Blackwood Catchment: Katanning zone (zone 6): catchment appraisal 2001

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Blackwood Rapid Catchment Appraisal Team (WA)

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Blackwood Catchment: Katanning Zone (Zone 6)

CATCHMENT APPRAISAL 2001

Prepared by the
Blackwood Rapid Catchment Appraisal Team
(Team Leader: Henry Brockman)

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EXECUTIVE SUMMARY

The aim of this report is to document the extent of salinity and land degradation within the Katanning Zone, and provide land managers with access to the best currently available information for understanding these issues. Coupled with management options aimed at reducing recharge and land degradation, this will enable land managers to make more informed decisions about their future activities.

The Katanning Zone covers almost 307,000 hectares in the south-east of the Blackwood Catchment in the south-west of Western Australia. The towns of Katanning, Nyabing and Broomehill are within the study area, which includes portions of the Kent, Katanning, Broomehill, Gnowangerup and Woodanilling Shires.

The area’s geology is dominated by the granite and gneiss of the Yilgarn Craton. The study area falls largely within the South-western and South-eastern Zones of Ancient Drainage where hydrology is influenced by relatively low rainfall (400 to 480 mm).

The main soil-landscape systems are East Katanning and Nyabing. The Coblinine System is significant as it features the broad river valleys and salt lakes, characteristic of much of the area.

The soils are dominated by deep and shallow sandy duplexes, with saline wet soils, alkaline grey shallow sandy duplexes and duplex sandy gravels also common.

Eleven land management units have been identified. The two most widespread are Poorly Drained Sandy Duplex and Sandy Duplex.

Prior to clearing, the Dumbleyung Vegetation System was the dominant type of native vegetation covering more than a quarter of the zone (28%).

About 6% or more than 18,000 hectares is currently at risk of salinity according to Land Monitor estimates, and this could rise to more than 91,000 ha or 31%.

Land degradation is also being caused by soil acidity (43% at risk); waterlogging (41% at risk); and wind erosion (23%)

About 10% of the original vegetation remains in which 10 rare species of flora and 6 rare species of fauna have been recorded. Between 80 and 85% of this remnant vegetation is on private land and 44% is at risk of rising watertables.

In the main township of Katanning, 26% of the town area is at risk of rising watertables, with 17% of Nyabing and 10% of Broomehill.

About 104 km of sealed roads (27%) and 237 km of unsealed roads (26%) are at risk of risking watertables.

Current approximate annual infrastructure costs (roads and townsites) total $300,000 which is estimated to rise to $591,000 per year for towns and $450,000 for roads at equilibrium.
The approximate loss to gross annual agricultural production at groundwater equilibrium is estimated at $8.4 million.

This report includes strategies from the best available information to reduce groundwater recharge and land degradation, as well as protect remnant vegetation.

To implement these strategies would cost an estimated $12.2 million or $45/ha. Economic analysis has shown that it is more cost effective to focus these strategies on the Poorly Drained Duplex, Sandy Duplex, Gravelly Ridges and Slopes and Grey/Greyish Brown Loams and Clays.

The Katanning Zone lacks bores drilled to bedrock which have been accurately described and monitored. While many shallower bores exist, only a small percentage have been monitored consistently to allow accurate estimations of watertable trends. Of the bores monitored regularly, 70% were in low landscape positions such as lower slopes, valley floors or next to drainage lines. It is preferable to have monitoring information across a range of landscape positions to give a true indication of trends. In future, emphasis should be placed on maintaining regular monitoring of bores to define trends more accurately.

This lack of groundwater data meant that many assumptions had to be made when the Flowtube model was used in the Katanning Zone.

Other gaps are the lack of knowledge of long-term impacts of management options, and of new farming systems more suited to this environment. Viable options for making saline land productive are also not yet readily available.

Given the limitations of the data available, this report provides the most up-to-date assessment of land degradation and its extent in the Katanning Zone. The strategies outlined for the main land management units may be useful for farmers when they come to assess the extent of land degradation on their own properties and consider options to manage them.

The scale of the information reported here will not easily allow land managers to directly relate the information to farm or paddock scale, but it will provide the State with a much more strategic allocation of resources into the areas that can be identified as information deficient.
Acknowledgements

This report was compiled by the Blackwood Rapid Catchment Appraisal team based at the Department of Agriculture’s Katanning District Office.

The Blackwood team also acknowledges the input and sharing of information from the other teams in the Great Southern, in particular the Western South Coast, Esperance and Central teams.

This report also had the valued input from the Department of Conservation and Land Management’s Katanning District Office with issues relating to biodiversity and conservation.

Heather Percy and others provided valuable technical editing.

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1: Climate
2: Hydrology and Hydraulic Characteristics
3: Soil Information Sheets and Soil-Landscape Systems
4: Economics
5: Earthworks
6: Vegetation List
7: List of Contacts
1. Introduction

The aim of the Western Australian State Salinity Strategy (Government of Western Australia 2000) is to ‘reduce the impact’ of salinity. Rapid Catchment Appraisal (RCA) is one of the projects to tackle salinity and its management.

The objective of RCA is to provide all landholders with access to the most up-to-date information for salinity management by 2005. The process provides information on risks to natural resources and best currently available options to manage these risks. Landholders are provided information on where to access further support if necessary.

The Blackwood Basin has been divided into nine zones based on biophysical and social boundaries. These zones were developed to assist in managing the natural resources of the Basin as a whole and form a strong community and agency network.

The selection of the Katanning Zone (Blackwood Zone 6) as the initial RCA site was based on its salinity risk and the lack of information. The Katanning Zone did not include any catchments that participated in the previous Focus Catchment process, therefore was seen as a priority to provide information to land managers.

This report conducts an inventory of current resources, the risk to these resources and options to manage these risks.

The study area

The Katanning Zone is situated in the south-east of the Blackwood Catchment and encompasses the Katanning, Broomehill and Nyabing townsites. The shires represented within the boundary include Kent, Katanning, Broomehill, Woodanilling and Gnowangerup. The total area covers approximately 307,000 hectares and retains 10% of its original vegetation. The major road and railway infrastructure includes the Great Southern Highway, Chester Pass Road, Tieline Road, Katanning-Nyabing Road, the Great Southern Railway and the Katanning-Nyabing railway (see Map 1).
Map 1: Location of the Katanning Zone
2. Natural resource base

2.1 Climate

*Muhammad Siddiqi, Catchment Hydrologist, Katanning*

The Katanning Zone has a Mediterranean climate characterised by hot dry summers and cool wet winters. Most rain is caused by the passage of cold fronts between May and October, with less frequent summer thunderstorms. The mean maximum and minimum temperatures in January are 30.3°C and 13.6°C, respectively. The mean maximum and minimum temperatures in July are 14.5°C and 5.4°C.

Plate 1: Typical summer weather map (courtesy of Bureau of Meteorology [http://www.bom.gov.au/info/weathmap/hotcold.htm#fig2]).

Plate 2: Typical winter weather map (courtesy of Bureau of Meteorology [http://www.bom.gov.au/info/weathmap/hotcold.htm#fig3]).
2.1.1 Rainfall and evaporation

During winter (May to October) cold fronts pass through the Katanning Zone and bring 85% of mean annual rainfall. In summer the easterly airflow is from the dry interior out of reach of humid air. This area relies on the winter westerlies for rainfall except on rare occasions when the remnants of a tropical cyclone move south, bringing heavy summer rain. Flooding occurred in January 1982 when 217 mm of rainfall occurred in two days.

Monthly and annual rainfall probabilities at 80%, 50% and 20% probability represent a dry, an average and a wet month or year. Annual and monthly rainfalls at 80%, 50% and 20% probability levels for Katanning and Nyabing are given in Table 2.1. The mean annual rainfall varies from 398 mm at Nyabing in the east to 482 mm at Katanning in the west. Mean annual pan evaporation is 1,473 mm for Katanning (Table 2.2).

Table 2.1. Comparison of monthly and annual rainfall probabilities for Katanning and Nyabing.

<table>
<thead>
<tr>
<th>Amounts of rainfall (mm) received or exceeded in per cent of years.</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>July</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Katanning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80% of yrs</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>8</td>
<td>33</td>
<td>47</td>
<td>51</td>
<td>40</td>
<td>26</td>
<td>18</td>
<td>7</td>
<td>3</td>
<td>399</td>
</tr>
<tr>
<td>50% of yrs</td>
<td>4</td>
<td>8</td>
<td>12</td>
<td>25</td>
<td>54</td>
<td>69</td>
<td>75</td>
<td>62</td>
<td>42</td>
<td>29</td>
<td>16</td>
<td>8</td>
<td>482</td>
</tr>
<tr>
<td>20% of yrs</td>
<td>18</td>
<td>31</td>
<td>34</td>
<td>46</td>
<td>89</td>
<td>112</td>
<td>98</td>
<td>79</td>
<td>69</td>
<td>54</td>
<td>32</td>
<td>27</td>
<td>573</td>
</tr>
<tr>
<td>Nyabing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80% of yrs</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td>25</td>
<td>36</td>
<td>34</td>
<td>27</td>
<td>18</td>
<td>11</td>
<td>4</td>
<td>0</td>
<td>327</td>
</tr>
<tr>
<td>50% of yrs</td>
<td>3</td>
<td>7</td>
<td>11</td>
<td>18</td>
<td>49</td>
<td>54</td>
<td>56</td>
<td>46</td>
<td>34</td>
<td>21</td>
<td>17</td>
<td>8</td>
<td>398</td>
</tr>
<tr>
<td>20% of yrs</td>
<td>23</td>
<td>30</td>
<td>30</td>
<td>46</td>
<td>78</td>
<td>89</td>
<td>86</td>
<td>69</td>
<td>50</td>
<td>41</td>
<td>33</td>
<td>22</td>
<td>469</td>
</tr>
</tbody>
</table>

Table 2.2. Monthly and annual pan evaporation data (mm).

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>July</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Katanning</td>
<td>246</td>
<td>191</td>
<td>169</td>
<td>98</td>
<td>63</td>
<td>38</td>
<td>40</td>
<td>51</td>
<td>77</td>
<td>110</td>
<td>161</td>
<td>229</td>
<td>1473</td>
</tr>
</tbody>
</table>

Average monthly rainfall in summer is below 25 mm and one-sixth of the monthly pan evaporation. Median monthly rainfall in the winter months from May to August generally exceeds evaporation. Water use by annual crops and pastures is lowest when rainfall is highest. Low water use means that rainfall can infiltrate quickly past the root zone to recharge the watertable. By the time plants are into maximum water use between September to November, most recharge has already occurred.

2.1.2 Seasonal rainfall trends

Winter rainfall records from 1901 to 2000 for Katanning indicate great variability during different years. On average Katanning receives 359 mm from May to October which is sufficient to meet crop water requirements.
Figure 2.1. Winter rainfall trend for Katanning

Figure 2.1 shows a downward trend in the winter rainfall received by Katanning over last century. Droughts and dry spells are common. Severe droughts were experienced in 1944-45 and 1969 and farm water deficiencies declared in 1980, 1986 and 1987 to allow farmers to cart water from off-farm sources. Winter rainfall was below average during 2000 and 2001.

Figure 2.2. Summer rainfall trend for Katanning

Figure 2.2 shows an upward trend in summer rainfall for Katanning over the past 100 years. It receives an average 106 mm of rainfall which is not sufficient to meet summer crop water requirements of more than 400 mm.

Frost is common. Agricultural crops suffered heavy losses during winter 1998 and 1999 and some losses during 2001. To enable sound planning of production it is necessary to be aware of risk of frost (see Appendix 1 in Resource Management Technical Report 233).
2.2 Geology
Tim Mathwin, Hydrogeologist, Katanning

The Katanning Zone overlies gneiss and granite of the Yilgarn Craton (Chin and Brakel 1986). Dolerite dykes have intruded into the gneiss and granite. The dykes trend predominantly east to west and are most numerous in the south and east.

Remnants of the lateritic profile that cover much of the Katanning Zone (see Appendix 2) are up to 60 metres deep and have formed mainly over a basement of gneiss. Profiles formed from a granitic basement are mostly restricted to the western half of the Katanning Zone. Although sedimentary rocks are largely absent, Quaternary and Cainozoic alluvial and lacustrine deposits are common on the valley floors. These consist of highly variable layers of sand, silt and clay.

Palaeochannels can occupy the valley floors of the wheatbelt (i.e. the current drainage depressions still follow the old river courses), and have been in-filled by alluvial and lacustrine deposits. These valley floors have very low gradients, typically in the range of 1:500 to 1:1,500 or less (Bettenay and Mulcahy 1972), resulting in sluggish drainage.

Plate 3: Typical laterite duricrust capping off Stott Road in the Katanning Zone
2.3 Soil-landscape information

Angela Stuart-Street, Soils Resource Officer, Katanning

Soil-landscape mapping identifies repeating patterns of landscapes and associated soils across an area at regional scale. This report provides soil and landscape information that is customised as far as possible within the Katanning Zone.

The area was surveyed as part of the regional land resource survey between 1992 and 1998. The results of this survey are found in the *Katanning Area Land Resources Survey* (Percy 2000) and in the *Nyabing-Kukerin Land Resources Survey* (Percy & Roberts, in prep). The Katanning Zone lies inside the Avon Soil-landscape Province, and sits largely within the South-western and South-eastern Zones of Ancient Drainage. A small area on the western fringe lies in the Southern Zone of Rejuvenated Drainage.

The landscape features undulating rises and occasional hills in the west, north and on the southern fringe. To the east, the landscape is more subdued with broadly undulating rises more common. In the south, the landscape flattens and is characterised as level to gently undulating plains. The broad alluvial plains of the Coblinine River and its tributaries are a central feature.

The soils are predominantly deep and shallow sandy duplex with a large proportion of subsoil being alkaline and sodic. Saline wet soil, alkaline grey shallow loamy duplex and duplex sandy gravels are also common.

### 2.3.1 Soil-landscapes of the Katanning Zone

Eight soil-landscape systems have been identified and are discussed in detail in Appendix 3.

The zone is dominated by two systems: East Katanning (22.5%) and Nyabing (22.1%). The broad valleys of the Coblinine System incorporate the Coblinine River, Lake Coyrecup, Ewlyamartup Lake and associated wetlands. This system covers 19.7% of the area, while the Tieline System covers 18.4%. The remaining systems, including Carrolup, Datatine, Kukerin and Upper Pallinup, cover less than 20%. Map 2 shows the distribution of soil-landscape systems across the Katanning Zone.

### 2.3.2 Land management units

Land management units are defined as “parcels of land, with common soils and landforms, which should be managed similarly in order to maximize their production and minimize land degradation” (Lloyd 1992). The details provided in Table 1 are to help land managers to understand the abilities of each different land management unit on their farm. The points outlined will assist with determining the land’s stability, resilience and potential to recover from disturbance. This information will broaden the information base for future decision making about each area of land to better achieve sustainable production.

Each land management unit description details its general landscape position, the most common soil type and the native vegetation commonly associated with those soils. Information about the characteristics of the soils is given, as well as considerations of
the possible problems associated with managing or developing the land. (See Section 4 for Best Management Options for each land management unit.)

Figure 2.3 shows a cross-sectional diagram of the landscape and the typical positions within the landscape that each land management unit will be situated.

Plate 4: Gently undulating plain typical of the Tieline Soil-landscape System
### Table 2.3: Land management units found in the Katanning Zone

<table>
<thead>
<tr>
<th>Land Management Unit</th>
<th>Area (ha)</th>
<th>Landscape position</th>
<th>Remnant vegetation</th>
<th>Dominant soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Poorly Drained Sandy Duplex</td>
<td>66,779</td>
<td>Lower slopes and broad valley floors</td>
<td>Mallee, wandoo, woodland, flat-topped yate salmon gum and York gum</td>
<td>Sand or sandy loam over clay at 10-60 cm; clay may be blue-grey in colour or very mottled; very wet in winter months. See: Alkaline grey shallow Sandy Duplex Soil information Sheet in Appendix 3.</td>
</tr>
<tr>
<td>2. Sandy Duplex</td>
<td>55,760</td>
<td>Crests, upper and lower slopes, areas of large lunettes and dunes</td>
<td>Mallee or wandoo mixed woodland</td>
<td>Sand or sandy loam over clay at 10-80 cm; See: Grey deep Sandy Duplex, acid shallow duplex and brown deep sand Soil Information Sheets in Appendix 3.</td>
</tr>
<tr>
<td>3. Gravel Ridges and Slopes</td>
<td>41,726</td>
<td>Hill crests and upper slopes</td>
<td>Mallee, low scrub including dryandra; mallee or wandoo woodland</td>
<td>Ironstone gravel &gt;60% overlying clay or hard ironstone at varying depths. See: Duplex sandy gravel, deep sandy gravel, loamy gravel and shallow gravel Soil information Sheets in Appendix 3.</td>
</tr>
<tr>
<td>4. Grey/Greyish Brown Loams and Clays</td>
<td>32,835</td>
<td>Slopes or valley floors</td>
<td>Moort, salmon gum, morrel, mallee; Melaleuca thickets</td>
<td>Hardsetting grey clay loam and clay. Grey/greyish brown loamy surface layers over clay at &lt;30cm, or clay at surface. See: Grey grey loamy duplex and Alkaline grey shallow loamy duplex Soil information Sheets in Appendix 3.</td>
</tr>
<tr>
<td>5. Red Soils</td>
<td>26,260</td>
<td>Upper to lower slopes</td>
<td>York gum, jam, morrel, wandoo Mixed open woodland</td>
<td>Reddish brown sandy loamy over clay at 10-20cm (red loam); red or reddish brown clay loam over clay at &lt;10cm or grading to red clay at depth (red clay). See: Alkaline red shallow loamy duplex and Calcareous loamy earth (red) Soil information Sheets in Appendix 3.</td>
</tr>
<tr>
<td>6. Salt-Affected Land</td>
<td>25,590</td>
<td>Valley floors, drainage lines and seeps on hill slopes</td>
<td>Dead trees, samphire and a range of barley grass coverage</td>
<td>A range of soils is affected by salt. See: Saline wet soil Soil information Sheet in Appendix 3.</td>
</tr>
<tr>
<td>7. Pale Deep Sand</td>
<td>9918</td>
<td>Crests and slopes</td>
<td>Leptospermum tea-tree, heath and Christmas tree</td>
<td>Pale grey, or white sands deeper than 80cm. Gravel (&lt;20%) may be present through profile. See: Pale deep sand, and gravelly pale deep sand, yellow deep sand Soil information Sheets in Appendix 3.</td>
</tr>
<tr>
<td>8. Mallet Hills</td>
<td>8143</td>
<td>Breakaways or upper slopes and ridges</td>
<td>Brown and blue mallet</td>
<td>Pink or reddish water repellent soils, maybe gravelly, often acidic. See: Acid shallow duplex Soil information Sheet in Appendix 3.</td>
</tr>
<tr>
<td>9. Yellow and Brown Deep Sands</td>
<td>4158</td>
<td>Slopes of lunettes, dunes and valleys</td>
<td>Rock sheoak, mallee, wandoo, Christmas tree</td>
<td>Yellow or brown sands deeper than 80 cm; gravel (&lt;20%) may be present through profile; may be over rock or clay at &gt;80 cm. See: Yellow deep sand and brown deep sand Soil Information Sheets in Appendix 3.</td>
</tr>
<tr>
<td>10. Salt Lakes</td>
<td>1685</td>
<td>Salt lakes, swamps and associated minor lunettes, swales and dunes</td>
<td>Swamp sheoak, Melaleuca thickets</td>
<td>Areas of salt lake beds and adjacent flat saline areas with salt-tolerant vegetation.</td>
</tr>
</tbody>
</table>
Figure 2.3. Schematic cross-section of land management units in the Katanning Zone
2.4 Hydrogeology

Tim Mathwin and Louise Hopgood, Hydrogeologists, Katanning

The Katanning Zone lies almost entirely within the Wheatbelt Hydrological Zone. A small area in the south-west lies within the Eastern Woolbelt Hydrological Zone. Refer to Appendix 2 for more detail.

2.4.1 Hydrogeological characteristics

Hydrology is greatly influenced by the relatively low rainfall, subdued landscape and relatively deep weathering profile (20-60 m to bedrock). Rainfall is in the range of 400-480 mm/year and deposits chloride at a rate of about 20 kg/ha/year (Hingston and Gailitis 1976).

Annual surface run-off is about 20 mm, which is 4% of the annual rainfall (George and Bennett 1998). The low run-off rate is due to a combination of the gentle slopes, sandy surfaced soils and sluggish drainage. With the exception of the occasional summer thunderstorm, water only flows in drainage lines during winter. In most years, the broad valley floors act as a sump for both run-off and salts, which accumulate in lakes and swampy depressions.

Run-off salinity levels have been recorded in the annual water quality ‘snapshot’ conducted by the Bunnings Watercare program in conjunction with the Blackwood Basin Group. Records from 1996 to 1999 show samples ranging from 650 mS/m high in the catchment in a valley south-east of Nyabing to 4,800 mS/m down on the shores of Lake Coyrecup. The samples were typically taken between August and September, and records are held at the BBG office in Boyup Brook.

The major surface water storages are the circular lakes that have formed on the valley floors. These include Lakes Coyrecup and Ewlyamartup and a number of other smaller lakes, swamps and water bodies that are either saline or becoming saline. Water and salinity levels in the lakes fluctuate seasonally and many of the smaller lakes regularly dry out completely over the summer.

The alluvial deposits are restricted to the Coblinine Soil-landscape System and overlie pallid zone and saprock from the lateritic profile. The lateritic profiles in the higher parts of the landscape store approximately 2,000 t/ha of salt (George and Bennett 1998), with up to 30,000 t/ha being stored under the valley floors.

There are relatively low rates of groundwater recharge because of the low rainfall. However, recharge has increased dramatically, from less than 0.2 mm/year before clearing, to the current 10 to 50 mm/year (George and Bennett 1998). Recharge occurs throughout the landscape, with major contributions coming via gravelly and sandy soils on the broad hill crests and divides. Valley floors are also a major area of recharge (when discharge is not occurring). As shown in Figure 2.4, discharge can also occur across many parts of the landscape.
Groundwater investigations have shown that five aquifer types are present:

i. Intermediate scale semi-confined/confined aquifers in weathered basement rocks;

ii. Intermediate scale surficial, semi-confined/unconfined aquifers in alluvial deposits

iii. Local unconfined (perched) aquifers in deep sand sheets and duplex soils;

iv. Local semi-confined / confined aquifers in weathered basement rocks; and

v. Fractured rock aquifers.

For the purpose of this report the term ‘local’ refers to an aquifer where recharge and discharge take place within 2 km of each other whilst ‘intermediate’ refers to where this distance extends between 2 and 10 km. Refer to Tille, Mathwin and George (2001) for further details.

Intermediate scale weathered basement aquifers refer to the saprock zone at the base of the lateritic zone (refer Appendix 2). The aquifers are typically 0.5-5.0 metres thick and are semi-confined or unconfined by the overlying pallid zone and so most of the lateral groundwater flow occurs in the more porous saprock zone. Lateral groundwater flow velocities in weathered basement aquifers are slow (generally .01 to 2m/year – refer to Appendix 2 for comparative table) because of low hydraulic gradients that are often below 1%.

The intermediate scale aquifers in the alluvial deposits on the valley floors may be surficial, semi-confined or confined. Sediments in which the majority of the grains are sand size or larger act as the aquifers, while sediments dominated by clay particles can act as confining layers. Discharge from these aquifers is common on the broad valley floors and results in large areas such as the Coblining System (19.1% of the Zone) being susceptible to waterlogging or inundation throughout winter. The
discharge is typically saline (>2000 mS/m) and leads to large areas being affected by salinity. These areas are left bare and eroded, or covered by barley grass and samphire during summer. Capillary rise from valley floor aquifers (Figure 2.5) is the most common form of discharge in these areas with discharge from semi-confined aquifers (Figure 2.6).

Palaeochannels are a more specific example of intermediate scale alluvial aquifers where “ancient river systems” eroded deeply (between 50 and 100 m) into the landscape and were filled with more recent alluvial sediments (Figure 2.6). While not proved to be present, exploration drilling by BHP in 1982 located a palaeochannel 5 km east of the Coblimine River entrance into Lake Dumbleyung. As this is the exit point for the Katanning Zone, the palaeochannel is likely to extend further back under the Coblimine System.

Plate 5: Excavated hillside seep in the Katanning Zone.
Figures 2.5–2.7: Discharge from typical intermediate flow systems in the South-west Hydrological Region (from George et al. 1997)

Although, the aquifer shown in Figure 2.5 occurs at intermediate scale it is more common at a local scale (Figure 2.8). Local aquifers (Figures 2.8–2.13) are the most common and widespread. They are found beneath 60-70% of the landscape and are
usually associated with undulating to hilly terrain. Flows may be permanent or temporary. The water is typically transported down a hill slope through unconfined aquifers that are relatively thin (<20 m) and close to the surface.

Local unconfined (perched) aquifers occur in the deeper sandy deposits of the sandplains such as those found in the North Coyrecup area (Figure 2.10). They generally occur as pale and gravelly pale deep sands that are more than 80 cm in depth. Duplex soils often act as a temporary aquifer (four or five years in 10) when recharge through rainfall exceeds the horizontal conductivity (refer Appendix 2 for range) of the sand layer which is typically around 1.8m/day (Cox 1988).

Local semi-confined to confined aquifers in weathered basement rocks exist in the same conditions as the intermediate scale, but have geological structures and conditions that cause the discharge to occur close to the recharge point. These geological conditions include bedrock highs (Figure 2.9), break of slope (Figure 2.11), and dolerite dykes (Figure 2.12).

Fractured rock aquifers occur at both the local and intermediate scales (Figures 2.7, 2.13). They refer to structures such as dykes, faults and shear zones that have created zones of fracturing within the unweathered bedrock. They extend from tens of metres to tens of kilometres. Sometimes, the fabric of the fractured zone is retained in the lateritic profile increasing the hydraulic conductivity (refer Appendix 2) sometimes causing preferential discharge over shear zones and faults (Figure 2.13).

Plate 6: Valley floor salinity off Schultz Road in the Katanning Zone.
Figures 2.8–2.13: Discharge from typical local flow systems in the South-west Hydrological Region (from George et al. 1997)
2.4.3 Groundwater

The Water and Rivers Commission hydrogeological database (AQWABase) contains 580 bores in the Katanning Zone. The bores were drilled between 1900 and 1996, mostly as exploratory bores for groundwater. Measurements of salinity or depth to the watertable over time are not available for these bores. The database contains just one measurement taken at the time of drilling. This information is of limited use as the bores have generally been abandoned and can not be located in the field. The most recent water monitoring data was collected in 1991 and is available for seven of the bores, the majority of which are situated low in the landscape, with watertable depths less than 2 m from the ground surface. Two bores however, located high in the landscape in the south east, measured approximately 12 and 24 m to water in 1991 (refer to Map 3). The remaining 573 bores have no data recorded after 1990 and are not shown on Map 3.

Monitoring data for water bores is also available from the Department of Agriculture’s AgBores database and the Katanning and Borden Landcare Centres ComBores databases. Water level monitoring data and bore location co-ordinates exist for 275 bores (Map 3). The accuracy of bore location co-ordinates is unknown in many cases, thus the bore locations plotted on Map 3 should be viewed as approximate. One water level for each bore was selected for plotting on Map 3. Due to the irregularity of monitoring of bores, the dates for which depth to watertable class is plotted vary from May 1998 to October 2000.

The data is biased towards bores drilled low in the landscape. About 70% are located on lower slopes or valley floors close to drainage lines. As a result, the majority (187 bores) indicate a watertable less than 2 m from the ground surface. A further 50 bores show groundwater at 2 to 5 m below ground surface whilst 38 bores are located in areas where the watertable is greater than 5 m from the surface.

Salinity measurements are available for 167 bores in the Katanning Zone from the AgBores and ComBores databases. Due to the bias towards lower slope and valley floor locations, the majority (108 bores) measure saline to highly saline (>1000 mS/m). Bores with highly saline water (>2000 mS/m) are predominantly located in the south east (Upper Coblinine and Kwobrup). In the west, high salinity has been measured for bores low in the landscape at North Ewlyamartup and Katanning Creek. Bores which measure fresh (<250 mS/m) are mostly found in the west and north-west (Bellakine Hill, Daping Creek, Katanning Creek and Johns Well).
2.5 Native vegetation
Angela Stuart-Street, Soil Resource Officer, Katanning

The Katanning Zone is situated within the South-west Botanical Province in the Roe and Avon Botanical Districts (Beard 1981). Seven vegetation systems occur within these two botanical districts. These original native vegetation systems have distinct vegetation associations that are largely a function of soil type, topography and rainfall. They are briefly described below:

Dumbleyung Vegetation System 85,532 ha (28% of Zone)

This system covers the area from Lake Coyrecup north to beyond the boundary of the Zone. It is gently undulating country with residual laterite capping, with salt flats and lakes occupying the principal valleys. The main vegetation associations are:

- Dryandra heath with blue, brown and silver mallet (Eucalyptus gardneri, E. astringens, and E. falcata) woodland on residual laterite areas
- Woodland of York gum (E. loxophleba), morrel (E. longicornis), salmon gum (E. salmonophloia) and wandoow (E. wandoow) on undulating country
- Small patches of mallee including sand mallee (E. eremophila), black marlock (E. redunca) and lerp mallee (E. incrassata)
- Tea-tree and samphire on salt flats, scrub-heath and low woodland on low sandplain.

Chidnup Vegetation System 70,949 ha (23% of Zone)

This system is dominates the south eastern region. This subdued landscape is covered mainly by mallee eucalypt associations including:

- Dominance by sand mallee–giant mallee (Eucalyptus eremophila – E. oleosa) and marlock–hook-leaved mallee (E. redunca–E. uncinata) associations
- Scrub-heath, generally with blue mallee (Eucalyptus tetragona) on sandy ridges
- Yate (E. occidentalis) and occasionally salmon gum (E. salmonophloia) occupy winter wet depressions; low forests of moort (E. platypus) predominate on grey clays.

Hyden Vegetation System 53,389 ha (17% of Zone)

The north-east is dominated by this vegetation system. This very gently undulating area is dominated by a vegetation mosaic including:

- Kwongan (scrub-heath and thicket) on sandplain areas, characterised by species including red toothbrushes (Grevillea hookerana), Casuarina pinaster, and white leaved mallee (E. albida)
- Mallee on slopes dominated by sand mallee (E. eremophila) and marlock (E. redunca) with a dense Melaleuca understorey
- Mallee with woodland patches including salmon gum (E. salmonophloia) and gimlet (E. salubris) on upper valley soils.
Broomehill Vegetation System  

40,855 ha (13% of Zone)

This undulating area covering the central western region of the Katanning Zone was once covered by woodland dominated by wandoo in various associations with other species. The main combinations are:

- Brown and blue mallet (*Eucalyptus astringens* and *E. gardneri*) with wandoo (*E. wandoo*) on lateritic rises
- York gum (*E. loxophleba*) in more undulating country, and rarely, salmon gum (*E. salmonophloia*)
- Morrel (*E. longicornis*) and yate (*E. occidentalis*) in depressions.

Understorey species commonly include jam and rock sheoak.

Pallinup Vegetation System  

28,876 ha (9% of Zone)

At the southern fringe of the Katanning Zone, this system denotes where the influences of the Pallinup catchment begins. The system is predominantly continuous woodland interspersed with mallee. Principal associations include:

- Yate (*Eucalyptus occidentalis*) and York gum (*E. loxophleba*) are the principal species with some wandoo (*E. wandoo*)

Wagin Vegetation System  

21,426 ha (7% of Zone)

The Wagin System occurs on the undulating, dissected land at the north-western margin of the Katanning Zone. Eucalypt woodland is dominant. Principal species include:

- Woodland of brown mallet (*Eucalyptus astringens*) and wandoo (*E. wandoo*) on Mallet Hills
- York gum (*E. loxophleba*) and rock sheoak (*Allocasuarina huegeliana*) on granitic outcrops
- York gum and wandoo woodland on slopes
- Mosaic of woodland, tea-tree scrub and samphire on salt flats.

Tambellup Vegetation System  

5,971 ha (2% of Zone)

A small area of this vegetation system occurs in the south-western region. This is dissected country of low relief, covered mainly by wandoo (*E. wandoo*) woodland. Other vegetation associations include:

- Scattered laterite-capped hills carry blue and brown mallet (*Eucalyptus astringens* and *E. gardneri*).
- Wandoo is associated with flat-topped yate (*E. occidentalis*) across much of the area, especially on valley flats where wandoo is dominant on sand, and yate on clay.
2.5.1 Remnant vegetation

The remnant vegetation dataset was compared against soil-landscapes to determine how vegetation was distributed across the Katanning Zone (refer to descriptions in Soil-landscape Map Unit table in Appendix 3 from Section 2.3.1 or the legend in Map 2). Table 2.3 shows how much remnant vegetation is remaining in each map unit and the comparative distribution of remnant vegetation.

The remnant vegetation data set identified 30,637 hectares of remnant vegetation remaining or about 10% per cent. The majority occur in the river valleys or areas that include uncleared conservation or Shire reserves.

Most remnant vegetation in the Katanning Zone is contained within the following landscapes:

- Cb2 containing broad valley floor of the Coblinine River and its tributaries;
- Cb3 containing the broad saline valley floor of the Coblinine River;
- Cb4 containing lakes and swamps including Lake Coyrecup, surrounded by lunettes and dunes.
- Map units in upper parts of the landscape, such as Ca1 and Ek1 have slightly higher levels of remnant vegetation. This is generally a reflection partly of the risk posed by toxic plants (e.g. Gastrolobium spp.) often found in these areas as well as the lower productivity expected from the gravelly, rocky and sandy soils which mainly dominate these regions.

The remaining landscapes suited to agriculture have been extensively cleared across the entire Katanning Zone.

<table>
<thead>
<tr>
<th>Soil-landscape unit</th>
<th>Area of remnant vegetation mapped (ha)</th>
<th>Proportion of soil-landscape map unit covered by remnant vegetation (%)</th>
<th>Comparative distribution of remnant vegetation across the Katanning Zone (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Pallinup 1 (Up1)</td>
<td>168</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>Upper Pallinup 2 (Up2)</td>
<td>394</td>
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</tr>
<tr>
<td>Upper Pallinup 3 (Up3)</td>
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<td>Carrolup 1 (Ca1)</td>
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<td>3</td>
</tr>
<tr>
<td>Carrolup 1s (Ca1s)</td>
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<td>0</td>
</tr>
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<td>Carrolup 2 (Ca2)</td>
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</tr>
<tr>
<td>Carrolup 3 (Ca3)</td>
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<td>Carrolup 4 (Ca4)</td>
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<td>1</td>
</tr>
<tr>
<td>Carrolup 5 (Ca5)</td>
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</tr>
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</tr>
<tr>
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<td>3</td>
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<td>Coblinine 3 (Cb3)</td>
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<td>11</td>
</tr>
<tr>
<td>Coblinine 5 (Cb5)</td>
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<td>60</td>
<td>2</td>
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<tr>
<td>Coblinine 6 (Cb6)</td>
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<td>1</td>
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<tr>
<td>Datatine 2 (Dt2)</td>
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<td>3</td>
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<tr>
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<tr>
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<td>0</td>
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<td>Nyabing 1 (Ny1)</td>
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<td>5</td>
</tr>
<tr>
<td>Nyabing 1s (Ny1s)</td>
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<td>13</td>
<td>0</td>
</tr>
<tr>
<td>Nyabing 2 (Ny2)</td>
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<td>5</td>
</tr>
<tr>
<td>Nyabing 2c (Ny2c)</td>
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<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Nyabing 3 (Ny3)</td>
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<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Tieline 1 (Tn1)</td>
<td>1487</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Tieline 2 (Tn2)</td>
<td>1847</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>
3. Katanning Zone resource condition and future risk

3.1 Salinity and groundwater
Tim Mathwin and Louise Hopgood, Hydrogeologists, Katanning

3.1.1 Current extent of salinity (as mapped by Land Monitor)

Land Monitor is an NHT-funded project that was co-ordinated by government agencies to:

- Map and monitor changes in the area of salt-affected land from 1988;
- Predict areas at risk from future salinisation;
- Monitor changes in the amount and quality of remnant vegetation and areas of revegetation from 1988;
- Produce highly accurate digital elevation models (DEM) from which 2 m contour intervals can be created;
- Distribute the derived information to the end users and the community; and
- Establish a baseline for continued monitoring.

Current extent of salinity was estimated using Landsat satellite imagery from 1993 and 1995 to identify areas with low or no production (see Map 3). In many cases Land Monitor was unable to distinguish between areas of low production and objects with similar reflectance such as dams, roaded catchments and buildings, with an overestimate of area by 5%. In contrast, saline areas with a dense covering of barley grass or saltbush were not mapped as areas of low productivity because of the amount of vegetative cover. This produced a typical underestimate of saline area by approximately 20% (George & Coleman 2001).

Map 3 illustrates that areas of consistently low production (AOCLP) are mostly found low in the landscape within the Coblinine System. These areas convert to 18,380 ha or 6% of the Katanning Zone.

3.1.2 Groundwater trends

Most of the 275 bores do not have sufficient monitoring data to determine watertable trends. Eight to 12 years of data is available for 15 bores at the Great Southern Agricultural Research Institute, Katanning Research Support Unit (GSARI KRSU), 7 km east of Katanning. Records for a further eight bores along Bushy Lane Rd 5 km south of Katanning, comprise five years of data whilst 10 bores to the north-west and south-east of Katanning comprise three to five years of data. Data for the remainder (242 bores or 88%) cover less than three years and so cannot be used to determine trends in the watertable.

Of the 33 bores for which more than three years of monitoring data is available, 18 have been monitored consistently enough to enable a HARTT analysis (Hydrograph Analysis which takes into account the Rainfall over Time Trend, Ferdowsian et al., in press) and estimation of watertable trends. The majority of bores are located on a
broad valley floor at KRSU trial sites. Seasonal variation in depth to the watertable is the most significant feature of the bore hydrographs, due to the effect of evaporation in summer. The watertable reaches close to the ground surface in winter and drops to between 1 and 2.5 m below in summer. Eight bores located at an alley farm trial site indicate an average fall in the watertable of 9 cm/year. One bore in the centre of the alley farm shows a fall of 17 cm per year (Figure 3.1). A further six bores in a saltbush trial site show an average fall of 5 cm per year.

![Figure 3.1. Water Level and Long-term Trend (HARTT), Valley Floor, Alley Farm Trial, KSU, Katanning-Nyabing Rd](image)

A HARTT analysis of two bores located on a broad lower slope, 5 km south of Katanning indicates seasonal variations in depth to the watertable and a small rising or falling trend of 5 cm per year (Figure 3.2).

![Figure 3.2. Water level and long-term trend (HARTT), lower slope, pasture, wheat, canola and widely spaced alleys, Bushy Lane Rd](image)

Despite the large number of bores in the Katanning Zone, there is a lack of information on watertable and salinity trends. This is partly because many of the
bores were drilled between 1998 and 2000 and trends cannot be reliably determined over such a short monitoring period. Many bores have not been monitored with sufficient regularity to allow a statistically valid trend to be determined. Furthermore, most bores for which significant water level data is available, are located on or adjacent to revegetation trials, so the observed groundwater trends cannot be expected to be representative. An emphasis must be placed on maintaining regular water bore monitoring, particularly for bores located in medium to high landscape positions so that watertable trends can be more accurately defined in the future.

3.1.3 Potential salinity risk (Flowtube and Land Monitor)

Flowtube is a two-dimensional model that allows simulation of groundwater levels while changing all the variables described in the catchment water balance equation (refer Appendix 2). Intensity and accuracy of measured data controls the level of confidence placed in the model. No data exists for construction of a transect across the Katanning Zone of geologically described bores drilled to bedrock. The model is therefore based on many assumptions including:

- Bedrock is generally deeper higher in the catchment
- Bedrock is a subdued reflection of the surface topography
- Main aquifer is saprolite grit overlying granite basement
- Saprolite grit has a uniform thickness of 5 m
- Hydraulic conductivity of the main aquifer is similar to that measured in the west of the Blackwood Catchment at Duranillan (Clarke et al. 2000) and is 0.6 m/day
- Porosity and conductivity of overlying clays is 10% and 0.01 respectively
- Recharge is 7% of the average annual rainfall at 400 mm/yr
- The length of the flowtube with a shallow watertable (two-dimensional) is linearly related to the area of the zone with a shallow watertable (three dimensional) as indicated by the Land Monitor results.

Including all the above assumptions, it was found that the model would only show significant changes in groundwater levels when changing the values assigned to recharge and hydraulic conductivity. In the “do nothing” scenario, allowing all 7% of the rainfall to recharge after approximately 100 years, the length of the flowtube with a watertable within 2 m will be approximately 88% (Figure 3.3). This equates to 32% of the area if applying the final assumption of a linear relationship when extrapolating the two dimensional model to three dimensions.

If recharge is reduced by 50% (e.g. lucerne over the whole landscape) the area affected after 100 years will be 80% and if reduced to 25% it falls to 72%. Reduction of recharge to zero shows only 47% being affected by shallow watertables after the same time. The increase in area with a shallow watertable under zero recharge is a consequence of the extremely low conductivities of the aquifers and the high current recharge rates relative to pre-clearing rates.
Table 3.1 Relationship of recharge rates to the percentage of transect and whole Katanning Zone with potential for shallow watertables

<table>
<thead>
<tr>
<th>Recharge (% of current rate)</th>
<th>Flowtube result (% of transect)</th>
<th>Extrapolation to 3-D (% of Katanning Zone) using Land Monitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>88</td>
<td>32</td>
</tr>
<tr>
<td>50</td>
<td>80</td>
<td>28</td>
</tr>
<tr>
<td>25</td>
<td>72</td>
<td>25</td>
</tr>
<tr>
<td>0</td>
<td>47</td>
<td>14</td>
</tr>
</tbody>
</table>

Numbers produced by the Flowtube model are much higher than would be forecast for the overall catchment average (Table 3.1) because the transect has been modelled down the landscape in a creekline. This creates an overestimate because the final assumption of a transect being able to be linearly extrapolated to three dimensions is not true.

Figure 3.3: Groundwater levels calculated for varying percentages of present recharge estimate.

HAVF maps (Height above valley floor) have been produced by Land Monitor and combine Landsat satellite imagery with digital elevation models (based on topographic contours), surface water accumulation models and ground-truthing to
predict areas with the potential for a shallow watertable. Table 3.2 shows the extent of potential for shallow watertables.

**Table 3.2 Areas of potential shallow watertable within the Katanning Zone**

<table>
<thead>
<tr>
<th>HAVF (metres)</th>
<th>Ha</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 0.5</td>
<td>47,170</td>
<td>15</td>
</tr>
<tr>
<td>0.5 to 1.0</td>
<td>21,470</td>
<td>7</td>
</tr>
<tr>
<td>1.0 to 1.5</td>
<td>15,610</td>
<td>5</td>
</tr>
<tr>
<td>1.5 to 2.0</td>
<td>12,800</td>
<td>4</td>
</tr>
<tr>
<td>TOTAL</td>
<td>97,050</td>
<td>31</td>
</tr>
</tbody>
</table>

Height above flowpath or valley floor (HAVF) is a measurement (in metres) above the lowest point in the landscape (i.e. valley floor). Therefore Land Monitor HAVF maps, as illustrated in Map 4, do not show potential groundwater levels or potential salinity. It may be interpreted that they map the potential for groundwater levels within 2 m of the surface given the assumption that all water levels are at the surface in every valley. This is clearly not the case higher in the landscape and other localised areas. As such, the maps need to be interpreted carefully in these areas and remember that they are only a derivative from digital elevation models. The HAVF maps should be ground-truthed as much as possible before any decisions are made using their data.

Ground-truthing in the Upper Coblinine Catchment provided an example of its importance. In an area mapped as having a potential for groundwater within 2 m of the surface a piezometer was found to be dry at 9 m.

In general, the closer to catchment divides and areas of increased relief, the less reliable the HAVF map becomes at estimating areas with potential for shallow watertables.

In addition to the possibility of overestimating potential for shallow groundwater levels the Land Monitor data will not include potential shallow groundwater sites midslope where seeps are already in existence.

Despite the potential inaccuracies of Land Monitor data, the estimate of 31% of the Katanning Zone with potential for shallow watertable is similar to estimates from other studies. In the National Land and Water Resources Audit, Short and McConnell (2001) indicated that in 2050, 33% of the Western Australian wheatbelt has potential for salinity due to shallow watertables. They also state that 30% of the Southern Zone of Ancient Drainage, in which most of the Katanning Zone lies, has potential for salinity.
3.2 Biodiversity
Jonathan Chamarette, Department of Agriculture, and Chrissy Rob, Department of Conservation and Land Management, Katanning

In Western Australia, biological diversity has been rapidly declining since land was cleared for agricultural production (Environment Australia 1993). Habitat destruction has directly and indirectly caused the decline of a number of native flora and fauna species and in some areas a total loss of native species, whilst allowing numbers of feral animals and weeds to increase.

3.2.1 Value of biodiversity in the Katanning Zone

The Katanning Zone covers a total area of 306,997 hectares, most cleared for agriculture (273,626 ha). The biodiversity is dominated by farmland biodiversity and includes introduced animals such as sheep and cattle and introduced plants such as subterranean clover, wheat, barley, canola and various weeds. The value of this farmland biodiversity is probably best estimated by the gross value of agricultural production that is generated from the region ($50-65 million annually).

Currently there is only 30,637 ha of remnant vegetation remaining which represents 10% of the total area. Section 2.5.1 discusses in more detail the distribution of remnant vegetation in the landscape. Most of the remnant vegetation is present on private land (80-85%) while the rest is located in public reserves. There are six significant reserves in the Katanning Zone, of which two contain lakes – Coyrecup Reserve (1010 ha) and Coblinine Reserve (2023 ha). The remaining reserves are Corneicup Reserve (1952 ha), Johns Well Reserve (385 ha), Kwobrup Reserve (120 ha) and Woorgabup Reserve (48 ha).

The vegetation in these reserves is generally woodland species – *Eucalyptus wandoo* and *E. loxophleba* over low forest of *Allocasuarina huegeliana* and *Acacia accuminata*, and heath containing numerous *Melaleuca* and *Dryandra* species. Rare species of flora are outlined in Table 3.3.

Plate 8: Wandoo (*E. wandoo*) woodland with *Acacia acuminata* at Johns Well Nature Reserve (photo courtesy of CALM Katanning 2001)
Table 3.3: Rare flora recorded in the Katanning Zone (CALM Katanning 2001)

<table>
<thead>
<tr>
<th>Reserve</th>
<th>Rare species of flora</th>
</tr>
</thead>
</table>
| Coyrecup Reserve | *Dryandra porrecta*  
                        | *Blennospora phlegmatocarpa*  |
| Coblinine Reserve | *Verticordia brevifolia ssp. brevifolia*  
                         | *Verticordia huegelli var. tridens*  |
| Cornecup       | *Dryandra drummondii ssp. macrorufa*  
                        | *Verticordia brevifolia ssp. brevifolia*  |
| Johns Well     | *Thysanotus acerosifolius*  
                        | *Dryandra rufistylis*  |
| Kwobrup        | *Acacia grisea*  
                        | *Daviesia crassa*  |
| Woorgabup      | Nil                                                        |

The major species of mammals are the western grey kangaroo and the introduced fox and rabbit. The main reptile species in the area is the bobtail skink. Many species of birds are found indicating the importance of the woodland tree species as habitats. A number of water birds migrate to the Coyrecup and Coblinine Lakes, making these features significant breeding grounds (CALM Katanning District Office 2001). Rare species of fauna are outlined in Table 3.4.

Table 3.4: Rare fauna recorded in the Katanning Zone (CALM Katanning 2001)

<table>
<thead>
<tr>
<th>Reserve</th>
<th>Rare species of fauna</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coyrecup Reserve</td>
<td><em>Stictonetta naevosa</em> (Freckled Duck)</td>
</tr>
<tr>
<td>Coblinine Reserve</td>
<td>Nil recorded but suspected presence of Freckled Duck</td>
</tr>
<tr>
<td>Cornecup</td>
<td><em>Psophodes nigrogularis</em> (Western Whipbird)</td>
</tr>
<tr>
<td>Johns Well</td>
<td>Nil recorded but Red-tailed Phascogale has been sighted nearby</td>
</tr>
<tr>
<td>Kwobrup</td>
<td><em>Falcunculus frontatus leocogaster</em> (Crested Shrike Tit)</td>
</tr>
<tr>
<td>Woorgabup</td>
<td>Nil, Tamar wallabies reported but not confirmed</td>
</tr>
</tbody>
</table>

3.2.2 Biodiversity risk in the Katanning Zone

It has been estimated that up to 1000 Western Australian plants and animal species are currently threatened with extinction caused by salinity (Greg Keighery, CALM pers. comm.). This is due to a high percentage of remnant vegetation being in the lower parts of the landscape, which are vulnerable to salinity. Many of these species do not occur outside the agricultural region, so are in real danger of becoming extinct.

In the Katanning Zone, 44% (13,534 ha) of native remnant vegetation stands, including 85% of the reserves, are in low-lying areas of the landscape in the Coblinine System (see Table 2.3 showing landscape positions of remaining remnant vegetation). Flora and fauna communities in these areas are at high risk of habitat destruction caused by shallow watertables. As a number of rare flora and fauna
species have been identified across these reserves, the salinity risk to these habits is very significant. The lack of revegetation corridors linking remnant vegetation stands is an additional pressure. If fauna habitats were destroyed by rising watertables there would be little opportunity for smaller species of fauna to migrate to other remnant vegetation. Added to this is the frequently degraded ‘health’ of farmland remnant vegetation due to grazing from sheep and cattle, colonisation of weeds and removal of dead logs for firewood.

Figure 3.4 shows the areas of remnant vegetation at risk of a shallow groundwater table in the Katanning Zone (calculated according to height above valley floor from Land Monitor). Vegetation placed under stress from rising watertables and salinity results in its degradation and associated decrease in biodiversity. These stresses can sometimes cause the total destruction of vegetation or colonisation by salt tolerant species such as samphire and saltbush.

![Figure 3.4: Remnant vegetation at risk of rising watertables (from Land Monitor)](image)

Remnant vegetation is also at risk of degradation from wind erosion, water erosion, weeds, pests and grazing. The remnant vegetation in the Katanning Zone is in varying states of ‘health’ from degraded to pristine. The pristine remnant vegetation and areas that contain endangered or threatened flora and fauna species have the highest biodiversity value. Coyrecup and Coblinine Reserves are partly degraded, as they have a number of salt-affected areas characterised by saltbush and dead or dying trees. This is an indication of the risk that rising watertables pose to these reserves. The remaining reserves are in relatively pristine condition, apart from some edge effects from adjoining farmland (weeds and grazing pressure). See Appendix 4 for more information relating to the value of biodiversity.

A large proportion of remnant vegetation is preserved on Gravel Ridges and Slopes. These areas have remained uncleared due to the poor agricultural quality of the soils. However they are used by shires as gravel reserves for the construction and maintenance of roads. To ensure that the remnant vegetation on these gravel reserves is not adversely affected by the activity of gravel removal, shires will need to develop and implement management plans targeted at preserving the biodiversity.
Given that the majority of remnant vegetation is on private land (80-85%), it will be necessary to provide landholders with incentives to actively manage the remaining remnant vegetation for conservation and preservation. This can be achieved by encouraging participation in the bush-brokering scheme, removal of land rates on remnant vegetation and financial assistance associated with fencing and protection of remnant vegetation.

Farmland biodiversity is at risk from land degradation issues including growing acidity, wind and water erosion and salinity. About 84,000 hectares (Land Monitor) of farmland is at risk of dryland salinity. The impact of salinity on farmland biodiversity is unclear because some areas can be rehabilitated with tolerant species while other areas will be inhospitable to both native and farmland species. However the maximum cost of this loss of previously productive farmland is likely to be approximately $15 million (=84,000 ha @ $180/ha - estimated annual gross value of agricultural production) annually once groundwater equilibrium is reached in 20 to 60 years).

The limited understanding of the dynamics of soil micro-organisms has led to them being undervalued, leaving their potential untapped (Abbott and Murphy 2000). Increased levels of soil disturbance, not to mention land degradation issues such as salinity, decline in soil pH and wind erosion, all have potential to adversely affect the biological, chemical and physical balance and fertility of the soil. There is substantial evidence that retention and protection of the diversity of soil biota has much to offer sustainable agricultural production (Abbott and Murphy 2000).
3.3 Infrastructure at risk  
Jonathon Chamarette, Regional Economist, Katanning

3.3.1 Roads

The Katanning Zone has almost 2000 km of gazetted roads, most of which are gravel roads or tracks. A summary of the roads is given in Table 3.5.

Table 3.5. Summary of roads in the Katanning Zone

<table>
<thead>
<tr>
<th>Length (km)</th>
<th>Sealed roads</th>
<th>Unsealed roads</th>
<th>Tracks</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>380</td>
<td>895</td>
<td>687</td>
<td></td>
<td>1963</td>
</tr>
</tbody>
</table>

The sealed roads include a 26 km length of the Great Southern Highway which is the only major highway. Using Land Monitor height above valley floor data it is possible to determine the length of roads that are at risk of shallow watertables. This is summarised in Table 3.6.

Table 3.6. Length of roads at risk of shallow watertables in the Katanning Zone (based on Land Monitor predictions)

<table>
<thead>
<tr>
<th>Height above valley floor</th>
<th>Sealed roads</th>
<th>Unsealed roads</th>
<th>Tracks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 0.5 metres</td>
<td>43 km (11%)</td>
<td>98 km (11%)</td>
<td>64 km (9%)</td>
</tr>
<tr>
<td>0.5 to 1 metre</td>
<td>22 km (6%)</td>
<td>59 km (7%)</td>
<td>37 km (5%)</td>
</tr>
<tr>
<td>1 to 1.5 metres</td>
<td>22 km (6%)</td>
<td>43 km (5%)</td>
<td>27 km (4%)</td>
</tr>
<tr>
<td>1.5 to 2 metres</td>
<td>18 km (5%)</td>
<td>37 km (4%)</td>
<td>27 km (4%)</td>
</tr>
<tr>
<td>Total length under threat of shallow watertable</td>
<td>104 km (27%)</td>
<td>237 km (26%)</td>
<td>155 km (23%)</td>
</tr>
<tr>
<td>Total length</td>
<td>380 km (100%)</td>
<td>895 km (100%)</td>
<td>687 km (100%)</td>
</tr>
</tbody>
</table>

Shallow watertables affect road construction costs and increase the maintenance cost of roads. These construction and maintenance costs vary according to the class of road affected by the shallow watertable. According to Dames and Moore (2001) roads constructed under normal conditions last around 40 years. However in the NSW and Victorian irrigation districts when roads are affected by shallow groundwater (<2 m), the life is halved. This information is summarised in Table 3.7.
Table 3.7. Typical road construction and maintenance costs experienced when shallow watertables are present (Dames and Moore 2001)

<table>
<thead>
<tr>
<th>Sealed</th>
<th>Unsealed</th>
<th>Tracks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction costs ($/km)</td>
<td>Construction costs associated with shallow watertable ($/km)</td>
<td>Annual maintenance cost ($/km/yr)</td>
</tr>
<tr>
<td>Major State Highway</td>
<td>390,000–400,000</td>
<td>71,000-115,000</td>
</tr>
<tr>
<td>Standard sealed country road</td>
<td>100,000</td>
<td>25,000-35,000</td>
</tr>
<tr>
<td>Minor sealed country road</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Gravelled road</td>
<td>7,000</td>
<td>3,000</td>
</tr>
</tbody>
</table>

Using the above information it is possible to estimate the cost that shallow watertables will have on maintenance and construction of roads within the Katanning Zone. No construction or maintenance costs for tracks have been included so it has been assumed that reconstruction costs are zero but an annual maintenance cost of $25/km is incurred when a shallow ground watertable (<2 m) affects the track.

Table 3.8. Extra annual cost of maintenance and construction for roads in the Katanning Zone associated with shallow watertables

<table>
<thead>
<tr>
<th>Sealed</th>
<th>Unsealed</th>
<th>Tracks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length under threat of shallow watertable (km)</td>
<td>104</td>
<td>237</td>
</tr>
<tr>
<td>Annual extra maintenance/km</td>
<td>$300</td>
<td>$400</td>
</tr>
<tr>
<td>Annual extra cost</td>
<td>$31,287</td>
<td>$41,717</td>
</tr>
<tr>
<td>Extra Construction cost/km incurred every 20 years</td>
<td>$25,000</td>
<td>$35,000</td>
</tr>
<tr>
<td>Extra Construction cost incurred every 20 years</td>
<td>$2,607,290</td>
<td>$3,650,206</td>
</tr>
<tr>
<td>Annuity of Extra construction cost (discount rate 7%)</td>
<td>$246,110</td>
<td>$344,554</td>
</tr>
<tr>
<td>Total Annual Construction and Maintenance cost ($/year)</td>
<td>$277,397</td>
<td>$386,270</td>
</tr>
<tr>
<td>Estimated annual cost of shallow watertable to roads in Katanning Zone ($/year)</td>
<td>$395,633</td>
<td>$504,506</td>
</tr>
</tbody>
</table>

From Table 3.8 the annual cost of shallow watertables to road construction and maintenance in the Katanning Zone has been calculated to be between $400,000 and $500,000 per year. This annual cost should be perceived as a maximum extra annual cost of road maintenance / construction, once groundwater equilibrium is reached or water levels reach the 2 m height above valley floor as indicated by Land Monitor data. Equilibrium is expected to be reached in this landscape in about 20 to 60 years (Mathwin pers. comm. 2001).
Currently, areas of consistently low production (1993-95) represent 6% of landscapes as salt-affected, while mapping indicates 9% of the landscape is salt-affected. These areas are expected to increase to approximately 30% (Land Monitor data) before groundwater rise reaches equilibrium with groundwater discharge.

Assuming equal amounts of sealed, unsealed road and tracks are affected at the same rate as the groundwater rises, an estimate of current annual cost of shallow watertables can be calculated. For example:

Lower estimate = (Area of consistently low production (1993-95) / total area expected to be affected) * $395,633
= 6%/31% * $395,633 or 9%/31% * $395,633
= $76,574 or $114,861

Upper estimate = (Area of salt-affected landscape as indicated by soil-landscape mapping / total area expected to be affected) * $504,506
= 6%/31% * $504,506 or 9%/31% * $504,506
= $97,646 or $146,469

These calculations indicate that the current annual cost of shallow watertables is between $77,000 and $146,000. The amount is likely to be closer to $146,000 because of the age of the data (1993-95) used to calculate the area of consistently low production. Data from 1993-95 is likely to be under-estimating the current area affected by shallow watertables so would be under-estimating the annual cost road construction and maintenance due to shallow watertables.

### 3.3.2 Railway lines

There are two major railway lines within the Katanning Zone. One connects Katanning to Nyabing and the other, known as the Great Southern Railway, connects Katanning to the port of Albany. In total there is 88 km of railway line, and the length of lines at risk of shallow watertables is summarised in Table 3.9.
Table 3.9. Length of railway line at risk of shallow watertables in the Katanning Zone (based on Land Monitor predictions)

<table>
<thead>
<tr>
<th>Height above valley floor (m)</th>
<th>Railway line</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 0.5</td>
<td>8 km (10%)</td>
</tr>
<tr>
<td>0.5 to 1</td>
<td>11 km (12%)</td>
</tr>
<tr>
<td>1 to 1.5</td>
<td>4 km (5%)</td>
</tr>
<tr>
<td>1.5 to 2</td>
<td>6 km (7%)</td>
</tr>
<tr>
<td>Length under threat of shallow watertable</td>
<td>30 km (34%)</td>
</tr>
<tr>
<td>Total length</td>
<td>88 km (100%)</td>
</tr>
</tbody>
</table>

### 3.3.3 Towns

The Katanning Zone has three major settlements within its boundary: Katanning, Broomehill and Nyabing. As part of the Rural Towns Program, Katanning has had a detailed groundwater investigation that includes drilling and modelling of current and predicted groundwater levels.

This estimated the damage costs to be $6.86 million, discounted at 7% over a 30 years (Dames and Moore 2001). Most of these costs are incurred in the housing sector (32%) and road maintenance (62%) and summarised in Table 3.10.

Table 3.10. Breakdown of Katanning damage costs associated with high watertables as outlined by Dames and Moore (2001)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Damage cost incurred over 30 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>$57,010</td>
</tr>
<tr>
<td>Industrial</td>
<td>$38,830</td>
</tr>
<tr>
<td>Public places</td>
<td>$107,840</td>
</tr>
<tr>
<td>Recreation</td>
<td>$262,840</td>
</tr>
<tr>
<td>Residential housing</td>
<td>$2,166,355</td>
</tr>
<tr>
<td>Roads</td>
<td>$4,232,780</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$6,865,655</strong></td>
</tr>
</tbody>
</table>

Using the total damage cost incurred for shallow groundwater tables, for Katanning, an annual cost is calculated at $480,596 (equivalent annual value 7% discount rate over 30 years). A proxy cost of high watertables damage to town infrastructure per hectare can be calculated assuming that there is a high degree of correlation between the areas considered at risk of a high watertable as indicated by the groundwater modelling data (as generated in Dames and Moore 2001) and the height above valley floor data (as generated by Land Monitor). Table 3.11 compares the area considered at risk of shallow watertables by the Dames and Moore and that indicated by the Land Monitor data.
Table 3.11. Katanning townsite area at risk estimated by Land Monitor and Dames and Moore modelling

<table>
<thead>
<tr>
<th>Depth to watertable</th>
<th>Dames and Moore</th>
<th>Land Monitor Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 0.5 metres</td>
<td>334</td>
<td>110</td>
</tr>
<tr>
<td>0.5 to 1.5 metre</td>
<td>75</td>
<td>127</td>
</tr>
<tr>
<td>Total area at risk of high watertables (0-1.5 m)</td>
<td>409</td>
<td>237</td>
</tr>
<tr>
<td>Annual cost of high watertables 7%discount rate</td>
<td>$480,596</td>
<td></td>
</tr>
<tr>
<td>Proxy cost/ha of town infrastructure **</td>
<td>$1,176</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.11 shows that Land Monitor indicates a smaller area associated with shallow watertables than the Dames and Moore modelling. This is probably reflects the more intense modelling and townsite bore information used. The Dames and Moore data indicates a proxy cost of shallow watertables per hectare of town infrastructure of $1,176/ha. This cost can then be used to estimate the cost of shallow watertables for Nyabing, Broomehill and a larger area of Katanning townsite not considered by the Dames and Moore report. The town areas considered and the associated Land Monitor shallow watertable data are shown in Appendix 4. Table 3.12 summarises these areas and estimates cost of shallow watertables for each of the towns.

Plate 9: Town infrastructure damage within the Katanning townsite.
Table 3.12. Risk of shallow watertables for Katanning, Broomehill and Nyabing and estimated annual cost

<table>
<thead>
<tr>
<th>Area (ha)</th>
<th>Katanning</th>
<th>Broomehill</th>
<th>Nyabing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area not at risk of shallow watertables</td>
<td>1,231 (74%)</td>
<td>101 (90%)</td>
<td>229 (83%)</td>
</tr>
<tr>
<td>Height above valley floor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 to 0.5 metres</td>
<td>166 (10%)</td>
<td>3 (3%)</td>
<td>15 (5%)</td>
</tr>
<tr>
<td>0.5 to 1 metre</td>
<td>98 (6%)</td>
<td>3 (2%)</td>
<td>10 (4%)</td>
</tr>
<tr>
<td>1 to 1.5 metres</td>
<td>97 (6%)</td>
<td>3 (2%)</td>
<td>10 (4%)</td>
</tr>
<tr>
<td>1.5 to 2 metres</td>
<td>83 (5%)</td>
<td>4 (3%)</td>
<td>14 (5%)</td>
</tr>
<tr>
<td>Total area at risk of shallow watertables (0-2 m)</td>
<td>443 (26%)</td>
<td>12 (10%)</td>
<td>49 (17%)</td>
</tr>
<tr>
<td>Total town area (as indicated by redline on image)</td>
<td>1,675 (100%)</td>
<td>112 (100%)</td>
<td>278 (100%)</td>
</tr>
<tr>
<td>Proxy cost/ha of infrastructure **</td>
<td>$1,176</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculated annual cost of shallow watertables</td>
<td>$521,626</td>
<td>$13,824</td>
<td>$57,133</td>
</tr>
<tr>
<td>Estimated current annual cost of shallow watertables (assumes currently affecting 10% of land)</td>
<td>$178,875</td>
<td>$4,608</td>
<td>$19,044</td>
</tr>
</tbody>
</table>

** see calculation of proxy cost per hectare of infrastructure in Table 3.11.

The calculated annual costs for each town should be considered as the maximum likely to be incurred when groundwater levels reach equilibrium or the 2-metre level (20-60 years). Calculation of current annual cost assumes that shallow watertables will affect town infrastructure at a constant rate and is currently affecting 10% of the landscape. High watertables are predicted to affect 30% of the landscape once groundwater equilibrium is reached.

Plate 10: Katanning Rural Towns Program groundwater monitoring bore indicating water level less than 1 m below surface.
3.4 Other natural resource management risks

*Angela Stuart-Street, Soil Resource Officer, Katanning*

Perceptions of land degradation are often influenced by visibility. The most obvious example is the distinctive images of salt-affected landscapes (Nulsen 1993). Salinity and rising watertables are clearly perceived as the most widespread land degradation concern in the Katanning Zone, especially regarding damage to infrastructure and townsites, as well as the agricultural and natural landscape.

The ‘invisible’ forms of land degradation such as soil acidity affect vastly larger areas than the more obvious salt but often go unnoticed and untreated (Nulsen 1993). These risks to the land resource threaten its natural and cultural assets and reduce agricultural productivity. The risk of land degradation has been assessed for each of the 11 land management units (LMUs) described in Section 2.3.2 and is summarised in Table 3.4.1.

The three most important types of land degradation within the Katanning Zone are soil acidity, waterlogging and wind erosion. These are described below, highlighting the LMUs at greatest risk of degradation.

### 3.4.1 Soil acidity

The soils most susceptible to subsoil acidification are sandy, highly leached soils (Dolling 1995). Within the Katanning Zone, the areas most at risk are the Poorly Drained Sandy Duplex, Sandy Duplex and Pale Deep Sand LMUs. Approximately 132,000 ha (43%) is highly susceptible to this form of land degradation.

### 3.4.2 Waterlogging

Waterlogging, or excess water in the root zone (Moore & McFarlane 1998), heightens the effect of saline soils on plant growth. These areas are often saline or at high risk of soil salinity. The LMUs most at risk from waterlogging are Poorly Drained Sandy Duplex and Grey/Greyish Brown Loams and Clays (particularly on lower slopes), and Salt-Affected Land. Approximately 125,870 ha (41%) is highly susceptible to waterlogging.

### 3.4.3 Wind erosion

Wind erosion events arise relatively infrequently, but they can leave a major impact on the landscape. Areas of unprotected loose dry soil, in higher landscape positions are most at risk (Moore *et al*, 1998). The LMUs which are most susceptible (particularly on crests and upper slopes) include Sandy Duplex, Pale Deep Sands and Yellow and Brown Deep Sands. Approximately 70,600 ha (23%) is highly susceptible to wind erosion.
Table 3.13: Assessment of land degradation hazards for Land Management Units in the Katanning Zone (*based on guidelines in Van Gool, Tille and Moore 2000*)

<table>
<thead>
<tr>
<th>Land Management Unit</th>
<th>Approx. Area (ha)</th>
<th>Salinity Risk</th>
<th>Waterlogging /Inundation Risk</th>
<th>Susceptibility to phosphorus export</th>
<th>Susceptibility to Water Erosion</th>
<th>Susceptibility to Wind Erosion</th>
<th>Susceptibility to subsurface (10-20 cm) acidification</th>
<th>Susceptibility to water repellence</th>
<th>Susceptibility to topsoil structure decline</th>
<th>Susceptibility to subsurface compaction (10-30 cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poorly Drained Sandy Duplex</td>
<td>66,779</td>
<td>High</td>
<td>Moderate to High for lower slopes</td>
<td>Moderate, low on valley flats</td>
<td>Low</td>
<td>High</td>
<td>Moderate</td>
<td>Low</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Sandy Duplex</td>
<td>55,760</td>
<td>Low risk*</td>
<td>Low</td>
<td>Moderate</td>
<td>Moderate to High **</td>
<td>High</td>
<td>Moderate</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td>Gravelly Ridges and Slopes</td>
<td>41,726</td>
<td>No risk</td>
<td>Nil</td>
<td>Moderate</td>
<td>Low</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td>Grey/Greyish Brown Loams and Clays</td>
<td>32,835</td>
<td>Low risk</td>
<td>Moderate to High on valley flats</td>
<td>Moderate</td>
<td>Generally low</td>
<td>Low</td>
<td>Low</td>
<td>Moderate to High</td>
<td>Low to Moderate</td>
<td></td>
</tr>
<tr>
<td>Red Soils</td>
<td>26,260</td>
<td>Low risk*</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Salt Affected Land</td>
<td>25,590</td>
<td>Presently saline</td>
<td>Very high</td>
<td>High</td>
<td>Low</td>
<td>Variable ***</td>
<td>Low</td>
<td>Not rated</td>
<td>Not rated</td>
<td></td>
</tr>
<tr>
<td>Pale Deep sand</td>
<td>9918</td>
<td>No risk</td>
<td>Nil</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Low to Moderate</td>
<td></td>
</tr>
<tr>
<td>Mallet Hills</td>
<td>8143</td>
<td>No risk****</td>
<td>Nil</td>
<td>Moderate</td>
<td>High</td>
<td>Presently acid</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Yellow and Brown Deep Sands</td>
<td>4158</td>
<td>Moderate</td>
<td>Very Low</td>
<td>Moderate</td>
<td>Moderate to High**</td>
<td>Moderate to High</td>
<td>High</td>
<td>Low</td>
<td>Low to Moderate</td>
<td></td>
</tr>
<tr>
<td>Salt Lakes</td>
<td>1685</td>
<td>Presently Saline</td>
<td>Not rated</td>
<td>Moderate</td>
<td>Low</td>
<td>Not rated</td>
<td>Not rated</td>
<td>Not rated</td>
<td>Not rated</td>
<td></td>
</tr>
<tr>
<td>Rock Outcrops</td>
<td>772</td>
<td>Variable</td>
<td>Nil</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Not rated</td>
<td></td>
</tr>
</tbody>
</table>

* Low risk, salinity likely to develop as hillside seeps where shallow bedrock forces saline groundwater close to the surface
** Highly susceptible to wind erosion on crests and upper slopes
*** pH on saline soils is highly variable but they are generally not economic to lime
**** Many Mallet Hills have acid clay subsoils that are often saline
4. Management options and impacts

The aim of this section is to provide the best options to manage the salinity and other land degradation risks identified in the Katanning Zone. The majority of the options are presented in best bet options tables for each land management unit (LMU). Additionally this section contains a summary economic analysis of the management options and information on farming systems, surface water and groundwater management.

4.1 Options per soil group/land management unit

Management options are presented for each of the 11 land management units described in Section 2.3.2. The options are presented in a series of best bet tables which recognise the problems associated with each LMU, and suggest various “best practice” management options for consideration. These options emphasise ways to minimise groundwater recharge and land degradation.

4.1.1 Best bet option tables

A best bet option table has been developed for each LMU. Each table has three main column headings: Land Management Unit; Water and Soil Problems and Management Options. A brief Economic Analysis is presented in the second column below the Water and Soil problems.

Land Management Units

The main soils and the landscape position are described for each Land Management Unit (LMU). This is coupled with a soil profile or landscape photograph to illustrate typical soils or landscapes found within each unit.

Water and Soil Problems

The most common water and soil problems that are likely to occur within each land management unit are described. This section highlights the degradation risks associated with each LMU. For example, whether an area is likely to be susceptible to soil acidity, or if it is an area which is the source of large amounts of recharge (e.g. Deep Sands LMU). These problems may not be currently obvious, but the level of risk of these problems developing in the future is stated.

Economic Analysis

The economic costs and production benefits are estimated for a selection of options. The total cost of implementation across the Katanning Zone is given for each LMU as well as the Benefit Cost Ratio.
Management Options

Management options to deal directly with the potential and existing problems are described. These management options are aimed at reducing both land degradation and recharge within the zone.

A more comprehensive section on earthworks mentioned in the tables is included in Appendix 5, and a detailed native vegetation species, and commercial and non-endemic species lists are included in Appendix 6.

Plate 11: Typical Trees on Banks found on The Meadows farm implemented at 3-4 ha per 100 ha.
<table>
<thead>
<tr>
<th>Land Management Unit</th>
<th>Water and Soil Problems</th>
<th>Management Options</th>
</tr>
</thead>
</table>
| Poorly Drained Sandy Duplex: (66,779 ha) | • Moderate groundwater recharge, highest where water ponds.  
• High risk of salinity developing usually along drainage lines and ponded areas.  
• Moderate to high waterlogging risk. Waterlogging is the major limitation in this area.  
• Highly susceptible to sub-surface acidification.  
• Moderately susceptible to wind and water erosion, traffic and plough pans. | Soil Management  
• Liming may be necessary to ensure good establishment of lucerne, and to enable good growth of pastures. Regular monitoring of surface (0-10 cm) and subsurface (10-20 cm) pH is advised.  
• Reduce traffic in paddocks and avoid traffic movement when soil is wet to minimise soil compaction risk.  
• Minimum tillage and no-till operations are recommended to reduce erosion and compaction problems and improve soil structure and maintain soil organic matter.  
• Practice stubble retention or aim to maintain >50% ground cover to control risk of wind and water erosion. |

Economic Analysis

- Average implementation of 3 km/100ha of oil mallees on banks.  
- 2003km of oil mallees on banks at a cost of $500/km for the grade banks and $500/km for two row belts of oil mallees below the banks.  
- Assume the generation of an extra $5/ha/year of production benefits from the remaining land and $50/ha/year from the oil mallees.  
- Total cost $2,003,000.  
- Benefit Cost Ratio 1.02.  
- Liming cost $35 - $60 per ha every 10 years.

Cropping and Pasture Options

- Perennial pastures of lucerne (in areas not subject to a high incidence of waterlogging and pH > 4.8) and/or tall wheat grass mixed with balansa clover are productive options. In summer moist areas, the perennial legume, strawberry clover, may be an option. These soils are often wet and so are not reliable producers of good yielding crops.  
- Oats or triticale may be suitable cropping options.  
- Summer cropping options such as sorghum, sunflowers or millet may be a consideration in summer moist areas.

Recharge Reduction and Surface Water Management

- Grade banks are effective in alleviating water erosion and waterlogging where interception of clay is possible. Well-designed and placed, earthworks may alter this LMU to a moderately drained Sandy Duplex.  
- Appropriate shallow surface (W-drains can effectively reduced ponding and associated risks.  
- Recharge is closely linked with waterlogging and ponding, so any activities which reduce waterlogging will reduce recharge.

Revegetation and Tree Planting Options

- Revegetation areas will need to be mounded - aligned parallel to banks  
- Belts of oil mallees (4 or 8 rows) separated by crop pasture areas (suitable machinery width).  
- Windbreaks/shelterbelts of Farm Forestry species (Eucalypt sawlogs) in four row belts - plant an extra row of hardy shrubs to maintain windbreak value.  
- Fence off remnant vegetation and allow to regenerate.
### Land Management Unit

**Sandy Duplex:**

(55,760 ha)

Sand or sandy loam over clay at 10 – 80cm, seasonally perched water table common. Occurs mainly on mid to upper slopes and on larger lunettes and dunes.

- Generally a moderate groundwater recharge risk; this may increase to a high risk in winter months, associated with perched water tables.
- Usually non-saline but may develop hillside seeps or saline drainage lines.
- High risk of wind erosion on exposed crests and upper slopes, otherwise the risk is moderate.
- Highly susceptible to subsoil acidification.
- Water erosion is a high risk on exposed upper slopes.
- Traffic and plough pans can be a risk.
- Moderate risk of water repellence.
- Soil water storage in sandy topsoils may be low.
- Low to moderate risk of soil structure decline (surface crusting and hardsetting soils).

### Economic Analysis

- Average implementation of 3 km/100ha of oil mallees on banks.
- 1873km of oil mallees on banks at a cost of $500/km for the grade banks and $500/km for two row belts of oil mallees below the banks.
- Assume the generation of an extra $5/ha/year of production benefits from the remaining land and $50/Ha/year from the oil mallees.
- **Total cost** $1,673,000.
- **Benefit Cost Ratio** 1.02.
- Liming cost $35 - $60 per ha every 10 years.

### Soil Management

- Minimum tillage and no-till operations are recommended to reduce erosion and compaction problems and improve soil structure and maintain soil organic matter.
- Any working up should be carried out on the contour. This is generally economically beneficial and should be standard best practice to improve water conservation for crops and to minimize erosion.
- Liming may be necessary to achieve crop and pasture production potentials and assist in the establishment of lucerne; regular monitoring of soil pH levels is advised.
- Practice stubble retention or aim to maintain >50% ground cover to control risk of wind and water erosion.

### Cropping and Pasture Options

- Phase farming between alleys of oil mallees or other trees is highly desirable.
- Cereals, narrowed leafed lupins (except for alkaline and shallow duplex areas) and canola rotations are recommended and can be included in rotation with lucerne (pH>4.8) and serradella.
- Pulse crops such as field peas, chickpeas or faba beans can be included to extend the rotation and provide economic and rotational management benefits.

### Recharge Reduction and Surface Water Management

- Grade banks are effective in controlling water erosion and waterlogging where interception of clay is possible.

### Revegetation and Tree Planting Options

- Belts of oil mallees (4 or 8 rows) below banks, separated by crop pasture areas (suitable machinery width).
- Deeper sand (50cm +) may be suitable for Maritime Pines or Tagasaste plots (need to be cut for sheep feed or managed for cattle feed).
- Fence off remnant vegetation and revegetate with species native to the catchment (seedlings).
- Shelterbelts of species like Sugar gum may be suitable for medium to shallow duplex soils (<50cm) where there is no waterlogging.
<table>
<thead>
<tr>
<th>Land Management Unit</th>
<th>Water and Soil Problems</th>
<th>Management Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel Ridges and Slopes: (41,726 ha)</td>
<td>• High groundwater recharge if cleared.</td>
<td>Soil Management</td>
</tr>
<tr>
<td></td>
<td>• Sandy topsoils are moderately susceptible to sub-surface acidification.</td>
<td>• Liming may be necessary; regular monitoring of soil pH levels is advised.</td>
</tr>
<tr>
<td></td>
<td>• Mild wind and water erosion on exposed sites where ground cover is &lt;50%.</td>
<td>• Maintenance of active growing plants is important here to reduce recharge which</td>
</tr>
<tr>
<td></td>
<td>• Low soil water storage.</td>
<td>contributes to problems lower in the landscape.</td>
</tr>
<tr>
<td></td>
<td>• Susceptible to water repellence.</td>
<td>• Cultivation should be carried out on the contour to reduce erosion risks and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>improve water conservation for crops.</td>
</tr>
<tr>
<td></td>
<td>Economic Analysis</td>
<td>• Minimum tillage and no-till operations are recommended to reduce erosion and</td>
</tr>
<tr>
<td></td>
<td>• Average implementation of 4 Ha/100Ha of alley’s of natives.</td>
<td>compaction problems and improve soil structure and maintain soil organic matter.</td>
</tr>
<tr>
<td></td>
<td>• 1669 Ha of direct seeded native alley’s at a cost of $300/Ha.</td>
<td>• Practice stubble retention or aim to maintain &gt;50% ground cover to control risk</td>
</tr>
<tr>
<td></td>
<td>• Assume the generation of an extra $5/ha/year of production benefits from the</td>
<td>of wind and water erosion.</td>
</tr>
<tr>
<td></td>
<td>remaining land.</td>
<td>Cropping and Pasture Options</td>
</tr>
<tr>
<td></td>
<td>• Total cost $500,700.</td>
<td>• Phase farming between alleys of oil mallees or other trees is highly desirable.</td>
</tr>
<tr>
<td></td>
<td>• Benefit Cost Ratio 1.41.</td>
<td>• Cereals, narrow-leafed lupins and canola can be included in rotations with</td>
</tr>
<tr>
<td></td>
<td>• Liming cost $35 - $60 per ha every 10 years.</td>
<td>lucerne (pH &gt; 4.8) and serredella.</td>
</tr>
<tr>
<td></td>
<td>Recharge Reduction and Surface Water Management</td>
<td>• Alley farming with mixed fodder shrubs (such as tagasaste) can improve productivity</td>
</tr>
<tr>
<td></td>
<td>• Soil profile and depth to clay need to be checked prior to commencing earthworks.</td>
<td>and minimise recharge, especially where gravelly topsoils are sandy.</td>
</tr>
<tr>
<td></td>
<td>• Absorption banks can be constructed only when essential to prevent water erosion.</td>
<td>Revegetation and Tree Planting Options</td>
</tr>
<tr>
<td></td>
<td>• Level banks can increase recharge. Sheep and vehicular tracks may require grade</td>
<td>• Direct seed native species - scalp areas with grader, scraper or chatfield.</td>
</tr>
<tr>
<td></td>
<td>banks across them to prevent water erosion.</td>
<td>• Farm Forestry species (Eucalypt sawlogs) in four row belts (max. 30m wide) -</td>
</tr>
<tr>
<td></td>
<td>• Maintenance of active growing plants (see Soil Management above).</td>
<td>plant an extra row of hardy shrubs to maintain windbreak value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Oil Mallee Alleys - unfenced 4 or 8 row belts.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Fence off remnant vegetation and allow to regenerate.</td>
</tr>
</tbody>
</table>

See: Duplex sandy gravel, Deep sandy gravel, Loamy gravel and Shallow gravel Soil Information Sheets in Appendix 3.
<table>
<thead>
<tr>
<th>Land Management Unit</th>
<th>Water and Soil Problems</th>
<th>Management Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grey/Greyish Brown Loams and Clays:</td>
<td>- Moderate groundwater recharge, highest where water ponds.</td>
<td>Soil Management</td>
</tr>
<tr>
<td>(32,835 ha)</td>
<td>- Salinity may develop on valley floors and drainage lines with shallow water tables,</td>
<td>- Minimum tillage and no-till operations are recommended to reduce erosion and</td>
</tr>
<tr>
<td></td>
<td>or on ponded areas, or as hillside seeps.</td>
<td>compaction problems and improve soil structure and maintain soil organic matter.</td>
</tr>
<tr>
<td></td>
<td>- Moderate to high risk of waterlogging and inundation, highest on flats and low-lying</td>
<td>- Adding gypsum may help improve soil structure and increase productivity. Investigate</td>
</tr>
<tr>
<td></td>
<td>areas.</td>
<td>with a gypsum test and test strips first.</td>
</tr>
<tr>
<td></td>
<td>- Moderately susceptible to topsoil structure decline.</td>
<td>- Avoid working the soil when excessively wet.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Activities which result in rapid loss of organic matter, such as long</td>
</tr>
<tr>
<td></td>
<td></td>
<td>fallowing in a crop rotation and stubble burning, should also be avoided.</td>
</tr>
<tr>
<td>Grey/Greyish Brown Loams and Clays:</td>
<td>See: Grey shallow loamy duplex and Alkaline grey shallow loamy duplex Soil Information</td>
<td>- Green manuring of a high legume percentage pasture or a legume crop such as</td>
</tr>
<tr>
<td>(32,835 ha)</td>
<td>Sheets in Appendix 3.</td>
<td>lentils or peas may improve organic matter content and soil structure and aid in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>improving yields.</td>
</tr>
<tr>
<td>Economic Analysis</td>
<td>- Average implementation of 3 km/100ha of oil mallees on banks.</td>
<td>Cropping and Pasture Options</td>
</tr>
<tr>
<td></td>
<td>- 985 km of oil mallees on banks at a cost of $500/km for the grade banks and</td>
<td>- Lucerne (where incidence of waterlogging is low and pH &gt; 4.8) or phalaris</td>
</tr>
<tr>
<td></td>
<td>$500/km for two row belts of oil mallees below the banks.</td>
<td>mixed with annual medics; Persian clover (pH &gt;5.5) or balansa clover are suitable</td>
</tr>
<tr>
<td></td>
<td>- Assume the generation of an extra $5/ha/year of production benefits from the</td>
<td>annual pastures that can be rotated with cereals.</td>
</tr>
<tr>
<td></td>
<td>remaining land and $50/Ha/year from the oil mallees.</td>
<td>- Phase farming between alleys of oil mallees or native species is highly</td>
</tr>
<tr>
<td></td>
<td>- Total cost $985,000.</td>
<td>desired.</td>
</tr>
<tr>
<td></td>
<td>- Benefit Cost Ratio 1.02.</td>
<td>- Pulse crops such as field peas, chickpeas or faba beans can be included to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>extend the rotation.</td>
</tr>
<tr>
<td>Recharge Reduction and Surface Water</td>
<td></td>
<td>Recharge Reduction and Surface Water Management</td>
</tr>
<tr>
<td>Management</td>
<td></td>
<td>- Appropriate shallow surface drains (W drains) can effectively reduce ponding and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the associated risks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Hard setting grey clays on slopes can be a good reliable run-off source for dams.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Revegetation and Tree Planting Options</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Belts of oil mallees (4 or 8 rows) below banks, separated by crop pasture areas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(suitable machinery width).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Fence off remnant vegetation/swamps and allow to regenerate, plant a buffer of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>suitable native/farm forestry species.</td>
</tr>
</tbody>
</table>
Land Management Unit Water and Soil Problems Management Options

Red Soils: (26,260 ha)

- Low to moderate groundwater recharge.
- Hillside seeps may occur on or near these soils as they are formed on dolerite dykes.
- Low risk of waterlogging. Lighter soils upslope from this LMU may experience waterlogging if the heavier red soil acts as a barrier to water movement.
- Moderately susceptible to water erosion and decline of topsoil structure.
- Surface and subsurface soils may be alkaline and unsuitable for some crops and pastures, and may exhibit nutrient toxicity and deficiencies.

Economic Analysis

- Average implementation of 3 km/100ha of grade banks.
- 788 km of grade banks at a cost of $500/km.
- Assume the generation of an extra $4/ha/year of production benefits from the remaining land.
- Total cost $394,000.
- Benefit Cost Ratio 1.51.

Soil Management

- Cropping operations should occur on the contour.
- Minimum tillage and no-till operations are recommended to reduce erosion and compaction problems and improve soil structure and maintain soil organic matter.
- Reduce traffic in paddocks and avoid traffic movement when soil is wet to minimise topsoil compaction.

Cropping and Pasture Options

- Phase cropping incorporating lucerne (pH 4.8) can be considered as a method to reduce groundwater recharge.
- Cereals in rotation with canola, peas, faba beans, vetches or good quality pastures are most profitable. In order to maximise production it is necessary to match soil pH with the pasture and crop requirements to minimise nutrient toxicity or deficiencies.

Recharge Reduction and Surface Water Management

- Grade banks and seepage interceptors will alleviate water erosion and waterlogging. Care should be taken when constructing earthworks on this LMU as banks striking rock may lead to increased recharge.

Revegetation and Tree Planting Options

- Belts of revegetation 20 to 30m wide placed below grade banks or interceptors. Can be:
  1. Farm Forestry species (Eucalypt sawlogs) in four row belts - plant an extra row of hardy shrubs to maintain windbreak value.
  3. Oil mallee alleys - 4 or 8 row belts (unfenced).
- Fence large areas of remnant vegetation and allow to regenerate.
- Rip into clay layer to assist root penetration of seedlings.

See: Alkaline red shallow loamy duplex and Calcareous loamy earth (red) Soil Information Sheets in Appendix 3.
<table>
<thead>
<tr>
<th>Land Management Unit</th>
<th>Water and Soil Problems</th>
<th>Management Options</th>
</tr>
</thead>
</table>
| **Salt Affected Land:** *(25,590 ha)* | • Mainly groundwater discharge but recharge may occur during winter.  
• Presently saline.  
• Very high risk of waterlogging and inundation.  
• Highly susceptible to serious water erosion problems (gully and rill), particularly along saline drainage lines. | **Soil Management**  
• Where possible, fence affected area to protect from compaction and erosion by stock and traffic.  
• Maintain ground cover to reduce risk of water erosion.  
• Salt tolerant pastures such as saltbush, puccinellia, saltwater couch or tall wheat grass and annuals such as balansa clover for mildly saline areas, are recommended to stabilise saline areas. |
| | Economic Analysis | **Recharge Reduction and Surface Water Management**  
• Appropriate shallow surface drainage is recommended (e.g. W-drains, grade banks). Notification of intent to drain may be required. Grader built intercepting banks to clay installed above the salt affected area may aid in alleviating perched water aggravating the saline areas.  
• Increase water use off-site as well as on-site. |
| | • Direct seed with a saltland pasture mix at a cost of $100/Ha.  
• In order for this strategy to break-even (BCR=1) over 20 years it requires a $9.50/ha/year increase in production.  
• **Total cost $2,559,000.**  
• Drains can be established for between $2000- $4000/km. Site-specific investigations are required.  
• Pumps, relief wells or siphons may be suitable for some areas. Site specific investigations are required. Costs can range from $4000-$40,000.  
Efficiency of engineering methods relates to how much water is moved by these methods i.e. the more water the better. Water moved can then be related to the investment e.g. $/litre removed. | **Groundwater Management**  
• Drains to relieve groundwater and groundwater pumping are expensive options. Good design is essential and should be site specific.  
• Drainage effluent should be disposed of without on or off site degradation.  
• A Notice of Intent to Drain will be required. |
| | Soil management and Tree Planting Options | **Revegetation and Tree Planting Options**  
• All revegetation areas should be mounded at 0.5 to 1 % slope to reduce waterlogging - mounds with a distinct 'V' work best.  
• Belts or rows of trees should complement surface water control and be planned once surface drains have been marked.  
• Mild saline areas - 4 row belts of tolerant oil malleses, with tolerant pasture species (balansa etc.) sown between - maintain for grazing.  
• Single rows of saltbush species (direct seeded or seedlings), separated by alleys of saltland pastures - managed for fodder.  
• Fence off creeks, waterways and adjacent bare/eroded areas. Allow regeneration of rushes, samphires, paperbarks and/or revegetate with tolerant native species/saltbushes - not grazed. |

See Saline Wet soil information sheet in Appendix 3.
<table>
<thead>
<tr>
<th>Land Management Unit</th>
<th>Water and Soil Problems</th>
<th>Management Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pale Deep Sands: (9,918 ha)</td>
<td><em>High groundwater recharge.</em>&lt;br&gt; <em>High risk of wind erosion on exposed crests and upper slopes, otherwise the risk is moderate.</em>&lt;br&gt; <em>These soils are very highly leached, do not retain nutrients, and are highly prone to sub-surface acidification.</em>&lt;br&gt; <em>Moderately susceptible to water erosion.</em>&lt;br&gt; <em>Highly susceptible to water repellence.</em>&lt;br&gt; <em>Soil water storage is generally very low.</em></td>
<td><em>Soil Management</em>&lt;br&gt; <em>Practice stubble retention or maintain approximately 50% ground cover to control wind and water erosion, and maintain soil organic matter.</em>&lt;br&gt; <em>Liming is likely to be uneconomical due to the characteristically low productivity of this soil.</em>&lt;br&gt; <em>Claying water repellent soils may be an option to consider where the problem is widespread.</em></td>
</tr>
</tbody>
</table>

**Economic Analysis**

- Direct seed with a serradella/perennial veldt grass pasture mix at a cost of $100/Ha.<br> - In order for this strategy to break-even (BCR=1) over 20 years it requires a $9.50/ha/year increase in production.<br> - **Total cost $991,800.**<br> - Liming cost $35 - $60 per ha every 10 years.

**Cropping and Pasture Options**

- Long season annual legume pastures suited include Cadiz French serradella, Santorini and Charano yellow serradella and Casbah biserrula in between alleys of trees.<br> - Perennial pastures of lucerne (pH > 4.8) or of Rhodes grass mixed with serradella in between alleys of trees.<br> - Phase farming with narrow-leaved lupins and cereals can be carried out in between alleys of fodder shrubs such as tagasaste and golden wreath wattle, or with native tree species. Yields are still likely to be relatively low due to infertility of the soil and low pH.

**Recharge Reduction and Surface Water Management**

- Grader built earthworks may alleviate soil erosion on slopes or inundation on flats, but have a high maintenance requirement. Unless the clay layer is reached, banks will be ineffective for waterlogging control.

**Revegetation and Tree Planting Options**

- Maritime Pine plantation over entire area.<br> - Plots of tagasaste planted in rows 3-6m apart - manage as fodder for cattle (will need to be cut for sheep) Tagasaste/Acacia saligna mix can be planted.<br> - Fence off low production areas and remnant vegetation, allow regeneration or plant suitable banksia, acacia species.<br> - Seedlings usually grow best on deep sands, plant as early as possible<br> - Ripping is recommended, mounding is not. Scalping a narrow area may remove non-wetting layer.

<table>
<thead>
<tr>
<th>Land Management Unit</th>
<th>Water and Soil Problems</th>
<th>Management Options</th>
</tr>
</thead>
</table>
| **Mallet Hills: (8,143 ha)** | - Generally low recharge because water runs off.  
- Highly susceptible to water erosion, particularly on breakaways with slopes > 10%.  
- Highly susceptible to water repellence and topsoil structure decline.  
- Subsoils are often acid and saline, and if exposed remain bare and unproductive. | **Soil Management**  
- Maintenance of ground cover is important to reduce water erosion risk.  
- The high salt content of the clay subsoil often attracts stock who use it as a salt lick. Leading to severe erosion. Such areas may need to be fenced off to avoid further erosion. **Recharge Reduction and Surface Water Management**  
- Grade banks below a water shedding area can alleviate erosion problems and may be a good water source for dams situated nearby.  
- Dams should not be constructed on this LMU due to the poor water holding capability of the subsoil. **Revegetation and Tree Planting Options**  
- Fence off and revegetate with species native to the catchment (see Appendix 6 for suitable species). |

Pink or reddish water repellent soils, maybe gravelly, often acidic. Isolated hillcrests and breakaways.

**Economic Analysis**

- Direct seed with a native species at a cost of $300/Ha.  
- In order for this strategy to break-even (BCR=1) over 20 years it requires the generation of $30/ha/year of non-market/market benefits.  
- **Total cost $2,442,900.**

See: Acid Shallow Duplex soil information sheet in Appendix 3.
<table>
<thead>
<tr>
<th>Land Management Unit</th>
<th>Water and Soil Problems</th>
<th>Management Options</th>
</tr>
</thead>
</table>
| **Yellow and Brown Deep Sand: (4,158 ha)** | • High groundwater recharge.  
• High risk of wind erosion on exposed crests and upper slopes, otherwise the risk is moderate.  
• These soils are very highly leached, do not retain nutrients, and are highly prone to sub-surface acidification.  
• Moderately susceptible to water erosion, traffic and plough pans.  
• Highly susceptible to water repellence.  
• Soil water storage is generally very low. | **Soil Management**  
• Practice stubble retention, brown manuring or maintain approximately 50% ground cover to control wind and water erosion and maintain soil organic matter.  
• Liming may be necessary to achieve crop and pasture production potentials and assist in the establishment of lucerne; regular monitoring of soil pH levels is advised.  
• Claying water repellent soils may be an option to consider where the problem is widespread.  

**Cropping and Pasture Options**  
• Long season annual legume pastures that are suitable include Cadiz French serradella, Santorini and Charano yellow serradella and Casbah biserrula. Perennial pastures of lucerne (pH > 4.8) or of Rhodes grass and veldt grass mixed with serradella in between alleys of trees is recommended.  
• Phase farming with the above mentioned pasture species or between alleys of fodder shrubs such as, tagasaste and golden wattle, or suitable native species with narrowed leafed lupins and cereals.  

**Recharge Reduction and Surface Water Management**  
• Generally not suitable for surface water control earthworks due to the structures.  
• Maximize water retention with good soil management practices such as working to the contour and maintaining a good pasture cover.  
• See also Pale Deep Sands LMU.  
• Ripping is recommended, mounding is not. Scalping a narrow area may remove non-wetting layer.  

**Revegetation and Tree Planting Options** |

<table>
<thead>
<tr>
<th>Land Management Unit</th>
<th>Water and Soil Problems</th>
<th>Management Options</th>
</tr>
</thead>
</table>
| **1.1.1.1 Salt Lakes:** (1,685 ha) | • High salinity and seasonal waterlogging and inundation render this soil unsuitable for the growth of most plants, except halophytes (e.g. saltbush and samphire) in fringing areas.  
• There may be degradation by sheet, rill and wind erosion and be devoid of vegetation in many areas. | **Soil Management**  
• Much of this area is non-agricultural land, but where possible, should be fenced off and managed separately, with emphasis on maintaining ground cover on surrounding associated areas to reduce risk of erosion.  
**Revegetation and Tree Planting Options**  
• Fence off and revegetate **fringing areas** with native salt tolerant species (see Appendix 6).  
• Mounding is recommended on this LMU. |

<table>
<thead>
<tr>
<th>Economic Analysis</th>
<th></th>
</tr>
</thead>
</table>
| • Fence off and revegetate with native salt tolerant species $300/ha.  
• Will require the generation of non market benefits for this strategy to break even. |  |
<table>
<thead>
<tr>
<th>Land Management Unit</th>
<th>Water and Soil Problems</th>
<th>Management Options</th>
</tr>
</thead>
</table>
| **Rock Outcrops: (772 ha)**<br>Includes outcrops of granite, dolerite and hard ironstone. Generally seen on ridges and upper slopes. | • Very high recharge through shallow gritty soil at the edge of outcrops.  
• Variable recharge can occur through fractures in the rock.  
• Hillside seeps can develop where outcrop forces saline groundwater to the surface.  
• Outcrops may shed water resulting in water erosion downslope. | **Recharge Reduction and Surface Water Management**<br>• Grade banks below a water shedding areas can alleviate erosion problems. Absorption banks can be used where no safe disposal point can be located, as a last resort due to the increased recharge risk.  
• Larger granite rocks can be a good run-off source for dams.  
**Revegetation and Tree Planting Options**<br>• Fence off and allow any existing vegetation to regenerate.  
• Sandalwood plantation - hosts required.  
• Revegetate with a mixture of native species around the rock areas - direct seed sandalwood after hosts are established.  
• Use direct seeding or seedlings as a method of establishing a buffer zone and extra habitat around these important nature conservation areas. |

**Economic Analysis**

- Direct seed with a native species at a cost of $300/Ha.  
- In order for this strategy to break-even (BCR=1) over 20 years it requires the generation of $30/ha/year of non-market/market benefits.  
- **Total cost $231,600.**  
- Sandalwood can be established on mixed stands of host species at a cost of $1000/ha.  
- Benefit cost ratio equal to 4.
### 4.2 ECONOMIC SUMMARY OF MANAGEMENT OPTIONS FOR THE KATANNING ZONE

The land management unit areas and the landcare strategies can be used to calculate the total implementation cost necessary to alleviate some of the land degradation issues facing the Katanning Zone. Table 4.1 indicates that the total cost of implementing the suggested landcare strategies is approximately $12.2 million at an average cost of $45/ha. This landcare implementation cost per hectare can be used as an indicative landcare implementation cost per hectare of arable land for the upper Blackwood and other catchments and shires within the ancient drainage zones.

An indication of the scale, likely impact and relative cost of each of the strategies can be gained by comparing the percentage of total area and the percentage of total cost that each land management unit represents. Table 4.1 indicates that Salt Affected Land and Mallet Hills represent 41% of the total cost of the landcare strategies but only represent 12% of the area within the Katanning Zone. Similarly Poorly Drained Sandy Duplex, Sandy Duplex, Gravel Ridges and Slopes, and Grey / Greyish Brown Loams and Clays represent 42% of the total cost of the landcare strategies but these Land Management Units represent 71% of the area. This information indicates that if landcare funds are targeted towards extensive ‘trees on banks’ or alley landcare strategies at a coverage of between 3 and 5% (3-5 ha/100 ha), the likely scale of impact (area of influence) is likely to be greater than if the same funds were directed towards revegetation of saltland and direct seeding of native species on Mallet Hills.

Table 4.1 outlines the assumptions used to calculate the benefit cost ratio for each of the landcare strategies. If the landcare strategies suggested generate the assumed benefits the overall strategy is likely to break even, meaning for every dollar invested a dollar of benefits is likely to be generated (BCR=1). If any of the suggested strategies fail to generate the assumed benefits, the overall strategy is likely to have a benefit-cost ratio of less than 1, indicating that the strategy will not break even.

Investment of $12.2 million into targeted landcare strategies is likely to generate public market and non-market benefits due to the preservation / enhancement of biodiversity and through savings of public expenditure on roads and public infrastructure. Public benefits associated with biodiversity can be maximised if biodiversity plantings are preferentially funded ahead of oil mallee establishment. This would also have the additional benefit of reducing the cost of the overall strategy from $12.2 million to about $11 million. Information relating to public/private benefits and market and non-market benefits is outlined in Appendix 4.

It should also be noted that the costed landcare strategies are likely to be sufficient to reduce the impacts of water erosion, wind erosion, soil structure decline, water logging and enhance biodiversity. However these are probably not extensive enough to reduce the extent and impacts of salinity and rising ground watertables. Greater adoption of perennials such as lucerne and direct intervention thorough the use of pumps, relief wells, siphons and drains are required to have an impact on salinity and shallow watertables. The costs of these additional strategies have not been included in the strategies. A detailed economic analysis of the suggested and other major landcare strategies is outlined in the Appendix 4.
Plate 13: A relief well and inter-row established lucerne. Far greater adoption of these strategies will be necessary to avoid the adverse impacts of salinity. Inter-row establishment of lucerne with a companion crop reduces the establishment costs.

Plate 14: Established saltland pasture (photo courtesy of Clive Malcolm).
### Table 4.1 Economic Summary of Selected Landcare options for the Katanning Zone

<table>
<thead>
<tr>
<th>Land Management Unit</th>
<th>Approximate Arable Area (ha)</th>
<th>Landcare option</th>
<th>Cost per unit</th>
<th>Total Cost of Landcare Strategy</th>
<th>Cost per ha</th>
<th>% of Area</th>
<th>% of Total Cost</th>
<th>Assumptions used in calculating the benefit cost ratio (over 20 year investment period)</th>
<th>Benefit Cost Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Poorly Drained Sandy Duplex</td>
<td>66,779</td>
<td>3km/100ha of oil mallee on banks</td>
<td>$1000/km</td>
<td>$2,003,370</td>
<td>$30</td>
<td>24%</td>
<td>16%</td>
<td>Assume the generation of an extra $5/ha/year of production benefits from the remaining land and $50/ha/year from the oil mallees.</td>
<td>1.02</td>
</tr>
<tr>
<td>2. Sandy Duplex</td>
<td>55,760</td>
<td>3km/100ha of oil mallee on banks</td>
<td>$1000/km</td>
<td>$1,672,800</td>
<td>$30</td>
<td>20%</td>
<td>14%</td>
<td>Assume the generation of an extra $5/ha/year of production benefits from the remaining land and $50/ha/year from the oil mallees.</td>
<td>1.02</td>
</tr>
<tr>
<td>3. Gravel ridges and slopes</td>
<td>41,726</td>
<td>4 ha/100ha of native alley's</td>
<td>$300/ha</td>
<td>$500,712</td>
<td>$12</td>
<td>15%</td>
<td>4%</td>
<td>Assume the generation of an extra $5/ha/year of production benefits from the remaining land.</td>
<td>1.41</td>
</tr>
<tr>
<td>4. Grey/Greyish Brown Loams and Clays</td>
<td>32,835</td>
<td>3km/100ha of oil mallee on banks</td>
<td>$1000/km</td>
<td>$985,050</td>
<td>$30</td>
<td>12%</td>
<td>8%</td>
<td>Assume the generation of an extra $5/ha/year of production benefits from the remaining land and $50/ha/year from the oil mallees.</td>
<td>1.02</td>
</tr>
<tr>
<td>5. Red Soils</td>
<td>26,260</td>
<td>3km/100ha of grade banks</td>
<td>$500/km</td>
<td>$393,900</td>
<td>$15</td>
<td>10%</td>
<td>3%</td>
<td>Assume the generation of an extra $4/ha/year of production benefits from the remaining land.</td>
<td>1.41</td>
</tr>
<tr>
<td>6. Salt Affected Land</td>
<td>25,590</td>
<td>Direct seeded saltland pasture</td>
<td>$100/ha</td>
<td>$2,559,000</td>
<td>$100</td>
<td>9%</td>
<td>21%</td>
<td>Assumes the generation of an extra $9.50/ha/year of production benefits</td>
<td>1</td>
</tr>
<tr>
<td>7. Pale Deep Sands</td>
<td>9918</td>
<td>Perennial pasture establishment</td>
<td>$100/ha</td>
<td>$991,800</td>
<td>$100</td>
<td>4%</td>
<td>8%</td>
<td>Assumes the generation of an extra $9.50/ha/year of production benefits</td>
<td>1</td>
</tr>
<tr>
<td>8. Mallet Hills</td>
<td>8143</td>
<td>Direct seed with native species</td>
<td>$300/ha</td>
<td>$2,442,900</td>
<td>$300</td>
<td>3%</td>
<td>20%</td>
<td>Assumes the generation of an extra $30/ha/year of non market benefits</td>
<td>1</td>
</tr>
<tr>
<td>9. Salt Lakes</td>
<td>1685</td>
<td>Fence off revegetate with salt tolerant species</td>
<td>$300/ha</td>
<td>$49,900</td>
<td>$0</td>
<td>1%</td>
<td>0%</td>
<td>Will require the generation of non-market benefits for this strategy to break even.</td>
<td>N/A</td>
</tr>
<tr>
<td>10. Rock Outcrops</td>
<td>772</td>
<td>Direct seed with native species</td>
<td>$300/ha</td>
<td>$231,600</td>
<td>$300</td>
<td>0%</td>
<td>2%</td>
<td>Assumes the generation of an extra $30/ha/year of non market benefits</td>
<td>1</td>
</tr>
<tr>
<td>11. Yellow and Brown Deep Sands</td>
<td>4158</td>
<td>Perennial pasture establishment</td>
<td>$100/ha</td>
<td>*$415,800</td>
<td>*$100</td>
<td>2%</td>
<td>3%</td>
<td>Assumes the generation of an extra $9.50/ha/year of production benefits</td>
<td>1</td>
</tr>
<tr>
<td>4158</td>
<td>4ha/100ha of native alleys</td>
<td>$300/ha</td>
<td>$49,900</td>
<td>$12</td>
<td>2%</td>
<td>0.5%</td>
<td>Assumes the generation of an extra $5/ha/year of production benefits from the remaining land</td>
<td>1.41</td>
<td></td>
</tr>
<tr>
<td><strong>273,626</strong></td>
<td><strong>$12,196,932</strong></td>
<td><strong>$45</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* used in total calculations
4.3 Farming systems

A report entitled ‘Low recharge Farming systems’ compiled by the Department of Agriculture outlines numerous case studies associated with the use of oil mallees, tagasaste, lucerne, saltbush and perennial pastures. Each study focuses on how the low recharge farming system fits into the other components of the farming enterprise. The adoption of low recharge farming systems is essential for the overall water management strategy of the Katanning Zone.

4.4 Surface water management

John Firth, Land and Conservation Officer, Katanning

Many land management options can be used to manage surface water before it contributes to erosion, eutrophication, sedimentation, waterlogging, flooding, groundwater recharge and salinity. The preferred approach is to reduce the speed and amount of surface water through land management and soil improvement, then manage the excess surface water (run-off) with earthworks. This section identifies and analyses surface water management options for the Katanning Zone.

4.4.1 Surface water earthwork options

Earthworks require careful planning because inappropriate and poor designs can cause more degradation than what the structure was intended to alleviate. Suitably qualified people need to be consulted for the legal aspects, design and construction of earthworks. The following points need to be addressed:

- **Land Assessment** should include information on soil condition, vegetation cover, catchment area, annual average rainfall and slope is used to calculate maximum flows, safe grades and safe velocity. For more information visit the Department of Agriculture website (http://www.agric.wa.gov.au/progserv/natural/assess/index.htm).

- The **Annual Recurrence Interval (ARI)** is the frequency (in years) an earthwork is designed to fill or safely fail. Important earthworks, such as dams, waterways and absorption banks are designed for at least a 20 year ARI. The minimum design of most surface drains and banks is a 10-year ARI (Bligh1989).

- **Legal Aspects** must be considered before earthworks are constructed. Diversion of flows, increasing flow velocities or increasing quantity of flow, could cause damage to neighbouring properties for which the drainage proponent may be responsible (Keen 1998). Catchment planning and discussing planned earthworks with potentially affected neighbours is essential.

After earthwork planning is completed, the type and design of earthwork to construct is selected. The design criterion for earthworks commonly used in Western Australia are listed in Table 4.2. For more information refer to Resource Management Technical Report 185, "Common Conservation Works used in Western Australia" or visit the Department of Agriculture web site (http://www.agric.wa.gov.au/land/draimwise/options/index.htm).
## Table 4.2: Design criterion for common surface water earthworks used in WA

<table>
<thead>
<tr>
<th>Earthwork design</th>
<th>Soil Type</th>
<th>Grade (%)</th>
<th>Landscape Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shallow relief drains</td>
<td>C / SD</td>
<td>Up to 0.2</td>
<td>VF</td>
</tr>
<tr>
<td>Levee and Levied waterways</td>
<td>C / S / DD SD</td>
<td>Up to 10</td>
<td>Variable</td>
</tr>
<tr>
<td>Diversion banks</td>
<td>C / SD / L / DD</td>
<td>Up to 10</td>
<td>LS</td>
</tr>
<tr>
<td>Seepage Interceptor Drains</td>
<td>SD</td>
<td>Up to 5</td>
<td>LS / MS</td>
</tr>
<tr>
<td>Reverse Bank Seepage Interceptor Drains</td>
<td>SD</td>
<td>5 - 8</td>
<td>LS / MS</td>
</tr>
<tr>
<td>Broad based bank</td>
<td>SD / L</td>
<td>2 - 6</td>
<td>US / MS</td>
</tr>
<tr>
<td>Grade banks</td>
<td>SD / L</td>
<td>Up to 10</td>
<td>US / MS</td>
</tr>
<tr>
<td>Absorption or level banks</td>
<td>SD / L</td>
<td>Up to 10</td>
<td>US / MS</td>
</tr>
<tr>
<td>Dams</td>
<td>C / SD / DD / L</td>
<td>Up to 10</td>
<td>Not watercourses</td>
</tr>
<tr>
<td>Roaded catchments</td>
<td>C / SD</td>
<td>Up to 6</td>
<td>Any</td>
</tr>
<tr>
<td>Raised bed</td>
<td>C / SD</td>
<td>0.1 - 2</td>
<td>VF</td>
</tr>
<tr>
<td>Deep drains</td>
<td>SD / DD / S / L</td>
<td>Up to 1</td>
<td>VF</td>
</tr>
<tr>
<td>Evaporation basin/pond</td>
<td>C / SD</td>
<td>Up to 0.2</td>
<td>VF / LS</td>
</tr>
<tr>
<td>Groundwater pumping</td>
<td>Transmissive profiles</td>
<td>Any</td>
<td>VF / LS</td>
</tr>
<tr>
<td>Relief well / syphons</td>
<td>Transmissive profiles</td>
<td>Up to 5</td>
<td>MS / US</td>
</tr>
</tbody>
</table>

### KEY

**Soil Types**    **Landscape**

- **C** - clay  
  - **VF** - valley floor
- **S** - sand  
  - **LS** - lower slopes
- **L** - loam  
  - **MS** - mid slopes
- **G** - gravel  
  - **US** - upper slope
- **SD** - shallow duplex  
  - **R** - ridge
- **DD** - deep duplex  
  - **B** – breakaway

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4.4.2 Land Management Options

Conservation land management options reduce the speed or velocity of surface water by slowing the rate of water movement. There are three land management options, which may be used within most areas of Catchments:

Vegetative cover to protect the soil from raindrop impact and impede surface water flow;

Working land along the contour to contain surface water in the furrows;

Grass strips and permanently grassed waterways to slow surface water.

4.5 GROUND WATER MANAGEMENT

John Firth, Land Conservation Officer, Dept. Agriculture Western Australia, Katanning

There are only a few options for managing groundwater before it contributes to waterlogging and salinity. The effectiveness of these options is limited due to the local and intermediate groundwater flow systems that typically have low permeabilities and gradients and therefore have a low ability to move groundwater.

Refer to the Department of Agriculture Drainwise Website for further information. (http://www.agric.wa.gov.wa/environment/land/drainwise/index.htm)

4.5.1 Groundwater Management Options

The Commissioner of Soil Conservation must be notified of any intention to construct deep drains at least 90 days before undertaking the earthworks.

4.5.1.1 Open Deep Drains

Open deep drains are used to lower watertables, preventing the accumulation of salts while allowing rainfall to leach salt from the upper profile.
Open deep drains may be leveed, unleveed or closed (i.e. buried). Leveed drains have the spoil placed along both sides of the drain to prevent surface water entering the drain and so remove only sub-surface water. Unleveed deep drains have the spoil placed on one side or alternating from side to side and remove both surface and subsurface water. Careful planning and application of engineering principles is essential so that drain specifications will cope with large run-off events without damage to the spoil or channel.

Closed drains are constructed by laying pipe or recycled tyres in a trench and backfilling with aggregate and/or excavated soil. Closed drains only carry groundwater. Construction of deep drains is an expensive option, remove land from production and their effectiveness is variable according to soil type.

The cost of drainage earthworks varies greatly from site to site due to local conditions and can cost between $2,500 and $9,000 per kilometre.

Hence, careful planning and site assessment is required to ensure deep drains can be effective.

4.5.1.2 Groundwater pumping

Groundwater is pumped out of the ground via a series of bores. Pumping is used to lower groundwater tables and remove seepage at depths too great to be intercepted by constructed drains. Pumping is most often used to protect sites in recovery catchments (nature conservation), rural towns and other areas where high value assets are at imminent risk.

Groundwater pumping is used to extract subsurface water from profiles that are affecting the landscape surface. Pumps are usually positioned at the break of slope and/or on semi-productive flats. Pumping is most effective in deep sands and gravels.

In this way, pumping systems can lower watertables and soil salinity levels within the root-zone of plants and improve production from the previously salt-affected areas. Groundwater pumping is most effective in permeable aquifer systems and where the pumped groundwater is used for some productive purpose such as water supply, aquaculture, or salt-harvesting.

4.5.1.3 Relief Wells (Artesian bores)

A relief well is a 'free flowing' groundwater bore driven by artesian pressure. That is, a bore that allows groundwater to continuously flow up to the surface by a steady release of confined pressure stored within the aquifer at depth. This 'confined' artesian pressure at depth is constantly being renewed by rainfall that infiltrates into the soil profile (at higher elevation) and recharges the deeper aquifers.

Relief wells are seen as one means of reducing the impact of salinisation and waterlogging around specific groundwater seepage areas and a way of developing water supplies for aquaculture and livestock.
Relief wells are most effective in reducing the impact of dryland salinity when placed on localized hillside seeps. Relief wells use artesian pressures within an aquifer at depth to force groundwater up.

4.5.2 Legislation - Notice of Intent to Drain Or Pump

Regulations established under the Soil and Land Conservation Act 1945 require that,

"When an owner or occupier of land proposes to drain or pump water from under the land surface because of salinity of the land or water and to discharge that water onto other land, into other water or into a watercourse, the owner or occupier shall, at least 90 days before the draining or pumping commences, notify the Commissioner in writing in the manner set forth in Form 2 Schedule 2"

Notification allows the Commissioner 90 days to consider whether or not the proposed drainage will cause on or off site land degradation.

A penalty will apply to the owner or occupier who fails to notify the commissioner.

Management of surface and sub-surface water through constructed drainage is recognized, as one of the legitimate tools available to fighting salinity, waterlogging and inundation, although increased use of water through vegetation or farming systems remains the preferred option.

Drainage proposals are best developed and implemented on a sub-catchment or catchment basis, with the involvement and agreement of all landholders, including local government, and other infrastructure managers, and reserve managers.

Landholders need to understand that they have a duty of care to ensure their management actions do not lead to land degradation or other damage, such as through severe erosion, flooding or environmental damage to wetlands and waterways.

Drainage proposals should demonstrate that they are part of an overall strategy to deal with the fundamental causes of the water management problems; and that it will be "environmentally friendly".

They will not contribute to land degradation such as downstream salinisation, erosion, flooding, environmental damage to wetlands and waterways or sedimentation in the long-term.

Need the approval of two downstream land owners.
4.6 USES FOR SALINE GROUNDWATER
Louise Hopgood, Hydrogeologists, Dept. Agriculture Western Australia, Katanning

Saline groundwater may be considered as a potential resource. It’s use in aquaculture for the production of commercial species such as trout, bream, brine shrimp and various species of algae is well documented. For more information refer to the Department of Agriculture’s site.

A number of alternative uses for saline water are currently employed or are under trial in other parts of Australia. They include desalination of water for drinking and industrial use, extraction of minerals from saline water for use by industry, animal nutrition and as dust suppressants and the production of energy using salt gradient solar ponds. These methods have an advantage in that they add value to saline water, however their applicability to the Katanning Zone is currently unclear. Refer to the Department of Agriculture’s site for more information.

Plate 15: Saline groundwater used in aquaculture ponds (photo courtesy of Alan Seymour).
4.7 WAYS FORWARD

The RCA process is a snapshot and baseline reference of the current situation and has been produced at a scale not suitable for detailed interpretation at paddock scale. Although awareness exists that salinity is a problem in the Katanning Zone, the real benefit of the RCA process is to show the extent of natural resource management problems (using the best available information) in the Zone. Secondly, it serves as a reference guide to establish the extent of change in this situation in the future and provides the current best management practices to address this problem. Another benefit is the current and predicted effects of the off-site impact of salinity, which is especially of use for Shires, landcare district committees, catchment groups, the Blackwood Basin Group and for strategic planning.

The outcome of the RCA process, is to establish the current situation and trends for the whole of the Blackwood Catchment (split into 9 Zones) before the end of 2005 and thereafter to revisit every Zone on a smaller, more detailed scale (most probably on a Shire basis). Gaps identified by the first assessment will then be addressed in the more detailed second process and an assessment of changes done against the first set of data in the same time.

Plate 16: School kids planting trees in the Katanning Catchment.
5. FUTHER INFORMATION AND CONTACTS  
_Sylvia Tetlow, Community Support Development Officer, Katanning_

There are many issues related to the land degradation caused by salinity and ways to try and manage it. Appendix 7 lists contact details to a number of these related issues as well as contacts relevant to the material presented in this document.

Appendix 7 List of Contacts and Further Information has been grouped into five categories for easy reference:

- Farming Systems Contacts
- Natural Resource Management
- Funding Opportunities
- Useful Community Contacts
- Useful Agricultural Internet Sites

Much of the information presented in Appendix 7 is possible first points of contact to further the details already presented within this report. One other useful source of current and relevant information, is the Department of Agriculture’s website, which can be found at: [www.agric.wa.gov.au/agency/Pubns](http://www.agric.wa.gov.au/agency/Pubns)

In particular, the site at [www.agric.wa.gov.au/environment/](http://www.agric.wa.gov.au/environment/) contains details regarding environmental management in Western Australia, but more importantly, the link to the Rapid Catchment Appraisal (RCA) page and its associated information.

Plate 17: Angela Stuart-Street, getting down and dirty at a catchment information day.
6. REFERENCES


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7. GLOSSARY

**ABSORPTION BANKS**: a level bank placed around a rock outcrop or mallet hill to slow water shedding from the area and preventing water erosion downslope.

**ALLEY FARMING**: the term used to describe farming systems where crops and pastures are grown between alleys of tree and shrub species. The layout of the alleys can take various forms from straight north-south plantings with narrow areas between trees to widely spaced alleys following the contour of the land (e.g. along a grade bank system).

**ALLUVIUM**: weathered material transported by water.

**AQUIFER**: a material that absorbs and transmits water in sufficient quantities to be of use.

**AVERAGE RECURRENCE INTERVAL (ARI)**: the average or expected probability of an occurrence (in years) of a given rainfall event that will cause the earthworks to fail.

**ARTESIAN**: an aquifer where the water is under sufficient pressure to flow freely from a bore without pumping; the hydraulic head is above the ground level.

**BEDROCK**: consolidated rock at the bottom of a profile, underlying soil and regolith material. Bedrock may be exposed at the surface as outcrops. Also referred to as 'basement rock'.

**COLLUVIUM**: weathered material transported by gravity.

**DISCHARGE**: groundwater flow from an aquifer. Evaporation from a shallow watertable by capillary rise is often referred to as passive or diffuse discharge.

**DOLERITE**: a medium-grained mafic igneous rock which occurs mainly as dykes, sills or small plugs

**DYKE**: an intrusive body of igneous rock which cuts across the bedding or structure of the host rock.

**FAULT**: a fracture in the earth where movement has taken place.

**GNEISSIC**: a metamorphosed rock that, like granite, contains quartz, feldspars and mica, but in which the minerals are aligned in bands. Banding is due to recrystalisation during cooling.

**GRADE BANKS**: a flat-bottomed bank with a grade of 0.5% (10cm in 20m).
**GRANITOID**: an igneous rock that falls within the granite range.

**GRASSED WATERWAY**: a depression/creekline that has been left grassed and not cropped over to allow for safe disposal of surface water from banks.

**HYDRAULIC CONDUCTIVITY**: a measure of the ability of a fluid to move through sediment or rock.

**IN-SITU**: description of a material that occurs in the position it was originally formed or deposited in.

**INTERCEPTOR DRAINS**: constructed with a cut into the clay subsoil to collect subsoil seepage from perched watertables. There are 2 types; conventional interceptors have the spoil downslope whereas reverse interceptors have the spoil upslope.

**LAND MANAGEMENT UNITS** (LMU): parcels of land, with common soils and landforms, which should be managed similarly in order to maximize their production and minimize land degradation.

**METAMORPHISM**: The partial or complete recrystallisation of rocks in the solid state due to applied heat and pressure.

**PHASE FARMING**: this is where a long-term pasture (3–7 years) is followed by a cropping rotation of a similar. The pasture can be either a perennial such as lucerne or a long season annual pasture such as Cadiz French serradella. E.g. 4 years lucerne, wheat, canola, wheat, barley.

**RECHARGE**: addition of water to the groundwater system.

**REGOLITH**: weathered or sedimentary material that overlies bedrock.

**TRANSMISSIVITY**: The rate at which water is transmitted through a metre width of an aquifer under a metre hydraulic gradient

**WEATHERING**: the mechanical or chemical breakdown of rock