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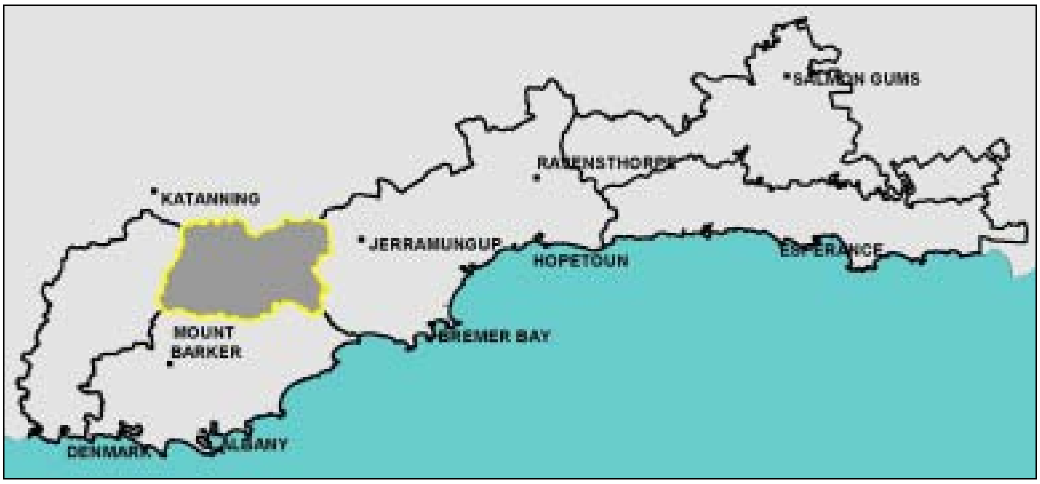

Department of Agriculture
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Groundwater trends in the North Stirling Pallinup sub-region

Ruhi Ferdowsian and Lisa Crossing, Hydrologists, Albany

The South Coast Regional Initiative Planning Team (SCRIPT) has divided the South Coast region of Western Australia into six sub-regions. This publication describes the groundwater trends, risk of shallow watertables, and technical feasibility of salinity management in the agricultural district of the North Stirling Pallinup sub-region.

This sub-region encompasses the Stirling Range National Park, the North Stirling Basin to the north-east of the Park, and the middle and upper catchments of the Pallinup River. Almost 90% (500,000 ha) of the sub-region's alienated land has been cleared for agriculture, and salinity has been identified as an important issue.

Soil-landscape zones are spatial units based on geology and geomorphology (Figure 1). Since most groundwater processes in WA are controlled by the geologic and regolith properties, typical landscape profiles within these zones can be used for allocating hydrological attributes such as groundwater characteristics and trends. The hydrological attributes are then used to assess the risk of shallow watertables and technical feasibility of salinity management.

Refer to *Further Information* for a description of groundwater flow systems, risk analysis and technical feasibility of salinity management.

Climate

The sub-region has a temperate climate with cool, wet winters and warm to hot dry summers. The average annual rainfall is 400 mm while the average annual evaporation is 1,800 mm/yr.

Pallinup Zone (241) and Jerramungup Plain Zone (243)

Pallinup Zone makes up 70% of the sub-region. It contains undulating rises and low hills on Archaean basement rocks. It has a weathered laterite profile that has been eroded into the Pallinup River, forming well-defined creeklines. Depth to basement rock is 5-20 m, with rock outcrops on some ridges and slopes. Soils are shallow duplexes, commonly with sodic and alkaline subsoils.

The Jerramungup Plain Zone covers 7% of the sub-region and contains Eocene marine sediments on gently undulating plains that are dissected by short rivers. Soils are alkaline sandy duplexes.

Two types of hydrological landscapes exist in zones 241 and 243:

1. Dissected landscape with low hills

Most areas contain dissected landscapes called low hills. They have gentle to steep slopes. These areas have well-defined creeklines, v-shaped valleys and erosional stream channels (Figure 2). Some of the valleys have been infilled by alluvial sediments. In these cases the valley floors have changed to elongated narrow flats with defined creeks cut into their floors.

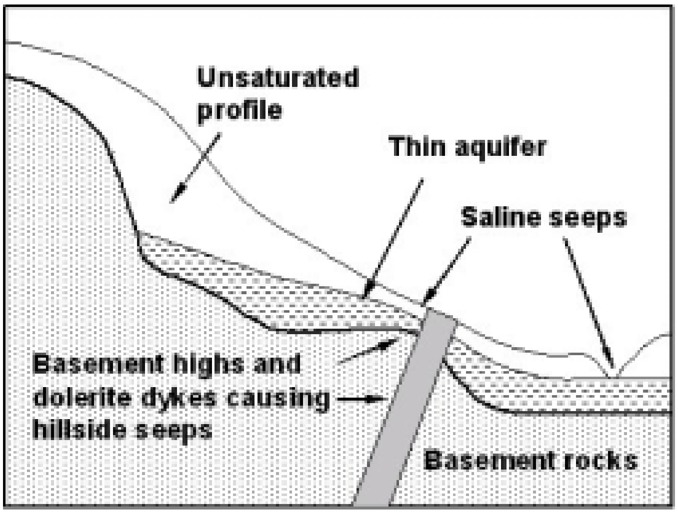


Figure 2: Typical cross-section of a dissected landscape and low hills

Groundwater flow systems

Groundwater flow systems are local and roughly align with the direction of surface drainage. In the more dissected areas, aquifers have a high gradient, which allows groundwater to move towards low-lying discharge areas such as creeks and valley floors. Shallow basement rocks and dolerite dykes can partially obstruct groundwater flow and cause many hillside seeps in this landscape. Faults and shear zones affect groundwater flows. The extent of salinity is limited to a few hillside seeps and creek beds.

Groundwater depth, quality and trends

Depth to groundwater ranges from 1 m to more than 8 m, depending on position in landscape and depth to basement rocks. Groundwater is saline and generally ranges from 1,000 mS/m (milliSiemens per metre) in upper slopes to 3,000 mS/m near creeklines. Short-term monitoring of groundwater levels indicates that the area is highly responsive to rainfall. Bores in a small upslope area in the more dissected areas are possibly in hydrological equilibrium because of the small recharge areas and high groundwater gradient (Figure 1: bores KT13431D and KT27812D).

Risk of shallow watertables

The dissected areas have a low to moderate risk of shallow watertables. Creeklines, low-lying and some upland areas are already saline and their extent will increase until a new hydrological equilibrium is reached in decades to come.

Technical feasibility of salinity management

As the groundwater gradient is high, there is some drainage towards discharge areas. Consequently, changes in management practices do not have to stop all recharge to be effective in preventing further spread of saline discharge. Under these conditions there is a good chance of recovering some saline land and an excellent technical feasibility of preventing further spread. Monitoring at several sites has shown a decrease in groundwater levels after perennial pastures were established (Figure 1: bore KT2851D).

Deep-rooted perennials such as lucerne that mimic the temporal and spatial distribution of leaf area that existed prior to clearing can effectively reduce land and water salinity. In the dissected undulating landscapes with a local groundwater flow system, two years of cropping is possible for every year of lucerne (Ferdowsian *et al.* 2002).

2. Moderately dissected undulating areas

This landscape has very gently inclined slopes (1–3%) and broad valleys. The valleys and lower slopes are depositional zones and may be stagnant flats with or without a defined creekline. These valleys have been targets for deep drains. The regolith is usually deep, however a few rock outcrops may be seen on hill tops and upper slopes. Systems 241Kb, 241Hd, 241Mb, 243Jm and 243Ug are typical in this landscape. Figure 3 depicts a typical cross-section.

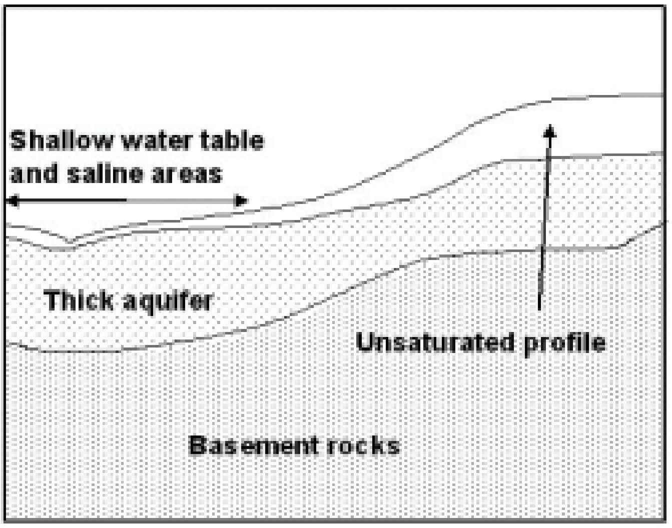


Figure 3: Typical cross-section of a moderately dissected undulating landscape

Groundwater flow systems

Groundwater flow systems are local to intermediate, and aquifers are usually thicker than those in dissected landscapes.

Groundwater depth, quality and trends

Groundwater levels in the stagnant flats are at or close to the soil surface and fluctuate seasonally (Figure 1: bore Ko55141D). The depth to groundwater increases on hillsides. Groundwater salinity is similar or higher than in the dissected landscapes.

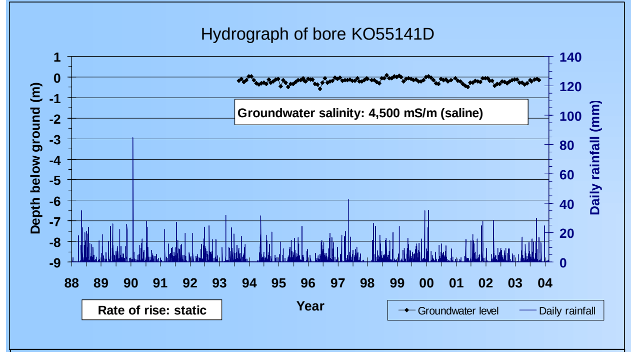
Risk of shallow watertables

Groundwater cannot flow quickly because of the low (1–2%) hydraulic gradient. Consequently, groundwater levels will continue to rise for a long period until significant areas become salt-affected. Therefore, this zone has a high risk of shallow watertables. Creeklines, flats and low-lying areas are already saline. It is likely that the extent of salinity will increase until a new hydrological equilibrium is reached.

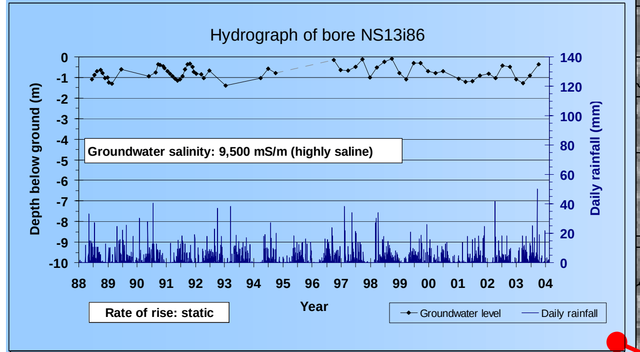
Technical feasibility of salinity management

In the hilly areas, it is possible to contain salt-affected areas or even recover small areas. The best management option for recovery or containment is to grow deep-rooted perennials such as lucerne, and although research has shown that lucerne is not as effective as in the dissected landscapes, it may still reverse (in hilly areas) or halt (in lower slopes) the rising groundwater trend. To contain salinity, one year of lucerne may be required to negate the effects of one and a half to two years of cropping.

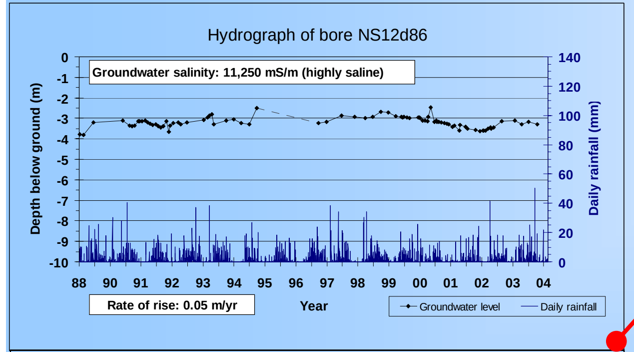
SCRIPT sub-region	Soil-landscape zone	Proportion of sub-region's agricultural land (%)	Time until potential salinity fully develops[SIF]	Salinity management technical feasibility[SIF]		
				Recovery	Containment	Adaptation
North Stirling Pallinup	Pallinup (241)	70	Short-medium term (20–30 yrs)	Good	Excellent	Moderate
	Stirling Range (248)	14	Imminent (<10 yrs)	Low	Moderate	Good
	Jerramungup Plain (243)	7	Short-term (10–20 yrs)	Good	Excellent	Moderate
	South-eastern Zone of Ancient Drainage (250)	5	Medium-term (30–75 yrs)	Low	Moderate	Moderate



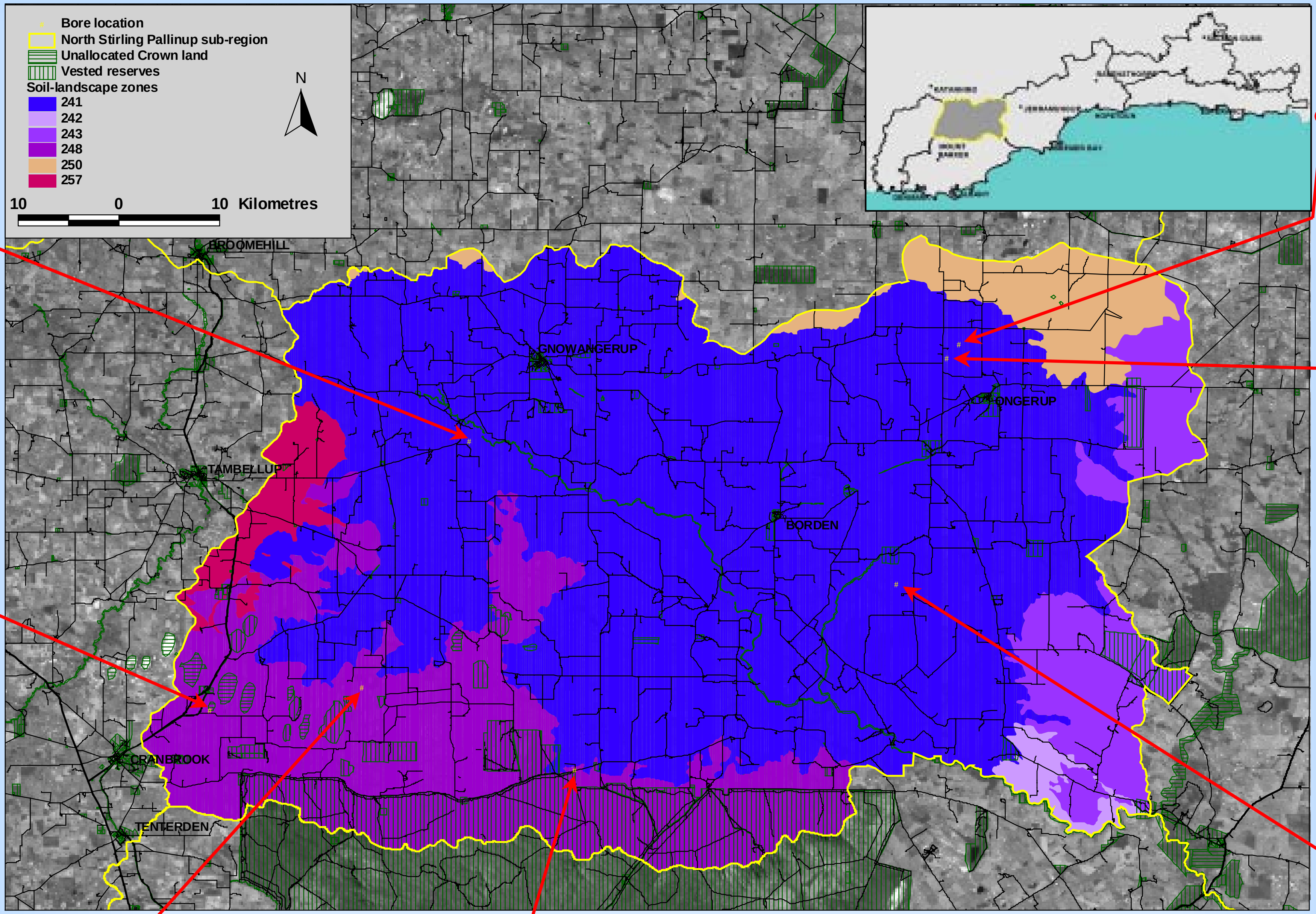
Location: South-west of Gnowangerup; Upper Pallinup Catchment
Soil-landscape system: Upper Pallinup (241Up)
Soil: Grey shallow sandy duplex
Land use: Annual pasture
Landform: Valley Floor
Average annual rainfall: 375 mm

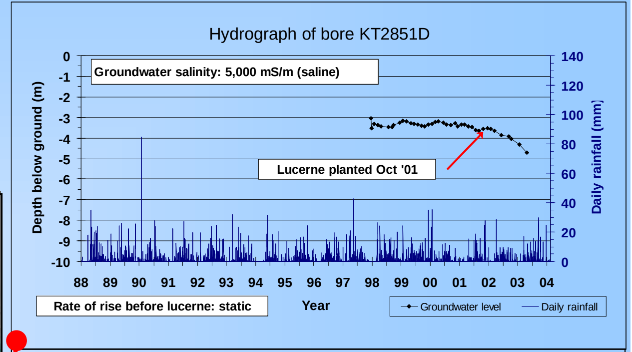


Location: East of Cranbrook; North Stirling Basin
Soil-landscape system: North Stirlings (248Nt)
Soil: Alkaline grey sandy duplex
Land use: Saltbush
Landform: Flat
Average annual rainfall: 425 mm

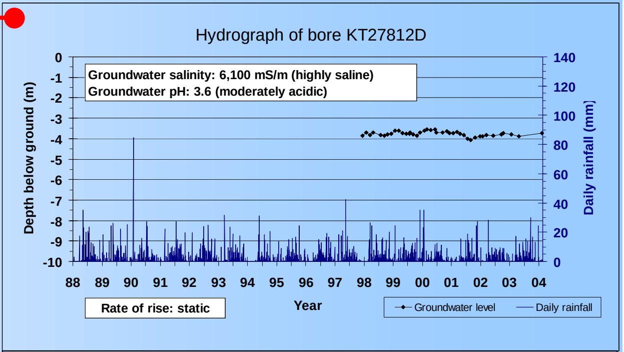


Location: East of Cranbrook; North Stirling Basin
Soil-landscape system: North Stirlings (248Nt)
Soil: Alkaline grey sandy duplex
Land use: Annual pasture (lucerne since 1998)
Landform: Simple-slope
Average annual rainfall: 400 mm

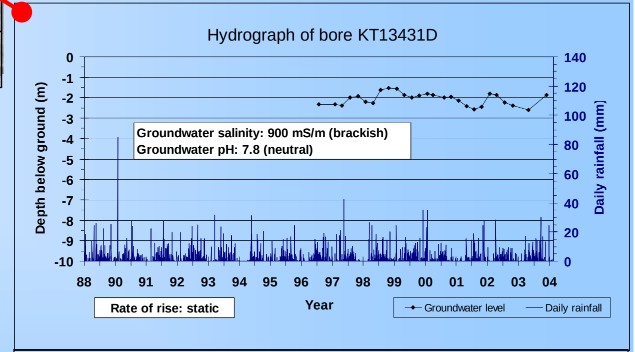




Location: North-west of Ongerup; Upper Pallinup catchment
Soil-landscape system: Upper Pallinup (241Up)
Soil: Alkaline grey shallow sandy duplex
Land use: Lucerne
Landform: Mid-slope
Average annual rainfall: 400 mm



Location: North-west of Ongerup; Upper Pallinup catchment
Soil-landscape system: Upper Pallinup (241Up)
Soil: Alkaline grey shallow sandy duplex
Land use: Annual pasture
Landform: Mid-slope
Average annual rainfall: 400 mm



Location: South-east of Borden; Upper Pallinup catchment
Soil-landscape system: Toompup (241Tm)
Soil: Grey deep sandy duplex
Land use: Cropping / pasture
Landform: Mid-slope
Average annual rainfall: 400 mm

Location:
Salt River Road; eastern edge of the North Stirling Basin
Soil-landscape system:
Stirling Range (248St)
Soil:
Duplex sandy gravel
Land use:
Annual pasture
Landform:
Flat
Average annual rainfall:
450 mm

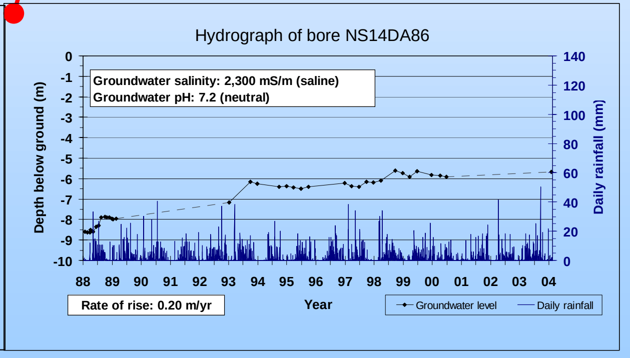


Figure 1: Groundwater trends in the North Stirling Pallinup sub-region

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The stagnant valley floors probably had subsoil salinity prior to clearing. It is difficult to recover salt-affected areas in valley floors but it is possible to reduce their waterlogging. A few deep drains have been constructed to improve salt-affected areas in these flats. In the best example, watertable drawdown close to a 2.5 m deep drain was 1 m and partial impacts were detected up to 80 m away. This drain reduced waterlogging and enabled the salt-affected land to be used for saltland agronomy.

Stirling Range Zone (248) and South-eastern Zone of Ancient Drainage (250)

The Stirling Range Zone covers 14% of the sub-region and includes the steep Stirling Range, undulating rises with granitic outcropping immediately north of the Range and the broad, poorly-drained plains of the North Stirling Basin with many salt lakes. The dominant soils are alkaline grey sandy duplexes.

The South-eastern Zone of Ancient Drainage covers 5% of the sub-region and contains smooth to irregularly undulating plains with salt lakes in the main valleys and duplex and lateritic soils on the uplands.

Both of these landscapes are derived mainly from marine sediments.

The salt lake and swampy terrains have coarse sandy Werillup Formation at depth (Ferdowsian and Ryder 1997). There may be a sequential change from undulating landscape to broad stagnant flats and then to the ancient drainage (Figure 4). The main hydrological landscapes are broad stagnant flats and ancient drainage with salt lakes and swamps (Figure 4).

Groundwater flow systems

This landscape has mainly regional and occasionally intermediate groundwater flow systems, which have very low groundwater gradients. The low gradient results in very little lateral groundwater flow into or out of the area. It is also the recipient of some groundwater flow and larger volumes of surface run-off from the gently undulating landscapes (Figure 4). The Stirling Range also contributes some surface water and groundwater flow onto the North Stirling Basin, which is typical of stagnant flats and ancient drainage units.

Groundwater depth, quality and trends

Groundwater is highly saline (>5,500 mS/m) with a neutral to low pH. Some fresh groundwater may perch on the highly saline regional groundwater systems. These fresh or brackish water resources are associated with sand dunes in the area.

There is a small, brackish water resource in the Kyballup Plain where a local aquifer is being used for stock water and drought relief. This brackish water is caused by recharge into a coarse sandy aquifer and is diminishing because it is being intruded by highly saline groundwater from surrounding areas.

Groundwater levels are no longer rising near discharge sites (saline flats, swamps and lakes) where the depth to groundwater is less than 2 m. In these areas groundwater levels fluctuate in response to rainfall and evaporation interactions (Figure 1: bore NS13i86). Areas with deeper groundwater (2–5 m) are rising at 0.05-0.15 m/yr (Figure 1: bore NS12d86).

The rate of rise increases with depth to groundwater and distance from discharge areas. On the western edge of the North Stirling Basin and higher in the landscape, levels are deeper and at one site are rising at 0.20 m/yr (Figure 1: bore NS14DA86). It is possible to see the effects of wet and dry years in all of the monitoring bores.

Risk of shallow watertables

The high salt storage and shallow groundwater mean that these zones have high risk of salinity. The area has always had some saline areas, however, its expression has increased considerably since clearing. Groundwater levels will continue to rise slowly until discharge through evaporation equals recharge. Even with shallow groundwater, areas with a moderately deep, sandy A horizon can continue to be productive because rainfall flushes accumulated salt from the root zone.

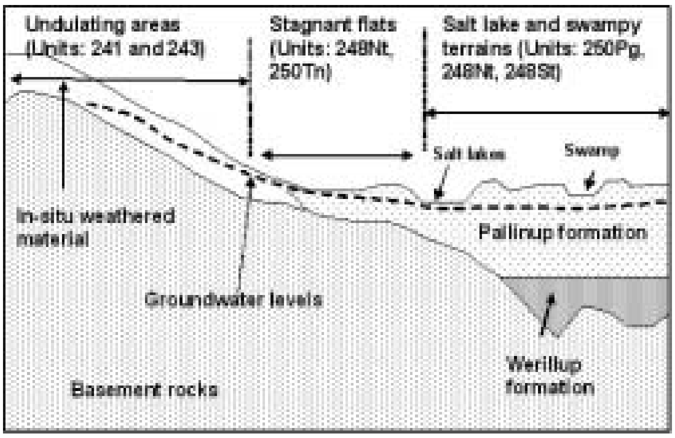

Figure 4: Sequential change of hydrological landscapes in North Stirling Pallinup

Salinity is expected to increase more quickly following a wet year as evaporation concentrates the salts brought to the surface by higher groundwater levels.

Technical feasibility of salinity management

Leakage of excess rainfall followed by evaporation from the soil surface causes saline watertables to fluctuate and occasionally inundate the root zone of plants. Under these conditions there is a low technical feasibility of recovering saline land by growing perennials. However, there is a moderate chance of containing salinity by reducing recharge with perennials, and an excellent opportunity to adapt to salinity using saltland agronomy.

Research results indicate that lucerne causes limited groundwater level reduction in the broad stagnant flats and ancient drainage areas. The net rate of groundwater level reduction is less than 1 m and this kind of reduction has not been sustained after lucerne was removed. The low rate of groundwater level reduction may be due to limited lateral movement of groundwater and the inability of lucerne to use saline groundwater. In these landscapes, two years of lucerne may be required to negate the effects of one year of cropping. It is important to note that lucerne is likely to be more effective in reducing groundwater levels prior to shallow watertables developing.

Further information

Soil-landscape zones and systems

Soil-landscape mapping in south-western Australia is based on a hierarchical system that enables correlation between surveys at different scales and maintains a consistent approach for dealing with areas of varying complexity in both landscape and soil patterns.

The first two levels of the hierarchy, *regions* and *provinces,* are based on the descriptions and framework introduced by the CSIRO Division of Soils in 1983 for the whole of Australia. The remaining four levels - *zones, systems, subsystems* and *phases* - are based on mapping conducted by the Department of Agriculture, Western Australia. At higher levels in the hierarchy the mapping units are based on regional geomorphological differences and at lower levels the individual soil and landscape components become more important.

The level of mapping unit is implicit in its label and as the scale of mapping increases, the label (in brackets) becomes more detailed. For example, the South Coast region falls into the Western Region (2) and predominantly within the Stirling Province (24) with some overlap into the Avon Province (25). Zones within these provinces are defined using geomorphological and geological criteria, and areas in these zones with recurring patterns of landforms, soils and vegetation, are grouped into systems. For example, the North Stirling Pallinup sub-region contains predominantly the Pallinup Zone (241), which contains a number of systems including the Upper Pallinup (241Up) and Toompup System (241Tm). The information in this publication pertains to zone and system levels.

Groundwater flow systems

Groundwater processes causing salinity can be categorised according to their flow systems because the scale (local, intermediate or regional) reflects the ease with which salinisation can be managed.

Local groundwater flow systems are those where recharge and discharge of groundwater are in close proximity to each other — usually within 1–3 km. These systems are very responsive to land use changes.

Intermediate groundwater flow systems have a horizontal extent of 5–10 km and generally occur across several properties.

Regional groundwater flow systems have groundwater recharge and discharge areas separated by distances of 50 km or more and consequently are very slow to respond to land use changes. Regional groundwater flow systems can be overlain by local and intermediate groundwater flow systems.

National Land and Water Resources Audit (NLWRA)

The NLWRA was established in 1997 under the *Natural Heritage Trust Act*, to collect and collate primary data and information related to natural resource management. The extent and impacts of dryland salinity were identified as part of NLWRA.

Risk of shallow watertables

Risk of shallow watertables was assessed using groundwater level trend data from the Department of Agriculture's AgBores database. Risk of shallow watertables (Table 1) was applied to entire system units based on an assessment of the most frequently occurring groundwater depth and trend data for each unit.

Table 1: Definition of risk categories

Risk	Groundwater level and trend
High (H)	<2 m 2–5 m and rising
Moderate (M)	<2 m and falling 2–5 m and static or falling 5–10 m and rising >10 m and rising
Low (L)	5–10 m and static or falling >10 m and static
No risk	>10 m and falling
Not assessed (NA)	Insufficient groundwater data to make an assessment

Salinity Investment Framework (SIF)

The SIF was undertaken to guide public investment in salinity management initiatives. As part of the process, an assessment of the range of salinity management options was undertaken for each soil-landscape zone. The options assessed included existing engineering and plant-based practices or systems that will deliver the maximum impact on the extent and severity of salinity.

Technical feasibility of salinity management

Technical feasibility is a measure of the availability and capacity of salinity management options to recover, contain or adapt to salt-affected land. The technical feasibility factors are largely qualitative and were based on published data and assessments by hydrologists from the Department of Agriculture. The technical feasibility is based on the average hydrological responsiveness of the entire soil-landscape zone.

Definitions of technical feasibility are:

- recovery – reverse the salinisation process and recover damaged land and water resources
- containment – manage salinity so that further impacts are minimised
- adaptation – live with and adapt to the consequences of salinity and minimise the losses.

Sources of information

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Acknowledgments

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