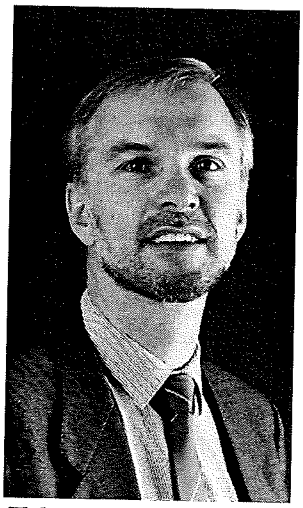
Aqua Australis

THE QUARTERLY MAGAZINE OF THE HYDROLOGICAL SOCIETY OF SOUTH AUSTRALIA **No 1 Vol 1**

ISSN 1323-0077 *Water is the driving force of all nature* - da Vinci November 1994



Welcome to Adelaide - from Claus Schonfeldt Chairman of the Water Down Under 94 Conference Organising Committee

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With over 250 papers by authors from 30 countries, 7 outstanding keynote speakers, 10 invited speakers, 60 display papers, 20 exhibition stands and an IAH plenary session, this will be the biggest hydrological and hydrogeological exchange in Australian history. It is unlikely to be repeated within the next decade.

The conference starts with 17 specialist workshops on Monday 21 November, followed by four days of the conference proper, all at around the same price as the last two day hydrological symposium in Newcastle. In large part this is due to the stirling efforts of the organising committee and in particular Chris Wright and Peter Dillon for their marvellous efforts at attracting sponsorship. We are indebted to our sponsors, Grundfos Pumps Pty Ltd, Australian Geological Survey Organisation, Alan Hickinbotham Pty Ltd, Department of Housing and Regional Development (Building Better Cities), Department of Transport SA, Engineering and Water Supply Department SA, Mines and Energy SA and MFP Australia.

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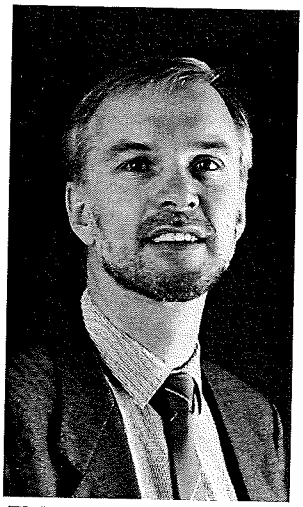

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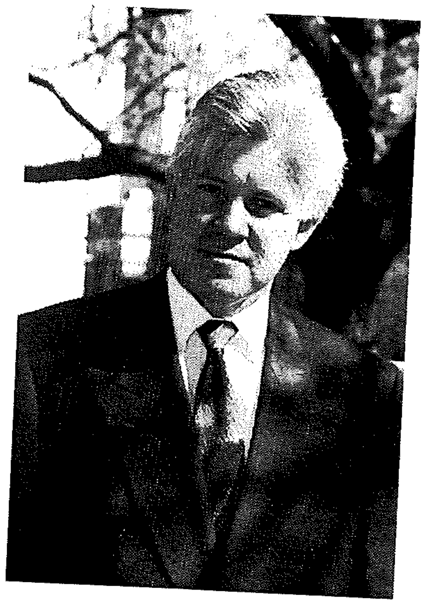
Executive Appointment



Peter Hoey, Director, Water Resources shares his vision on water resource management in South Australia

PETER has a long association with water resources management in South Australia. After living and working in Western Australia, New South Wales and Queensland, he joined the (then) Water Resources Branch of the Engineering and Water Supply Department in 1976. He progressed to Principal Planning Engineer, Water Resources in 1987, and then transferred to the Riverland for three years in the mid-1980s. Peter was appointed Manager, Operations Support in 1988, and in this position he established the important role of South Australian Contact Officer for the Murray Darling Basin initiative.

In December 1993, Peter was seconded to the Department for the Premier and Cabinet, initially as the Acting Director, Office for Public Sector Management, and then as Manager of the HILMER SA Project. He has an Associateship in Civil Engineering from the Western Australian Institute of Technology, and a Master of Engineering Science from the University of Adelaide. He is married to Arnon de Kroon and has one child, Marianne.

" THE WATER RESOURCES GROUP has achieved a great deal in a range of areas, particularly in the measurement and understanding of the quantity and quality of our fresh water, and in the involvement of the community in the management of local resources. I think that we need to build on these strengths and begin to support community action with advice to Government on some well formulated policies which address the fundamental issues, such as:

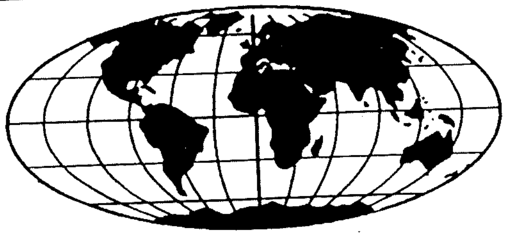
- *the part water will play in the economic recovery of the State*
- *water allocations, transferability and resource pricing*
- *the role of local government, especially with regard to stormwater*
- *extending the role of communities in resource management and administration.*

We will be well supported in this work by the South Australian Water Resources Council, the Murray Darling Basin Commission, and the Water Forum of the Agricultural Resource Management Council of Australia and New Zealand (ARMCANZ), which are themselves institutions with a great deal of experience in policy advice and formulation.

To contribute effectively to the wider environmental objectives, we must strengthen the integration of the Water Resources Group with the rest of DENR. This will mean looking at the best way we can provide and receive the services necessary to do our job. The efforts and outcomes of the Water Resources Group will need to complement the programs of other Groups in DENR.

My vision for the Group is that it will become an influential and excellent source of technical information and policy advice for the Government and the community in water matters. An early indication of our success will be when we receive interstate and international visitors who come to study our model of water resource management."

MAJOR WORLD ITEMS



WATER SCARCITY - A WORLD ISSUE

Although fresh water is a renewable resource, it is also a finite one. The water cycle makes available only so much water each year in a given location. That means supplies per person, a broad indicator of water security, drop as population grows. Thus per capita water supplies worldwide are a third lower now than in 1970 due to the 1.8 billion people added to the planet since then.

One of the clearest signs of water scarcity is the increasing number of countries in which population has surpassed the level that can be sustained comfortably by the water available. As a rule of thumb, hydrologists designate water-stressed countries as those with annual supplies of 1 to 2 megalitres per person. When the figure drops below one megalitre, nations are considered water-scarce - that is, lack of water becomes a severe constraint on food production, economic development, and protection of natural systems and human health.

Today, 26 countries, collectively home to some 230 million people, fall into the water-scarce category. Many of them have very high population growth rates, so their water problems are deepening fast. Africa has the largest number of water-scarce countries. All in all, and by the end of this decade, four others will join the list. By then, the total number of Africans living in water-scarce countries will climb to 300 million - a third of the continent's projected population.'

Nine out of 14 countries in the Middle East already face water-scarce conditions, making it the most concentrated region of water scarcity in the world. Populations in six of them are projected to double within 25 years, so a rapid tightening of supplies is inevitable. With virtually all Middle East rivers being shared by several nations, tensions over water rights are a potent political force throughout the region, and could ignite during this decade. For a country like Egypt, which gets practically no rainfall, water flowing in from upstream neighbours is a precious lifeline.

Although the population-water equation suggests where to expect trouble, numerous physical symptoms of water stress already exist and not just in water-scarce countries, but in parts of water-wealthy ones as well. Among the most pervasive problems is that of declining watertables, which is caused by using groundwater faster than nature replenishes it. Overuse of groundwater is now ubiquitous in parts of China, India, Mexico, Thailand, the western United States, north Africa, and the Middle East (*Ed note - and in parts of Australia*).

Some of the most worrisome cases of unsustainable groundwater use involve "fossil" aquifers, underground reservoirs that hold water hundreds or thousands of years old and that receive little replenishment from rainfall today. Like oil reserves, these aquifers are essentially non-renewable so that pumping water from them depletes the supply in the same way that extractions from an oil well do. Farms and cities that depend on this water will eventually face the problem of what to do when the wells run dry.

In the United States, a large and important aquifer system in the High Plains. which contains the well-known Ogallala formation, has been undergoing depletion for several decades. Stretching from southern South Dakota to north west Texas, the High Plains aquifer supplies about 30 percent of the groundwater used for irrigation in the United States.

The most severe depletion has occurred in north west Texas, where heavy pumping for irrigation began to expand rapidly in the forties. As of 1990, 24 percent of the Texas portion of the Ogallala had been depleted, a loss of 164 billion cubic meters - equal to nearly six years of the entire state's water use for all purposes. As pumping costs rose and irrigation became uneconomical, the irrigated area in north west Texas shrank rapidly, falling from a peak of 2.4 million hectares in 1974 to 1.6 million hectares in 1989, a drop of one third.

In many regions, as demands continue to rise and as water supply projects get more difficult to build, water budgets are becoming badly imbalanced. China - with 22 percent of the world's people and only 8 percent of its fresh water - faces obvious water constraints. The nation's predicament is particularly severe in and around Beijing, the important industrial city of Tianjin, and other portions of the North China Plain, a vast expanse of flat, fertile farmland that yields a quarter of the country's grain. Watertables beneath the capital have been dropping 1-2 meters a year, and a third of its wells have reportedly gone dry. All told,

PREDICTED RESOURCE PROBLEMS IN YEAR 2000			
Country	Population in 2000 (millions)	Water availability (Ml per person)	
		From internal renewable resources	Including river flows from other countries
Egypt	2.4	0.029	0.934
Saudi Arabia	21.3	0.103	0.103
Libya	6.5	0.108	0.108
U.A.E	2.0	0.152	0.152
Jordan	4.6	0.153	0.240
Mauritania	2.0	0.154	2.843
Yemen	16.2	0.155	0.155
Israel	6.4	0.260	0.335
Tunisia	9.8	0.384	0.445
Syria	17.7	0.430	2.008
Kenya	34.0	0.436	0.436
Burundi	7.4	0.487	0.487
Algeria	33.1	0.570	0.576
Hungary	10.1	0.591	11.326
Rwanda	20.4	0.604	0.604
Botswana	1.6	0.622	11.187
Malawi	11.8	0.760	0.760
Oman	2.3	0.880	0.880
Morocco	31.8	0.943	0.943
Somalia	10.6	1.086	1.086

some 100 Chinese cities and towns, mostly in the northern and coastal regions, have suffered shortages in recent years.

In some cases, water problems stem directly from mismanagement and degradation of the land. When rain hits the earth, it either runs off immediately into rivers and streams to head back to the sea, soaks into the land to replenish soil moisture and groundwater supplies, or is evaporated or transpired (by plants) back into the atmosphere.

Land degradation, whether from deforestation, overgrazing, or urban development, shifts the proportion of rainfall following each of these paths. With reduced vegetative cover and soils less able to absorb and hold water, degraded land increases flash runoff and decreases seepage into the soil and aquifer recharge. As a result, less soil moisture and groundwater are available to draw upon during the dry season, and during the rainy season the rapid runoff intensifies flooding and soil erosion.

These examples together illustrate some of the clearest signals of water stress. Shrinking groundwater reserves, falling water tables, increased flooding and droughts, and water budgets that are badly out of balance are tangible indications of unsustainable water use a situation that, by definition, cannot continue indefinitely.

FAO HAS POLICY RETHINK ON IRRIGATION

The failure of many irrigation schemes to deliver increased food output, the competition for water between agriculture and cities and industry, and the fact that agriculture is a relatively low-value, low-efficiency and highly subsidised water user is forcing a rethink in irrigation policies worldwide, according to the UN Food and Agriculture Organisation (FAO).

In many countries for the first time, FAO points out, "agriculture is being obliged to give up water for higher-value uses in cities and industries." As a result, governments and donors are having to take a fresh look at the economic, social and environmental implications of large publicity funded and operated irrigation projects.

As much as 60% of the water diverted or pumped for irrigation is wasted according to FAO. Although some losses are inevitable, *in too many cases this excess water seeps back into the ground, causing waterlogging and salinity.*

Yet irrigation remains essential. *Over the next 30 years, an estimated 80% of the additional food supplies required to feed the world will depend on irrigation. Food security in the next century will be closely allied to success in irrigation.*

Stormwater Q/Q

Kym Good

Approximately ten million dollars is spent annually on stormwater drainage works in South Australia. Unfortunately there is a lack of reliable field data on which to base the design of these works. The S.A. Stormwater Quantity/Quality Monitoring (or "Q/Q") Group was formed to gather funds and implement a project to help rectify this lack of quantity data in the South Australian urban environment and simultaneously collect selected data on stormwater quality.

THE GROUP OPERATED INITIALLY UNDER THE aegis of the Australian Centre for Water Quality Research. It has recently become affiliated with the Urban Water Resources Centre of the University of South Australia. The project involves the participation and support of eight organisations and a range of local government agencies. The primary aims of the project are:

1. to determine reliable statistical runoff coefficients for the different land use components of a fully developed urban catchment;
2. to determine appropriate values for parameters used in ILSAX modelling of urban catchments in South Australia;
3. to explore the potential for a reliable regional flood estimation method for urban catchments in Adelaide;
4. to achieve reliable stormwater quality prediction using either an existing model (preferred) or a new model if necessary.

The interpreted quality data will be of value to managers of recreational and other water bodies which receive runoff from urban catchments. It is expected that the findings of the project will be relevant to other urban environments in Australia and also to many overseas situations. Wide dissemination is intended.

CATCHMENT LOCATION

A small catchment in the Marion/Glenelg area was selected after consideration of a number of criteria. The concept of a *"nested catchment"* was developed with the expectation that the network will provide valuable information on hydrological and water quality interactions occurring down through the catchment. In particular such an approach provides an opportunity to examine the extent of re-entrainment of pollutants which have previously settled within the system and which are expected to be a major influence upon water quality at the catchment outfall.

Three monitoring locations were therefore chosen as follows :

Station 1: Upper portion of catchment (56 hectares). Land use medium density residential.

Station 2: Upper and mid section of catchment (total area 102 hectares). Some higher density residential area included.

Station 3: Total catchment (182 hectares). Commercial and higher density residential areas in the lower third of the catchment.

SITE INSTRUMENTATION

Instrumentation at each site includes an 'in-pipe' flow measuring device and an additional depth transducer. Most other equipment has been chosen on the basis of in-field experience within the Department of Environment and Natural Resources (formerly E&WS) Water Resources Group.

Water quality monitoring sensors at each station are a conductivity coil and a turbidity probe. An autosampler has been installed at Station 1, and identical units have been purchased for Stations 2 and 3. A tipping bucket pluviograph has been installed at or near each station, and at three other locations within the catchment. This provides unprecedented coverage of the catchment by South Australian standards. Rainfall measurement commenced in August 1990.

The monitoring station design work was carried out by the Water Resources Group. The stations are presently maintained, and the data collected, by hydrographers from this Group.

Calibration of Velocity Transducers

The ultrasonic velocity transducers used in the Marion/Glenelg network are currently being calibrated in-situ by comparison with velocity readings derived from salt velocity gauging. Salt velocity measurement involves timing the travel of a "parcel" of salt through the reach under investigation - in this case, along the section of pipe containing the ultrasonic velocity transducer.

The field procedure involves dissolving salt in a container the contents of which are then discharged into the pipe upstream of the ultrasonic velocity transducer. Two toroidal coils, set at suitable distances apart along the pipe, measure the electrical conductivity of the parcel of salt as it travels downstream.

The output from the toroidal coils is logged by two small data loggers which are set to record the output at one-second intervals. After a series of measurements have been completed, the data is downloaded into a spreadsheet file and the times coinciding with the passage of the centroid of each parcel of salt are noted. Velocities are calculated from the travel time of the parcels of salt along the known distance between the toroidal coils.

When sufficient field measurements are obtained, it is intended that a relationship will be derived relating actual velocity to recorded (ultrasonic) velocity over the full depth of the stormwater pipe. This "calibration" will, hopefully, minimise any errors induced by the ultrasonic transducers not accurately measuring the average velocity across the full range of depths encountered at each site.

Data Transmission and Downloading

At each monitoring station, data from the array of water quantity and quality transducers is stored on two separate data loggers. The flow monitoring data logger stores velocity and depth data from which it derives flow, while the second data logger stores turbidity, conductivity, temperature and rainfall.

Data from each logger is periodically downloaded in the field using a laptop computer. The second data logger has an additional option which allows the memory module or EPROM to be replaced during a visit and brought back to the office for downloading.

Telephone lines have been connected to the three monitoring stations to allow remote communication and, if desired, data transmission. Currently only some of the data loggers are fitted with modems : these provide the facility to remotely view real-time data during a flow event, or to download data for more detailed analysis. It is intended that the flow monitoring devices will also be connected to modems.

Once the data is retrieved from the field and checked for continuity and consistency, it is transferred to the DENR Hydrological Database, HYDSYS. This database is the most commonly used by water authorities in Australia and has the advantage of being able to output the stored data in a variety of formats.

FUTURE PLANS

It is proposed to continue rainfall and flow monitoring in the network for a further five years. This will necessitate further requests for support from sponsors and granting agencies. Any organisations interested in supporting the project can contact the Urban Water Resources Centre ((08) 302 3862).

Regarding water quality monitoring, the correlation between the turbidity data obtained at the monitoring sites and total suspended solids data obtained by sampling will be the focus of particular attention. This is perceived as being of special interest to other parties involved in urban water quality monitoring. Urban wetland water treatment is currently of great interest in Adelaide and elsewhere, and automatic real time monitoring of the quality of wetland inflows and outflows by use of turbidity, conductance and other probes is one obvious application area.

Other specific water quality studies will be conducted as funding permits.

Dissemination of the findings of this study is expected to provide opportunities for correlation with those of other quantity/quality studies on a broad front.

This report is an extract from a paper: *Planning, Instrumentation and Data for an Urban Drainage Network in Adelaide, South Australia, by Argue, JE., Mulcahy, DE. & Good RK.,* prepared for presentation at the Water Down Under Conference in Adelaide in November, 1994.

Treasurer's Report 1993-1994

REVENUE 1993/1994

		$	$
Subscriptions		1690.00	
Interest	Term Deposit	346.53	
	High Performance Account	23.62	
	Cheque Account	7.63	
Farm Dams Seminar		87.00	
Water Pricing Seminar		1585.00	3739.78

EXPENDITURE

Scientific Expedition Group		700.00	
Ian Laing Prize		350.00	
Waite Donation		250.00	
Postage	Meeting Notices	142.10	
	Miscellaneous	45.00	
Stationery	Miscellaneous	19.45	
Printing	Meeting Notices	19.00	
Catering Expenses		387.46	
Guest Speaker Dinners		99.30	
Farm Dams Seminar		6.90	
Water Pricing Seminar		831.80	
Interest on Trust Funds		12.72	
State Taxes		13.20	2876.93
	PROFIT	for year	862.85

ASSETS

Term Deposit	7682.64	
High Performance Account	947.62	
Cheque Account	2515.90	
Cash	36.20	11182.36

LIABILITIES

Dry Land Salinity Technical Forum (Funds held in trust)	628.71	
Unpresented cheque 383378	43.05	
Unpresented cheque 383380	43.46	
Unpresented cheque 383385	66.65	
Unpresented cheque 383389	552.50	
Unpresented cheque 383390	700.00	2034.37

NET ASSETS

9147.99

ACCUMULATED FUNDS

Balance to 31 July 1993	8285.14	
Profit for Year	862.85	9147.99

AUDITOR R.G. Shepherd
(Signed)
DATE 11/8/94

Aqua Australis, November 1994

Welcome to the first edition of *Aqua Australis* a new magazine format to continue traditions of the *Newsletter of the Hydrological Society of South Australia.*

The change coincides with a number of other important water resources developments in our State. We are hosting *Water Down Under 94*, a hydrological Grand Prix. The *State Water Plan,* a blueprint for water resources development (to be released next year) is well into the consultation process. And last but not least, we have a new Director, Water Resources, in the Department of Environment and Natural Resources.

The business of hydrology

Aqua Australis is about hydrology, and the basic business of hydrology is to solve the water balance equation:

Runoff = Rainfall - Evaporation

so that we can better understand the impact of water on everyday lives.

Fortunately, neither of these terms can be measured accurately, so fiddling with hydrological numbers is actually plenty of fun. With rainfall globally underestimated, *"evaporation - the most desperate branch of the desperate science of meteorology"*, and patchy runoff figures, there is plenty of room for improvement there.

Improvement may come by divine revelation or by sharing of thoughts, information and interests, the latter being more practicable and less chancy. That's where the Hydrological Society and *Aqua Australis* play their parts.

The role of *Aqua Australis*

The role of this magazine is dissemination of information to provide ever increasing confidence in our understanding of the water balance equation.

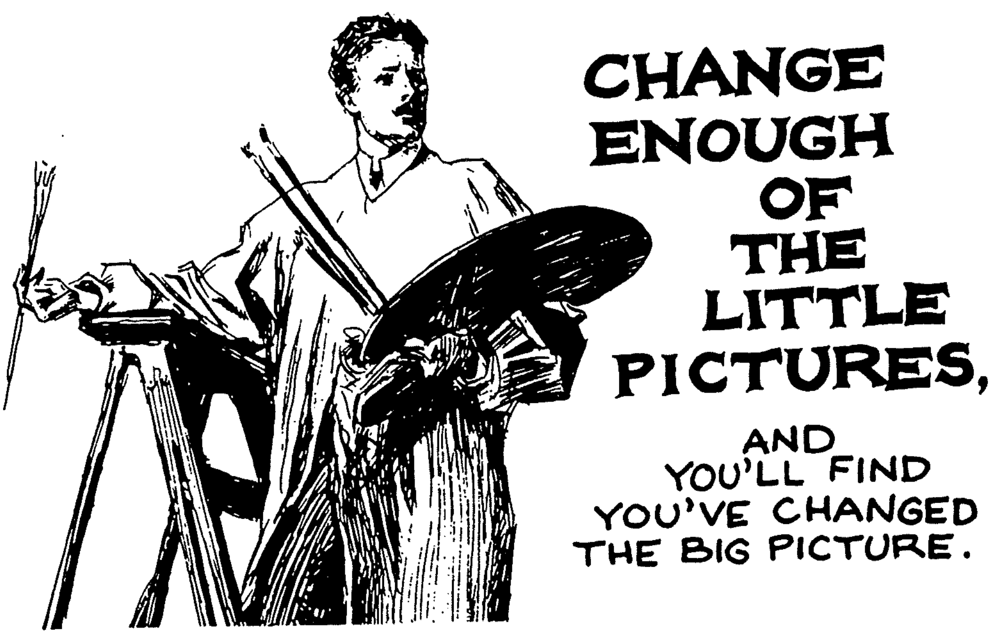
In this magazine we will be presenting local engineering activities and solutions. We will be looking for theoretical considerations on hydrological problems in our specific conditions, trying not to lose sight of a much wider perspective. Whilst we will focus on hydrological, meteorological and environmental developments in our own State, we will also attempt to present developments from further afield. We will be encouraging contributions from other States and countries.

Concise reports from overseas trips and attendance to international conferences are likely to be of interest and would benefit our hydrological community.

We will present our ideas, seek opinion and communicate with prospective members of our Society, members and leaders of similar groups, government officials, elected or appointed, community groups, key civic, industry or other leaders as well as radio, TV, newspaper and other journalists.

We will seek local expertise and free expression of opinions on a range of issues. Is sustainability sustainable? What do we want to sustain? Our wasteful ways perhaps? Are we into a change of climate or perhaps only a climate of change? Which changes are likely to benefit our society? What questions should we ask ourselves?

Vincent Kotwicki



State Water Plan

Status of our water resources

South Australia has plenty of water but we need to manage it carefully because its availability and quality are highly variable.

Water resources of the South East, the Great Artesian Basin, and the Murray Mallee can all sustain new well-managed economic development. There are also opportunities for further use of River Murray water during periods of high flow.

In other areas, such as the Northern Adelaide Plains and Angas Bremer, there is significant overuse of water which threatens development. Solutions to these problems can be found by recycling effluent and urban stormwater or by transferring water from more plentiful sources (eg the River Murray).

In areas where water resources are fully allocated, we can still get more out of our water by better management of it. We need to use water more efficiently (eg by improving irrigation practices) and effectively (eg by using it to produce high-value crops or crops that stimulate value adding industries).

Urban stormwater and wastewaters are valuable resources that provide opportunities for significant economic expansion (eg the disposal of Bolivar effluent in the Northern Adelaide Plains). Use of these resources will also reduce adverse impacts on the environment.

We have two major areas of concern that we must address. These are the gradual deterioration in the quality of our water resources and the unnecessary degradation of our water environment.

Why we need to change

Our water is precious. The long term health of our water resources is vitally important to our quality of life and the long term health of South Australia's economy. We need to look after our water carefully.

We must recognise that the way we have managed water has helped us to develop as a society and a State. This development and our use of water have had negative side effects, however, which lead us to conclude that we must manage our water better. The more significant side effects are:

- the quality of our water resources has deteriorated
- our water resources are being degraded by over-use in some areas
- fresh-water, estuarine, and marine environments have been altered.

We have the knowledge and technology to achieve sustainable development of our water resources *and* to help stimulate the economy through higher economic returns from their use.

These are some of the issues that have been raised in national environmental and water resources policies, negotiated through the Council of Australian Governments (CoAG) and its predecessors. In particular, the following agreements have been struck between the Commonwealth, State and Territory Governments and the Australian Local Government Association:

- Inter-Government Agreement on the Environment (1992)
- National Strategy for Ecologically Sustainable Development (1992)
- CoAG Water Resource Policy Framework (1994).

We need to implement these policies to protect our precious water resources, to be able to use them better and to achieve a fairer sharing of costs. We must implement them in a way that is appropriate for our State and its regions.

Managing our water better

Quick fixes are not the answer. A long-term view is essential. It will yield significant economic and environmental rewards. We need to concentrate on five key areas:

1) *using our water resources more effectively*

2) *improving the quality of our water*

3) *working together*

4) *improving our expertise and understanding*

5) *providing cost-effective water services that distribute the costs equitably.*

Reform in water management will benefit most South Australians although some individuals may be adversely affected. These potential obstacles can be overcome, particularly through community involvement.

Consultation process

The South Australian Water Resources Council has been asked by the Minister for the Environment & Natural Resources to provide recommendations on a comprehensive Water Plan for South Australia. These recommendations are to be delivered to the Minister in April 1995.

The Government's vision for water is that:

> **South Australians recognise water as a most precious resource and that through innovation and best practice in its management and use water will sustain healthy ecosystems and South Australia's development opportunities.**

The discussion papers have been developed to provide a basis for discussion of the key issues confronting water resources management today.

The South Australian Water Plan will focus on change. It will build on the things we do well now as well as challenge current practice.

The papers are in two parts:

- Part 1: A State-wide Focus
- Part 2: Status of Key Water Resources in South Australia

continued on page 19

Blue Lake, stormwater recharge and lake management

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GPO Box 1047 Adelaide South Australia 5001

INTRODUCTION

Blue Lake is one of the spectacular blue lakes in the world. It is unique in Australia and it appears to be unique in global terms because of its regular colour change from grey in winter to a luminous blue in summer. The lake also provides the water supply for the City of Mount Gambier and it is one of the few large, oligotrophic lakes in Australia.

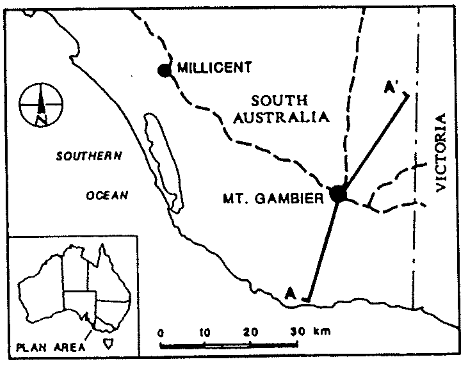

Figure 1. Locality plan

Mount Gambier is located in the south east corner of South Australia (145°45'E, 37°50'S, Fig 1). The area has a mediterranean climate, with hot dry summers and cool wet winters. The average annual rainfall is 686 mm, and average annual evaporation is 1490 mm (Penney,1983).

The topography of the area is subdued. The depth to water table ranges from zero, to 35 m beneath rare topographic highs. Calcareous sediments underlie the area. Despite the high rainfall there is no natural surface drainage network. Karst features are common.

The city of 23000 people is located on the northern flanks of a picturesque complex of Quaternary volcanic craters (maars). Groundwater is exposed in three of the craters. Blue Lake is the largest lake in the volcanic complex. This oligotrophic, steep-sided lake has a surface area of about 60 ha and reaches a depth of 77 m (Tamuly, 1969). The limestone aquifer is exposed in the walls of Blue Lake.

STORMWATER RECHARGE TO THE AQUIFER

All stormwater run-off in Mount Gambier recharges the underlying Gambier Limestone, and has done so for over 100 years. Recharge occurs through 300 to 500 drainage bores and karst features completed throughout the urban area (Fig 2). This disposal mechanism is an accident of history, and it is now known that the aquifer is hydraulically connected to the lake.

The artificial recharge of stormwater is effective because there is a large number of bores, and because many of them appear to intersect karst features. The karstic nature of the subsurface is apparent in calliper logs and down-hole video examinations of some of the drainage bores. The video footage shows the presence of both horizontal and vertical karst features. Several drainage bores have been simultaneously pumped and flow logged. In many of the bores, all the flow comes from a small interval (around 0.5 m thick) tens of metres below the water-table.

Point source recharge (through drainage bores and karst) will tend to recharge the karst systems, whereas diffuse source recharge (reaching the aquifer via the unsaturated zone) will tend to recharge the matrix.

A conceptual model of the transport and distribution of stormwater recharge and its pollutants through the aquifer is shown (Fig 3).

The quantity of stormwater recharging the aquifer is the sum of

1) runoff from impervious areas (RO_I),
2) runoff from pervious areas (RO_P), and
3) recharge through pervious areas (RC_P).

Around 25% of a typical urban Adelaide (South Australia) catchment is impervious (Fisher, *pers.comm.*). Around 90% of stormwater falling on the impervious areas is harvested, and from zero to 30% of rainfall on the pervious areas reaches the stormwater system.

Mount Gambier has an average rainfall of 686 mm (Penney, 1983) and an urban area of 16.8 km². The annual recharge rate through grassland in the vicinity of Mount Gambier is around 85 mm (Allison and Hughes, 1972). The stormwater budget can be therefore calculated in three parts, as follows;

RO_I = Area* % impervious*rainfall* % runoff
= $16.8*10^6 m^2$ * 25% * $0.686\ m.year^{-1}$ * 90%
= $2600\ Ml.year^{-1}$

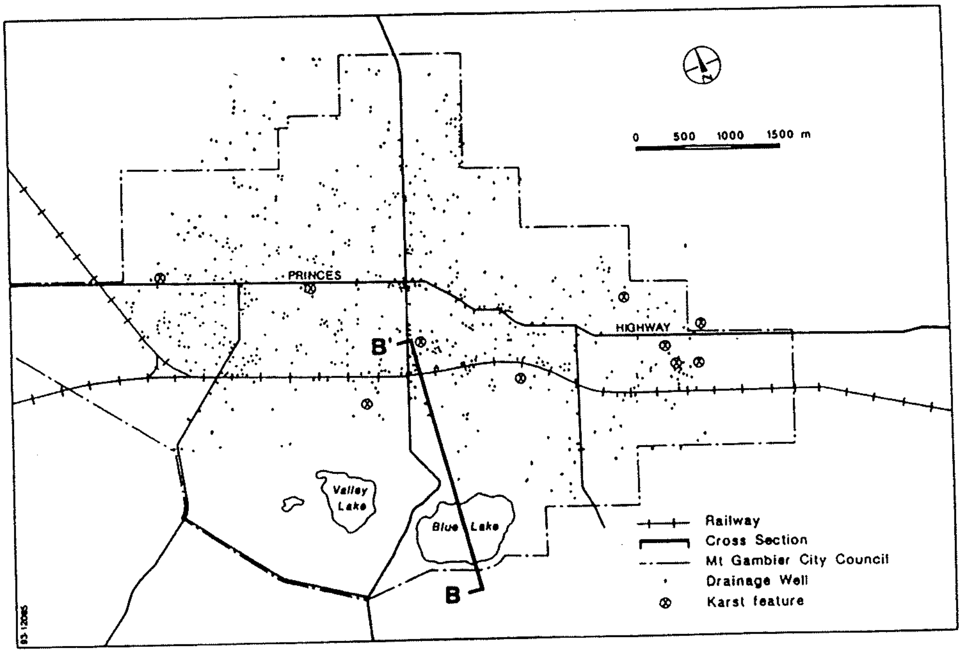

Figure 2. Stormwater drainage bores

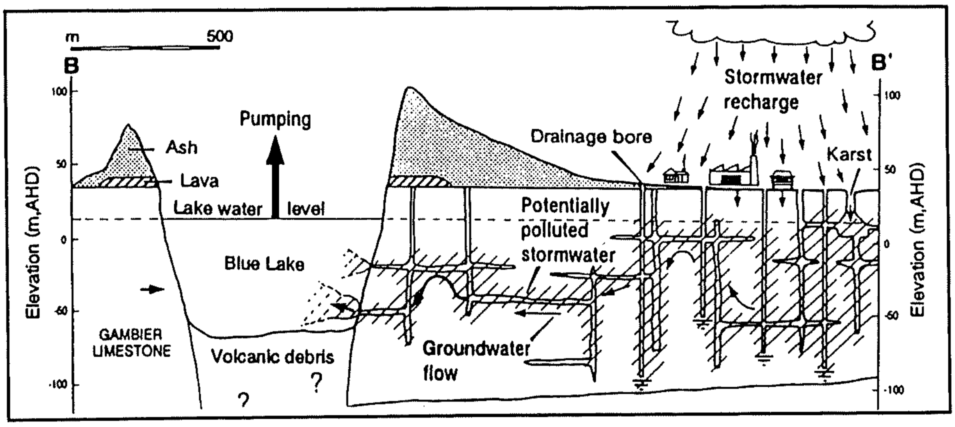

Figure 3. Stormwater flow

RO_P = Area * % pervious * rainfall * % runoff
= $16.8*10^6 m^2$ * 75% * 0.686 m.year^{-1} * (0 to 30)%
= 0 Ml to 2600 Ml.year^{-1}

RC_P = Area * % pervious * recharge rate
= $16.8*10^6 m^2$ * 75% * 0.085 m.year^{-1}
= 1100 Ml.year^{-1}

Total stormwater recharge (SWR) to the aquifer ranges between;

$SWR_{min} = RO_I + RO_{P(min)} + R_P$
= (2600 + 0 + 1100) Ml.year^{-1}
= 3700 Ml.year^{-1}

and

$SWR_{max} = RO_I + RO_{P(max)} + RC_P$
= (2600 + 2600 + 1100) Ml.year^{-1}
= 6300 Ml.year^{-1}.

Therefore the total stormwater recharge volume is between 3700 Ml and 6300 Ml per year.

It is important to consider what part of the aquifer the stormwater is going in to. The runoff from both impervious and pervious areas (RO_I + RO_P) is directed into drainage bores and karst features, whereas the recharge through pervious areas (RC_P) will deliver stormwater to the matrix. Therefore between 2600 and 5200 Ml.year^{-1} (70% to 83%) of the stormwater is directed straight into the karst network. This stormwater is available for immediate transport toward the lake.

The availability of the stormwater for transport toward the lake has two important corollaries. Firstly, drainage bores in Mount Gambier emplace a volume of stormwater (and pollutants) direct into the karst network which is at least equal to the annual extraction from Blue Lake, possibly significantly greater. Stormwater therefore has the potential to contibute significanly to the water budget of Blue Lake. Secondly, the volume of stormwater emplaced into the karst network will *suppress* the flow of native groundwater and pollutants from matrix to karst. The native groundwater serves only to provide the difference between lake demand and stormwater supply.

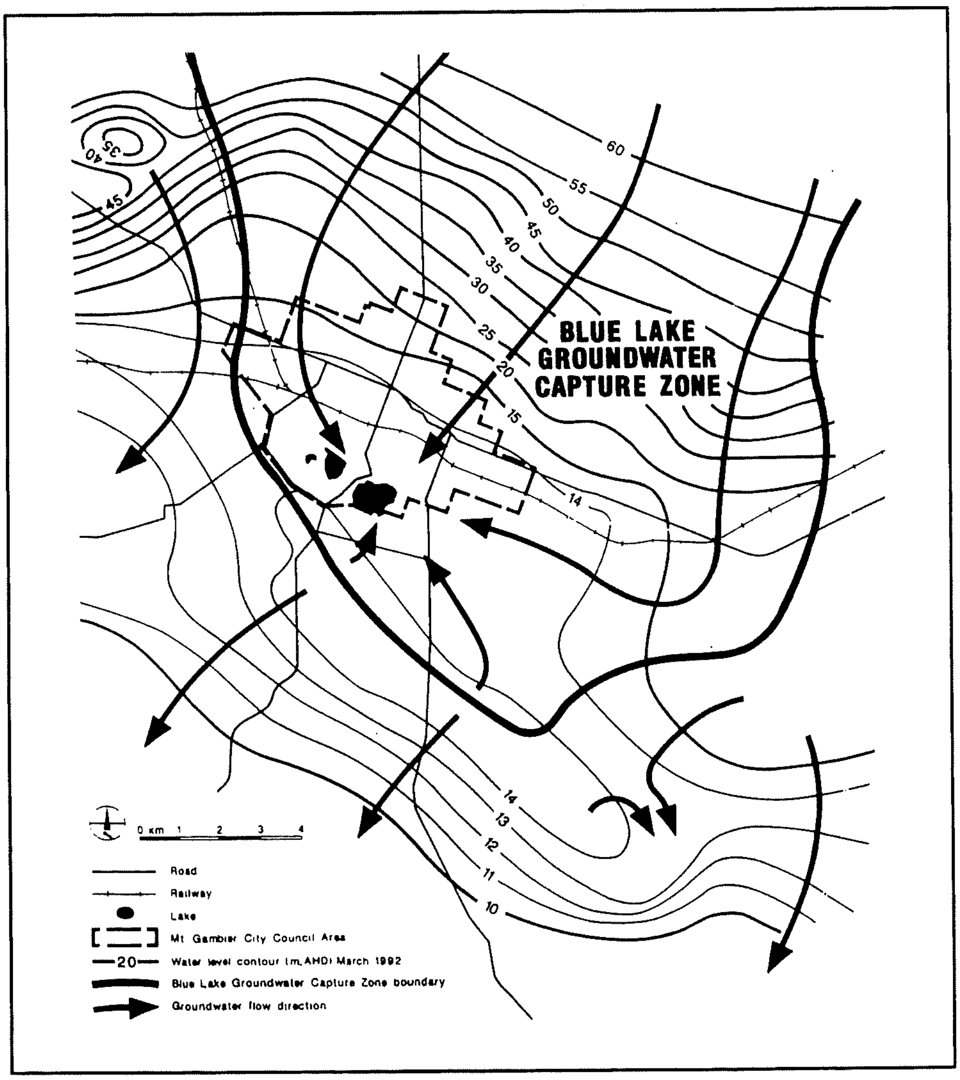

Figure 4. Defining the groundwater management zones based on hydrogeology

BLUE LAKE WATER BALANCE

The Blue Lake water budget is defined by;

$$I + R = O + E + P + \Delta S$$

where

I = groundwater inflow (unknown)
R = rainfall (595 Ml/year)
O = natural outflow (0 Ml/year)
E = evaporation (898 Ml/year)
P = pumping from lake (3500 Ml/year), and
ΔS = change in lake volume (-36Ml/year)

Note that there are no surface water inflow and outflow terms. This reflects the lack of surface flows to and from the lake.

R, E, P and ΔS are calculated from the available data. The lake contains ≈37000 Ml of potable groundwater (Tamuly, 1970). Records from the Engineering and Water Supply Department show that around 3500 Ml of this water is currently pumped from the lake and reticulated to Mount Gambier per year.

Evaporation, based on a lake surface area of

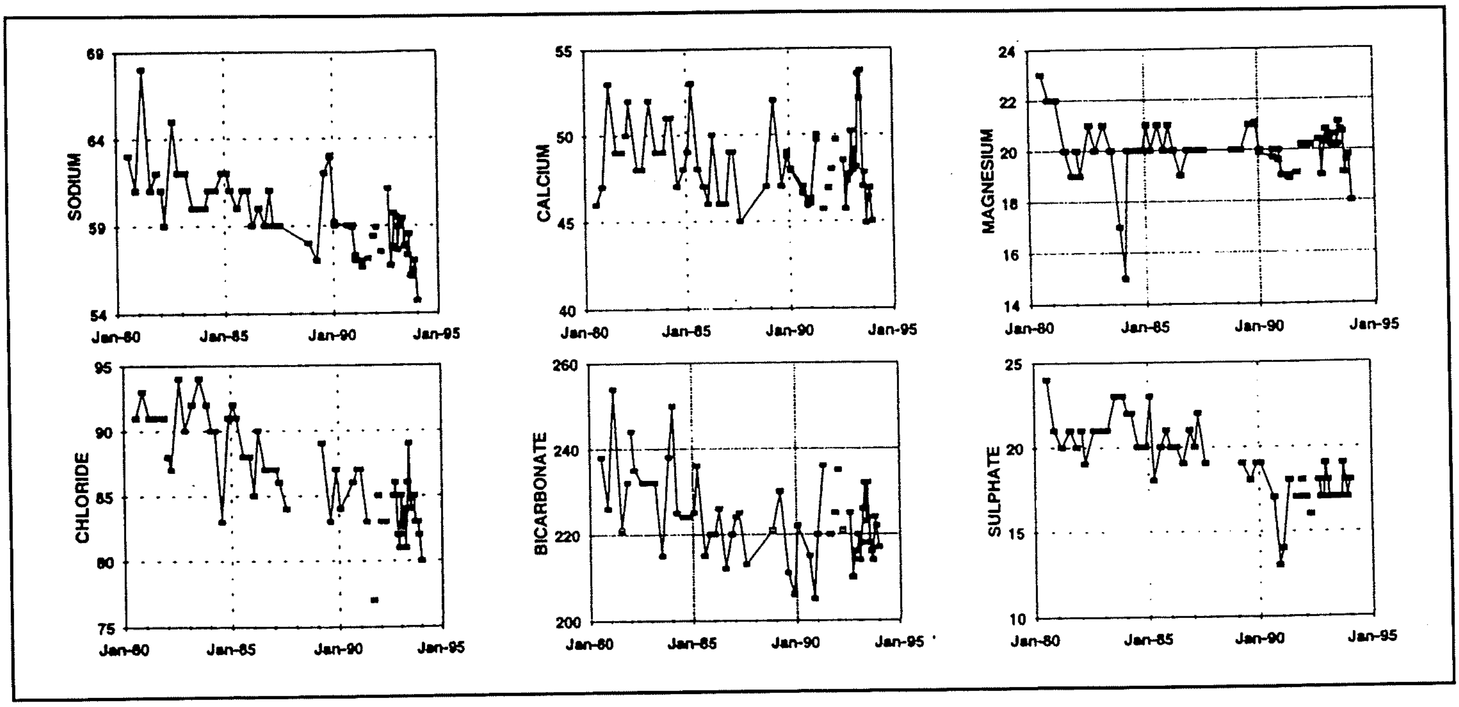

Figure 5. Trends in major ions in Blue Lake (all concentrations in mg/l)

60.3 ha (Tamuly, 1970) and an average annual Class A pan evaporation at Mount Gambier Aerodrome of 1.49 m.year^{-1} (Penney, 1983) consumes 898 Ml.year^{-1}.The lake has a catchment of 86.75 ha, and an average annual rainfall (1966-1978) over this catchment of 686 mm.year^{-1} (Penney, 1983) adds 595 Ml.year^{-1} (assuming that evapotranspiration is negligable). The lake level is currently declining, and the change in volume based on 0.06 m.year^{-1} decline is 36 Ml.year^{-1}.

The groundwater inflow and outflow volumes are more problematic. Turner and others (1984) calculated, using ^{3}H, ^{2}H, ^{18}O and ^{14}C mass balance techniques, that inflow to the lake in 1979 could range between the extant extraction rate (4000 Ml at that time) and 6000 Ml per year. Ramamurthy and others (1985) calculated an inflow rate in 1980, based on Pb210 dating of lake sediments and Ca and Uranium mass balances in the sediment cores, of up to 6000 Ml.year^{-1}. Again, the lower limit was based on existing extration rates.

Recent data suggests that the there is current ly no outflow from the lake. Additions to the piezometric network around the lake since 1980 clearly show that the lake is a sink for groundwater flow from all directions (Fig 4), and therefore there can be no groundwater outflow from the lake. In addition, stable isotope data collected in 1991/92 from bores around the lake show that the evaporated lake water signiture is not found in the groundwater, suggesting that there has been no significant outflow from the lake for many years. Therefore the current outflow from the lake is assumed to be zero, and the inflow can be calculated as;

$$I = O + E + P + \Delta S - R \qquad (1)$$
$$I = 0 + 898 + 3500 + (-36) - 595$$
$$I = 3767 \text{ Ml.year}^{-1}$$

The stormwater recharge to the aquifer (3600 to 6300 Ml.year^{-1}) is therefore at least equal to the average annual extraction from Blue Lake, and possibly significantly greater.

STORMWATER RECHARGE TO BLUE LAKE

The salinity of Blue Lake has reduced by 10-12% in the last 15 years. Most major ions are contributing to this decline, although sodium (Na) and chloride (Cl) show the clearest trends (Fig 5). Stormwater is the only source of low NaCl water in the capture zone of Blue Lake. The percentage of stormwater in the groundwater recharging the lake can be calculated by using chloride and volume mass balances, and then partitioning the inflowing water into stormwater and native groundwater. The chloride mass balance is;

$$I{*}C_I + R{*}C_R = O{*}C_O + E{*}C_E + P{*}C_P + \Delta S{*}C_S + S{*}\Delta C_S \qquad (2)$$

where

C_I = inflow chloride concentration (unknown)
C_R = rainfall chloride concentration (10 mg/l)
C_O = outflow chloride concentration (82 mg/l)
C_E = evaporation chloride concentration (0 mg/l)
C_P = pumping chloride concentration (8 2mg/l)
C_S = lake chloride concentration (82 mg/l)
ΔC_S = annual change in lake chloride concentration (-0.73mg/l/year)
S = lake storage volume (37000 Ml).

The remaining volume terms are defined earlier. Rainfall, and hence stormwater chloride, is around 10 mg.l^{-1}. This is supported by chloride concentrations as low as 10 mg/l in bores within two kilometres of Blue Lake. The outflow and pumping chloride concentrations equal the current lake chloride concentration of 82 mg/l (Fig. 6).

Rearranging Equation (2) to solve for groundwater inflow concentration gives;

$$C_I = (O{*}C_O + E{*}C_E + P{*}C_P + \Delta S{*}C_S + S{*}\Delta C_S - R{*}C_R)/(I)$$
$$C_I = (0{*}82 + 898{*}0 + 3500{*}82 + (-36){*}82 + 37000 * (-0.73) - 595{*}10)/(0 + 898 + 3500 + (-36) -595)$$
$$C_I = 66.7 \text{ mg/L}$$

Therefore the inflow salinity is 66.7 mg/l in an inflow volume of 3767 Ml.

The stormwater - groundwater partitioning can be calculated from;

$$I{*}C_I = SW{*}C_{SW} + GW{*}C_{gw} \text{ and} \qquad (3)$$
$$I = SW + GW \text{ where} \qquad (4)$$

SW = stormwater volume (unknown)
C_{SW} = stormwater salinity (10mg/l)
GW = groundwater volume (unknown)
C_{GW} = groundwater salinity (115 mg/l)

Combining Equations (3) and (4) gives;

$$I{*}C_I = SW{*}C_{SW} + (I-SW){*}C_{gw}$$

Historical lake chlorinity data (Figure 6) shows that the initial lake chloride concentration was around 115 mg/l. This is taken to be the average groundwater inflow chlorinity. Therefore the stormwater volume now flowing into the lake is;

$(3767*66.7) = SW*10 + (3767 - SW)*115$
$SW = 1733 \text{ Ml.year}^{-1}$.

Stormwater inflow is 1733 Ml.year^{-1} and total inflow is 3767 Ml, therefore;

Stormwater inflow contributes 46% of the inflow water.

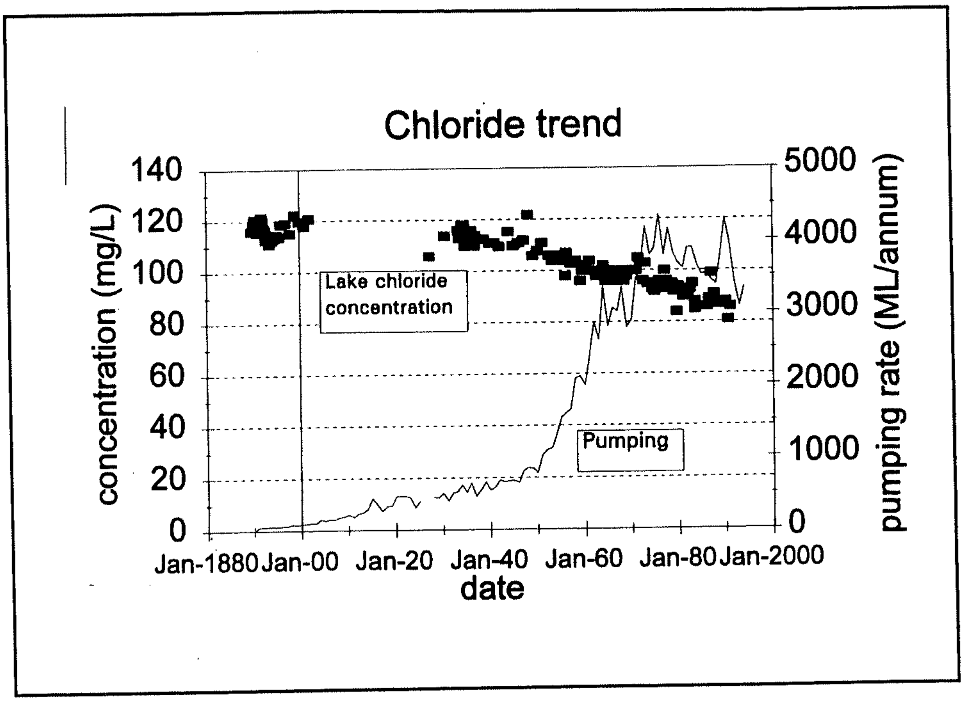

Figure 6. Chloride concentration and trend in Blue Lake

DISCUSSION

Blue Lake is one of the spectacular blue lakes in the world. It is unique in Australia and it appears to be unique in global terms because of its regular colour change from grey in winter to a luminous blue in summer. The lake also provides the water supply for the City of Mount Gambier and it is one of the few large, oligotrophic lakes in Australia.

Blue Lake has much in common with Crater Lake (Oregon) and Lake Tahoe (Nevada). They are examples of very blue, oligotrophic lakes renowned for their scenic beauty.

A recent visit to both Crater Lake and Lake Tahoe provided me with an opportunity to review the management issues for these lakes and the approach taken in addressing these issues. At Crater Lake, maintaining the colour is an important issue. They have just completed a 10-year base-line monitoring program to evaluate the status of many aspects of water quality in the lake, and additional monitoring programs focussing on specific aspects of the lake are now in place. At Lake Tahoe there is development all around the lake, and the optical properties and quantity of algae in the lake are changing. The algal production is steadily increasing and the clarity of the lake is steadily decreasing. As a result, the colour of the lake appears to be becoming less intense.

The Lake Tahoe experience illustrates that the spectacular blue lakes of the world are not inviolable; they are at risk from the effects of anthropomorphic changes in their watershed.

This is a timely warning for Blue Lake because the lake is being driven, by stormwater and associated pollutants, from a pre-European equilibrium toward a new equilibrium. Management to date has concentrated on measuring lake water quality and preventing gross groundwater pollution. However the optical and trophic status of the lake are equally as important.

This paper illustrates that stormwater has a significant role in the limnology of the modern Blue Lake. It is now time to assess the effect of stormwater on the nutrient, trophic and optical status of the lake.

The Water Resources Group of the Department of Environment and Natural Resources is currently addressing some of these issues. We are; (1) collecting base-line data on the current colour of the lake in summer and winter, the current nutrient budgets and the trophic status of the lake; and (2) developing models that replicate water quality trends and the optical properties of the lake. The role of stormwater is being considered in these models.

Appropriate wholistic management strategies for this unique and valuable water resource can only be developed after the base-line data is collected and the models are developed.

ACKNOWLEDGMENTS

The generous support of the Engineering and Water Supply Department and the Depart ment of Environment and Natural Resources for funding research is gratefully acknowledged.

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The composite sampling: a way to go?

The traditional method of taking monthly grab samples provided inadequate results in that it was difficult to obtain an understanding of the hydrological processes of entrainment and transport. The composite method of sampling overcomes many of the problems.

Bruce Nicholson and Richard Clark

Theoretical and practical considerations

The calculation of loads of water quality determinands requires the integration of the two continuously varying records of determinand concentration and flow rate, ie.

$$Load = \int cq.dt$$

where c is the concentration and q is the flow rate.

Due to finacial and technological constraints a method employing discrete water quality sampling had to be adopted, which could be combined with the continuous flow record.

Whilst theory dictates that the accuracy of the flow:concentration integration will increase to an upper limit as the number of water quality samples obtained increases, both the practicality of manually collecting large numbers of discrete samples and the cost of laboratory analysis of their individual concentrations rapidly becomes prohibitive.

The composite method of sampling is designed to overcome these problems by (i) replacing manual sample collection by automatic collection at regular intervals of flow passing the sampling location, and (ii) bulking the individual samples so that a single sample taken from the bulked 'composite' sample can represent the mean flow-weighted concentration of the flow during the period of sampling. The method became feasible due to the development of software for the existing data loggers.

Collection

An automatic sampler, activated by a data logger, was used to sample the stream. The sampler extracted a set sample volume (eg 500 mL) every time a predetermined volume of flow (eg 10 ML) passed the sampling point. Each sample was delivered into a single composite container.

The key to greater accuracy and convenience of the method rests in its significantly increased sample frequency and in the relation of sampling interval to flow rather than time. By replacing

$$Load = \int cq.dt$$

by its direct equivalent

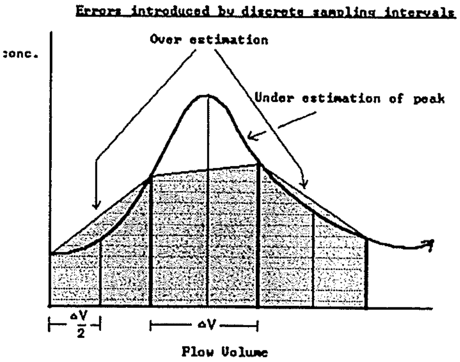
$$\int c.dv$$

it is possible to sample at discrete intervals of flow volume, in order to derive a flow weighted mean concentration which approximates to the continuously integrated value.

The method requires that an accurate predetermined calibration of the river flow versus height relationship is available covering the full range of flow to be sampled. This relationship is programmed into the logger and becomes the basis for continuous calculation by the logger of the cumulated flow passing the sampling location from the continuous measure of river height.

The flow volume 'step' for triggering the collection of each sample was selected to ensure that a maximum number of samples were taken without overtopping the container into which the individual samples were discharged.

Errors introduced by discrete sampling intervals



At the end of each sampling period, when the station was visited, the container was stirred and one representative sample removed. During each visit a grab sample was also taken from the flow passing the station. This was divided into two sub-samples. One sub-sample was left on site in the equipment shed and the other, along with the sub-sample which had been left in the shed since the last station visit (and the single composite sample of the container contents), were returned to the State Water Laboratory for analysis.

The sampling period between station visits varied from 2 to 6 weeks depending on the volume of water flowing past the station and other operational factors. The number of individual samples taken during any sampling period varied between 5 and 180 depending on the duration of the sampling period, the flow during the period and the selected pre-set volume 'step' between each individual sample.

As can be seen from the accompanying schematic figure it is important that the volume increment ΔV is small enough to accurately define the concentration curve. In this example, ΔV is too large causing the peak concentration to be greatly under estimated and the remainder slightly over estimated.

In the limit, as the number of individual samples becomes very large, ΔV tends to zero and the true load L (the integration of the concentration and the flow curve) would be measured.

Thus the total load L passing the station can be approximated by:

$$\text{Total } L = C_1 \times V_1 + C_2 \times V_2 \ldots + C_n \times V_n$$

or, since $V_1 = V_2 \ldots = V_n = V$, the preset volume step for triggering the sampler.

$$\text{Total } L = n \times V(C_1 + C_2 \ldots + C_n)$$

and the total load l entering the composite container is:

$$\text{Total } l = C_1 \times v_1 + C_2 \times v_2 \ldots + C_n \times v_n$$

and, since $v_1 = v_2 \ldots = v_n = v$, the preset sample volume

$$\text{Total } l = n \times v(C_1 + C_2 \ldots + C_n)$$

By stirring the composite sample container, taking a single sample from it and analysing its concentration, the mean value of $(C_1 + C_2 \ldots + C_n)$ is determined. Hence, since n and ΔV are also known, the determination of the concentration of the contents of the composite sample container allows the total load passing the site to be calculated.

Since, in the absence of continuous measurement methods, the variability of the concentration passing the location is not known, the sampling interval should be kept as small as possible.

Effect of storage on determinand concentrations

A detailed comparison was made between the analysed concentrations of the two sub-samples separated from the single grab sample taken from the passing flow during the station visit; the first sub-sample ('Grab') having been returned to the laboratory directly after the station visit, whilst the second sub-sample had been left on the site ('LonS') and only returned for analysis following the next station visit, ranging from 2 to 6 weeks later.

For all stations and all determinands (i) the mean of the arithmetic sum of the percentage differences between the concentration values, and (ii) the standard deviation of the percentage differences between the two sub-samples were calculated. The table below gives a summary of the results.

The Houlgrave[1] result is for the period November 1989 to May 1991, when a refrigerator was installed and all composite and 'LonS' samples were stored at approximately 5°C.

The results showed that the concentrations of the individual nutrients in the samples changed considerably (as signified by the often very large standard deviations), but as expected, TDS did not. Whilst, the size and frequency of changes in one direction tended to balance those in the other direction, as indicated by the relatively small average differences, all determinands showed an overall reduction in concentration after storage.

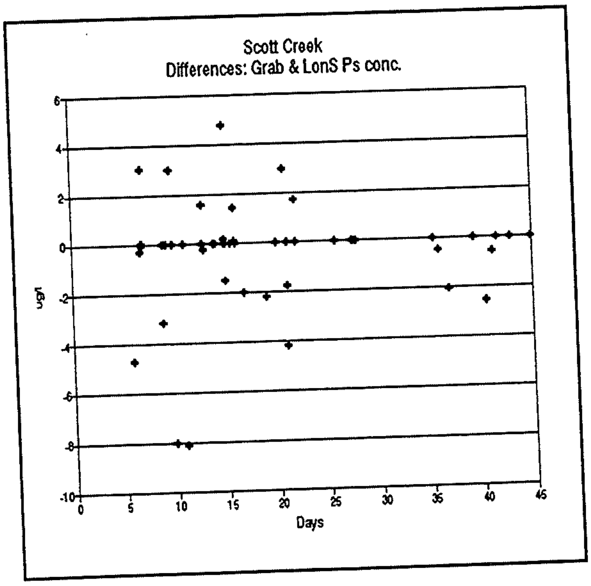
For each determinand, the differences between the Grab and LonS samples have been converted to percentages and therefore valid comparisons regarding their relative stability can be made.

In terms of both the standard deviation and the mean of the % differences the determinands appeared to range in stability from TDS (most stable), through N_{Tot}, TKN, P_T, P_s to Nox (least stable).

Despite the fact that Nox is the worst performer in both cases, N_{Tot} (TKN + Nox) appeared to be relatively stable over time.

Since the standard deviations for all the determinands, other than TDS, are high, it is likely that only those composite samples which contain large numbers of sub samples are likely to provide a reasonably 'true value' sample.

This provides a good incentive to use the composite sampling method, with a small flow volume sampling step, since this enables a large sample set.



The effect of refrigeration appears to have no discernible benefit and an alternative method of 'fixing' the samples is urgently needed.

The differences between the two sub-sample results were also plotted against the number of days the LonS sample was left on site (an example is given on the accompanying diagram). The analysis showed that after the initial change, overall, there appeared to be little correlation with elapsed time.

Whilst it is not known whether the changes that occur in an individual sample left on site are directly comparable to the changes that occur in the composite sample, which is being gradually accumulated during the same period, such a similarity had to be assumed for the purposes of calculation .

Table 1 : Summary of % difference of Grab and LonS samples.

Location	TDS		P_s		P_T		TKN		Nox		N_{TOT}	
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd
Houlgrave 38 samples	-0.4	1.7	-2.5	25	-7.9	47	-4.8	54	-15	67	-3.6	37
Scott Ck. 42 samples	0.4	4.8	-31	148	-3.2	35	0.7	67	-81	191	-4.8	73
Echunga 36 samples	-1.1	2.9	-28	124	-29	131	-2.2	50	-31	129	2.5	42
Average	-0.4	3.1	-20	99	-13	71	-2.1	57	-42	129	-3.5	51
Houlgrave[1] 19 samples	-0.2	1.7	-6	26	-5	23	-13	67	-11	50	-9	44

National Groundwater Scientific Consultative Group

South Australian report by Bryan Harris

• Great Artesian Basin Hydrogeological Assessment

In response to potential additional mining development in the State's Far North, a review of the groundwater resources along the Southwestern margin of the GAB has commenced. The program essentially involves the compilation of all available hydrogeological data into a comprehensive database and computer modelling to predict the likely impact of additional water withdrawals on the more environmentally sensitive areas.

• Upper South East Dryland Salinisation

Large areas of land in the Upper South East have been degraded by salinisation caused essentially by high and rising groundwater levels. After a lengthy public consultation process, a supplement to the management plan and draft EIS has been completed. A key component of the plan is a regional coordinated groundwater drainage scheme, with discharge of excess surface water and groundwater to the sea and possibly the Coorong.

• Stormwater Aquifer Recharge

The inground storage of wetland treated stormwater using recharge wells is currently being trialled at 4 sites in the Adelaide region. These are collaborative projects with local government and authorities who plan to reuse the water for irrigation purposes. One of the objectives of these trials is the formulation of irrigation water quality guidelines. Results to date are very positive.

• Water for Aboriginal Communities

MESA provides ongoing professional assistance to the Pitjantjatjara Council in the selection of water supply well sites in the far northwest homelands. In conjunction with the State's Department of Aboriginal Affairs, automatic recorders are being installed in Aboriginal community water supply wells to monitor groundwater withdrawals and the corresponding water level drawdowns. MESA has also been requested to assess the possibility of additional groundwater development in communities with water supply shortages.

• Groundwater Irrigation Areas

Management plans have been revised or are under development in a number of groundwater irrigation areas which are experiencing lowered potentiometric levels and/or increased salinity levels. The approach taken in community consultation plays a crucial role in community acceptance of the plans. Plans developed by peak, community based advisory groups without extensive consultation during the course of plans' development have experienced significant community resistance. Where intensive efforts have been put into this consultative process, the plans have been accepted.

An issue common to a number of groundwater irrigation areas is resource degradation due to leaking wells ie saline groundwater contamination through corroded casing or well annulus. The impact of leaking wells is currently being assessed for the North Adelaide Plains and Barossa Valley irrigation areas. One of the related issues is funding sources for any rehabilitation program.

• Guidelines for Landspreading of Agricultural Wastewater

Water Resources Group in the Department of Environment and Natural Resources commissioned the Centre for Groundwater Studies to develop guidelines for landspreading of agricultural wastewaters in the South East of South Australia. The Centre has provided draft guidelines for comment.

The region is underlain by a unconfined Tertiary Limestone aquifer which is vulnerable to point source pollution. Landspreading of agricultural wastewaters from piggeries, dairies, cheese factories, abattoirs and saleyards is practised as a disposal technique. This has resulted in instances of high nitrates and increased salinity levels in some areas mainly due to poor spreading practices by land holders.

The guidelines will form the basis for performance - based licensing for landspreading of waste waters.

• Atrazine Occurrence in Groundwater in SA

Ciba-Geigy Australia Ltd initiated a joint study in SA into the occurrence of atrazine in groundwater. Partners in the study were SA Department of Mines and Energy, Engineering and Water Supply Department and the Centre for Groundwater Studies.

The study was undertaken in two stages, the first stage involving collation of data on use of atrazine and existing groundwater quality data where atrazine had been analysed. The second stage involved investigating two different land uses where atrazine had been used, irrigated cropping and softwood plantations.

Site selection was based on information on localities of fields and forests where use of the herbicide was know, and by avoiding sites with deep water tables. That is site selection favoured locations where aquifers are vulnerable to contamination. Two bores were drilled at each site to sample groundwater at the watertable. Atrazine was detected in concentrations from 0.3 to 2.0 ug/l at three of four sites in irrigated agriculture where atrazine was used for up to ten years to suppress weeds in irrigation channels.

The highest concentrations coincided with the site with the heaviest application rate over the longest period. Also this was the only site at which the metabolite desethylatrazine (0.3 ug/l) was detected. Simazine was found at two other irrigated sites (0.15 to 0.23 ug/l). In pine forests atrazine was detected at one of four sites (0.16 to 0.75 ug/l) where it is used in the establishment of new plantings. At each site where atrazine (or desithyiatrazine) was detected it was found in samples from both bores.

- **Contamination of Groundwater by Pulp and Paper Mill Effluent in SA**

Pulp and paper mills have operated in the South East of SA since the 1940s. Effluent is discharged to a coastal lake via unlined drains up to 11 km in length. The shallow groundwater in a Tertiary limestone aquifer has been impacted by the effluent at one particular site where the watertable is below the base of the drain for most of the year.

This site was investigated in detail by the Engineering and Water Supply Department and the Department of Mines and Energy from 1990-1992. Only the top 10 m of the 150 m aquifer sequence had been impacted. High levels of organochlorine and other organic compounds typical of pulp mill effluent were found in a plume up to 1 km long adjacent to the drain.

The mill discharging to this drain has undertaken a major redevelopment including effluent recycling and treatment which has resulted in an effluent that meets the guidelines set by the SA Government for this activity. The beneficial use of the groundwater has not been affected due to the stratification of the plume and therefore it was decided that active remediation of the plume is not required.

- **Potential for Groundwater Salinisation : Mallee Region, Murray Basin. LWRDC funded project CWS3 CSIRO/MESA/DENR**

Large scale clearing of Mallee vegetation is the Murray Basin has resulted in a dramatic increase in recharge rates from less than 1mm/year up to 100 mm/yr. The Mallee region contains a large area (~1500 km^2) of fresh groundwater (<1500 mg/l) which is used for townwater supplies and irrigation. The unsaturated zone contains saline soil water(20-30 000 mg/l) which will be displaced into the aquifer due to the new increased recharge rates. The aim is to determine if there is already a measurable impact on the resource and to develop models to predict the time frame for groundwater salinisation. An important aspect is to determine the extent of mixing within the aquifer so that we can predict changes in salinity at various depths in the aquifer. The results will be used by the Mallee Water Resource Committee to ensure long term management of the resource.

- **Sustainable Development of the Confined Dilwyn Aquifer of the Otway Basin**

Radiocarbon and stable isotope data indicate that goundwaters in the Kingston-Robe artesian district are palaeowaters recharged during the last glacial period. Modelling of the aquifer system indicates that at this time recharge to the confined aquifer occurred over a larger area with a potentially greater flux.

Today active recharge has contracted to a relatively small zone between the hydraulic hinge line and the Kanawinka Fault. Groundwater both above and below the confined aquifer is more saline. Overuse of the resource has the potential for increased salinisation of the groundwater. For sustainable development of the resource the amount of recharge entering the system needs to be determined.

A number of cores have been taken through the confining bed and analysed for permeability, stable isotopes and major ions to estimate recharge to the confined system. To date two papers in the *Journal of Hydrology* have been published. □

DRILLING FOR SALT

Rick Aldam

The Groundwater Division of MESA has successfully completed an exploration well at Penrice Soda Products' Dry Creek site to assess the potential of using highly saline groundwater to generate mineral products in the adjacent evaporation ponds. Currently, Penrice uses sea water with a salinity of 35 000 mg/l for this purpose. Precipitated salts are redissolved and pumped as a brine under the Port River to the company's Osborne plant for processing.

The well was drilled into the South Maslin Sand aquifer which is the deepest in the St Vincent Basin which underlies the Adelaide metropolitan area. The sand aquifer was intersected from 437 to 501 m, but was found to be non-homogenous with interbedded clay and lignite layers. Weathered basement was encountered at 502 m.

Results are encouraging, with an airlift yield of 30-40 l/sec and a salinity of 79 000 mg/l recorded during the well development phase. Further testing will be carried out to obtain hydraulic and water chemistry information. If the yield and water chemistry are acceptable, then further drilling and testing to establish a production wellfield is likely. Obviously, if the salinity of feed water from groundwater wells is double that of sea water, large increases in production efficiency will be obtained because of reduced time required for evaporation.

Penrice's Osborne plant is Australia's only produce of soda ash (sodium carbonate), which is used in manufacturing glass, chemical processing, metals refining, detergents and water purification. The company also manufactures large quantities of bicarbonate of soda, which is used in baking powder, environmentally safe cleaning agents, stockfeed and laundry bleaching powders. Current production of soda ash is ~340 000 t/year, 20% of which is exported. Annual production of salt from the 4 000 ha of evaporation ponds is 650 000 t. □

International Symposium on

ARTIFICIAL RECHARGE OF GROUNDWATER

Peter Dillon

Orlando, Florida

THE CONFERENCE commenced on Sunday, July 17, with a continuing education seminar on artificial recharge. This was led by David Pyne, who has pioneered the development of Aquifer Storage Recovery (ASR) technology involving injection and recovery of potable water in brackish aquifers. Dr Herman Bouwer, Chief Engineer of the US Water Conservation Laboratory Phoenix, led sessions on artificial recharge of water and treated wastewater via infiltration ponds.

The seminar was attended by 44 people, mainly involved in water supply, resource management and consulting. This served as a useful background for the conference and demonstrated the rapid growth in application of both classes of methods in the United States.

ASR is now operating in 12 states and is proving very economic for expanding water supply capacity in comparison with alternatives. An anthology of operation experience is accumulating in overcoming problems with clogging, recovery efficiency, hydrogeochemical interactions and water quality, at least for injection of drinking water. US regulations currently impede the development of ASR for non-potable water.

Infiltration basins are still the cheapest form of artificial recharge, and experience in their use and maintenance is well established. Their role in reducing bacteria, viruses and THM's (dri-halo methanes), HAA's (halo acetic acids) and organic carbon, is currently being explored.

The five day Conference commencing Monday, July 18, attracted 216 registrants from 25 countries. There were 12 delegates from the Netherlands and three from each of the UK, Indonesia, and Australia. Other countries in Europe, the Middle East, India and Japan were also represented. The three Australians were: Andrew Telfer (SA Department of Environment and Natu-ral Resources), Nabil Gerges (Mines and Energy, SA) and Peter Dillon (Centre for Groundwater Studies).

The conference allowed operators of artificial recharge schemes to compare notes and enabled those contemplating ASR to gain an understanding of its feasibility. Six years had elapsed since the first international conference on artificial recharge and in that time the number of ASR schemes had trebled, and issues such as THMs and HAA's in drinking water had emerged.

As a broad generalisation most of the US work on ASR was performed as consultancies not as research projects. A number of solutions had been found to operational problems, and procedures for establishing these schemes which may identify such problems had been introduced. However there was little demonstration that groundwater processes were understood. Clients problems had been solved, but an ability to extrapolate to other sites or alternative recharge-discharge schedules was not understood.

There were some exceptions to this. Studies on geochemical changes in South Carolina (Joffre Castro), New Jersey (Mark Lucas) and Virginia (Meg Ibison) progressed an understanding of redox processes, involving Fe and Mn precipitation. Adam Hutchinson (formerly University Arizona now CH2M Hill) identified an index with which to predict well clogging which was applied at a number of sites in a range of formations.

Among the most novel developments were the use of ASR wells to produce energy. Daniel Wendell, (California) described the recovery of energy by recharging a deep well under gravity through a pump which under reverse flow acts as a turbine. The energy recovery system would pay for itself in 3 years. Hiroto Abiko described the use of an artificial recharge scheme at Yamagata City Japan, where groundwater from a bore north of the city was pumped through a network of pipes buried under roads and footpaths to melt winter snow and ice. The resulting cooled water was stored in the same aquifer via a recharge well south of the city. In summer this cooler water was extracted, used in heat exchangers for cooling buildings, and the heated water reinjected in the northern bore.

Two discussion sessions during the conference proved provocative. The first flushed out what was not known about storage of artificial recharge in confined aquifers. The questions "Does the same aquifer storativity apply for injection and extraction? and if not why? drew out at least four different schools of thought. These questions could readily be resolved with some well instrumented experiments. The second discussion session focused on the basis for water quality guidelines for artificial recharge. This highlighted an anomaly in the USEPA regulations which provides no protection for aquifers which are not considered to be storages of potable groundwater. Note that groundwater

:h salinities up to 10,000 mg/L may considered potable. This is conered the threshold for application reverse osmosis as a water treatent for drinking water supplies.

ı the final session a series of reearch needs were listed including:

- chemical and biological processes in the saturated zone;
- removal of bacteria and viruses in relation to travel time;
- effect of chlorination on injection and infiltration;
- performance of soil aquifer treatment systems;
- performance of dry wells and their water quality requirements;
- geochemical compatibility of injected and antecedent groundwater;
- recovery efficiency (mixing with native groundwater) for water stored over longer periods, say 10 years.

A series of related activities is also desirable:

- advances in regulatory requirements;
- ASR in hardrock/basalt and efforts of hydrofracturing;
- irrigation uses of ASR.

Site Visits

Following the conference I visited Phoenix on 25-26 July where Herman Bouwer, Chief Engineer of US Water Conservation Laboratory, is co-ordinating a National Academy of Science project to establish guidelines for artificial recharge of groundwater. Black and Veatch (Consultants) gave me a tour of their pilot treatment plant which purifies secondary treated effluent using Memtec ultrafiltration and reverse osmosis prior to injection via dry boreholes. I was also taken on a visit to the Salt River Project which conjunctively manages surface and groundwater storages. Members of the laboratory (about the same size as the Adelaide laboratory) have research interests in; atmospheric CO_2 feedback effects on crop growth and transpiration; use of remote sensing to map actual evapotranspiration as a percentage of potential evapotranspiration for irrigated wheat and cotton crops at different stages of growth; and nitrogen management in irrigation areas including measurements of volatilisation of ammonia.

The trip concluded on 27 July with a brief visit to Orange County Water District's Water Factory 21, south of Los Angeles where for 20 years wastewater has been treated and injected into confined aquifers to prevent saline intrusion. The injectate now constitutes 95% of water extracted for potable water supply at the nearest well.

Very useful discussions covered the scientific basis for the Californian guidelines for wastewater treatment prior to artificial recharge, and revealed a good epidemiology report to summarise these findings and a draft of proposed groundwater recharge regulations for the state of California. These will assist a CGS project supported by UWRAA to develop Australian Guidelines for Injection of Stormwater and Treated Wastewater.

Groundwater recharge and recovery or mixing in surface water bodies is seen to be highly desirable for reuse of treated effluent from a public acceptance point-of-view. It may be some time before pipe-to-pipe reuse of water comes of age.

The purpose of these visits was to understand the basis for water quality guidelines for artificial recharge where this is practiced in order to develop guidelines appropriate for Australia. It was recognised that the future of artificial recharge, and particularly ASR would depend on having guidelines which protect groundwater quality, are equitable, including for future generations, and are flexible to account for local situations.

The visit was most valuable as face to face discussions were essential in identifying the water quality issues in artificial recharge, why they arise, and why they are different between eastern, central and western states. □

State Water Plan

continued from page 9

The South Australian Water Resources Council is keen to hear your views on any aspects of these two papers but particularly on:

- what issues and key areas for change may have been missed
- the areas of greatest priority for change
- how change can be managed most effectively with least disruption
- what outcomes you expect from changes you suggest
- any other points on water management that you want to raise

You can let us know your views by:

- completing a response form or
- making a submission

Responses can be posted or faxed to:

The Executive Officer,
South Australian Water Resources Council,
GPO Box 1047,
Adelaide, 5001

Fax No (08) 204 1454

or contact Julie/Susan with any telephone enquiries on (08) 204 1821. Responses forwarded by 22 December 1994 will be summarised and used in consultation workshops to be held during February/March 1995.

In addition, over the next month the Water Resources Council will approach peak organisations with an interest in water, to develop papers which focus on particular stakeholders in water management, including Local Government, irrigators, farmers in water catchments, industry and the environment.

These 'stakeholder papers' will be used as a basis for more extensive consultation later this year and in the new year. The discussions will focus on appropriate strategies and their impact.

These papers will be available in late November 1994. If you would like to receive copies please ring or fax.

SUPPORTING COMMUNITY BASED WATER RESOURCES MANAGEMENT

Steve West

A NEW UNIT has been set up within the Water Resources Group, Department of Environment and Natural Resources. The role of the Community Support Unit is to:

- raise people's **awareness** about water resources issues,
- enable people to **understand** why water resources need to be looked after, and
- provide people with **information** they need to be able to do their part to ensure that **best practice water resources management** is achieved.

This is basically an education process. To be truly effective, education must be a two way process. There is lots of important information which we need to share with the community to help them to look after their water resources. At the same time we want to learn from the community, so we can benefit from their 'local knowledge'. This is often critical when we are seeking to implement new or changed water resources management practices or policies.

Its our role to help bridge the gap between water resources policy makers and the people in the community who are affected by these policies.

The community is actively encouraged to participate in the policy making process. The South Australian Water Resources Council and Water Resources Committees in water resource sensitive areas of the state, provide a formal mechanism for the community to participate in the policy making and policy implementing process.

One of the main functions of the Community Support Unit is to educate the community about water resources management issues. A well informed community which understands the opportunities and threats associated with **their** water resources is the essential prerequisite to meaningful and effective community participation in water resources management.

During 1993/94 the Unit's activities have focussed on setting up and commencing a number of projects which have received Commonwealth Government funding assistance through the Waterwatch and National Landcare Programs. These have been designed to educate and raise community awareness about water resource management issues.

WATERWATCH

Waterwatch commenced in South Australia during 1993/94. A State Facilitator (Ian Grant) was appointed and has assisted a variety of school and community groups to undertake water quality monitoring. Groups are also being assisted with interpreting the data they collect and developing and implementing action plans to address any water quality problems they detect.

The *'Catchment Care and Water Quality Monitoring Manual for South Australia'* was developed as a co-operative effort involving staff from the Department of Environment and Natural Resources, the Department of Education and Children's Services and the SA Waterwatch Steering Committee.

It is planned to increase the number of groups participating in Waterwatch during 1994/95 in order to give statewide coverage. Landcare groups will also be encouraged to participate in Waterwatch. Note that there is more information about Waterwatch in this magazine.

National LANDCARE program

The National Landcare Program has provided funding assistance for three 'Watercare' projects which are being undertaken by the Community Support Unit. The projects focus on school and community education about water and water resources management. Their titles are:

- *Teacher Resources Kits for Curriculum Areas of Study*
- *Caring for Water Throughout the Total Water Cycle*
- *Information Extension to Water Resources Sensitive Areas and Industry Groups*

The 'Teacher Resources Kits' project is being managed by Angela Colliver, a teacher/curriculum writer seconded from the Department of Education and Children's Services (DECS). The objective of this project is to develop and market quality educational support materials which teachers can use to teach a wide range of subjects using a water theme.

We traditionally think of subjects like *Society* and *Environment and Science* as those where water might be taught. We will certainly be covering these areas, but will also be providing teachers with ways they can use water to teach subjects like *Art, Language, Music* and other less traditional areas. The opportunities are endless and fascinating. Teaching about water in some of the 'emotional' subjects will help young people develop a deeply felt empathy for water, which hopefully they will carry with them as adults.

The 'Teacher Resource Kits for Schools' project is an example of a collaborative effort involving the Department of Education and Children's Services, the National Landcare Program and the DENR Water Resources Group.

Education systems throughout Australia are currently supporting the development of initiatives to assist Australian teachers in implementing national priorities for school education. This project is one of these initiatives, as it is using the National Curriculum for Australian Schools as a framework for development.

The 'Caring for Water Throughout the

l Water Cycle' project is the res- ibility of another seconded teach- enn Hughes. The objective of this ɔct is to prepare and market infor- ion resources which can be used to e awareness and inform students l people in the community at large, out water quality and water resource anagement issues, in all stages of ater's journey through the water cle.

s you will probably be aware there as been a lot written about the water ycle. The preliminary research for this oject has involved talking to a range f teachers to find out what sort of eaching resources they need. The esponse has been that students (and dults!) learn best when they really get nvolved in doing things, not just hav- ng things taught to them in the class- oom. A series of surveys are being carried out to clarify this further.

Basically though, the resources devel- oped by this project will seek to en- courage students to research and discuss water issues, to form their own opinions and make judgements about water problems and encourage them to take action to improve water quality. In the area of community education, our aims will be to explain the water cycle to the community, to show how we have influenced the natural water cycle and what all of us, both as individuals and in groups, can do to improve water quality, starting in our own 'backyards'.

The *'Water Resources Extension'* project will focus on promoting best practice water resources management in water resources sensitive areas (eg, around Blue Lake Mt Gambier) and in water resource sensitive industries (eg, manufacturing, construction, etc). This project is being managed by David Leek. You guessed it, he's a teacher too! Currently he's working on riparian areas management, the Blue Lake Management Plan, Great Artesian Basin bore drain issues and storm- water management policy development and promotion (in conjunction with the EPA).

The riparian areas project is being coordinated by Jim Burston and Mi- chael Good. One of its main aims is to establish some base line data about the "health" of the watercourses in four Adelaide Hills catchments. Some "measurement" of the community attitude to their watercourses is also important and David has prepared a unit of work for local school children that will give an indication of their understanding of, and feelings about, their local watercourses. It is planned to repeat this exercise in three or four years time to ascertain whether there has been any attitudinal change in young people as a result of the riparian areas project.

The challenge in Mount Gambier is to get the local population, tourists and industry to adopt behaviour that im- proves the quality of stormwater that gets into the aquifer which feeds Blue Lake. David has developed and is implementing an action plan which includes the production of pamphlets, posters, units of school work and use of the local media, to give the issues a high profile and to eliminate bad prac- tice resulting from ignorance.

National Water Week 23-29 October 1994

The DENR Community Support Unit has been working collaboratively with the Corporate Communications Unit in EWS to develop a program of activities and events to promote *National Water Week* in South Australia.

The Unit has been involved in develop- ing a resources package for schools. *'The Wonderful World of Water'* con- tains a taped ballad about *'Patrick Platypus'*, a fair minded and coopera- tive environmental crusader. Students have been asked to illustrate the bal- lad. Their work will be judged in a competition, with winners gaining 'Mys- tery Flights' sponsored by Q~~U~~ANTAS. The kit also contains substantial teach- er resource material, all with a water theme and covering the whole range of areas of study included in the national- ly developed curriculum for Australian schools. The resource package has been distributed to all schools in SA, after receiving very good feedback from its initial trial.

The Community Support Unit has also been involved in developing a 'Water Trail' in Botanic Park. Various other activities are also being planned. They mainly focus on young people. Nick Vall, an Adelaide singer, will provide concerts with a water theme, 'Patrick Platypus' artwork will be displayed and judged, other water exhibits will be on show and students will be encouraged to explore the 'Water Trail' with the help of teachers and parents. Water- watch will also be there 'testing the waters'. There will even be sample bags of National Water Week goodies!

In short, the Community Support Unit (Steve West, Sue Leahy, Angela Colliver, Ian Grant, David Leek and Fenn Hughes) is up and running! For any queries or suggestions, please contact Steve West on 226 2485. □

DID YOU KNOW...

- On average, Australians use 300 litres of water each day in their homes, and in many parts of Australia, over half the daily household water consumption is used in gardens.
- The UN estimates that 1.2 billion people do not have access to safe water.
- In developing nations, 80% of diseases are related to poor quality water.
- One drop of oil can render up to 25 litres of ~~oil~~ unfit for drinking. water
- Transpiration in higher plants accounts for about three quar- ters of the water that is vapor- ised at the global land surface.
- The water content of all plants and animals on Earth would occupy a cube with 8 km sides.
- Carbonaceous chondrites, which are the most primitive meteorites, contain up to 20% of water.
- Water constitutes up to 95% of matter ejected during volcanic eruptions.
- There is more water in the crust and mantle of the Earth than in its oceans.

WATERWATCH SA

Ian Gr

HISTORICAL OUTLINE OF WATERWATCH SA

WATERWATCH seeks to portray water quality as the indicator of environmental health. Water quality provides a measure of quality of land management in the catchment. Waterwatch assists community groups and schools to monitor water quality. Its real purpose is to develop and foster environmental awareness in the community.

Waterwatch is a national program, with origins in the Streamwatch (Sydney Water Board), and Ribbons of Blue (Victoria and Western Australian). It was launched as an Australia wide program via the Prime Minister's 'Statement on the Environment', December 1992, and was allocated $2.9 million over 3 years; 1993-94 - 1995-96. South Australia gets approximately $110 000 pa. With inkind support, the gross dollar value is estimated to be around $500 000.

Waterwatch is administered nationally by the Australian Nature Conservation Agency (ANCA), and Commonwealth Environment Protection Authority (CEPA). The national Waterwatch Facilitator is Mr Chris Mobbs. Each state and territory has a Facilitator. SA Waterwatch program is overseen by the SA Waterwatch Steering Committee, of which Mr Steve West (Coordinator, Community Support, Water Resources Group) is the Chair. Monitoring programs within catchments are coordinated by regional/catchment coordinators. Part of their role is to link, (with the assistance of the State Facilitator), local government, school groups, business, landcare agencies, environment groups, and other interested parties in their region.

WATERWATCH FUNDING

In South Australia, Waterwatch funding contributes no more than 50% of the salary and running costs for regional or catchment coordinators.

Other activities that are funded include; travel, training exercises, preparation of education and awareness material, (provided material is not duplicated on a national level) and the development of regional, catchment or local Waterwatch action plans. Waterwatch funding does not normally contribute towards the purchase of water test kits and the running costs associated with water quality testing.

WATERWATCH METHOD

In summary the Waterwatch method involves:

- data gathering
- data storage
- data access
- data interpretation
- development of action plans to address any problems revealed
- implementation of action plans.

The SA Waterwatch strategies are as follows:

- Encourage water quality monitoring proposals which help to achieve catchment wide coverage.
- Support monitoring proposals which demonstrate involvement of a wide cross section of commun
- Conduct workshops and sem nars for community grou leaders and Training ar Development days.
- Encourage monitoring grou to obtain sponsorship fro sources other than Waterwatc
- Involve media in promotir Waterwatch activities.
- Encourage and help implemer a statewide communicatio network between groups ar the facilitator.

Important dates in South Austra ian Waterwatch program include:

May 1993, 1st meeting of the S Waterwatch Steering Committee.

June 1993, the initial fundin bids were submitted to the Na tional Waterwatch Steering Com mittee for assessment.

April 1994, the launch of the stat Waterwatch Manual, largely pu together by members of the steer ing committee and Chris Bayly Project Officer, Environmenta Education DECS. A Training anc Development day which wa attended by 40 interested per sons.

June 1994, Waterwatch group actively involved in water qualit monitoring and data recording environmental assessment o condition of water body, anc sourcing funds.
August 1994, the distribution o the inaugural Waterwatch News The commencement of the Patawalonga Waterwatch monitoring program.

ɪgress Highlights

Ardtornish Primary School actively involved in monitoring stormwater basins for 2 years.

Patawalonga Waterwatch involves 30 schools, 3 Universities, EPA, DENR, and was filmed September 15th, 1994 by Channel 10, Brisbane, for broadcast nationally and to New Zealand.

- Also in the Patawalonga Basin, Mitcham City Council is employing a Community Health Officer to assist in the Councils's water monitoring program and link with Patawalonga Waterwatch.
- To date the register of interest from schools is approaching 100 across the state.
- School of the Air in Port Augusta are interested in incorporating water quality assessment as part of their school program. (Ororoo and Kimba Area Schools have commenced sampling underground water).
- Kalangadoo - groundwater sampling being assisted by EWS and DENR.
- Waterwatch group forming in Christie Creek catchment to monitor water from source to sea, through a variety of land uses.
- Department of Mines and Energy have offered technical and financial assistance for the development of a Ground Waterwatch kit. Areas selected for initial monitoring include Mt Gambier basin, Upper South East and the Barossa Valley. Up to 10 kits will be constructed and circulated to community groups and schools in each region.

CONTACT OFFICER: Ian Grant,
SA Waterwatch Facilitator
SECTION: Water Resources Group
TELEPHONE: 226 2049 □

Rainy figures

AVERAGE ANNUAL RAINFALL over the entire surface of the Earth is estimated to be 730 mm. Although the exact figure is not known precisely on a global scale, it should be relatively uniform from year to year, say within 1%, which is dictated by the solar radiation constant. A precise figure may be a long coming, as global hydrometric network is somewhat inadequate.

In fact it is hopeless. What is more, raingauges are not corrected for wind speed (causing some droplets to jump over the orifice), so rainfall is virtually always underestimated. Global fall is quite possibly some 15% more than we think.

Local peculiarities of the planetary relief, solar incidence and atmospheric circulation cause noticeable variation in rainfall. Thus, Cherrapunji in Assam snatched not less than 26 461 mm in the year which ended on 31 July 1861 (with 9299 mm in July alone!) whereas parts of the notorious Atacama Desert in Chile have received none whatsoever in the last 400 years (if old folk tales are to be believed).

The record for one day is held by the island Réunion in the Indian Ocean, which received 1870 mm in a single 24-hour period, more than three times annual rainfall of Adelaide. Reading a gauge seems to be a full-time job on Réunion.

Highest recorded short-term rainfall intensities oscillate around 25 mm/min worldwide. Calculate the rainfall intensity during the 40 days of the Deluge and see for yourself whether it was better than that.

The annual global rainfall amounts to 375 000 km^3, and would fill the World Ocean in some 3600 years. It would fill the entire Earth (if it was hollow) thousands of times in geological time. Fortunately, recycling was invented naturally long before we thought of it.

Further primary school maths shows that the global fall in one second is some 12 000 000 m^3 (which would fill Kangaroo Creek reservoir in just two seconds). Incidentally, this amount of water would furnish the daily drinking needs of the world's population.

At any time there is enough water in the atmosphere to supply eight days of the world's rainfall. Good that it's being replenished daily (and nightly, on the other side).

Lack of topographical relief results in some of the driest deserts (areas with little rainfall) of the world being situated in areas covered by oceans: namely parts of the Pacific Ocean west of South America and parts of the Indian Ocean, west of Australia.

Australia is located in the belt of the lowest rainfall and highest evaporation in the whole of the habitable world. Due to its low relief, Australia is one of the driest continents (Antarctica leads this list with less than 100 mm of precipitation per year). Lake Eyre is the driest part of Australia: there have been periods when the annual rainfall here has been less than 75 mm.

South Australia receives some 200 km^3 of rainfall per year (which is 200 000 gigalitres or 200 000 000 megalitres) of which more than 99% evaporates back to the atmosphere without reaching the sea. The highest daily rainfall of 273 mm was recorded at Motpena on 14 March 1989. Similar amounts were recorded around the Barossa Valley on 2 March 1983.

Rainwise, Adelaide fares better than most of the State, receiving on average 585 mm per year. The highest recorded was 883 mm in 1992, well above the second best of 768 mm in 1851. The daily record is 141 mm on 7 February 1925.

What is the most important but least known process which determines the size of South Australia's water resources?

Watch this space in the next magazine for the intriguing answer!

Water politics

Water resources planning, project authorisation and level of funding are all essentially political processes. Hence, *the planners decide the feasibility of the project, and politics decide the implementation of the plan.* One could say that:

> No matter how sound a project may be physically, no matter how profitable it will be economically, it will come about only if effective political leaders can champion its cause in the right way at the right time.

The story of the Grand Coulee Dam will illustrate the point. The dam was proposed in 1918 by Rufus Wood, and yet a decision to build it was not made until the spring of 1933 because of the personal interest of Senator Clarence Dill of Washington, who had been preconvention Roosevelt Democrat in 1932. Preside Roosevelt promised a dam to Senator McNary, Republic Minority Leader, to reduce unemployment in Orego Senator Dill, not to be put off, demanded a dam to Roosevelt, according to Dill, initially offered him $4 million. Dill protested vigorously: "We can't even pu concrete across the river for that!" Roosevelt increased th offer to $50 million and Dill still objected. "Sixty million, Clarence, and that's as far as I will go!" said Roosevelt. And so the final decision to build the Grand Coulee was made - initially as a low dam and a work-making project. Later, plans for the original dam were reinstituted.

... and today, the Grand Coulee is appreciated as one of grandiose projects of mankind.

Letters to the Editor

Dear Sir,

Whilst it was pleasing to have your Prize of Prizes awarded to CSIRO for getting it right with the name 'Division of Water and Land', I regret to point out that the name 'Division of Water and Land Resources' only endured from 1982 to 1987. A review at the end of that time effectively split off much of the Division's expertise in land and vegetation, and concentrated its water expertise in a new Division of Water Resources. This is the Division that is now headquartered in Adelaide, with other larger laboratories in Perth, Canberra and Griffith.

The name change essentially represented a response to sustained pressure from the major urbans for more CSIRO activities in their area, The process, however, failed to root out the natural resource base of the Division, with the result that a substantial amount of its work is still squarely in the land phase of the hydrological cycle. Examples are decision support systems for catchment management, dryland salinity, recharge studies, floodplain management and large-scale hydrologic applications of remote sensing. At the same time there has been an increase in urban-based research, such as stormwater conservation, urban catchment management and groundwater contamination in cities.

The inability of the Division to immediatel abandon research that integrated water an land has proven fortunate in the long run. B fudging its response in the late 80s to intens political pressure and holding on to its visior the Division now finds itself politically correc again - except perhaps in name! There ar lessons in this story for the water industry a well as research planners generally. Fo researchers the lessons must include 'be aler and responsive but not servile to politica pressure', and 'maintain faith for the whee will turn"!

Peter Martin
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1994/1995 Executive Committee

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