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Aqua Australis

Newsletter of the Hydrological Society of South Australia Inc.

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REVISITING THE HYDROGEOLOGY OF THE WESTERN MARGIN OF THE GREAT ARTESIAN BASIN, AUSTRALIA

Presented by Dr. Pauline Gueutin at the Hydrological Society of SA Inc. technical meeting May 17 2012

Summary by Renae Eden

In the Great Artesian Basin (GAB) - one of the largest groundwater basins in the world - groundwater flow and storage has long been considered to occur through a continuous sand sheet-like aquifer that underlies one fifth of the Australian continent.

Under this scenario groundwater travels up to 2000 km from recharge areas in eastern Australia with major discharge occurring along the south west spring zone line. While this model describes the hydrogeology in broad regional terms it does not account for the complexity of the system, in particular faulting providing conduits to deep-seated groundwater flow.

On Thursday May 17 2012 at the Hydrological Society of SA Inc. technical meeting, Dr Gueutin discussed the development of a new conceptual model which gives consideration to more recent observations. These include:

- New geochemical data which indicate a small volume flux of deeply derived (endogenic) fluids mixing into the aquifer system at a continental scale;
- Hydrogeological data which indicate multiple recharge sources and fault portioned sub basins; and
- Neo-tectonic data which indicates active tectonism today that provides a fluid pathway through faults for the deeply sourced endogenic fluids to discharge in GAB travertine depositing springs.

The following is a summary of that presentation. The GAB extends over 22% of Australia's subsurface, and 40-50% of this water source is potable with a salinity of less than 1000 mg/L. Artesian conditions result in natural discharge processes which can be broadly described as 'springs' and 'upward leakage'. Springs are the only permanent water in the desert, host to more than 30 endemic specialist species reliant on them and culturally significant for Aboriginal and European cultures as a water source upon which they relied for survival. Today, of the once geyser-like 4,700-odd artesian bores drilled, only 3,400 boreholes continue to flow at a steadily decreasing rate.

The previously accepted conceptual model of the hydrogeology of the GAB depicted below makes a number of assumptions; simple geology, no interaction with over or underlying geological basins, simple groundwater flows, important upward leakage and that the system as a whole is in a steady state, however this model didn't elucidate why these bores were decreasing in flow.

Accordingly, a need to refine this model was identified, giving rise to the project "Allocating water and maintaining springs on the western margin of the GAB", in order to both improve resource management and protect the springs. This was funded by the National Water Commission and was a collaborative work between Flinders University, Adelaide University, CSIRO, SA and NT Government Department, SAALNRM and overseas researchers.

The project had 2 main components:

- Ecology, with the purpose of characterising the ecology of the Groundwater Dependent Ecosystems (GDE) and develop new tools to study them, including two sub-projects: Spatial Analysis and Remote Sensing of GDE
- Hydrogeology, with the aim of understanding the groundwater system by studying the recharge, aquifer and discharge parts of the system, including three sub-projects: Recharge, Aquifer system and Discharge.

The remote sensing sub-project of the ecology component aimed to;

- develop and evaluate methods to detect, map and monitor GAB spring-fed wetlands and surrounding environments;
- delineate the extent and distribution of perennial wetland associated with GAB springs and differentiate these from surrounding dryland vegetation
- delineate the extent and distribution of dominant wetland vegetation species associated with GAB springs
- quantify changes in GAB spring wetlands over time
- relate the extent of wetland vegetation to spring rates

To do this, very high resolution satellite imagery (QuickBird satellite image, 2.4 m resolution) was

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used to determine the relationship between image greenness and ground vegetation cover, and Hyperspectral airborne imagery (Hymap, 3m resolution) was used for mapping dominant vegetation species

The satellite imagery indicated that spring tails were highly dynamic over short periods of time and that there was a strong correlation between spring flow and wetland area. Hyperspectral imagery enabled visual differentiation of plant species as a result of their location related to the spring function– i.e. the vent or tail.

The objective of the hydrogeological component for this project was to understand the groundwater by examining recharge, aquifer system and discharge. Recharge for the springs occur via three mechanisms; diffuse recharge, ephemeral river recharge and mountain system recharge.

Diffuse recharge generally occurs by rainfall infiltration through the soil surface followed by percolation through the unsaturated zone to the water table below. Previous estimations of the recharge contribution by this process were of around 0.16 mm/y. The aim for the diffuse-recharge sub-project was to gain a regional estimation of recharge contribution by this process across the western margin and measure the paleo-recharge signal in unsaturated zone soil profiles.

Using chloride deposition rate estimates, diffuse recharge was in the range of <0.1 to 1.8 mm/y along the western margin, with a mean of 0.15 mm/y.

To determine paleo recharge, a continuous core was obtained from the unsaturated zone and analysed for chloride and soil water potential. The results indicated that the mean pore water residence times were up to 20,000 - 30,000 years in the unsaturated zone (~100 m), indicating that actual diffuse recharge occurring at the water table results from Pleistocene rainfall.

Ephemeral river recharge is indirect recharge resulting from episodic flow events in arid zone rivers. Monsoonal rainfall in the region results in flooding events. A flow event on the Finke River of 8.5 days was measured during the study period and a corresponding groundwater level increase of 3.4m was recorded, which concurrently saw aquifer recharge of 1275 mm for the event at a rate of 150 mm/d. Thus, unlike what was previously assumed, the surface water and groundwater systems are contiguous and actively exchanging water. An event of this magnitude might occur every 3 years. Recharge through ephemeral riverbeds ranges between 380 – 850 mm/y in the Finke River and 17 – 92 mm/y in the Plenty River .

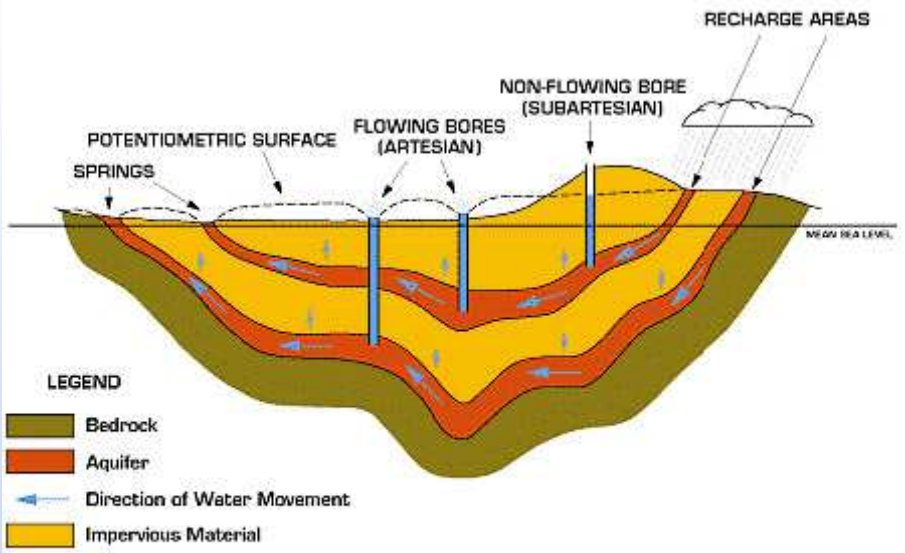
Mountain System Recharge (MSR) is groundwater recharge derived from mountains feeding into adjacent aquifers. This project sought to identify MSR processes on the western margin, and to characterise MSR along the Peake and Denison Inlier. Techniques employed to ascertain this characterisation included groundwater chemistry analyses (for major ions, strontium isotopes, radiocarbon, stable isotopes of water, noble gases), drilling and geophysics (electrical resistivity imaging).

The results indicated that MSR was occurring in the J aquifer in the past and continues to presently . Most recharge identified in this study was paleo-recharge, but some modern recharge is occurring at Marla. The MSR processes occurring can be directly related to the complexity of spring systems, originating from the J aquifer, MBR springs and mixed sources springs

It was necessary to examine three different components to understand aquifer hydrogeology in the study - horizontal flow, vertical flow and the hydrodynamic state of the western margin aquifer. The aim of studying horizontal flow was to interpret and model its movement on a corrected potentiometric surface map. This was a difficult task due to the variability of water density in the GAB due to salinity, temperature and pressure.

To correct for this variability, it was necessary to produce a potentiometric map from a reference constant density, which also necessitated correction of the measured hydraulic heads. The new map is compared with the previous potentiometric surface overpage, with striking results.

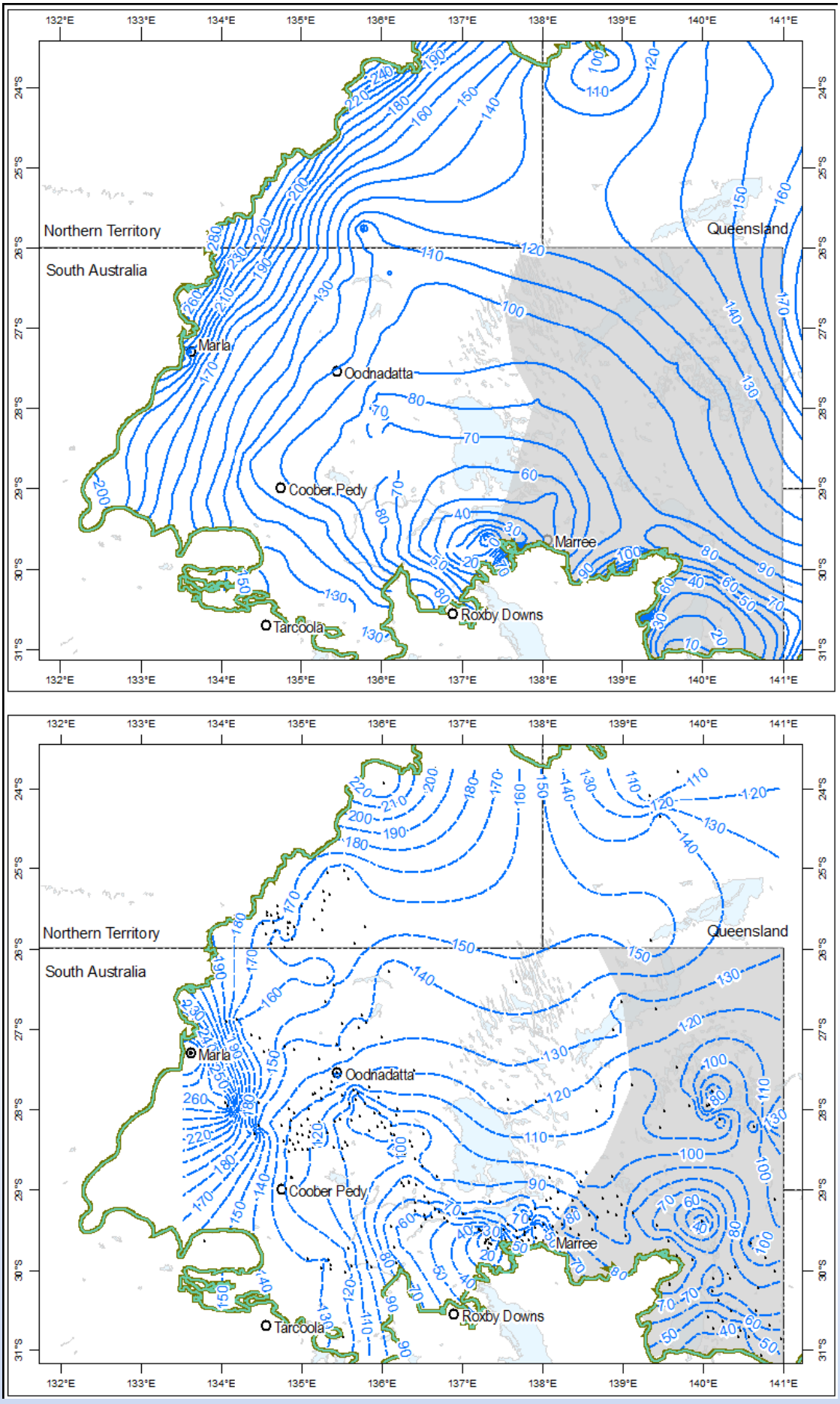
The potentiometric surface is more complex than previously estimated



Present conceptual model of the GAB

(Continued on page 4)

Uncorrected potentiometric map for the western GAB (top) vs. corrected potentiometric map (bottom)



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(Continued from page 2)

and indicatesthat groundwater flows are not continuous from QLD to the Lake Eyre discharge area as previously modelled. The new map shows that the area is in fact influenced by eastern state groundwater flows by up to 30% less than previously estimated.

The aim of studying the vertical flow component was to determine the potential connection between aquifers by recording pressure-elevation plots and conducting cross-sections analyses. The cross-section indicates that there are flows to the discharge area near Lake Eyre, but there was not enough data for below and above the J aquifer to infer vertical cross-formational flows.

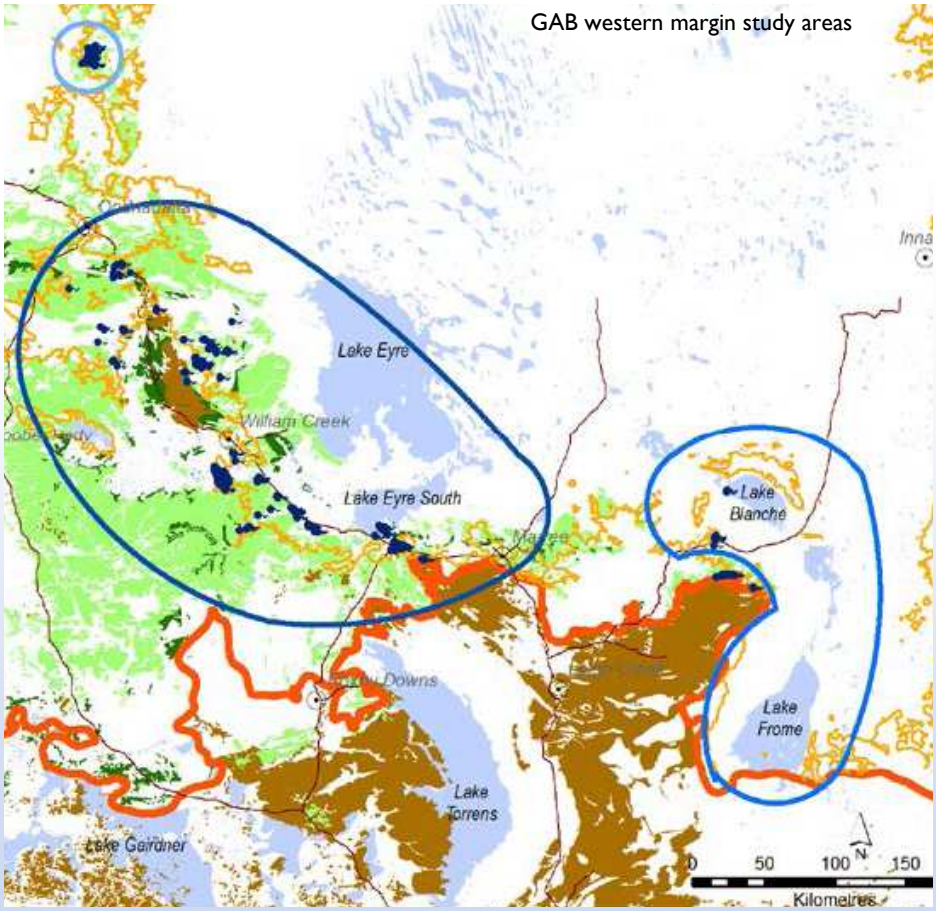
The aim of studying the hydrodynamic state of the aquifer system was to determine if it was a steady state or a transient state, as this has great implications for any modelling. Numerical modelling was used to compare transient and steady state assumptions, which indicate that the transient state of the western GAB is estimated to last for 55,000years. Assumption of a steady state instead of transient leads to an overestimation of the ratio recharge rate to hydraulic conductivity, or in practical terms, an overestimation of the amount of water available.

The aim of studying discharge was to characterise the different mechanisms occurring on the western margin, broken down into three objectives: to;

- understand source and origin of spring water
- understand and time paleo-discharge as an indicator of paleo-hydrogeology and paleo-climate
- estimate the diffuse discharge process through the Bulldog Shale

To ascertain the source and origin of spring water, it was sampled and analysed to determine its hydrochemical makeup – e.g. major ions; trace elements; strontium, sulphur and oxygen isotopes; carbon dioxide and helium. This enabled identification of hydrochemical zonations: mixtures of water from different recharge regions and different flow paths. For example, deeply sourced fluids moving along faults were enriched in helium-3 and helium-4, these being trace elements of mantle derived gases.

Acid sulphate soils were also traceable. Acidic soils occurred in springs due to oxidation of pyrite, resulting in iron-rich salt efflorescence with a pH in the range of <2-3. Different soil profiles have a different pH, and perhaps a different cause for that pH. Acidity of up to 30,000 moles per tonne was recorded in some Acid Sulphate Soils. It was determined that decrease in hydraulic heads exposes pyrite to oxidation, thus a risk for spring ecology, as it results in a change in pH unsavoury for spring specialist species.



GAB western margin study areas

The aim of studying paleo-discharge was to understand and time paleo-discharge as an indicator of paleo-hydrogeology and paleo-climate. This was ascertained by uranium series dating of travertine deposits associated with mound springs. The ages determined ranged between 687,000 years at Dalhousie spring to 9,000 years at Sulphuric spring. The results confirmed that paleo-recharge source for the GAB springs is southern recharge rather than monsoonal recharge

The aim of studying diffuse discharge was to estimate the process through the Bulldog Shale. A field site was selected at Nancy's Bore, where coring to the base of the confining aquitard and shallow groundwater sampling was conducted. Helium-4 was measured in the phreatic aquifer at seven locations across the discharge area. Elevated helium-4 indicates that a preferential discharge mechanism is occurring.

The results showed that in diffuse

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discharge situations the following assumptions are incorrect; there is no interaction with underneath or above geological basins, groundwater flow is simple; there is important upward leakage and that the GAB systems are in a steady state.

The results of hydrochemistry analyses indicate that there are actually fault-influenced sub-basins and that important mixing along faults is occurring, which shows that there is in fact complex geology existent in the GAB.

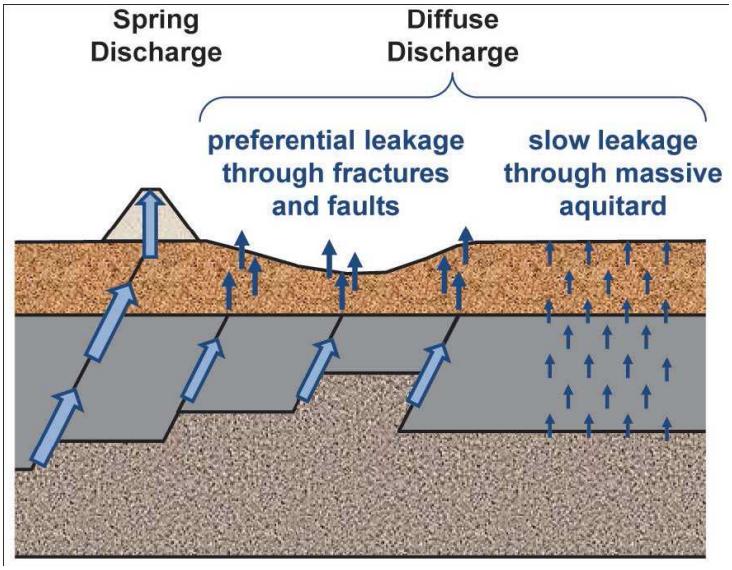
The helium present in fluids sampled indicates that there are upward fluid movements from deep depths; Dalhousie spring hydrochemistry has a distinctly Permian aquifer signature. Therefore, interaction *is* occurring with underneath or above geological basins – there is, in fact, a vertical connection through the fault.

The results also indicate that faults and other driving forces such as gravity and buoyancy, play an important role, signifying that groundwater flows are not simple, but are actually very complex.

It was concluded that upward leakage is in the order 103 to 106 times smaller than previous estimations, and preferential pathways through fractures and faults much more important than diffuse sources. It was also ascertained that the last climate transition was around 10,000 - 6,000 years ago, that the time it will take to reach a new steady state is in the order if 55,000 years, and that discharge is currently exceeding recharge indicates that the GAB is not in a steady state, but in a transient state.

These findings have significant implications for water allocation planning for the GAB, which will need to be addressed in policies to ensure sustainable management of this resource.

Conceptual cross-sectional diagram indicating discharge processes



ONE STOP SHOP FOR GROUNDWATER INFORMATION

The Department of Environment Water and Natural Resources has launched a one-stop shop for well information. The online application enables users to find important information and data on wells, also called drillholes and bores, across South Australia. Groundwater Data combines two existing systems (Obswell and the Drillhole Enquiry System) so that well information can be easily found in one place.

It is expected that a range of people from drillers and farmers to real estate agents and consultants, will use the system, with information ranging from the number of wells in a particular area to the groundwater quality in a certain location.

The new application is fast and easy-to-use enabling users to find important information about groundwater across the state. Benefits of the new application include:

- Improved access to the latest information, including water levels and water quality.
- Interactive Google Maps, including street view and satellite imagery.
- Map layers can be selected to show different boundaries for local government areas, NRM regions, prescribed areas, observation well networks and mining tenements.
- Improved search facilities and features.
- The ability to print and download information in different formats including spreadsheets.
- Graphs showing water levels and/or salinity levels for a selected well, if available.

The tool is designed to be used by members of the public, including landowners, drillers, irrigators, property service companies and consultants. The application uses much clearer graphics and is more user friendly. There are also a number of help videos to guide people through using the application. It will help to answer most enquiries and provide details on how to get further information for specialist users, such as drillers, scientists and research organisations.

To find out more about the Groundwater Data application visit www.waterconnect.sa.gov.au.

GREETINGS FROM CANADA...

David Seeliger

Hasn't time flown, we have been living in the land of snow and mountains (Calgary, Canada) for a little over 2 years now. Yes they have real mountains, sometimes lots of snow, pristine lakes and rivers with lots of water, well not as much as you might think, but more on that later.

Being a Commonwealth country you would expect that the language would be the same. Well they do speak predominantly French in some of the eastern parts of Canada, but in Alberta it is surprising to find many differences, especially in Engineering. At least Canadian's work mainly in SI units though.

Besides driving on the right side of the road which was easy to adopt, it was harder to walk down the right side of the corridor. Car number plates stay with the person rather than with the vehicle, a Truck is the usual term for a 4WD and most houses have basements.

Terms like pound key (#), light switches are up for on are other examples. Similarly for engineering, a catch basin is a side entry pit, a storm sewer is an underground drain, a release rate is a flow rate (often stated as L/s/ha) and Low Impact Development is the same as WSUD.

It is a generalized statement, but stormwater management and modeling techniques here are said to be 10 years behind the practices in Adelaide. Many of the hydrological modeling packages still require text based input files and they all use only a 1 hour and 24 hour Chicago storm event. These temporal patterns have all the shorter duration events nested in the 1 hour and the 24 hour events.

I believe that the BC Tonkin GENDRAIN program also used a similar temporal pattern or envelope storm to reduce the computer run time in the 1980's and early 1990's. It is surprising to discover that many civil engineers don't know what a hydraulic grade line is or have never calculated one. This is because storm sewers are designed not to surcharge to protect basements from flooding. Often inlet control devices ICD's or orifices are placed on the catch basins and all structures are streamlined to reduce the potential for surcharging.

One innovative hydrological analysis method for sizing detention basin storage involves using a continuous simulation model (running 50 years of 1 hour data) to determine annual maximum storage volume to achieve a particular predevelopment release rate. A statistical analysis is then conducted to determine the storage required for the 100 year event. The larger of the storage volume derived from the event and the continuous model is then adopted for the design.

There is a big push to implement WSUD or LID's within urban development within Alberta. A not-for-profit society called the Alberta Low Impact Development Partnership (ALIDP) has been established about 5 years ago to promote LID's.

The partnership involves a broad range of disciplines including hydrologists, civil engineers, landscape architects, horticultural and ecological specialists. It has allowed broad dialog between disciples and broken down many of the traditional silos. Its mandate is to provide education and training, advocacy and research into LID's within Alberta.

I have been actively involved in giving presentations and undertaking design work for their research indicatives. I have recently been nominated to the board and been elected Vice President.

The Bow River, the main river passing through Calgary, has been closed to new water allocations for a few years now. This has constrained development expansion in a number of municipalities as water allocation trading is very immature in Alberta. These limitations will increase the value of water over time. The Bow River is also reaching and exceeding its total suspended solids and phosphorus loading limits and is one of the key driver to adopt best management practices, particularly WSUD. The province is developing a stakeholder driven plan to reduce the phosphorus loading on the Bow through BMP's to mitigate existing point and non point source loadings.

Another driver to adopt WSUD is the recent volume control targets being placed on local tributaries that are under urban development pressure. Volume targets down to 11mm/year have been set based on predevelopment runoff volumes and limiting environmental damage such as stream erosion. This is for a climate with an average precipitation of 420mm/year.

I have had the opportunity to work in a variety of water resource areas, including dam safety, urban and rural hydrology, stormwater management planning and detailed design (including for oil sands developments) and many aspects of LID. This has included developing detailed technical guidance for absorptive LID practices (bioretention, bioswales and absorbent landscapes) one of six LID modules being prepared for the City of Calgary.

Preparing a policies and procedures guideline to implement volume control targets for future urban development, detailed design of bioretention facilities and planning of several subdivision with significant LID components. Even though LID's are still in the infancy in Alberta, the intent is that they will become standard within most if not all development within Calgary in the not too distant future.

I hope to expand on some of the unique issues and aspects of water resources and stormwater management within Alberta and Canada in future articles. Bye for now!

UPCOMING EVENTS

13th International Conference
Wetland Systems for Water Pollution Control

IWA International Water Association | Specialist Conferences

25 - 29 Nov 2012 Murdoch University

Hosted and Organised by Murdoch University Perth, Western Australia in collaboration with IWA and AWA, this is the biennial meeting of the IWA Specialist Group on the Use of Macrophytes in Water Pollution Control.

The major aim of the Conference is to bring together researchers and professionals to discuss new developments and exchange experiences in the field of constructed wetland systems. The Conference will highlight the latest improvements and achievements in the treatment of urban stormwater runoff, domestic and municipal wastewaters, agricultural and industrial effluents.

Conference Topics include:

- Process Dynamics
- Management and Control
- Case studies
- Design criteria
- Economics
- Environmental issues and operation policies
- CW Components
- Modelling of wetland treatment processes
- Systems with enhanced/ active aeration
- Floating emergent macrophyte wetlands
- Suitability of treatment wetlands for developing countries
- Removal of pharmaceuticals, heavy metals, surfactants and other emerging pollutants
- Stormwater and industrial wastewater treatment
- Mine water treatment
- Combined algal systems
  Wetland and waterway restoration
  Non point source pollution control

Option of two day pre-conference tour to South West of Western Australia and a two-day post-conference Wetland Modelling workshop
More information from website
http://www.promaco.com.au/events/wetlandsystems2012.html

Griffith UNIVERSITY

The 16th International Workshop on Physical Processes in Natural Waters

Queensland, Australia
July 8 - 11, 2013
Venue to be confirmed

The focus of the PPNW workshops is the physics of inland and coastal water bodies and their interactions with the physical and biogeochemical processes that control water quality, ecosystem function, and the services such systems provide.

The workshops traditionally cover a broad spectrum of scientific topics. Besides general topics, the Queensland workshop will pay special attention to the coupling of physical and ecology processes and water quality in sub-tropical lakes.

PPNW is an open workshop, actively seeking to expand contacts with neighbouring fields such as physical oceanography, the atmospheric sciences, and engineering.

With 40 to 60 participants and a small number of invited speakers, the PPNW meetings are characterized by their active workshop atmosphere and a comfortable time frame for presentations and discussion.
http://www.griffith.edu.au/conference/physical-processes-natural-waters-workshop-2013

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MEDIA WATCH

Looking for link between Indonesian Throughflow and Australian climate
CSIRO scientists are heading to the Ombai Strait and Timor Passage to collect data vital to understanding how an ocean current in the region affects Australia's climate and weather.
http://csironewsblog.com/2012/09/25/looking-for-link-between-indonesian-throughflow-and-australian-climate/

Australia setting the standard for water information exchange
CSIRO research has been turned into an international standard with the adoption of a water information exchange standard, WaterML2.0.
http://www.csiro.au/Portals/Media/Australia-setting-the-standard-for-water-information-exchange.aspx

Bath time's over for computer models
It's time for computer models of tsunamis and storm surges to get out of the bath, according to a CSIRO researcher speaking at the Coast to Coast Conference in Brisbane on September 21, 2012. More realistic models are needed for infrastructure planners and emergency managers to better prepare for disasters.
http://www.csiro.au/Portals/Media/Bath-time-is-over-for-computer-models.aspx

Sustainable Coastal Management and Climate Adaptation examined in new book
Sustainable management of Australia's much-loved coast is complex and challenging. Much is already known about coastal environments, but to date, coastal management has had limited success; in some cases management decisions have made problems worse.
http://www.csiro.au/Portals/Media/Sustainable-Coastal-Management-and-Climate-Adaptation-examined-in-new-book.aspx

New Aquatic Ecosystems Toolkit released
The Aquatic Ecosystems Toolkit has been prepared, in collaboration with states and territories, as a set of good practice tools designed to provide a nationally consistent framework for mapping and classifying aquatic ecosystems, identifying high ecological value aquatic ecosystems and assessing their ecological condition.
http://www.environment.gov.au/water/topics/aquatic-ecosystems.html

Major changes needed to protect Australia's species and ecosystems
A landmark study has found that climate change is likely to have a major impact on Australia's plants, animals and ecosystems that will present significant challenges to the conservation of Australia's biodiversity.
http://www.csiro.au/Portals/Media/NRSreport2012.aspx

Report card shows Australia's oceans are changing
Launched August 17, the 2012 Marine Climate Change in Australia Report Card demonstrates that climate change is having significant impacts on Australia's marine ecosystems.
http://www.csiro.au/Portals/Media/Oceans-are-changing.aspx

Gillard Labor Government acts to stop super trawler
Environment Minister, Tony Burke, has announced plans to legislate to extend his legal powers over the super trawler FV Abel Tasman, (formerly FV Margiris), to prevent the vessel fishing in Australian waters.
http://www.environment.gov.au/minister/burke/2012/mr20120911.html

Meeting the challenges of the future on the Great Barrier Reef
Work is set to begin on the strategic assessment of the Great Barrier Reef to ensure future development along the Queensland Coast is well planned and the area's unique values are protected.
http://www.environment.gov.au/minister/burke/2012/mr20120831.html

Climate change adaptation in the frame
Minister for Sustainability, Environment and Conservation Paul Caica launched a new framework to shape climate change action by Government and the community in South Australia.
http://www.premier.sa.gov.au/images/news_releases/12_08Aug/climate_change_adaptation_framework.pdf

Assessing water stress in Australian catchments and aquifers
The findings presented in this report represent a first step to open a dialogue with governments to identify overused and overallocated systems, as the precursor for advancing this critical NWI objective.
http://www.nwc.gov.au/publications/topic/planning/water-stress