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Aqua Australis

Newsletter of the Hydrological Society of South Australia Inc.

INSIDE THIS ISSUE

RIVER MURRAY SALINITY – A PROBLEM SOLVED? LEARNINGS FROM 20 YEARS OF SALINITY MITIGATION

Renae Eden, Adelaide Airport Ltd

Over the past 20 years, a mix of engineering works and irrigation management measures have mitigated some of the salinity problems across the Murray-Darling Basin (the Basin). Peter Forward and Bob Newman addressed the membership on July 28, presenting an overview on various basin wide salinity management issues, and cumulative results from the ensuing investigations, design and operations of the salt interception schemes (the Schemes) that have been established within the South Australian reach of the River Murray. Their presentations are summarised as follows.

Salinity in the Basin is caused by a number of factors, including naturally occurring low flow regimes with groundwater salinities often exceeding that of sea water, weathering of ancient rock, low-laying slow draining landscapes and deposition via rainfall over thousands of years. However, irrigation and land-clearing practices have contributed to salinisation of the River Murray's (the Murray) floodplains and wetlands in particular, in some cases resulting in dryland salinity.

As early as 1990, the Schemes were implemented by SA Water under strategies developed by the Murray-Darling Basin Commission (now the Murray-Darling Basin Authority). The Schemes, located at Bookpurnong, Waikerie, Woolpunda and Loxton to name a few, significantly reduce saline groundwater entering the Murray by intercepting the more concentrated salt accession zones with bores, and pumping the saline water either the Noora or Stockyard Plain Disposal Basins. Utilising over $200 million worth of infrastructure which includes around 250km of pipelines, 194 bores and two disposal basins, the Schemes will be intercepting in excess of 500 tonnes of salt per day by late 2011.

Over the decades, 45 continuous electrical conductivity (EC) recorders have been placed in the main river channel and various anabranches within South Australia to monitor Murray salinity. These EC recorders are usually deployed on pontoons located mid stream at the upper and lower end of a reach of river where concentrated salt accessions are suspected. However, they are affected by a number of variables including high variability of river flow and salinity dynamics and the effects of drought, land clearance, irrigation development and changes in irrigation management. Also, as they remain in situ, they don't indicate where in the reach more concentrated salt load accession may be occurring.

In 1985, this fixed location continuous salinity monitoring was augmented by Run of River salinity surveys, which measure the change in salinity of water as each river kilometre is traversed, determining salt load in 1km intervals, expressed as tonnes/day/km. Originally, water samples were collected in manually in bottles and following the run tested for EC. Later, the same data was collected using an EC sensor in a flow through cell attached to a pump that continuously sampled whilst the boat moved along the river. This method has been further enhanced over time with the data being recorded 'live' and combined with geolocation data from an onboard GPS and water depth readings from a depth sounder.

This methodology has some inherent but well recognised limitations in that with the EC probe at approximately 500mm below the surface, it only provides a simple 'snapshot' of river salinity in a centreline track down the river. Consequently, salt accessions from the sides or bottom of the river that may take some time to mix into the water profile and register on the EC probe at mid stream may not be indicated until up to 8km downstream from the actual accession location. This method is also subject to the influence of varying river flows or levels for up to a month prior to the survey as these events can mobilise or suppress salt inflows. In recognition of these factors, surveys are only undertaken under stable river conditions and only at low flows (3,000 to 4,000 ML/day) that provide the greatest sensitivity and accuracy for salinity measurements. In practice surveys are undertaken at a rate of 130 to 200 km per day with successive runs over the same reach on 4 or 5 successive days to average out spatial and temporal variations.

To more reliably locate specific reaches of more concentrated accessions the run of river sampling method has been augmented with a technique that provides detailed 3D measurements

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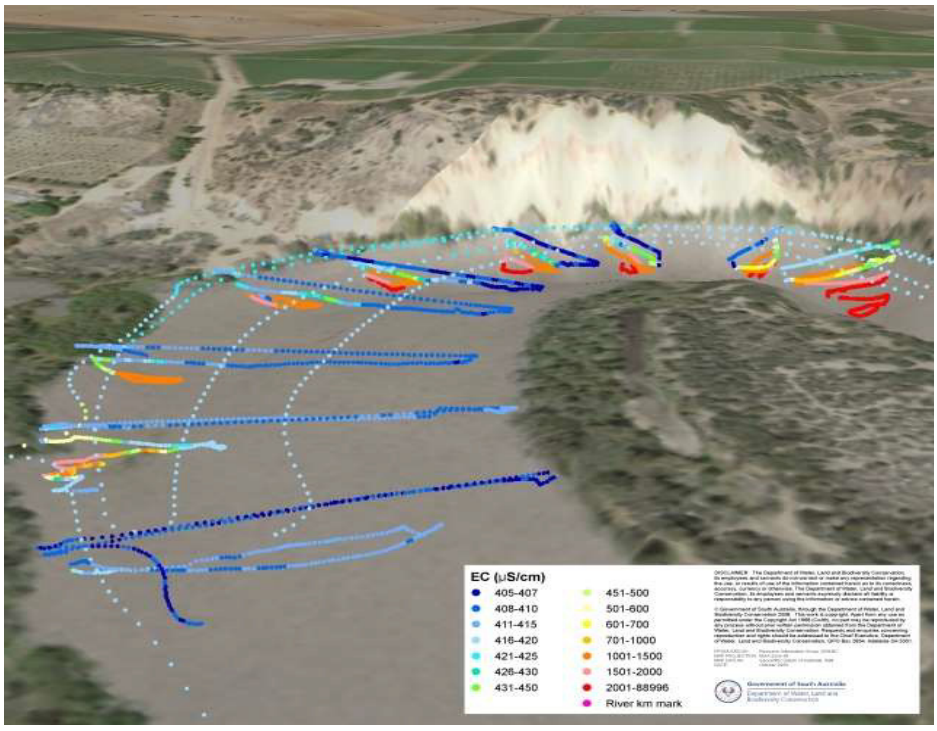
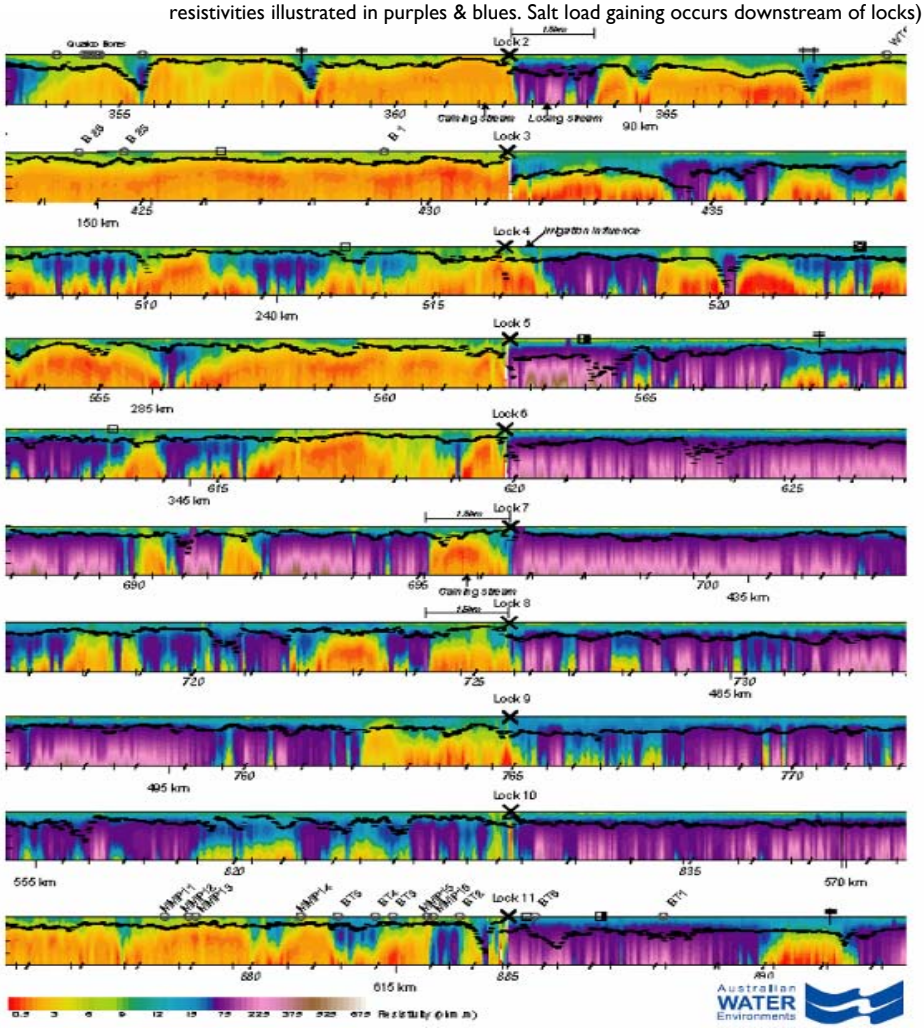


Above: 3D In-Stream EC modelling at Bookpurnong.
Below: Data collected via NanoTEM. Lower restivities (higher ECs) illustrated in oranges & reds, higher resistivities illustrated in purples & blues. Salt load gaining occurs downstream of locks)



(Continued from page 1)

of salinity within a focussed area of the river. This method uses a continuously recording EC sensor suspended by weighted cable on a winch attached to a boat that moves along and across the area of interest with the sensor set at various depths thus creating a 3D map of EC in the river segment. This method allowed georeferencing of salt accessions, indicating whether salt was entering via the river bottom or bank, and at what depth. A number of accession locations were identified this way, often depositing salt loads via paleochannels or groundwater seepage.

While EC data collected between the different methods was comparable, identifying sites with the level of accuracy offered by 3D In-Stream EC enabled strategic placement of bore pumps, and measurement of the other parameters also offered insight into the hydrology of these sites, mapping salt plumes and gaining a better understand of the mixing that was taking place.

More recent advances made possible by newer technologies include NanoTEM instream electromagnetic salinity surveying. NanoTEM measures the EC (resistivity) of saturated geological materials. This technique induces a subsurface electromagnetic field by means of a current loop. A secondary current loop measures the decline of this electromagnetic field, which is expressed as resistivity. Different geological materials have identifiable electrical resistivities, which are affected by the properties of that material (clays are more conductive than sand), porosity and saturation of the material, and water salinity.

Instream NanoTEM is influenced by gaining and losing stream conditions (generating lower or higher resistivities respectively) and riverbed geology. It also registers groundwater salinity, recording lower resistivities with increasing EC. Accordingly, potential benefits of NanoTEM include;

- Identifying where gaining and losing stream conditions occur
- Identifying locations of regional clay aquitards beneath the river

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- Illustrating where the Schemes have been effective in preventing saline groundwater inflows (before and after the Schemes comparison)
- Assisting with Scheme investigations and Scheme design through identifying potential areas of salt inflow (although NanoTEM can't quantify flux)
- Identifying where freshwater lenses may have been created adjacent the river by SIS over pumping
- Optimisation of Schemes by identifying areas of over or under-pumping

Data collected with NanoTEM was compared with previous monitoring methods, and it was found that the results were comparable. The data collected by the suite of tools developed illustrated very encouraging correlations between salt loads and the reductions achieved by the Schemes, the location and quantum of salt inflows to the river, and evidence of the modification of groundwater flow patterns caused by Scheme pumping - including the development of freshwater lenses adjacent the river.

Conclusively, the effectiveness of the Schemes is demonstrated by the significantly reduced salt loads as measured by a variety of techniques. There are opportunities to use the Schemes for purposes other than just salt load reductions by the deliberate creation of freshwater lenses adjacent the river channel to aid in the reduction of post flood salt loads from the floodplains, and improve floodplain vegetation health.

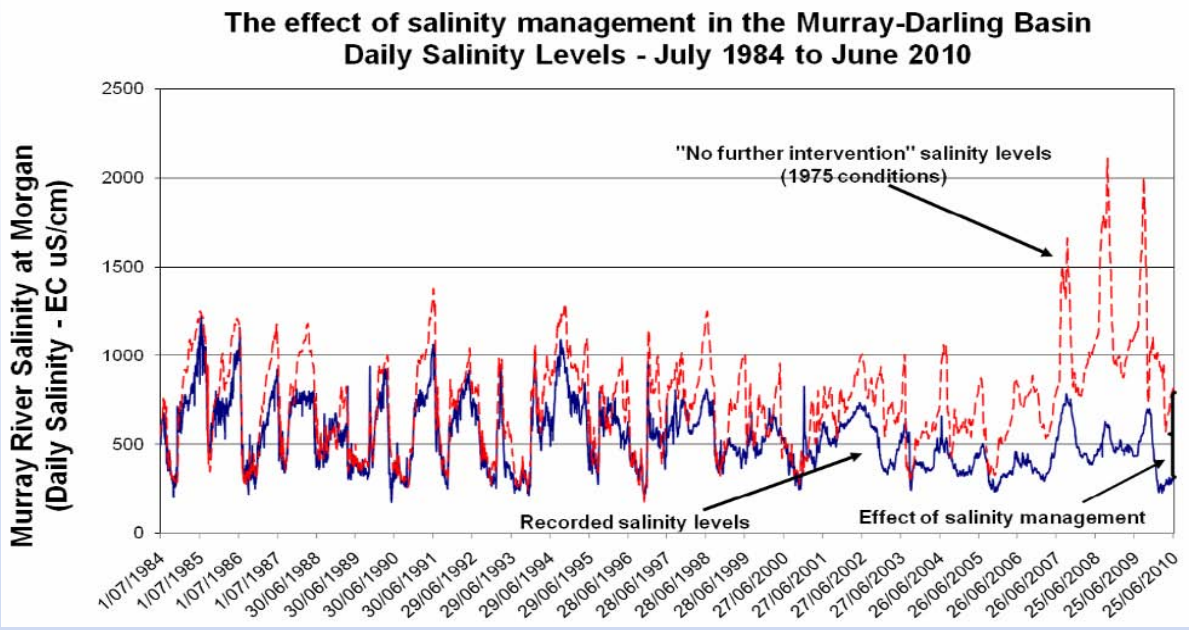
Following these positive results, a new scheme will be commissioned for Murtho by December 2011, and another at Pike River has been accepted by MDBA as a technically viable scheme although they have not yet provided the $25 Million funding for installation of approximately 30 bores. However, SA has received $2M NAP funding to start the Pike River Scheme with 2km pipeline and 4 bores, which were commissioned in September 2011.

Beyond these, optimisation, enhancement and augmentation of existing Schemes is anticipated rather than more, new large scale Schemes. Aging infrastructure, higher maintenance requirements, harsh operating environments and increasing electricity costs are some of the challenges that require attention in the coming years.

The Schemes were but one aspect of the Basin Salinity Management Strategy 2001-2015 issued by the Murray-Darling Basin Ministerial Council, who in the strategy proposed to address salinity through a number of mechanisms, including:

- Salinity targets
- Salinity registers
- Irrigation policy
- State accountability and
- Engineering interventions
- 5 year reviews

So where to from here? The undeniable solution is that regular larger environmental flows are needed to flush the salt out of the Murray system and export it to sea. In light of the uncertainties and variability presented by climate change, ongoing irrigation accountability and implementation of efficient and sustainable irrigation management is a large part of the solution, to avail the necessary environmental flow. Economic modelling is also important to factor in. This should be supported with environmental actions such as revegetation and 5 year reviews to assist adaptive management of these long term strategies. With the Murray-Darling Basin Plan draft due for release later this year (see pg. 7), it's the opportune time to consider the measures the Plan proposes to undertake and contribute your thoughts during the comment and review phase.



EC monitoring to demonstrate impact of Salinity Interception Schemes

STRATEGY FOR MANAGING URBAN RE-DEVELOPMENT WITH AN 'AT CAPACITY' STORM-WATER INFRASTRUCTURE

John Argue, University of South Australia

A paper (Tennakoon & Argue, 2011) presented at the 34th IAHR Congress held in Brisbane in June/July addresses a common problem for many 'older' municipalities: how to handle re-growth or re-development with a stormwater infrastructure that is already "at capacity"?

The City of Gosnells is an outer, south-east Perth suburb with population around 100,000. Gosnells was established in the early 1900s and is experiencing annual growth of 3% in the wake of Western Australia's mining boom.

The City's stormwater infrastructure was designed for ARI, Y = 5-years capability; its flat gradient coupled with the intensity of urbanisation have resulted in substantial portions of it being "at capacity". Faced with the need to cater for re-development in these circumstances, the City received professional advice that (conventional) upgrade of the stormwater infrastructure would incur a cost of around $ 120 million. An alternative strategy has been adopted which avoids this expenditure. The strategy is based on WSUD 'source control' measures (Argue, 2004/2011) and involves storing, temporarily, a significant portion of the runoff (roofs, paved areas, etc) and subsequently releasing it *slowly* over a period of two or three days into the storm drainage network.

Gosnells is located on the edge of the Perth (sandy) Plain but its area also reaches into the foothills of the Darling Range. Common practice in the deep sandy areas of Perth is for roof runoff to be diverted directly to "soakwells" and, hence, into the (reasonably stable) groundwater table. This practice is available in about half of the Gosnells municipality, but areas of the foothills are characterised by less permeable soils - peaty sands and gravely sandy clays. The adopted strategy fully exploits the opportunities presented by "soakwell" disposal but has combined this with a requirement – where circumstances demand - for impermeable area runoff to be temporarily stored on properties in concrete wells with orifice-controlled discharge to the stormwater infrastructure.

The latter practice has two regimes of operation:

1. in the early and very late stages of runoff "free fall" conditions apply with orifices discharging (by design) a maximum flow equivalent to the ARI, Y = 5-years (peak) determined for *pre-developed* site conditions; and,
2. as the street drainage network approaches 'capacity', the orifices are drowned and outflow to the street is reduced to a fraction of the 'free fall' condition, resulting in slow emptying. [A non-return flap is incorporated to prevent possible back-flow in these circumstances.

The **first** regime condition, above, corresponds to 'conventional' design which, in the Gosnells' case requires an investment of $120 million. The **second** condition is an acceptable approach provided that storm successions are properly accounted for. City of Gosnells has adopted the storage emptying time criteria presented in Table 1.

The focus of the City's adopted strategy is the ARI, Y = 100-years *worst possible* storm condition experienced on each re-developed site. This is determined as the **volume** of runoff collected from connected impervious areas in "100-year" (design) storms investigated for the duration range 10 minutes to 72 hours: two categories of site conditions lead to 'optimum' volumes which must be stored ("soakwells" or concrete wells) and their contents duly emptied.

Formula 1: "Soakwell" diameter formula; [This formula includes the assumption, D ≈ H]

$$D = \sqrt{\frac{\forall}{\frac{\pi}{4}(H + 120\, k_h.\tau.U)}}\,(metres)$$

Where

$\forall$ = volume of (roof) runoff in storm of critical duration (m^3)

D = diameter of soakwell (m)

H = height of soakwell (m)

k_h = soil hydraulic conductivity (m/s)

τ = time base of design storm runoff hydrograph (mins)

U = Moderation Factor : 0.5 (sand);

Formula 2: "Soakwell" emptying time, T in seconds (Argue, 2004/2011):

$$T = -\frac{4.6D}{4k_h} log_{10}\left[\frac{\frac{D}{4}}{H + \frac{D}{4}}\right]\,(seconds)$$

Category A: deep sand sites where the *worst possible* storm condition, together with "soakwell" size and number are optimised using two formulae - the **first** providing the link between (worst possible) storm duration and well diameter (see formula 1); the **second** enabling emptying time to be calculated and checked against the appropriate Table 2 criterion (see formula 2).

Category B: sites with low-permeability soils where the *worst possible* 100-years storm condition, together with (concrete) well size and number are determined. An optimum volume is calculated assuming constant outflow from the site – ARI, Y = 5-year pre-development flow, assumed constant – and the 10 minutes to 72 hours storm durations for ARI, Y = 100-years events. The resulting (optimum) volume is stored

Table 1—Interim Relationship Between ARI and 'Emptying Time' (Argue, 2004/2011)

Ave Recurr. Interval (ARI), Y-years	1-year or less	2-years	5-years	10-years	20-years	50-years	100-years
Emptying time, T in days	0.5	1.0	1.5	2.0	2.5	3.0	3.5

STRATEGY FOR MANAGING URBAN RE-DEVELOPMENT WITH AN 'AT CAPACITY' STORM-WATER INFRASTRUCTURE

John Argue, University of South Australia

Formula 3

$$A_0 = \frac{Q_{des}}{B.C_d.\sqrt{2.g.h}}$$

Where

C_d = orifice discharge coefficient (0.6)

B = blockage factor (0.5)

h = depth of water above centroid of the orifice (m)

A_0 = orifice area (m^2)

Q_{des} = design discharge (m^3/s)

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and an orifice (area, A) fitted according to Formula 3 over page.

City of Gosnells has prepared a spreadsheet for use by developers and/or their consultants to determine design-layout solutions that are acceptable to the City's approval process. The spreadsheet website can be viewed at http://www.gosnells.wa.gov.au/scripts/viewurllist.asp?NID=21183.

Use of the spreadsheet represents a saving in design cost for developers together with clear instructions from council. It also has a benefit for the City through reduced time spent on inspection of building applications.

REFERENCES

Argue, J R (2004/2011): *WSUD: basic procedures for 'source control' of stormwater – a Handbook for Australian practice.* J R Argue, Editor, Urban Water Resources Centre, UniSA, 6th Printing, Adelaide.

Tennakoon, A and Argue, J R (2011): *Managing urban regrowth with an 'at capacity' stormwater infrastructure.* Proc. 34th IAHR Congress, Engineers Australia, June/July, Brisbane, Australia.

WATER RESOURCES IN JEOPARDY? PROCEEDINGS OF HYDSOC SYMPOSIUM, AUGUST 1970

Renae Eden, Adelaide Airport Ltd

The Hydrological Society of South Australia (Hydsoc) committee has recently been presented with a copy of the proceedings of Hydsoc's second Water Resources Symposium entitled 'Water Resources in Jeopardy?'.

Jointly presented with the Department of Adult Education of the University of Adelaide, the Symposium took place at the YWCA Hall in North Adelaide, on August 6, 1970.

In the foreword, Rob Culver, founding chairman of Hydsoc, writes:

> "The Hydrological Society of South Australia was founded in March, 1969, to bring together the wide range of professional disciplines involved with water into a single learned society linked by interest rather than professional grouping. Membership is completely open to lay people also so that, ideally a proper and wide appreciation might be fostered of this vital natural resource.
>
> This Seminar, considering the … question of its title, is the second the Society has sponsored in the hope of seeing balanced answers to such questions … We welcome your participation in this Seminar and in other activities of the Society."

The proceedings feature seven papers pertaining to a range of familiar water management issues; surface water and groundwater contamination, water resources management and legislation, the role of the government in these matters, cultural perspectives and a call for good science to underpin management practices.

The summary of 'The Effects of Land Management on Quantity and Quality of Available Water' by Walter C. Boughton is provided as follows.

> "Change in the use and management of rural land in Australia have produced many serious effects on the Quantity and Quality of surface runoff and groundwater resources. Large scale irrigation development has substantially increased salinity levels in the Murray River, and the leaching of both fertilizer and pesticide residues from agricultural lands can create problems of water quality.
>
> Forestry practices have raised turbidity levels in surface runoff, and the conversion of the plant cover of a catchment from trees to grass can change the amount of runoff or groundwater recharge. Bushfires can substantially increase both peak rates of flood flow and rates of erosion from an affected area.
>
> Some examples of these problems in Australia are given. "

The article concludes that research of catchment science warrants immediate attention, so that systematic teaching and training can be delivered to those working in this field, and be used to drive catchment management.

Other papers featured are entitled:

- River Hydrology and River Regulation
- Contamination of Underground Water Supplies
- Some Legal Aspects of Water Pollution Control
- Re-Thinking the Role of Government in Water Resources Management
- Medico-Social Aspects of Water Pollution
- Water and Society. Geographical Perspectives on Water Use

The committee gratefully acknowledges Annette Barton for providing a copy of the proceedings, which is now hosted at www.hydsoc.org. The committee is looking to collate and document the history of Hydsoc, so if anyone has any further information, contacts or materials pertaining to the history and activities of Hydsoc between 1968 – 1990, please contact the editor via the details provided on the back page of the newsletter.

UPCOMING EVENTS

THE UNIVERSITY of ADELAIDE

Adelaide Water Forum

The second annual Adelaide Water Forum, a joint initiative of the Water Research Centre and SA Water, will be held on Wednesday 19 October 2011 in the Attenborough Room at The Sanctuary, Adelaide Zoo.

More details will be made available later in the year - so save the date!

http://www.adelaide.edu.au/environment/wrc/event/2011/adelwaterforum/

Topics delivered at the conference include:

- Future scope for the use of water recycling
- Water quality reform in Australia
- Implementing the new national recycling guidelines
- Managed aquifer recharge: viability of adding stormwater to water supplies
- Integrating alternative water supplies into the urban water cycle
- Developing a decentralised water master plan
- Legal requirements for water recycling arrangements
- Recycled water: future opportunities
- Review of greywater in Australia
- Lessons learnt in the design & construct
- Delivery of a MBR plant improving recycling water plants performance
- Direct potable water recycling
- Improving regulation & reducing uncertainties of recycled water
- Toolbox to evaluate water quality for recycling
- Stormwater harvesting technologies
- Roof water harvesting
- Community attitude towards using storm water treated through MAR
- Water management in mining sector

Many case studies pertaining to these topics will be presented, as well a series of panel discussions on

- Stormwater harvesting: is this an effective solution?
- Status of water recycling in Australia
- Industrial water recycling in Australia - present & future

To register, go to: www.ibrc.com.au

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MEDIA WATCH

Overview of feedback on the Guide to the proposed Basin Plan

The Guide to the proposed Basin Plan was prepared to help people understand the basis of the proposed Basin Plan and get feedback on the key decisions the MDBA is required to make under the Water Act 2007 (Cwlth).
In the Guide's introduction, the MDBA asked for the views of the community and stakeholders about our proposals in the Guide, the quality of the data and evidence used and the analysis undertaken. We are considering this feedback in further preparing the Basin Plan. This page provides an overview of that feedback.
http://www.mdba.gov.au/communities/having-your-say/feedback-overview

Basin Plan: having your say

In late-2011 the MDBA will be releasing the draft Basin Plan and supporting documents. The release of these documents will start a formal consultation period of at least 20 weeks. During this time, you are invited to lodge a formal submission to help us develop the Basin Plan. The MDBA will provide more details about how to lodge your formal submission closer to the time of the draft plan's release.
http://www.mdba.gov.au/communities/having-your-say

Science and the draft Basin Plan

The Authority has invited CSIRO to lead a review on how the hydrological indicator sites method has been applied to determine the sustainable level of diversion in the Basin. This will assist the Authority in ensuring that the draft Basin Plan represents a sensible starting point for the seven years of implementation to 2019
http://www.mdba.gov.au/communities/latest-news/science-draft-basin-plan

Water Accounting Consultation Paper

The Auditing and Assurance Standards Board and the Water Accounting Standards Board have issued a joint consultation paper: Assurance Engagements for General Purpose Water Accounting Report . Input is sought from stakeholders in relation to the development of a standard for assurance engagements on general purpose water accounting reports. Comments are to be submitted by 31 October 2011.
http://www.bom.gov.au/water/standards/wasb/gpwareports.shtml

19,000 wetlands assessed for acid sulfate soils

A 3 - year study by the Murray–Darling Basin Authority and stakeholders has identified the broad scope of acid sulfate soils in the Basin.
http://www.mdba.gov.au/media_centre/media_releases/19000-wetlands-assessed-for-acid-sulfate-soils

Call for Basin Community Committee members

The Murray-Darling Basin Authority is calling for expressions of interest for the second term of the Basin Community Committee (BCC). The BCC gives key advice to the Authority on community engagement for the Basin Plan and other community issues .
http://www.mdba.gov.au/media_centre/media_releases/calls-for-expressions-of-interest-in-Basin-Community-Committee

UPM closes in on lowest water footprint goal

UPM has published the results of a pilot study around paper's water footprint in cooperation with the Water Footprint Network (WFN).
http://www.ben-global.com/Business/News/UPM_closes_in_on_lowest_water_footprint_goal_8659.aspx

WORLD WATER WEEK: Wrap up

In over 100 sessions at the seminal World Water Week conference, over 2,500 business and NGO leaders, scientists, politicians, mayors and water professionals are exploring challenges and best practice around the theme of 'Water in an Urbanised World'.
http://www.ben-global.com/Business/News/WORLD_WATER_WEEK_Wrap_up_8644.aspx

Six National Water Account 2010 reports available

These regions are Adelaide, Canberra, Perth, Ord, South East Queensland and Sydney. A quick guide is available to help navigate the information.
http://bom.us1.list-manage1.com/track/click?u=91e77db1cb6e1956adfabd736&id=136c6a41cd&e=904340b80a

New dolphin species discovered

Victorian researchers have discovered a new species of dolphin living right under their noses on Melbourne's doorstep.
http://www.abc.net.au/news/2011-09-15/new-dolphin-species-discovered/2899894