Productive Saltland Pastures
Salinity Manual

Module 6
Groundwater flow systems

Department of Primary Industries and Regional Development
GOVERNMENT OF WESTERN AUSTRALIA
natural resource management program

All photos from SGSL DAFWA team

FLOW SYSTEMS

INTRODUCTION

An understanding of the groundwater flow systems can help in a number of ways. Planning for landuse, resource assessment, expected responsiveness of an aquifer or help gain some insight into the possible impact of applying a management technique all depend on the groundwater flow system.

GROUNDWATER FLOW SYSTEMS IN SW OF WA

Groundwater flow systems (GFS) are scale dependent (see Fig 1). They are either local, intermediate or regional, based on their spatial extent and influence. The classification groups groundwater systems with similar recharge and flow behaviour, and other measures such as length of flow paths through aquifers, aquifer permeability and driving pressure gradients for groundwater flow. GFS can be isolated or found in the same part of the landscape or sit on top of each other. For example, a local system such as an aquifer formed in deep sand may sit above an intermediate flow system which is semi-confined.

The extent of the system has implications for its responsiveness to change in water balance and therefore influences the types of management options that are more appropriate for modifying the water balance.

- **Local groundwater flow systems** respond rapidly to increased groundwater recharge. Generally, recharge occurs some 1-3km away. Watertables rise rapidly and saline discharge typically occurs within 30 to 50 years of clearing for agricultural development. These systems can also respond relatively rapidly to salinity management practices, and therefore afford opportunities to mitigate salinity at a farm scale.
- **Intermediate groundwater flow systems** have a greater storage capacity and generally higher permeability than local systems. Generally, recharge occurs some 5-10 km away. They take longer to 'fill' following increased recharge. Increased discharge typically occurs within 50 to 100 years of clearing of native vegetation for agriculture. The extent and responsiveness of these groundwater systems present much greater challenges for dryland salinity management than local groundwater flow systems.
- **Regional groundwater flow systems** have a high storage capacity and permeability. Generally, recharge occurs greater than 50km away. They take much longer to develop increased groundwater discharge than local or intermediate flow systems-probably more than 100 years after clearing the native vegetation. The full extent of change may take thousands of years. The scale of regional systems is such that farm-based catchment management options are ineffective in re-establishing an acceptable water balance. These systems will require widespread community action and major land use change to secure improvements to water balance.

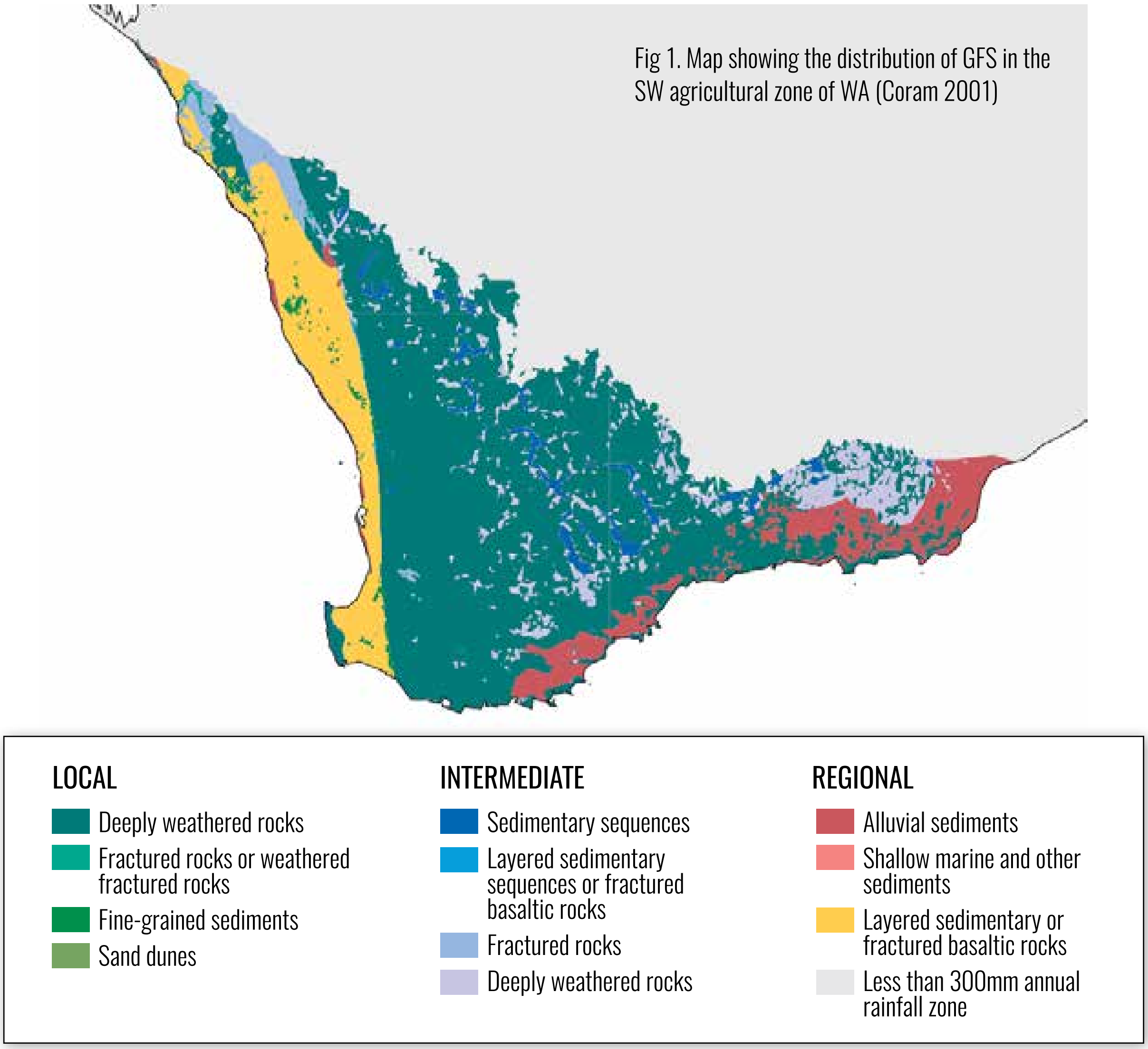


Fig 1. Map showing the distribution of GFS in the SW agricultural zone of WA (Coram 2001)

Within the agricultural region of WA, local and intermediate flow system occur mainly within the Yilgarn Craton while regional flow systems occur mainly in the Perth Basin and alluvial sediments of the South Coast.

The capacity of a given groundwater flow system to respond to changes in land use is driven mainly by its ability to move groundwater and is defined by:

- the groundwater gradient (water flows from a higher to a lower position in the landscape); and
- permeability of the material through which the groundwater flows (gravel, sand, clay).

In summary:

- Local flow systems have a relatively small capacity to store the additional recharge and so respond relatively rapidly to changes in land use; in many cases, they also have a relatively small discharge capacity through which to drain the excess water.
- In contrast, regional flow systems have a very large capacity to fill and subsequently respond very slowly to changes in land use, they will also take a long time to empty of excess water. Intermediate flow systems behaviour falls between local and regional systems.

LOCAL FLOW SYSTEMS IN DEEPLY WEATHERED ROCKS (See Fig 2 and Fig 3)

These groundwater systems typically occur within the ancient drainage zone. They were formed by deep weathering in early Tertiary (65 million years ago to now) times and occur most commonly where deep chemical alteration of the upper regolith of granitic terrain has resulted in extensive zones of pallid clay and silt. These clay zones are a very effective medium for storing salts introduced as aerosols through rainfall and concentrated in the saprolite through evapotranspiration.

In these simple systems, groundwater recharge generally occurs on the slopes of catchments. Vertical movement dominates groundwater hydrogeology and is compounded by lateral convergence on the lower landscape, causing rising watertables and ultimately saline groundwater discharge at breaks of slope or valley floors. In these systems the timeframe between clearing land of native vegetation and the onset of groundwater discharge is short, on average 20 years. Once the system fills and without intervention, the time for the groundwater systems to empty out excess water is likely to be much longer, due to the low permeability of the rock material.

The critical attributes of this groundwater flow system for salinity management are the low permeability of the aquifers and the relatively high groundwater salinity levels.

Fig 2. Example of local flow systems

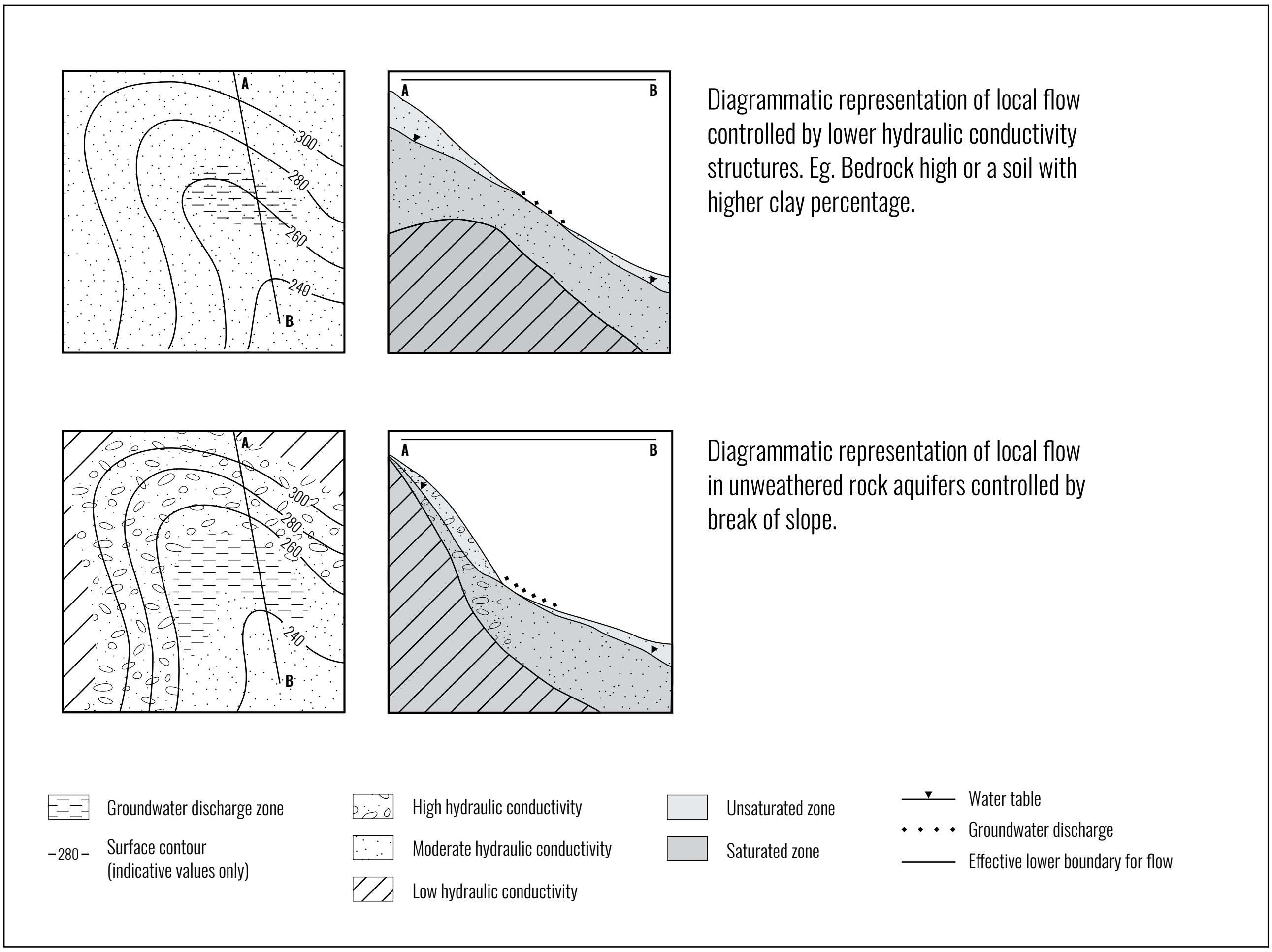
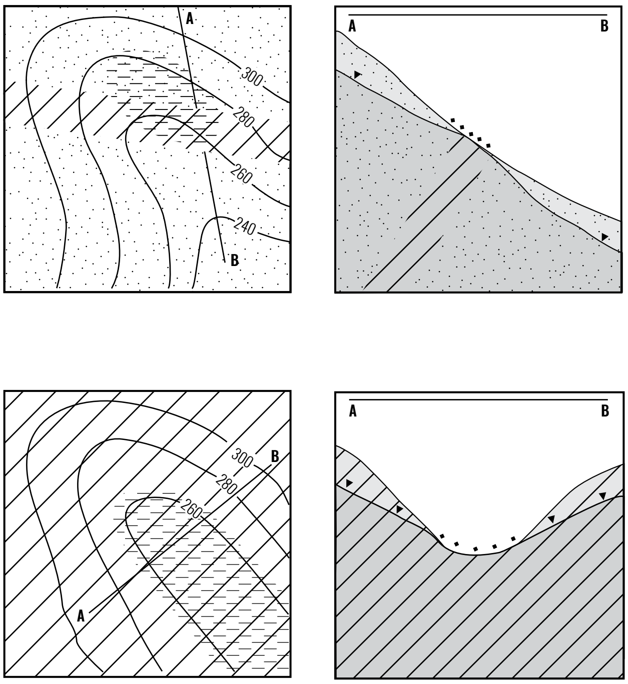


Fig 3.



Diagrammatic representation of local flow where discharge is controlled by linear features of contrasting hydraulic conductivity. Eg. Dolerite dyke, shear zone or fault.

Diagrammatic representation of local flow from low conductivity aquifers. Eg where playas, swamps, depression overlie saprock aquifers.

Groundwater discharge zone

–280– Surface contour (indicative values only)

High hydraulic conductivity

Moderate hydraulic conductivity

Low hydraulic conductivity

Unsaturated zone

Saturated zone

Water table

Groundwater discharge

Effective lower boundary for flow

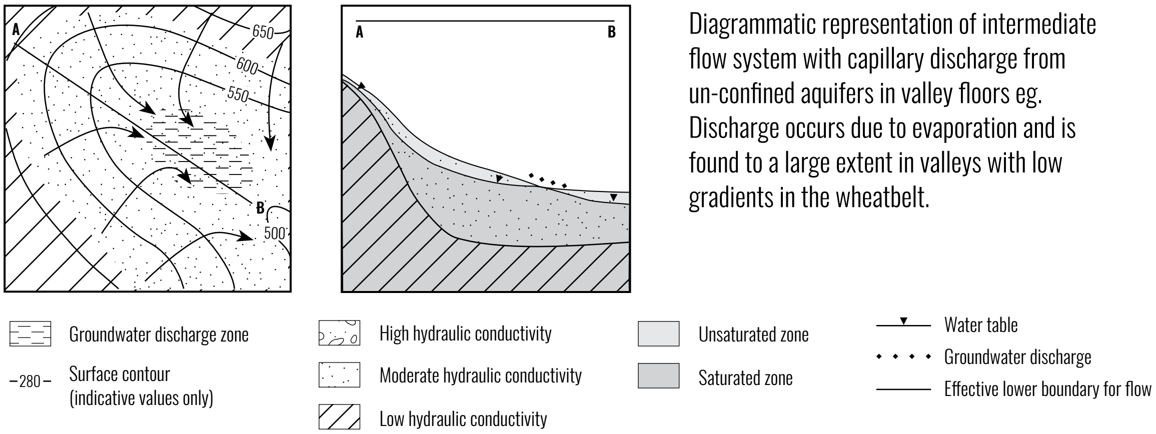
Natural species zonation, with bluebush colonising salt affected areas with patchy barley grass and no saltbush growing.

INTERMEDIATE FLOW SYSTEMS WITHIN SEDIMENTARY SEQUENCES INFILLING LARGE VALLEYS (See Fig 4)

This groundwater flow system is made up of ancient valleys (paleo-channels) that once formed an integrated river basin draining the south-west of Western Australia. The old valleys were extensively disrupted by tectonic activity during Tertiary times, and have been infilled with both coarse and fine-grained alluvium. Each ancient river basin now forms a series of discrete, elongate linear groundwater basins that may be contiguous over distances of 10 to 20 km or more. The alluvial fill in the valleys forms the main aquifer and the groundwater it contains is extremely saline.

Groundwater recharged on the slopes of the broad valleys converges on these unconfined/semi-confined transmissive aquifers in the plains of the valley floors. Salinity is manifest as expansive areas of saline groundwater discharge within these linear plains. The diffuse and episodic nature of recharge means that it is extremely difficult to manage recharge rates using conventional farming systems. Although transmissivity rates are variable in these aquifers, engineering options are theoretically feasible, but the high salinity of groundwater limits the potential uses for extracted groundwater.

Fig 4. Examples of intermediate flow systems

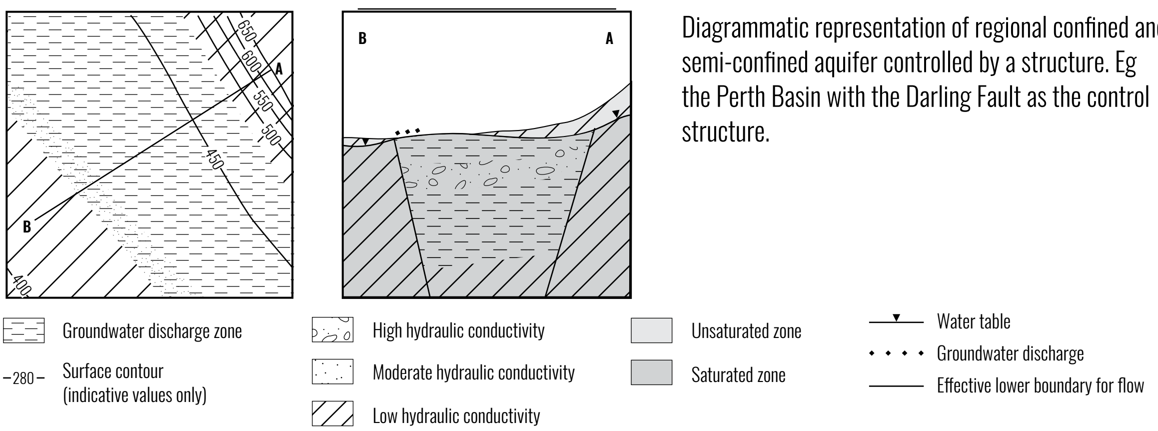


Diagrammatic representation of intermediate flow system with capillary discharge from un-confined aquifers in valley floors eg. Discharge occurs due to evaporation and is found to a large extent in valleys with low gradients in the wheatbelt.

REGIONAL FLOW SYSTEMS (See Fig 5)

Regional groundwater discharge occurs from regional confined and semi-confined aquifer systems as the result of relatively abrupt changes in hydraulic gradient, usually at low points in the topography where the hydraulic conductivity of the regional aquifer has been reduced through structural changes in the stratigraphy such as faulting and folding. This form of groundwater discharge is characteristic of deep sedimentary basins, where aquifer transmissivities are reduced as the result of faulting, folding or the presence of angular unconformities. Examples are the Perth Basin and North Stirlings Basin.

Fig 4. Examples of regional flow systems



Diagrammatic representation of regional confined and semi-confined aquifer controlled by a structure. Eg the Perth Basin with the Darling Fault as the control structure.

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QUESTIONS

1. **What are the three types of groundwater flow systems?**
   - ❑ Watertable, piezometric head and baseflow
   - ❑ Local, intermediate and regional.
   - ❑ Recharge, discharge and surface flow.

2. **Which groundwater flow systems occur mainly within the Yilgarn Craton?**
   - ❑ Recharge and baseflow
   - ❑ Local and intermediate
   - ❑ Watertable and surface flow

3. **The capacity of a groundwater flow system to respond to changes in landuse can be defined by its:**
   - ❑ the amount of rainfall falling on the landscape
   - ❑ the density of plants growing above the system
   - ❑ groundwater gradient and permeability of the material

4. **Local flow systems are dominated by:**
   - ❑ vertical water movement through the profile
   - ❑ high salt storages
   - ❑ low permeability

5. **Regional groundwater discharge occurs as a result of:**
   - ❑ very low groundwater movement
   - ❑ abrupt changes in hydraulic gradient such as folding or faulting
   - ❑ broad valley floors

NOTES

PRODUCTIVE SALTLAND PASTURES

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