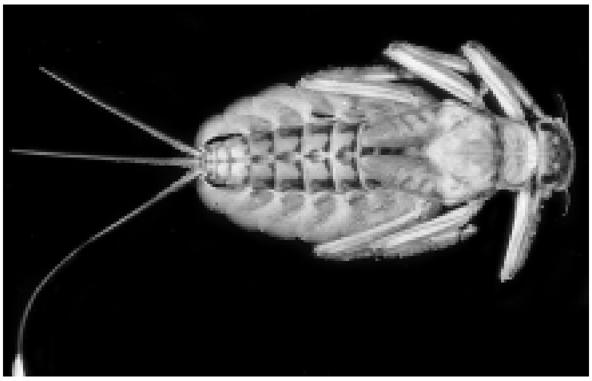

Photo: John Hawking

The feature creature for this issue:

Class Insecta
Order Ephemeroptera (mayflies)
Family Leptophlebiidae
Genus *Kirrara sp.*

Mayflies are used extensively in biological monitoring of aquatic ecosystems. Common in mountain streams throughout south-eastern Australia, *Kirrara sp.* use modified gills as suction pads, adhering to stones in fast flowing streams and feed almost exclusively on detritus.

CRCFE web site:
http://freshwater.canberra.edu.au

Comments, ideas and contributions are welcome and can be made to:

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- Department of Natural Resources and Mines
- Department of Natural Resources and Environment, Victoria
- Environment ACT
- Environment Protection Authority, NSW
- Environment Protection Authority, Victoria
- Goulburn-Murray Rural Water Authority
- Griffith University
- La Trobe University
- Lower Murray Water
- Melbourne Water
- Monash University
- Murray-Darling Basin Commission
- Murray-Darling Freshwater Research Centre
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- Sydney Catchment Authority
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