# H2O thinking

eWater CRC

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## Water sensitive urban design

## music v4

## Desalination: the inevitable future of urban water supply?

## Catchment modelling

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**Front cover photo:**
Maroochydore Water Sensitive Urban Design Retrofit, demonstrating porous pavement (at right) and a bioretention system (at left), and that WSUD can be easily integrated into existing urban areas. Project by Sunshine Coast Regional Council and BMT WBM. More details on p. 11.

# DESALINATION

## the inevitable future of urban water supply?

*Professor Gary Jones*
*CEO, eWater CRC*

*Water, water, everywhere, nor any drop to drink.*
Rime of the Ancient Mariner. Samuel Taylor Coleridge

Within the space of a decade, Australia will have created almost 500 billion litres (GL) of new annual urban water supply, thanks to the 'miracle' of seawater desalination. By 2013, all coastal capital cities, with the exception of Darwin and Hobart, will have a major desalination plant.

Nationally, this new water supply capacity will provide about a quarter of all urban water needs. Some cities are rapidly becoming even more reliant on desalination than this figure suggests. When the Port Stanvac desalination plant in Adelaide is completed in late 2012, it will supply 70% of Adelaide's drinking water (WSAA, 2009).

I used the term 'miracle' somewhat ironically in my opening, but it is indeed remarkable how we have moved, in only a few years, from desalination being no more than a specialist water treatment option for remote desert locations, to it being a critical part of mainstream urban water supply security.

The reason for this is well summed up in the recent WSAA Report Card, which states '*the great virtue of desalination is that it is a reliable source of water, has a small (physical) footprint, and can be constructed in a relatively short period of time*'.

And for a politician on a three year election cycle, it is nice to be able to launch the project, and cut the ribbon at the opening ceremony, all within a single term! No dam can ever offer such a rapid water-security outcome for a Premier or Minister.

For urban water suppliers on the Australian coastline, it is the 'climate independence' of seawater desalination that is its great attraction. The traditional approach of building new dams to meet increasing water supply requirements holds little water, quite literally, in a drying climate. No point building a new dam if there is no rainfall to fill it.

Demand management can help, but it is unlikely ever to be enough to offset the need for an increasing volume of secure climate-independent supply.

Of course, desalination is not without its downsides and detractors. The biggest concern is the high energy requirement to fuel it, and the potential high greenhouse-gas emissions as a consequence.

Typical energy consumption for seawater desalination is in the range of 4–5 kWh/kL. When the Kwinana desalination plant in Western Australia came on-line in late 2006, annual energy consumption for Perth's water supply increased from 2000 GJ/GL to 3540 GJ/GL, even though that plant represented less than 20% of water supply (Kenway et al. 2008). In their report, Kenway et al. suggest that, by 2030, in the 'extreme' case where desalination meets all the water growth requirements for Australia's capital cities, energy consumption by capital water supply providers could increase by up to 400%.

To meet this high energy demand, all major urban desalination plants in operation or under construction in Australia have, according to WSAA, significant, or full, green-energy feed-ins. Whether this is enough to allay community concerns about desalination's greenhouse-gas effects remains to be seen.

There are also concerns about environmental impacts of desalination on coastal waters, and aesthetic issues about unsightly infrastructure adjacent to beaches. The potential marine effects relate to discharge of concentrated brine, and to marine life being accidentally sucked into the plant's intake. Few scientific data on the extent of the latter problem seem to exist; and detailed modelling studies for positioning outlet pipes and ensuring rapid mixing indicate minimal local changes from discharged brine. Nevertheless, it is very early days, and monitoring programs need to be alert for any impacts.

In 2060, 50 years from now, Australia's population will have doubled, and the vast majority of those new Aussies will live in coastal towns and cities. Another 20 million people need about 2000 GL more drinking water annually; perhaps 1500 GL if we can get on top of urban water demand management.

"Desalination must be seductively attractive to any urban water supply authority in coastal Australia"

Prior to desalination, that would probably have meant at least one new major dam for every coastal capital city.

This is one of the environmental upsides of desalination plants. That is, that no — or fewer — new dams, with their associated negative effects on river ecology, may need to be built for coastal cities.

And by providing a 'new' water alternative for these cities, desalination plants could remove the need to transfer irrigation water supplies from inland rural to coastal urban areas, with its associated controversies.

While the urban water industry will continue to invest in other new water sources — stormwater and wastewater recycling most notably — the projected growth in desalination far outstrips projects for water recycling. Over the next decade, in which desalination water supply capacity will reach 500 GL, recycled water supply will increase by only around 100 GL (based on the rate of recycling growth over the past decade).

The desalination die seems irrevocably cast for the Australian urban water supply industry.

Recycling will always be an important component of urban water supply and management, if only for its beneficial environmental outcomes on water quality. But desalination must be seductively attractive to any urban water supply authority in coastal Australia, and is likely to become the major source for meeting future urban water needs.

Are there any downsides to desalination that have not been contemplated? An impossible question to answer, but one that people should, and no doubt will, keep a close eye on over the coming years and decades.

I should make it clear that I am not an opponent of desalination. The 'seduction' of desalination I alluded to above is founded on a reasonably compelling case of water security benefits, especially in Australia with our highly coastal population and an increasingly dry climate. I am merely an interested and curious observer of a phenomenon that has emerged so rapidly as to amaze me.

My hesitation, if any, is simply because in moving so fast we may have missed something important. What this might be, I do not know. But I do believe we will need to keep a close eye on desalination over the coming decades to make sure no unintended and unpredicted side-effects pop up to bite us.

If Coleridge's ancient mariner had a portable desalination plant handy, he would have had little to bemoan. Today in Australia, there seems no stopping the desalination juggernaut.

### Emerging practice in active environmental water management

In the last issue of 'H2O.thinking' I mentioned a workshop for environmental water managers, held in February jointly by eWater and the National Water Commission. Some important messages from came out of the day (for example, see p. 7), as well as some memorable quotes, including these:

"Plans made for environmental flows to particular targets have been unravelled by the drought."

"We would like to be guided by science — to have quick, clear messages of how to deliver and prioritise environmental flows. This has not happened."

"Management is often on the fly, adapting plans in the short term in response to unexpected rain."

"We need flexibility to do the job, and to be trusted to get on with it."

"Most people learn environmental water management on the job."

I encourage you to read the report of the workshop, and help environmental water management as a practice to move forward, respected and valued by all stakeholders.

### Further reading

Kenway SJ et al. (2008). Energy use in the provision and consumption of urban water in Australia and New Zealand. CSIRO Water for a Healthy Country Flagship-WSAA Report.

WSAA (2009). WSAA Report Card 2008-9: Performance of the Australian urban water industry and projections for the future. Water Services Association of Australia.

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**For more information**

## Letter to the Editor

I always enjoy reading 'H2O thinking'. Your articles on groundwater modelling and management are excellent. I was however surprised to see an article on Water Divining in the latest edition.

Groundwater divining is akin to voodoo; it conjures up images of 14th century England in the Dark Ages when witches were burnt at the stake and people actually believed in water divining. Alas, education about groundwater processes amongst the community has not progressed much since then. Divining has been shown time and time again to be without scientific foundation.

It is good to see that while running an article on divining, the title shows that you are not trying to give it scientific credibility.

In a sense, diviners are never wrong, there is groundwater everywhere! The real questions are: what is the depth, what is the quality, what is the yield, where does groundwater come from, where does it discharge to?

It would be good in the future to have more articles on groundwater science. With the current renaissance recognising groundwater processes, it is important for water resource planning and management in Australia that good groundwater science is used.

Dr Richard Evans
Principal Hydrogeologist
Sinclair Knight Merz, Victoria


# H2O news

SEQ HEALTHY WATERWAYS PARTNERSHIP WINS BANKSIA | MUSIC VERSION 4 LAUNCH IN SPRING | RIVER MODELLING PROGRESS | PETER CULLEN WATER AND ENVIRONMENT TRUST | INTEGRATED WATER MANAGEMENT IN ACT | 2009 PETER CULLEN POSTGRADUATE SCHOLARSHIP WINNER | EWATER TOOLS ON TRIAL AS V1-BETA | AUSTRALIAN RAINFALL AND RUNOFF REVISION | EMERGING ENVIRONMENTAL WATER MANAGEMENT — REPORT

## SEQ Healthy Waterways Partnership wins Banksia

The South East Queensland Healthy Waterways Partnership has won the 2009 Banksia Environmental Award for Water. The Award was given in recognition of the Partnership's dedication to protecting and improving the waterways of South East Queensland (SEQ). (See also article, p. 17.)

The Banksia Environmental Awards are regarded as the most prestigious environmental awards in Australia and include the Water category for the protection, conservation or enhancement of Australia's freshwater resources and marine environments. The Partnership's entry faced steep competition in the Water category with runners-up such as Greening Australia Capital Region, Reef Check Australia and Yarra Valley Water.

www.healthywaterways.org

**For more information**

SEQ Healthy Waterways Partnership Interim Management Board with the 2009 Banksia Award. Mr John Cherry, Mr John Bishop, Mr Mark Pascoe and Mr Terry Wall (l to r).

## MUSIC version 4 launch in Spring

**music v4** is to be launched this Spring, with significant extra features upgrading the existing version 3. (See article on p. 8.)

MUSIC (**m**odel for **u**rban **s**tormwater **i**mprovement **c**onceptualisation) is an important urban water decision-making tool that shows practitioners what they need to do to meet stormwater-quality targets. It is used by over 3000 members of state and local government, water utilities and consulting firms, and its use continues to grow rapidly. Right now, the functionality of v4-beta is being tested by a large group of experienced users and developers.

Release of **music** v4 will be via eWater's new **music** site music.ewater.com.au. The system for ordering and payments has also been upgraded to include new online licensing.

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**For more information**

## River modelling progress

The team building eWater's River Manager software, for integrated river modelling, continues to meet important milestones this year. In July, as planned, the team released prototype version 0.7.0 to partner organisations. And in early September, first versions of the user guide and training manual were tested at a training workshop for partner participants.

The significant government funding granted in 2008 has meant 25 new modelling and project staff have joined the team in recent months, keeping the project on track to meet the specifications agreed with the governments of jurisdictions across Australia, including functionality and usability.

Trial applications of River Manager will begin in late 2009 in four 'focus catchments': Murray River, Goulburn-Broken-Loddon-Campaspe, Macintyre Brook, and Namoi. Each selected catchment has different management needs, from complex management rules to groundwater reserves.

Peter.Wallbrink@csiro.au

**For more information**


Hon. John Thwaites and Senator the Hon. Penny Wong at the launch of the Trust in March.

## Peter Cullen Water and Environment Trust

Dr Sandy Hinson has been appointed to head-up the Peter Cullen Water and Environment Trust.

The Trust, formed in memory of Professor Peter Cullen, facilitates learning and informed debate to benefit Australia's aquatic environments, especially through the activities of early career scientists.

On launching the Trust, in March on the first anniversary of Peter Cullen's death, Senator the Hon. Penny Wong announced that the federal government was kick-starting the Trust's work with a $1 million contribution.

These funds, with others to be raised soon, are intended to support a variety of projects which will be publicised in more detail at a later date.

The Trust, Chaired by Hon. John Thwaites, has an office at the Institute for Applied Ecology, University of Canberra, managed by Deana Darrant, phone 02 6206 8606.

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**For more information**


Speakers at the meeting: Chris Hepplewhite, Matt Hardy, Sue Nichols, Heath Chester, Jennie Gilles, Ralph Ogden, Fiona Dyer.

## Integrated water management in ACT

Water management organisations in ACT are working with eWater to trial integrated urban water management (IUWM) as a practical concept. At the Australian Water Association (AWA) branch meeting in June, the audience of around 70 people were introduced to this first trial of IUWM and decision science. The trial is running in the ACT region largely because there is good data and knowledge there from a large body of previous science.

Key team members speaking at the meeting included Sue Nichols (coordinator) and Dr Fiona Dyer from University of Canberra, and Dr Matt Hardy from BMT WBM in Melbourne, with Dr Chris Hepplewhite of the ACT's water corporation ACTEW, and Jennie Gilles and Heath Chester from the ACT Government Department of Environment, Climate Change, Energy and Water (DECCEW).

The issue in IUWM in this region is diversification of water supply. Once proved, eWater's IUWM tools will give DECCEW and ACTEW a way to coordinate and make repeatable and timely predictions of water supplies and demand, variability and future scenarios, without damage to water-dependent ecosystems, and to communicate readily with all involved parties including the community.

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**For more information**

## 2009 Peter Cullen Postgraduate Scholarship winner

Winner of the 2009 Peter Cullen Postgraduate Scholarship, established by the NSW Government, is Celine Steinfeld, of the University of New South Wales. Celine is studying water management in the Macquarie Marshes and Gwydir Wetlands of NSW.

www.dwe.nsw.gov.au/about/scholarship.shtml

**For more information**

## eWater tools on trial as v1-beta

Innovative software tools by eWater for managing ecological water requirements and catchment modelling are currently on trial as beta versions, in real-world situations across eastern Australia.

Eco Modeller and eFlow Predictor have joined WaterCAST and Causal Criteria in the hands of partner staff who are trialling the functionality and usability of these components of eWater's integrated modelling suite.

Trials are underway in 'focus catchments' of the Great Barrier Reef, SE Queensland, the Mt Lofty Ranges (SA), the Nattai River (near Sydney), the Yarra River (Melbourne), the Goulburn and Ovens rivers (Victoria), and ACT, and at Hattah Lakes (a River Murray Icon Site).

www.ewatercrc.com.au/publications

**For more information**

## Emerging environmental water management — report

The report from the workshop 'Emerging practice in active environmental water management in Australia' is now available at www.ewatercrc.com.au/publications, or in hard copy.

Around 30 active managers of environmental water from every state and territory attended the workshop in February to discuss their environmental watering tactics, particularly in conditions of water shortage. The workshop was run jointly by eWater CRC and the National Water Commission (NWC).

The day was valuable for its insights and for the interactions it set up. Practitioners facing similar challenges in widely different parts of the country were able to compare notes and share their solutions. The workshop and its background investigation revealed several important messages, for example:

- active environmental water management is a practice in its infancy; nevertheless, environmental water managers comprise a cohort of very committed, skilled and knowledgeable people;
- these practitioners often have to use their own initiative and enterprise to achieve environmental outcomes with the water available;
- most environmental water managers work in regional communities and they understand and feel the economic and social implications of environmental watering.
- practitioners have clear needs, through their organisations, for operational guidelines, appropriate administrative procedures, coordination among government environment agencies, sharing of operational experience, timely data, and professional development and training in all aspects of integrated water resources management.

In a separate initiative of the AWA and the NWC, environmental water managers have since set up a community of practice, and details are available at www.cop4ewm.com.au.

info@ewatercrc.com.au

**For more information**

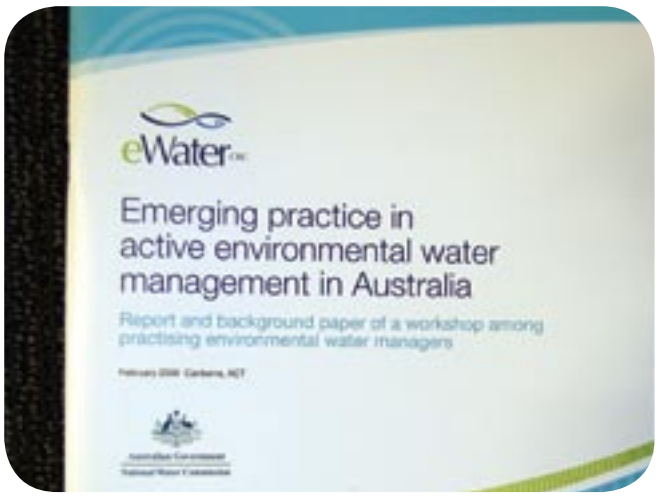
## Australian Rainfall and Runoff revision

'Australian Rainfall and Runoff' is being fully revised for the first time since 1987. These guidelines are a standard resource for such activities as retrofitting urban-water infrastructure, installing dam walls, or planning the management of floods and king tides. Associate Professor James Ball from UTS and Mark Babister from WMAwater are managing the 21 projects that are collecting updated information for the three-stage revision over four years on behalf of Engineers Australia's National Committee on Water Engineering. New topics in this revision include environmental flows, system (rather than point) analysis, risks resulting from climate change, flooding in heavily populated areas, and uncertainty estimates.

A key component is the rainfall Intensity-Frequency-Duration (IFD) information, being updated by the Bureau of Meteorology. The longer records now available from rainfall networks across Australia are being analysed with modern data-handling and analysis techniques to make the IFD data as up-to-date as possible. For more information, contact j.green@bom.gov.au.

www.arr.org.au

**For more information**

# MUSIC
## simplifying urban stormwater

## MUSIC V4 TO BE RELEASED THIS SPRING

*After listening to enthusiastic users, eWater's MUSIC development team has built a new version of its popular urban stormwater software. The new version, **music v4**, has core refinements, bug fixes and an improved interface that will continue to ensure that MUSIC is the software for urban stormwater professionals.*

Already more than 3000 urban stormwater scientists, engineers, planners, policy staff and managers in state, regional and local government, utilities and consulting firms are registered users of earlier versions.

Decoding the acronym, MUSIC stands for 'model for urban stormwater improvement conceptualisation', and, true to its name, the 'conceptualisation' part means that the software is designed to help urban water professionals visualise possible treatment strategies to tackle urban stormwater hydrology and pollution impacts.

It is not a detailed design tool in itself, but aims to clearly set out the options for improving stormwater quality. With MUSIC you can assess the pros and cons of a range of types of treatment systems for improving stormwater quality — biofilters, swales, wetlands and the like.

MUSIC gives ready answers to typical urban stormwater questions: where is the stormwater coming from; what is its quality; how effective, in water quality terms, is a biofilter compared to a swale; should they be replaced by a full-blown wetland; and which of these is most cost-effective?

**music v4** features major advances to the science, and better ability to model new stormwater technologies like porous pavements, and it is more flexible than previous versions. Although it does call for a sound knowledge of urban stormwater management principles and practices, one of its best features is the straightforward interface that allows users to rapidly get to work on real-world problems.

The new version offers features that improve flexibility and usability, such as more accurate modelling of bioretention and infiltration systems, better reuse options and capacity to model parameters in addition to total suspended solids, total phosphorus and total nitrogen, as well as many other refinements.

### Science-based

The MUSIC software first saw the light of day back in 2001 after research by Dr Tony Wong and colleagues at Monash University and the CRC for Catchment Hydrology (a forerunner of eWater).

That team realised that urban water professionals needed a decision support system to evaluate treatment measures and strategies if urban stormwater quality was to be improved. Fundamental to this was research that showed that treatment of nearly all urban stormwater systems could be simulated using one model, the 'universal stormwater treatment model'. This breakthrough, combined with a detailed understanding of the hydrology and pollutants of urban areas, gave Tony Wong's team the necessary building blocks that became MUSIC.

The MUSIC development team focused on having a tool that, though easy to use, was underlain by high quality science. Wong recognised that the science of estimating water quality had tended

Point Fraser demonstration wetland, Perth, WA.

to become event-based and deterministic, whereas the quality of urban stormwater really depends on the statistical outcome of many rainfall events interacting with a handful of physical and chemical processes. If this 'actuarial approach' could be captured with an appropriate algorithm, calculations would be much simplified.

The hydrology inside MUSIC, developed by Francis Chiew and colleagues in the CRC for Catchment Hydrology, is based on defining an impervious area and the properties of related pervious areas. Once this is done, the runoff from an area can be estimated. More and more, confident estimates of hydrology are becoming as important as estimating water quality. In fact, changes in urban hydrology can have major impacts on the health of creeks and streams, as work by Associate Professor Tim Fletcher (a member of the MUSIC development team) and colleagues at Monash University has shown.

## Quality aspects

MUSIC uses statistics when it considers pollutant concentrations and loads. In the model, total suspended solids, total phosphorus and total nitrogen are generated according to published data on urban, agricultural and forested catchments, based on detailed reviews of urban stormwater quality data from Australia and overseas.

The MUSIC user can choose from a range of treatment devices ('nuts and bolts', see box p. 10) that can make up a system for improving stormwater quality. The size of an installed device, and its shape, are key factors in how it performs, for they control the 'hydraulic efficiency' of the system (i.e. how well water moves through it).

In modelling these systems, MUSIC simulates hydrodynamic performance by assuming that stormwater will move through a system as if it is a series of well-mixed water bodies (known in the jargon as continuously stirred tank reactors, or CSTRs, a name derived from chemical engineering). The number of these CSTRs is dependent on the shape of the system. In **music V4**, users can now pick from a range of different shapes to reflect the system they are proposing.

Within each installed system, MUSIC calculates the 'decay' of each water parcel that passes through it. Although the detailed behaviour is complex, the researchers found that the overall effect is that contaminants are removed exponentially, with the rate determined by a fixed decay constant (k, m/year) and by the background concentration (C*, mg/L).

Since 2001, when MUSIC was first released, the program has been used and tested by hundreds of users, and their suggestions have made it better, more robust and reliable. Version 2 extended the features and provided export options, version 3 introduced life-cycle costing, rainwater tanks and infiltration basins. Now **music v4** adds new biofiltration treatment nodes, enhanced reuse functionality and more flexible reporting, amongst numerous updates and improvements.

**music v4** also contains raw rainfall data for 50 major population centres in Australia; users who take up the 'support' option will have access to over 1000 pluviometer stations across Australia!

**music v4** is about to be released; it is currently being beta-tested.

### Further reading

Wong THF, Fletcher TD, Duncan HP, Coleman JR, Jenkins GA (2002) A Model for Urban Stormwater Improvement Conceptualisation. Proceedings of the International Environmental Modelling and Software Society, Lugano, Switzerland, pp. 48-53.

http://www.iemss.org/iemss2002/proceedings/pdf/volume%20uno/358_wong.pdf

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## For more information

Ski-jump GPT and wetland. Forster, NSW. Photo: BMT WBM.

See also p.24 for WSUD websites.

## The 'nuts and bolts' of MUSIC

When you want to capture stormwater runoff, remove its contaminants, and reduce the frequency of runoff, there is a wide range of treatment devices you can use, including those below which can be modelled within MUSIC. The idea is to evaluate these building blocks until the best combination of cost, hydrology and water quality improvement has been achieved.

1. *Gross pollutant traps* (GPTs). These mesh-like devices are designed to remove floating and suspended rubbish and debris above 5 mm in size. Many are proprietary off-the-shelf items.
2. *Buffer strips*. Strips of vegetated land beside a road are effective in the removal of coarse and medium-size suspended particles; they provide good pre-treatment prior to a bioretention system or other vegetated treatment measures.
3. *Vegetated swales*. Open channels that use vegetation to primarily remove suspended solids. Subject to high flows, they rely on shallow slopes and the density and height of vegetation, to work well.
4. *Ponds and sedimentation basins*. Open water bodies act as temporary stores to allow the settling of suspended solids. They can include ornamental ponds, but usually lack vegetation. Reuse of the water is an option.
5. *Rainwater tanks*. These domestic water stores enable roof runoff to be captured and used. Contaminants can either settle in the tank or are removed when the water is used on a garden. Tanks can reduce stormwater flows and help to counteract the increase in impervious area that urbanisation brings. They also provide an alternative water supply.
6. *Wetlands*. These are heavily vegetated water bodies; the physical, chemical and biological processes that they facilitate remove fine suspended sediment and soluble and insoluble contaminants. Wetlands are commonly used as 'end of pipe' measures, but recent research shows they also work well earlier on. MUSIC can also model reuse of the water in a wetland's permanent pool.
7. *Generic treatment nodes*. MUSIC allows the user to model a treatment device that is not a specific node within the program, if the user has sufficient data to model it effectively; for example, flow diversions, flow dilutions or contamination by sewer overflow. In these cases, MUSIC allows the user to define 'transfer functions' for flows and water quality.
8. *Bioretention systems*. Vegetated stormwater filtration systems that use a soil- or sand-based filtration medium to remove particulates and soluble contaminants. The system may be lined or unlined and may or may not have an underdrain. In **music v4**, based on significant extra data and research (see article p. 12), bioretention nodes take better account of the characteristics of the filter media and vegetation. Users of **music v4** can more accurately design or represent a variety of different bioretention systems.
9. *Infiltration systems*. Unvegetated infiltration systems, for removing contaminants, which have no underdrain. **music v4** offers a greatly enhanced infiltration modelling capacity to account for horizontal flows from storage and allow for changes in flow with depth. There is greater flexibility to model systems with lined sides or base.
10. *Media filtration systems*. Unvegetated stormwater filtration systems for removing contaminants, using media such as gravel, sand or other fine granular material. They are assumed always to have an outlet pipe (underdrain). **music v4** is the first MUSIC version to include this as a treatment node.

## Case study — MUSIC in practice

As a case study, consider how MUSIC was applied in this actual project to retrofit WSUD (water sensitive urban design) in Queensland.

Retrofitting WSUD into existing urban areas is important if current water quality issues around our urban areas are to be dealt with. WSUD is not just a concept for greenfield developments.

At Maroochydore, where the Maroochy River had shown signs of stress, including impacts by excessive stormwater runoff, eWater partner BMT WBM, working in partnership with the Sunshine Coast Regional Council, has assisted Council in retrofitting multiple WSUD elements into existing areas at and near the Council Library. The elements include porous pavements and bioretention systems (photo shows examples of both), as well as grassed swales, rain-gardens and rainwater tanks. MUSIC was a key tool for site selection and design stages.

A range of stormwater management devices was assessed in a MUSIC model of the area. All the measures were ranked, via MUSIC's estimates of their treatment effectiveness and life-cycle costing. This showed that the best options for stormwater were an integrated system of swales, bioretention systems and porous pavements. Several types of rainwater tank have been installed as well, for water harvesting for use in toilets, with overflow from the tanks directed into a rain-garden which promotes infiltration.

Using MUSIC, the project team evaluated and coordinated stormwater treatment measures from a network of related urban catchments and subcatchments at once. The software also allowed rapid assessment of different scenarios to be completed, and the results were examined both for particular rainfall events and for the long term.

By playing around with these scenarios in MUSIC, and looking at their costs, the modelling quickly showed which options were most cost effective, and that the information could easily be used in a broader decision making framework.

The Maroochydore Library project highlights both the success of integrating WSUD into existing urban areas and the value of partnerships of industry and government in delivering such projects. As a measure of its success, this project was recently nominated as a finalist in the 2009 Healthy Waterway Awards WSUD Category. The project has helped other MUSIC users in evaluating prefeasibility, conceptual design and lifecycle costing of similar projects, across Australia.

Swale and porous pavement, Maroochydore, QLD.
Photo: BMT WBM.

## A spectrum of use

MUSIC can simulate urban stormwater systems ranging from a suburban block up to 10 km$^2$ (a whole town or suburb); the time scale can start at 6 minutes and stretch up to 24 hours. Complex stormwater management scenarios can be quickly and efficiently created, and the output viewed as graphs and tables. The result is a fairly good sense of what is the best strategy, in any given situation, for managing stormwater.

- Environmental and engineering consultants around Australia use MUSIC every day to design urban development proposals that meet water sensitive urban design standards. For example, some developers have been given the opportunity to contribute to WSUD schemes in lieu of some required on-site works. They 'trade' stormwater quality improvements with council requirements.
- Great Lakes Council in NSW used MUSIC to look at the effects of WSUD both in new developments and in existing urban areas to protect the sensitive Wallis Lake, part of the Great Lakes system.
- MUSIC is being used to look at the effects of wetlands in agricultural catchments near the Great Barrier Reef.
- MUSIC guidelines have been, or are being, written for a range of locations across Australia, including Melbourne, Sydney's drinking water catchments, South East Queensland, Brisbane, Gold Coast, Mackay, Perth and Darwin.
- Melbourne Water has used MUSIC to assess land development proposals and to design stormwater treatment strategies for new and existing drainage schemes. They have also used MUSIC to develop a simpler STORM tool to assist with smaller developments.
- Brisbane City Council uses MUSIC for urban catchment planning, and to design new stormwater treatment measures in the city.

music.ewater.com.au

## For more information

# Keeping urban waterways clean

*New studies are sharpening our choice of plants and soils for use in biofiltering urban stormwater.*

Do you live in a water-sensitive suburb, with features such as rain-gardens and vegetated swales to collect and slow-down stormwater where it falls?

'Biofiltration', as it is called, uses natural materials — plants and soil — to remove particulates, nutrients and heavy metals from, and slow down, stormwater that otherwise would surge off urban surfaces and into creeks and other waters, lowering their quality.

It is accepted wisdom that water filtered through sand beds can be clean enough for human consumption. But now data are being gathered on the detail of how this type of system works.

Researchers at the Facility for Advanced Water Biofiltration (FAWB) at Monash University in Melbourne have been finding answers to questions such as these: What percentage of suspended solids is removed in biofilters? How far must water travel through a biofilter to guarantee capture of nutrients dissolved in it? What plant species contribute best to a biofiltration bed? How can clogging and compaction be avoided in biofilters?

Bioretention system, Victoria Park (Zetland, Sydney). Photo: www.wsud.org

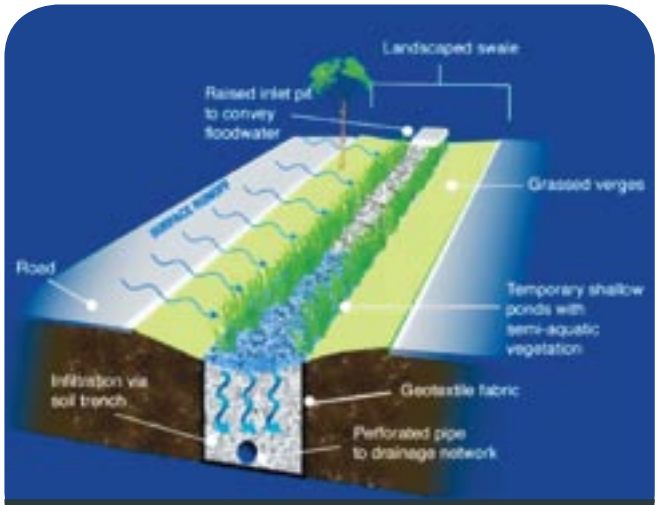
## Physical tests

Research manager at FAWB, Professor Ana Deletic, says: "Our research has shown that biofiltration is flexible in terms of size, location, configuration and appearance. Biofilters can take the form of vegetated roadside strips or rain-gardens within parks or public space. They are fairly robust, though our work has challenged the concept that biofilters simply need to be vegetated to be effective."

The research team has used hundreds of microcosms — PVC columns filled with various combinations of soil and plants — to test the performance of a range of configurations. And they have closely monitored instrumented installations over several years to see what works best. One small installation (15 $m^2$) is in a carpark at Monash University. Another (20 $m^2$) is retrofitted into a residential area at McDowall, Queensland. A third (17,400 $m^2$) is a large basin beside a road in Bracken Ridge, near Brisbane. These three consist of sandy loam of high hydraulic conductivity, planted with various sorts of vegetation.

In a nutshell, the latest findings from these and the PVC columns show that:

- Biofilters effectively attenuate peak runoff rates by at least 80%.
- Runoff volumes are reduced by 33% on average.
- Vegetation is important for maintaining hydraulic conductivity. Root growth counters compaction and clogging.
- Suspended solids and heavy metals are effectively removed, with load reductions in excess of 90%.
- Nitrogen retention is variable, ranging from appreciable removal to consistent leaching. Its solubility makes reliable removal difficult; removal depends on the wetting and drying cycles and the type of vegetation employed.
- Biofilters rely strongly on vegetation (and symbiotic bacteria and fungi) for nitrogen removal. The best plants for nitrogen removal are those with dense root systems and high growth rates. In Melbourne, *Carex appressa* (a sedge) and *Melaleuca ericifolia* (a small paperbark) are good choices.
- Consistent phosphorus removal is easier to achieve; a filter medium low in phosphorus is recommended.




A biofilter designed for alongside a road.

## Biofilters: how they work

Biofiltration systems operate by filtering diverted runoff through dense vegetation, followed by vertical filtration through soil media, usually sandy loam of high hydraulic conductivity. The aim is to reduce stormwater quantity (peak rates and volumes) and to increase water quality (by removing pollutants). In some contexts they are known as biofilters, bioretention systems, or rain gardens.

Treatment is achieved by a number of processes acting in concert: sedimentation, filtration, sorption, and biological uptake. Water is collected by pipes at the bottom of the media; the water can be discharged to receiving waters or kept in store for reuse.

Although the idea is simple, the performance of the system is not always predictable, particularly when we lack years of data. Long term, there are large uncertainties about what will happen as the sediment builds up. Some engineers think scraping off the first few centimetres of surface may be required periodically, but it is unclear what to do with the layer as it may contain high levels of heavy metals.

Clogging of the filter may also occur with time, and again long term performance is unknown. At this stage it seems best to rely on long-lived plants with deep roots, like some sedges and paperbarks.

Simple concept, complex science.

Retrofitted bioretention system, Cremone Street (Richmond), City of Yarra, Victoria. Photo: www.wsud.org

## Optimising performance

Associate Professor Tim Fletcher, who leads an FAWB project that recently won funding for an ARC Linkage project to study the role of vegetation in biofilter design in Western Australia, points out that plants should be chosen carefully.

"Some plants contribute total nitrogen, not reduce it, and if a plant is unsuited to the locality it can struggle to grow, or easily die. Drying out of the system is generally not helpful — think how difficult it is to get water into your garden's dry topsoil. It's imperative to test plant species before they are used in bioretention systems.

"Although the technique works, there's a lot still to be done to fully optimise biofilters for a full range of Australian conditions. In particular, their long-term performance is unknown."

"Initial conductivity of a filter is probably the best indication of long-term performance," says Ana Deletic, "so it's best to aim high."

Adding vermiculite and perlite can help, but it is better to build in a safety factor of 2, meaning that the design area should roughly be double that suggested by calculations (say 2% of the catchment area instead of 1%). Dispersive clay and silt are generally unsuitable, and it is important to test conductivity of a soil before using it in a biofilter.

One field finding has been that age, area, and inflow volume were not useful predictors of long-term conductivity of biofilters. Systems often start out with high hydraulic conductivities, say 180 mm/hour, but within a few months they can compact and run at less than 100 mm/hour. Nearly half the systems FAWB has tested have had a field infiltration rate of less than 50 mm/hour, sometimes due to poor construction or maintenance.

FAWB is a joint venture with EDAW Australia Ltd (now part of AECOM) and was set up to provide proof of concept for stormwater biofiltration, and foster industry-wide adoption of the technology. The research has led to some definite conclusions and recommendations, enabling the team to develop a computer model of hydrological and treatment performance of bioretention and infiltration systems. The model is performing well with data gathered in Melbourne.

eWater's urban software **music** version 4 (see p. 8) includes bioretention and infiltration modules developed in collaboration with FAWB, and **music** will continue to incorporate the latest in biofiltration science.

Professor Deletic says: "Based on the results of our research, biofiltration can be trusted as an effective and reliable urban stormwater treatment technology".

### Further reading

Hatt BE, Fletcher TD, Deletic A. (2009) Hydrologic and pollutant removal performance of stormwater biofiltration systems at the field scale. Journal of Hydrology 365, 310-321.

Bratieres K, Fletcher TD, Deletic A, Zinger Y. (2008) Nutrient and sediment removal by stormwater biofilters: a large-scale design optimisation study. Water Research 42, 3930-3940.

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**For more information**

# TURNING REALITY into catchment models

Farm dams can affect the volume of streamflow leaving a catchment. Photo: James Milligan.

*Computer models of sediment movement, farm dams and groundwater processes are finding application via the catchment management model 'WaterCAST'.*

Understanding of natural-resource processes in catchments is commonly captured in algorithms and individual models that may or may not find practical use in real-world situations. But when such models are integrated into a broadscale catchment model, they can soon prove their worth.

Three new models, now being tested for their performance in a catchment context, assess effects of groundcover on erosion and water quality, and of farm dams and groundwater flows on streamflow.

The models are being trialled in eWater's 'WaterCAST' — a broadscale integrating model designed to help manage the generation and transport of runoff and its constituents in unregulated upland catchments. It uses existing algorithms and models of particular processes, and applies them to subunits of topography, climate and land use to produce an integrated prediction of streamflow for a whole catchment.

## Groundcover modifies erosion

Ross Searle and colleagues at Department of Environment and Resource Management in Queensland have developed a model linking groundcover to the volumes and patterns of sediment moving across catchments. The 'variable cover model' combines the Bare Ground Index (BGI, a remotely sensed measure of groundcover) and a recognised soil-loss equation.

Derived from satellites scanning the regions passing beneath them day after day, the BGI records variation in groundcover across an area and through time. Building these real observations into WaterCAST via the new model gives scientists and managers a means of not only predicting sediment moving into streams but also finding temporary 'hotspots' of erosion.

The team has tested two methods of predicting sediment loss, and compared the predictions to daily sediment loads measured in streams monitored over the same period.

The test bed was the Fitzroy catchment, which runs into the Great Barrier Reef lagoon. This large catchment has diverse climates, soils and topography, and land use ranging from forest to grazing, cropping and mining (complete canopy — bare ground). Based on these factors, the catchment was notionally subdivided into around 2750 subunits — detailed enough to also identify erosion hotspots.

One test method used the team's newly developed variable cover model, linking the BGI to the 'revised universal soil loss equation' (RUSLE). (RUSLE expresses slope, soil, rainfall and land management in numbers, to predict a long-term average sediment load.) The other test method, EMC/DWC, estimates the turbidity of flows during rain events as a proportion of turbidity of flows during dry weather. (EMC/DWC is a method generally used by WaterCAST.)

Sediment loads predicted using the variable cover model compared very favourably to observed loads, and better than predictions made using EMC/DWC. The variable cover model also outdid EMC/DWC in matching predicted and observed turbidity (concentration of sediment), though here there is room for improvement. Further tests and development are now underway.

Bare ground, Fitzroy catchment. Photo: Ross Searle.

## Farm dams and catchment water yields

Lydia Cetin of the University of Melbourne, working with colleagues in Victoria and ACT, has been integrating the existing farm dam model 'TEDI' into the WaterCAST modelling framework. (TEDI stands for 'tool for estimating dam impacts'.) It is important for WaterCAST to be able to account for farm dams in its predictions — given that the density, distribution and sizes of farm dams can be closely related to land use, and greatly affect the volume of streamflow in a catchment.

The model generates a number of individual farm dams per subunit ('functional unit'), based on the density of dams in that area and a relationship between farm dam volume and size, rather than mapping specific dam locations. And it assumes each farm dam intercepts and stores catchment runoff rather than water pumped from streams. The various types of functional units in WaterCAST, with their differing land uses, can be customised to model farm dams with different monthly patterns of water demand or different ratios of large and small dams.

The WaterCAST farm dam model calculates a daily water balance (independent of water quality) for each dam, based on inflows from its own catchment area and rainfall, and outflows to consumption (crops, stock, house), evaporation and spills. Demand changes with season.

The team has tested the WaterCAST farm dam model on the Campaspe River basin, which is rich in farm dams. First, comparing the performance of WaterCAST and TEDI with standardised inputs of climate, dam data, demand and streamflow, and a daily time-step for years 1982 to 2002, the models came up with similar numbers and total capacity of dams per catchment area.

Average drop in catchment water yield because of farm dams was assessed in a second test. Results of a previous study (SKM Pty Ltd, using modelled and actual data) were compared to predictions from a 'farm dam version' of WaterCAST built for the Campaspe River upstream of Lake Eppalock. Four functional units in each of 28 subcatchments were assigned appropriate densities of farm dams and levels of demand derived from actual data, excluding areas such as forests where farm dams are absent. The farm dam model and the SKM study came up with comparable average annual values for the upstream catchment. WaterCAST could also explore the degree of impact from farm dams on catchment water yield associated with different land use practices.

It appears that hydrological impacts of farm dams in upland catchments can be realistically predicted, with the WaterCAST farm dam model also offering better tailoring to actual catchment conditions than the previous TEDI model.

## Groundwater–surface water interactions

Mat Gilfedder and colleagues at CSIRO in Brisbane have built a model which accounts for groundwater–surface water interactions in upland catchments that have relatively small, local, groundwater flow systems. It estimates groundwater flows (both to and from the stream) in those areas, and when applied in WaterCAST it helps predict daily outflows from unregulated tributaries entering large river systems.

A dry Wimmera River pool refilled by baseflow during an environmental water release in spring 2007.
Photo: Mark Toomey, courtesy Wimmera CMA.

The model works on subcatchments of various surface terrains and patterns of groundwater flow, each with functional units having defined soil types, climates and land uses.

It uses the 'deep drainage' component from existing one-dimensional water balance models, which it splits into groundwater recharge and shallow lateral flow. The model calculates groundwater response timescales (based on topography and geology), and uses these to delay groundwater discharge to the river baseflow. The model also accounts for losses of water from the stream (into groundwater) and the impacts of groundwater pumping.

When the preliminary model was tested in NSW in the Murrumbidgee catchment, it matched observed monthly data very well for the period 1960-1990. The model has since been developed to work at a daily time-step. It appears capable of improving the prediction of low flows feeding tributary flows into larger rivers, and is now being developed further.

## Better representation of processes

These three new models are among several that look likely to find work in the WaterCAST framework, improving the way WaterCAST functions as a whole. WaterCAST is currently being trialled by eWater partner organisations for use in catchments of the Great Barrier Reef, SE Queensland, the Mt Lofty Ranges, the Nattai and Cattai rivers, the Yarra River, and the ACT.

See also papers at
http://mssanz.org.au/modsim09,
by Searle, Cetin and Gilfedder.

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## For more information

# Creature.feature

## MOSQUITOES

The good and the bad. The mosquito above (*Aedeomyia venustipes*) is one of the many that doesn't bite humans. Not so benign, the mosquito above left (*Aedes aegypti*) is the carrier of dengue fever. Photos: Stephen Doggett, NSW Health.

### Mosquitoes: the good and the bad

Mosquitoes have a bad name. Buzzing and biting mosquitoes are a real nuisance, and they seem to lack any redeeming features. But next time they annoy you, you could remind yourself that things could be worse: only females seek blood, and only those from a fairly small number of species (albeit widespread). Of the 275 species of mosquitoes found in Australia, most avoid humans, preferring to take a meal from other mammals or birds, or even frogs.

And they do have a good side. Their larvae — wrigglers and tumblers — form an important part of aquatic ecosystems, where they consume a wide range of organic material. In turn, they form a food source for fish, tadpoles, birds, and other larvae.

Mosquitoes breed in still water such as puddles and ponds — and plant-pot saucers and tree hollows. Depending on temperature, they take 12–20 days to develop from an egg into an adult. The problem is that mosquitoes can breed prolifically, quickly growing to pest proportions.

When urban stormwater facilities such as ponds and wetlands are being constructed, people are often concerned that the waters will become a breeding ground for mosquitoes. In a balanced ecosystem with adequate predators that shouldn't be a problem, however.

It is therefore important to design ponds and wetlands in a way that minimises mosquito breeding; for example, by:

- shaping ponds and wetlands to avoid the creation of stagnant areas that predators cannot access,
- ensuring the water levels in ponds and wetlands sometimes fall — this can 'beach' the mosquito larvae and break the growth cycle,
- intercepting and disposing of floating trash where wrigglers can 'hole-up' and avoid predators.

Wrigglers are an important part of aquatic ecosystems. This one (*Aedes* sp.) is a common food source for many aquatic and terrestrial animals. Photo: John Hawking, Murray–Darling Freshwater Research Centre.

# Queensland Working in partnership for healthy waterways

STATEVIEW: Queensland

Freshwater sampling to check river health. Photo: Healthy Waterways Partnership.

South East Queensland stretches from the Queensland/NSW border in the south to Noosa in the north and west to the Great Dividing Range. It occupies 22,672 km$^2$ and includes 14 major river catchments and Moreton Bay. Today, the region's aquatic ecosystems are under enormous and increasing pressure. By 2030 South East Queensland's population is predicted to grow from 2.73 million people to over 4 million. This rapid growth will result in increasing demands for reliable supplies of potable water, an estimated 50% increase in point source pollution and a 20% increase in diffuse source pollution, plus increased recreational pressures on natural areas including our waterways.

The significance Moreton Bay's biodiversity is recognised at international, national and state levels through its listing as an international Ramsar wetlands site and creation of the Moreton Bay Marine Park.

The ecosystem health of Moreton Bay, which underpins the region's lifestyles and livelihoods, is the driver for the South East Queensland Healthy Waterways Partnership — winner of the 2009 Banksia Environmental Award for Water.

The Partnership is a whole-of-government, whole-of-community collaboration of over 113 organisations which focuses on understanding, planning and managing the use of the waterways and catchments of South East Queensland (SEQ). Its primary objective is to halt water quality decline and improve the ecosystem health of Moreton Bay and the region's estuarine and freshwater assets.

Particular achievements of the Partnership over the past two years include:

- the development of the SEQ Healthy Waterways Strategy 2007-2012 which contains over 500 management actions and has the commitment and endorsement of the Queensland Government and all SEQ local governments;
- ongoing significant investment in wastewater treatment plant upgrades to reduce nitrogen and phosphorus discharges;
- increased uptake of water sensitive urban design, supported by the nationally recognised capacity building program (Water by Design);
- provision of leading scientific advice and decision support tools to assist in evaluating and prioritising management actions; and
- the annual Ecosystem Health Report Card (providing a snapshot of waterway health) and establishing an Event Monitoring Program to monitor the impact of big rainfall events.

The adaptive management cycle (AMC) approach underpins the methodology of the Partnership. The five interconnected elements that make up the AMC approach — learn, plan, do, monitor and evaluate — are applied rigorously to all work the Partnership undertakes.

The Partnership's systematic approach began with benchmarking the state of SEQ waterways by identifying their environmental values and then translating these values into water quality objectives that are measurable indicators of ecological health. Partnership teams have measured and monitored these indicators regularly, whilst reporting the results publicly and in a way that is easily interpreted.

The teams use the data to calibrate and validate decision support tools such as computer models of catchment and receiving water quality. The models allow the partners to 'predict the future' for waterways that depend on managed catchments.

The Partnership's credibility has been built on the rigour of its scientific findings, which emanate from a multitiered Scientific Advisory Group, and are validated by independent academic and peer review mechanisms.

A Brisbane wetland for stormwater management, designed to be mosquito-free. Photo: BMT WBM.

# Queensland

## STATEVIEW: Queensland

Launching the report card, Professor Paul Greenfield, Minister Andrew McNamara and Lord Mayor Campbell Newman.

The scale of the Partnership is significant. In addition to its multi-tiered policy, scientific review, advisory and steering committee structure (involving no less than 167 individuals), the Partnership encompasses three national agencies, 11 Queensland state agencies, two State corporations, 11 local governments (19 prior to recent amalgamations), 36 industry groups, nine research organisations and 41 community/catchment/environment groups spanning SEQ.

These combined resources create a critical mass of activity (political, planning, on-ground works, community and awareness-raising) directed at achieving the Partnership's vision of healthy waterways for future generations to enjoy.


eWater CRC is currently collaborating with the SEQ Healthy Waterways Partnership in the development of regional and local scale decision support tools for waterway rehabilitation.

www.healthywaterways.org

**For more information**

# Northern Territory

## STATEVIEW: Northern Territory

As drought prevails and diminished rainfall trends continue in southern regions of the continent there is an increasing national interest in northern rivers as potential sources of water for agricultural and other development.

This interest has the historical context of the Ord River scheme and the Lake Argyle storage providing an abundant year-round irrigation water resource, which has led to optimistic extrapolations and assumptions about the amount of water available elsewhere in the north.

The reality, becoming increasingly clear in the Territory, is that there is not boundless water available year round in our existing systems to sustain large new consumptive enterprises. Where significant consumptive water use occurs, rivers and groundwater resources are coming under increasing pressure from incremental growth in existing residential, agricultural and industrial demand. For example, in the Darwin rural, Katherine and Mataranka regions, groundwater use is approaching sustainable yields while in other areas such as Ti Tree and Alice Springs the groundwater resources are effectively being 'mined'.

In light of the development pressures being exercised or projected on the Territory's largely unregulated water resources, resource management actions are occurring on many fronts. Most recently (August 2009) a 10 year Water Allocation Plan (WAP) for the Tindall Limestone Aquifer, Katherine, was officially declared by the Minister for Natural Resources, Environment and Heritage. This represents the culmination of some three years collaborative work by NRETAS* involving community engagement, data gathering and information collation.

Other regional WAPs are being developed by the Department's Water Resources Branch, in collaboration with a wide range of stakeholders; for example, for the Oolloo aquifer/Daly River and for the portion of the Tindall aquifer that sustains various groundwater dependent ecosystems in the Mataranka area and surface flows to the Roper River. Further afield, planning work is progressing on the Tiwi Islands north of Darwin and in the near Darwin region at Howard East. The Tiwi Island Plan will represent a first in Australia for fully Indigenous tenured land and when completed will provide valuable templates for use in other planning areas where there is a mix of Indigenous and other tenures. Southwards in the Territory, a WAP has

A Top End river. Photo: Michael Lawton.

# Water in the North — getting the balance right

STATEVIEW: Northern Territory

Katherine River near Galloping Jacks gauge station. Photo: Michael Lawton.

been previously developed for groundwater resources at Ti Tree (irrigated table grape production area) with a statutory 5 year review currently taking place. And further south again, and well into the arid zone, a comprehensive water strategy has been developed for Alice Springs.

There has been a flurry of activity in water resource inventory and research across the region, to better assess the potential water resource opportunities that may be available in Australia's north. The Tropical Rivers and Coastal Knowledge (TRaCK) consortium, the North Australia Water Futures Assessment program of work and a range of other research and study activities inclusive of the North Australia Land and Water Taskforce have allowed some of the strategic knowledge needs in Australia's wet dry tropics to be better identified. This work has allowed for some inroads to be made in developing more informed assessments on potential water availability together with a better understanding of the constraints and ecological risks associated with accessing these resources. Much of this work is due to report and make recommendations in 2009/2010.

In anticipation of the growing demands and expectations on Territory water resources, and to avoid the manifest failures in water resource management elsewhere, the Territory Government in April 2009 released a discussion paper on a way forward to a Living Rivers Strategy. This will provide an important policy framework for getting the balance right between development and conservation for water resource management in the Territory. The draft Strategy aims to:

- establish maintenance of river health as a core goal in all relevant Territory law and processes for land and resource management;
- accord special status to rivers that are particularly valued by the Territory community;
- provide mechanisms for genuine community involvement in setting and achieving targets for maintaining the character and functions of our rivers; and
- develop standards, criteria and processes for the maintenance of ecological, cultural and recreational values of rivers.

Government is currently considering stakeholder comments on the discussion paper.

Other recent achievement milestones in NT water resource management activities include development of a Water Quality Protection Plan for the Darwin Harbour catchment to underpin the existing Darwin Harbour Regional Plan of Management and the completion of a water quality monitoring and management framework for the Katherine and Daly River catchment.

*Michael Lawton, Senior Advisor, Natural Resource Division NRETAS*

** In the NT the Department of Natural Resources Environment the Arts and Sport (NRETAS) administers the primary legislation for water resource management, the* Water Act.

Pivot irrigator at Katherine. Photo: Michael Lawton.

# Living on the edge
## — comparing urban water systems

Postgrad. THINKING

Jill Fagan was an invited speaker at Singapore International Water Week.

What's the best way to assess and compare alternative water systems? Jill Fagan reckons most models in use have serious drawbacks and she's been developing a new way to compare urban water systems by taking a whole-of-system view. Jill is an eWater CRC PhD candidate at the Department of Civil and Environmental Engineering, the University of Melbourne.

Her method is being demonstrated at Aurora, a new suburb of 8,500 households on the northern edge of Melbourne. The suburb is expected to achieve in excess of 55% water savings by using a range of innovations. These include a suburban-scale wastewater treatment plant and water recycling to every dwelling, energy efficient homes, gas-boosted solar hot water systems, provision for rainwater harvesting, biofiltration swales and wetlands.

"The tool I'm developing is a dynamic system engineering modelling framework which assesses and compares alternative water systems on the basis of their cost-effectiveness, technical robustness and sustainability," explains Jill.

"We selected Aurora because it is important to assess innovations and see whether they delivered the benefits we expected, and also because it has advanced wastewater treatment and recycling, which is something existing integrated water models do poorly.

"We are using the modelling framework to compare Aurora's state-of-the-art water system with the standard, centralised water infrastructure you typically find right around Australia," says Jill. "It uses dynamic material and energy balances, thermodynamics and kinetics to link water supply, wastewater transport and treatment, various water consumers, and urban runoff and stormwater treatment. Life cycle assessment calculates environmental impacts and greenhouse gas emissions from water system operation and infrastructure, and process economics is used to determine the cost-effectiveness of options."

Most importantly, the process engineering model provides the results to assess innovations and inform policy and decision makers. For each water-system scenario, the model simultaneously calculates the dynamics of many variables: water consumption, waterborne contaminants, energy consumed and produced, environmental impacts, greenhouse gas emissions, and cost. The beauty of the all-encompassing system framework is that it ensures that water savings are not made at the expense of higher energy consumption, environmental damage or cost, since these are taken into account.

Jill has employed the model to compare various water-system policy, design, and management scenarios, including: a comparison of infrastructure scale (conventional city-scale, suburban-scale like Aurora, and household-scale, where each house has grey water recycling); assessment of environmental performance by different methods (life cycle assessment, ecological footprint); and innovative water demand management policies at Aurora.

"In the latter case, for example, I used my urban system model to investigate, by simulations, a number of potential policy scenarios to achieve consecutive step-by-step reductions in potable water consumption at Aurora," she says.

The modelling indicated that installation of water-efficient household appliances leads to a 27% reduction in total water consumption. If, on top of this, recycled water is used in washing machines, and rainwater tanks supply hot water systems, there's a dramatic reduction in the peak demand for potable water (on an average day). This implies that water supply pipes could be smaller, which leads to large capital cost savings.

The model also demonstrated that installation of water-efficient appliances not only saves water, but also reduces greenhouse gas emissions and energy consumption from operation of household water-using appliances. "This result is even more significant when you see it in the wider context. For Aurora, my modelling has shown that water-related energy consumption by households is on average ten times that consumed in the rest of the urban water cycle combined," explains Jill.

"This means that decision-makers aiming to reduce energy consumption or greenhouse gas emissions in the urban water cycle need to focus first on households."

"This is just one illustration of the objective, science-based results that the dynamic system modelling framework can provide to policy makers as they grapple with the consequences of climate change, water shortages, population growth, the likely introduction of a market in carbon, and numerous economic and environmental pressures," concludes Jill. "In other words, the new framework can inform policy by helping us to make more efficient use of limited resources and moving us towards more sustainable solutions to water challenges."

Jill's PhD supervisors are Professor Markus Reuter and Professor John Langford.

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**For more information**

# Fine sediments,
## small creatures, big headaches

Postgrad.THINKING

Evan Harrison assessing streambed condition in the Goodradigbee River, one of many sites for his sediment studies.

Fine sediments accumulating in river beds have serious implications for river health. With some 30,000 km of streambed thought to be being 'suffocated' by a coating of fine mud or sand, this is no small problem in Australia.

PhD student, Evan Harrison, supported by the Institute for Applied Ecology at University of Canberra, and CSIRO and eWater CRC, has been investigating the relationship between fine sediments and the various species of macro-invertebrates[1] that live on streambeds or amongst the stones and other rubble on the stream floor.

"Whereas previous studies have tended to concentrate on just a few hundred metres of stream, I've been investigating how and where fine sediments affect these invertebrate communities at a larger, catchment scale, throughout the upper Murrumbidgee River catchment in south-eastern Australia," says Evan.

Macroinvertebrates are regarded as good biological indicators of river health or ecological condition, because they respond to human disturbance, including sedimentation, in a variety of ways.

And macroinvertebrates themselves are an important food source for fish and other larger species, so changes to their numbers and types have a ripple effect in the stream environment.

A streambed smothered by fine sediment in Jugiong Creek, NSW.

"We already know that sediments settling on a stream bed can have a murderous impact on many streambed invertebrates, especially in certain groups, such as caddisflies, stoneflies and mayflies," says Evan. "The fine particles (less than 2 mm in size) clog up the spaces between coarser gravel and stones, depriving many creatures of their preferred habitat.

"As well, fine sediments can cause increased drift of small invertebrates downstream; affect oxygen uptake by clogging animals' gills; and smother algae on river stones, a prime food source."

To investigate the links between sediments and macroinvertebrates, Evan set small wire baskets, filled only with coarse gravel, in streambeds for a month or so; then collected them and measured the quantities of sediments and the kinds and numbers of water bugs present in the baskets. Streams he sampled included the Murrumbidgee, Goodradigbee and Numeralla rivers as well as a range of smaller streams in NSW and the ACT.

His results indicate that even a small increase in fine sediments on the streambed can have a dramatic impact. When he graphed invertebrate diversity against fine sediment accumulation in the substrate, the richness of the invertebrate community showed a steep downward curve, before flattening out at a low level.

"Baskets collecting little fine sediment contained sometimes up to 15 different kinds of macroinvertebrates," says Evan.

Wire baskets were buried in the streambed to sample macroinvertebrates and fine sediment.

"But when sediments exceeded a low threshold, water bug diversity fell dramatically, to as few as five different types."

For land managers, the message seems to be that efforts to control soil erosion need to be quite thorough. Small quantities of fine sediments in streambeds, even 3% by weight, degrade stream ecology more than might be expected.

"The good news is that growing understanding that river sediments that affect river health should reinforce managers' efforts to protect streams from further sediment accumulation, so that in time degraded waters may be able to recover," says Evan.

Evan's PhD supervisors are Professor Richard Norris, University of Canberra, and Dr Scott Wilkinson, CSIRO Land and Water.

Some of the aquatic macroinvertebrates, mostly larvae or nymphs of flying species, affected by fine sediment.

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For more information

[1] A macroinvertebrate is an organism that lacks a backbone and can be seen without the aid of a microscope.

# H2O business

## The benefits of being a 'green plumber'

What motivates 30 plumbers to take time off from their busy profession and sit down all day in an unfamiliar environment? Why would a plumber want to listen to a lot of words, take notes, and ask questions?

They want to learn how to become green plumbers — to understand the latest water-efficient techniques and how they are installed. They want to know what new household appliances are ecofriendly and what qualifies them for such a label.

'GreenPlumbers' is an initiative of the Master Plumbers and Mechanical Services Association of Australia (MPMSAA) who have developed a series of workshops for plumbers interested in expanding their skills and knowledge. Since 1999, more than 8200 plumbers from over 4700 Australian businesses have attended the free workshops, which are held a number of times each year around the country.

There are a range of 4, 8, and 16 hour units that the plumbers can choose from, including 'Caring for our water' and 'Water efficient technology'. The first covers a range of issues at both state and local levels, including water recycling opportunities, rainwater and stormwater tanks, water efficient appliance labels, and local water restrictions, available rebates, and caring for watercourses and bays. The second unit deals with water recycling, greywater and rainwater harvesting, new developments, public health, environmental safety, and sustainability. Other units cover such topics as climate care, solar hot water, and inspections and reports.

To earn the title GreenPlumber, each participant must be a licensed plumber and complete a total of 40 hours of training from the 10 courses on offer. At the end, they receive a recognised qualification and their name is listed on a directory accessible from the GreenPlumbers web site. Victoria has the biggest number of green plumbers — about 3500 — and the numbers are growing.

The MPMSAA estimates that 70% of the environmental water and energy savings achievable within new and existing buildings is plumbing related. Heating, cooling, hot water, water efficiency and the harvesting and use of alternative water


sources all call for a sustainable plumbing solution, they say. The organisation wants to ensure that plumbers can deliver a reliable service that protects the health and safety of the public and the environment.

Graduates from the course are in a position to give their clients up to date information and advise them on the environmental impacts of appliances and plumbing options; they can offer cost comparisons from energy and water saving installations and list the on-going benefits. Many of the plumbers find that the qualification expands their business, giving them new opportunities and customers. The time spent sitting in a training room all day does pay off.

Brent Papadopoulos, a graduate of the course and owner of a plumbing business in Melbourne, recently won the Premier's Sustainability Award — Small Business. The award was given for outstanding achievement in adopting and promoting sustainable measures.

The MPMSAA is pleased with the success of their initiative, and finds that the GreenPlumbers web site attracts thousands of visits each week from people wanting to find an environmental product and a plumber who can install it. Recently, the program has been extended to New Zealand, Canada, Mexico, the United States, and India. They have teamed up with a number of supporting partners, including the Queensland Government, Gold Coast Water, the Building and Construction Industry Training Fund of Queensland, and a range of water-saving enterprises.

**For more information**

www.greenplumbers.com.au


# Doing it my way

## RIVERKEEPERS GIVE THE YARRA A VOICE

Dolphins and jellyfish in the Yarra: signs that the lower river is a saline estuary.

The Yarra River, southern Victoria, is presently running at 10% of its previous average natural flow, but Yarra Riverkeeper Ian Penrose is still hopeful it can be returned to its former majesty, and he's still keen to sing its praises.

"The Yarra is Melbourne's lifeblood," he says. "It was central to the lives of the Wurundjeri people and is no less important to today's Melburnians. The main source of the city's water supply is the Yarra, but the combined impacts of extraction and low rainfall have meant the river is now a shadow of its former self."

As spokesperson for the Yarra Riverkeeper Association, Penrose sees his job as getting people to appreciate the values of the waterway that is so central to Melbourne's existence. "People protect what they love, and so the first step is to get the community involved, to care for the river and enjoy it — whether by boating, kayaking, fishing, picnicking or walking along its banks.

"The aim of Yarra Riverkeepers is to protect and restore the Yarra River from source to mouth," says Penrose, "so that future generations can share in its benefits.

"We work to raise awareness about the Yarra, its delights and its plights. We want everyone to be a stakeholder in the river's future health. Our aim is to give the Yarra a voice."

Yarra Riverkeepers is a community-based organisation formed in 2004, and is linked with the international Waterkeeper movement of 180 community groups around the world all involved in protecting the health of precious waterways. Like the gate keeper of old, they keep an eye out for anything untoward; a sort of Neighbourhood Watch of the river.

Twice a week, the Yarra Riverkeeper boat patrols up and down the river, looking for environmental alerts — sewage leaks, industrial pollution, damage to banks, and the like. The boat has become a familiar sight on the water. Recently, a black swamp wallaby was seen scurrying among the blackberries near the Abbotsford brewery, and native water rats at Hawthorn and Kew.

The organisation has become an important link between many people and organisations with a stake in the Yarra. It holds regular events and outings. Invited experts deliver talks about the history, values and health of the river. Its submission contributed to the legislated maximum cap on the amount of water that could be extracted from the river.

Yarra Riverkeepers is one of a number of community groups in Australia which are speaking up for their local waterway, whether it be river, lake, wetland, estuary or creek.

Waterkeeper groups are active in South Australia (Coorong, Lakes and Murray), Queensland (Bramble Bay Wetlands) and New South Wales (Upper Hunter, Upper Snowy, Mimosa) as well as in 12 areas of Victoria.

### For more information

Yarra Riverkeepers
www.yarrariver.org.au
Waterkeepers
www.waterkeepers.org.au

# Water management resources

## eWater Toolkit

The eWater Toolkit website (toolkit.ewater.com.au) is a source of software tools and information related to the modelling and management of water resources. It is designed for use by water industry professionals involved in the management and modelling of catchments and water resources. Formerly known as the Catchment Modelling Toolkit, the eWater Toolkit is now integral to the way eWater CRC manages its business.

eWater is proud to announce plans to further develop the Toolkit. Users will begin to notice changes taking effect over the coming months.

One major recent change is the introduction of PayPal services to the website, explicitly for the MUSIC software tool, in response to popular demand. Credit card services were previously absent from the website. The new PayPal system has vastly simplified the process for purchasing MUSIC via the eWater Toolkit. Users no longer have to wait for manual processing of cheques; payment is quick, easy and secure; registration codes are sent out via email efficiently and automatically.

Some planned changes for the future include a new 'look' for the site, an introduction of special website areas for eWater's partners, and generally improved usability, look and feel.

To facilitate this process the eWater team is using a number of techniques and initiatives. The first is a market research survey focused on the Toolkit itself and how people use it. Future initiatives may include user testing.

Please look out for the survey at toolkit.ewater.com.au, and join us in making this excellent resource a more useful tool for the future.

toolkit@ewatercrc.com.au

**For more information or to send feedback**

## Water sensitive urban design: Where do I start?

A plethora of ideas is gathered together under the one umbrella of 'water sensitive urban design' (WSUD). It can be daunting to try looking for industry guidelines.

Here is a list of information resources to get you started.

A good entry point for understanding what it all means is the classic 'Water Sensitive Urban Design Guidelines' published by The City of Melbourne in 2005. It addresses issues specifically asked by local government engineers and provides examples of opportunities for WSUD within a municipality.

A sister publication, again from Melbourne Water in 2005, is 'WSUD Engineering Procedures: Stormwater manual' which gives practical engineering guidance, design and maintenance procedures, checklists, landscape requirements, worked examples and case studies.

The Institution of Engineers Australia published 'Australian Runoff Quality: A guide to Water Sensitive Urban Design' in 2006.

The industry-standard model, MUSIC, is designed for planning urban stormwater management systems (MUSIC = model for urban stormwater improvement conceptualisation). See article on page 8 of this issue.

### Other useful resources:

www.wsud.org — 'Water Sensitive Urban Design, Technical Guidelines for Western Sydney' (Upper Parramatta River Catchment Trust, 2004)

www.goldcoast.qld.gov.au/stormwater — 'Water Sensitive Urban Design Guidelines' (Gold Coast City Council, 2007)

www.brisbane.qld.gov.au/BCC:STANDARD:369665131:pc=PC_1898 — 'Water Sensitive Urban Design Engineering Guidelines: Stormwater' (Brisbane City Council)

www.waterbydesign.com.au — 'WSUD Technical Design Guidelines for South East Queensland' (South East Queensland Healthy Waterways Partnership)

www.clearwater.asn.au — 'Hydraulic performance of biofilter systems for stormwater management: lessons from a field study' (Clearwater InfoExchange)

www.planning.sa.gov.au/go/wsud — 'WSUD Technical Manual for Greater Adelaide' (Planning SA, 2009)

www.nt.gov.au/lands/planning/wsud — 'Water sensitive urban design: strategy for Darwin harbour' (Northern Territory Government 2009)

www.urbanwater.info — 'Managing the urban water cycle: tools and resources' (Hunter Councils Inc. 2005)

## UPCOMING TRAINING courses

### Upcoming training courses in MUSIC v.3 and v.4

| Location | Dates* | Register by* |
|---|---|---|
| Ballina/Lismore (NSW) | October | early October |
| Dubbo (NSW) | October | early October |
| Townsville (Qld) | October | early October |
| | | |
| Brisbane | November | late October |
| Hobart | November | late October |
| Melbourne | November | early November |
| Sydney | November | early November |

*When confirmed, dates will be available at **www.ewatercrc.com.au/training**.

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Photo: Shaun Leinster. Location: Coomera Waters, Queensland