Australian Government
Department of Agriculture, Fisheries and Forestry
Bureau of Rural Sciences

Connected Water

Managing the linkages between surface water and groundwater

Introduction

Groundwater and surface water are interconnected and interchangeable resources in many regions of Australia. This connectivity can have significant implications for both water availability and quality, and presents major challenges for water managers and policy makers in Australia. Understanding the connectivity between surface water and groundwater is critical if Australia's water resources are to be sustainably managed.

Increasing demand for water and a decline in the availability of surface water has seen significant growth in groundwater extraction in Australia. Independent management of groundwater and surface water means that there is a risk of allocating the same water twice. Discharge of fresh groundwater into a stream is critical for surface water users and aquatic ecosystems during the low-flow period. Pumping from an aquifer near a river can dramatically change the amount of this baseflow to the stream. In contrast, if the groundwater is salty or contaminated, increased groundwater discharge can have a negative effect on surface water quality. Hence, effective management of water quantity and quality issues requires an understanding of these surface water and groundwater interactions.

What is connectivity?

Connectivity refers to flows between water resources located above ground (surface water) and below ground (groundwater). Factors such as topography, geology and climate can change the direction and magnitude of these flows. Gaining streams can be fed by groundwater and losing streams can recharge underlying aquifers (Figure 1). With rainfall so variable in Australia, streams can vary between gaining and losing over time.

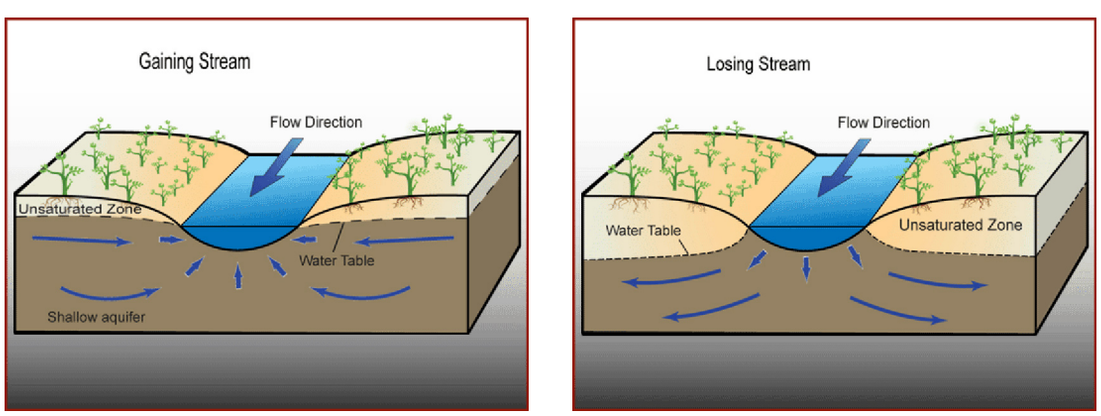


Figure 1: Examples of gaining and losing streams

Why is connectivity important?

As groundwater is abstracted from bores, the water table around the bore will decline. Water is drawn from within the aquifer towards the bore, reducing the flow moving through to streams, natural springs or other bores and aquifers (Figure 2). More generally, any groundwater abstracted can be expected to result in reduced surface water flows at some time in the future. Similarly, a change in the way in which surface water is managed (for example, by the construction of additional surface water storage capacity) can alter groundwater dynamics through increasing or reducing recharge.

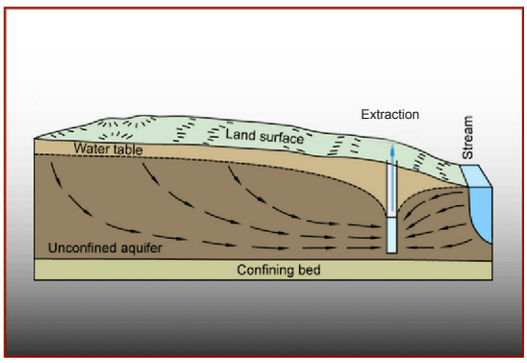


Figure 2: Bore interception of stream baseflow and bore induced aquifer recharge

Supporting National Water Reform

The *Managing Connected Water Resources* project examines the nature of connectivity between surface water and groundwater resources and the management and policy implications of this connectivity. The project is consistent with the goals of the National Water Initiative (NWI). In particular, it represents a major contribution towards "*recognising the connectivity between surface and groundwater resources and managing connected systems as a single resource*" (NWI Clause 23 x).

An Adaptive Management Framework for Connected Groundwater and Surface Water Resources

An adaptive management framework for connected groundwater and surface water resources has been developed to support national water reform. The framework aims to provide a consistent national approach to conjunctive water management in Australia in line with the principles of the NWI (www.nwc.gov.au/nwi/index.cfm).

It is designed to help water managers, water authorities, policy makers, catchment groups, industry groups and others to learn more about evolving water management priorities and requirements to facilitate coordinated responses.

This framework provides a context within which existing groundwater and surface water management can be integrated and provides social, environmental and economic outcomes across industries and regions. The framework is comprised of six toolboxes structured within a generic adaptive management cycle (Figure 3). Each of the toolboxes is designed to house 'tools' in the form of water management methods or guides. Tools represent different options available at that point of the management cycle.

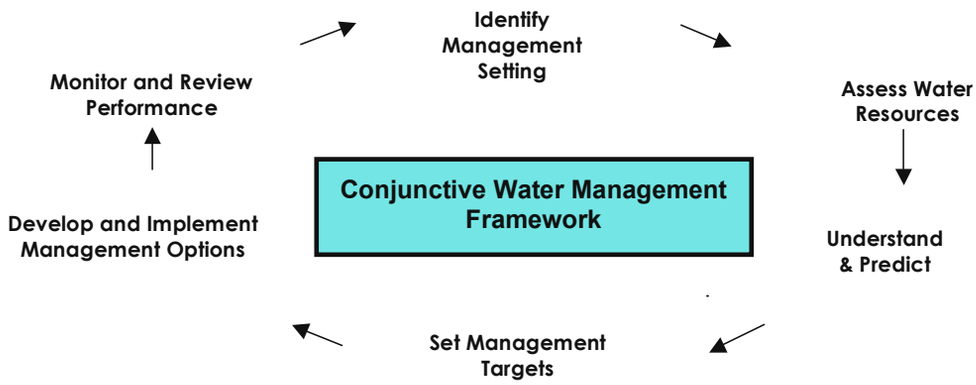


Figure 3: An adaptive management framework for connected groundwater and surface water resources in Australia

Tools to Assess Connectivity

Assessing groundwater and surface water interactions is often complex and difficult. However, there are a range of methods available to assess the nature and degree of connectivity. These tools can be defined in terms of: spatial scale, temporal scale, cost, ease of use, advantages, limitations and application. A summary of these tools is presented on the following page. Detailed information on various tools can also be accessed through the Connected Water website (www.connectedwater.gov.au).

Summary of tools to assess groundwater and surface water connectivity

Tools	Scale	Cost	Ease of Use	Comment
Hydrographic analysis Processing of time-series stream flow monitoring to define baseflow (groundwater discharge) component	Intermediate to regional	Low	Easy	Commonly applied method for unregulated Australian catchments
Hydrogeological mapping Mapping of groundwater systems including flowpaths, groundwater quality, aquifer structure and properties and geomorphology	Intermediate to regional	Medium to High	Moderate to Difficult	Groundwater flow system, surface geological and hydrogeological mapping is available at a coarse scale for most groundwater management regions across Australia
Modelling Simulation of water flow regime around streams using mathematical equations	River reach to catchment	Low to High	Moderate to Difficult	Requires data from other methods for calibration. Surface water models are commonly developed in isolation to groundwater models
Geophysical survey Use of a range of remote sensing technologies that are useful for mapping hotspots and landscape parameters that indicate connectivity	Stream reach to catchment	Medium	Moderate to Difficult	Opportunities may exist to use geophysical data collected for other purposes eg. mineral exploration. Satellite imagery is commercially available, some free in public domain
Seepage measurement Direct measurement of water flow between stream and aquifer at specific points	Site specific	Low to Medium	Easy	Main application to date in Australia has been investigating leakage from irrigation channels or studying aquatic ecosystems
Artificial tracers Monitoring movement of introduced tracers such as fluorescent dye	Stream reach to site	Medium	Moderate	Not routinely applied in connectivity studies in Australia. Overseas focus is on karstic aquifers or investigations of contaminated sites
Hydrochemical and environmental tracers Use of the chemical constituents of water (such as major cations, anions, stable isotopes, radon and chlorofluorocarbon) to track water flow	Stream reach to catchment	Medium to High	Moderate to Difficult	Commonly used in Australia in connectivity studies to identify the sources of recharge and groundwater inputs to streams
Temperature Measurements of variations in stream and sediment temperatures as 'tracers' to identify gaining and losing reaches	Site specific	Low	Easy to Moderate	Limited examples of being applied to study groundwater and surface water interaction in Australia to date
Hydrometric analysis Measurement of hydraulic gradient between aquifer and surface water feature and the hydraulic conductivity of the intervening aquifer material	Site specific to reach to catchment	Low to Medium	Easy to Moderate	Comparison of stream levels with nearby groundwater levels commonly used to define seepage direction
Water budgets Use of river reach water balances to define seepage component	River reach to catchment	Low to Medium	Easy to Moderate	Need to quantify stream inputs and outputs such as diversions and extractions. Some examples using the available stream flow gauging data

Management options

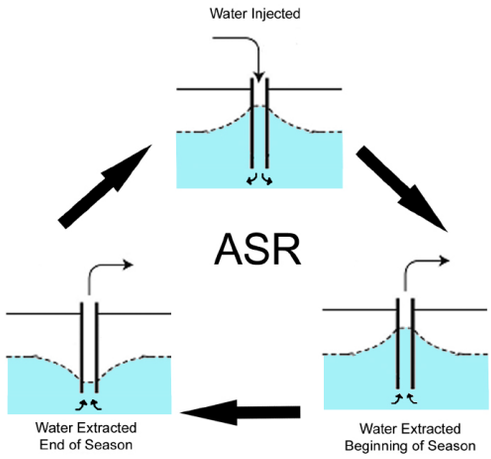
There are a range of policy and on-ground investment options available for implementing a conjunctive water management approach. The management options are:

Policy Options

- **Licencing and Allocation** - total water accounting, linking of management plans, coordinated embargoes, tiered access, triggers and thresholds
- **Water Trading** - compatible licences, cost structures, infrastructure capacity and ownership
- **Management Zones** - stream buffer zones
- **Risk Management** - aquifers as drought reserves, coordinating groundwater-surface water storages, using climate predictions
- **Land Use Planning** - salinity mitigation, water quality protection

Investment Options

- **Water banking** - aquifer storage and recovery (ASR), infiltration ponds, underground dams, recharge releases
- **Water treatment** - bank filtration, dune filtration, soil aquifer treatment
- **Water interception** - salt interception schemes
- **Water supplementing** - streamflow augmentation, water provision for groundwater dependent ecosystems (GDEs)



Connected Water Website

The Connected Water website contains information on groundwater and surface water connectivity issues for policy makers, water managers and catchment groups.

Log on to the Connected Water website (**www.connectedwater.gov.au**) to find out:

- How does groundwater interact with surface water?
- Why should groundwater and surface water be managed conjunctively?
- How connectivity can be assessed?
- What tools are available to assess and manage connectivity?
- What are the policy implications for managing connected systems as one resource?

Key features of the website:
- Information on conjunctive water management policy
- Tools to assess stream-aquifer connectivity
- Latest national and international case study reports
- Extensive reference database with over 1,500 entries to search and download
- Comprehensive glossary of groundwater and surface water terminology
- Colourful photo gallery
- Additional groundwater and surface water web links

How can I obtain more information?
For further information visit **www.connectedwater.gov.au** or contact us at **connectedwater@brs.gov.au**

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