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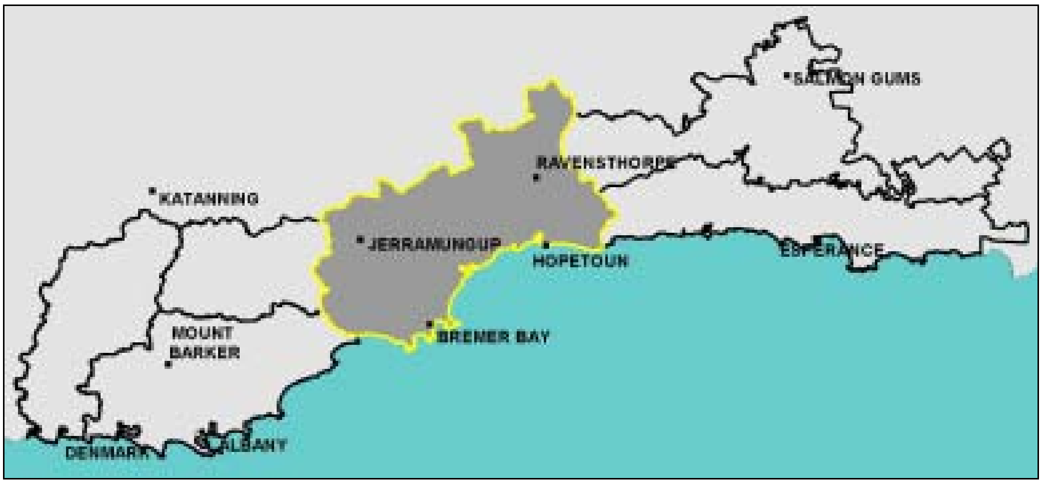

Department of Agriculture
Government of Western Australia

Groundwater trends in Fitzgerald Biosphere sub-region

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The South Coast Regional Initiative Planning Team (SCRIPT) has divided the South Coast region into six sub-regions. The Fitzgerald Biosphere sub-region is located in the centre of the South Coast region of Western Australia (Figure 1). It is bounded by the Pallinup River to the east, Jerdacuttup River to the west, and includes the catchments of the Gairdner, Fitzgerald and Phillips Rivers. The sub-region encompasses the Fitzgerald Biosphere Reserve and just over half (730,000 ha) has been cleared for agriculture.

This publication describes the groundwater trends, risk of shallow watertables, and technical feasibility of salinity management in the soil-landscape zones within the agricultural land.

Soil-landscape zones are spatial units based on geology and geomorphology. As most groundwater processes in WA are controlled by the geological 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 on the coast is about 600 mm and decreases inland to less than 400 mm. Rainfall reliability also decreases with distance from the coast, though evaporation increases from 1,500 mm/yr on the coast at Bremer Bay to nearly 1,800 mm/yr in the north.

Jerramungup Plain Zone (243)

Jerramungup Plain Zone covers half (370,000 ha) of the sub-region. It consists of a level to gently undulating plain, which forms the upper catchments of the southerly-flowing rivers.

The plain consists of sands overlying deeply weathered marine sediments, granites and gneisses. The granites and gneisses can be exposed in valleys and hillsides as well as forming large rocky hills. The southern margin of the plain drops away towards the coast, forming a set of low hills.

This soil-landscape zone has broad valleys with very gently inclined (1–3%) slopes (Figure 2). Where rivers have been rejuvenated through uplift, the valleys are more dissected, forming V-shaped valleys with gently to moderately inclined (greater than 3%) slopes (Figure 3).

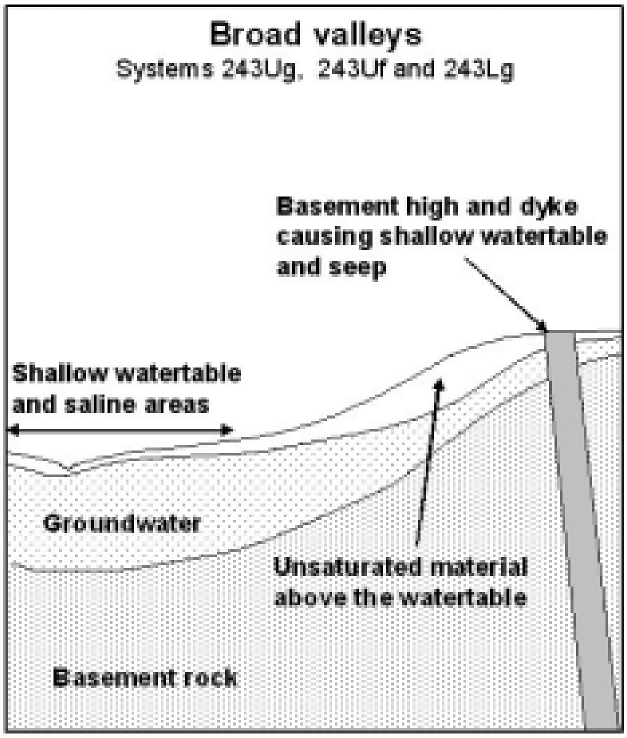


Figure 2: Representation of broad valleys with gently inclined slopes

Groundwater flow systems

The groundwater flow systems are local to intermediate and discharge into low-lying areas such as valley floors. Groundwater flows roughly in the same direction as the rivers and creeks.

Groundwater movement is slower in the broader valleys than the more dissected valleys as they have a lower groundwater gradient. Dolerite dykes and basement highs are common and can force groundwater close to the surface, producing hillside seeps and saline scalds.

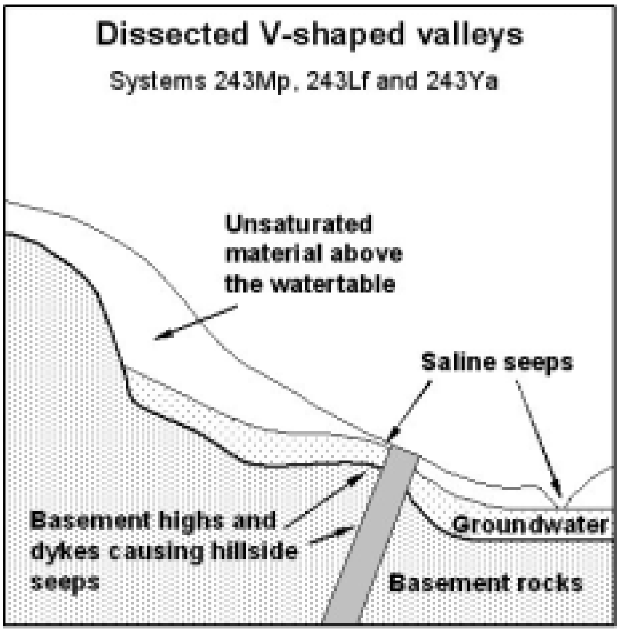


Figure 3: Representation of dissected V-shaped valleys

Groundwater depth, quality and trends

The depth to groundwater ranges from less than 1 m to greater than 20 m, depending on the depth to the basement and the landscape position. Although groundwater salinity ranges from 220 mS/m (milliSiemens per metre) (marginal) to 6,500 mS/m (highly saline), most groundwater is saline (900–5,500 mS/m). The pH ranges from 2.8 (moderately acid) to 7.6 (neutral), although typical pH is neutral.

Groundwater levels at depths less than 2 m fluctuate seasonally (Figure 1: bore JER40D89) with rates of rise of 0.05–0.1 m/yr. At depths less than 10 m groundwater shows responses to wet and dry years (Figure 1: bore JER64D89) and is rising at 0.15–0.30 m/yr. Groundwater deeper than 10 m is rising at 0.15–0.40 m/yr and often shows little response to rainfall as it can take over 12 months for rainfall to reach the aquifer (Figure 1: JER75D89).

Groundwater levels in some of the dissected valleys, particularly those with moderately inclined slopes, are close to hydrological equilibrium. Due to the steepness of the slope, the groundwater is able to discharge at the same rate as it is recharging. Therefore groundwater levels can be static (Figure 1: bore JER101D89) or showing rates of rise less than 0.05 m/yr.

Risk of shallow watertables

There is a high risk of shallow watertables in this zone (Table 1). Though the risks are similar, the areas that could be affected by salinity are greater in the broader valleys than the dissected valleys (see Table 1).

Technical feasibility of salinity management

Technical feasibility of using existing management options to contain salinity is excellent, and is good for recovering some salt-affected areas (Figure 1). In one case, use of perennial pastures, combined with below-average rainfall, lowered the groundwater at 0.5 m/yr (Figure 1: bore GB1D90).

Albany Sandplain (242) and Esperance Sandplain Zone (245)

Albany Sandplain Zone (Figure 1) covers 11% (80,000 ha) and the Esperance Sandplain Zone covers 7% (51,000 ha) of the sub-region. These zones are characterised by a level to very gently undulating sandplain that extends inland for 15 to 20 km.

The sandplain has poor drainage with intermittent lakes and swamps. Southerly-flowing rivers that cross the sandplain have cut through sediments and exposed granitic and gneissic basement.

Groundwater flow systems

Groundwater flow systems can be divided into two types (Figure 4). The system on the coastal plain is local to intermediate and has some connection to the ocean. Behind the coastal plain, the system is intermediate and stagnant with a very low groundwater gradient. The groundwater in this system discharges into rivers and lakes.

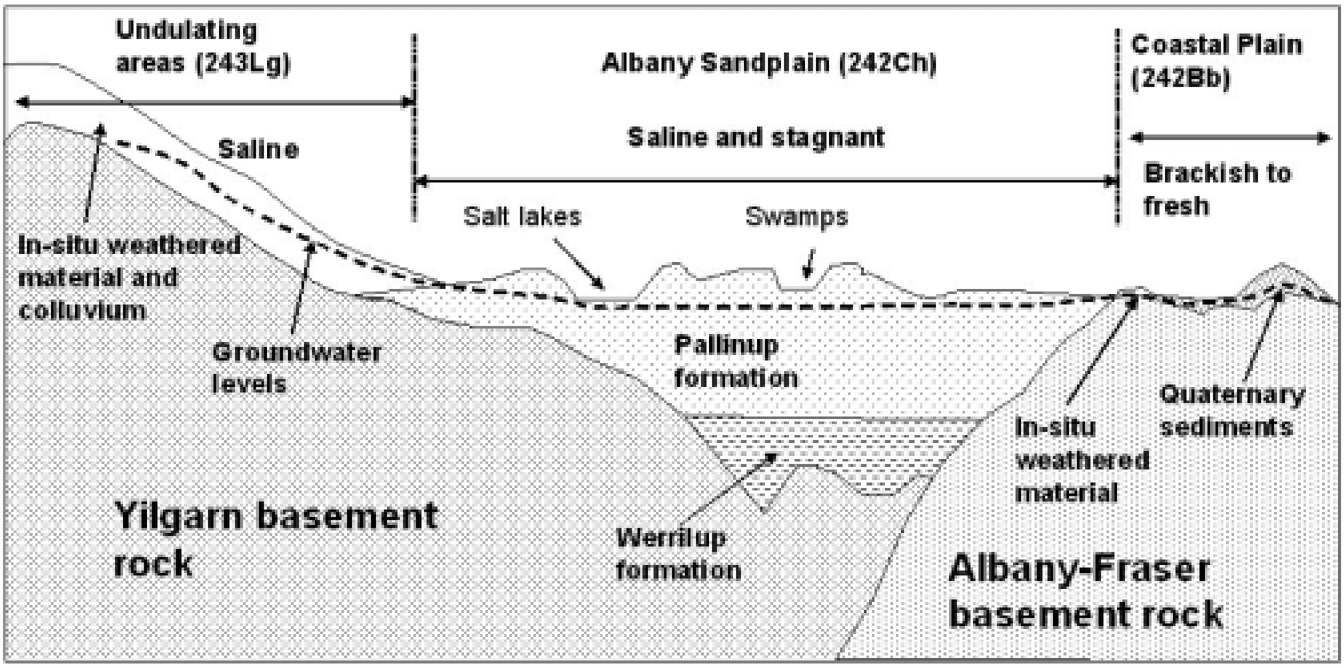


Figure 4: Conceptual cross-section of landscape in the sandplain zones

Groundwater depth, quality and trends

Depth to groundwater varies from 10 m to greater than 20 m in the stagnant aquifer. Groundwater salinity ranges from fresh to brackish in the coastal plain, which is a potential water resource, while saline (up to 4,400 mS/m) in the stagnant system. Groundwater pH is typically neutral, from 6.1 to 6.6. Groundwater levels are currently rising at 0.1–0.15 m/yr in the stagnant aquifer (Figure 1: bore JER7I89).

Risk of shallow watertables

The sandplain has a moderate risk of shallow watertables from the stagnant system at the current rate of rise. It will be more than 50 years before levels are close to the surface (Table 1).

However, most low-lying areas such as deep swamps are already salt-affected and as groundwater levels continue to rise, the extent and number of these areas will grow.

Technical feasibility of salinity management

The intermediate stagnant groundwater system in the sandplain, due to its low hydraulic gradient, has low technical feasibility for recovery of salt-affected land because it would require significant reduction in recharge over large areas. However, the technical feasibility for containing salinity by integrating existing salinity management options across the whole landscape, is good.

South-eastern Zone of Ancient Drainage (250)

The South-eastern Zone of Ancient Drainage covers 17% (124,000 ha) of the Fitzgerald Biosphere. It consists of ancient in-filled river valleys separated by weathered granitic hills, as well as internally drained sandplain. The zone is in the upper catchment of southerly flowing rivers such as the Fitzgerald.

Groundwater flow systems

In areas of more defined drainage, the groundwater flow systems are local on the upper slopes and join intermediate to regional systems in the ancient drainage valleys. In the areas of undulating sandplain the groundwater systems are local (Figure 5). These systems discharge into internally drained lakes and sumps.

Groundwater depth, quality and trends

The depth to groundwater is commonly less than 2 m in the valley floors and levels fluctuate seasonally (Figure 1: bore SMART15C). During the wetter months groundwater flows slowly into internally drained lakes, sumps and stagnant flats and then evaporates during the drier months. This recharge followed by evaporation causes fluctuation of shallow watertable.

In the adjacent hills, the depth to groundwater can be greater than 20 m, with levels rising at 0.10–0.25 m/yr (Figure 1: bore JER28D89). Groundwater salinity ranges from 1,000 mS/m (saline) to 7,800 mS/m (highly saline), though is usually around 5,600 mS/m. Groundwater pH

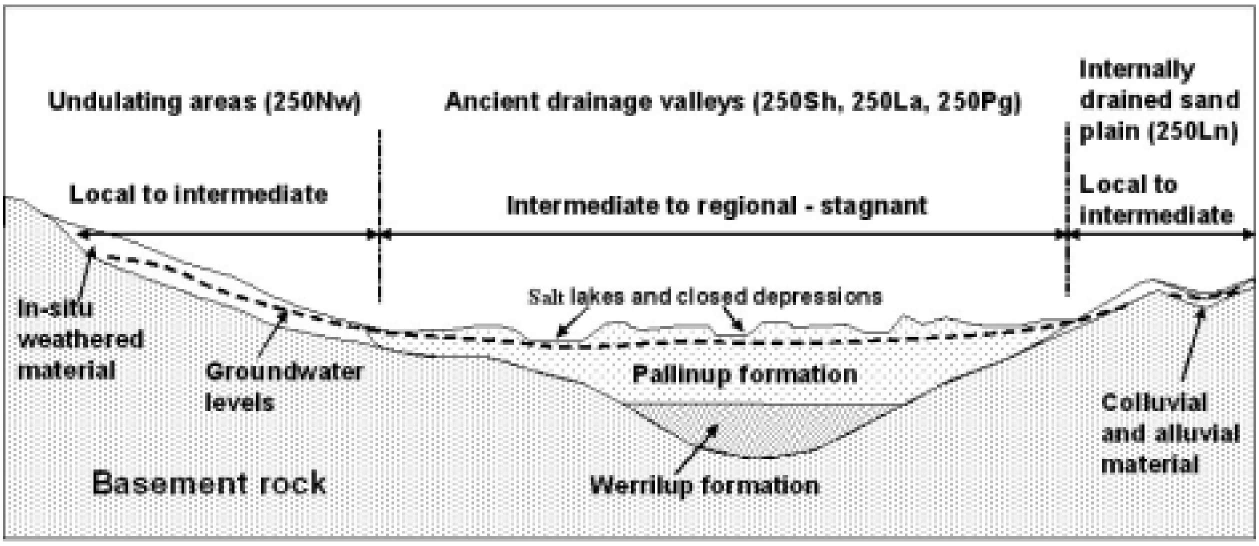


Figure 5: Conceptual cross-section of landscape in the South-eastern Zone of Ancient Drainage

ranges from 2.9 (moderately acid) to 7.6 (neutral), although typically it is neutral. Where sand, colluvium or permeable material lie over relatively impermeable materials such as clays, fresh to brackish, perched watertables can develop. These perched systems are commonly used for on-farm livestock water supplies.

Risk of shallow watertables

There is a high risk of shallow watertables because these systems are internally drained and any additional recharge increases the groundwater level. Areas with a moderately deep, sandy A horizon can continue to be productive, even with shallow groundwater, because rainfall flushes accumulated salt from the root zone.

Technical feasibility of salinity management

The technical feasibility of recovering salt-affected land using existing management techniques is low because these systems are typically naturally saline and internally drained. The technical feasibility for containing the areas affected by salinity is moderate. Management options are more effective in undulating areas.

Ravensthorpe Zone (244)

Ravensthorpe Zone covers 14% (100,000 ha) of the sub-region and contains the Ravensthorpe Ranges. The agricultural areas consist mainly of rolling to undulating low hills formed on a greenstone belt of mafic and ultra-mafic rocks from which distinctive red fine-textured soils are derived.

The rest of the zone, including the Fitzgerald River National Park, contains Proterozoic granitic and meta-sedimentary rocks and Tertiary sediments. The complex geology of the greenstone belt strongly influences the hydrology. The rejuvenated drainage system contains incised, southerly-flowing rivers such as the West and Phillips Rivers that drain externally to coastal estuaries and lakes.

Groundwater flow systems

Groundwater flow systems are local to intermediate. The intermediate systems discharge into low-lying areas such as valley floors, rivers and lakes, where the groundwater intersects the land surface. Local systems are separated and influenced by geological structures and discharge on hillsides.

Groundwater depth, quality and trends

There is limited, long-term groundwater data available for the intermediate systems. The depth to groundwater varies from less than 2 m to greater than 20 m and the rate of rise is currently 0.1–0.2 m/yr.

Although groundwater salinity ranges from 100 mS/m (fresh) to 6,000 mS/m (highly saline), most is saline.

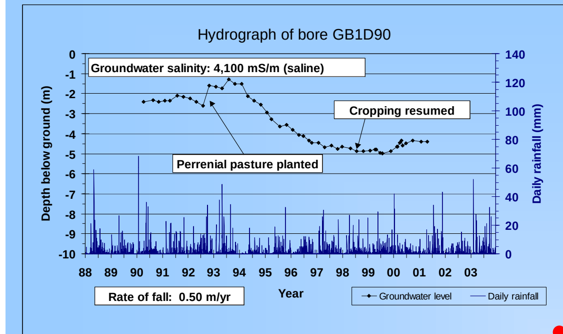
Risk of shallow watertables

The zone has a moderate risk of shallow watertables and risk will remain moderate for the next 20 years (Table 1).

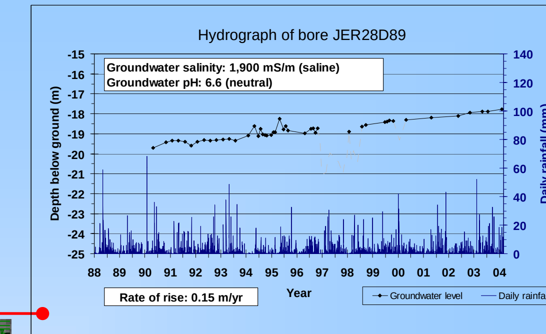
Technical feasibility of salinity management

The technical feasibility of recovering or containing salt-affected areas using current management practices is moderate because of large areas of remnant native vegetation and the relative steepness of the topography.

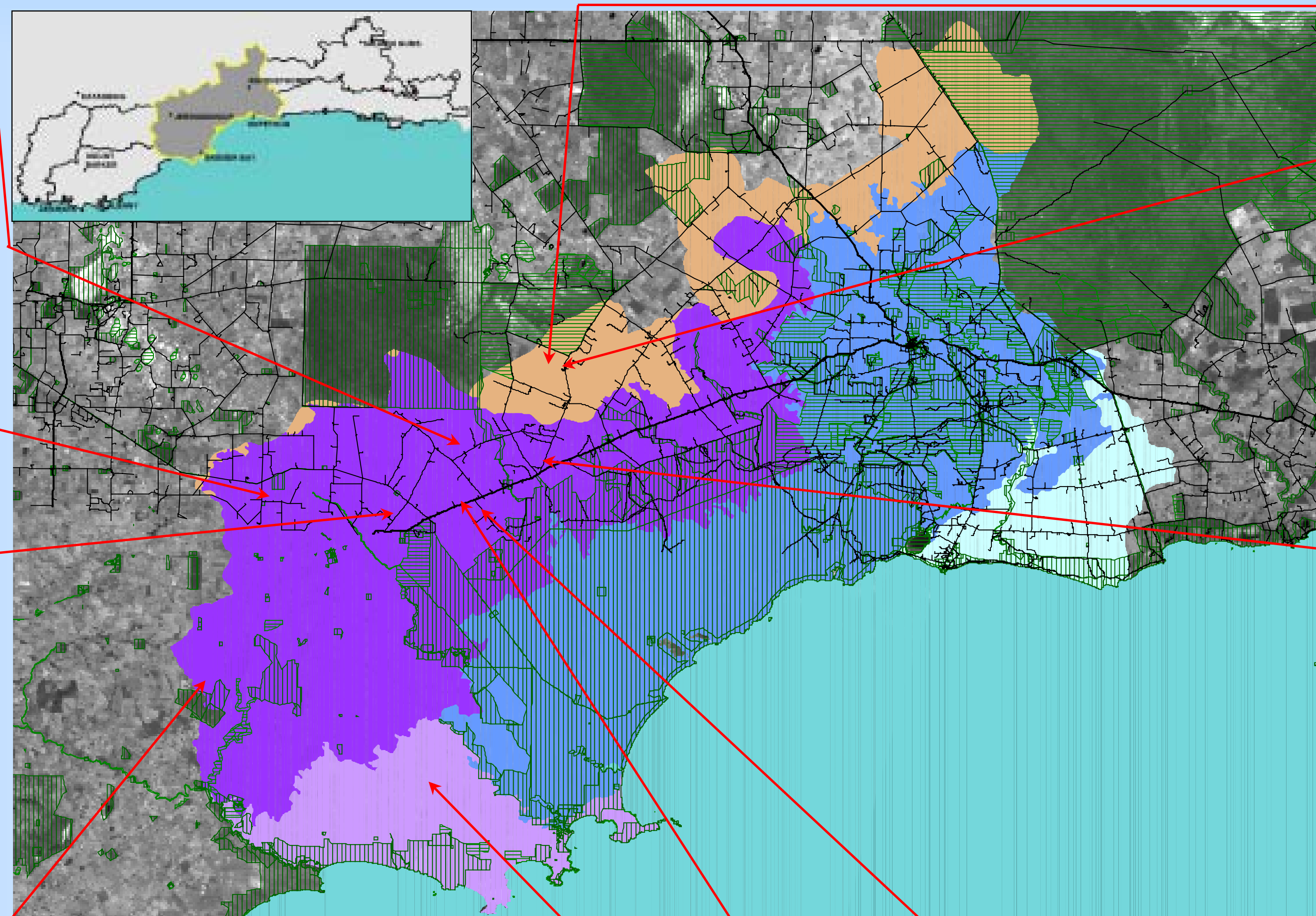
SCRIPT sub-region	Soil-landscape zone	Proportion of sub-region's agricultural land (%)	Time until potential salinity fully develops[SIF]	Salinity management technical feasibility[SIF]		
				Recovery	Containment	Adaptation
Fitzgerald Biosphere	Jerramungup Plain (243)	51	Short-term (10–20 yrs)	Good	Excellent	Moderate
	South-eastern Zone of Ancient Drainage (250)	17	Medium-term (30–75 yrs)	Low	Moderate	Moderate
	Ravensthorpe (244)	14	Medium-term (30–75 yrs)	Moderate	Moderate	Moderate
	Albany Sandplain (242)	11	Medium-term (30–75 yrs)	Low	Good	Moderate
	Esperance Sandplain (245)	7	Medium-term (30–75 yrs)	Moderate	Good	Excellent

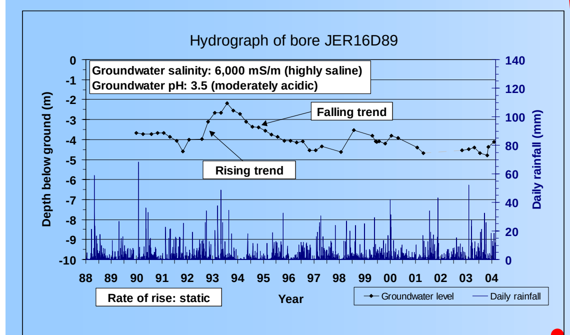


Location: North-west of Jerramungup; Gairdner River area
Soil-landscape system: Upper Fitzgerald (243Uf)
Soil: Grey deep sandy duplex
Land use: Cropping / annual pasture / lucerne (1992-1998)
Landform: Mid-slope
Average annual rainfall: 400 mm

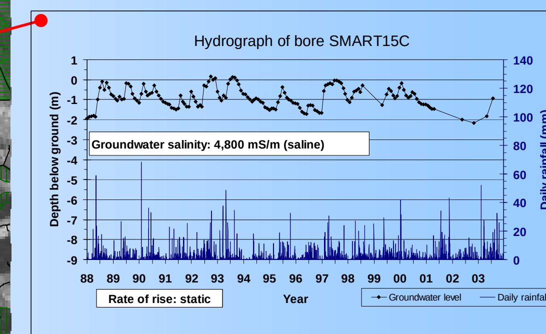


Location: North-east of Jerramungup; Mallee Road Sump
Soil-landscape system: Newdegate (250Nw)
Soil: Yellow / brown shallow sandy duplex
Land use: Cropping / pasture
Landform: Upper slope
Average annual rainfall: 375 mm

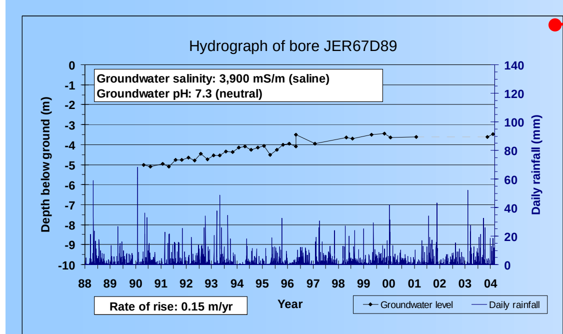




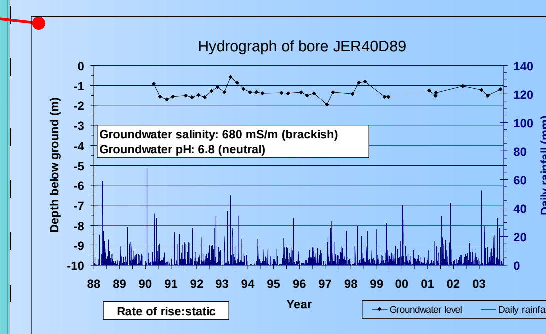
Location: West of Jerramungup; Gairdner River Catchment
Soil-landscape system: Upper Gairdner (243Ug)
Soil: Grey shallow sandy duplex
Land use: Cropping / pasture
Landform: Valley floor
Average annual rainfall: 400 mm



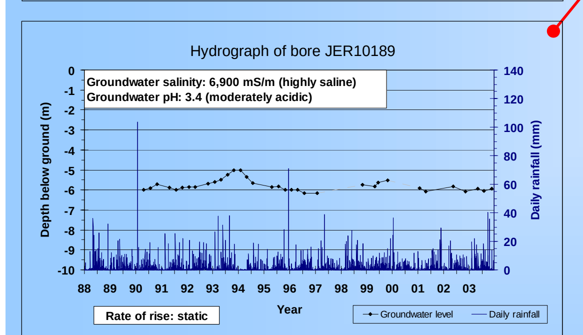
Location: North-east of Jerramungup; Mallee Road Sump
Soil-landscape system: Lagan (250La)
Soil: Alkaline grey shallow loamy duplex
Land use: Cropping / pasture
Landform: Flat
Average annual rainfall: 375 mm



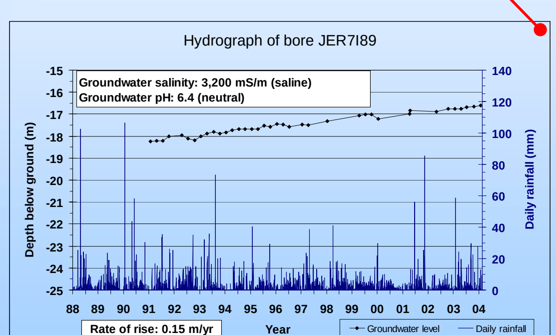
Location: West of Jerramungup; Gairdner River Catchment
Soil-landscape system: Yarmarlup (243Ya)
Soil: Grey shallow sandy duplex
Land use: Cropping / pasture
Landform: Valley floor
Average annual rainfall: 425 mm



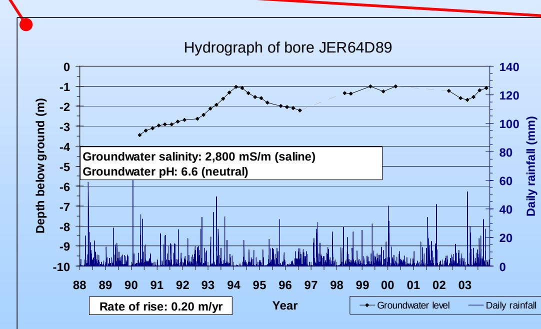
Location: West of Jerramungup; Fitzgerald River Catchment
Soil-landscape system: Jerramungup (243Jm)
Soil: Grey deep sandy duplex
Land use: Cropping / pasture
Landform: Drainage depression
Average annual rainfall: 400 mm



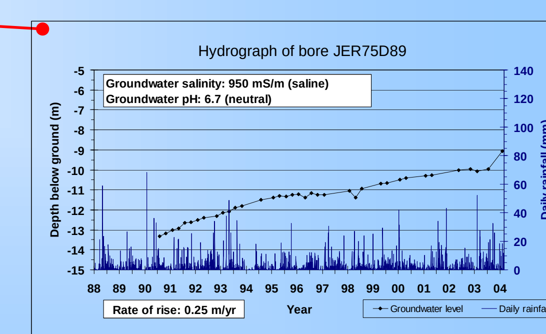
Location: South-west of Jerramungup; Corackerup Creek Catchment
Soil-landscape system: Middle Pallinup (243Mp)
Soil: Yellow / brown deep sandy duplex
Land use: Cropping / pasture
Landform: Lower slope
Average annual rainfall: 425 mm



Location: North-west of Bremer Bay; Devil Creek Catchment
Soil-landscape system: Chillinup (242Ch)
Soil: Grey shallow sandy duplex
Land use: Roadside reserve
Landform: Plain
Average annual rainfall: 550 mm



Location: East of Jerramungup; Fitzgerald River Catchment
Soil-landscape system: Upper Fitzgerald (243Uf)
Soil: Grey deep sandy duplex
Land use: Cropping / pasture
Landform: Lower slope
Average annual rainfall: 425 mm



Location: North-east of Jerramungup; Fitzgerald River Catchment
Soil-landscape system: Jerramungup (243Jm)
Soil: Grey deep sandy duplex
Land use: Cropping / pasture
Landform: Mid-slope
Average annual rainfall: 425 mm

Figure 1: Groundwater trends in the Fitzgerald Biosphere sub-region

Table 1: Risk of shallow watertables for systems in the Fitzgerald Biosphere sub-region

Soil-landscape zone	Soil-landscape system	% of sub-region's agricultural land in system	Risk of shallow watertables[NLWRA]			Proportion of system with low-lying areas (0–0.5 m)[LMP]
			2000	2020	2050	
Jerramungup Plain (243)	Jerramungup (243Jm)	13	H	H	H	10
	Upper Gairdner (243Ug)	9	H	H	H	15
	Yarmarlup (243Ya)	7	M	H	H	10
	Upper Fitzgerald (243Uf)	6	H	H	H	15
	Middle Pallinup (243Mp)	6	H	H	H	10
	Lower Gairdner (243Lg)	6	H	H	H	15
	Lower Fitzgerald (243Lf)	4	H	H	H	10
Albany Sandplain (242)	Chillinup (242Ch)	8	M	M	M	25
	Bremer (242Bb)	1	L	L	L	15
	Lower Pallinup (242Lp)	1	M	M	H	10
Esperance Sandplain (245)	Munglinup (245Mu)	7	M	H	H	25
Ravensthorpe (244)	Oldfield (244Od)	4	M	M	M	5
	Hammersley (244Hm)	4	M	M	H	20
	Ravensthorpe (244Ra)	3	M	M	M	10
	Kybulup (244Ky)	2	M	M	M	5
South-eastern Zone of Ancient Drainage (250)	Newdegate (250Nw)	7	H	H	H	10
	Lillian (250Ln)	6	H	H	H	25
	Sharpe (250Sh)	2	H	H	H	40
	Lagan (250La)	2	H	H	H	70

Source: Short and McConnell (2001)

NLWRA and LMP: Refer to *Further Information* for definitions and risk categories

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 with recurring patterns of landforms, soils and vegetation are grouped into soil-landscape systems. For example, the Fitzgerald Biosphere sub-region contains predominantly the Jerramungup Plain Zone (243), which contains a number of soil-landscape systems, including Jerramungup System (243Jm) and Upper Fitzgerald System (243Uf). The information in this publication pertains to soil-landscape zone and system level.

Groundwater flow systems

Groundwater processes causing salinity can be categorised according to their flow systems because the scale (local, intermediate or regional) of the system 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 these systems 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 the 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 2) was applied to entire system units based on an assessment of the most frequently occurring groundwater depth and trend data for each unit.

Table 2: 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

Land Monitor Project (LMP)

LMP was a satellite and terrain-based assessment combined with mapping of salinity, topography, and vegetation extent and change.

Low-lying areas

A digital elevation model was used to determine 'height above flowpath' in order to map low-lying areas. Height above flowpath measures the vertical elevation from flowpaths, which are areas where water flow accumulation is high (not just creeklines). Once the flowpath is defined, the low-lying areas within a discrete (0.0–0.5 m) height class above the flowpath can be identified. Low-lying areas may be at risk of flooding, inundation and waterlogging, and where groundwater levels are rising, indicate potential to develop shallow watertables.

Salinity Investment Framework (SIF)

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

Timing of salinity

Hydrological equilibrium occurs when the groundwater in an area of risk ceases to rise and the area of groundwater discharge ceases to expand. The average time required for a soil-landscape zone to reach hydrological equilibrium (Table 3) was assessed on the basis of available groundwater trend data and analyses prepared for the National Land and Water Resources Audit.

Table 3: Timing scales of salinity

Term	Time until potential salinity develops fully
Imminent	<10 years
Short-term	10–20 years
Short-medium term	20–30 years
Medium-term	30–75 years
Long-term	>75 years

Technical feasibility of salinity management

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

Definitions of technical feasibility are:

- recovery – reverse the salinisation process and recover degraded 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.

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Acknowledgments

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