National Groundwater Committee

Issue Paper 1

Integrated Groundwater – Surface Water Management

The Problem

It has been known for many decades that water in the hydrological cycle is in a continuum between the various parts of the cycle, and development or contamination of one component will impact on the other parts of the cycle. Surface water rights are also potentially affected when groundwater extraction has an impact on the timing and volume of surface water flows. Yet groundwater and surface water have traditionally, and generally continue, to be managed separately in Australia.

Major developed groundwater systems with identified connections to surface water resources have been mapped for inland NSW (Braaten and Gates, 2002). Similar connections exist in all States but the spatial and temporal information is not readily available. Recent work for the Murray-Darling Basin Commission shows that growth of groundwater usage in the Basin from 1993/94 to 2002 represents a 2% undermining of the Cap by capturing baseflow. This amount is expected to grow in the coming years. Failure to appreciate the connection between surface and groundwater has resulted in major rivers and streams in the United States, the United Kingdom, China and other countries drying up because of large groundwater pumping.

The separate management arrangements for surface and groundwater that exist across much of Australia are artificial and, in some important groundwater resources, detrimental to good natural resource management and nett community interest.

With a maturing of natural resource management in Australia, there has been a move towards integrated natural resource management across catchments. However there remains much to be done, with policy settings, institutional arrangements and lack of understanding of surface and groundwater connectivity of specific resources, being some of the major impediments.

Background

Surface and groundwaters are often intimately connected, with changes in one affecting the other over short time periods and distances. In Australia, water fluxes may change direction several times during the length of the river, changing from a losing river to a gaining river depending on local geological controls. Determining where this occurs requires detailed studies.

***NOTE**: some significant Australian groundwater resources can be considered to be "fossil waters", deposited in much wetter times in geologic history and effectively dis-connected from surface water systems within contemporary management time scales. Such resources are outside the scope of this paper.*

In a pre-development aquifer water balance, over the long term, river leakage and other inputs such as rainfall infiltration balance river discharge and other outputs like discharge to lakes and wetlands, and evapotranspiration. Water levels may fluctuate from year to year but remain relatively stable over the long-term. Development of groundwater extraction bores introduces a new form of discharge and the system must respond by moving to a new equilibrium.

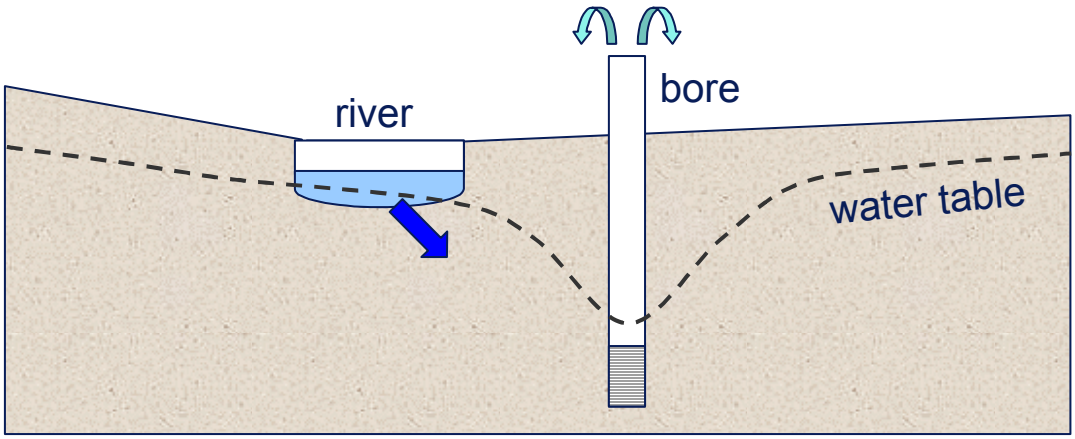

Figure 1 **A 'cone of depression' formed around a pumping bore and inducing river losses**

Initially the groundwater pumped comes from a loss in aquifer storage as water levels decline around the pumping bore and form a cone of depression. As this cone expands, it begins to affect the other fluxes - either inducing additional recharge or decreasing discharge until the change in these fluxes balances the pumping losses. If the cone of depression intersects a river, then streamflow losses will occur through either reduced baseflow or induced seepage (see Figure 1).

Generally, stream losses, caused by groundwater pumping, will increase when the stream is hydraulically connected to the aquifer. As rainfall recharge is generally not sensitive to groundwater levels, the majority of losses will come from the river or from other discharge sinks.

As the cone of depression must expand and intersect the stream before losses occur, there is a time lag between groundwater pumping and the maximisation of streamflow depletion. Both the **volume** and **timing** of stream depletion are critical factors for management. The main influences on these factors are:

- the distance between pumping bores and the river;
- aquifer and streambed properties (transmissivity and storativity);
- the length and location of hydraulic connection;
- the distribution and degree of interaction with alternative discharge sinks and/or sources of induced recharge.

Generally large and rapid river losses will occur in response to groundwater pumping when the aquifer is highly transmissive, the pumping bores are close to the river, the river is hydraulically connected near the location of pumping and there are no other large discharge sinks nearby.

Several approaches have been used to characterise the degree of stream depletion in river-aquifer systems including numerical models, analytical functions, tracer studies and general rules of thumb, with the method used dependent on the complexity of the system, the magnitude of extraction and the risk to other users and the environment. Some of these methods have been developed overseas, and work is needed to adapt them to Australian conditions. Simple methods then need to be developed which allow regulating agencies to predict the reduction in surface water flow that is likely to result from existing and proposed groundwater extraction regimes, and the timescale over which this reduction will occur.

Policy and Management Directions

The management implications of groundwater – surface water interaction will vary according to the timing of the impacts.

- Where time lags between groundwater pumping and stream depletion are very large, say in the order of decades or longer as they are likely to be for many of the larger inland aquifers of the country, the issue is one of long-term planning and intergenerational equity.
- Where time lags are within a management timeframe, the impacts of groundwater extraction on surface water users and environmental flows need to be incorporated into the water management framework.

In highly-connected systems where groundwater and surface licences have been issued separately, the same megalitre of water may have been allocated twice and systems which would not be considered to be over-allocated in isolation may in fact be over-allocated when considered in tandem. Likewise in connected systems where the surface water component has been embargoed or capped but the aquifer has not, further allocation of groundwater could result in either impacts on environmental flows or reduced reliability for surface water licensees, or both. This issue is particularly significant in the Murray-Darling Basin where surface water extraction has been capped under an inter-state agreement but groundwater extraction is not capped for all major aquifers.

In unregulated rivers, the seasonal timing of impacts is also important. Management systems are in place ensuring that surface water users share summer low flows with other users and the environment. Groundwater users are generally not part of these systems. While their impacts under current levels of extraction may have been implicitly factored into management strategies, any change or increase in the pattern of extraction could affect the availability of low flows for surface water users and the environment.

Groundwater – surface water extraction is an emerging issue in Australia and substantial technical investigation and policy development will be needed.

Technical challenges include:

- characterisation of the spatial aspects of connection for the major river-aquifer systems of Australia, including the location and extent of hydraulic connection and the reaches where the majority of the impact will be felt;
- characterisation of the temporal aspects of connection including the lags, attenuation and seasonal variation in extraction impacts;
- development of generic approaches/tools to identify and quantify the nature and extent of interaction between the surface and groundwater;
- detailed case studies to develop a conceptual understanding of connection in Australian systems and evaluate the applicability of overseas research.

Policy challenges include:

- management frameworks that explicitly recognise that, in highly connected systems, rivers and aquifers are ‘one resource’ and that integrate extraction limits, embargoes and caps for the two systems;
- strategies to address groundwater extraction in both regulated and unregulated river systems and meet surface water environmental flow requirements;

- methods for accounting for stream depletion due to groundwater extraction under the Murray-Darling Basin surface water cap.

Another major challenge is the likely resistance by water users to management change given the already substantial changes they have endured in recent times.

The Way Forward:
Where groundwaters and surface waters are 'highly' connected then fully integrated management must be the long-term goal. Where a lesser connection exists it may be practical to manage the water resources separately, but recognise in planning and management the effect that one resource has on the other.

There are specific water resources in Australia that are considered 'highly' connected and which require early attention. Preliminary work in NSW for example has highlighted the importance of the issue for Murray Darling Basin catchment and suggests several aquifers require integrated management (eg. Upper Murrumbidgee and Upper Lachlan). Similar detailed information is not generally available elsewhere however the need for integrated management extends nation wide wherever rivers and aquifers are closely connected.

The following is a suggested way forward on this issue

- NGC to prepare a short paper that defines a 'highly' connected groundwater surface water system for the purpose of integrated management.
- Jurisdictions to identify key ground/surface water systems, with high agricultural, environmental and social values that are 'highly' connected.
- Development of generic methods/tools for assessing/measuring the degree of hydraulic connection between surface and groundwater systems for use by individual jurisdictions as appropriate
- Detailed case studies to develop a conceptual understanding of connection in Australian systems and evaluate the applicability of overseas research.
- Development of educational materials for water users to explain the nature and extent of surface/groundwater connections and the implications for extractive use of either form of the resource for use, by individual jurisdictions as appropriate

Reference

Braaten R, and Gates G. 2002. Groundwater – surface water interaction in New South Wales: a scoping study. Presented at River Symposium 2002, Brisbane, Sept 3-6.