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contents



# The National Water Quality Management Strategy

**by Professor Peter Cullen and Professor Barry Hart in consultation with Ian Lawrence, Associate Professor Bill Maher and Dr John Whittington**

In 1992 the Commonwealth and State Governments, along with the water industry, developed the National Water Quality Management Strategy. This initiative was was established to integrate the Agriculture and Resource Management Council of Australia and New Zealand's (ARMCANZ) and the Australian and New Zealand Environment and Conservation Council's (ANZECC) water quality and management practice guidelines.

The National Water Quality Management Strategy has produced a series of National Guidelines, developed with extensive State input. These guidelines are being used and are seen as an essential building block in water quality management for Australia.

The guidelines are important documents, but if they are to provide real benefits they need further work.

- It is important to provide training in the use of the new risk-based guidelines to professionals and community groups.
- It is important to draw together documents demonstrating best practice with regard to various issues.
- It is important to realise that our understanding of water quality is still imperfect and evolving, and there is an ongoing need to update and review guidelines in the light of emerging knowledge.

*continued on page 2*

- More work is needed to develop more user-friendly ways to use these guidelines – in particular to develop simple computer based models and decision support systems.
- More work is needed to develop appropriate monitoring protocols, statistical analysis tools and presentation tools so that the guidelines can be effectively used within the context of integrated catchment management.

## Key Issues in Managing Water Quality in the next Five Years

We face a situation in Australia of increasing competition for scarce water resources, and increasing degradation of those resources through inappropriate development and mismanagement of land.

In this context of competition, regulators and scientists will be under increasing pressure to demonstrate the community benefits from particular guidelines. This will require better understanding of aquatic ecosystems and how they respond to various pollutants, as well as other factors such as river regulation, riparian zone damage and introduced species. Water quality must be seen as only one element of river health, and needs to be managed in an integrated way along with flow and other aspects.

*increasing competition for scarce water*

We also need to better communicate to the wider community why various contaminants are important. Simple conceptual diagrams need to be developed to show the linkages between, for instance, phosphorus and nitrogen and algal growth, and possibly with seagrass loss and so on. Science does have these simple models; but we have not been effective in communicating them to the community.

*Professor Peter Cullen, Chief Executive CRCFE*

There are of course many unknowns in aquatic ecology, which presently inhibit our predictive capacity. We clearly need more work in food web analysis, and in understanding the role carbon plays in driving various ecosystem processes. As part of this we need better understanding of natural conditions and their variability so that changes can be assessed.

An ongoing challenge for the scientific community is to develop measures of ecological health of rivers and other water bodies. At present we have augmented the traditional chemical measures with a range of biological measures. It may be possible to go further and develop useful tools that are based on ecosystem functions rather than ecosystem structure which is the basis of the current biological measures.

There are a number of specific water quality issues that we see will increase in importance in the next five years:

- Salinity – especially its impacts on ecosystems and human health;
- Agricultural chemicals such as pesticides and herbicides and their impacts on aquatic organisms and ecosystem functions. For instance, how are the increasing levels of herbicides in many waterways affecting patterns of algal succession?
- Urban stormwater and its impacts;
- Acidity arising specifically from acid sulphate soils and from more general soil acidification. How is this affecting the mobility of various ions?
- Hydrocarbon discharges from oil production facilities;
- Improved approaches to assessing risks from new chemicals;
- Nitrogen and its various species, its relation to phosphorus and other nutrients and their availability to stimulate algal and macrophyte growth;
- Sediment and turbidity;
- Trace metals like selenium.

## Further Development of National Water Quality Guidelines

The current guidelines are necessary and provide a critical framework for regulators and managers. We hope, however, they can be improved in a number of ways:

- Guidelines that are more specific for particular ecosystems such as terminal wetlands, summer rainfall ephemeral rivers and so on will need to be developed.
- Guidelines that are more oriented to ecological outcomes and ecosystem function and process rather than ecosystem structure.
- The concept of reference condition that has been developed in AUSRIVAS will be more widely used within water quality. This is an attempt to identify levels of contaminant in un-impacted systems comparable to the one of concern.
- The new risk-based framework would benefit from further development to make it more robust and easier to use. This will involve the development of quantitative protocols and computer-based decision trees.
- For many contaminants and issues, the total mass of contaminant (load) may be more important than the spot concentration (which, if flow is low may provide a trivial mass). We anticipate the development of triggers based on total load over some period.
- Sediments are a key store for many contaminants and the conditions under which the contaminants may be released to affect water quality are important. We anticipate considerable further developments in the sediment contaminant guidelines.
- The European Community and the US EPA are working in great detail on emerging issues such as endocrine disruptors. In Australia the appropriate strategy is to track what is happening in these jurisdictions and ensure the current thinking is brought to Australia. An appropriate group needs to assume responsibility for this function.

The National Water Quality Guidelines are an important foundation in water quality management in Australia. To maximise the value of the Guidelines, however, they need significant improvement. It is also crucial that the Guidelines are consistent with best international research and practice and kept up to date with the latest knowledge.

*we need to ensure the current thinking is brought to Australia*

*Digital electron microscope image of a water boatman*
*Photo: John Ward, CSIRO Forestry and Forestry Products*

The feature creature for this issue:
Water boatman.
Order Hemiptera (Aquatic bugs)
Family Coroxidae

Water boatmen are usually plentiful and can quickly invade temporary pools. To help them dive and feed, they can trap a bubble of air underneath their body and take it with them under the water.

# Australian Freshwater Crayfish: Yabbies or Crays

by Dr Susan Lawler

Many Australians know the yabbie, a common freshwater crayfish. Yet Australia is home to more than 120 different species of freshwater crayfish, some of whom are found in unusual places.

The freshwater crayfish of Australia originated in Gondwanaland and so live only in the Southern Hemisphere. They belong to the family Parastacidae. Nine of the fourteen genera in the family are found only in Australia, and the rest are found in New Zealand, Madagascar and South America.

*A male crayfish covered in the eggs of an unknown ectoparasite (Wongungarra River in Victoria). Photo: Sue Lawler, La Trobe University*

Yabbies belong to the genus *Cherax* and have smooth shells. There are many species of *Cherax*, including the marron of Western Australia and the red claw of Queensland. These species are adapted to still waters and grow well in farm dams, making them valuable to the aquaculture industry.

Spiny crayfish on the mainland, like the Murray River Crayfish, belong to the genus *Euastacus*. All the spiny crayfish live in rivers with clear, fast moving water, and unlike yabbies, may take 20 years to reach maturity. Although the Murray River Crayfish is the most well known member of its genus, there are actually 42 species: each major river system in Victoria and New South Wales has a different species of *Euastacus*. This is why you must never move crayfish from one river to another: you may unwittingly introduce a foreign species that could wipe out the locals.

The Tasmanian genus is very similar and includes the Giant Tasmanian Freshwater Lobster, *Astacopsis gouldi*, which has recently been declared endangered. These magnificent animals have suffered from fishing pressure as well as catchment degradation.

In addition to these familiar animals, there are dozens of crayfish that live underground and are too small to eat. These are the burrowing crayfish. Their tails are reduced, their backs are humped, and their claws are turned upright so they can dig their burrows. They live in muddy chimneys near creeks and swamps. Their burrows vary from simple holes to extensive tunnel systems, with the animal hiding in a chamber up to six feet below the surface. No wonder few people know of these beautiful animals, which can be brightly coloured: bright red and white in Gippsland, or with one purple claw in Western Australia.

A recent study by CRC researchers in collaboration with scientists overseas used mitochondrial DNA sequences from members of every Australian crayfish genus to trace their evolutionary history (Crandall et al. 1999). As expected, the spiny crayfish were closely related, with the yabbies on a separate branch of the tree. Surprisingly, the burrowing crayfish were not closely related at all. It seems that the burrowing form and behaviour arose independently at least four times in the history of the Australian crayfish fauna.

*A baby Murray Crayfish.*
*Photo: Sue Lawler, La Trobe University*

In fact, our burrowers include the most land-based crayfish on earth: some of the members of the genus *Engaeus* catch rainwater in their clay-lined burrows and can live far away from water. Interestingly, there are no blind crayfish species in caves in Australia, even though this is common among the Northern Hemisphere crayfish.

***one of the best indicators of river health***

Crayfish play an important role in the ecosystems in which they live. In addition to the usual roles as prey (for platypus) and predator (of fish and invertebrates), they provide substrate for other species. Freshwater crayfish can be covered in ectoparasites: flatworms, polychaetes and mites, which do not harm the cray but find food and shelter on its shell. The photo of a male crayfish from Wongungarra River shows the cray covered in the eggs of an unknown ectoparasite.

Freshwater crayfish are one of the best indicators of river health because they are easy for everyone to see and enjoy, and they are so closely linked to the ecology and history of the streams in which they live. The Murray River Crayfish used to be found throughout the River Murray. It is now extinct in the South Australian stretch of that river, and in decline elsewhere. Given that we rely on the river as much as they do, isn't this a warning we should heed?

Reference:

Crandall, K. A., Fetzner, J. W., Lawler, S. H., Kinnersley, M. and Austin, C. 1999, 'Phylogenetic relationships among the Australian and New Zealand genera of freshwater crayfish (Decapoda: Parastacidae)', *Australian Journal of Zoology*, 47 (2): 199-214.

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# Photosynthetic Bacteria in Billabongs: Occurrence & Importance

by Dr Gavin Rees

Photosynthetic bacteria[1] may play a more important role in freshwater ecology than was previously realised. Preliminary observations in Normans Lagoon, an ancestral course of the Murray River near Albury, suggest photosynthetic bacteria may make a substantial contribution to nutrient cycling and energy flows within such systems. A CRCFE project is underway to examine the occurrence and importance of photosynthetic bacteria in billabongs.

Photosynthetic bacteria are unusual in that they carry out photosynthesis in the absence of oxygen. Different photosynthetic bacteria do this by replacing water as it is used in 'aerobic photosynthesis' with a range of sulfur compounds or dissolved organic carbon compounds. Photosynthetic bacteria normally live in sediments but if the overlying water becomes anoxic[2], these microbes can move from the sediment into the water column. Since a number of waterways, such as billabongs, have periods where oxygen levels in the water column are low, it is likely that there are times when these bacteria make a significant contribution to carbon cycling. Some photosynthetic bacteria are also able to obtain nitrogen from the atmosphere, implicating this diverse group of bacteria in carbon, sulfur and nitrogen cycles.

*photosynthesis without oxygen*

## Normans Lagoon

Drs Gavin Rees (MDFRC), Roger Croome (La Trobe University), and Honours student Deb Gribben are concentrating an initial study on Normans Lagoon near Albury. Normans Lagoon is a clear-water billabong, with large areas of open water amongst stands

*A stand of Tall Spikerush (*Eleocharis sphacelata*) at the back of Normans Lagoon with Watershield (*Brasenia schreberi*) on the water's surface in front of the Tall Spikerush. The aquatic plant, watershield, can be easily confused with water lilies.*
*Photo: Gavin Rees, CRCFE*

*The aquatic plant, watershield (Brasenia schreberi), dies back in winter, putting significant amounts of organic carbon into the billabong.*
*Photo: Gavin Rees, CRCFE*

of Eleocharis[3]. The floating fern Azolla is common in the shallower areas, and the unusual 'Watershield' Brasenia is also present. Every month, the team examine a range of aspects of water quality, compare the water quality information with the distribution of algae and photosynthetic bacteria in the water column, take samples for laboratory isolation and characterisation of bacteria, and manipulate the bacterial populations in the lagoon with enrichment experiments (adding acetate, sulfur, nitrogen, phosphorus).

On the first sampling trip, the dominant organism was Chrysosphaerella brevispina, a golden-brown type of algae never previously reported from the Australian mainland.

The first results have shown photosynthetic bacteria are indeed present in the water column of Normans Lagoon. Nil dissolved oxygen is present below 0.5 m depth in summer, providing a niche for the anaerobic photosynthetic bacteria, which are present at up to 800 mg/L bacteriochlorophyll at around 1 m depth.

A diverse range of organisms are present in Normans lagoon. Two typical genera isolated are *Rhodopseudomonas* and *Thiocapsa*. The first organism can use dissolved organic carbon as well as carbon dioxide for its growth. The second organism also is capable of using sulfur compounds if such compounds are present. In addition to known photosynthetic bacteria, organisms representing new genera have also been found.

**new genera have been found**

Following this initial work, the project will be extended to examine the populations present in similar aquatic environments, and an attempt will be made to estimate the true input of these organisms to nutrient and carbon cycling within our aquatic systems.

1 *Photosynthetic bacteria*: Bacteria that use light as a source of energy and either dissolved organic carbon or carbon dioxide as a source of carbon to build new cells
2 *Anoxic*: The absence of oxygen
3 *Eleocharis*: An aquatic plant common to many billabongs, sometimes called Tall Spike Rush

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# Factors Determining Algal Growth and Composition in Reservoirs

By Ian Lawrence

Algal blooms are now a significant reservoir management problem, having the potential for severe environmental, social and economic impacts. Reservoir and catchment managers seek better information in order to minimise algal blooms.

A major study on factors controlling algal growth and composition in Burrinjuck Reservoir has recently been completed by the CRC for Freshwater Ecology in association with CSIRO Division of Land and Water, for the Land & Water Resources Research Development Corporation (LWRRDC). The study was funded jointly by LWRRDC and the Murray-Darling Basin Commission as part of the National Eutrophication Management Program.

The Burrinjuck research indicated that the key factors determining algal growth and composition for many deep (stratified) reservoirs are:

- the phosphorus derived from reservoir sediments. viz: it is the factors determining release of phosphorus from sediments (organic material loading, stratified or poor mixing conditions) which are generally critical in driving algal growth and bloom conditions, not the direct discharge of phosphorus.
- the rate of inflow[1] as a significant modifier of the pattern and form of delivery of nutrients and organic material and in-reservoir processes;
- the role of drawdown[2] in modifying nutrient pathways and significantly increasing the risk of algal growth and incidence of blue-green algae;
- the role of nitrate in limiting the development of anaerobic conditions under which phosphorus would be released and promote algal growth;
- the role of nitrate in limiting the potential for nuisance blue-green algal growth.

An important part of the Burrinjuck project has been the development, in collaboration with reservoir managers, of guidelines to limit the incidence and severity of algal blooms in reservoirs. The implications identified in a series of reservoir managers' workshops included:

- the need to limit the organic material exports (direct and indirect) from catchments and loading on reservoirs, with control of P or N discharges more related to limiting the potential for instream transformation to organic material.
- the need to carefully select water abstraction levels to ensure that abstraction does not exacerbate either the nutrient transfer to surface waters during periods of reservoir stratification, or release of waters high in dissolved nutrients.

*Blue-green algal bloom on Burrinjuck Reservoir.*
*Photo: Dep't Housing and Construction*

- the need to limit the rate and level of reservoir drawdown as a means of reducing the risk of blue-green algal blooms.
- the need to design and manage the reservoir inlet depositional zone[3] to minimise the potential for release of phosphorus and ammonia from the sediments, thereby exacerbating blue-green algal growth.
- where organic loading is sufficient to drive bottom waters anaerobic, the important role of well nitrified wastewater effluent in buffering release of phosphorus from sediments, and in reducing the risk of blue-green algae formation.

The reservoir managers' workshops identified a range of management and catchment options, and flow charts guiding the selection of these.

A report *Factors controlling algal growth and composition in reservoirs: Report of Reservoir Managers' Workshops January 2000*, summarises the research findings and the management implications and options. The Report is available from the CRC for Freshwater Ecology.

1 *Rate of inflow:* the amount of water flowing into a reservoir over time. For example, megalitres of water per day.

2 *Drawdown:* a reduction in the water level in a reservoir as a result of release of water for downstream use

3 *Inlet depositional zone:* the area around the inlet(s) to a reservoir where organic material, such as leaves, vegetation, algal detritus, soil and wastewater organic materials gathers.

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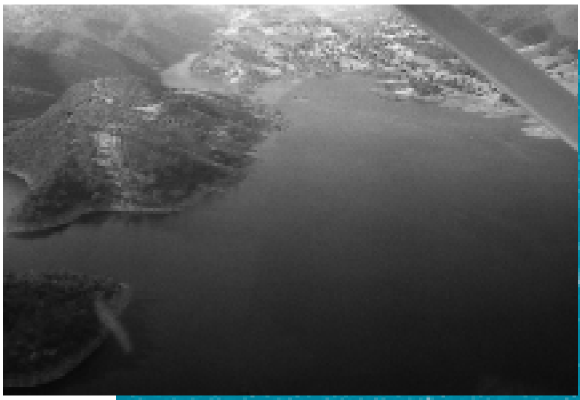

*The Goodradigbee Arm of Burrinjuck Reservoir.*
*Photo: Ian Lawrence, CRCFE*

*The Yass Arm of Burrinjuck Reservoir.*
*Photo: Ian Lawrence, CRCFE*

# The Northern Laboratory, Goondiwindi

**by Dr Terry Hillman**

The Cooperative Research Centre for Freshwater Ecology (CRCFE) is establishing a new Northern Laboratory of the Murray-Darling Freshwater Research Centre at Goondiwindi, Queensland. The new laboratory enables scientists to study the Murray-Darling near the summer rainfall areas of the North, arid zone ephemeral systems and extensive floodplains, some of which are subject to agricultural development. The Northern Laboratory (NL) is also near a major cotton growing area.

The new laboratory sees the completion of a network of research facilities positioned to study the ecology and ecological management of the Murray-Darling in its diverse forms. The CRC for Freshwater Ecology has two major regional laboratories, one at the Murray-Darling Freshwater Research Centre in Albury and one at the Lower Basin Laboratory at Mildura.

*near a major cotton growing area*

The Albury laboratory is centred in the winter-rainfall catchment, which provides most of the system's flow, and contains the major storages. It is upstream of large abstractions from the system and near some relatively unregulated winter-spring flowing rivers and flood-plain forests.

The Lower Basin Laboratory (LBL) at Mildura is situated in the lowland reaches near the junction of the Murray and Darling Rivers. It is downstream of New South Wales and Victorian abstractions from the system and within reach of ephemeral lakes and streams of the lower Darling and Anabranch, weir pools, and low rain-fall floodplains.

Situated on the border, The Northern Laboratory at Goondiwindi facilitates collaborative research involving State Government partners of the CRCFE. The Department of Natural Resources and Griffith University both have facilities there with the potential to accommodate the new laboratory.

A Community Advisory Committee chaired by Leith Boulley has been established and the position of Research Scientist in Charge has been advertised.

While preparations for the new laboratory have been progressing, the CRCFE has been developing its new research portfolio. Of the new work proposed, the NL will play a key role in project C2, Dryland River Refugia, and project C1, Patterns of Endemism in Eastern Australian Rivers. Current work on the Condamine-Ballone river system could also be staged from the facility. Work involving significant in-kind inputs will also be supported at Goondiwindi and is likely to include ecological assessment of pesticide residues and flow-related studies.

Clarification of the research role of the laboratory is a necessary step before finalising the selection of staff and equipment. A meeting of the Community Advisory Committee, its first face-to-face, will be held in mid-April after which the CRCFE research at Goondiwindi will become a reality.

La Trobe University recently awarded an honorary degree, the Doctor of Science (honoris causa), to Dr Terry Hillman. Dr Hillman, Director of the Murray-Darling Freshwater Research Centre, studied at Dookie College and the Australian National University before embarking on a distinguished career with CSIRO and the Cooperative Research Centre for Freshwater Ecology. Congratulations, Terry.

# StreamLine

## Collaboration Takes Faith

Work is underway to improve the way we assess and predict river health. Scientists at the CRC for Freshwater Ecology are currently developing innovative and simple methods that use macroinvertebrate[1] communities to evaluate the condition of potentially damaged waterways. These methods operate on a similar philosophy to the existing AUSRIVAS models by calculating an ideal community at a certain site and comparing this to the animals that are actually found in the test site. These new approaches will add control and precision when they are incorporated as options in the AUSRIVAS web site.

Three scientists are working on these new methods: Dr Dan Faith, Principal Research Scientist at the Australian Museum; Simon Linke, a visiting scholar from Germany at the CRC for Freshwater Ecology and Associate Professor Richard Norris from the CRC for Freshwater Ecology. This follows directly from previous work by Dr Dan Faith and Daveean Stockwell for the National River Health Program.

1 *macroinvertebrates* are animals without a spine that can be seen with the human eye. Dragonfly Insect larvae, flatworms and water snails are some of the invertebrates used by the AUSRIVAS model to assess the health of a waterway.

## New Research Portfolio

The CRCFE has consulted extensively to establish a broad research portfolio. This process involved identifying important national issues (most of which are also major issues for our partners), defining the key knowledge gaps associated with each of these issues, and then selecting a number of research thrusts to address these gaps.

The Board considered the proposed new integrated projects on March 3, 2000. Following the Board's recommendations on which research projects they wish to develop further, the Program Leaders and project teams will develop full proposals. These will be reviewed by the Research Committee, sent to external peer review, reviewed by Program Advisory Committees, and then submitted to the Board for final approval. We expect to have the new projects up and running by June 2000.

## National River Health Program

A four day meeting was held in February at the University of Canberra to discuss the National River Health Program (NRHP). The agenda included state by state progress with assessment, research and development results, Australia wide assessment, bioassessment and AUSRIVAS. The next phase, phase 3, was discussed in detail.

## Recent Publications

Recent publications available from the CRC for Freshwater Ecology include the technical reports *'Scientific Forum on River Condition and Flow Management of the Moonie, Warrego, Paroo, Bulloo and Nebine River Basins'* by Peter Cottingham; *'Factors determining algal growth and composition in reservoirs'* by Ian Lawrence (on the web at: http://www.nemp.aus.net); *'Technical Review of Elements of the WAMP Process of the Queensland DNR'* by John Whittington.

Mark Linterman's report *'Status of fish in the ACT'* is available from Environment ACT.

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

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