Landscapes & Industries

KNOWLEDGE

Groundwater Flow Systems Framework

ESSENTIAL TOOLS FOR PLANNING SALINITY MANAGEMENT

Summary Report

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MURRAY-DARLING BASIN COMMISSION

The Groundwater Flow Systems Framework – a tool for regional natural resource management planners

There is nothing new about salt in the Australian landscape - it has been accumulating there for millions of years. Relatively recent is its mobility, propelled by clearing, land use and land management practices that collectively have increased groundwater recharge, leading to increasing groundwater flows.

Dryland salinity and its impact on water quality is now a national problem, occurring in all states and territories and impacting directly or indirectly on all Australians.

Commonwealth and state governments are leading a strategic response to this and other environmental threats through the National Action Plan for Salinity and Water Quality and the Natural Heritage Trust. In the first instance this response calls for a consistent national appreciation of the issue:

- how big is the problem?
- where are the most urgent or most significant threats?
- what time frames characterise the problem and its resolution?

Regional natural resource management groups are now charged with developing and implementing their own land and water management plans. To do this, they need to answer similar questions at the regional scale, set achievable targets, identify appropriate management options and the likely costs, and monitor their progress.

A **Groundwater Flow System** (GFS) is a model developed by hydrogeologists to describe and explain the behaviour of groundwater in response to recharge. This is a *conceptual* model, similar to an architect's model of a building. It takes into account the geology and geomorphology of the catchment, and the hydraulic properties of the landscape and the aquifer.

That part of the landscape in which a particular GFS (or several GFSs of the same type) operates is referred to as a **salinity province**. Whilst the GFS is clearly influenced by catchment characteristics, the salinity province does not necessarily share a common boundary with the catchment. Surface flow systems do not necessarily match underground flow pathways.

This booklet describes a new and innovative tool – the Groundwater Flow Systems Framework – that makes a significant contribution to this task.

Making sense of a vast, complex landscape

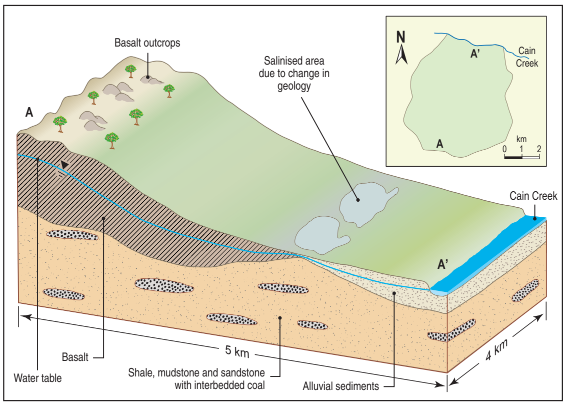
The basic process of salt mobilisation and resultant salinisation of the landscape and rivers is relatively simple and consistent across Australia. However, there are important differences in the detailed processes from one catchment to another, making it difficult to accurately predict the rate of spread of salinity and the impacts of remedial measures.

There is such a vast array of catchments throughout Australia, that it is quite impractical to investigate each in detail and accurately define the salinity risk and prescribe specific management options. However, there is some confidence that similar groundwater flow systems in similar landscapes should present similar salinity issues and therefore respond to similar management.

The Groundwater Flow Systems Framework allows the knowledge and experience from one catchment to be transferred to other similar catchments.

Finding some order

The 'National Classification of Catchments' has defined three major groundwater flow system types – local, intermediate and regional. While examples of each of the major systems have certain similarities, there are significant enough differences to warrant the classification into the fifteen sub-systems – eight local, four intermediate and three regional. Conceptual models have been developed to describe each of these fifteen GFSs and their distinctly different characteristics that influence the processes of recharge and discharge leading to salinity.



A concept model for groundwater flow

Source: Mirko Stauffacher

Source: Mirko Stauffacher

The Groundwater Flow Systems Framework uses these conceptual models to assess the risk of salinity and identify the potential management responses. Next we need to identify where these GFSs exist in the landscape.

Putting GFSs on the map

Groundwater Flow Systems Framework allows us to extrapolate knowledge and experience

Drawing on a long history of data and professional experience, hydrogeologists have identified where these GFSs might be found in Australia's diverse landscape. Based on measurable features such as landscape slope, elevation, geology and geomorphology they have established principles for mapping these groundwater flow systems.

In this way we can now map *salinity provinces* at any scale - regions in the landscape where the physical processes contributing to dryland salinity are characterised by a particular GFS. Those salinity provinces with similar GFSs are likely to respond to similar salinity management options.

The features of each salinity province allow us to address important planning questions for that area:

- What are the current impacts?
- What are the risks of doing nothing?
- How much recharge reduction is needed to achieve an acceptable reduction in discharge?
- Where might recharge reduction be best targeted?
- What are the impacts on water quality?
- What extent of land use change is required and how many landholders will be affected?
- What is the feasibility of removing groundwater by engineering means?
- What is the likely time interval between intervention in the GFS and a satisfactory salinity benefit?

We have now considered the major component parts of the Groundwater Flow Systems Framework – the 'National Classification of Catchments', its associated conceptual models and the maps of the GFSs and their categorisation into salinity provinces. Next we need to test the conceptual models.

Case studies

We predict salinity trends using computer models that simulate groundwater behaviour using existing landscape conditions. To have confidence in these predictions, we use case-study catchments to test our understanding of groundwater processes using real data and measured outcomes.

Researchers have selected nine case study catchments to test the Groundwater Flow Systems Framework. These case-study catchments represent some of the fifteen conceptual models of groundwater flow systems discussed earlier. They were also selected on the basis of the abundance of existing data.

These are catchments with relatively well documented information on many of the factors that affect recharge, salt mobilisation and discharge:

- land clearing (when and where)
- farming practices (what has been grown where)
- deep drainage (leakage under various land uses)
- seasonal rainfall, run-off and evaporation
- piezometer and borehole data
- landscape elevation
- soil properties, and
- regional geology.

The results demonstrated that the nine case study catchments supported the 'National classification of groundwater systems' at the major system level – local, intermediate and regional.

We now have a consistent and validated method for mapping groundwater flow systems and distinct salinity provinces, supported by conceptual models.

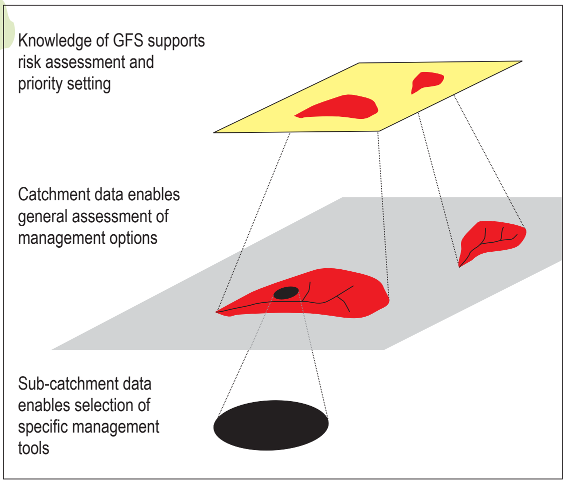
Case studies support the Framework

We can describe in broad terms how groundwater behaves in each part of the landscape. From this we can identify the typical processes leading to dryland salinity, prioritise catchments, propose options for managing them, and predict the most likely outcomes.

A matter of scale

At national and state scales the Groundwater Flows Systems Framework is beginning to guide policy decisions. The identification of local, intermediate and regional GFSs is helping to determine broadly where salinity risk is greatest and where management activities are most likely to be successful.

In the Murray-Darling Basin, more detailed regional mapping has enabled more accurate predictions of salinity risk. This is being used to inform policy decisions and to identify broad management options.



Groundwater flow systems are complicated and it is increasingly difficult to describe them accurately down to the catchment, sub-catchment or paddock scale. There are real limits to how reliably we can expect to transfer management principles from one well studied catchment to another that is not well described.

Good catchment scale data reveals the power of the Framework

This approach recognises that there is no one-size-fits-all solution to dryland salinity, and that management responses must be tailored to local conditions.

The real power of the GFS Framework is revealed when catchment scale data is available, giving local communities more specific information for salinity management. The MDBC Tools project has provided this advice for twelve catchments (presented in ten Regional Information Packages available at www.ndsp.gov.au) and the same principles have now been applied in several catchments throughout South Australia and Victoria.

A framework for tough decisions

The Groundwater Flow Systems Framework links land use and management strategies to catchment-groundwater behaviour. The framework brings together all the key elements of a valuable and credible tool for salinity managers:

- an understanding of the causes of salinity - how groundwater recharges, mobilising salt, in response to changes in land use and management
- conceptual models that describe groundwater processes leading to discharge
- sound methodology for mapping the different groundwater flow systems
- case studies where groundwater processes have been closely studied and model predictions tested and validated, and
- groundwater and surface water data along with quantitative descriptions of hydrogeological features.

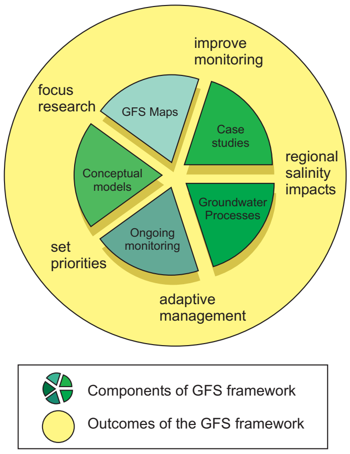
Understanding Australia's groundwater flow systems opens our eyes to the real magnitude of the problem. It is clear that a consistent framework to support regional planning is needed. Catchment communities and individual land managers then have an essential role to play, but as part of regional initiatives. These will be strengthened by sharing information between well-studied catchments, supported by the skills and experience of a handful of technical experts.

Working with the GFS Framework

The Groundwater Flow Systems Framework contributes in several ways to the task of salinity management.

Partitioning - the GFS Framework partitions the landscape into discrete areas, salinity provinces. Each area is characterised by a particular groundwater flow system. Planners (regional, state, national) can prioritise catchments in terms of salinity risk and likely responsiveness to salinity management.

This will help establish reasonable expectations for progress. The GFS approach also assists in designing more detailed data gathering and investigative programs.



Groundwater Flow Systems framework

Extrapolating – the GFS Framework can be used to extrapolate our understanding of well studied catchments to other catchments of the same type.

Aggregating – the GFS Framework enables the aggregation of information across the landscape. We can plan to meet targets for salinity, salt loads and base flow at downstream points of a river by aggregating the anticipated impacts of land use and management changes within particular GFSs.

Many data sets can be used to influence management decisions for a salinity province

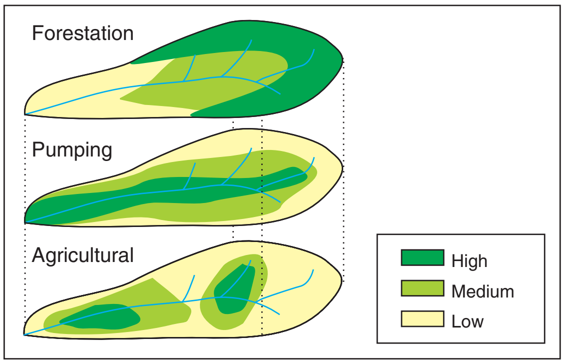
Setting regional priorities

The GFS Framework ranks catchments on the basis of groundwater factors – the key driver of salinity. It brings together the NLWRA's 'National Classification of Catchments', its associated conceptual models, the GFS and salinity province maps, supported by the understanding of groundwater and salinity management options from the nine detailed case studies.

It provides a tool for an *initial* approach to prioritisation at the regional scale, allowing us to divide options into those that have a low, medium or high likelihood of success. With further field work and modelling we can determine the actual *feasibility* of particular management options before the *design* stage.

Choosing management options

Ten regional groups in the Murray-Darling Basin developed salinity province maps and ranked the appropriateness of management options for each GFS (low, medium, high). The results of these workshops are incorporated in Regional Information Packages for improved salinity planning and management (available at www.ndsp.gov.au).



Prioritisation of management options for a salinity province

A decision support tool for engineering options (available at www.ndsp.gov.au) also fits the GFS framework. This provides salinity province guidelines for choosing and designing drainage and pumping approaches to salinity management.

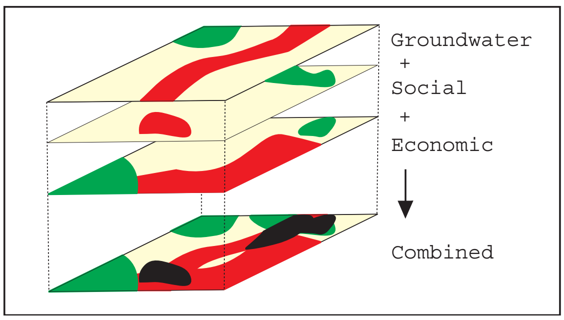
Whilst groundwater might drive salinity, it is not the only consideration. Management plans must also take account of other biophysical factors, together with environmental, economic, and social aspects.

Any ranking process should therefore combine salinity province maps with spatial information on these various factors. Inevitably, natural resource management decisions will result in trade-offs and synergies between catchment objectives and the feasibility of the various management options.

Adapting to change

Our understanding of salinity processes continues to advance as data is collected and processed and as experiences are shared. Management strategies need to adapt to this new knowledge.

The GFS Framework does not overcome the need for locally relevant data and investigations. It provides a platform to inform monitoring and data collection at this scale. Because current groundwater data is so sparse, it makes sense to focus monitoring activities (based on bores and piezometers) in key catchments rather than spread them thinly across a vast landscape. The GFS approach helps us design these investigative programs and optimise our research investment.



Socio-economic factors will influence management decisions for salinity provinces

The GFS Framework - good news for catchment planners

The Groundwater Flow Systems Framework now enables sound national policies for salinity management based on risk assessment.. Ten regions in the Murray-Darling Basin have used the GFS Framework, together with regional GFS and salinity province maps, to define broad management options.

The GFS Framework assists regional natural resource management planners to prioritise their response to the salinity threat based on:

- the assets at risk
- the time scale for further salinity increase
- where best to target remedial action
- the time scale for remediation
- the social and economic cost of mitigation, and
- how and where to effectively monitor progress.

In this way the Framework provides catchment managers and regional planners with the tools to develop sound plans with technically supported priority actions.

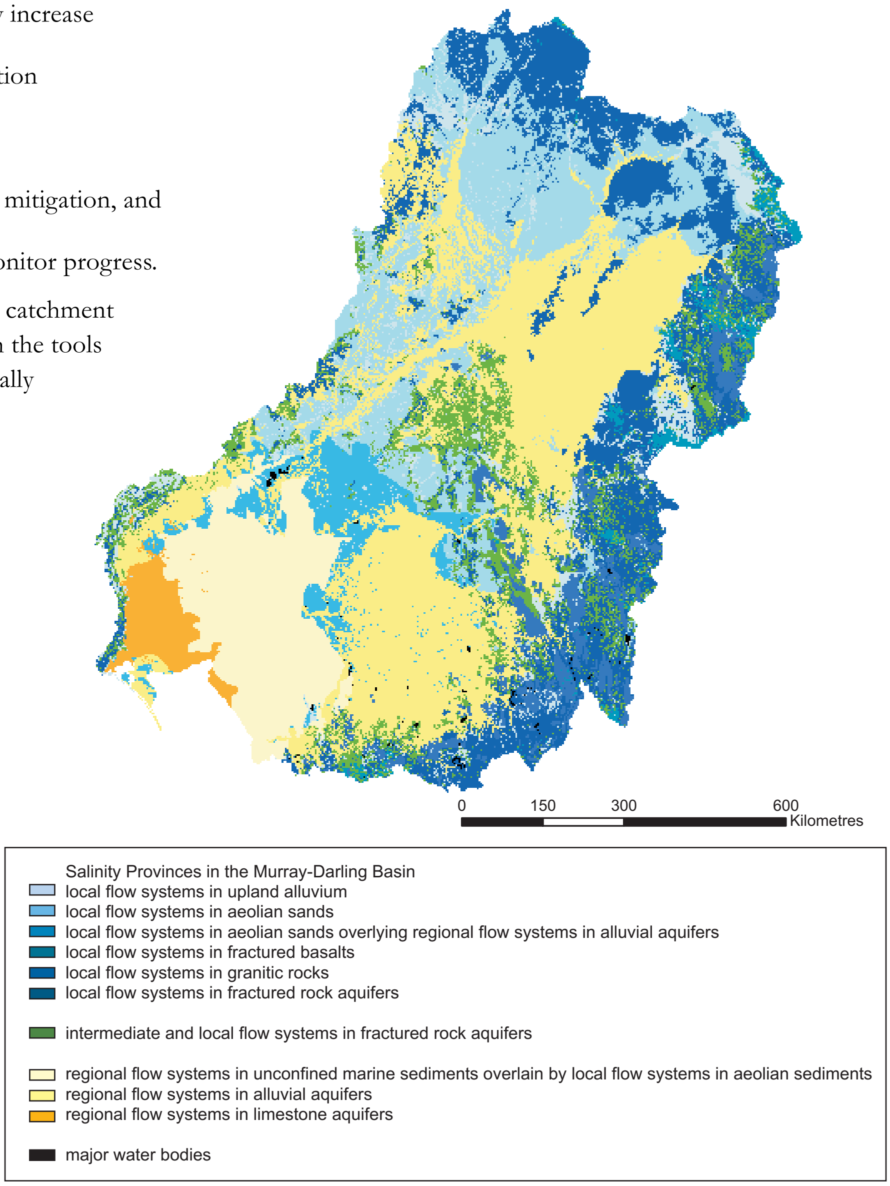
The power of the Framework will grow as new data becomes available and as researchers test and reassess hypotheses. In the same way we will continue to reassess and adapt regional strategies in the light of new data and improved understanding.

The immediate challenge is to capitalise on the existing national and Basin-wide frameworks and the available regional information to guide the delivery of the National Action Plan and Natural Heritage Trust, together with the MDBC's Integrated Catchment Management Policy Statement and Basin Salinity Management Strategy.

These achievements should then be built upon by developing more detailed catchment, sub-catchment and property level information.

At the smaller scales, groundwater flow systems may be quite complex, so that interpretation will require considerable skills and experience. The Framework will allow us to extrapolate from other successfully managed catchments and to take advantage of rapidly growing and increasingly accessible natural resource data.

Further detail on the GFS Framework can be found in the full report.



Salinity provinces in the Murray-Darling Basin

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