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East Mortlock : catchment appraisal 2002

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Department of Agriculture
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EAST MORTLOCK

CATCHMENT APPRAISAL 2002

Compiled by Don Cummins

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East Mortlock

CATCHMENT APPRAISAL 2002

Edited by

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CONTENTS

SUMMARY

This report describes the soils, hydrology, natural vegetation and farming systems of the East Mortlock catchment and provides information on the threats to agriculture, infrastructure and natural resources caused by land degradation.

East Mortlock covers over 800,000 hectares in the central wheatbelt. The catchment drains into the Avon River, which becomes the Swan River, before flowing into the Indian Ocean. The climate is Mediterranean with cool wet winters and hot dry summers and the annual rainfall is approximately 350 mm.

The agricultural systems are primarily broad acre with winter cropping and livestock production. Crops grown include wheat, barley, lupins, oats and canola, and the main livestock focus is sheep for wool and meat. Crop rotations and production mix vary between farms depending on soil types, capital structure and expertise in the business.

Soils and landscapes are variable, with shallow loamy duplexes, sandy earths and ironstone gravelly soils comprising 53 per cent of the catchment. Soil degradation issues include: acidification, compaction and soil structure decline, erosion, waterlogging and water repellence.

Salinity currently affects 9.2 per cent of the catchment (79,000 ha) and 32 per cent (275,000 ha) is low-lying and could be affected by surface water runoff or shallow watertables in the future.

Waterlogging, seepage and rising watertables can be controlled by constructing well-planned and designed earthworks. Grade banks on sloping land provide an important tool to manage surface water, which should be treated as a resource and used on-farm. Safe disposal of surface water to waterways should be considered a secondary alternative.

The catchment has a very low proportion of remnant vegetation - approximately 41,000 ha (4.8 per cent) - of which about 7,000 ha (17 per cent) are located in low-lying areas. Maintaining, enhancing and expanding remnant vegetation would deliver biodiversity, landscape and farming systems benefits.

1. INTRODUCTION

Soil degradation on farmland reduces agricultural production and damages infrastructure and natural resources such as remnant vegetation, waterways and wetlands. While dryland salinity, waterlogging and soil erosion cause serious environmental problems in Australia, several other forms of soil degradation are of concern such as water repellence, wind erosion and soil acidity.

The objective of Rapid Catchment Appraisal is to assess the condition of, and future risks to agricultural and natural resources, and provide information for reducing those risks within regional geographic catchments. The process also attempts to identify the most suitable options to manage the risk. As part of the process, landholders are given direction on where to access further information and support.

This report summarises current information on risks and impacts to agricultural production and natural resources within the East Mortlock catchment. The report has been divided into three sections: the agricultural resource base; catchment risks; and management options and impacts. It is important to cross-reference between chapters to gain an understanding of how different risks and management options affect the agricultural resource base.

The work was completed with funding assistance from an Avon Catchment Council/ Department of Agriculture, Natural Heritage Trust partnership project.

2. NATURAL RESOURCE BASE

2.1 Catchment description

The catchment is the drainage basin of the east branch of the Mortlock River, which is a tributary of the Avon River. It occupies 859,617 hectares and covers parts of the shires of Cunderdin, Dowerin, Goomalling, Kellerberrin, Koorda, Mount Marshall, Quairading, Tammin, Trayning, Wongan-Ballidu and Wyalkatchem. Major towns within the catchment are: Cunderdin, Tammin, Wyalkatchem, Dowerin and Koorda. Large salt lake chains form much of the drainage, dominated by the Cowcowing system to the southwest of Koorda townsite.

The catchment is bounded by the latitudes of: 476235 and 581245 (E) and 6621166 and 6475552 (N), (Figure 2.1).

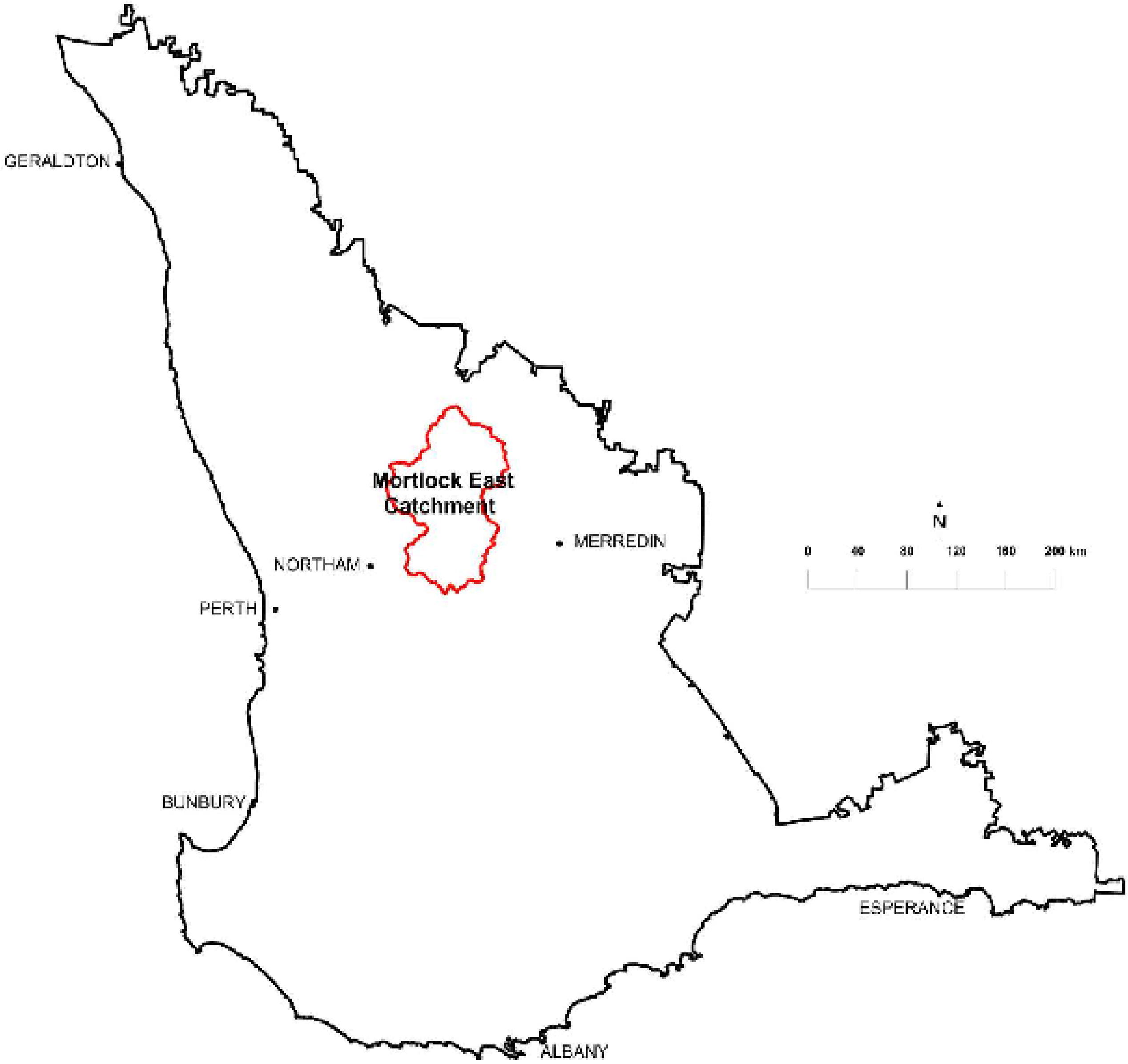

Figure 2.1 East Mortlock Catchment location map.

2.2 Climate

Harry Lauk and Trevor Lacey

The catchment has a Mediterranean climate, with hot dry summers and mild wet winters with rainfall peaking sharply in mid winter. Moisture deficit over summer limits the growing season for traditional, annual agriculture systems, to between May and September (Figure 2.3). On average about 70 per cent of annual rainfall occurs through the growing season (Figure 2.2). Winter and spring rainfall is associated with the passage of cold fronts across the state. Strong northerly winds are often generated as the fronts approach, providing the potential for wind erosion particularly in late autumn and early spring when ground cover is at its lowest.

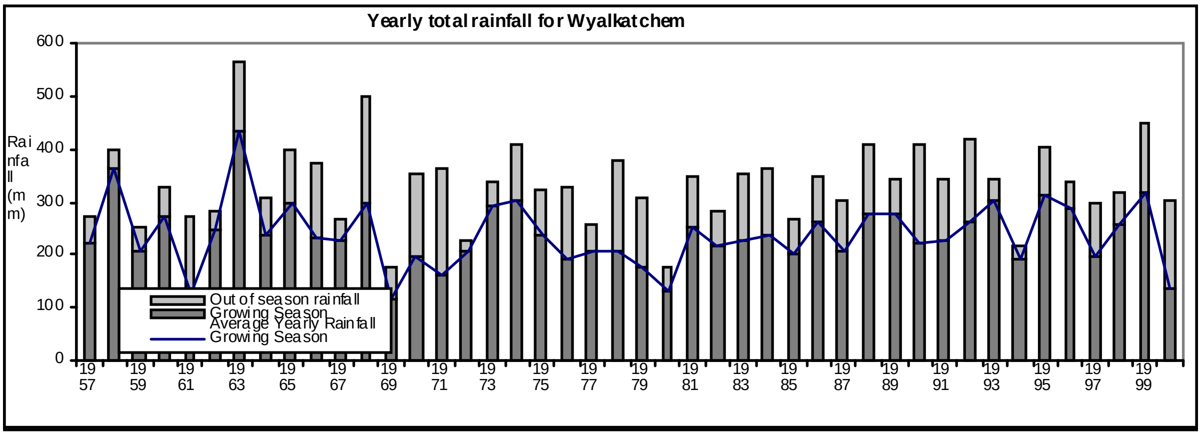

Figure 2.2. Annual rainfall patterns.

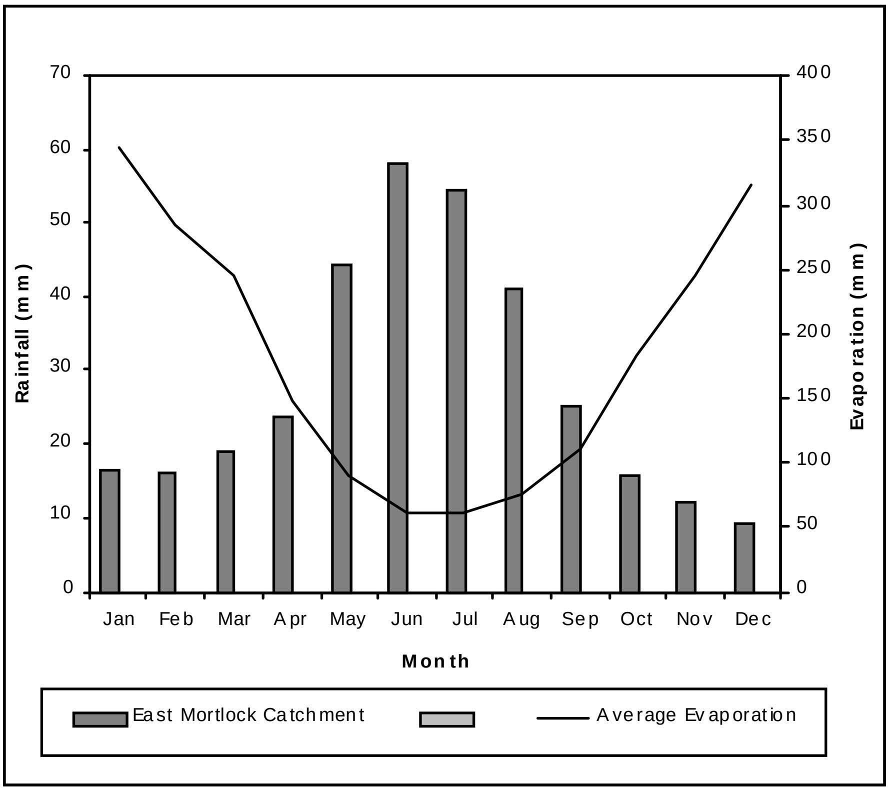

Figure 2.3. Monthly rainfall and evaporation.

Summer thunderstorms are sporadic and cause intense rainfall in some years, such as the rains of February 2000. These storms can cause major run off, erosion and recharge events. Wetter than average summers present opportunities for summer cropping, particularly of forage crops.

Frost is most likely to occur after fronts have passed and a new high-pressure system establishes itself. The combination of events from the preceding cool days and cold southerly air flow followed by clear skies and low or light winds can cause the land surface cool rapidly. Cold air flows to the lowest points in the landscape with the potential to cause damaging frost events (as experienced in 1998 and 1999). The level of crop damage is related to the minimum temperature reached, the period over which the frost persists and the sensitivity of the crops. The most damaging frosts are often those that occur in mid to late spring around the time crops are flowering.

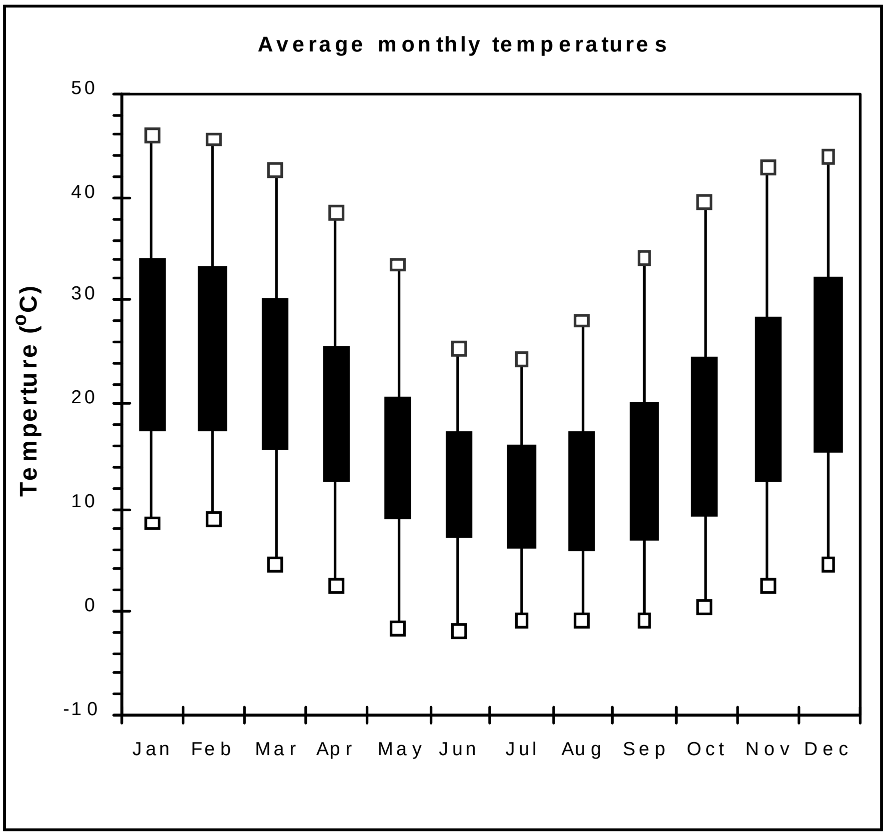

Figure 2.4. Monthly temperature ranges for the catchment

(The bars represent the monthly average range for daily temperatures and the lines represent recorded monthly absolute minima and maxima.)

2.3 Farming systems

Trevor Lacey

2.3.1 Current farming systems

Farming systems are dominated by annual crop/pasture rotations and to a lesser extent continuous cropping rotations. The main crops grown are wheat, barley, oats, lupins, canola, peas and chickpeas. Within these rotations pastures account for 37 per cent and crops 50 per cent of the total farmed area (Figure 2.5). The main pasture species sown are subterranean clovers and medics.

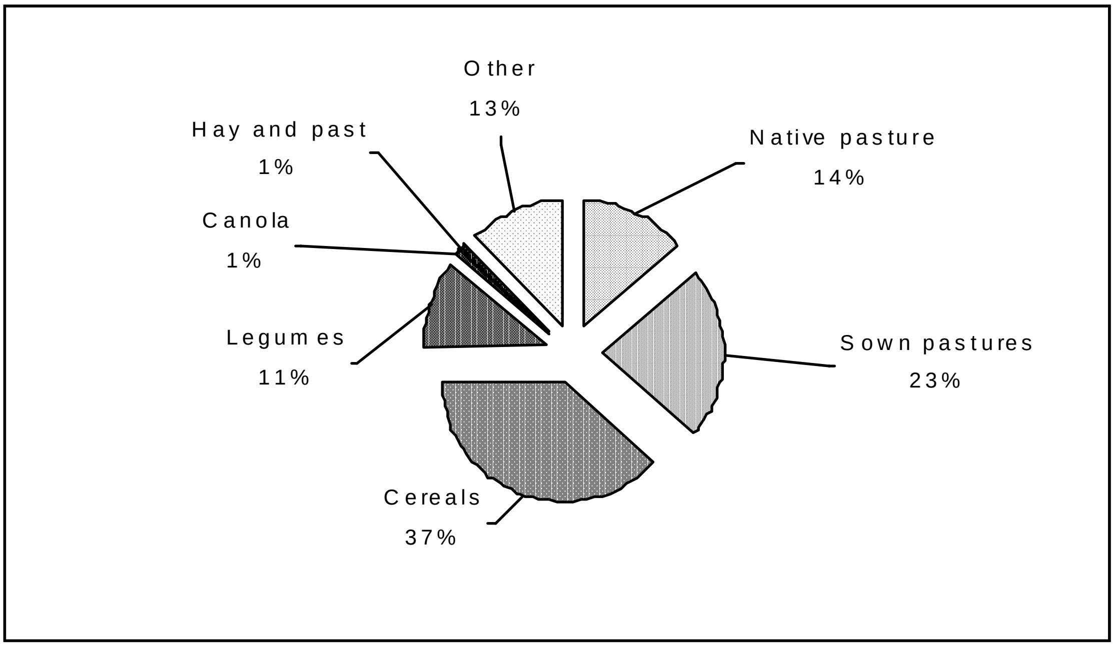

Figure 2.5. Enterprises distribution as percentage of farmed area.[1]

Crop yields show a great deal of variability from year to year but have an underlying upwards trend of 50kg per year (Figure 2.6). This trend may be attributed to technological improvements in areas such as weed control, varieties, fertilisers, rotations and machinery. Crop water use efficiency (yield per mm of rainfall) has generally increased over the period 1983-1999. Average annual wheat yields range from around 1 t/ha in 1983 to over 2 t/ha in good seasons in the late 1990's.

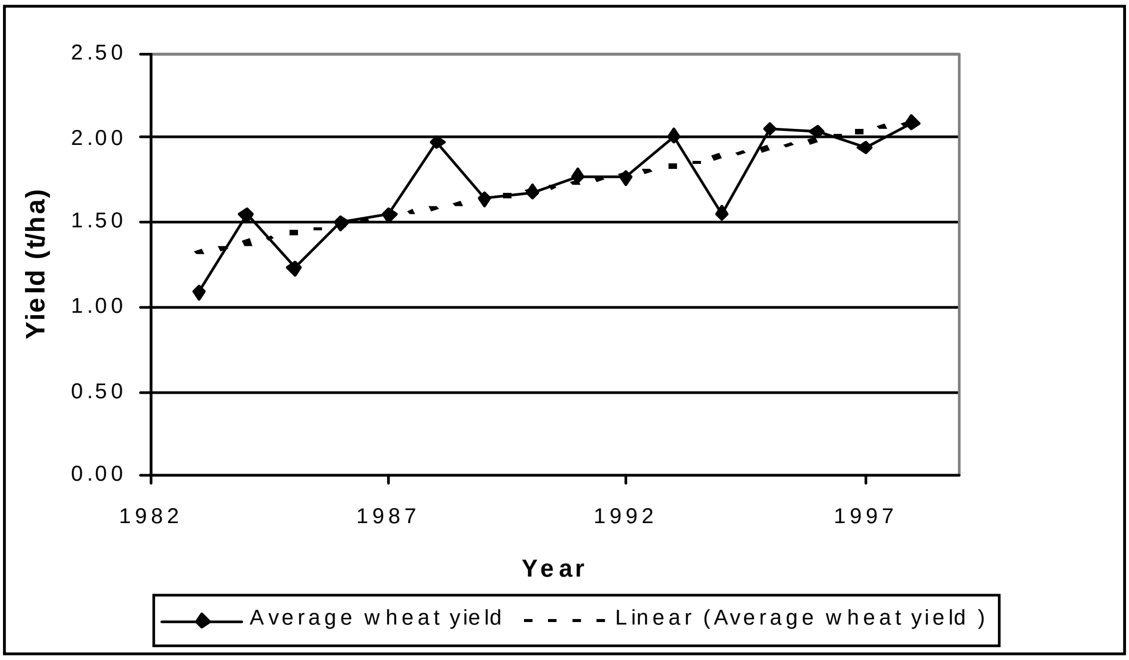

Figure 2.6. Average wheat yields for East Mortlock catchment (t/ha). Based on Cunderdin, Dowerin, Tammin and Wyalkatchem shires.

[1] based on average figures from 1983 to 1999, for the shires of Cunderdin, Dowerin, Tammin and Wyalkatchem.

Average gross value of production (GVP) for the catchment is estimated at $172 million. From the late 80's to the early 90's the GVP from crops hovered around 70 per cent, getting as low as 63 per cent in Dowerin in 1988. Production from cropping increased through the 90's reaching a high of 90 per cent of GVP in Wyalkatchem and Tammin in 1999. Crops currently contribute 81 per cent of gross value of production (GVP). Thus, improvements to cropping should have the biggest impact on total profitability, which may facilitate investment in sustainable management practices.

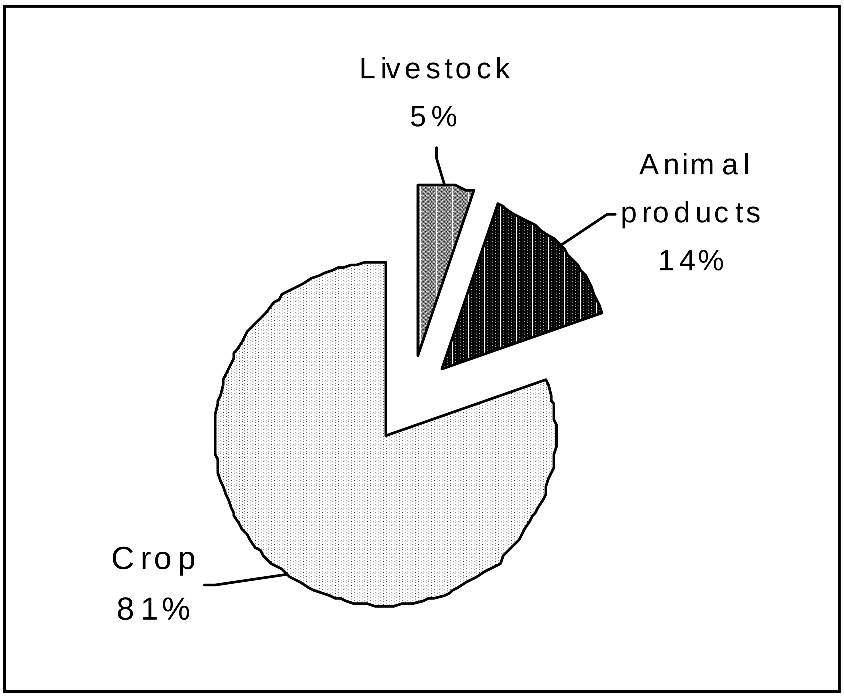

Figure 2.7: Average gross value of production (GVP) for agricultural production in the shires of Cunderdin, Dowerin, Tammin and Wyalkatchem

2.3.1 Summary of farmer survey

Thirty-seven farmers, representing 13 per cent of the catchment area, provided information on farming systems.

The survey results were:

- Farm businesses largely comprise mixed stock (mainly sheep and some cattle) and crop enterprises.
- Crop/pasture rotations and continuous cropping rotations are common on most soils.
- Wet and waterlogged areas are grow permanent annual pastures or perennial vegetation, including some perennial-annual mixes such as alleys and phased lucerne rotation.
- Serradella was by far the most widely adopted higher water use option, having been sown onto 2 per cent of the area farmed by 50 per cent of farmers. Although farmers plan to increase this area to 3 per cent this is significantly less than the area suited to serradella (approximately 30 per cent of the catchment).
- Salt bush is grown by 40 per cent of farmers on 1.3 per cent of the catchment, falling well short of the potential suitable area for it (approximately 25 per cent of the catchment).

- Some farmers are growing lucerne, balansa and persian clovers, warm season crops and forage, oil mallees, pines, tagasaste and acacia.

2.4 Hydrogeology

Shahzad Ghauri and Paul Galloway

2.4.1 Geology and geomorphology

The catchment is located on the Yilgarn Craton, which formed over 2500 million years ago. Most rock outcrop in the area is granite and adamellite. Depth to bedrock is generally shallower in the west, particularly along stretches of the east branch of the Mortlock River, adjacent to Great Eastern Highway. Numerous dolerite dykes that have intruded the bedrock display an east-northeasterly trend and often delineate fractures and possible faults. These dykes are dark-coloured, mostly medium-grained rocks and they often cross the catchment's main flow direction, sometimes forming barriers to groundwater movement.

Physical, biological and geo-chemical processes differentially weather the various minerals and fabrics of the underlying geology. These processes alter hard rock to soft, weathered and transported materials known as 'regolith'. Regolith is usually thickest where rock is deeply weathered and where sediments accumulate.

Most of the catchment lies in the zone of ancient drainage where primary salt lake chains occupy the lowest parts of valley floors (Mulcahy, 1967; Churchward, 1992; Grealish and Wagnon, 1993; Frahmand, unpublished data). In contrast, the far south-west has rejuvenated drainage, characterised by a dissected, undulating landscape and winter flowing rivers (Lantzke and Fulton, 1993; Verboom and Galloway, in press).

2.4.2 Groundwater quality

Groundwater salinity varies considerably depending on aquifer types and landscape position. Salinity increases as water migrates through the regolith and mobilises stored salts. Perched (sandplain) aquifers often have fresh to brackish groundwater and are particularly common in the north and west with scattered occurrences elsewhere. Groundwater samples from the saprock aquifer in Elashgin and North Wyola sub-catchments range from 2000 mS/m to 2700 mS/m. In contrast, similar aquifers in upper South Tammin sub-catchment are often less than 1200 mS/m. South Tammin's upper catchment position and local recharge sources (sandplain hills), with low salt stores account for the differences. Groundwater salinity in the palaeo-channel at South Tammin ranges from 4000 m/Sm to 7000 m/Sm. Where this groundwater reaches the surface, evaporation accumulates salts and hyper-saline water results.

Groundwater pH varies from highly acidic (pH < 4) to slightly alkaline (pH = 7.5). Recent data reveals that highly acid groundwater is more widespread than initially perceived (Grey *et al.* unpublished data). Acid groundwater has the potential to affect agricultural production and is difficult to dispose of.

2.4.3 Water resources

Fresh to brackish water is usually found in piezometers in mid to upper landscape positions, close to sandy soils or rock outcrop. Sumps or depressions in small to moderate sandplain sub-catchments (20-100 ha) are also worthy of test drilling. Many deep bores in the catchment have a lag time of around 20 months between rainfall events and watertable response.

Examples of areas with perched aquifer resources include:

- immediately south of Rifle Range Rd in Wyalkatchem Shire, deep piezometers at and down gradient of the perched aquifer are fresh;
- approximately 10 km north of Great Eastern Highway along Wyola North Road in Cunderdin Shire;
- west of North Road in Dowerin Shire, here a sandplain catchment is discharging water into a large saline lake;
- south of Amery Benjabeering Road in Dowerin Shire and;
- 18 km east of Koorda heading towards Bencubbin.

Examples of areas with fresh-brackish saprock aquifer resources are:

- Several kilometres south of the Goomalling-Wyalkatchem Rd and Cunderdin-Minnivale intersection. Drilling in 2001 confirmed this area as a modest yielding saprock aquifer bore hole (estimated 40 m^3/day and 800 mS/m).
- Approximately 15kms south of Tammin near Dixon Rd in Tammin Shire.
- Two kilometres south of the Kulja-Mollerin Rock Road and Koorda-Kulja Road intersection.

Groundwater found in the Koorda and Bencubbin bore networks is predominately salty, although some minor perched aquifer stores are present.

2.5 Soils

Paul Galloway

Soils of the catchment are inherently variable, often changing over tens of metres. They can, however, be grouped into soil groups (Schoknecht, 2002) that are managed similarly during broad-acre agriculture. These soil groups have been combined into soil supergroups to simplify complex soil-landscape information and to create the simplified soil map of the catchment and Figure 2.8 shows the spatial distribution of soils in the catchment.

The main soils comprise two major soil supergroups and three common soil supergroups that together account for 71 per cent of the catchment (Table 2.1). The major soil supergroups are:

- deep loamy duplexes, which occupy 24 per cent, mostly in valley floors with minor occurrences on lower slopes in the north and;
- sandy earths, which occupy 19 per cent on freely drained crests and slopes, mostly in the north and central areas.

The three common soil supergroups are ironstone gravels (10 per cent), deep sands (9 per cent), and deep sandy duplexes (9 per cent). Table 2.1 describes the abundance and location of these soil supergroups and defines typical soil profiles (see Schoknecht, 2002 for further details).

Other less prevalent but still significant soil supergroups are loamy earths, shallow sandy duplexes and wet/waterlogged soils. Six other soil supergroups occupy only small areas of the catchment. These can be identified in Appendix A1.

Table 2.1. Major soil supergroups

Soil supergroup **Abundance in catchment**	**Profile description** **Dominant location in catchment**	**Soil group components (per cent of catchment)**
Shallow loamy duplexes 208 000ha 24 per cent of catchment	Soils with a loamy surface and a texture contrast at 3 to 30 cm. Valley floors and lower slopes in the north.	Alkaline grey shallow loamy duplex (14 per cent) Alkaline red shallow loamy duplex (5 per cent) Yellow/Brown shallow loamy duplex (4 per cent) Other shallow duplex soils (1 per cent)
Sandy earths 161 000ha 19 per cent of catchment	Soils with a sandy surface grading to loam by 80 cm. May be clayey at depth. Freely drained crests and slopes in the north and centre.	Yellow sandy earth (9 per cent) Red sandy earth (4 per cent) Acid yellow sandy earth (3 per cent) Pale sandy earth (2 per cent) Brown sandy earth (1 per cent)
Ironstone gravelly soils 83 000 ha 10 per cent of catchment	Soils that have ironstone gravels as a dominant feature of the profile. Crests and slopes throughout the south and central catchment.	Loamy gravel (8 per cent) Deep sandy gravel (1 per cent) Shallow gravel (1 per cent) Duplex sandy gravel (<1 per cent)
Deep sands 77 000 ha 9 per cent of catchment	Sands greater than 80 cm deep. Smooth rises in the south west of the catchment around Dowerin.	Yellow deep sand (5 per cent) Gravelly pale deep sand (2 per cent) Pale deep sand (1 per cent) Calcareous deep sand (<1 per cent)
Deep sandy duplexes 76 000 ha 9 per cent of catchment	Soils with a sandy surface and a texture or permeability contrast at 30 to 80 cm. Colluvial slopes, around granite outcrops and sometimes in valley floors.	Grey deep sandy duplex (6 per cent) Alkaline grey deep sandy duplex (2 per cent) Red deep sandy duplex (1 per cent) Yellow-brown deep sandy duplex (<1 per cent)
Other minor soil-supergroups 256 000 ha 29 per cent of catchment	Loamy earths (8 per cent), Shallow sandy duplexes (7 per cent), Wet or waterlogged soils (6 per cent) and six other minor soil-supergroups each comprising 2 per cent or less.	Calcareous loamy earth (7 per cent) Alkaline grey shallow sandy duplex (4 per cent) Grey shallow sandy duplex (2 per cent) Saline wet soil (3 per cent) Hard cracking clay (2 per cent)

The soil supergroups described above provide a basis for Land Management Unit mapping. More detail about the soil-landscape mapping process, soil groups and Land Management Units (LMUs) is provided in appendix A1, to assist mapping LMUs at the farm scale.

Insert Soil Map (A3), as figure 2.8

2.6 Surface water

Harry Lauk

The following information was drawn from the farmer survey:

- Earthworks are widely used, with 70 per cent of farmers using contour banks, 27 per cent using deep drains and 11 per cent using other forms of surface water drainage for waterlogging management. Farmers indicated a potential increase in deep drains and surface drainage in the future.
- All farmers surveyed are connected to scheme water, which supplies on average 60 per cent of water used on-farm (ranges from 1 per cent to 100 per cent).
- Over half the farmers considered their water supplies to be adequate with the remainder requiring further information on developing reliable water supplies.
- Dams generally rely on banks or natural catchments to help them fill, with only 10 per cent having roaded catchments.

Improvements could be made in water harvesting techniques, to reduce reliance on scheme water. The potential also exists for farmers to expand and improve earthworks for surface water management.

2.7 Remnant vegetation

Don Cummins

Only 4.8 per cent of the original vegetation remains. This is comparable to most central wheatbelt catchments, which retain between 5 and 10 per cent remnant vegetation. Loss and fragmentation of remnant vegetation can have major impacts on genetic diversity and associated ecosystems. Analysis of the remnant vegetation found in the catchment has shown:

- York gum and salmon gum woodland, represents only 1.5 per cent of its original coverage.
- Succulent steppe with mallee and thickets: Mallee and *Melaleuca uncinata* thickets on salt flats have disappeared from the catchment. This vegetation association is poorly represented statewide with only 92 ha remaining, all of which is found outside CALM reserves. While these species are represented elsewhere in the catchment, as a grouping they no longer exist.
- Average remnant size in the catchment is 8.3 ha; the significance of this data is discussed in the 'risk' section of this report.
- The wandoo, York gum, salmon gum, morrel and gimlet vegetation association covers only 2.8 per cent of its original area (44 per cent) and mallee and Casuarina thicket covers only 6.7 per cent of its original area (19 per cent).

- The majority of remnant vegetation is found on hilltops and along drainage lines. The salt lake chains within the catchment have the bulk of large remnants (greater than the average 8.3 ha), generally dominated by samphire with open woodland fringing vegetation. These areas are shown in association with vegetation type in Figure 2.9.

2.7.1 Catchment wetlands

- Lake Noonying (12 ha) is found in the Noonying Nature Reserve (48 ha) in the Shire of Tammin, 3 km southwest of Tammin townsite and is a seasonal lake, which has become saline in the last 10 years. The lake is covered by a stand of dead swamp sheoak, however, this species and broom bush are still found on the lake's fringes (Weaving 1999).
- Lake Wallambin (121 ha) is located in the Wallambin Nature Reserve in the northeast corner of the Shire of Wyalkatchem and is a generally dry salt lake, surrounded by samphire flats and woodland on upper slopes (Weaving 1999).
- Yorkarakine Rock Reserve (157 ha) in Tammin contains an ephemeral freshwater system based on granite rock pools, which are listed as being nationally significant by the Commonwealth Government (Safstrom 1999). The vegetation is predominately rock sheoak, jam, salmon gum and wandoo.

2.7.2 Significant reserves

- Derdibin Nature Reserve, 17 km south of Wyalkatchem, covers and area of 134 ha and is considered by CALM to be an important habitat for at least 9 bird species (Weaving 1994).
- Charles Gardiner Reserve (799 ha), 15 km south of Tammin, has three species of declared rare flora: sticky hemigenia, moth trigger plant and woolly sheoak and a total of 443 plant species have been found in this reserve.

2.7.3 Rare and endangered flora*

Name	Common name	Found	Habitat
Allocasuarina fibrosa	woolly sheoak	Found in Charles Gardiner Reserve, Tammin.	Sandheath
Daviesia euphorbioides	Wongan cactus	Found in road, rail and nature reserves in the Shire of Dowerin	
Eremophila resinosa	resinous erimophila	Found in a single road reserve in the shire of Wyalkatchem	Open mallee scrub on sandy clay loams.
Eucalyptus synandra	jingymia mallee	Found in road reserves and private land in the Shire of Koorda.	Open mallee heath or dense scrub in sand over laterite.
Roycea pycnophylloides	saltmat	Found on private land in the Shire of Cunderdin.	Open sandy, saline flats.

Name	Common name	Found	Habitat
Verticordia hughanii		Found in a nature reserve and on private land in the Shire of Dowerin.	Grey sandy soil on the edge of salt lakes
Hakea aculeata	column hakea	Found on private land and road reserves in the Shires of Tammin and Cunderdin.	
Hemigenia viscida	sticky hemigenia	Found in road, rail and nature reserves and on private land in the Shire of Tammin	Low heath on sand over gravel.
Pityrodia scabra		occurs on a single site on a road reserve in the Cowcowing area of Wyalkatchem	

Insert Figure 2.9 Remnant Vegetation Extent x Type.

3. CATCHMENT RISKS

3.1 Salinity and groundwater

Shahzad Ghauri

3.1.1 Current extent of salinity

The catchment has 79,000 hectares of saline land (9.2 per cent), based on Land Monitor data, shown in Figure 3.1.

Salinity is most common in the valley floors but farmers rated salinity occurring at the change of slope as the biggest problem. This may indicate where salinity is currently developing or where management options are available. Salinity is likely to expand in low-lying areas adjacent to existing salinity, however this expansion is highly dependent on elevation, slope, and soil type.

3.1.2 Potential salinity risk

Land-height information from the Land Monitor project indicates that approximately 275,000 hectares (32 per cent of the catchment) is located in low-lying areas (close to surface-water flow paths) some of which could become waterlogged and/or saline if watertables rise sufficiently. Sandy soil types and areas close to large discharge areas are unlikely to be so affected.

Details and accuracy statements of the Land Monitor data sets can be found in CSIRO Mathematical and Information Services (CMIS) Report No. 01/111.

3.1.3 Groundwater trends

Groundwater trends in the catchment are variable: borehole data indicates rising, falling or relatively static trends over short and long monitoring periods.

Rising trends

Middle and upper slope areas show the greatest rates of groundwater rise (> 0.15 m/yr). In Elashgin, piezometers in the upper catchment show definite groundwater rises of between 0.13 m and 0.64 m per year and groundwater is relatively fresh in these piezometers. It is clear that the upper catchment rise is caused by perched groundwater recharging deep groundwater. Groundwater in the valley is much more saline (2180 and 2660 mS/m) and is rising. Variations in groundwater salinity do not seem highly correlated with rates of rise, meaning that both localised recharge and regional scale recharge are responsible for rising watertables.

Falling trends

Twenty four bores have also been identified as having significant falling trends (> 0.10 m/yr), just over half of which are located in lower landscape or valley positions and proximal to discharge areas. Most falling trends are explained by recent climatic events and do not significantly reduce the threat posed by salinity.

Static bores

Many bores show both rising and falling trends of less than 0.10 m/yr over various monitoring periods. The bulk of these bores are located in lower slope or valley/discharge areas and are due to reductions in rainfall/run-off in recent years and/or discharge via capillary action.

3.1.4 Effect of rainfall

Analysis of all piezometer data was conducted using the Hydrograph Analysis and Rainfall Time Trends program (HARTT), (Ferdowsian *et al*. 2001). The program assists in explaining long term groundwater trends by removing the effects of rainfall events from the underlying time trend.

Figure 3.2 details hydrographs and HARTT values (where applicable) of East Mortlock piezometers.

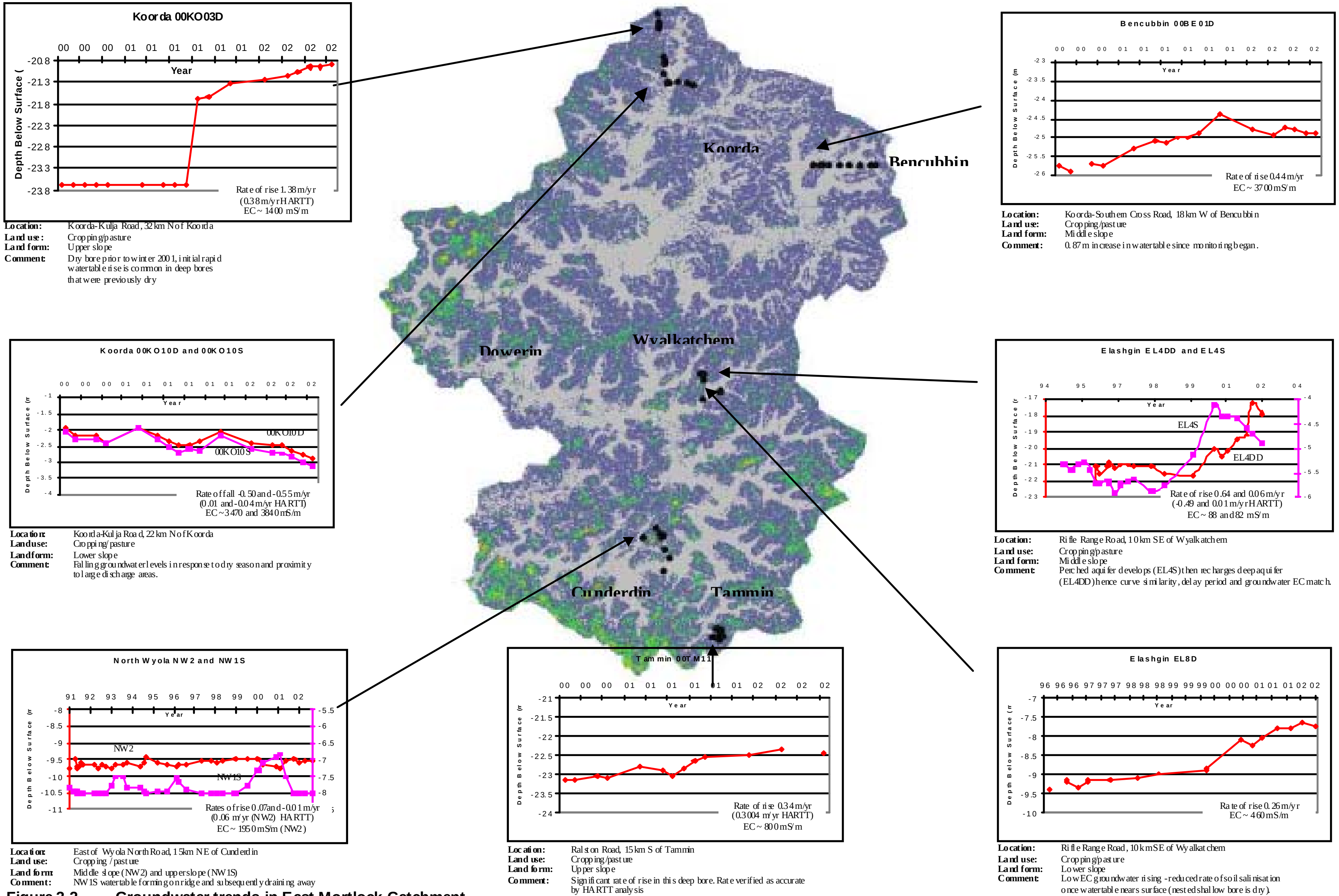

Figure 3.2 Groundwater trends in East Mortlock Catchment.

3.1.5 Areas of increased salinity risk

Landscape constrictions, spurs and low gradient points have been identified as possible causes of increased salinity risk in the catchment. Converging ridgelines at drainage outlets hinder flow, and spurs that extend into drainage lines are prone to lateral groundwater flow accumulation. An example of constriction salinity can be seen at the intersection of Old Koorda and Underwood Flat Roads in Dowerin Shire. Salinity associated with spurs can also be found approximately 15 km north of Tammin along the Yorkrakine Road.

The specific sites listed below are shown on Figure 3.1, as areas of increased salinity risk due to constrictions, spurs and low gradients.

- Area 1 (2700 ha) - low gradient zone with constriction near discharge point. Piezometers showing rising trends and current salinity expected to increase in severity.
- Area 2 (250 ha) - narrow linear zone with distant discharge point ie. small outflow to inflow ratio.
- Area 3 (250 ha) - low gradient zone with moderate constriction to flow.
- Area 4 (500 ha) - low gradient zone with moderate spur hindering flow.
- Area 5 (350 ha) - low gradient zone with moderate constriction to flow.
- Area 6 (1000 ha) - low gradient zone with moderate spur hindering flow. This area is occupied by sandy duplex soils that may reduce the overall salinity risk. Sandy surfaces decrease capillarity and are easily leached by rainfall infiltration.

3.2 Soil and land degradation risks

Paul Galloway

The major land degradation hazards are soil acidification and soil structure decline. Both hazards are manageable using existing methods but are likely to affect large areas now and into the future unless best management practices are adopted. Other hazards that potentially affect significant areas are subsoil compaction, wind erosion, waterlogging and water repellence. These less visible forms of land degradation affect larger areas than salinity. However, they often go unnoticed and untreated (Nulsen, 1993).

Options for best managing each degradation hazard vary, depending on site characteristics and farming systems. A site analysis and farming system appraisal should be undertaken before recommending one option over another. Degradation hazards and management options are more fully described in Moore (1998) and in the farmnotes listed in further reading.

3.2.1 Soil acidity

Approximately 400,000 ha (46 per cent) is moderately to highly susceptible to increased rates of acidification and 35,000 ha (4 per cent) of this is naturally acidic. Testing soil pH in the surface (0-10 cm) and subsurface (10-20 cm) layers is the only accurate way of monitoring acidification. Soils most susceptible to acidification are the deep sands, sandy earths and ironstone gravels, which occupy 320,000 ha, or 37 per cent and are associated with lateritic landforms.

Liming is the most common method of halting and reversing acidity on these productive soils. The total annual lime requirement for the catchment is calculated to range from 30,000 to 50,000 tonnes, based on acidification rates of between 75-125 kg Lime Equivalent/ha/yr (Porter and Miller 1998). Lime use has increased significantly within the catchment from 1994-1995, when only 10-20 per cent of the required lime was applied, to 1998-1999, when between 65-110 per cent of required lime was applied (Figure 3.3). Annual lime applications currently average about 35-60 per cent of the total required, similar to the state average of between 50-60 per cent (Miller 2002). These rates vary significantly with the seasonal economic situation.

Mount Marshall and Kellerberrin shires are under-performing in lime application rates compared to the catchment as a whole, with lime applications averaging 34 per cent in Mount Marshall and 52 per cent in Kellerberrin, of the lower estimated liming rate shown in Figure 3.3. This can probably be attributed to difficult seasonal and economic conditions and limited farmer exposure to liming campaigns within both shires. Transport costs to farms in Mount Marshall may also contribute to low lime application rates.

From the farmer survey, it was found that lime has been used on over 20 per cent of the catchment area (of farmers surveyed) with intended use on 46 per cent. The Lime and Nutrient Calculator, available from Top Crop Administration, Department of Agriculture Northam, can be used to calculate the lime requirements for individual paddocks.

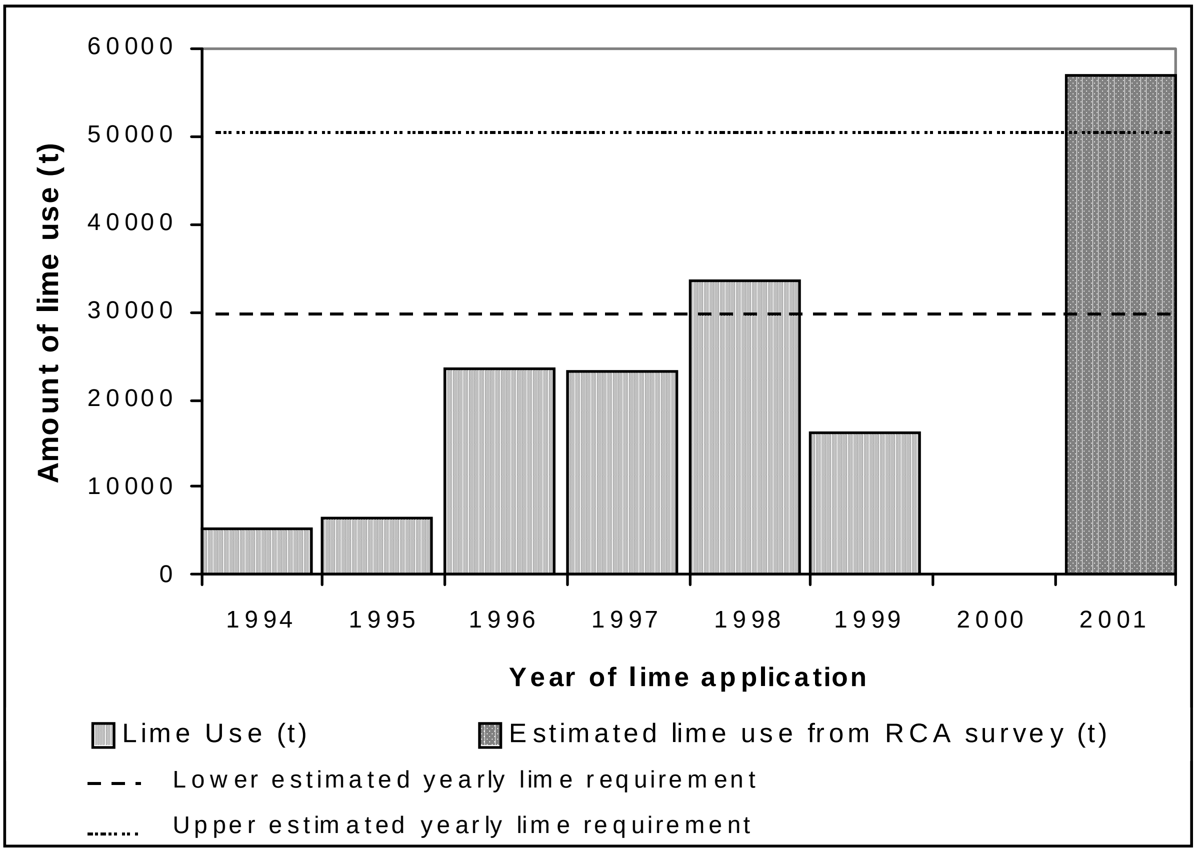

Figure 3.3 Lime use and catchment lime requirement

* Annual lime use in 2001 is based on farmers RCA survey information (farmers surveyed applied lime to 7400 ha at an estimated rate of 1 t/ha).

Lime responses are variable on the naturally acidic yellow sandy earths, or Wodjil soils, which account for about 25,000 ha (3 per cent), in the north of the catchment. Andreini and Dolling (unpublished report) suggest that economic responses to liming Wodjil soils are marginal or ineffective. However, some trial results suggest that lime applications are economically beneficial to production (Gazey, pers. comm.). Best soil acidity management on acid sandplain is a liming program in conjunction with planting acid tolerant species and using less acidifying management practices (Gazey, pers. comm.). The other naturally acidic soil is the agriculturally unproductive shallow duplex soil (8000 ha or 1 per cent) generally found below breakaways. These should be fenced and revegetated.

3.2.2 Soil structure decline

Approximately 328, 000ha (38 per cent) has loamy and clayey surfaced soils that are moderately to highly susceptible to soil structure decline. Of these, the shallow loamy duplex (24 per cent) and loamy earth (8 per cent) soils are most at risk, due to their clay mineralogy, chemistry, landscape position and past management.

Soil structure decline can be minimised and reversed by applying gypsum, increasing organic matter, blanketing the soil surface with stubble, practising minimum tillage and removing stock during wet periods.

Gypsum has been used on 7 per cent of the farmed area (surveyed farmers) with intentions of use on approximately 12 per cent.

3.2.3 Subsurface compaction

Approximately 57 per cent is moderately to extremely susceptible to compaction, but the sandy earths (19 per cent) and deep sands (9 per cent) should be targeted first, as they are both most susceptible and most likely to respond, if no other root-limiting layer is present.

Controlled traffic farming minimises the extent of compaction after pans are removed by deep ripping. It also delivers other benefits to the farming system. Deep ripping has been carried out by approximately 30 per cent of farmers on 6 per cent of the area farmed.

3.2.4 Wind erosion

Areas of bare loose, dry soil, in higher landscape positions are most at risk (Moore *et al.* 1998). The most susceptible soils are deep sands, sandy duplexes and sandy earths on crests and upper slopes. About 52 per cent of catchment soils are moderately to extremely susceptible to wind erosion but areas of the catchment at risk are usually much less because of landscape factors and effective paddock management.

Wind erosion can be controlled by maintaining cover, stock management and planting windbreaks to protect susceptible areas. The minimum requirement is 50 per cent cover on paddocks to prevent wind erosion, which translates to 750 kg/ha of cereal crop residue and 500 kg/ha of dry matter in pasture paddocks.

3.2.5 Waterlogging

About 28 per cent of the catchment is moderately to severely susceptible to waterlogging and the main soils affected are shallow sandy and shallow loamy duplexes on lower slopes and valley floors. Waterlogging management is addressed in more detail in the surface water management section.

3.2.6 Water repellence

Water repellence mostly occurs on sandy surfaced soils that have hydrophobic organic matter present. This situation most commonly occurs on the highly productive sands, sandy earths and gravelly soils that are managed under a cereal-legume rotation. About 23 per cent of the catchment is moderately to highly susceptible to water repellence and this figure is thought to be increasing within the Cunderdin shire (Godfrey pers. comm.).

Water repellence is most commonly managed by clay spreading and furrow sowing.

3.3 Surface water

Harry Lauk

The catchment has many broad flat valley systems – Figure 3.4 shows that thirty one per cent of the catchment has slopes of less than 1%. Rising watertables are likely to cause widespread waterlogging and salinity in the valley floors. In wet years, surface flooding will also be a problem.

Fifty five per cent of the area has slopes between 1 and 3%, where 80% of the soils are sandy or loamy duplex types. In these areas, runoff would be insufficient for stock/farm water supplies with below-average or even average rainfall. In above-average rainfall years, erosion and waterlogging would affect these sandy/loamy duplex soils.

Surface water management should be a higher priority than subsurface water/moisture control in this catchment.

Insert figure 3.4 Slope map

3.4 Vegetation risk assessment

Don Cummins

3.4.1 Remnants at risk from salinity

The salinity risk in relation to remnant vegetation has been determined using Land Monitor salinity mapping.

- The succulent steppe with open woodland and thicket: York gum over *Melaleuca thyiodes* and samphire association is at greatest risk from shallow groundwater tables. The open woodland of this association, which fringes samphire flats, could be significantly affected if salinity expands in the future.
- While shires such as Koorda, Tammin and Dowerin have relatively large areas of vegetation affected by salinity (Table 3.1) much of this is confined to vegetation fringing existing salt lake chains and saline drainage lines.

Table 3.1. Salinity and remnant vegetation

Shire*	Area of vegetation		Area of affected by salinity	
	(ha)	per cent	(ha)	per cent
Cunderdin	3,095	2	700	23
Dowerin	6,638	4	1,080	16
Goomalling	874	3	100	11
Kellerberrin	1,509	7	20	1
Koorda	10,143	7	1,170	12
Mt Marshall	3,384	6	280	8
Quairading	5	1	0	0
Tammin	5,180	5	1,520	29
Trayning	1,602	4	90	6
Wongan-Ballidu	885	5	35	4
Wyalkatchem	7,751	5	2,120	27
All Shires	**41,066**	**5**	**7,115**	**17**

* referring only to the portion of the shire found in the catchment.

3.4.2 Fragmentation and biodiversity loss

Fragmentation of remnant vegetation can disrupt ecological processes and remnants may become too small to maintain viable breeding populations of species. Table 3.2 shows that the catchment has vegetation associations that are fragmented into a series of small remnants, the majority of which are below 10 ha.

The York gum, salmon gum, morrel and gimlet vegetation association originally covered 44 per cent of the catchment. Such woodlands are now found in isolated islands of mature trees, often with grazed understorey and little or no regeneration. All species in this association are slow maturing and fragmentation/isolation probably means the loss of such woodland in the long-term. None of this vegetation association is located in CALM reserves within this catchment.

A critical threshold of 30 per cent of the landscape occupied by woodland has been suggested as essential for sustaining bird and mammal populations (McAlpine and Loyn 1998). This catchment contains less than 2 per cent woodland, making this vegetation type generally unsuitable for many fauna species. Critical thresholds for individual species need to be determined before management decisions are made locally. For example a study in Wyalkatchem has shown that wrens have a range of up to 15 km but will rarely cross gaps in vegetation greater than 60 m wide (Brooker 1999).

Table 3.2. Fragmentation of catchment remnants

Vegetation association		Area (ha)	Average remnant (ha)
Medium Woodland	York and salmon gum.	526	3
	York gum, salmon gum, gimlet.	3483	3
	York gum.	1	1
	Mallet.	1	1
	Wandoo, York gum, salmon gum, morrel, gimlet.	10,723	2
Shrubland	Tea-tree thicket	9	1
	Allocasuarina campestris thicket.	62	4
	Scrub-heath on yellow sandplain and banksia-xylomelum alliance.	1,031	4
	Allocasuarina campestris thicket with wandoo.	420	9
	Mallee and Casuarina thicket.	10,951	5
	Acacia, Casuarina and Melaleuca thicket.	2,681	2
	Melaleuca uncinata thicket and scattered York gums.	430	23
Mosaic	Shrubland, scrub-heath/shrubland *A.campestris* thicket.	1,713	1
	Medium woodland; York gum, salmon gum, morrel/succulent steppe; saltbush and samphire.	36	1
	Shrubland, Melaleuca, patchy scrub/succulent steppe and samphire.	1,858	19
	Medium sparse woodland, salmon gum, yorrell/succulent steppe; saltbush and samphire.	1,877	2
Low woodland	*Allocasuarina huegliana* and jam	69	2
Succulent Steppe	With thicket - *Melaleuca thyoides* over samphire.	462	7
	With open woodland and thicket: York gum over *M. thyiodes* and samphire.	3,800	58
	Samphire.	60	2
	Other areas e.g rock outcrops	870	N/A
Total		**41,063**	**8**

*** This is the average total remnant size each vegetation association is found in; remnants may contain several vegetation associations.**

4. MANAGEMENT OPTIONS AND IMPACTS

4.1 Farming systems

Trevor Lacey and Shahzad Ghauri

4.1.3 Catchment modelling

Two computer models were applied to determine the impacts of farming systems based management options on groundwater recharge. The Flow tube model utilises real bore data gathered across a local sub-catchment transect. The bore data used in the construction of this model was collected during April 2000 and scenarios are presented representing differing levels of intervention by all landholders within the entire catchment. The AgET model concentrates on estimating the amount of water flowing beyond plant roots for different farming rotations on different soil types. AgET data had a further layer of analysis applied at the catchment scale, via the Catcher model, which estimates the impact of changing farming rotations on the catchment water balance.

Combined modelling results have developed the following recharge scenarios:

1. **Do nothing.** Recharge under existing rotations is estimated to be 11 per cent of annual rainfall.
2. **Low intervention.** Could see a reduction of recharge to 9 per cent of annual rainfall by increasing perennials from 5 per cent to 14 per cent of catchment area.
3. **Moderate intervention.** This would involve an increase in perennials to 19 per cent, through the introduction of phase farming and could reduce recharge to 8 per cent of annual rainfall. Significantly, these perennial systems may provide the basis for profitable production from areas with shallow water tables. Increasing the level of perennials in the catchment from 5 per cent to 19 per cent only reduces pasture area from 30 per cent to 28 per cent and cropped area from 64 per cent to 61 per cent. The total production from this optimistic intervention should be at least as good as from current rotations. Stock carrying capacity is likely to be similar or increased, with a better spread of feed throughout the year (from 8 per cent perennial pastures), providing the opportunity to target higher-priced markets for out of season stock.
4. **High intervention.** A reduction of recharge by 50 per cent could be achieved through the widespread adoption of perennial pastures, alley farming, tagasaste and oil mallees.

It is important to note that altering farming systems to include some phased crop and perennial pasture rotations can significantly reduce recharge without major changes to the total area of crop and pasture. However, changing from continuous annual pasture to crop-annual pasture rotation or to continuous cropping will only reduce recharge slightly.

The use of lucerne and woody perennials in farming systems is considered highly beneficial, as they use almost all of the annual rainfall. While annual crops permit approximately 5-15 per cent of rainfall to flow past the root zone and clover/medic pastures allow 10-30 per cent of rainfall past the plant root zone, depending on soil type.

When recharge is examined from a soil and landscape perspective the following should be noted (see Figure 4.1):

- Deep sands and ironstone gravels are major soils with high recharge potential. The best way to manage recharge on them is by planting permanent perennials (e.g. revegetation with natives, tagasaste, rows of shelter belts, etc.) and phase cropping with perennial pastures, or less effectively, deep-rooted annual pastures (e.g. serradella) or continuous cropping.
- Shallow sandy duplexes are major soils that contribute significantly to recharge via preferred pathways such as large cracks and root channels, particularly when the soil profile is saturated or waterlogged. Recharge will reduce on this soil by improving surface water management (reducing waterlogging) and altering the farming system to increase perennials and improve crop and pasture water-use.
- General results show that middle and lower slopes are at risk of salinisation within 20 years and that the onset of salinity in middle slope areas can be delayed by many years, depending on the level of intervention. However, lower slope and valley areas must not be seen as being completely unproductive in the future, as many areas within salinised paddocks will remain highly productive for salt tolerant pastures.
- Areas with steeper slopes and shorter distances to discharge points will be less affected by salinisation because of higher groundwater gradients and less constrictive flow, thus reducing groundwater rise. Examples of such areas include stretches of Mortlock River East, particularly on the western flank of the catchment around Dowerin-Meckering Road and south of Great Eastern Highway between Meckering and Cunderdin.

The rotations used on each major soil of the catchment, shown in the modelling are presented in more detail in Appendix A3.

Note: Flow tube modelling cited in this report assumes a constant annual rate of recharge. It does not take into account episodic recharge (high rainfall/flood events which often results in watertables rising and not lowering to their previous, deeper levels). Another major assumption is that all strategies implemented take effect immediately with full potential e.g. lucerne is transpiring water at its full potential from the moment it is included in the program.

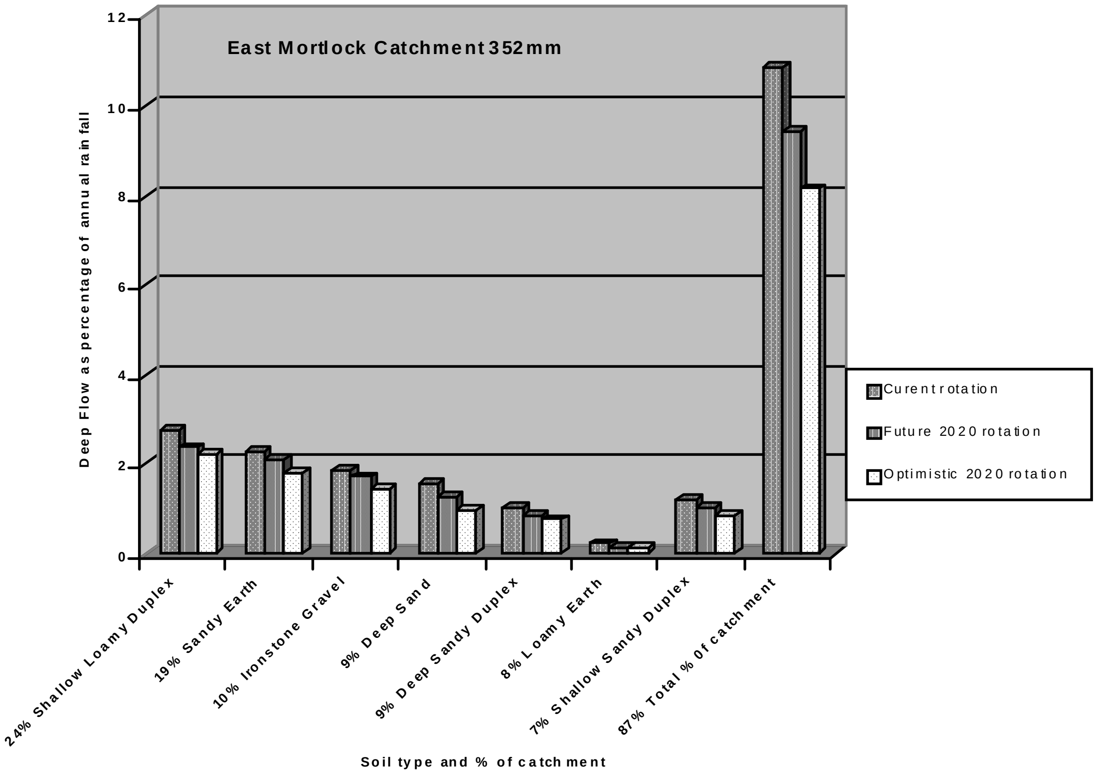

Figure 4.1. Catchment recharge from current and future rotations*.

*** For details of rotations on soil types and recharge from components of the rotation see appendix A3.**

4.1.4 Farming systems options summary

4.1.4.1 Annual crop rotations and the use of best farming practices

Best practice annual crop and pasture agronomy will marginally improve water use. Doubling crop yields only increases water use by 5 per cent, and annual crops use more water than traditional annual pastures. Annual summer crops use similar amounts of water as traditional annual crops, but are able to use summer rainfall and moisture stored in soil. This has a net positive impact on year-round water use if winter crops or pastures follow summer crops. However, effective surface water management and perennial species are needed to reduce recharge rates significantly.

4.1.4.2 Integrating perennial pastures into the farming system

Perennials use water year-round and are generally deeper rooted than annuals, so are better at drying the soil profile. Perennial pastures do not use as much water as woody perennials, but they can be used on a large scale in farming systems without changing land use and without major changes to farming practices. Lucerne is a perennial legume pasture that can successfully be incorporated into farming systems. Some subtropical and temperate perennial grasses (including sorghum, which can grow as an annual or perennial) are currently being evaluated by farmers in WA.

Soils that are difficult to crop, or that have marginal economic returns, are a good opportunity for perennial pastures, forage crops and woody perennials. Perennial pastures are well-suited to stock enterprises as they can provide a better distribution of feed throughout the year, thus removing or reducing the need for feed supplements and enabling high-priced markets to be targeted.

Rotations using perennial pastures have farming benefits including:

- managing herbicide resistant weeds;
- increasing the range of enterprises;
- extending green feed;
- finishing stock out of season;
- providing ground cover; and
- reducing the need for supplementary feeding of stock.

Sites where fresh water accumulates provide perennial vegetation with the opportunity to maximise water use and production. 'Best bet' sites to maximise the production from perennial species such as lucerne include:

- above break of slope positions;
- on soil changes where the up-slope soils are lighter than the down-slope soils;
- in gritty soils around rock outcrops; and
- above dykes and faults.

Lucerne dryland grazing systems:

- grow on various soil types and environmental conditions throughout Western Australia;
- produce feed with quality and quantity equal to or better than sub-clover;
- produce green feed from April to December and later throughout summer, depending on moisture availability;
- provide an opportunity to finish meat sheep out of season for premium markets; and
- require rotational grazing management.

4.1.4.3 Integrating woody perennials into farming landscapes

Woody perennials use more water than perennial pastures. They best fit into the farming system in landscape or soil niches, in alleys or block plantings. For information on commercial woody perennials that fit into the landscapes of East Mortlock refer to Table 4.3.

4.2 Groundwater management

Shahzad Ghauri

4.2.1 Managing recharge

Flow tube modelling suggests that revegetation will impact future groundwater trends. Following are two local examples of revegetation to control recharge:

1. Over 10, 000 salt tolerant eucalypts in a mildly saline area of land had been successfully established in 1986 south of Tammin. In 1989, multiple rows of four to five trees were planted down slope, with a strip of cultivated land (25 to 30 m) in between. The area was dominated by barley grass prior to trees being established and had a groundwater salinity of < 2000 mS/m. Post-establishment groundwater levels indicate

that a 0.5 m fall in watertable occurred very soon after planting, followed by further drops until a 1 m drop was achieved at the end of summer 1991 (Figure 4.3). This effect appears to be long term. Additional measurements show that groundwater salinity has reduced by up to 40 per cent over the decade long period.

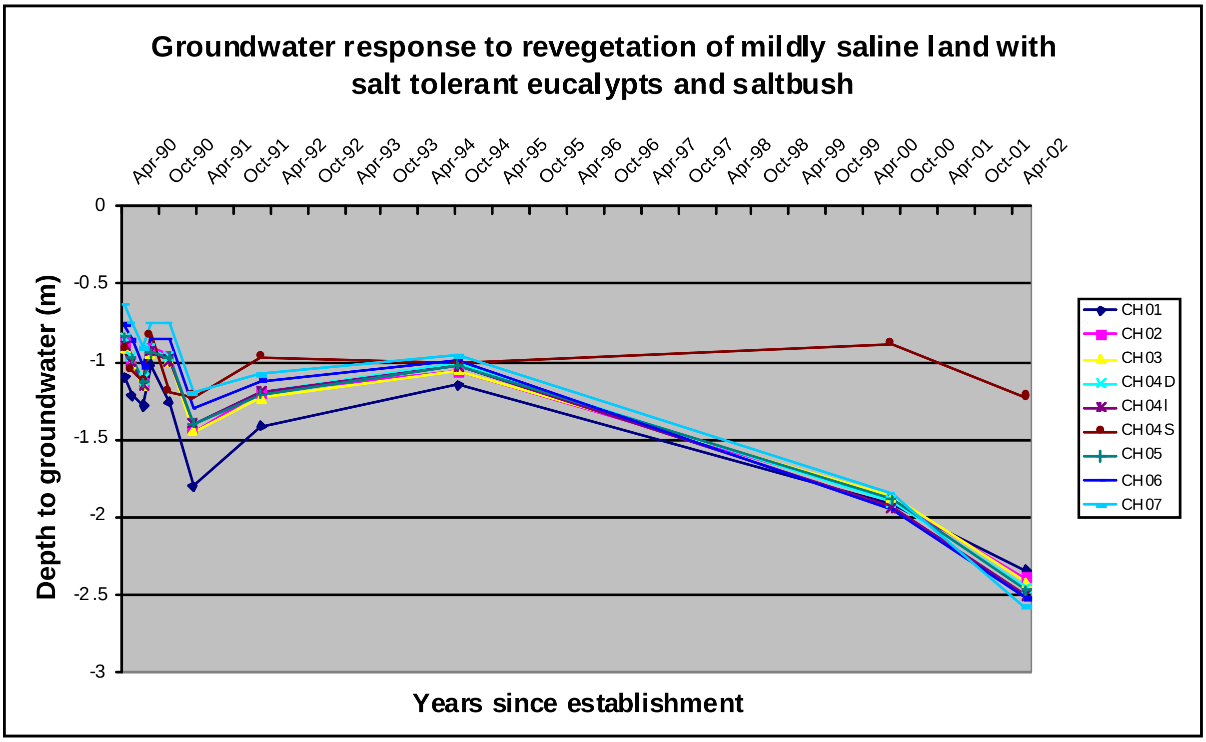

Figure 4.2. Groundwater level data beneath a revegetated mildly saline area south of Tammin.

2. A second site located south of Tammin is one that is easily reproduced on small hill slopes across the wheatbelt. In this case, tagasaste was planted a few hundred metres upslope of an area (including a public road) which often became wet and boggy during winter. From anecdotal evidence this planting has intercepted groundwater moving down slope and may have contributed to the reduced incidence of road damage. Such targeted revegetation would be useful to manage hillside seeps.

4.2.3 Managing discharge

Deep drainage

Installing drains in soils with low hydraulic conductivity such as heavy clays, may only impact on as little as 10 m of land either side of the drain. However, deep drains can be effective where they intercept more permeable aquifers, that have a hydraulic gradient, even when these are quite thin. These include clay overlying permeable saprolite, sandy sediments, clays with preferred pathways such as sand seams and old root channels. Proper design, land degradation potential and safe disposal of water should always be considered before constructing drains. Visit the following website for more information on deep drainage:

www.agric.wa.gov.au/environment/land/drainwise/options/engineering/deep_drains.htm

Groundwater pumping

Groundwater pumping is a valuable tool, particularly for controlling watertables under high value assets. Aquifer pump tests in Koorda town site indicate that the production bore could provide a high yield, but only over a short period. Groundwater barriers limited watertable draw-down to 0.2 m, just 40 m from the production bore (Hopgood, 2001a). Aquifer pump tests in Dowerin town site achieved a small draw-down of 0.1 to 0.2 m at a site 43 m away, and about 0.4 m at a site 19 m away.

Qualified groundwater hydrogeologists should conduct site investigations to locate production bores, as groundwater systems are complex and variable.

For more information on groundwater pumping, visit the following website:

www.agric.wa.gov.au/environment/land/drainwise/options/engineering/Gwtr_pump.htm

4.3 Surface water management

Harry Lauk

4.3.1 Introduction

Surface water management should focus on the following problems:

- waterlogging on the slopes of the sandy/loamy duplex soils;
- large valley floors and smaller hillside seep areas of waterlogging;
- hillside seepages and flooding prone areas in wet years;
- inadequate maintenance of existing surface water control earthworks;
- on farm water supplies in below average rainfall years;
- water erosion on slopes from 3-10 per cent.
- inappropriate design of some earthworks; and
- lack of industry standards for deep drainage earthworks.

4.3.2 Land management principles

Conservation land management options reduce the velocity and erosiveness of surface water and include:

- vegetative cover to protect the soil from raindrop impact and reduce surface water, e.g. steep loam/clay slopes in upper catchment;
- working land along the contour to hold surface water in the furrows;
- grass strips and permanently grassed waterways to slow surface water that has been concentrated by natural landforms and earthworks, e.g. do not cultivate natural drainage lines or waterways and double fence major waterways; and
- managing your farm according to Land Management Units.

4.3.3 Surface water control

The amount of surface water run-off from each of the four main soil types is affected by slope grade and landscape position (for example: valley floor, footslope, upperslope, crest). A quick assessment of these slope classes can be made using orthophotos overlain with 2-metre contours. Earthworks can then be planned, taking soil type into account, to help reduce waterlogging (Table 4.1).

Higher slopes (3 per cent to10 per cent) are mainly present in the southern and western parts of the catchment; in the northern half of the catchment slopes, are generally less than 3 per cent (see Figure 3.4).

Table 4.1. Possible earthworks for slope classes and landscape elements

Slope Class (%)	Landscape element	Suitable earthworks
0-1% slope (38% of EM catchment)	Valley floors/lower footslopes	Shallow relief drains Levee and levied waterways
1-3% slope (55% of EM catchment)	Long slopes/footslopes	Seepage interceptor drains Reverse bank seepage interceptor drains Levee and levied waterways Diversion bank Broad-based bank (not less than 2%)
3-5% slope (6% of EM catchment)	Mid-slopes/minor upperslopes	Grade bank Seepage interceptor drains Reverse bank seepage interceptor drains Levee and levied waterways Diversion bank Broad-based bank
5-10% slope (1% of EM catchment)	Upperslopes	Grade bank Level/adsorption banks directly below steep slopes of Mallet Hills Levee and levied waterways Diversion bank
> 10% slope (0% of EM catchment)	Steep slopes/Mallet Hills/rock outcrop	Use conservation land management practices Absorption banks if erosion a problem

4.3.4 Surface water earthworks

Earthworks require careful, long term planning, as inappropriate designs can cause more problems than they solve. The following should be considered when planning earthworks:

- **Land assessment** - information on soil condition, vegetation cover, catchment area, annual average rainfall and slope is used to calculate maximum flows, safe grades, safe velocity and safe disposal points. For more information visit the Department of Agriculture website (http://www.agric.wa.gov.au/progserv/natural/assess/index.htm).
- **Average recurrence interval (ARI)** - describes the average period in years between the occurrence of a rainfall event of specified magnitude (duration and intensity) and an equal or greater event. For example, a 20 year ARI rainfall event would occur, on average, five times in 100 years and would have a 5 per cent probability of occurring in

any year. Earthworks should be designed and built to fill or 'safely fail' when subjected to a specified ARI. Important earthworks, such as dams, waterways and absorption banks should be designed for at least a 20 year ARI. The minimum design of most surface drains and banks is a 10 year ARI (Bligh 1989).

In the catchment, grade banks, absorption banks, reverse bank interceptors drains and waterways may be used on slopes between 1 and 10 per cent depending on the site. The most suitable soils for these earthworks are loams, sandy surfaced duplex soils and clays. Shallow surface drains may be used on slopes with less than 1 per cent slopes. The most suitable soils for shallow drains are duplex and clay soils.

The range of appropriate engineering options for the main soil groups are described in Table 4.2.

Table 4.2. Recommendations for surface water control

Soils	Management issues	Appropriate earthworks
Sandy earths (19% of catchment)	Water management only a problem in a wetter average year - waterlogging main issue	Grade bank systems to stable waterway Levee waterways
Loamy earths (32% of catchment)	Surface water erosion may be issue on steeper slopes. Waterlogging may also be problem in wet years	Grade banks to intercept excess surface water Reverse bank interceptors if duplex soils
Deep sandy duplex (9% of catchment)	Usually no surface water issues	Not required Usually no surface water issues
Deep sands (9% of catchment)	Usually no surface water issues	Not required Usually no surface water issues
Ironstone gravelly soils (10% of catchment)	Usually no surface water issues unless on breakaways	Grade or level banks if erosion present
Wet or waterlogged soils (6% of catchment)	Water erosion Flooding on valley flats Waterlogging	Grade bank systems Shallow relief drains/w-drains Conventional or Reverse bank seepage interceptor drains
Other 4 soil super groups (15% of catchment)	Usually erosion or waterlogging or flooding on valley floors	Various bank types per situation

4.3.5 Earthworks for water conservation, supply and management

Earthworks, including grade banks, diversion banks, grassed waterways, roaded catchments and dams, are the primary method of water conservation and storage. The works described earlier in this section can often be used to divert water into storage. However, rarely are earthen storage structures 100 per cent efficient, so they usually contribute to recharge via preferred pathways and matrix flow, particularly given the significant hydraulic gradient under such structures. Design is therefore important to maximise storage efficiency and to minimise recharge.

Roaded catchments are designed to capture rainwater and provide an efficient method of increasing run-off into farm dams. A well constructed and maintained roaded catchment can start to shed water after only 4-6 mm rainfall, whereas grade banks will not. However, poorly maintained roaded catchments can require up to 10-15 mm of rainfall to produce run-off. There are very few roaded catchments on farms in the catchment.

For more information see:

http://www.agric.wa.gov.au/environment/land/drainwise/tools.htm#Surface

4.4 Remnant vegetation management

Don Cummins

4.4.1 Focal species for biodiversity

Fauna focal species can assist in planning for the preservation and expansion of remnant vegetation. The basic principles outlined by CSIRO in their focal species approach to maintaining and enhancing biodiversity in remnants are:

- Choose a focal species, preferably a bird, which has a habitat requirement which is similar to a range of birds found in the catchment, e.g. the Rufous Whistler, which is found in nearly all vegetation associations in this catchment and is typical of 95 per cent of woodland birds in its requirements for a minimum of 10 ha of shrubby woodland.
- Understorey is essential, revegetation or grazed remnants that are composed of trees only, are of little value to fauna.
- Large remnants, preferably around 100 ha, need to be part of any corridor. All other remnants in any corridor need to be at least 10 ha in size.
- Remnant ‘stepping stones’ are needed at least every 1 km.
- While roads can present a significant barrier to many species, at present they are still considered vital habitat for many birds.

For more information go to www.csiro.au

4.4.2 Case study for biodiversity protection/enhancement

Namalcatching Reserve, approximately 15 km east of Dowerin, can be used as an example of the benefits of, and the process for, protecting and enhancing remnants.

This reserve is made up of a large remnant covering 259 ha and is managed by the Department of CALM. The vegetation association is predominately medium woodland: wandoo, York gum, salmon gum and gimlet. The advantages of this site are its large size, good vegetation condition and links to neighbouring remnant vegetation, particularly a similarly sized remnant, 5 km north at Minnivale. Disturbance of the reserve from neighbouring agricultural land is also minimal. The Minnivale Reserve contains a similar vegetation association.

The suggested process for enhancing this remnant and its biodiversity values are:

- Fence out remnants on private land to the north between Namalcatching and Minnivale Reserves - in particular, woodland of similar composition found on hilltops, running roughly parallel to the Cunderdin-Minnivale Road.

- Buffer existing remnants (4-5 rows of oil mallees may be a viable option) to ensure minimal weed encroachment from neighbouring farmland and to provide a way of limiting the effects of agricultural fertiliser and spray-drift on remnants.
- Creation of a large-scale, fenced revegetation corridor to fill in the gaps between remnants. Such corridors need to designed, in terms of width and vegetation composition, with a fauna species in mind. Bird species should be considered a priority. CSIRO has completed studies on optimal corridor composition to encourage species movement.

Ultimately this corridor can be expanded west to Amery town site and then south west to Dowerin town site, linking a further seven large scale (average size of 56 ha) remnants, of the same vegetation association.

Other significant catchment corridors are listed in Appendix A2 and are shown on Figure 2.9.

4.4.3 Commercial options

The range of commercial revegetation options for low rainfall areas is generally limited. The recommendations are shown in Table 4.3. The key reference for revegetation information is www.agric.wa.gov.au, and further information can be found in Lefroy *et al*. (1991).

Table 4.3. Commercial revegetation options

Species	Soil type	Annual rainfall	Limitations
Tagasaste	Deep sands, sandy earths.	300 mm +	Preference for grazing by cattle, susceptible to pests, doesn't tolerate waterlogging, grazing with sheep requires rotational grazing and slashing.
Oil Mallees	Nine species available that suit a range of soil types from sands to loams and clays.	200 mm +	Markets not well established, scale of production needs to be increased to meet biomass markets, harvesting and processing methods still being developed.
Sandalwood	Free draining ironstone gravels and loams.	400-600 mm. Generally drought tolerant	20 years to reach commercial size, sensitive to fire and requires host plant (jam).
Banksias	Well drained sandy earths and deep sands.	250 mm +	May require irrigation to encourage production, susceptible to dieback, will not tolerate waterlogging. Markets can be variable.
Broombush	Sands through to gravels and clays, can be waterlogging and salt tolerant.	250 mm +	Economics of block plantings dubious, small market and suitable species for commercial use still being researched by CALM.
Maritime Pine (Forest Products Commission offer share farming arrangements for this species.)	Deep sands, gravelly soils and sandy earths.	400 mm +	30 year+ rotation. Note, the rainfall requirement limits this species to the western edge of the catchment. 150km haulage limit to be profitable. May be growth/form problems in wheatbelt plantings.

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6. APPENDICES

A1. Soil-landscape information as a basis for Land Management Unit (LMU) mapping

Paul Galloway

The information for East Mortlock catchment derives from data intended for publishing at a scale of 1:100,000 to 1:250,000. It is useful for regional planning and provides only a preliminary basis for catchment planning. More detailed mapping is required for catchment and farm planning purposes, and should be conducted by defining the spatial extent of LMU's. To assist this process soil supergroups have been extracted from the soil-landscape mapping information (Table A1.1). Soil supergroups comprise a suite of soils with similar characteristics and can be regarded as preliminary LMU's. They have not been explicitly mapped. Rather, their spatial extent has been calculated from the proportion that each occupies in the soil-landscape map-units present in the catchment.

LMU's should comprise both soil and landscape elements to best partition the landscape for effective and sustainable management. Presently, the preliminary LMU's only relate soil type to landscape position through the broad description of the Soil-landscape units found in the existing soil-landscape maps held by the Department of Agriculture.

Table A1.1. Soil supergroups (preliminary LMU's) of East Mortlock catchment

Soil supergroups (suggested preliminary Land Management Units)	Area (ha)	% of catchment
Shallow loamy duplexes	207,953	24
Sandy earths	161,332	19
Ironstone gravelly soils	82,824	10
Deep sands	76,186	9
Deep sandy duplexes	75,189	9
Loamy earths	71,077	8
Shallow sandy duplexes	59,663	7
Wet or waterlogged soils	49,138	6
Cracking clays	18,895	2
Rocky or stony soils	17,872	2
Shallow sands	15,770	2
Deep loamy duplexes	10,909	1
Non-cracking clays	6,380	1
Shallow loams	3,896	< 1
Miscellaneous soils	2,530	<,1
Total	**859,618**	**100**

A2. Remnant vegetation

Table A2.1. Remnant vegetation by extent by type

Beards Vege Association	Associated soils	Original cover (ha)	Proportion of catchment (%)	Proportion of original cover remaining (% of catchment)	Proportion of original cover remaining (% of vegetation type)
Medium woodland					
York gum, salmon gum, gimlet	Loamy duplexes and sandy earth.	78,403	9.1	< 1	4.4
York gum and salmon gum	Loamy duplexes and sandy earth.	34,470.5	4	< 1	1.5
York gum	Sandy and loamy duplexes	739.5	< 1	< 1	< 1
Mallet	Sandy and loamy duplexes.	38.7	< 1	< 1	1.3
Wandoo, York gum, salmon gum, morrel, gimlet	Sandy and loamy duplex soils, sandy earths, deep sands and gravelly soils (upland).	379,931.2	44	2.1	2.8
Shrubland					
Tea-tree thicket	Shallow sands, shallow loams, rocky soils	316.3	< 1	< 1	2.8
Thicket, Jam and *Allocasuarina huegeliana*	Loamy duplex soils.	796.8	< 1	< 1	28.3
Allocasuarina campestris thicket	Loamy and sandy duplex soils and sandy earth.	1,639	< 1	< 1	3.7
Scrub heath on yellow sandplain, banksia-xylomelum alliance	Deep sands and gravelly soils.	41,438.7	4.8	< 1	2.4
Allocasuarina campestris thicket with wandoo	Sandy earths and deep sands.	2,519.9	< 1	< 1	16.7
Mallee, Casuarina thicket	Sandy and loamy duplexes.	162,857.1	18.9	1.2	6.7
Melaleuca uncinata thicket and scattered York gum	Loamy duplexes and sandy earths.	3,526.7	< 1	< 1	12.2
Acacia, Casuarina, Melaleuca thicket.	Loamy duplex and sandy earths.	44,576.2	5.2	< 1	6

Table A2.1. (Continued)

Beards Vege Association	Associated soils	Original cover (ha)	Proportion of catchment (%)	Proportion of original cover remaining (% of catchment)	Proportion of original cover remaining (% of vegetation type)
Mosaic					
Scrub heath, *Allocasuarina campestris* thicket	Sandy earths and deep sands.	34,265.6	4	< 1	4.9
Medium Woodland York gum, salmon gum, morrel/ Succulent Steppe saltbush and samphire	Salt lakes, saline soils and sandy and loamy duplexes.	1,926.4	< 1	< 1	1.8
Shrubland melaleuca scrub/ Succulent Steppe samphire	Sandy earths, deep sands and salt lakes.	11,150.9	1.3	< 1	16.6
Medium sparse woodland, salmon gum, yorrell/ succulent Steppe saltbush and samphire	Salt lakes and saline soils.	16,843.1	1.9	< 1	11.14
Low woodland					
Allocasuarina huegliana and jam	Sandy earths, deep sands and gravelly soils.	556.1	<1	<1	12.4
Succulent Steppe					
Samphire	Salt lakes, loamy duplexes and cracking clays.	2,840.7	<1	<1	2.1
Mallee thickets: mallee and *Melaleuca uncinata*	Loamy duplexes.	73.1	<1	0	0
With open woodland and thicket - York gum over *Melaleuca thyoides* and samphire	Salt lakes, loamy duplexes (especially alkaline) and cracking clays.	9,384.8	1	<1	40.5
With thicket - *Melaleuca thyoides* over samphire	Loamy duplex and cracking clays.	4,548.2	<1	<1	10.1
Bare areas/salt lakes	Salt lakes	24,757.4	2.8	<1	2.8
Bare areas/rock outcrops	Bare areas/rock outcrop	2,016.5	<1	<1	33.59
Total		**85,9617**	**100**	**4.8**	

Significant catchment corridors

1. Salt River drainage channel/lake chain from Derdibin Road Reserve (Wyalkatchem) southeast to the Mackin Road (Tammin) area. The average distance between remnants is 2.3 km and the total distance of the corridor is 10km. The Derdibin Road Reserve is in particularly good condition and has fringing low woodland on upper slopes. The vegetation association in this corridor is consistent, being succulent steppe with open woodland.
2. Mortlock River East branch, from west of Cunderdin to approximately 10 km north of Tammin. The dominant vegetation association is mosaic: shrublands, melaleuca, patchy scrub/succulent steppe and samphire. This drainage line is broad and saline and the vegetation in most areas of the corridor is not grazed (some fenced). The average distance between large remnants is 3 km, although vegetation in the river channel is generally intact.
3. Elashgin Soak Reserve southeast to Carrabin Rock and Yorkarakine Rock. This corridor covers approximately 10.5 km and there is an average of 3.75 km between large remnants. The vegetation association is generally similar and contains a shrubland mosaic and woodland, dominated by York gum, salmon gum and morrel.
4. Korrelocking townsite to Korrelocking Nature Reserve and Wyalkatchem Nature Reserve. The total distance of this corridor is 6.5 km and will provide a linkage between relatively healthy stands of medium woodland.

A3. AgET and Catcher analysis for East Mortlock

AgET formerly known as WAttle calculates average recharge (Argent and George, 1997).

Recharge under a crop rotational system is proportional to the number of years of crop or pasture in the rotation and can be calculated as follows: a pasture, pasture, wheat, lupin, wheat, barley rotation on a shallow sandy duplex would be two years of pasture and four years of crop.

$$\text{Recharge} = \frac{(2 \text{ years X pasture recharge**}) + (4 \text{ years X crop recharge**})}{\text{Total years in rotation}}$$

$$\text{Recharge} = \frac{((2 \text{ X } 24\%) + (4 \text{ X } 15.5\%))}{6} = 18.3$$

(** East Mortlock % recharge from table 15 below.)

The recharge as a percentage of annual rainfall has been estimated using a water balance model for a number of farming options on the major soil groups in the catchment. These results (Table A3.1) are not expected to accurately predict water use occurring in the catchment due to unpredictable natural variation. However, they highlight the relative differences in water use of annual and perennial species as outlined above.

Table A3.1. Predicted recharge for some options on main soil supergroups for shires in the catchment

Soil type	Options	Predicted recharge as percentage of annual rainfall. (%AR)				
		Wyalkatchem 329 mm	Cunderdin 369 mm	Dowerin 361 mm	Tammin 342 mm	East Mortlock 352 mm
Deep Sand	Clover/medic pasture	23	30	29	27	28
	Continuous crop	5	12	12	10	11
	Lucerne	0	0	0	0	0
	Woody Perennials	0	0	0	0	0
Ironstone Gravel	Clover/medic pasture	23	31	30	28	29
	Continuous crop	8	16	15	13	14
	Lucerne	0	0	0	0	0
	Woody Perennials	0	0	0	0	0
Shallow Loamy Duplex	Clover/medic pasture	13	21	19	17	18
	Continuous crop	4	13	12	9	10.5
	Lucerne	0	0	0	0	0
	Woody Perennials	0	0	0	0	0
Deep Loamy Duplex	Clover/medic pasture	-	9	9	7	8
	Continuous crop	-	4	4	2	3
	Lucerne	-	0	0	0	0
	Woody Perennials	-	0	0	0	0

Table A3.1. Continued

Soil type	Options	Predicted recharge as percentage of annual rainfall. (%AR)				
		Wyalkatchem 329 mm	Cunderdin 369 mm	Dowerin 361 mm	Tammin 342 mm	East Mortlock 352 mm
Loamy Earth	Clover/medic pasture	6	-	11	10	10.5
	Continuous crop	2	-	6	5	5.5
	Lucerne	0	-	0	0	0
	Woody Perennials	0	-	0	0	0
Shallow Sandy Duplex	Clover/medic pasture	17	26	25	23	24
	Continuous crop	10	17	16	15	15.5
	Lucerne	1	2	1	1	1
	Woody Perennials	0	0	0	0	0
Deep Sandy Duplex	Clover/medic pasture	14	21	20	18	19
	Continuous crop	5	12	12	10	11
	Lucerne	0	0	0	0	0
	Woody Perennials	0	0	0	0	0
Sandy Earth	Clover/medic pasture	12	21	20	18	19
	Continuous crop	5	14	13	11	12
	Lucerne	0	0	0	0	0
	Woody Perennials	0	0	0	0	0

The results from AgET were used to run Catcher, a model that calculates the catchment water balance based on the percentage of soil types and options being used within the catchment. Catcher was run with three scenarios - current practice, predicted practice in 2020 and an optimistic option for 2020, with a higher level of recharge intervention including phased perennial pastures and woody perennials (Table A3.2). Current and predicted 2020 rotations were taken from McConnell (2001). Note: Difficulties were encountered when trying to compare soil types across zones.

Table A3.2. Percentages of major soil types allocated to land use options in the current, future 2020 and optimistic future 2020 rotations modelled in the catchment

Soil type and percentage of catchment	Rotation	Land use						
		Bare Earth	Sub Clover	Lucerne	Commercial trees	Serradella 19%	Crop	Pre-clearing vegetation
Deep Sand 9%	Current rotation		40%	0%			49%	11%
	Future rotation 2020		30%	5%	5%		49%	11%
	Optimistic rotation 2020		20%	5%	5%	10%	49%	11%
Ironstone Gravel 10%	Current rotation		30%				64%	6%
	Future rotation 2020		30%	5%	0%		54%	11%
	Optimistic rotation 2020		20%	10%	0%	0%	59%	11%
Shallow Loamy Duplex 24%	Current rotation		25%	0%			75%	
	Future rotation 2020		15%	10%			75%	
	Optimistic rotation 2020		15%	10%	5%		70%	
Shallow Sandy Duplex 7%	Current rotation		25%	0%			69%	6%
	Future rotation 2020		15%	10%			69%	6%
	Optimistic rotation 2020		10%	10%	10%		64%	6%
Deep Sandy Duplex 9%	Current rotation		25%	0%			69%	6%
	Future rotation 2020		15%	10%			69%	6%
	Optimistic rotation 2020			10%	5%	15%	64%	6%
Sandy Earth 19%	Current rotation		40%	0%		0%	49%	11%
	Future rotation 2020		35%	5%			49%	11%
	Optimistic rotation 2020		15%	5%	5%	15%	49%	11%
Loamy Earth 8%	Current rotation		25%	0%		0%	75%	
	Future rotation 2020		15%	10%			75%	
	Optimistic rotation 2020		15%	10%	5%		70%	

The optimistic rotation outlined above is only one example of a combination of options that might be adopted. Individual farming enterprises should consider different combinations of these options in conjunction with other management options outlined in this report.

A4. Shire summary

Table A4.1. Shire area in catchment

Catchment name	Catchment area (ha)	LGA	Shire area (ha)	Shire area in RCA study	% in RCA study area
East Mortlock	859,617	All Shires	3,020,389	859,617	28.5
		Cunderdin (S)	186,092	132,294	71.1
		Dowerin (S)	186,145	159,568	85.7
		Goomalling (S)	183,381	29,806	16.3
		Kellerberrin (S)	191,398	22,436	11.7
		Koorda (S)	283,058	144,622	51.1
		Mount Marshall (S)	1,017,981	57,036	5.6
		Quairading (S)	201,499	729	0.4
		Tammin (S)	110,106	98,900	89.8
		Trayning (S)	165,000	37,875	23.0
		Wongan-Ballidu (S)	336,307	16,930	5.0
		Wyalkatchem (S)	159,420	159,420	100.0

Table A4.2. Roads and built up areas in catchment

LGA	Road length (km) - Hwy	Road length (km) - Main	Road length (km) - Local	Road length (km) - Other	Road length (km) - Total	Built-up area (ha)	% of built-up area in RCA study area
All Shires	78.5	85.6	4,191.9	1,352.7	5,708.7		0.0
Cunderdin (S)	45.5		675.1	267.8	988.4	896.3	0.7
Dowerin (S)		36.3	858.4	300.6	1,195.3	906.2	0.6
Goomalling (S)		3.3	118.5	31.7	153.5		0.0
Kellerberrin (S)	2.6		105.9	32.3	140.8		0.0
Koorda (S)	0.8		663.8	127.1	791.7	259.1	0.2
Mount Marshall (S)			278.6	56.2	334.8	172.6	0.3
Quairading (S)			1.3	0.6	1.9		0.0
Tammin (S)	29.6		440.3	228.6	698.5	129.5	0.1
Trayning (S)		2.7	178.1	49.9	230.7		0.0
Wongan-Ballidu (S)			82.3	32.4	114.7	53.3	0.3
Wyalkatchem (S)		43.3	789.6	225.5	1,058.4	803.3	0.5

Table A4.3. Roads and built up areas affected by salinity

LGA	Area of shire affected by AOCLP (ha)	Road length affected (km) - Hwy	Road length affected (km) - Main	Road length affected (km) - Local	Road length affected (km) - Other	Road length affected (km) - Total	Built-up area affected (ha)
All Shires	78,673	0	0.3	27.5	12.3	233.9	
Cunderdin (S)	10,860	0	0	0	0	53.4	6
Dowerin (S)	10,559	0	0	0	0	66	6
Goomalling (S)	4,272	0	0	0	0	23	
Kellerberrin (S)	592	0	0	0	0	3.7	
Koorda (S)	18,523	0	0	0	0	0	2
Mount Marshall (S)	3,300	0	0	0	0	0	4
Quairading (S)	2	0	0	0	0	0	
Tammin (S)	8,943	0	0	0	0	43.6	4
Trayning (S)	2,663	0	0	0	0	3.8	
Wongan-Ballidu (S)	551	0	0	0	0	0	2
Wyalkatchem (S)	18,408	0	0.3	27.5	12.3	40.3	10

A5. Contacts

The most important source of up to date agricultural resource management information is: www.agric.wa.gov.au

Natural resource management information can also be found at: www.avonicm.org.au

Table A5.1. Contacts list

Area	Contact name	Contact details
Farming systems	Trevor Lacey	Department of Agriculture, Northam Tel: 96902101 Fax: 96221902 Email: tlacey@agric.wa.gov.au
Soils	Paul Galloway	Department of Agriculture, Narrogin Tel: 98810227 Fax: 98811950 Email: pgalloway@agric.wa.gov.au
Hydrology	Shahzad Ghauri	Department of Agriculture, Northam Tel: 96902102 Fax: 96221902 Email: sghauri@agric.wa.gov.au
Surface water management	Harry Lauk	Department of Agriculture, Northam Tel: 96902162 Fax: 96221902 Email: hlauk@agric.wa.gov.au
Remnant vegetation/ revegetation	Don Cummins	Department of Agriculture, Northam Tel: 96902242 Fax: 96221902 Email: dcummins@agric.wa.gov.au

A6. Further Reading

Farmnotes from the Department of Agriculture on soils

32/85	Gypsum improves soil stability
57/90	Identifying gypsum-responsive soils
87/94	Stubble needs for reducing wind erosion
4/95	No tillage sowing minimises soil erosion
35/96	Preventing wind erosion
61/96	No-till sowing machinery to control wind erosion
65/96	Soil management options to control land degradation
66/96	Stubble management to control land degradation
110/96	Assessing water repellence
14/97	Claying water repellent soils
70/00	Looking at liming - consider the rate
78/00	The importance of soil pH
80/00	Management of soil acidity in agricultural land

Best practice agronomy

Bulletin 4443 (2000). The Wheat Book - Principles and Practices. Department of Agriculture (formerly known as Agriculture Western Australia).

Department of Agriculture web site at www.agric.wa.gov.au

Lucerne farmnotes

Devenish, K.L.., Lacey, T.M. and Latta, R. (2001). Farmnote No. 36/2001 "Grazing sheep and cattle on dryland lucerne".

Latta, R, Devenish, K.L. and Bailey, T. (2000). Farmnote 135/2000 "Lucerne in pasture-crop rotations : establishment and management".

Revegetation factsheets

26/2000	Brown Mallet
30/2000	Eucalyptus Oil Mallees
33/2000	River-Red Gum
24/2000	Banksias for cut flower production
25/2000	Broombush
29/2000	Maritime Pine
35/2000	Southern Sandalwood
37/2000	Tagasaste
38/2000	Wandoo