DALYUP AND WEST DALYUP RIVERS

ACTION PLAN

Water and Rivers Commission

Dalyup and West Dalyup Rivers Action Plan

Water and Rivers Commission

Natural Heritage Trust

Water and Rivers Commission
Water Resource Management Series
Report No WRM 34
December 2002

Acknowledgments

Catherine Field and Kaylene Parker prepared this CD and report for the Dalyup River Catchment Group and the Water and Rivers Commission. The Water and Rivers Commission and the Natural Heritage Trust provided the funding.

The work of the land managers who assisted with the on-ground survey is greatly appreciated. Also the land managers who volunteered their properties as 'case studies' to capture their rivercare experiences, including Ray and Shirley Sullivan, Des and Jo Neale, Rob and Robyn West, Tom and Jenny Murray and Peter and Sue Smithson.

Lawrie Shaw, Faye Lewis, Graeme Read and John Luberda who were funded by the Water and Rivers Commission to be involved in demonstration projects in the catchment. Their time and on-ground assistance is greatly appreciated. The work done by school children, teachers, Jamie Bowyer (AgWest), Jack Mercer (Bushcare) and the Lewis's who coordinated and planted the seedlings on the demonstration sites is also appreciated.

Thanks to the Department of Agriculture Catchment Support Team's contributions to this project, particularly Jamie Bowyer, Brendan Nicholas, Carina Calzoni, John Simons, Steve Gee, Rod Short, with assistance from Tilo Massenbaur and Klaus Tiedeman, the Department of Conservation and Land Management. The Dalyup Catchment Group subcommittee members provided overall guidance and support throughout the project, particularly Sue Smithson, Des Neale, Brad Lewis, Faye Lewis, Nigel Brodie and Tom Murray. Alan Longbottom's expertise on local fauna in the district and Coral Turley, (Esperance Wildflower Society) and Lisa Grant's (volunteer) assistance in the flora surveys was also appreciated.

Marg Wilke edited and prepared the final version, Geotask provided the maps.

Reference details

The recommended reference for this publication is: Water and Rivers Commission 2002, *Dalyup and West Dalyup Rivers Action Plan,* Water and Rivers Commission, Water Resource Managment Series, No WRM 34.

ISBN 1-920687-27-0

ISSN 1326-6934

Cover photograph: Dalyup River Kaylene Parker, Water and Rivers Commission and Lake Gore (Marek Komarzynski, Agwest, Esperance).

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Purpose of this Action Plan

The purpose of this Plan is to help guide the protection and management of the Dalyup and West Dalyup rivers. In particular, the Action Plan provides:

- a summary of information on the Dalyup River and Lake Gore;
- a record of river condition;
- a summary of completed on-ground works on waterways in the catchment;
- an indication of problem areas;
- management guidance and technical advice;
- a mechanism to increase community knowledge of waterways management issues;
- a mechanism for recording and prioritizing on-ground work; and
- a tool to apply for funding opportunities.

How to use this Action Plan

The Plan was prepared for the land managers in the Dalyup Catchment Group and the Water and Rivers Commission.

Section 1 describes the background to the project and the aims of the project.

Section 2 describes the natural resources of the catchment including flora and fauna in the catchment, geology, soils and climate information. .

Section 3 provides information on the Dalyup and West Dalyup rivers and Lake Gore. This includes information on the water quality of the river, macroinvertebrates, native fish populations and aquatic flora that rely on the river systems.

Section 4 reports on the condition of waterways in the catchment. This includes the condition of the riparian vegetation, water quality, and other major threatening processes.

Section 5 includes general management recommendations and future actions to protect waterways in the catchment. This includes suggested actions for revegetation, crossing design and weed control.

Section 6 contains examples of river restoration activities undertaken by farmers in the catchment.

Section 7 includes results of the foreshore survey of the Dalyup and West Dalyup rivers and the major tributary. It includes the individual maps and specific actions for sections of the Dalyup and West Dalyup rivers. Look up your location number, and turn directly to the map of your property. This will tell you the condition of your river and suggests actions to protect your section of the river.

This report is designed so that the maps can be updated and information easily added to and updated! The actions in this report are suggestions only.

Executive summary

The Dalyup River is located approximately 35 km west of the town of Esperance on the south coast of Western Australia. Protection of the Dalyup and West Dalyup rivers is a priority of the Dalyup Catchment Group. The importance for protecting the Dalyup and West Dalyup rivers is highlighted by the recent listing of Lake Gore as a RAMSAR 'Wetland of International Importance'.

The Dalyup River has important social, cultural, historical, economic and ecological values. Ecologically it is a habitat to many flora and fauna species that rely on the riverine environment. In many cases it is the only remaining significant vegetative corridor in the catchment. Lake Gore is a significant water bird habitat, with an estimated 20 000 birds visiting the lake each year.

Loss of riparian vegetation, erosion and sedimentation, salinity and weed invasion are the major threatening processes to the health of the river system. These issues were demonstrated during the flood events of 1999 and 2000, which resulted in considerable damage to the river and surrounding agricultural land. In addition, rising groundwater levels, increasing salinity and nutrient levels draining from the catchment, are likely to impact on the long-term health of Lake Gore. Many sections of the river have been degraded through historical land use practices.

Land managers have undertaken considerable on-ground works to protect and restore the waterways in the catchment. Almost every land manager surveyed had conducted some river restoration works on their property and most planned to conduct further works in the future.

- 450 km of fencing along the river, tributaries and around remnant vegetation in the catchment, with land managers proposing a further 66 km of fencing;
- 267 ha revegetated with land managers proposing a further 246 ha of revegetation;
- 69% of the left bank and 92% of the right bank of the Dalyup River fenced;
- 88% of the left bank and 78% of the right bank of the West Dalyup is fenced; and
- 71% of the left bank and 92% of the right bank of the Dalyup River's major tributary is fenced.

Specific maps of each section of the Dalyup and West Dalyup rivers are included in this report. These show the condition of the foreshore vegetation and the on-ground works completed. Land managers are encouraged to update these to record ongoing work to protect waterways in the catchment.

Future protection of the Dalyup and West Dalyup rivers will require a whole-of-catchment approach, where land managers recognise that they are in a catchment. Issues such as salinity need to be addressed on a catchment scale. This Plan should be read in context with the Dalyup Catchment 2000 report (AgWest, 2001).

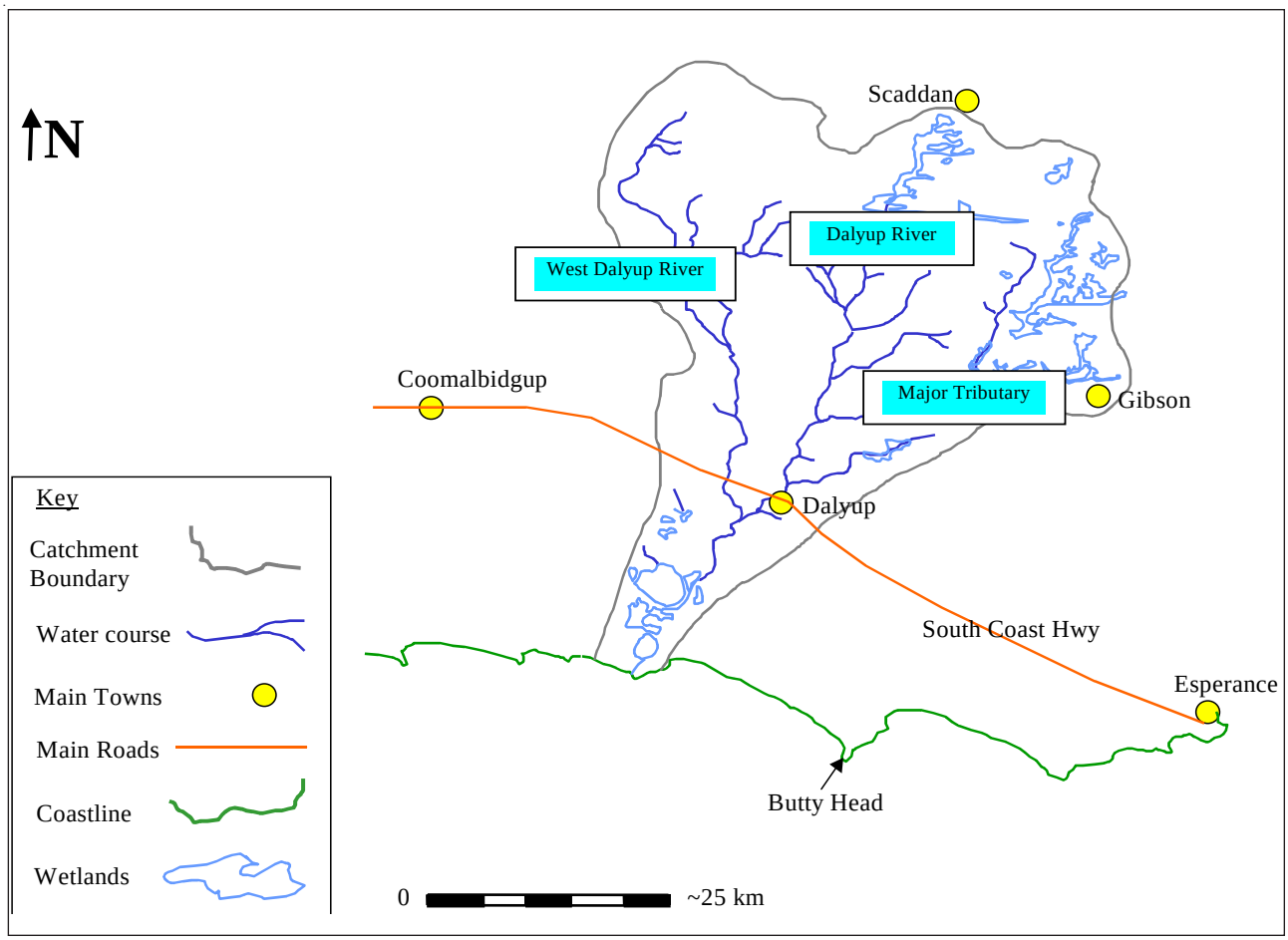


Figure 1. Location map for the Dalyup River catchment

1 Introduction

1.1 Background

Many Western Australian rivers are becoming degraded as a result of human activity within and along waterways and through the off-site effects of catchment and land uses. The erosion of foreshores and invasion of weeds and feral animals are some of the more pressing issues. Water quality in our rivers is declining with many carrying excessive nutrient and sediment loads, and in some cases, contaminated with synthetic chemicals and other pollutants (Water and Rivers Commission, 1999a).

A priority strategy of the South Coast Regional Land and Water Care Strategy (SCRIPT, 1997) is to "develop a strategic network of healthy, well-vegetated riparian corridors and improve and protect the water quality of rivers, estuaries and wetlands". In response, the Water and Rivers Commission initiated a project to help coordinate the protection of river systems in the South Coast Region, funded by the Natural Heritage Trust.

The Water and Rivers Commission identified the Dalyup River system as an important waterway because it drains to Lake Gore, a Ramsar-listed wetland. Lake Gore has significant value for migratory birds and the threatened Hooded Plover.

The Dalyup River Catchment group felt that little was known about the Dalyup and West Dalyup rivers and requested more information on water quality, historical and ecological information on the rivers. They also asked that the flood damage from the 1999 and 2000 flood event be mapped. Considerable amounts of on-ground works have been completed along the waterways including fencing, revegetation, construction of creek crossings, erosion control and sediment removal. However, there are still sections where on-ground works are required to ensure the long-term protection of the rivers.

1.2 Aims, goals and objectives

"To work together to protect and restore the Dalyup and West Dalyup rivers".

The aim of the Plan is to encourage a more coordinated approach to protect the Dalyup and West Dalyup rivers. The Plan maps the condition of the riparian vegetation, weed location, channel characteristics, and flood damage and on-ground works such as fencing and revegetation. It also specifies management recommendations for future on-ground restoration works.

Dalyup River, De sand Jo Neale's property (photograph Kaylene Parker)

The objectives of the Plan are to:

1. Collate information on the Dalyup and West Dalyup rivers and Lake Gore.
2. Assess the condition of the Dalyup and West Dalyup rivers.
3. Provide a benchmark against which future works to protect the rivers can be assessed.
4. Provide a tool to improve the guidance of the limited resources available for weed control, erosion control and revegetation.
5. Provide a sound technical basis for future funding and/or project submissions.

1.3 The study area

The Dalyup River Catchment is located on the south coast of Western Australia, approximately 35 km west of the town of Esperance (Fig. 1). The catchment is located within the Shire of Esperance and includes the townships of Gibson, Dalyup and Scaddan. It covers an area of 82 607 ha which stretches from Lake Gore to Griggs Road in the Mallee district.

The Dalyup and West Dalyup rivers and Lake Gore are the major waterways in the Catchment. The Dalyup River flows approximately 54 km from the township of Scaddan to Lake Gore and the West Dalyup River, a major tributary of the Dalyup River, flows 45 km before meeting the Dalyup River 8 km upstream of Lake Gore. The Water and Rivers Commission surveyed and assessed the condition of the riparian vegetation along the Dalyup River system, its tributary the West Dalyup River and a further tributary which drains from the Esperance Research station. …of the tributary of the Dalyup River. The method used to survey the waterways is outlined in Section 7.

1.4 Dalyup Catchment Group

The Dalyup River Catchment Group formed in 1999 when four subcatchment groups including Upper West Dalyup Inc., Upper East Dalyup, Lower East Dalyup and Lower Dalyup amalgamated. The Dalyup River Catchment was chosen as a focus catchment under the '*State Salinity Action Plan'* in 2000/2001. The Dalyup Catchment Group then had priority access to technical teams (Catchment Support Teams) for catchment and farm planning.

The *"Dalyup Catchment 2000"* (AgWest, 2001) report is the product of the focus catchment process. It provides a summary of the condition of the catchment, records the current level of knowledge of natural resources in the catchment and identifies management issues and options. The document is a tool for resource planning and provides a benchmark for future

Members of the Dalyup Catchment Group discussing water management options (Photograph Kaylene Parker).

catchment monitoring (AgWest, 2001). The catchment report includes results of a catchment survey, conducted on farms across the catchment, to record the extent of land degradation. The work included mapping areas of waterlogging, salinity, water and wind erosion and water repellency, as well as planned and existing on-ground works.

Members of the Lower Dalyup, Upper West Dalyup and West Scaddan Landcare Group (now in recess) have received grants from the Natural Heritage Trust, State Revegetation Scheme, the Gordon Reid Foundation for Conservation and the WA Landcare Trust.

1. *Recreating the Dalyup River, 2001 – 2002.* The Dalyup Catchment Group was recently successful in obtaining funds from the Natural Heritage Trust for $156 678. This is matched to the land managers contribution to fund on-ground rivercare activities including, fencing 60 km of waterways and planting of 131 000 seedlings. The project also will develop a 'water management plan' to address whole-of-catchment water management issues. A coordinator has been funded to help coordinate and manage the project.

2. *Greening the Upper Dalyup – Upper East Dalyup Catchment Group.* This project aimed to revegetate a small area of the major tributary of the Dalyup River. The main outcomes were direct seeding 10 ha in a site located on the Norseman Road. This project was funded by corporate sponsorship from the Team Poly via the WA Landcare Trust, and allocated $ 5010. This was matched in kind from the land managers and funds from the Water and Rivers Commission.

3. *The Revegetation of the Upper-West Dalyup catchment – Upper West Dalyup Catchment Group.* This project primarily aimed to protect the biodiversity of the local area by protecting and enhancing the vegetation along the catchment's creeklines. The main outcomes included fencing 70 km of creeklines and planting 94 400 trees. This project started in January 1998 and was funded for three years by National Heritage Trust.

4. *Dalyup River Revegetation and Protection Project – Lower Dalyup Catchment Group.* This project aimed to achieve sustainable agriculture within the Dalyup catchment. In achieving this aim the Group objectives are to "protect the remnant vegetation of the Dalyup River and its tributaries" and to "improve surface water management and quality". Outcomes of this project included: fencing 46 km of creeklines; planting 57,000 seedlings; establishing 2 ha of direct seeding to stabilise eroded riparian areas; and protecting 305 ha of remnant vegetation currently under covenant. This project was funded by NHT for three years for $51 863 and started in January 1998.

5. *Vegetation survey – West Scaddan Landcare Group.* This project was funded by the Gordon Reid Foundation.

2 Natural Resources of the Dalyup catchment

Detailed catchment information can be found in the report Dalyup Catchment 2000 (AgWest, 2001).

2.1 Climate and rainfall

The Dalyup River catchment has a Mediterranean-type climate, – cool winters with reliable rainfall and warm dry summers with occasional thunderstorms. This climatic pattern is influenced by the Indian Ocean where north-west cloud bands originate, accounting for 25 – 40% of the rainfall. Most of the rainfall occurs during winter and is associated with a series of low-pressure systems in the Southern Ocean. Periodic rainfall occurs in summer due to thunderstorms or rain-bearing depressions formed from tropical cyclones. The last two floods in January 1999 and March 2000 were the result of ex-tropical cyclones.

The Dalyup River catchment receives an average of 484 mm of rainfall a year with 76% of this falling between April and October. The southern end of the catchment has an average annual rainfall of 590 mm (80% in winter) while the north of the catchment 40 km away receives an average of 368 mm (70% in winter). The amount of rainfall received from year to year is also variable. For example, within two years there was a record wet (1992) and a record dry (1994) year.

The average monthly minimum and maximum temperatures recorded at the Esperance Bureau of Meteorology range from 16–26°C during summer and from 8–17°C during winter (Johnson and Baddock, 1998).

2.2 Physiography

The Dalyup River catchment is located on the south coast of Western Australia approximately 35 km west of Esperance. It encompasses the boundaries of the Dalyup and West Dalyup rivers and associated tributaries (Fig. 1). The catchment is bounded by the Coobidge Creek catchment to the west, Mortijinup Lake Catchment to the south-east and Coramup Creek Catchment to the northeast (Gee and Simons, 1997).

Lake Gore is located at the bottom of the Dalyup Catchment. Adjacent to Lake Gore is Carbul, Kubitch and Gidong lakes to the west, Quallilup Lake to the south and Mortijinup Lake 3.5 km to the east. The Southern Ocean is approximately 1 km south of Quallilup Lake. (Lane et al., 1996).

The surrounding Esperance landscape of the Esperance region is described as flat to gently undulating sandplain country that rises gradually from sea level over a series of hills to 260 m AHD (Johnson and Baddock, 1998). Four physiographic divisions identified within the Esperance region include the Coastal Plain, Lower Sandplain, Esperance Sandplain and Red Inland Sandplain (Johnston and Baddock, 1998). The Dalyup Catchment changes from Coastal Plain around Lake Gore to Esperance Sandplain in the majority of the catchment with some Red Inland Sandplain towards the top of the catchment. The divisions are commonly called the Esperance Sandplain denoted by the sandy soils and the Esperance Mallee denoted by the domination of a Mallee form of the Eucalyptus species.

2.3 Geology

Basement rocks from both the Proterozoic Albany-Fraser Orogen and Archaean Yilgarn Craton underlie the Dalyup Catchment area. The basement rocks mostly comprise granites and gneisses. The divide between the basement rocks of the Proterozoic Albany-Fraser Orogen and the Archaean Yilgarn Craton follows a line that runs approximately north-east of the Dalyup River (Short, 2000). Basement rocks are seen as coastal headlands, islands or hills.

The formation of the current-day geology of the Dalyup catchment started 64 to 135 million years ago, during the Cretaceous Period, when Antarctica began to break away from Australia. This caused the edge of the continent to sag and form the Bremer Basin. About 40 million years ago (during the Middle to Late Eocene Period) as the climate became drier, Tertiary sediments of the Plantagenet Group (Werillup Formation and the Pallinup Siltstone units) began filling the drainage

system and depressions in the basement (Hocking, 1990).

Thirty million years ago (during the Oligocene Period) the Darling Plateau was uplifted and resulted in the southern coastline tilting south to form the Ravensthorpe Ramp. The structural hinge line is known as the Jarrahwood Axis (Short, 1996).

This process caused the Dalyup and West Dalyup rivers to be partly rejuvenated and start to drain in a southerly direction where they had previously flowed in an east-west direction. Over time rejuvenated rivers, such as the Dalyup and West Dalyup, etched away the weathered profile and sandplain exposing granite along the bottom of drainage lines and leaving remnant Tertiary sedimentary rock with laterite profiles exposed on the flanks of low hills (Dodson, 1999).

The more recent 'Ice Age' (about 12 000 years ago) had a major impact on sea levels along the coast. The sea level changes eroded coastal sediments and cut back the shoreline to its present day position. Limestone dune systems, forced along the coastline, were blown inland by prevailing winds. Carbonate leaching and laterisation followed and the present topography and soil profiles were formed (Short, 2000).

2.4 Hydrogeology

Alluvium deposits are found within the lower parts of the catchment along the Dalyup River below South Coast Highway and surrounding Lake Gore. These deposits are grey to brown silt and clay, which form unconfined aquifers with low permeability and a maximum saturated thickness of several metres (Johnson and Baddock, 1998). The regional watertable is typically close to the surface where these sediments exist resulting in groundwater discharge that is associated primarily with evaporation from lake floors. Groundwater flow is localised with discharge as springs or seepages into surface rivers such as the Dalyup or West Dalyup rivers. The groundwater in these sediments is of poor water quality and is generally saline (<16 000 mg/L TDS) although small areas of brackish groundwater exist in the alluvial sediments of the Dalyup River (Johnson and Baddock, 1998).

Eolian dune deposits occur in small patches on areas of sandplain soils within the Dalyup catchment. They are made up of fine-grained quartz sand and silt and are derived from reworked Pallinup Siltstone and coastal sediments. The dune deposits range in size from a few centimetres to several metres in height (Johnson and Baddock, 1998). During winter a perched watertable often forms within these sands and causes seasonal waterlogging. These perched aquifers are only a few metres thick and contain fresh to brackish water that could be used for stock (<2000 mS/m) (Short, 1996). They can quickly become saline or depleted if the soaks are over pumped (Johnson and Baddock, 1998). The perched groundwater is recharged by rainfall and forms mounds above the regional watertable level. Soaks, paperbark and yate swamps form at the edge of these dune deposits and may be either recharge or discharge sites of deeper regional aquifers (Short, 1996).

Pallinup Siltstone consists of multicoloured siltstone, spongelite, small amounts of fine-grained clayey sandstone and marine fossils. The Pallinup Siltstone sediments were deposited when the ocean moved over the land in the late Eocene. The sediments are exposed along the upper slopes of the river valleys to the south of South Coast Highway (Johnston and Baddock, 1998). The two sub-units of the Pallinup Siltstone are found in the catchment including Shorelines facies and Siltstone facies. Shoreline facies are found in small pockets between the Dalyup and West Dalyup rivers approximately 2.5 km above South Coast Highway, to the west on locations E1437 and E1436 and in the Upper West catchment south of Boydells Road along the catchment divide. Siltstone facies (TPp) are found along the western boundary of the Catchment (west of the West Dalyup River) below the South Coast Highway.

The Pallinup Siltstone rocks are characterised by low permeability due to their fine-grained and clayey nature (Johnson and Baddock, 1998). This means groundwater recharge is slow and mostly through fractures and permeable pathways such as solution cavities and root channels. These pathways have been observed at 8 m below the surface (Short, 1996). Groundwater salinity in the Pallinup Siltstone is highly variable, ranging from brackish to hypersaline (Johnson and Baddock, 1998). Unconfined to semi-confined aquifers can be formed that are not always connected and can contain waters of different salinities (Short, 1996). These aquifers form the largest source of brackish to saline

groundwater in the Esperance region (Johnson and Baddock, 1998). Rainfall and downward leakage from overlying sediments recharge the Pallinup Siltstone. Groundwater flow is generally southward, although it may be constrained by irregular bedrock topography and lateral difference in hydraulic conductivity.

2.5 Soils

The soils of the catchment are dominantly grey sandy duplex soils usually with ironstone gravels within the sandy topsoil and pale deep sands. In the northern part of the catchment the soils are alkaline grey shallow sandy duplex soils of the mallee (AgWest, 2001). The major Western Australian soil groups (Schoknecht, 1997) described in the map units of the Dalyup River Catchment are shown in Table 1. Grey deep sandy duplex soils (gravely), Pale deep sands and Alkaline grey shallow sandy duplex soils are the three most common soil groups in the catchment.

Table 1. WA Soil groups in the Dalyup River catchment

WA Soil Group	Hectares (ha)	Percentage (%)
Grey deep sandy duplex	31 466	38.1
Alkaline grey shallow sandy duplex	22 330	27.0
Pale deep sand	11 668	14.1
Grey shallow sandy duplex	6599	8.0
Calcareous loamy earth	4442	5.4
Saline wet soil	1704	2.1
Moderately deep sandy gravel	1577	1.9
Salt lake soil	1146	1.4
Alkaline grey deep sandy duplex	1119	1.35
Grey non-cracking clay	315	0.38
Brown deep sand	162	0.19
Bare rock	39	0.04
Calcareous deep sand	39	0.04

Thirteen soil-landscapes have been identified within the Dalyup River catchment. The most common soil-landscape is Es1, which occupies 38% of the catchment and represents typical Esperance sandplain country. The Sc1 soil-landscape occupies 31% of the catchment and represents the shallow duplex soils of the mallee plains in the north of the catchment. Occupying nearly 10% of the catchment is the Yo4 soil-landscape of the incised valley of the Dalyup River. The 10 remaining soil-landscapes occupy just over 20% of the catchment.

2.6 Artificial drainage

As part of the Dalyup Catchment Survey the existing man-made drainage structures were mapped. This was then intersected against soil-landscapes to determine which landscapes are receiving most attention for draining. This has been mapped in the *Dalyup Catchment 2000* report (AgWest, 2001). The survey recorded 300 km of drainage structure in the catchment and 18 km of proposed drainage works. The landscapes where drainage has mostly occurred are in the Es1, Es3 and Sc1 Yo4 map units (AgWest, 2001). The landscape where drainage is proposed to occur is the Es1 unit with some amount in the Sc1 and Yo4 units.

2.7 Flora

2.7.1 Riparian vegetation

Information collated by Catherine Field and Coral Turley.

There are over 287 different plant species recorded as part of the Water and Rivers Commission foreshore survey and Esperance Wildflower Society surveys (Appendix 1). The Water and Rivers Commission's survey recorded a mix of vegetation communities along the Dalyup River System, including Coastal, Sandplain and Mallee community. A summary of the main vegetation communities is provided over.

Hakea laurina – *common along the Dalyup River (photograph Catherine Field)*

1. Coastal

A small area of coastal vegetation occurs around Lake Gore. The dominant vegetation surrounding the lake is Saltwater Paperbark (*Melaleuca cuticularis*) with an understorey of Coastal Saw Sedge (*Gahnia trifida*), *Schoenus brevifolius* and samphires *Suaeda australis* and *Sarcocornia quinqueflora*. Native Couch (*Sprorobolus virginicus*) and the herb *Samolus repens* also occur around the lake. On the steep dunes to the south of Lake Gore, Showy Banksia (*Banksia speciosa*) is dominant.

2. Sandplain

This vegetation community generally occurs in the lower half of the catchment relative to the sandplain soils.

a) Riverine Type

This vegetation community occurs mostly along the river in sandplain depressions and is dominated by Swamp Yates (*Eucalyptus occidentalis).* These are virtually pure stands, with few associated understorey species except *Throptomene saxicola*, Coastal Saw Sedge (*Gahnia trifida*) with the occasional Zamia Palm (*Macrozamia dyeria*) in the lower reaches of the catchment (common throughout the sandplain area of the Dalyup Catchment).

b) Saline Type

In highly saline areas Saltwater Paperbark (*Melaleuca cuticularis)* dominates because of its ability to survive. *Melaleuca brevifolia* is often associated with *M. cuticularis*. On flat, salt pans in the middle to upper catchment *Frankenia* sp. and *Halosarcia* sp. often form thick mats across the hypersaline riverbed. [Naturally occurs on Dalyup River – locations E1512 and E1511-11, West Dalyup River – locations E1503 and E1499, Dalyup River Trib 1 – E1410 and E1512].

c) Mallee Heath

A form of mallee heath occurs in pockets along the river and is characterised by Blue Mallee (*Eucalyptus tetragona*), Chittick (*Lambertia inermis*) and Christmas Tree (*Nuytsia floribunda*). This vegetation community occurs on the Dalyup River just above Lake Gore to Boydells Road and from the junction with the Dalyup River to between Brownings and Boydells roads on the West Dalyup River.

d) Shrub Heath

On deep sand there is a change of dominance with the disappearance of *Eucalyptus tetragona* in favour of Showy Banksia (*Banksia speciosa)* plus Christmas Tree (*Nuytsia floribunda)* and Coastal Jugflower (*Adenanthos cuneatus*). This vegetation type occurs in pockets on the Dalyup River just upstream from Lake Gore to location E1412 (mainly on the left bank), on the West Dalyup River from the junction with the Dalyup River almost to Boydells Road, and on the Dalyup River Tributary 1 in a small section on the boundary between E1444 and E1548.

e) Granite Type

Small pockets of granite vegetation communities exist along the river mostly in the middle part of the catchment. Where the granite is close to the surface *Allocasuarina huegelliana* dominates with a few associated understorey species. A good example exists along the Dalyup River on 'The Oaks' property.

Where sands lie over shallow granite, dominant species are One-sided Bottlebrush (*Calothamnus quadrificus*), Honeybush (*Hakea lissocarpa*) and Frog Hakea *(Hakea nitida*). This is common along the lower reaches of the Dalyup and West Dalyup rivers.

f) Deep sand

Characterised by Blue mallee (*Eucalptus tetragona*), Southern Plains Banksia (*Banksia media*) and *Hakea* species such as *Hakea clavata*.

3. Mallee

The dominant plant cover is mallee with a variety of diverse understorey species including *Eucalytpus forrestiana, Eucalytpus angustissima* (on waterways*),* Broom bush (*Melaleuca uncinata,* Tangling Melaleuca (*Melaleuca cardiophylla*), *Eucalyptus redunca, Eucalyptus flocktoniae, Hakea adnata* and *Hakea cinerea*.

2.7.2 Remnant vegetation

Beard (1973, 1979) described and mapped the vegetation of the Dalyup catchment. This was mainly done before the clearing for major agricultural development. The vegetation of the Dalyup catchment is classified in three broad vegetation systems according to Beard (1973). The *Dalyup Catchment 2000* (AgWest, 2001) intersected the remaining remnant vegetation with main vegetation associations mapped by Beard (Table 2). This indicates the prevalence of each vegetation association that was in the catchment before clearing (AgWest, 2001).

Table 2. Vegetation systems and associations of the Dalyup Catchment

Vegetation System	Vegetation Association	Hectares (ha)
Esperance	Medium woodland; yate	1665
	Shrublands; banksia scrub-heath	13 241
	Shrublands; tallerack mallee-heath	34 456
	Shrublands; teatree scrub	2160
Fanny Cove	Saltlakes; mostly devoid of vegetation	687
	Shrublands; scrub-heath	1412
Lort	Shrublands; mallee scrub	28 983
Total		**82 607**

The catchment survey also intersected remaining remnant vegetation against soil-landscapes to determine how vegetation was partitioned. The survey identified 8738 ha of remnant vegetation within the catchment. This indicates that about 10% of the Dalyup catchment's remnant vegetation still remains. Most of the remnants occur in the larger soil-landscapes or in landscapes with land unsuitable for farming such as river channels or saltlakes (AgWest, 2001).

Dalyup Catchment 2000 (AgWest, 2001) also mapped existing and proposed revegetation plantings. Revegetation of 2306 ha was recorded in the Esperance Sandplain soil-landscapes (Es1, Es2 and Es3) and the River valley (Yo4) soil-landscape (AgWest, 2001). The catchment survey indicated that revegetation is proposed for all major landscapes, including those associated with drainage lines.

The Importance of vegetation along waterways

Fringing or riparian vegetation along waterways is essential to maintain a stable and ecologically sustainable riverine system. Once degraded the native vegetation is slowly replaced by exotic weeds and introduced grasses. In summary, vegetation along waterways is important becaue it supports the ecosystems within the river system and Lake Gore are driven by the input of riparian vegetation.

a) stabilises streambanks and controls erosion

Vegetation stabilises streambanks and protects them from erosion and bank subsidence. The root architecture of riverine vegetation provides a framework to stabilise sediments, reduce soil erosion and intercept surface run-off. Adapted aquatic plants such as rushes and sedges are particularly useful for this purpose (Water and Rivers Commission, 1999b). Vegetation also decays and drops organic matter into the system. This provides food for many aquatic animals including macroinvertebrates. This inputs carbon into the system and is vital to drive the ecological functions of the river system.

b) slows water flow and maintains channel width

Vegetation along a waterway slows the flow of water by forcing the running water to manoeuver past the rough edges of the riverbanks. Good vegetation along a riverbank will deepen it and also contract the channel width by about 50% (NSW Agriculture, 1997). By removing this vegetation, water flow and its power to erode streambanks increases. As erosion increases on the streambanks the river channel widens and becomes shallow. This leads to a broadening in the floodplain. A channel will also widen if the main channel becomes overgrown with vegetation and blocks flow causing the river to form a secondary channel (NSW Agriculture, 1997).

c) improves water quality and reduces sedimentation

A band of vegetation along a waterway provides a buffer strip between land and water. A buffer strip can be used to remove nutrients, organic material and sediments from surface run-off. Sediment is

trapped because the vegetation slows down the runoff and catches particles around the roots and stems of plants (NSW Agriculture, 1997). Plants can trap, bind and sometimes use nutrients, such as nitrogen or phosphorus that are trapped in sediments. The length of a buffer strip is the significant factor in how effective it will be in filtering nutrients. Grazed pasture has little effect on nutrient retention.

Nitrogen and phosphorus are the main nutrients that enter waterways and have detrimental effects on water quality. Phosphorus enters the water from fertilisers when it is attached to soil particles and washes into the waterway. Although agricultural fertilisers are often cited as causes of high phosphorus levels in waterways, other activities including dairies, piggeries, poultry enterprises, cattle, sheep, detergents, domestic waste (sewage) and industrial wastes also can be contributing factors.

d) enhances biodiversity

Vegetated waterways can provide a range of habitats for a large variety of flora and fauna, particularly those that are restricted to aquatic environments. Waterways such as the Dalyup River form wildlife corridors that enable a natural ecosystem to function and support a diverse range of inhabitants.

e) provides recreational, educational and aesthetic opportunities

The Dalyup River has important aesthetic values with several small land managers choosing to live near the river for the surrounding picturesque views across the water. Recreational values include fishing, canoeing (on Lake Gore) and picnicking. Before the mid 1970s people (indigenous and non-indigenous) fished for Black Bream in the lower Dalyup River. Today, some land managers fish their own sections of the river, and many tourists and local residents visit the Dalyup Pioneer Reserve on Murray's Road.

2.8 Fauna

2.8.1 Birds of the Dalyup catchment

There are a variety of birds found in the Dalyup River catchment. Many of these species rely on the waterways as a source of food, habitat and breeding grounds. Anne Henderson (West Speddingup), Kay Walter (West Speddingup) and Alan Rose (Esperance Bird Observers Group) have recorded 144 different birds in the catchment (Appendix 2).

2.8.2 Birds of Lake Gore

Information collated from Klaus Tiedemann, CALM, Esperance.

Lake Gore and the surrounding wetland system of Lake Curbul, Lake Gidong, Overflow Swamp and Quallilup Lake are significant wetlands for breeding, moulting and drought refuge of migratory waterbirds (Jaensch et al., 1988). The Lake Gore wetland system is considered to be of international importance and has recently been listed as a Ramsar 'Wetland of International Importance'.

Lake Gore and the surrounding wetland system ranks in the top 1% of wetlands in South West WA (602 surveyed) for numbers of individual waterbirds (Raines, unpublished). Over 20 000 birds a year have been recorded at Lake Gore (Jaensch et al., 1988). A total of 54 different waterbird species have been recorded on the Lake Gore Wetland System, of these 12 have been recorded breeding (Appendix 3).

The highest numbers of Hooded Plover (*Charadrius cucullatus)* and the second highest numbers of Banded Stilt (*Cladorhynchus leucocephalus*) and Common Sandpiper (*Tringa hypoleucos*) have been recorded on Lake Gore (Jaensch, et.al, 1988). Up to 12 000 Australian Shelducks (*Tadorna tadornoides*) have gathered on Lake Gore because of its desirability as a moulting area for the ducks. The lake is also significant for the Greenshank (*Tringa nebularia*) and Sanderling (*Calidris alba*). Lake Gore is a preferred drought refuge for waterbirds such as the Banded Stilt (*Cladorhynchus leucocephalus*) and Hooded Plover (*Charadrius rubricollis*) (Halse et al., 1993).

Many of the waterbirds' main food sources are brine shrimp and a small pink cone-shaped snail (*Coxiella* species) that are found in the lakes.

In January 1995, 1600 Hooded Plovers were recorded on Lake Gore. Its population, estimated at 5000, is classed by IUCN as 'Rare' (Jaensch, et.al., 1988). This represents 32% of the estimated world population. The Hooded Plover is also listed under Schedule 2 of the *Wildlife Protection (Regulation of Exports and Imports) Act* 1982.

The Japan-Australian Migratory Bird Agreement (JAMBA) and the China-Australia Migratory Bird Agreement (CAMBA) are international treaties that have been signed by the Australian Government. These treaties list certain bird species that the Australian government and community are obliged to conserve and enhance the survival rates. Seventeen birds that occur on the JAMBA treaty and 16 that occur on the CAMBA treaty have been found on the Lake Gore Wetland System (Jaensch, et. al., 1988).

2.8.3 Snails

Information collated by Alan Longbottom, "Sieda", Grass Patch.

There are 13 different species of snails likely to be found in the Dalyup catchment (Table 3). The only species identified in the catchment is a small (5–8 mm long) pink saltwater snail, *Coxiella striatula*. Large numbers of these snail shells blanket the north shore of Lake Gore (Setter, unpublished).

Bothriembryon are the largest snails in the area and there are several undescribed species. All are litter-dwellers and are far more common on soils with a high calcium level i.e. mallee soils. This allows them to make stronger shells. Shells of some species that live on the sandplain are quickly recycled by survivors due to the lack of calcium available in these soils. Many known species are restricted to small areas due to the soil type, vegetation or micro-environmental factors. Further degradation of remnant bush may lead to their decline.

Themapupa, Omegapilla, Gastrocopta and *Paralaoma* groups are litter dwelling, small to very small snails and consequently not seen by most people even though they are reasonably common. *Limnidae,* a freshwater snail group, has recently been found in the Esperance town vicinity. These snails are hosts of the Liver Fluke parasite that can infect humans.

Table 3. Snails likely to be found in the Dalyup River catchment

Scientific Name	Other comments
Bothriembryon dux	
Bothriembryon balteolus	
Bothriembryon sp	sandplain species
Themapupa	
Omegapilla	
Gastrocopta	
Paralaoma caputspinulae	
Austrosuccinea	samphire flats
Coxiella	saltlake snails
* *Coxiella striatula*	Found at Lake Gore
Physa	freshwater snails
Physastra	
Isodorella	
Ferrissia petterdi	(Limpet) Robert's Swamp

** Specimen identified in Dalyup Catchment*

Source: Alan Longbottom, Grass Patch

2.8.4 Frogs

There is likely to be about 12 species in the Dalyup catchment, of which eight have been sighted in the mallee region (Table 4). Most are from the wetter coastal region but three or four are 'burrowing' frogs from the drier parts. Most frogs are adversely affected by chemicals or rising saline groundwater (Alan Longbottom, pers. comm., 2000).

2.8.5 Spiders

There are hundreds of spider species in the Esperance region but it is predicated that about two-thirds are undescribed. Numerous specimens, sent to the WA Museum by Alan Longbottom, have been named as new species (Alan Longbottom, pers. comm., 2000).

Many spiders disperse into new areas by 'ballooning'. They can float great distances on a long thread of silk. This allows for the ready re-occupation of areas after severe fires or floods. Other species have to extend their range by walking. If there are 'barriers' preventing this it will not be possible and thus the species survival is put further at risk.

Table 4. Frogs found in the Dalyup River catchment

Common Name	Scientific Name	Comments
	Hylidae	
	Litoria adelaidensis (Gray)	Wet coastal areas
	Litoria moorei (Copeland)	Doubtful, maybe in swamps west of Esperance.
	Litoria cyclorhynchus (Boulenger)	Common in wet areas including domestic situations and dams with surrounding trees (local green frog).
	Leptodactylidae	
Guenther's Toadlet	*Pseudophryne guentheri* Boulenger	
* Humming Frog	*Neobatrachus pelobatoides* Werner)	Burrows near temporary water.
* Trilling Frog	*Neobatrachus centralis* (Parker)	Drier areas, burrowing near temporary water.
* Turtle Frog	*Myobatrachus gouldii* (Gray)	Often associated with termites. No tadpole stage. (Presume they change to frogs while still in the egg mass).
* Western Banjo Frog or Pobblebonk	*Limnodynastes dorsalis* (Gray) *Heleioporus psammophilus* (Lee & Martin)	Common in dams and swamps. High-pitched "putt-putt-putt", probably coastal.
* Moaning Frog	*Heleioporus eyrei* (Gray)	Long, low-moaning call, probably coastal.
*	*Crinia georgiana* Tschudi	'Quack-quack-quack' call found in wetter areas near the coast.
Orange-crowned Toadlet	*Kankanophryne occidentalis* (Parker)	Possibly in drier areas.

** species that have been seen in the Esperance-Mallee area.*

Reference: Cogger, H.G. (1979). *Reptile & Amphibians of Australia*

Source: Alan Longbottom, Grass Patch

Table 5. Spiders recorded in the Dalyup River catchment

Mygales	Trapdoors	Several common and restricted genera are found in the catchment. Trapdoors live in web-lined burrows that, depending on the species, will or will not have a hinged lid. They capture invertebrates and small vertebrates. Generally they have trouble surviving in areas with stock access as they trample their burrows.
Lycosids* (ground-hunting)	Wolf Spiders	Common. Found in paddocks, remnant bush and riparian vegetation. Other common groups that share the ground hunting habits are the Zodarids and Ctenids.
	Orbweavers*	A common name given to numerous families of spiders These range from the large *Nephilla* to tiny species no bigger than a pin-head.
Salticids	Jumping Spiders	Usually small, these have excellent eyesight and are active hunters even on hot days. Several new species have been named from this area.
Gnaphosids, Clubionids and Miturgids	Sac Spiders*	Night hunters that hide in a web sac during the day. Includes the White-tailed and Mordax spiders that are known to inflict painful bites. The ulceration that infrequently follows is mostly due to a secondary bacterial infection.
Sparassids	Huntsmen*	Widespread, though habitat-dependent. Two new species have been named from the Grass Patch area.
Therids*	includes the Red-Back	There are numerous species in this group, which are related to the Daddy-long-legs. The Red-back is the only known, potentially lethal member.

2.8.6 Other fauna

No published fauna surveys of the Dalyup River and its catchment have been made and there are no fauna records at the WA Museum. In 1992 Leighton and Watson surveyed the fauna of four river corridors along the South Coast. The Lort River located approximately 45 km west of the main Dalyup River was one of these rivers surveyed. The survey of the river corridor and existing museum records indicate approximately 73 different species existed along the Lort River (Table 6).

Table 6. Fauna found along the Lort River

Fauna	Number of species
Mammals	9
Frogs	5
Reptiles	45
Invertebrates	14

Source: Leighton and Watson (1992)

2.9 Heritage of the Dalyup catchment

2.9.1 Indigenous heritage

Information supplied by Jim Dimer–Esperance Aboriginal Corporation.

The name Dalyup originates from a Noongar word 'Djaylup' which means King Parrot or Hookbill (*Platycercus spurius*). It appears in previous reports that the Njunja inhabited the region along the Esperance sandplain with Kalaako people overlapping in the north. The region has not been subject to a full Indigenous heritage study and there are possibly many undocumented ethnographic and archaeological sites (State of Western Australia, 1999).

Jim Dimer, an elder, of the Esperance Aboriginal Corporation recalls that his people used to fish for Black Bream in the Dalyup River near the South Coast Highway and often camped in an area near the river which is now a Shire of Esperance gravel reserve. Jim also thinks there may be a grave of a member of his family somewhere at Dalyup.

The Esperance Aboriginal Corporation has an interest in the Dalyup Catchment as it manages the Aboriginal Lands Trust (ALT) reserve on Speddingup West Road. The main tributary of the West Dalyup River runs through that area of bushland. It was purchased by the ALT sometime in the 1960s.

The Bullenbuk people currently have a Native Title Claim over the Esperance Region, including the entire Dalyup Catchment. It is not known if there are any significant sites on the Dalyup River.

2.9.2 European heritage

The Dalyup River catchment includes the towns of Gibson (along the Norseman Highway) and Dalyup (along the South Coast Highway) with the township of Scaddan located just north of the upper boundary of the catchment. Areas in the Dalyup River catchment have very different histories and patterns of settlement. Information on European heritage is presented in the areas of, Dalyup, Gibson and Speddingup/Scaddan.

2.9.2.1 Dalyup

In 1895 the first settler in the Dalyup area was Mr F. J. Daw. Mr Daw is noted to have taken up some of the 'she-oak' country. 'Park Farm', adjacent to Lake Gore at the bottom of the Dalyup catchment, was established in 1897 by the Stewarts–another pioneering family. Other settlers who established properties in the area were the Goodliffe, Rouse and Gibson families. There is little documented about these post-Federation settlers.

The history of the Stewart family is the only remaining evidence of what the Dalyup River and catchment was like before the turn of the century. Clearing of the property 'Park Farm' began in 1897. In an unpublished account of their early activities on their property, it is noted that the Dalyup River was salty with a few fresh water swamps on their property. The Stewarts also used to collect salt from nearby lakes to treat their meat. They grew vegetables and had a fruit orchard as well as some sheep. The family travelled along the telegraph line to Esperance, now known as Telegraph Road. The settlers had to depend mainly on soak-water for drinking and stock use, as the Dalyup River was salty. It was also noted as far back as 1946 that rabbits were a problem.

In June 1897 a reporter from the 'Chronicle' visited the district and wrote:

"The river is about a chain wide, with a well defined basin and abrupt banks. The valley, which extends about ten chains each side of the river, and its branch gullies, is well timbered with eucalypti and is remarkably well grassed…The soil is firm and dark…A temporary camp has been erected on a rise near a pool of fresh water, the river water being salt….Fencing, clearing and other improvements necessary to agricultural pioneering are also in progress."

In November 1899, Mr Erskine May, Chief Inspector of the Lands Department visited the Dalyup area. He reported that:

"The Dalyup area is reached by travelling over dreary sand plain country, situated on both sides of the Dalyup River. Nine different selectors have taken up twelve blocks (between April and December 1897) which comprise an area of 1817 acres. Nearly all the holdings are fenced and are being improved. Among the most advanced in this respect is Park Farm, the property of Mr Stewart. The place is appropriately named, for in driving through the paddocks, one cannot help noticing the park-like appearance of the land, well grassed, and timbered with dark-wooded yate, which stand out conspicuously against the stately snow white paperbarks peculiar to this part"

A report by Sarah Ann Stewart (aged 65, a farmer and widow who had twelve children) said she held Dalyup locations 1,2,3,4,5,6,16,17,18,19,21,22,23 – totalling approximately 2 000 acres.

The township of Dalyup was not gazetted until 1962 (Murray, 1985).

2.9.2.2 Speddingup/Scaddan

Mr G.L. Sutton, Commissioner for the Wheatbelt, visited the Esperance Mallee district in 1912 and subsequently submitted a scheme of development, which was adopted. This included locations along Raszyk, Griffith and Speddingup West Roads. The development scheme in the Speddingup area provided monetary advances to settlers for the purpose of clearing, cropping, excavating dams, fencing and other improvements. The maximum advance was five hundred pounds.

The farmers struggled with a myriad of problems including lack of labour during World War One, lack of machinery, lack of horses, high costs for building dams and not being able to control re-growth of native mallee suckers. The biggest problem was the lack of transport and high freight costs.

It was expected that the Norseman to Esperance railway would be completed one to two years after the farmland was opened up but the state government delayed the project in favour of promoting the port of Fremantle as the link to eastern Australia. By the 1929 depression many early settlers in the area had abandoned their holdings. The government took control of this land and allowed the natural bush to grow back. The land was again released around 1950, after the discovery of trace element deficiencies.

Around the time land was released in the mallee, it was being debated how much salt in the soil was too much to grow crops. A report by a government analyst on the soils of the mallee strongly stressed the unsuitability of soils in the mallee region to grow crops because of the levels of soil salinity, between 0.10 to 0.22%. At that time the lower limit for salt was set at 0.05% and any higher was considered a restriction to growing crops. In 1916 when settler James Lewis of Circle Valley was asked whether he thought there was too much salt in the soil to grow wheat he replied:

" It is a scandalous report, and there is no truth in it. There is hardly enough salt down here".

The township of Scaddan was gazetted in 1924 just a few years before the railway line passed through the town (Murray, 1985). It was named after the then Western Australian Premier of the day. However, the landowners of the district blamed Mr Scaddan for the slow progress in extending the railway to Esperance. This in turn gave Fremantle additional time to become the established port for trade with eastern Australia instead of Esperance.

A map of agricultural land (housed at the Esperance Historical Society) shows that a significant proportion of land between Raszyk Road and the north side of Speddingup West Road was released between December 1911 and April 1912. Some blocks in the area were released earlier than this.

A township was also allocated at Flemming Grove, between Scaddan and Gibson along the railway line, but today it is still bushland.

2.9.2.3 Gibson

Gibson was established as a watering point for travellers on their way to the Goldfields. There was a well, a windmill and the Gibson Soak Wayside Inn. The Gibson Soak was the initial building in the area and was opened on Christmas Day 1896 by Mr and Mrs Harry Jenkins to provide accommodation for travellers. Billy Gibson, one of the early day teamsters, found the Gibson Soak water supply. The Stewarts, settlers from Dalyup, were familiar passers-by who took vegetables and fruit to Norseman. The Gibson townsite was gazetted in 1921 (Murray, 1985).

2.10 Land tenure and land use

The predominate landuse within the Dalyup catchment is agriculture, worth an estimated $14 million annually (AgWest, 2001). There are over 70 farming enterprises in the Catchment. The Agricultural production is primarily winter cropping (wheat, barley, canola and lupins) and livestock (beef, wool and sheep meat). There is some diversification of agriculture in the lower catchment including a nursery and a vineyard.

The majority of the Dalyup and West Dalyup rivers and their corresponding tributaries are privately owned, except for a section from Lake Gore to the junction of the Dalyup and West Dalyup rivers. This section of the river is vested with the Department of Lands Administration as unallocated Crown land.

In the catchment, there are 25 publicly-owned reserves totalling approximately 3021.76 hectares. The largest reserve is on Speddingup West Road and is vested with the Aboriginal Land Trust (1618.74 ha), followed by the Lake Gore Nature Reserve (792.43 ha) at the bottom of the catchment vested with the Conservation Commission. Many of the other publicly-owned lands are gravel reserves in areas less than 2 hectares. Overall less than 4% of the catchment is under public ownership.

3 Waterways information

The main waterways and wetlands in the Dalyup catchment are the Dalyup River, and its major tributary named the West Dalyup River, their corresponding tributaries, and Lake Gore. There are also many internally draining wetlands in the northern section of the catchment.

3.1 Dalyup River system

The Dalyup River system is a part of the Esperance drainage district, which includes river systems such as the Young and the Lort rivers; through to smaller creeks that drain the salt country north of Esperance including the Dalyup and West Dalyup rivers.

The main Dalyup River system flows for approximately 54 km from the township of Scaddan, through the districts of Gibson and Dalyup to Lake Gore. The West Dalyup River flows 45 km before meeting the Dalyup River 8 km upstream of Lake Gore. The Dalyup River is the primary source of water supply to Lake Gore.

The Dalyup River is an ephemeral system that flows mainly after winter rains. Summer flows are generally due to groundwater influxes from the surrounding land. The river consists of numerous pools that form important wildlife habitat during summer months. These river pools then join during the winter months as the rain begins to fill the low-flow channel.

The Dalyup and West Dalyup rivers formed thirty million years ago (during the Oligocene period) when the Darling Plateau uplifted and the southern coastline tilted toward the south to form the Ravensthorpe Ramp. This partly rejuvenated the rivers and they started to drain in a southerly direction instead of the previous east-west direction. Over time the rivers etched the weathered profile and sandplain, exposing granite along the bottom of drainage lines and left remnant Tertiary sedimentary rock with lateritic profiles exposed on the flanks of low hills (Dodson, 1999).

3.1.1 Water quality

There has been no comprehensive water quality monitoring programs undertaken in the catchment. Various spot sampling projects have been undertaken by different agencies, including monitoring by: Tim Setter (as part of a Murdoch University course), the Water and Rivers Commission, students from Esperance Senior High School (Ribbons of Blue), the Department of Conservation and Land Management and the Esperance Downs Research Station (EDRS) (Table 8). The water quality results of these programs are attached in Appendix 3.

Dalyup River "The Oaks" (photograph Catherine Field)

Table 7. Water quality monitoring programs undertaken in the catchment.

Water and Rivers Commission
1.1997: once-off sampling for total nitrogen (TN), total phosphorus (TP), total Kjeldahl nitrogen and total oxidised nitrogen.
2.July 2000: a "snapshot" conducted to provide a picture of the condition of the water quality in the catchment. Salinity, pH, temperature and dissolved oxygen were tested at eight sites.
Tim Setter, Murdoch University/AgWest
Sampling of Lake Gore, Dalyup River (Dalyup Pioneer Reserve, South Coast Highway, Brownings Road) and West Dalyup River (South Coast Highway, Brownings Road). Parametres measured included, TP and TN, salinity, chlorophyll a, estimate of water flow, identification of algae and invertebrate species.
Esperance SHS (Ribbons of Blue)
Organised by science teacher Dennis Smith and carried out twice a year at Lake Gore.
Department of Conservation and Land Management
Lake Gore is monitored biannually for water depth and quality. Data on Lake Gore shows an increase in depth possibly due to a higher than average rainfall events in the catchment.
AgWest, Esperance
1995 onwards: monitoring the drainage network on the Esperance Downs Research Station (EDRS) for nitrogen (N) and phosphorus (P) since 1995 to determine the quality of water as it passes through a large block of remnant bush into the major tributary of the Dalyup River.

3.1.1.1 Salinity

The salinity of the water in the Dalyup and West Dalyup rivers is brackish on average and ranges from half to almost twice that of seawater (Pen, 1999). It is likely that the salinity levels have increased in the Dalyup River due to secondary salinity.

Water and Rivers Commission recorded salinity levels in the Dalyup and West Dalyup rivers ranging from 25.3 – 70.3 mS/cm. Setter (2000) recorded salinity readings from March to June 1998 ranging from 30–70 mS/cm (which is approximately 60–140% the salinity of seawater). Salinity levels of 130 mS/cm were recorded in Lake Gore.

Dalyup River Snapshot

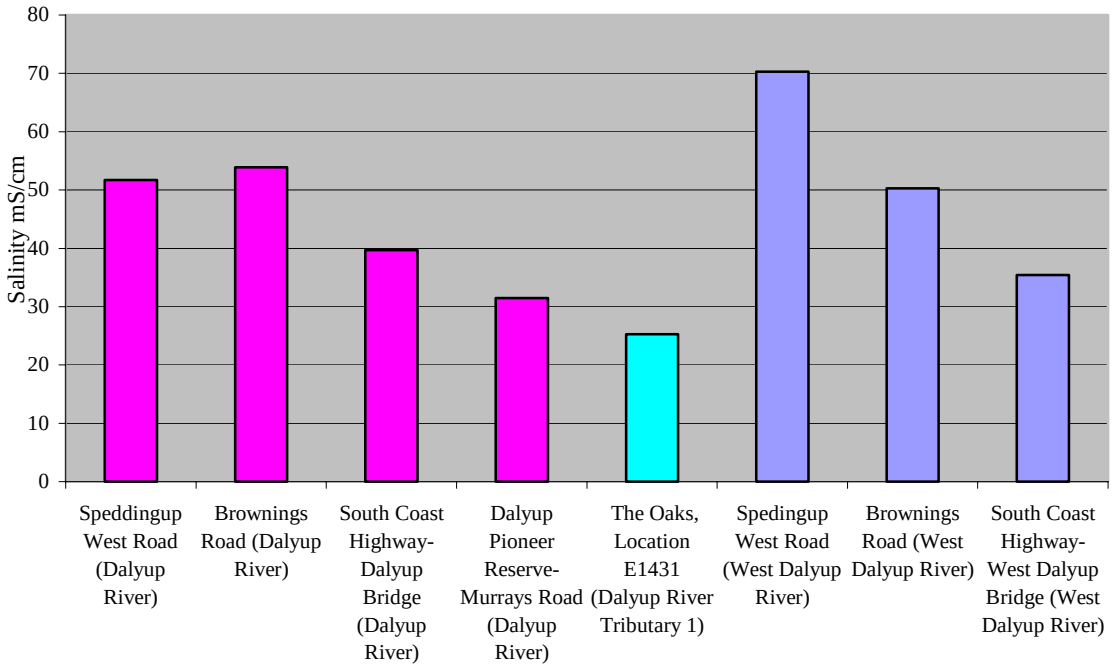
Catherine Field on behalf of the Water and Rivers Commission in July 2000 carried out a "snapshot" of the Dalyup River in July 2000. The catchment had received rainfall the day before the sampling and the rivers were flowing. Eight sites were sampled including four sites on the Dalyup River, three sites on the West Dalyup River and one site on Dalyup River Tributary 1 (the Oaks property). Conductivity, water temperature, dissolved oxygen and pH were measured in addition to observations of flow.

The salinity of the Dalyup, West Dalyup and Dalyup Tributary 1 ranged from 25.3 mS/cm to 70 mS/cm. The salinity levels decreased further down the catchment suggesting that the water is being diluted with fresh rainwater flowing into the river closer towards the coast. At the top of the catchment, the conductivity was 51.7 mS/cm and 31.5 mS/cm at the Dalyup Pioneer Reserve (Fig. 2).

3.1.1.2 Nutrients

Since 1995, water draining from the Esperance Research Station has been monitored for nitrogen (N) and phosphorous (P) to determine the quality of water draining from the Research Station into the Dalyup River. High nitrogen and phosphorous concentrations ranging from 3.5 mg/L and 11 mg/L respectively indicate that high levels of nutrients are being discharged into the Dalyup River. The Australian and New Zealand Environment and Conservation Council (ANZECC, 1992) water quality guidelines suggest that total phosphorous should be less than 0.1 mg/L and total nitrogen should be less than 0.75 mg/L.

Setter (2000) also monitored TN and TP between March and June 1998 in the Dalyup and West Dalyup River. Total nitrogen recordings were extremely high ranging from 2–8 mg/L at the beginning of the season. Total phosphorous ranged from 0.01–0.7 mg/L. Half the survey locations, including the Dalyup and West Dalyup rivers, were above the ANZECC guidelines.



*** The salinity of seawater is 53 mS/cm*

Figure 2. Salinity measurements of the Dalyup and West Dalyup rivers (WRC snapshot results, July 2000).

Nutrient and flow monitoring – Esperance Research Station, 1995

Information collated by Steve Gee, Department of Agriculture, Esperance and Catherine Field

The conductivity of water leaving the east side of the Esperance Research Station, via the highway culvert, ranged from 24 – 2500 mS/m. In late April 1995, superphosphate fertiliser was applied to all pastures on the station at a rate of 85 kg/ha. This rate has a total TP content of approximately 7.7 kg/ha. (J. Lemon, AgWest, pers. comm., 2000). The area of paddocks fertilised that contributes to the drainage network covers approximately 200 ha above monitoring Site 2.

Results indicate high P and N concentrations ranged from 3.5 mg/L and 11 mg/L respectively. ANZEEC (1992) water quality guidelines show that TP and TN should be less than 0.1 and 0.75 respectively. Samples taken before 17 July 1995 possibly recorded little surface or sub-surface runoff from the station with only 2 small peaks seen in the hydrograph after rainfall events. The drain hydrograph for Site 2 shows that the drain flowed continuously from the 15 July 1995. The P values show a peak concentration at this site of 0.95 mg/L during the initial flow, or first flush, followed by a fall in concentration as discharge increased. Subsequent rainfall events after the peak flow in late July show a concentration of approximately 0.17 mg/L P to the end of the monitoring period – 16 July to 28 September 1995 (75 days).

In April TP applied to pastures in the drainage catchment area was approximately 1540 kg/ha. The P load in the drain during monitoring was calculated as 17 kg. Approximately 1 % of TP may have been lost from the paddocks via runoff and subsurface through-flow to the drains during the monitoring period. It should be noted that the drains pass through large areas of revegetation on the site that was not fertilised and it may be filtering nutrients and intercepting sediment. The highest P and N results were from monitoring Sites 1 and 3 that have little or no fringing vegetation upstream of the monitoring sites.

3.1.1.3 Flow rates of the Dalyup River

There has been no long-term flow monitoring of the Dalyup and West Dalyup rivers. A mean annual flow of 11 000 ML has been estimated (Pen, 1999). It has also been estimated that flow rates have increased 2 to 4 times since clearing (Luke Pen, pers. comm. 2000). Setter (2000) has undertaken some monitoring of flow rates and recorded maximum flow rates between March and September 1998 of 25m^3/min for the Dalyup and 8m^3/min for the West Dalyup River. During sampling, the Dalyup River had a greater flow rate than the West Dalyup River. Flow rates were calculated by using stream cross-sectional area and stream velocity calculations.

AgWest also monitored discharge from the eastern side of the Esperance Research Station. In July 1995, flow rates reached approximately 500 m^3/hour (14 cm on Rating curve). The volume of discharge water passing Site 2 was approximately 83 400 m^3 during the 75 days from 16 July to 28 September 1995. During this period there was 161 mm of rainfall recorded. The discharge at Site 2 represents approximately 26% of the total rainfall (over the 75 days) in the drainage network catchment.

3.1.1.4 Flood events 1999 and 2000

The Dalyup River system has flooded on average every 10 years. The first flood to be noted by locals was in the 1940s. The first damaging flood was around 1968/69. Since then flooding has occurred in 1979, 1989, 1999 and 2000 (J. Marold, pers. comm., 2000). Joy has lived on the western side of Lake Gore since the 1960s. She remembers that Lake Gore in the 1960s was very dry with a small amount of water and a large amount of mud. Since the flood event of 1968/69, Lake Gore has been full and hardly ever dry. However, this flood was apparently minor compared to the following ones in 1989, 1999 and 2000 (J.Marold, pers. comm., 2000).

In January 1999, a significant flood event occurred in the Lake Gore catchment. The Dalyup and West Dalyup rivers sustained severe flood damage. There were bridges, road crossings and fences lost. The riverbanks were severely eroded and massive amounts of sediment were dumped into the channel and river pools.

In March 2000, another storm event produced a flood estimated to be slightly greater in magnitude than the 1999 event. The rainfall was estimated to be about 110 mm over a 24-hour period. This corresponds to an Average Recurrence Interval (ARI) of 50 – 100 years. This means that it would be most unlikely to occur more than once in a 50 to 100-year period. The annual rainfall in the catchment varies from about 330 – 680 mm (Main Roads Western Australia report 00/009/E). During the March 2000 flood, peak discharge of the Dalyup River at the bridge was calculated to be about 300 m^3/s and at the West Dalyup Bridge to be 200 – 250 m^3/s with an estimated average velocities of 3.9 m/s and 3.5 – 3.8 m/s respectively (Gerome Goh, Main Roads Western Australia, pers. comm., 2000).

Floods – the inevitable habit of rivers

Information extracted from 'Managing Our Rivers' (Pen, 1999)

In summer, our rivers are mainly a series of river pools, along an otherwise dry riverbed. These become increasingly connected downstream by a trickle of water as the rivers pass through higher rainfall country towards the coast. When the first rains come (usually between April and June), the tributaries begin to flow and the low-flow channel of the rivers is filled – connecting the river pools once again. By mid-winter, many sections of the rivers' floodplains are inundated, some permanently and other sections for a few days at a time. If rain persists over a number of weeks, floods drown the river valley and spill out onto the floodplains. This pattern of summer drought and winter flood is important as it drives the ecology of river systems. Flooding creates habitat ready to be exploited by highly mobile animals or plant species that can lay dormant for many years. Drought conditions are also important because they allow fringing plant species time to dry out. Many of our aquatic fauna rely on this cycle including some of our native fish species breed in floodwaters as it spills onto the floodplains. Although flood and drought cycles make farming challenging, these natural events help to create the unique rivers that we have on the South Coast.

3.1.2 Macroinvertebrates

Macroinvertebrates or aquatic bugs consist of worms, snails, crustaceans (prawns and marron) and insects (including mayflies, stoneflies, beetles and bugs) found in our waterways. Many macroinvertebrate species are found in the waterways throughout the Dalyup River catchment.

Macroinvertebrates play an important role in the ecology of the river system. In the upper catchment, macroinvertebrates are responsible for shredding larger particles including bark, leaves and other detritus that falls into the waterway. Further downstream, macroinvertebrates such as worms, gilgie and marron take small particles of organic matter from the sediment and digest them further. Algae that grow on the rocks are 'scraped off' by snails and limpets. There are also predator species of macroinvertebrates including the dragon fly, adult beetles and stonefly larvae that prey on smaller animals, responsible for breaking down the organic matter. This process is critical for returning carbon into the ecological system.

Des Neale and Robyn West sampling macroinvertebrates in the Dalyup River – June 2002 (photograph Kaylene Parker)

The survival of macroinvertebrates is linked to the quality of the water and in turn larger animals such as fish. Macroinvertebrates are sensitive to changes in the physical and chemical conditions of the water, including salinity, flow and temperature.

The most important feature in a stream is vegetation – including logs, branches, bark and leaves. This forms the basis of a food web for macroinvertebrates in our waterways. Vegetation removal can impact on food availability, light penetration, water flow, sediment levels, and temperature of the water. Protection of foreshore vegetation is vital to ensure the protection of the ecological attributes of our river system. Removal of riparian vegetation upstream can have serious consequence on downstream macroinvertebrates that rely on the input of organic matter to the system.

Macroinvertebrates have been sampled in the Dalyup River as part of the National Rivers Health Program in 1997. Only a few species of macroinvertebrates were found (Table 8).

Macroinvertebrates sampled as part of a Water Awareness Day, held by the Water and Rivers Commission in June 2002, found eight different macroinvertebrates in the Dalyup River, north of the South Coast Highway on Lawie Shaw's property (Table 9).

Table 8. Macroinvertebrate species collected in the Dalyup River (1997)

Site Name	Date	Sample location	Scientific name (Family)	Common Name
ESP13	13/09/1997	Channel	Ceinidae	Mayfly larvae
ESP13	13/09/1997	Channel	Ceratopogonidae	Biting midge larvae
ESP13	13/09/1997	Channel	Culicidae	Mosquito larvae
ESP13	13/09/1997	Channel	Ephydridae	Fly larvae
ESP13	13/09/1997	Channel	Orthocladiinae *	Non-biting midge larvae
ESP13	13/09/1997	Channel	Oligochaete indeterm.	Aquatic worm

National River Health Dataset 1994–1998, CALM

Table 9. Macroinvertebrate species sampled in the Dalyup River (2002)

Date	Sample location	Common name
9/06/2002	Channel	mayfly larvae
9/06/2002	Channel	caddisfly larvae
9/06/2002	Channel	water boatmen
9/06/2002	Channel	predaceous diving beetle
9/06/2002	Channel	non biting midge
9/06/2002	Channel	biting midge larvae
9/06/2002	Channel	mosquito larvae
		amphipod

* The site is located on Lawrie Shaw's property.
Details are held on the Waterwatch Database, WRC.

3.1.3 Fish

An unpublished study of riverine fish in the South West of WA found three fish existed in the upper reaches of the Dalyup River. They included the Spotted Minnow (*Galaxias maculatus or Galaxias truttaceus*), Swan River Goby (*Pseudogobius olorum*) and Wallace Hardyhead (*Atherinosoma wallacei*) (David Morgan, Murdoch University, pers. comm., 2000). Black Bream are also found in the lower Dalyup River (Jim Dimer, pers. comm., 2000), and a species was sampled by Water and Rivers Commission in June 2002 north of South Coast Hwy. There is also reports that the Black Bream where trying to head up the Dalyup River after the first initial rain in 2002 (Jenny Murray, pers. comm. 2002).

Wallace Hardyhead (also commonly known as Western Hardyhead) are small fish that are generally an olive-green colour with a silvery sheen on their sides and belly. They are normally seen in schools near the surface or around the shoreline vegetation and log debris. Spawning occurs during spring and summer months. Their diet consists largely of insects and small crustaceans (Allen, 1989).

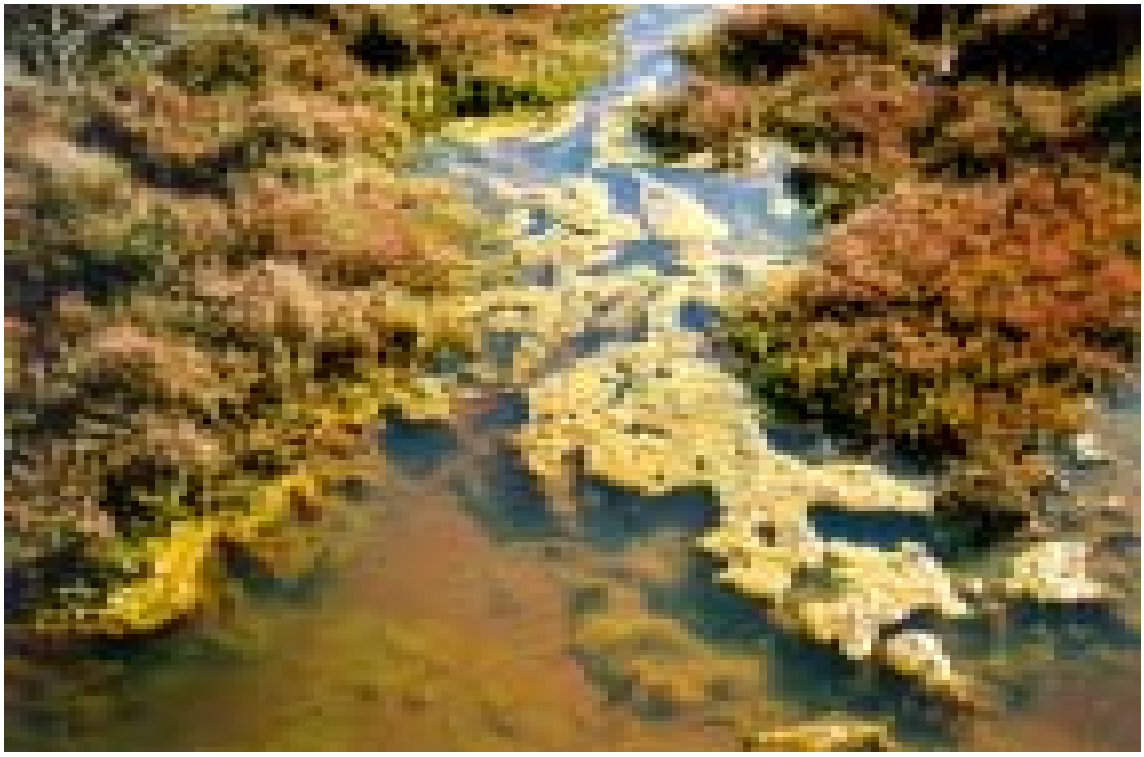
Spotted Minnow *(Galaxias maculatus or Galaxias truttaceus*) are small fish found in a variety of habitats, but most commonly in still or slow-flowing waters – mainly in streams, rivers and lakes within a short distance of the sea. They can survive in salinities up to 50 ppt (Allen, 1989).

Swan River Goby (photograph Kaylene Parker)

Swan River Gobies are fish with a brown or tan colour and narrow darker brown blotches. They are a silvery-white colour on the belly, and the dorsal fins may have irregular blackish stripes. It is found in many parts of Australia and inhabits streams, ponds and brackish estuaries. It is usually found over mud bottoms, sometimes among weeds or adjacent to rocky areas. Spawning occurs during spring, and each female deposit up to 150 eggs. The male guards the eggs during the incubation periods. The larvae then often migrate to fresh water, however there is evidence that some populations are landlocked. Their diet consists mainly of insects, crustaceans and algae (Allen, 1989).

3.1.4 Aquatic flora

There have been no long-term monitoring programs for macrophytes, phytoplankton or algae in the Dalyup river system or Lake Gore. Setter (2000) recorded chlorophyll levels in the Dalyup River and Lake Gore. Chlorophyll levels were all above the ANZECC maximum guidelines of 40 ug/L. The highest chlorophyll concentrations were associated with an algae bloom in Lake Gore that reached over 120 ug/L (Setter, 2000). A green algae species was found in the Dalyup River in 2000 (Plate 7). Excessive growth of green algae species can indicate high nutrient levels in the water.



Green algae species growing in the Dalyup River (photograph Catherine Field)

Aerial view of the Dalyup River (photograph Marek Komarzynski, AgWest)

3.2 Lake Gore

Information sourced directly from " A Directory of Important Wetlands in Australia". Second edition. Australian Nature Conservation Agency, Canberra. Halse, S.A., Jaensch, R.P., Munro, D.R. and Pearson, G.B. 1990.

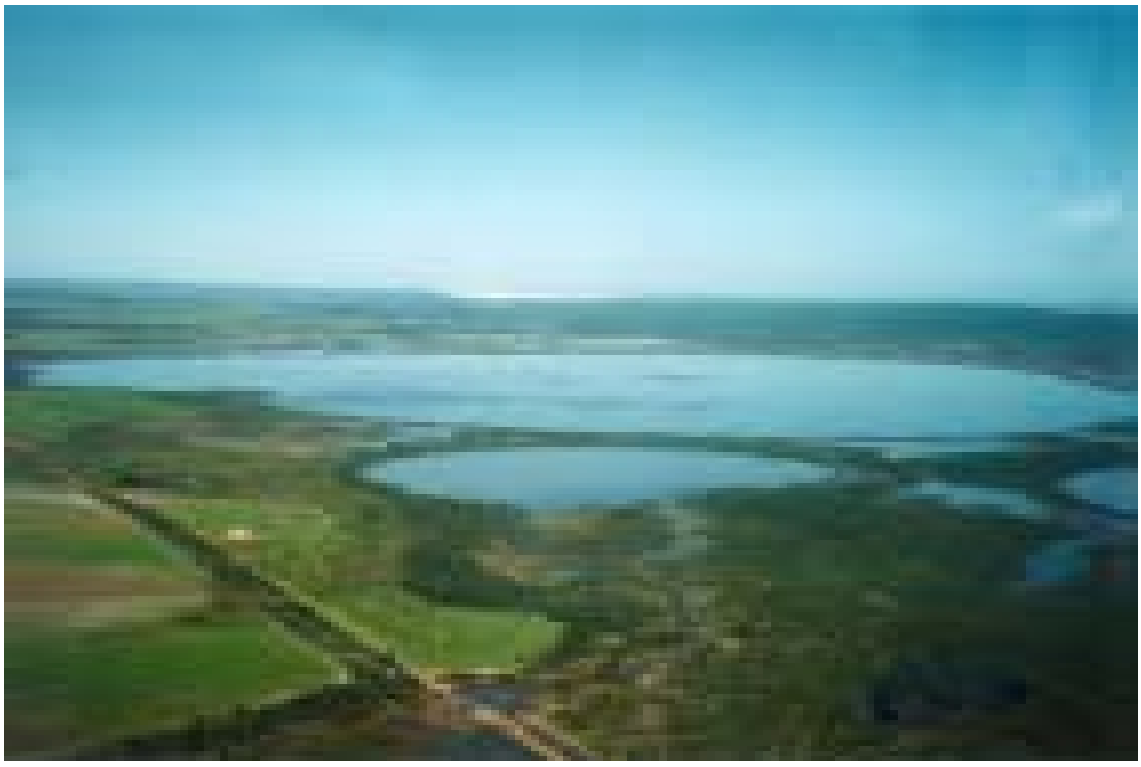
3.2.1 Location of Lake Gore

Lake Gore is in the Shire of Esperance, 34 km west of the town of Esperance. Lake Gore Ramsar Site comprises the entire area of Nature Reserve 32419 and the eastern part of Nature Reserve 26885, which are almost contiguous. The western boundary of the Site is the 'protected road' (unformed track) that provides vehicular access across Nature Reserve 26885 to Warrenup Beach. Wetlands within the Site include Lake Gore and part of a downstream system of inter-connected lakes and swamps of varied sizes ('the overflow wetlands'). Lakes Gidong, Kubitch and Carbul, which are adjacent to Lake Gore, are not in the Ramsar Site; neither are Quallilup Lake or the un-reserved overflow wetlands that connect that Lake to the Site.

The Site comprises a near-permanent saline lake and part of a downstream system of inter-connected lakes and swamps of various sizes, which are intermittently inundated. Lake Gore supports the largest known populations of Hooded Plover *(Thinornis rubricollis)*, it is important for moulting by thousands of Australian Shelduck *(Tadorna tadornoides)* and for drought refuge by thousands of ducks and shorebirds, and supports thousands of Banded Stilt *(Cladorhynchus leucocephalus)*.

3.2.2 Physical features

The Site is situated in the Albany-Fraser Orogen, in alluvial/lacustrine sediments overlying marine limestone and gneiss/sandstone on a sub-coastal plain. It includes a large lake (Lake Gore: 738 ha), and a downstream system of inter-connected small lakes, swamps and creeks ('the overflow wetlands'), all of which are natural wetlands. Water is derived from a relatively large surface catchment, mainly from Dalyup River, Coobidge Creek and minor seasonal streams. The total wetland area downstream of Lake Gore and within the Ramsar Site boundary is about 600 hectares. The greater part of the surface catchment of the Ramsar Site is cleared of native vegetation. Lake Gore is a sub-terminal drainage basin. It is seasonal or near-permanent, sometimes being dry in autumn: maximum depth recorded is 2.0 m (September 1996) and the September mean is 1.4 m. In particularly wet years,



Aerial view of Lake Gore – January 2000 (photograph Marek Komarzynski, AgWest)

which have occurred at least four times in the last 25 years, Lake Gore flows out at two points into the overflow wetlands: at times flow may continue for another 1-2 km beyond the Ramsar Site to Lake Quallilup (a terminal basin) and exceptionally also about 12 km westward beyond the Ramsar Site to Barkers Inlet.

Water may be more than 1.0 m deep in the overflow wetlands and may persist for more than 12 months before drying out, unless there are further floods. The salinity of Lake Gore ranges from 6.5 parts per thousand (September 1989) with a September mean of 52.1 ppt (n=12). The pH ranges from 7.1 to 9.4; and the water is colourless. Water data are from monitoring by the Department of Conservation and Land Management.

3.2.3 Ecological features

Lake Gore and many of the overflow wetlands support a zone (generally narrow, wide in some overflow swamps) of open-woodland of saltwater paperbark *Melaleuca cuticularis* over understorey of the sedges *Gahnia trifida* and *Schoenus brevifolius* at or near the margins (Halse et al. 1993; Lane et al. 1996). Areas of low shrubland dominated by the samphires *Suaeda australis* and *Sarcocornia quinqueflora*, the grass *Sporobolus virginicus* and the herb *Samolus repens*, occur in the overflow wetlands. There is little information on long-term changes to the vegetation though many dead trees in the paperbark woodlands are indicative of prolonged inundation, possibly due in part to increased inflow to the Lake following land clearance in the surface catchment. Surrounding areas support mainly open-scrub or open-heathland, or are cleared.

3.2.4 Noteworthy fauna

More than 29,000 waterbirds have been counted at Lake Gore. The number of individual waterbirds that use the lake each year probably exceeds 20,000 and the annual data on water depth suggest conditions are suitable for use by 20,000 waterbirds at least several times within a 25-year period.

Lake Gore is the single most important wetland for Hooded Plovers. Almost one third of the world population (Rose & Scott 1997) of the Hooded Plover occurs regularly at Lake Gore: the maximum count was 1600 in January 1995. The birds often occur in loose groups and sometimes in dense flocks, along the broad north and north-east beaches of Lake Gore. Few if any have been seen in the overflow swamps and there is no evidence of Hooded Plover breeding anywhere in the Site. Despite many surveys, Lake Gore remains clearly the single most important wetland for this species – although other nearby wetlands, including the Gidong suite of lakes and the Ramsar-listed Lake Warden System (at Esperance), also support hundreds of Hooded Plovers.

Up to almost 10% of the world population of Banded Stilt (20,000 in March 1988) occurs at Lake Gore, usually when the Lake has dried back substantially. This is one of the most important drought refuges for Banded Stilt in South-Western Australia.

Thousands (up to 12,000, November 1986) of Australian Shelduck use Lake Gore each year in spring-summer for moulting. It is one of the most important moulting sites for shelducks in the bioregion. Use by shelducks and stilts indicate that Lake Gore also is one of the most important drought refuges for waterbirds in the bioregion. The highest number of waterbirds counted was 29,273 in March 1988 and though no other counts have reached 20,000 the number of individual waterbirds that use the lake each year probably exceeds 20,000. The most abundant species at Lake Gore are Banded Stilt, Australian Shelduck, Grey Teal *(Anas gracilis)* (3500, December 1987) and Hoary-headed Grebe *(Poliocephalus poliocephalus)* (1000, March 1988). Surveys have recorded 48 waterbird species at Lake Gore and about 33 at the overflow wetlands; 14 are migrant shorebirds. Fairy Tern *(Sterna nereis)* (unusual inland) and Freckled *Duck Stictonetta naevosa* sometimes occur in small numbers. Eight species of waterbirds have been recorded breeding at Lake Gore; several species (eg. Chestnut Teal *Anas castanea*) breed in the overflow wetlands. Most breeding is in wetter years, mainly in samphire and inundated woodland. The most abundant migrant shorebird is Red-necked Stint *(Calidris ruficollis)* – 625 at Lake Gore. Major roost sites for waterbirds in Lake Gore are at the delta-spit of Dalyup River and on rock outcrops (flightless shelducks). The beaches of Lake Gore have red shell deposits of an ostracod (cf *Australocypris* sp.) that thrives in the lake (S. Halse pers. comm.). Data are from Jaensch et al. 1988, Halse et al. 1990, Lane et al. 1996 and data sets held by the Western Australian Department of Conservation and Land Management.

3.2.5 Land tenure/ownership

The Ramsar Site comprises A-Class Nature Reserve 32419 and the eastern part of Nature Reserve 26885, both vested in the Conservation Commission, for the purposes of 'Water and Conservation of Flora and Fauna' (32419), and 'Conservation of Flora' (26885). Reserve 26885 has been proposed as an addition to Stokes Inlet National Park (CALM 1991). Surrounding areas include freehold (privately owned) land, Nature Reserve, Recreation Reserve, Unallocated Crown Land and marine waters.

3.2.6 Current land use, recreation and tourism

The principal land use within the Ramsar Site is nature conservation. In addition, low level recreational use occurs. There are no developed facilities for nature-based recreation within the Ramsar Site. The most important land uses in the surface catchment are agriculture (cereal, other seed crops) and grazing of sheep. Some adjoining areas are reserved for nature conservation. Some recreational fishing by local residents occurs at or near Warrenup Beach, which is also popular for surfing, and the closest beach is Rose's beach (access on track off Murray's Road). Low level recreation occurs, mainly in Reserve 26885 and associated with the coastline (fishing, swimming). There is a lime extraction industry south of Lake Gore.

3.2.7 Factors adversely affecting the site's ecological character

Major algal blooms, probably due to use of agricultural fertilisers in the Dalyup River catchment, occur at Lake Gore from time to time and result in deposits of algal mats on the shores. The impact of these blooms/mats on waterbirds including Hooded Plovers is not known. It is thought that the site's wetlands were naturally saline and that further substantial salinisation probably will not occur. Dead trees in the paperbark woodlands are indicative of prolonged inundation, possibly due in part to increased inflow to the Lake following land clearing in the surface catchment. Eutrophication and salinisation are significant threats in surrounding farmland and wetlands. Changes in agriculture are possible, eg. possible establishment of tree plantations, which if extensive may reduce surface and ground water inputs and input of nutrients and salt.

3.2.8 Conservation measures taken and proposed (but not yet implemented):

Cooperative management of parts of the surface catchment, with substantial community participation (Dalyup Catchment Group), is occurring under the federally funded Landcare program. The Water and Rivers Commission is preparing an Action Plan with the Dalyup Catchment Group to protect the Dalyup River. This work includes foreshore surveys of the Dalyup and West Dalyup rivers and tributaries and the development of recommendations addressing management issues. Most of the shoreline of Lake Gore has less than 50 m of buffer zone within protected areas. There is some local interest in the surface catchment becoming designated as a 'Key Wetlands and Natural Diversity Catchment' under the Salinity Action Plan for Western Australia and in the Site becoming part of a continuous 'macro-corridor' of natural lands, including protected areas, along the South Coast between Albany and Esperance. There is potential to extend the Ramsar Site in the future, subject to resolution of land tenure and other issues. A strip of land oriented east-west and approximately 686 m wide inside the northern boundary of Nature Reserve 26885 is excluded from the Site in anticipation of possible future exchange of this land for freehold land that may be added (subject to negotiation with and voluntary agreement of the present owner) to Nature Reserve 32419, and which would substantially enhance the conservation values and management of the wetlands

3.2.9 Current scientific research

The Western Australian Department of Conservation and Land Management has measured depth, salinity and other water quality parameters at least annually at Lake Gore since 1979. Waterbird usage was surveyed annually during 1981–91, with an emphasis on shorebirds and ducks (e.g. Jaensch et al. 1988, Halse et al. 1990). Birds Australia has undertaken intensive study of the Hooded Plover at Lake Gore and elsewhere in the bioregion. Murdoch University and the University of Western Australia have undertaken research on classification and management of the Coobidge Creek wetlands. Also see items 21 and 26. Since 1994, depth, salinity and other water quality parameters have been measured at Lake Gore every three months by the Esperance Senior High School as part of a 'Ribbons of Blue' community-based water monitoring program. The Site is difficult to access without a 4-wheel-drive vehicle.

4 Condition of the Dalyup and West Dalyup rivers

The Dalyup River system is showing signs of degradation similar to other rivers in Western Australia (table 11). Using the *Statewide Waterway Needs Assessment* (Water and Rivers Commission, 2002), the Dalyup and the West Dalyup rivers would be rated as having a low value, a low-pressure response, and a low condition. Lake Gore however would have a high value, with a low-pressure response, and a medium condition.

Overall the Dalyup River system is in medium to poor condition. The health of the vegetation along the river is declining and in many sections the riverbanks are unstable resulting in severe erosion and sedimentation. A delta of sediment is visible in Lake Gore. In the upper catchment, rising groundwater levels and changed catchment hydrology is increasing areas affected by secondary salinity and waterlogging. This is the major threatening process to the long-term health of the river. Flood events in 1999/2000 highlighted the problems the river is facing, and considerable damage occurred including formation of secondary channels, head-cuts and severe erosion across farmland.

There are however, some sections of the Dalyup and West Dalyup rivers in good to excellent condition with foreshore vegetation grading of A and B grade. In addition, almost every farmer surveyed had conducted some river restoration works on their property and had planned to conduct further works in the future. In particular, 450 km of fencing has been completed along waterways in the catchment and most of the Dalyup and West Dalyup rivers are fenced. Two hundred and sixty seven hectares of revegetation has been completed in the catchment, and land managers planned a further 246 hectares. Most of the Dalyup River system is fenced (table 12).

Potential significant long-term threats to Lake Gore and its associated wetland system include eutrophication, sedimentation and salinisation. Major algal blooms have occurred in Lake Gore from time to time and result in deposits of algal mats on the shores. The impact of these blooms/mats on waterbirds, including Hooded Plover, is not known. Dead trees in the paperbark woodlands are also indicative of prolonged inundation, caused by an increased inflow to the lake following wet years.

4.1 Condition of foreshore vegetation

Foreshore vegetation (also termed riparian vegetation) is the vegetation found along waterways. This is responsible for maintaining the health of the system. The vegetation provides habitat for a large range of animals. It supports the soil that sustains it as the root systems form a matrix that holds the riverbank together. The vegetation also drops leaves into the water providing a food source for aquatic animals and provides shade and habitat as well. If the vegetation is removed, erosion increases, weeds take over, rabbits become more plentiful and native aquatic animals such as fish start to decline.

The foreshore vegetation condition was assessed as part of the river survey conducted on the West Dalyup and Dalyup rivers in 2000. Extensive areas of riparian vegetation along the Dalyup and West Dalyup rivers and tributaries in the catchment are degraded due to clearing, grazing, weed infestation, drainage, salinisation and bank erosion. There are however, some sections of riparian vegetation in good to excellent condition.

Table 10. Foreshore vegetation condition of the Dalyup and West Dalyup rivers

Vegetation condition	Hectares (ha)	Percentage of total ha (%)	Total (%)
A1	0	0	A grade = 9.6
A2	26.8	1.4	
A3	160	8.2	
B1	395	20.2	B grade = 53.9
B2	416.32	21.3	
B3	241.83	12.4	
C1	140.5	7.2	C grade = 21
C2	151	7.7	
C3	119.4	6.1	
D1	166	8.5	D grade = 14.4
D2	70.3	4	
D3	37	1.9	

The results of this survey may be slightly misleading, as the survey recorded the area of the vegetation (%), rather than traditional foreshore surveys that compared condition of the river to channel length. This was not possible for this survey, as the river channel was extremely wide in the upper catchment.

Table 11. Summary of waterways degradation issues for waterways in the Dalyup catchment

	Waterways Issues	Cause/pressure	Current Status
Waterway Condition	Nutrient enrichment	Domestic sewerage in the lower catchment, fertiliser uses in the agricultural areas.	• Total phosphorous and total nitrogen levels are higher than ANZECC guidelines in previous monitoring programs. Algal mats have been noted at Lake Gore. • No long term monitoring to detect changes or determine impacts.
	Foreshore vegetation	The major threatening processes to the health of the riparian vegetation is secondary salinisation and stock grazing.	• Foreshore vegetation condition (% area) - A Grade = 10%, B Grade = 54G= 21%, D Grade = 14%.
	Exotic plant and animal invasion	Garden escapees, agricultural weeds.	• Feral cats and foxes in the catchment are impacting on native wildlife. • Rabbits are a particular problem on the sandplain causing severe damage to native vegetation and hindering rehabilitation. • Weeds dominate cleared areas that have, or are being grazed and areas impacted heavily by the flood. Major weed species include African Love Grass and Bridal Creeper (lower catchment).
	Stream salinisation, waterlogging and stream flow changes.	The catchment is approximately 90% cleared. Land managers recorded 5187 ha of the catchment being affected by secondary salinity. AgWest have shown that watertable levels are rising on average 0 – 55cm per year (AgWest, 2001). Resulting in increased groundwater flows, increased catchment discharge (estimated 2 to 4 times more runoff).	• Waterlogging, inundation and salinity is causing loss of riparian vegetation, particularly Yate trees and many understorey species, particularly in the valley floors in the upper catchment. • Lake Gore is under threat from increased water flow in the catchment following clearing. Rising water levels could inundate surrounding vegetation and destroy important waterbird habitat. • Increased flood risk (see floods) due to changed catchment hydrology has the potential to result in further loss of culverts, bridges and fencing as evident in the 1999 and 2000 floods.
	Erosion and sedimentation	Altered catchment discharges and loss of vegetation. Channel deepening and widening, instream erosion and sedimentation, loss of river pools.	• Dalyup River is becoming wider and deeper resulting in further bed and bank erosion. • Numerous headcuts are spreading up the Dalyup, West Dalyup and associated tributaries. New channels have formed along the river where it has deviated from its natural course. • Many river pools in the main Dalyup and West Dalyup rivers have started to fill with sediment (obvious after the flood events). • Sediment plumes are visible in Lake Gore.
Waterway Pressures	Land development – residential, agriculture	Increased intensification in the lower catchment. Inappropriate boundary locations due to historical settlement of the area, particularly in farms south of the catchment. Broadacre farms becoming bigger in the upper catchment.	• Lower catchment – increased pressure to use floodplains for agriculture. Increased risk of flood damage to property. • Upper catchment – increased farm size often inhibits landcare efforts as time and funding becomes limiting.
	Pollution from point-sources	No industrial development in the catchment. Some intensive feed lot properties in the upper and lower catchment. Also community concerns about pesticides and herbicides. Some refuse tips are located close to the river.	• Nutrient enrichment is the major point source of pollution impacting waterways in the catchment. • The impact of pesticides and herbicides on the health of the waterways is unknown. • Impact of tips on the health of the waterways unknown, but could is contaminated ground and surface water.

Table 11. Summary of waterways degradation issues for waterways in the Dalyup catchment (cont)

	Waterways Issues	Cause/pressure	Current Status
Waterway Pressures (cont)	Water development	No water development along the river.	• None.
	Recreation	No recreational pressure in Lake Gore as it is a Conservation Estate. Some recreational day use by local residents of the Dalyup Pioneer Reserve.	• Small localised impact at Pioneer Reserve.
	Commercial fishing	No commercial fishing.	• None
	Water abstraction, industrial discharge	No industrial discharge or water abstraction.	• None
	Drainage (saline land drainage)	Many inappropriately designed deep drains in the upper catchment, and there are plans for more drains to be implemented. Community opinion differs on how to address salinity and waterlogging issues.	• Deep drains are causing soil erosion and sedimentation of waterways in the upper catchment.
Waterway Values	Economic benefits	Possibly increased farm values with river frontage and waterways in good condition. Loss of productive land due to salinity and waterlogging.	• Incentive to complete restoration activities.
	Recreation		• Low recreational values for the river, none for Lake Gore.
	Aesthetics		• Medium values, land managers that own the river have higher values of the river.
	Uniqueness		• Relatively typical river system in Sandplain area in the Esperance District.
	Spirituality and cultural values		• Little known about social and cultural values of the waterways. • No ethnographic or archaeological studies completed in the area to determine the importance/ connections to the river by indigenous Australians.
	Biodiversity/ conservation values		• Low biodiversity values for the river system. Lake Gore – significant environmental values, as it is a RAMSAR wetland with international significance.
Management Response	Regional or town planning schemes		• Esperance TPS 22 Limited Rural Strategy covers the Dalyup Catchment. • Town Planning scheme is currently being updated. Community action • Subcatchment groups have previously applied for funding from NHT to complete restoration works • 450 km of fencing completed along waterways, 66 km of proposed fences. • 267 ha of revegetation completed in the catchment, 246 ha of revegetation proposed by land managers.
	Technical support programs (Agency)		• State of the Dalyup Catchment 2000 (AgWest, 2001) • Dalyup River and West Dalyup River Action Plan (2002).
	Funding programs		• Funding opportunities are likely to increase due to Lake Gore being a RAMSAR wetland.
Overall Condition	Highlight lowlight		• The Dalyup and West Dalyup rivers are rated overall as medium to poor condition. Lake Gore is an internationally-recognised wetland hence is a 'high' priority for protection.

Many land managers within the Dalyup Catchment are trying to protect their waterways by fencing the riparian vegetation. The majority of both the Dalyup and West Dalyup rivers (main channels only) are fenced from livestock, however many sections have been lost during the 1999 and 2000 flood events.

4.2 Erosion and sedimentation

The Dalyup and West Dalyup rivers and associated tributaries are experiencing severe bank instability problems resulting in bank erosion, subsidence and subsequent sedimentation of river pools. Erosion of unstable banks is resulting in river pools being filled with sediment, channel widening, retarded streamflows, silted up channels and lateral erosion.

There are extensive plumes of sediment visible along the Dalyup and West Dalyup rivers. Aerial photographs show a delta of sediment deposited in Lake Gore from the Dalyup River. Sedimentation of river pools is a major concern and as sediment moves downstream and catches up with one another, forming a long slug that can smother aquatic habitat and fill river pools (Pen, 1999).

Undercutting of the banks, subsidence and massive erosion is a major issue in the lower to middle reaches of the Dalyup and West Dalyup rivers. It is a particular problem on the West Dalyup River – downstream of Boydells Road and on the Dalyup River, downstream of Speddingup West Road. It is particularly severe at the junction of the West Dalyup and Dalyup rivers to Lake Gore. The sandplain soils seem to be more prone to erosion and thus siltation problems. The more stable mallee soils and lower slopes in the upper Dalyup catchment make this area less susceptible to erosion. Numerous headcuts are visible in paddocks adjoining the Dalyup and West Dalyup rivers and associated tributaries. These are particularly obvious in the middle and lower catchment where the slope of the land is greater. Headcuts will continue to erode if not managed and will cause a chain of small headcuts until they are stabilised.

The shift of a stream channel where the river "jumps" out of its natural course to form a secondary channel is termed lateral erosion. Many farmers noted extensive lateral erosion after the 1999 and 2000 floods where the river channel eroded adjacent cleared paddocks. There were also numerous incidents of erosion of tracks (particularly those leading to river crossings), firebreaks and exposed sandy areas noted during the Dalyup and West Dalyup rivers survey.

4.3 Salinisation and waterlogging

Early history of the Dalyup area suggests that the Dalyup River was naturally saline even when the first settlers arrived in the late 1890s. Salt has been naturally accumulating in the soils of the Dalyup catchment over thousands of years. The clearing of native vegetation in the catchment and its replacement with lower water using annual crops and pastures has allowed more water to pass into the groundwater aquifers causing the watertable to rise and mobilised the salt in the soil bringing it to the surface. These changes have generated land degradation problems associated with salinity such as water erosion (sheet, rill and gully erosion), waterlogging, inundation and flooding.

Secondary salinity has the potential to continue, degrading waterways and agricultural land in the catchment. Salinisation impacts on the health of waterways by increasing the salinity of the river, degrading foreshore vegetation and increasing erosion.

Table 12. Fencing completed on the Dalyup and West Dalyup rivers

	Total River length (km)	Fenced left bank (km)	Fenced right bank (km)
Dalyup River(Griffiths Rd)	48	33 (69%) 15 km remaining to fence	44 (92%) 4 km remaining to fence
West Dalyup River(in section of Dalyup River to Raszyk Rd)	41	36 (88%) 6 km remaining to fence	32 (78%) 9 km remaining to fence
Major tributary(to Norseman/ Esperance railway line)	24	17 (71%) 7 km remaining to fence	22 (92%) 2 km remaining to fence

*** looking upstream to determine left and right bank*

Bank of the Dalyup River showing a channel that is incising and becoming deeper. Note the Yate and how it has retained some of the soil in its root system (photograph Kaylene Parker).

The West Dalyup River – showing widening and braiding. There is little or no vegetation to help stabilise the banks (photograph Kaylene Parker).

Dalyup River – A River in a Landscape

Steve Janicke, Water and Rivers Commission

Steve Janicke undertook a fluvial geomorphology survey of the Dalyup and West Dalyup rivers in 2000. The survey covered the Dalyup River from Lake Gore to Brownings Road and the West Dalyup River from its junction with the Dalyup River to Brownings Road. The survey recorded floodplain and channel features including erosion points, areas of severe subsidence, sediment loads in the river system, headcuts, and the actual form of the river.

The survey outcomes indicated that the type and extent of vegetation were critical factors in maintaining stable river channels and flood plains. The survey noted that rocky and 'V'-shaped valleys in the middle sections of both branches of the Dalyup were more stable – upstream and downstream – than the broader floodplain areas, although in many places the sides of the valleys showed signs of severe weakening and erosion.

The survey recorded where the floods had widened the channel. It could be seen in some areas that the native vegetation, particularly sedges, rushes and other shrubs held the banks and bed material in place against the considerable force of the floods. The floods quickly stripped away pasture and weedy areas first and then huge quantities of soil.

The creation of new flood channels was particularly evident in the 10 km-section of the river immediately upstream of Lake Gore. Water flowed out of the existing channel, formed new pathways and exposed the existing strengths and weaknesses of the floodplain.

Erosion and sedimentation are a consequence of increased runoff due to catchment clearing and degraded foreshore vegetation (Pen, 1999). An increase in runoff means a wider and deeper channel forms to cope with the increased volume of water. The process of building a bigger channel results in active erosion of the riverbanks and the riverbed.

Land managers mapped 5187 ha of land impacted by secondary salinity or 6.3% of the catchment (AgWest, 2001). The majority of this landscape is within the Es3 soil-landscape – which is the low-lying valley floor areas. Over half of this area is mapped as being saline. Groundwater rise in the catchment is estimated at between 0 – 55 cm per year.

Waterlogging is also impacting on many areas of the catchment (waterlogging often corresponds with salinity). Many areas along the waterways that would have normally dried out immediately after rain, now remain waterlogged for longer periods (Pen, 1999). The effect of waterlogging, together with salinisation is shown as dead and dying trees along many tributaries of the Dalyup and West Dalyup rivers. The Yate tree, (*Eucalyptus occidentalis*), is particularly sensitive to salinity and inundation.

Lake Gore is also under threat from excessive inundation due to major floods and increased water flow in the catchment following clearing (SCRIPT, 1997). An increase in the depth of the water in Lake Gore over the last decade has caused the death of about 20% of the existing paperbarks around the lake and also affected trees in the adjoining Overflow Swamp (Halse et al., 1993). It is predicted that this problem will worsen in the future.

4.4 Catchment hydrology changes

Since the land has been cleared, there are greater volumes of water draining from the catchment into the waterways. This is resulting in changes in the surface water and sub-surface processes in the Dalyup landscape. In particular, catchment hydrology changes are likely to result in:

- larger volumes of runoff;
- faster surface flows;
- higher peak flows during floods (high water levels during floods);
- shorter periods of peak flows (high velocity of water flow);
- siltation (flood water slows down and drops suspended soil particles);
- more water entering the groundwater system;
- higher proportion of waterlogged areas;
- increase in frequency of waterlogging and inundation; and
- increase in areas affected by groundwater discharge and salinity.

The Dalyup and West Dalyup rivers are unstable due to catchment hydrology changes. There may be increased flood risks as the water velocity and volume increases. This means there is a greater risk of damage to fences and riparian vegetation placed in flood plains. Further impacts of catchment hydrology changes include increased areas affected by salinity and waterlogging.

4.5 Water quality and nutrient enrichment

Nutrient enrichment is evident in many waterways of the catchment. Samples taken by AgWest show that nutrient levels were above ANZECC guidelines.In addition to this, Setter (2000) found nutrient levels were higher at the bottom of the catchment than the top. This could possibly be due to more intensive settlement and farming on the lower section of the catchment with approximately 30 landowners located within 15 km of Lake Gore. This intense settlement could mean greater domestic waste (sewage) and more intensive livestock enterprises are contributing to nutrient levels. Algae mats have been noted at Lake Gore with a number of blooms recorded during winter months.

4.6 Weed Invasion

Extensive weeds exist along the Dalyup and West Dalyup rivers, particularly in areas impacted by the 1999 and 2000 flood events. Local farmers suggested that 1999 and 2000 flood events resulted in weeds spreading into areas where they previously did not exist. Weeds are successful because of their ability to establish and reproduce quickly. They are often 'disturbance opportunists' that invade disturbed areas rapidly before the native vegetation has a chance to establish (Hussey et al., 1997). Weed dispersal can occur through animals, wind and water. This presents a problem in many areas as weeds can infiltrate the remnant through no fault of the land manager. A list of common weeds found along the rivers is summarised in table 13.

Table 13. Weeds recorded on the Dalyup and West Dalyup rivers

Common Name	Botanical Name
African Lovegrass	*Eragrostic curvula*
Annual Veldt Grass	*Ehrharta longifolia*
Afghan weed	*Solanum hoplopetalum (PP)*
Black berry Nightshade	*Solanum nigrum*
Bridal Creeper	*Asparagus asparagoides*
Capeweed	*Arctotheca calendula*
Doublegee	*Emex australis (DP, PP)*
Flaxleaf Fleabane	*Conzya bonariensis*
Geranium	*Erodium* sp.
Prickly Paddy Melon	*Cucumis myriocarpus (PP)*
Stinkgrass	*Eragrostis minor*
Spear Thistle	*Cirsium vulgare*
Tall wheatgrass	*Thinopyrum elongatum*
Tumbleweed	*Amaranthus albus*
Wild Oats	*Avena fatua*
Wireweed	*Polygonum aviculare*
	Hypochaeris sp.
	Spergula salina

DP = Declared Plant
PP = Pest Plant

5 Management recommendations

Waterways in the Dalyup River catchment face a myriad of challenges. There are many management techniques to address degradation of waterways including protecting foreshore vegetation, revegetation, channel stabilisation, and the management of water on-farm. It may include erecting appropriate signs, building walk trails or increasing awareness of the rivers' values. A summary of management recommendations to protect the Dalyup and West Dalyup rivers is provided (Table 14) and is further explained in this section of the report. In addition, specific management recommendations for sections of the rivers are included in Section 7.

Some activities may require approval from relevant management agencies. There are laws covering the management of a river's drainage, flood management, and protection of wildlife and heritage, including Indigenous heritage. For clarification of legal matters and the need for coordination in a particular area, contact the Water and Rivers Commission's office in Albany.

5.1 Fencing

Controlling access of livestock to waterways is a simple management decision that will improve the condition of a waterway. It is generally recommended that riparian zones are fenced to completely exclude stock – particularly where the river is steep and where the embankments are poorly to moderately cohesive. In lower order streams, fencing may be used to manage stock to encourage paddock management of the issues.

In the Dalyup catchment, many fences were lost in the 1999 and 2000 flood event and farmers have spent large amounts of capital replacing these fences. Fences should be located away from the floodway of the river where they will not be damaged by high velocity flows. It is a good idea to note the flood water levels or where secondary channels formed during the previous floods and place fences outside of these areas. It also makes sense to note the stability of the riverbank – and if the riverbanks are actively eroding or headcuts are forming – then fences will need to be placed further back.
Fencing across waterways is common along the Dalyup and West Dalyup rivers. These are more likely to be

Dalyup Catchment Group discusses various options to control headcuts on the Dalyup River (photograph Jodie Oates,WRC).

Table 14. Waterways management issues and recommended remedial actions

Waterways Issues	Recommendations/Actions
Nutrient enrichment **Water quality issues**	• Monitor water quality to identify hotspots and determine long-term trends in salinity and nutrient levels. • Develop a monitoring program to assess the levels of pesticides and herbicides in waterways in cooperation with chemical companies.
Exotic plant and animal invasion	• Coordinate fox, feral cat and rabbit control programs in the catchment. • Control and manage weeds in riparian zones, particularly invasive weeds and those weeds as required under existing legislation.
Degradation of foreshore vegetation	• Fence and revegetate areas identified in the foreshore survey (section 7). • Obtain funding to help land managers implement on-ground works to protect waterways in the catchment. • Develop a catalogue of species and methods used in successful revegetation projects in the catchment, particularly in saline areas. • Develop a fire management strategy for the Dalyup and West Dalyup rivers in cooperation with CALM, Bushfires WA and local bushfire brigades that encourages natural regeneration and protection of riparian vegetation.
Stream salinisation and waterlogging.	• Monitor groundwater levels across the catchment to assess groundwater rise. • Revegetate saline river valleys with salt tolerant species, and increase the buffer width to allow for groundwater rise. • Increase water use throughout the catchment through perennials, surface water management, management of waterlogged and water-repellent soils (AgWest, 2001). • Design and implement suitable water management options throughout the catchment, in particular appropriate surface water management options.· Increase buffer width around Lake Gore to compensate for increased catchment discharge.
Stream flow changes/flooding	• Extend buffer widths of saline creeks to ensure they are adequate for flood events and where possible incorporate floodplains into the protected areas. • Assess options to develop flood mitigation devices in the upper catchment to slow water during high flow periods. • Encourage land managers to manage flood paddocks to minimise the risk of flood damage by planting perennial vegetation and woody perennials. • Main Roads and the Shire of Esperance design culverts and bridges take into account changed catchment hydrology.
Drainage	• Develop appropriate design criteria for deep drainage, and determine the most appropriate location in the catchment. • Increase community awareness of various water management options in the catchment.
Erosion and sedimentation	• Restore actively eroding banks and headcuts as identified in the foreshore survey (Section 7). • Redesign firebreaks, access tracks and crossing points to minimise the risk of erosion. • Protect and restore riparian vegetation as identified in the foreshore survey to help protect banks from further erosion (Section 7). • Where channels are filled with sediment, encourage establishment of vegetation to help channels re-form naturally. Excavation of channels is not sustainable, as they will simply fill in.
Social, cultural and heritage values	• Capture the cultural, social and historical values of the waterways in the catchment, including Indigenous heritage. • Conduct field tours and community eduction programs to raise awareness of waterway degradation issues and the best-practice management. • Increase community understanding of the waterways in the catchment through community walks, information evenings.
Land use planning	• Encourage the Shire of Esperance to develop appropriate development guidelines in the Dalyup Catchment. This is to include appropriate buffer zones, re-design of lot boundaries to protect the river, and specific guidelines for intensive agricultural industries.

Table 14. Waterways management issues and recommended remedial actions (continued)

Waterways Issues	Recommendations/Actions
Community action	• Continue to implement existing NHT applications. • Identify future funding sources through SCRIPT (Southern Incentives), NHT, Salinity Action Plan, Gordon Reid Foundation. • Implement recommendations in the Dalyup River Action Plan (Water and Rivers Commission, 2002), and the State of the Dalyup Catchment (AgWest, 2001). · Continue to develop subcatchment and catchment groups.

A vision for the Dalyup River in a Landcare Catchment

(Modified from Pen, 1999)

The Dalyup River Catchment Group is leading the way in looking after their productive farming land whilst protecting the natural resources of their catchment – including the Dalyup and West Dalyup rivers and Lake Gore.

The group is achieving a hydrological balance by controlling drainage and groundwater recharge. In the upper catchment great use is made of perennial pastures, fodder crops, contour cultivation and contour banks. Remnant vegetation is protected, and tree plantations including Blue gums and Mallees have been established to reduce groundwater recharge in strategic areas. These species harvest the extra water in the catchment, and provide an extra income. To further reduce groundwater recharge, perennial pastures, annual pastures and crops are rotated – dependent upon the rise and fall of the groundwater levels – monitored by land managers monthly. Productivity is improving as the perennial pastures are putting nitrogen back into the soil and the deep roots are helping to improve soil structure. In addition, waterlogged and saline areas are improving as more water is used higher up in the landscape.

All of the minor drainage lines are strengthened with perennial pasture or fodder crops and where necessary have been managed or fenced off to protect both planted and naturally regenerating vegetation.

Flood plains – the areas where the water often spills onto the farmland during floods – are managed differently to the rest of the paddock and a variety of perennial fodder crops help stabilise the soil whilst producing stock fodder . Land managers carefully graze these areas but ensure that the stock is removed when the plants are not regenerating.

Finally, broad well-vegetated and fenced off riparian lines have been created along the Dalyup and West Dalyup rivers to protect the major river system from further erosion. These riparian corridors are wide and often include the floodplain – the area where water spills into the catchment during times of flood.

Although the runoff is greater and swifter in this catchment, the perennial vegetation, remnant vegetation, riparian vegetation and the surface water management techniques are still slowing it significantly. The severities of the floods are reduced as the catchment holds some of the water in the upper catchment, and releases it slowly over the few days after the flood. This is helping to protect Lake Gore, the RAMSAR wetland of international significance at the bottom of the catchment.

Each member of the Catchment is proud of the healthy condition of the Dalyup and the West Dalyup rivers. Children in the catchment plant trees along the river each year and regularly monitor the health of the river.

damaged than those fences running parallel to the direction of the water. Posts or markers located either side of the river could be a cheaper and more effective method of designating a boundary line rather than trying to have a fence across the river. Also fencing across the river would not be required if land managers upstream and downstream also fenced their rivers. In some cases the boundaries of properties could be renegotiated with neighbours so that one neighbour 'owns' or 'manages' the river rather than having a boundary fence through the middle of the river. In some cases the realignment of paddock fences is needed so that paddocks run alongside and not across the river.
It is advisable to use plain wire when fencing along the river to reduce resistance. Ringlock holds the debris better than plain wire and therefore has an increased chance of surviving a flood. Using fence posts angled at 45^{o} and simple low-cost sacrificial fencing in the floodplain will help to protect fences during flood events. Some types of low cost sacrificial fencing include star pickets with plain wires, fences that use polypipe posts and low-level electric fences. Star pickets located within the floodway should be braced with short 'tie downs'. These tie downs consist of two 60 cm-long star pickets inserted at 45^{o} angles at the base of the vertical picket to increase the fence's withstanding force.

5.2 Crossing construction

Following the flooding of the Dalyup and West Dalyup rivers in 1999/2000, almost all the river crossings on the two main channels where washed away. This included concreted crossings, large bridges and rock crossings. The majority washed away due to the poor design and location of the crossing. This is a considerable expense for land managers and the Shire of Esperance in addition to causing further degradation of the downstream waterways.

Crossings should be established where sediment deposition is occurring rather than erosion, and where the bedrock is rocky and hard. The crossing should preferably use the existing base of the channel and be lined with small stones rather than installing culverts, which increase the erosive power of the water downstream. The following are some basic principles for crossing design.

1. *Firm foundations* – choose a site that has stable soil or visible rocks in the river. Sandy bottoms and river pools are the worst locations, with rock sheets and clay soils being the best.

2. *Straight river section and crossing* – choosing a straight section of river is important if the crossing is to survive big storm events and floods. Putting a crossing on a bend means that in high flows the erosive force of the river acts mainly on one point

Flood proof fencing on the Dalyup River – note the fence posts are polypipe that will flex during flood events. This section of fencing also has different strainer posts than the fencing along the river, hence won't drag the rest of the fence if impacted by a flood event (photograph Kaylene Parker, WRC).

of the crossing rather than equally on all points of the crossing if on a straight stretch of river. Crossings on bends will wash out more often than crossings on straight sections. Similarly the crossing should be placed straight across the river and not on an angle or the same principle will apply.

3. *Angled approach roads* – roads that head straight down a steep river embankment are more likely to erode. Therefore, build an approach road across and angled down towards the embankment to minimise erosion of the road.

4. *Crossing materials* – heavy, small rocks are probably the best materials that most land managers land managers have readily available, however, some use concreted meld mesh. It is important to ensure a mixture of sizes.

5. *Height of crossing* – keep the crossing low and flat so that when high flows occur the water flows over the top of the crossing and not through the crossing. A rocky crossing that follows the stream contour is more likely to survive high flows than a culvert.

For further information on designing river crossings please read Water Note 6 *Livestock Management – Construction of Livestock Crossings* or phone the Water and Rivers Commission in Albany on (08) 9842 5760.

5.3 Revegetation

Riparian vegetation along a river is important because it helps combat erosion – necessary for the maintenance of habitats, bio-filtering and ecological corridor functions of the river, to combat erosion and preserve the riverine landscape (APACE and Pen, 1995). Some sections of the Dalyup and West Dalyup rivers are devoid of vegetation and need intensive rehabilitation. Where large buffer zones have been recently fenced out, and grazed land has been incorporated into the buffer zone, weeds dominate. These sections are ideal for rehabilitation by either direct seeding or seedlings.

In the upper catchment or along floodplains, there may be opportunities to graze lower order streams or manage these differently than the rest of the paddock. These can be planted out to high water-use pastures that could be grazed or harvested. There are various species that can be used to increase water use in these areas including *Acacia saligna*, Sorghum, Kikuya or Lucerne. These species not only increase the water use in the low-lying areas, but also stabilise soils during winter flow periods or flood events. Management of streams in the upper catchment is challenging, especially since many of these are showing signs of secondary salinity. This reinforces the whole-of-catchment approach needed to protect waterways in the catchment.

Crossing on Sue and Peter Smithson's property. This is an excellent example of a crossing as it has many small and varied sized rocks, follows the contours of the river and is located in a relatively straight section of the waterway. This design is recommended, as it is more likely to survive flood events and cause less erosion and sedimentation. The rocks cause the water to trickle downstream adding oxygen to the water that is important for aquatic fauna (photograph Kaylene Parker, WRC).

There are successful revegetation sites throughout the catchment that have used a variety of species including, native trees, pine trees and salt bush. Some suitable species that can be used for revegetation are listed in figure 17. Advice on suitable species can also be obtained from local nurseries and the Bushcare Officer.

5.3.1 Rushes and sedges

These unnoticed plants are a vital component of foreshore vegetation. Rushes and sedges are excellent species for stabilising slopes, filtering nutrients and sediment out of the water and providing habitat for animals such as frogs and fish. They also are an excellent plant species for rehabilitation of actively eroding banks and headcuts. The most common rush and sedge species found along the Dalyup and West Dalyup rivers' channels are described below:

Table 15. Native tree and shrub species suitable for revegetation of waterways in the Dalyup catchment

Botanical Name	Form	Preferred Site	Mallee (M) or Sandplain (S)
Acacia acuminata	Tree	Granite	S
Acacia cyclops	Tree	Sandy/loam saline	S M
Acacia saligna	Tree	Sandy/loam saline	S M
Allocasuarina huegeliana	Tree	Sandplain/Granite	S
Banksia nutans	Shrub	Sandplain	S M
Banksia speciosa	Shrub	Deep sand	S
Calothamnus quadrificus	Shrub	Granite	S
Dryandra armata	Shrub	Granite	S
Eucalyptus anceps	Mallee tree	Mallee soils	M
Eucalyptus angustissima	Mallee tree	Sandy/loam saline	M
Eucalytpus angulosa	Mallee tree	Sandy/loam saline	S M
Eucalyptus densa	Mallee tree	Mallee soils	M
Eucalyptus flocktoniae	Mallee tree	Mallee soils	M
Eucalyptus forrestiana	Mallee tree	Mallee soils	M
Eucalyptus kersellii	Mallee tree	Mallee soils	M
Eucalyptus occidentalis	Tree	Sandy/loam saline	S
Eucalyptus redunca	Mallee tree	Mallee soils	M
Eucalyptus tetragona	Mallee shrub	Sandplain	S
Eucalyptus uncinata	Mallee tree	Sandplain	S
Grevillea paniculata	Shrub	Sandplain	S
Hakea adnata	Shrub	Sandy/loam saline	S M
Hakea laurina	Shrub	Granite	S M
Hakea lissocarpha	Shrub	Sandplain/Granite	S
Hakea nitida	Shrub	Sandplain	S
Isolepis nodosa	Sedge	Sandy/Loam saline	S
Isopogon polycephalus	Shrub	Sandplain	S
Lambertia inermis	Shrub	Sandplain	S
Melaleuca brevifolia	Shrub	Sandy/Loam saline	S
Melaleuca cuticularis	Shrub	Sand/Loam saline	S
Melaleuca pulchella	Shrub	Sandy/Loam saline	S M
Melaleuca striata	Shrub	Sandplain	S
Melaleuca uncinata	Shrub	Granite	S M
Nuytsia floribunda	Tree	Sandplain	S
Templetonia retusa	Shrub	Sandplain/coastal	S

Table 16. Sedge and rush species suitable for revegetation of waterways in the Dalyup catchment (wet saline areas)

Common Name	Botanical Name	Propagation Technique
Pale Rush	*Juncus pallidus*	Seed
Shore Rush	*Juncus kraussii*	Seed
Bare Twig Rush	*Baumea juncea*	Tissue culture, division
Jointed Twig Rush	*Baumea articulata*	Tissue culture, division
Coastal Saw Sedge	*Gahnia trifida*	Seed
Knotted Club Rush	*Isolepis nodosa*	Seed
Native Couch	*Sporobolus virginicus*	Seed, rhizome spreader

Source: Linda Taman, Native Environmental Systems

Note: There has been no inventory of the rushes and sedges of the Esperance region.

The Knotted Club Rush is an excellent species that can be used to stabilise riverbanks and can survive in many environments. These can be grown by seed or gently separated and replanted during the wetter months. The bull rush – a common species seen in paddocks – is also excellent in stabilising riverbanks, however they can become a nuisance for land managers in the paddocks.

5.3.2 Native grasses

Native Couch (*Sporobolus virginicus)* is a viable alternative to help in rehabilitation of river foreshores. Native Couch has many good assets as it grows on eroded riverbanks, spreads easily by rhizome, is highly salt tolerant, is a local/native plant (grows at Lake Gore) and will not become a weed or climb over other vegetation. Native seed can be sourced from Perth but care must be taken not to get the lawn variety of Couch.

Windmill Grass (*Chloris truncata*) – is a native grass of the mallee region and is palatable stock food if kept grazed

5.4 Weed management

Weed invasion is an issue in the Dalyup River catchment and control is needed, particularly when establishing vegetation. The best method of weed control is prevention of establishment by ensuring minimal disturbance in native vegetation (Hussey et al., 1997). Burning can also increase weed invasion, as bare ground is a perfect place for weed seeds to blow and establish – especially after a fire. This can cause an even greater fire risk. Contact the Department of Agriculture or your local Bushcare Officer for specific information on weed control.

Direct seeding site – Faye and Peter Lewis's property February 2002 (photograph Kaylene Parker, WRC).

John Luberda, Jack Mercer (Bushcare Officer) and Jamie Bowyer (AgWest) examine the native couch (Sporobolus virginicus) *growing in the West Dalyup River.*

5.5 Erosion and sedimentation

Following the two consecutive floods in the Dalyup catchment erosion control is one of the most important management issues that needs to be addressed for the Dalyup and West Dalyup rivers. The flood has highlighted the instability of the banks of the Dalyup River. The river is currently finding a new equilibrium due to increased flooding frequencies and the increased volume and speed of water coming down from the catchment. In addition to this, the foreshore vegetation is often not adequate to help stabilise the banks. This is resulting in unstable riverbanks, severe erosion and subsequent sedimentation. Management is needed to ensure that fence locations and vegetative buffers are wide enough to cope with these changes, also, that erosion control measures are put in place in severely degraded areas to stabilise eroding channels.

Eroding stream embankments can be protected and repaired in a number of ways. Different methods of bank stabilisation will depend on the steepness of the slope, the power of the water flow in a normal year and the cost and available materials to stabilise the banks. Ultimately, the bank must be revegetated for the streambanks to be stable.

Brushing uses cut trees or branches that are secured to the bank to provide erosion protection. This method is most applicable where bank erosion is caused by direct washing action of the water removing material from the face of the bank. The brush needs to be anchored to the top of the bank. This can be achieved by encasing the brush in old ringlock fencing. The bank may need to be battered prior to placing the material on it (Davey, 2000). Brushing using *Melaleuca cuticularis* or *Melaleuca brevifolia* is recommended. The seed can be released from the brushing and can provide natural regeneration and the woody cover provides protection for the seedlings. Brushing is only a temporary stabilisation technique that relies on establishment of vegetation on the bank. This technique is not as stable as some methods, however it is one of the less expensive options that encourage natural regeneration.

Vegetative mats can be used to stabilise banks, however the bank will need to be battered prior to laying the mats. Mats can be secured by burying the edge and pinning them to the banks. Seed can be layed beneath the mats and mats wetted along the bank contours. The mats have a limited life and require vegetation to establish. This is a comparatively expensive option.

Hard engineering options are for steeper slopes where the softer techniques of brushing and vegetative mats may not work. These options are usually more expensive and require expert design and construction, but will provide long-term protection. Techniques include, rock gabions, rock revetment/riprap, geotextiles and flexmats.

5.6 Woody debri

Woody debris (logs and vegetation within the river channel) is extremely important for waterways as it provides a habitat for aquatic fauna and inputs a food source into the river. It also can slow the water down during high flow periods. Too much woody debris in the river system is often a result of bank collapse or subsidence, which can undermine vegetation causing the debris to fall into the channel and be washed downstream during floods. Large woody debris can become jammed in the channel and can be damaging during floods.

During the 1999 flooding of the Dalyup and West Dalyup rivers, large trees and other debris washed downstream causing loss of fences and clogging up culverts. From reports by land managers within the catchment – the 2000 flood, although it was not as big as the flood in 1999, did more damage. The water apparently flowed faster, which increased the erosive power of the river and caused more damage, particularly for the lower catchment. Removing some woody debris may be beneficial but woody debris is valuable to slow the water speed down. It is recommended that intervention may be needed to remove some woody debris in areas that are very 'jammed' in the main channel. There needs to be a balance between the removal of woody debris, and the slowing down of the water during high flows. Water and Rivers Commission can provide advice on the placement and removal of woody debri.

5.7 Salinity and waterlogging

Encroaching salinity affects the production capabilities of the land, threatens the economic feasibility of farming systems and degrades our natural environment. A whole-of-catchment approach is needed when tackling the salinity and waterlogging issues. This involves changing farm management practices to reduce the amount of recharge. Recharge is rainfall that soaks deep into the soil and replenishes the groundwater. This causes the water table to rise and bring the stored salts in the soil with it (Negus, 1991). Stream salinisation occurs when surface water transports salt into waterways or when increasing groundwater flows carry larger quantities of salt directly to streams (Pen, 1999). Options to address salinity in the catchment are outlined in the *Dalyup Catchment 2000* report (AgWest, 2001).

The Dalyup Catchment Survey (AgWest, 2000) identified 18 km of proposed drainage works in the catchment and recorded 340 km of existing drainage works including banks, shallow surface drains and open deep drains.

A 'Drainage Information Day' was held in March 2000 to discuss and generate ideas and opinions on groundwater management. There were differences of opinion between landowners in the upper catchment and the lower catchment. It is mostly about a concern by the lower catchment over the volume and speed of water travelling through the Dalyup River and the upper catchment – issues of rising watertable and salinity affecting crops and pastures. Surface water techniques also have the potential to fail and cause considerable erosion and subsequent sedimentation of downstream waterways.

Rising groundwater levels (secondary salinity) and waterlogging impacts most waterways in the upper catchment. This is resulting in the loss of riparian vegetation, and the decline of agricultural productivity adjacent to the waterways. Many landholders have implemented deep drainage options in the upper catchment. In many cases these are ineffective in addressing issues resulting from secondary salinity, and are causing significant erosion and sedimentation problems in the main channels. In many cases, the vegetative buffer along waterways needs to be widened to cope with rising groundwater levels, more salt tolerant vegetation species needs to be planted, and natural channels encouraged to re-form to move water more efficiently from the landscape. In addition, land already impacted by salinity can still be managed as salt-land, where perennial pastures can be planted for grazing over summer periods. The landholder needs to evaluate the benefits of all options, and identify where these options are most suitable for their own landscape.

Many of the existing waterways are now clogged with sediment. A common management options is to excavate the main channel to encourage the water to flow in a confined channel. Removal of this sediment with an excavator is an unsustainable practice, as the channels will simply re-fill with sediment. The most effective and efficient way to ensure the natural waterways move water is to encourage vegetation to grow. Water will then form its own channel, which will be self-maintaining.

The use of permanent raised beds in the catchment is restricted to a small number of properties. In general, raised beds used on wet areas function successfully and land managers commented on improvement in the productivity and reduction of waterlogging and/or ponding. Permanent raised beds located at Esperance Downs Research Station are performing well in waterlogging control and improvement to production. Application of raised beds increased yield by 45% at the station (Hamilton 1997). There were some cases of severe erosion that occurred during recent floods. Raised beds gathered and diverted surface water flow onto downhill paddocks. These cases illustrate the need to include safe water disposal areas or drainage works during the design process.

Grassed Waterways/Grade Banks can be useful for controlling erosion and loss of nutrients into waterways. An excellent publication that addresses the factors to consider for grassed waterways and grade banks is *Preventing Soil Erosion and Soil Structure Decline* published by Agriculture WA, 1997.

In summary, the current options available for salinity management in Western Australia are summarised below:

1. Increase the water use of annual crops and pastures. Annual pastures allow nearly twice the amount of water to flow to recharge as annual cereal or legume crops.

2. Grow perennial pastures (e.g. tall, wheat grass, lucerne, kikuyu and fodder crops including Tagasaste, *Acacia saligna*).

3. Control surface water using different types of banks and drainage structures.

4. Plant commercial plantations – combining forestry and agriculture for recharge control and diversification of income (e.g. Oil Mallees, Maritime Pines, Bluegums).

5. Improve and manage remnant native vegetation through de-stocking, weed control, feral animal control and fire management. Better management means the remnant vegetation in the catchment can continue using water in the catchment for longer and not go into decline and increase water going to recharge.

6. Grow high water-use crops on a small area of land with potentially higher returns (e.g. potatoes – deep sands, grapes – Dalyup loams and olives).

7. Grow summer crops – this utilises untapped summer rain (e.g. forage sorghum, grain sorghum and sunflowers).

8. Use perennial forage plants on salt-affected land as this provides surface mulch to reduce salt accumulation on the soil surface and the plants use groundwater.

9. Drain groundwater–can alleviate rising groundwater problems in some locations however is often the most expensive option available. Notice of intent to drain and approval by downstream neighbours needs to be applied for through AgWest.

10. Pump groundwater to lower the groundwater table as a temporarily and short term solution. Safe disposal of saline groundwater and cost of running and maintaining pumps are problems. Notice of intent needs to be applied for through Agriculture WA (George et al., 1997).

Taken from Negus (1991)

Currently not one of these options works perfectly in isolation. Salinity management has no easy solution and is often a combination of a number of these strategies. The onset of salinity is leading land managers in the Dalyup Catchment to address salinity and implement precautionary measures.

5.7.1 Water management plan - Natural Heritage Trust Project 2002

Water management is the major issue identified in the *State of the Dalyup Catchment Report* (AgWest 2001) and in this report. In response, the Dalyup Catchment Group submitted an NHT application to develop a Water Management Plan to address whole-of-catchment water management issues. This is to be completed by December 2002.

Catchment runoff has increased by an estimated 2 – 3 times (Pen, 1999). This is resulting in faster surface flows, higher peak flows during floods, shorter periods of peak flows (higher velocity of water flow), increased siltation, more water entering groundwater system, increased frequency and proportion of landscapes affected by waterlogging and inundation, and an increase in areas affected by groundwater discharge and salinity. Increased flood frequencies will increase the risk of fence loss along watercourses, damage roads and bridges (Dalyup Bridge was washed away in 2000), increase dispersal of weeds, risk loss of paddocks adjacent to the main channel, and continue to erode river banks and deposit sediment. Lake Gore – a RAMSAR wetland – is under threat from excessive inundation due to major floods and increased water volumes.

This project has local, regional and statewide significance, as it is a likely scenario for most cleared catchments in the state. It has economic benefits as land managers, local authorities, and the State and Commonwealth governments have invested considerable funds to protect the natural resources in the State. In addition, considerable infrastructure including West Dalyup River bridge and the Dalyup River bridge, various road crossings, stock crossings and many kilometres of fencing were lost in the 1999/ 2000 flood events. Finally the productivity of many areas in the catchment is being severely impacted by salinity and waterlogging.

The reasons for the project development are numbered below.

1. The Dalyup Catchment Group identified water management as a major issue in the *Dalyup Catchment 2000* report (AgWest, 2001).
2. Water management issues (in particular salinity and waterlogging) are the major issues impacting on agricultural productivity in the upper catchment.
3. Many land managers in the upper catchment are keen to use deep drains as a management tool to address water management issues. Drains have the potential to increase sediment and nutrient input into downstream waterways, and may not be the most cost effective, efficient method of managing water.
4. Flood impacts in 1999/2000 caused considerable infrastructure damage including loss of two bridges, numerous culverts, crossings, fences, revegetation and roads. This has emphasised the real need for a water management plan to address catchment hydrology changes – in particular looking at options to hold water in the upper catchment during peak flood flows.
5. Lake Gore is a Ramsar-listed wetland and catchment hydrology changes threaten its long-term protection. Already existing fringing vegetation is suffering from excessive inundation and waterlogging due to increased catchment runoff.
6. The project has considerable benefits for other catchments that have similar issues and problems.

5.8 Water quality and nutrient enrichment

With broad scale agriculture in the catchment, it is inevitable that rivers will receive large quantities of nutrients, either dissolved in water, adhering to soil particles eroded from the land or contained within dead plant and animal material – including manure washed from the paddock (Pen, 1999). There are also point sources of pollutants such as animal feedlots, or sewerage that can input considerable amounts of nutrients into the system. Excessive amounts of nutrients can cause excessive growth of microscopic algae – a classic symptom of nutrient enrichment.

Suggested causes for the algal blooms are:

- runoff of fertilisers from agricultural land (Setter, 2000) possibly on sandplain soils;
- runoff of animal faeces nutrients particularly in the intensively farmed Lower Dalyup area;

- leaching of household septic tanks in the Lower Dalyup into the river (approx 23 along 14 km stretch of river); and
- stored nutrients in the sediments that have built up to such a level that algal blooms occur regularly.

The main management actions to reduce the risk of nutrient enrichment of waterways includes:

- conducting soil tests to ensure that the fertilizer regime is appropriate and that there is minimal runoff into the waterways;
- ensuring that sewerage systems in the catchment do not transport runoff into the downstream waterways (in particular that they have an adequate depth to groundwater and where the effluent is not able to runoff to nearby waterways); and
- ensuring an adequate buffer of vegetation along the waterways to trap nutrients that otherwise would drain into the waterways, and also to ensure that the banks do not erode and transport nutrients into the system.

5.9 Refuse disposal

During the survey of the Dalyup and West Dalyup rivers a number of landowners have disposed of refuse close to or in the river. The location of refuse disposal sites close to rivers can cause considerable problems for waterways in the catchment, including heavy metal contamination, nutrient enrichment in addition to aesthetic problems. The refuse included old vehicles, old machinery, household rubbish and empty chemical drums. The practice of dumping refuse close to rivers or in salt scalds where it might leach into groundwater is illegal under the *Environmental Protection Act* 1986. Improper disposal of waste can contaminate ground or surface water, transport pathogens such as salmonella bacteria, encourage vermin such as feral cats and foxes, increase fire risk and loss of visual amenity (Department of Environmental Protection, 1996).

Refuse can be taken to local landfill sites at Esperance (Wylie Bay) and Scaddan. These sites have been designed to specific standards so that pollution and the impact on the surrounding environment are minimised. Locating a refuse site at a farm can be more convenient for many land managers rather than transporting it to a specific site. There are several factors that need to be considered when locating a refuse disposal site on a farm. These guidelines are from the Department of Environmental Protection and are the same as those set out for rural shire councils. Farm refuse disposal sites should be located:

- on level ground where there is no risk of flooding or erosion;
- well clear of houses, dams, bore water or stock watering places;
- where the watertable is at least 3 metres below the surface or deeper;
- soil is at least 2 to 3 metres above bedrock to allow for percolation;
- in clay soils rather than sand; and
- At least 30 to 100 metres from natural creeklines and man-made drainage systems.

The disposal of chemical drums can be carried out on farms by triple rinsing them, putting holes in the bottom to drain, crushing the containers and burying them at least 0.5 m below the surface. It is illegal to burn pesticide containers (Barden, 2000). Preferably recycle chemical drums or take them to an approved landfill site.

The Shire of Esperance has organised the collection of recyclable chemical drums under the Drum Muster program. Landholders can leave all types of chemical drums at collection points within the Shire of Esperance. Triple rinsing of drums is required before delivery to the recital points and appointments must be made prior to delivery. The Shire of Esperance is willing to accept any type of chemical drums for the initial period of the program. After that only specific drums with Drum Muster labeling on them will be accepted.

The other recycling option is for the subcatchment groups to collect certain types of recyclable drums and freight them to Drum Services in Perth. Each drum collected is worth between $0.50 and $0.75 delivered to Perth. One or more collection points would need to be established and the recital of drums supervised to ensure that the drums are triple rinsed before drop-off. The Neridup Soil Conservation Group gains hundreds

of dollars a year in income from this program. Telephone Drum Services in Perth for more details.

5.10 Feral animal control

Rabbits and foxes have long been a problem within the Esperance region – particularly on sandplain areas. Rabbits impact severely on native vegetation and hinder revegetation. They also will feed on native vegetation – commonly in summer when food is scarce (Hussey and Wallace, 1993). The control of these species needs to be carried out together. If foxes and cats are controlled there may be an increase in rabbit numbers while only controlling rabbits could mean foxes and cats prey on native animals or stock (foxes) (Hussey and Wallace, 1993). Feral cats are often an unseen problem within the Dalyup Catchment. Feral cats can catch animals up to the size of a brushtail possum including birds, lizards, beetles and small mammals.

Controlling feral cats is often difficult. The three main methods used are shooting, poisoning and trapping (Hussey and Wallace, 1993). Shooting cats is very difficult, as they are often very secretive and more wary than foxes. Poisoning with 1080 is unlikely to work, as they do not usually scavenge. However they have been known to die through eating rabbits that have consumed 1080 baits. Baits are available from Agriculture WA. Trapping cats seems to be the most effective method especially when used during times of food shortage such as summer. Traps should be set with a strong smelling fish-type catfood in the evening and cleared in the morning.

Shooting, poisoning, fumigation and exclusion fencing can control foxes. The best time to control foxes is during spring when cubs are being reared – although supplementary control during the year may be necessary (Hussey and Wallace, 1993). Shooting is most effective during August to October when new cubs are being reared and mid-January to April when the cubs are dispersing and finding a new territory. Targeting areas that foxes prefer such as creeks, fence lines and tracks can achieve the best results. Based on a trial in Victoria, a shooting campaign will remove about one third of the population. Poisoning using 1080 baits can be effective. Baits can be placed under shrubs or buried 5 cm deep to prevent birds and other animals taking the baits. The Department of Conservation and Land Management research has shown that baiting once a month is sufficient to keep an area reasonably free of foxes and that baiting less frequently than this can also be beneficial (Hussey and Wallace, 1993).

Fumigation of dens can be carried out in the same way as with rabbits if it is known that young cubs are in residence. CSIRO, Agriculture WA, CALM and Curtin University are currently researching a genetically engineered fox virus. The virus is aimed at attacking the fox's immune and reproductive systems. Exclusion fencing can also control foxes – although it is very expensive (Hussey and Wallace, 1993).

Shooting, poisoning, fumigation, warren destruction, genetic methods and exclusion fencing can control rabbits. Shooting is generally a short-term measure and is not effective on its own due to the ability of rabbits to breed rapidly (Hussey and Wallace, 1993). Poisoning using 1080 on oat baits is effective in reducing numbers, especially if done in late summer/early autumn before the breeding season. The *Bunny Buster* – a product that uses gas to blow up burrows, appears to be highly effective on small landholdings in the lower Dalyup. Reliance on diseases such as myxomatosis and the calicivirus is not enough. If calicivirus passes through the rabbit populations, it is recommended that follow up baiting occur, as it doesn't affect juveniles. The best options are destroying the rabbit burrows by deep ripping, with follow-up baiting. Baiting is done with One Shot 1080 Oats, which need to be ordered through Agriculture Western Australia. The shoot could be for foxes, cats and rabbits and would ideally be held in spring.

5.11 Development and landuse planning

The Dalyup locations were first surveyed for 'homestead blocks' in about 1895. The original boundaries of the locations did not coincide with the Dalyup and West Dalyup rivers and were drawn up before the South Coast Highway existed. Today the rivers are having a greater impact on the surrounding landscape, as both rivers are now much wider and carry larger volumes of water than in the 1890s. The landuse, percentage of the catchment cleared, and the number of people living in the area has changed dramatically.

Access to many locations along the river is limited and river management issues are neglected. Some land managers have not been able to access their land since the floods in 1999 except via neighbouring properties. Current problems due to lot boundary design include:

- difficult access to paddocks and buildings where the river runs through the property;
- no foreshore reserve set aside for the river; and
- no development or building guidelines to inhibit development in the floodplain.

The condition of the Dalyup and West Dalyup rivers south of the highway is graded on average C – D Grade. Problems with block access, numerous river crossings, inappropriate paddock boundaries that cross the river and small block sizes are all impacting on the condition of the river. Realignment of lot boundaries is recommended in most locations. It is recommended that the Shire of Esperance incorporate the properties in the Dalyup catchment into their *Local Rural Strategy*. This will help to ensure that future developments are adequately planned with appropriate guidelines for future developments. The *Local Rural Strategy* should have guidelines that protect waterways from inappropriate boundary locations, inappropriate developments, and that all waterways retain an adequate vegetative buffer. The Shire of Esperance should look favorably on landowners in the Dalyup area who are willing to realign location boundaries to coincide with the rivers and make agriculture in the area more sustainable. Future development proposals in the Dalyup area also should have guidelines for development. Guidelines should ensure that:

- the river be fenced and a vegetative buffer be retained or replanted with native species;
- buildings are not permitted in the 1:100 year flood level; and
- boundaries coincide with the river layout (not crossing the river).

The buffer should consist of at least 50 m of vegetation either side of the river depending on the height of the floodplain. Some houses are currently too close to the river and may be structurally undermined by the river in future flood events – particularly if the river further degrades over time as predicted.

5.12 Fire

The Dalyup and West Dalyup rivers have not been burnt for many years. There is increasing concern within the community that there is a fire risk associated with the rivers and tributaries in the catchment. There is also a risk that fires along the waterways will increase the growth of weed species likely to colonise.

Fire management needs to be carried out in the catchment with consideration for the impact on vegetation. The impact of fire on riparian communities depends on the floristic and structural composition of riparian communities and on the intensity and frequency of burning. Different species respond differently to fire, some benefit from frequent burning, and others suffer. Riparian communities are generally not adapted to frequent burning, with many species sensitive to fire. Frequent fire can encourage fire-tolerant species and discourage fire-sensitive species, leading to changes in the composition and structure of plant communities (Askey-Doran and Pettit, 1999). If burns are of low intensity and well controlled they should not affect riparian vegetation. However, escaping fires do burn into riparian areas and can lead to the death of plants (Askey-Doran and Pettit, 1999).

Mallee vegetation needs to be burnt periodically to encourage regeneration of native eucalyptus species and undergrowth species. Alan Longbottom at Grass Patch has noted that 50 – 70-year-old mallee trees on his property have never been burnt. Over the last decade many of these species have fallen victim to fungal attacks or been eaten out by termites. These old trees do provide short-term nesting sites and habitat for birds and small mammals. It is likely that these trees required burning before they reached 50-years old (Alan Longbottom, pers. comm., 2002).

Fire was evident on a property below Brownings Road along the Dalyup River. It is evident by the height and age of vegetation on other properties that the riverine vegetation had been burned several years ago. Remnant vegetation on roadsides and in reserves has also been burnt.

5.13 Other

Our creeks, rivers and wetlands form a unique part of European and Indigenous culture. There is a lack of Indigenous history of the area. It is important to ensure that management recognises the historical values of the rivers – from indigenous occupation and early settlement. Waterways are important from a traditional aspect in that they were often used as a source of food and occupation sites. Increased understanding and awareness of these social, cultural and historical values is needed.

There also is social change happening throughout the catchment, particularly in the lower catchment. There are new industries developing such as horticulture ventures, viticulture and wildflower farms that are becoming the primary income from the land. There are also many issues associated with socio-economic situations in the catchment, particularly in the upper catchment with the need to maintain or improve farm economic viability. Falling prices has lead to many farm businesses becoming marginal. This has often resulted in smaller farms being incorporated with other farms. This means that there are fewer landowners in the upper catchments – hence there is often less resources (particularly time) to deal with fire, weed control and landcare activities.

Tourism is also a growing industry in the South Coast. There is an opportunity to develop the district to accommodate tourists and promote ecotourism. There are many opportunities to promote the district through signage and interpretive material.

6.1 Case Study 1

Lower East Dalyup - Ray and Shirley Sullivan "Kalabity Moorna", Gibson

Background

Ray and Shirley Sullivan purchased their property in 1989 from a corporate body Kalabity Moorna. The property was originally cleared in the late 1960s to early 70s. They have undertaken extensive work on their property to protect their section of a branch of the Dalyup River.

Issues and outcomes

The Sullivan's started fencing their Dalyup River tributary in 1990 excluding the main creek and river systems from stock. These works were carried out to preserve the plants and animals the river and encourage regeneration as well as protect tree planting. All the work was undertaken at their personal expense.

Since fencing and destocking the river has undergone excellent regeneration and the salt flats are well covered with native salt-loving species. Prior to fencing the river stock had access to the creek systems and many areas were totally bare and blew in summer.

Around the same time the Sullivans started fencing off their creeklines they also began to develop and implement a whole farm plan. This was focused on fencing to soil type and better water use management.

The Sullivans have since planted 500 000 Oil Mallees on their property. These are integrated with their farming practices – providing a possible commercial return in the future.

in their nursery business has allowed the Neale's to employee a local neighbour part-time through the Landcare Traineeship program.

Growing teatrees is the current focus of the Neale's energies. An alternative industry in growing, harvesting and extracting teatree oil has got the Neale's interested in growing *Melaleuca alternifolia*. Teatree oil can be harvested and extracted from these trees and used as a bacteria deterrent, fungicide or in relief for burns patients. The Neale's are planning to plant some seedlings this winter along the floodplain area of their section of the Dalyup River. The *Melaleuca alternifolia* can, not only be used to produce oil, but also act as a buffer zone if extreme flooding events occur again. The process of distillation, harvesting and establishing markets still need to be worked out.

The Neale's also believe there could be great potential in interesting tourists in their activities on their property. They have also grown *Eucalptyus citrodora*, which can be harvested to produce the well-known mosquito repellent, citronella oil. They have noticed some other native regeneration of plant species. Des and Jo are also involved in the 2002 NHT project "*Recreate the Dalyup River*". Des will be doing further revegetation of the river, in addition to growing rush and sedge species to be used as a trial in stabilising eroding riverbanks.

Des Neale and Jack Mercer (Bushcare Officer) identify rush and sedge species growing along the edge of the Dalyup River. These species provide habitat for native fish growing in the river and also armour the banks against the power of flood waters.

6.4 Case Study 4

Peter and Sue Smithson, "Mozzie Flats", North Dalyup

The Smithson's say they "bought a farm with a problem" back in 1988. They decided they had to make the farm more sustainable if they still wanted to farm in 10 years. Integrating water and soil management with their enterprises has helped them achieve higher production and make the 1099 ha-farm more attractive.

AM & DM Campbell, Sue's parents, purchased Esperance Location 1499 in 1988. Pete and Sue managed the farm until they bought it in 1995. Jeremy Frankpitt was the original owner who cleared the property in the 1970s. The Campbells finished the clearing in 1988 and 1989.

"Mozzie Flats" is situated on the middle reaches of the Upper West Dalyup River north of Boydells Road. The main West Dalyup River and another tributary of the West Dalyup dissect the Smithson's property. The West Dalyup River is extremely flat, naturally saline and up to 400 metres wide in parts. The West Dalyup River meets the Dalyup River approximately 24 km to the south. The West Dalyup River is in B Grade condition although some areas are starting to suffer badly from rising groundwater. The dominant vegetation type is Saltwater Paperbarks over salt tolerant samphire vegetation.

Issues and outcomes

Salinity, waterlogging and wind erosion was the main problems that the Smithson's faced when they took over the property in 1988.

"Fences half buried in sand and sheep were the first problems that we tackled at Mossie Flats. Destocking in 1992 helped solve the soil erosion problem and allow them to recover. A drop in the wool price was also a deciding factor in this decision," said Sue.

"Reintroducing 400 sheep in 2000 has been a positive outcome of managing soil erosion and saline areas over many years. Sheep can now graze the planted salt tolerant pastures along with some newly introduced *Cadiz serradella* as a way to diversify the Smithson's operation.

"*Fencing existed on about half the creeklines when the property was purchased from Mr Frankpitt. Sheep grazed some sections of the river where it wasn't fenced. Fences were erected or replaced and shifted further out from the river. Revegetation adjoining the river was undertaken to buffer the river from rising saline groundwater. Regeneration of the river has occurred since the replanting of trees and exclusion of stock*".

The Natural Heritage Trust (NHT) funded about one third of the work under a grant to the Upper West Dalyup Catchment Group. The Smithson's funded the rest themselves.

"Planting of pucinellia, saltbush and tall what grass on waterlogged or saline land helped revive some of these unproductive areas by using up some of the surface water and helping to control rising groundwater. Since the fencing and replanting along the river self-sown seedlings can now be seen growing in the river channels. Increasing salinity is still a problem," says Sue.

"Cost saving erosion, sheep feed off land that can't be cropped. Surface water management has also included putting in surface water drains. These drains have helped reduce the amount of waterlogging in some areas and allow crops to be grown. We have also installed groundwater-monitoring bores on the property".

Tom has found that the flooding has given him an opportunity to allow for the natural regeneration of the wetlands. *"We hope to fence off all these paperbark areas and areas that are wet during the winter. You can see the yate that's germinated from the flooding and it beats planting trees. You can see the massive germination of paperbarks. I'm confident that we'll get more paperbarks and things from successive lots of seed amongst the litter as the water recedes.*

One of the lakes is actually an offshoot to the river and it tends to fill up in most years. "We put a fence around it and excluded the stock from it about four or five years ago. We haven't really noticed much regeneration in amongst the older established trees and I suppose we probably won't. We certainly won't see the significant regeneration like down there [at the main lake]. The flat areas where the samphire and other things can get going that's certainly covering up what was previously bare salt scald, so that's nice to see".

The wetland adjacent to Lake Gore on the western boundary of the property was fenced in about 1994. Tom explained that, *"There's several lunettes associated with Lake Gore and the paperbark has been dying on those. I guess that's just a function of the increased water that's coming down the river from the clearing. There's probably not much we can do to arrest that. This area was grazed up until seven or eight years ago and the samphire have re-established in the lower areas. But I don't know what the extent of regeneration will be out through these lunettes. I guess we'll have to wait and see".*

The main lake on the property was fenced during 1998 but after the flood in January 1999 Tom found that the fence wasn't out far enough. *"You can see that the posts of the fence that was put in 12 months ago are now mostly underwater. We had pasture down to that point and it wasn't salt affected so I thought that it was a reasonable level to have the fence at. Now the water is about a metre higher. In the future it may well stay dry down to there but to increase the riparian zone with a strip along the edge I think was a great opportunity and we just had to take it. We regard that as something good that we got from the floods".*

Tom is also planting trees in areas that were eroded during the flood. *"The flood scoured out some bends on the river and they are not useable for grazing or anything so we're fencing them off and planting some trees. We've planted an area to pines and in the lower sections we've put in paperbarks (Melaleuca cuticularis) and yates. The wattles and paperbarks are also coming back. With the damage to this area we thought that it was pointless fencing it into a paddock, so we fenced it out and planted the pines along the ridge and also planted a range of trees and shrubs along the rip lines. We have noticed that in a couple of spots a good way to get yates going is brushing using branches that were lodged in the trees after the floods".*

Most of the fencing has been erected and financed by the Murray's except for a section of remnant vegetation on the river. "We're using all electric fencing around the remnant vegetation and that way we can go around curves and things fairly economically and it's a lot cheaper for materials. With the remnant vegetation we don't have livestock on both sides so the fences don't come under quite so much pressure as when they're on both sides".

Tom is in the process of fencing off a section of a drainage line in the northern section of the property at present and he will probably plant some trees just to kick start things. He has also done some planting directly along the river on areas where previously the paddock went right up to the bank.

The outcomes and observations

Tom is very pleased with the results of his fencing after flooding. *"It would have been foolish of us to pass up the opportunity of fencing it off and just allowing that regeneration to occur. Our sort of landcare is fairly low input. I prefer trying to create a situation where it heals itself. Because I think in many cases there is the capacity there for it to do that, particularly with the species that we have down here that are well adapted".*

Tom has noticed that weeds are a problem in some areas where stock has been excluded and also weed seeds are carried downstream to his property after a flood. *"With the floods we copped a fair amount of lovegrass, there was no lovegrass in some of the paddocks before the flood, and we even got a few doublegees".*

6.6 Demonstration project

Faye Lewis (WJ Lewis and Sons), "Em-A-Lee Downs"
Flemming Rd/Coolgardie Hwy

This project will demonstrate the benefits of fencing and revegetating waterways in the upper catchment. The area was grazed by stock, and showed bare areas impacted by salinity and waterlogging. There were also other signs of degradation including loss of riparian vegetation, erosion and sedimentation.

The property drains to the Dalyup River. The creekline links to 240 ha of fenced remnant vegetation that has never been cleared. This unique remnant vegetation contains several wetlands formed on limestone deposits. It also contains a unique array of vegetation communities ranging from wetland vegetation communities through to Mallee Heath community types.

A direct seedling trial has also been completed on the property. The site will be monitored over time to record the success of the project.

Faye Lewis and Jack Mercer (Bushcare Officer) examine native vegetation alongside a site to be direct seeded (photograph Kaylene Parker, WRC).

Proposed direct seeding site, 23 May 2001 (photograph Kaylene Parker, WRC).

Direct seeding site, February 2002 (photograph Kaylene Parker, WRC)

6.8 Demonstration project

Lawrie Shaw, Location No. E106, Dalyup River, South Coast Hwy

The Dalyup River upstream of the South Coast Highway suffered considerable damage from the flood events of 1999/2000. Previous photos also indicated that the river was in relatively good condition, however it is only the low flow channel that was fenced. The river has an extensive floodplain, which is approximately 100 – 300 metres wide.

Flood damage included the formation of new channels (avulsion), loss of crossings, undercutting and erosion on the original river channel, further loss of riparian vegetation due to flooding, and considerable sedimentation of the main channel.

The floodplain has been fenced to help survive flood events. This includes electric fencing, four line plus flexible pipes that will break during high flows. Also "sacrificial" fencing has been used as boundary fences across the river for flood events. This will not pull the whole fence down, rather the section across the river only. The project will also promote alternative farming uses of the floodplain. Lawrie has also fenced his floodplain and is growing *Acacia saligna* on the floodplain. This area will be grazed differently to the rest of the land hence may help to stabilise the floodplain during future high flow events.

Lawrie Shaw's revegetation of the floodplain with Acacia saligna *– adjacent the Dalyup River (photograph Kaylene Parker, WRC).*

7 Foreshore survey results

7.1 Foreshore survey assessment technique

The vegetation associated with the river was graded using the *Stream Foreshore Assessment and Survey Technique* developed by Pen and Scott (WRC, 1999). The vegetation was graded as A, B, C or D Grade, which represent respectively a pristine foreshore to a degraded foreshore (Fig. 13.) Sections of the river were surveyed by walking from Lake Gore to Speddingup West Road and the West Dalyup River between its junction with the Dalyup River and Brownings Road. Catherine Field conducted the survey with assistance from Kaylene Parker, Steve Janicke, Johanna Cappelluti (Jerramungup Landcare Centre), Coral Turley (Esperance Wildflower Society) and Lisa Grant (volunteer). The remaining sections of the Dalyup River, Dalyup Tributary 1 and West Dalyup River were surveyed using a combination of walking and driving. Surveying was carried out between April – June 2000. In some instances the land manager accompanied the assessor providing further information on their section of the river. The survey used aerial photographs of the properties and recorded:

- foreshore condition (A1, A2, A3, B1, ….D3);
- fencing status (existing and proposed);
- crossings (design, location, survival of floods);
- revegetation (present);
- presence of weed species; and
- channel bank stability

Steve Janicke of the Water and Rivers Commission also undertook a Channel Morphology Survey. The survey covered the Dalyup River from Lake Gore to Brownings Road and the West Dalyup River from its junction with the Dalyup River to Brownings Road. This survey recorded the fluvial geomorphologic characteristics of the river. Photographs were also taken along the entire section of the river walked.

Steve Janicke surveying the Dalyup River in April 2000 (photograph by Kaylene Parker, WRC)

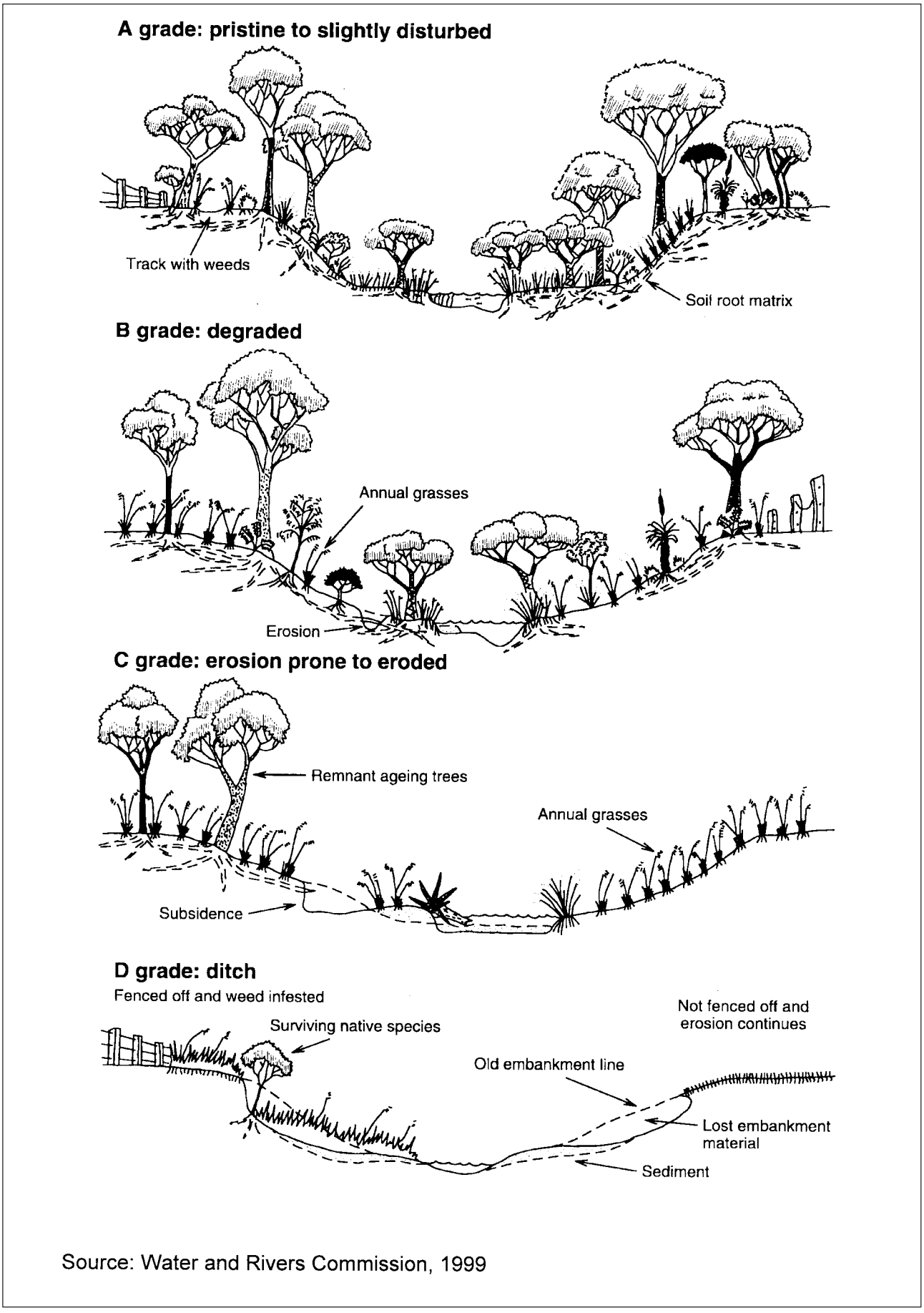


Figure 3. Stages of river degradation

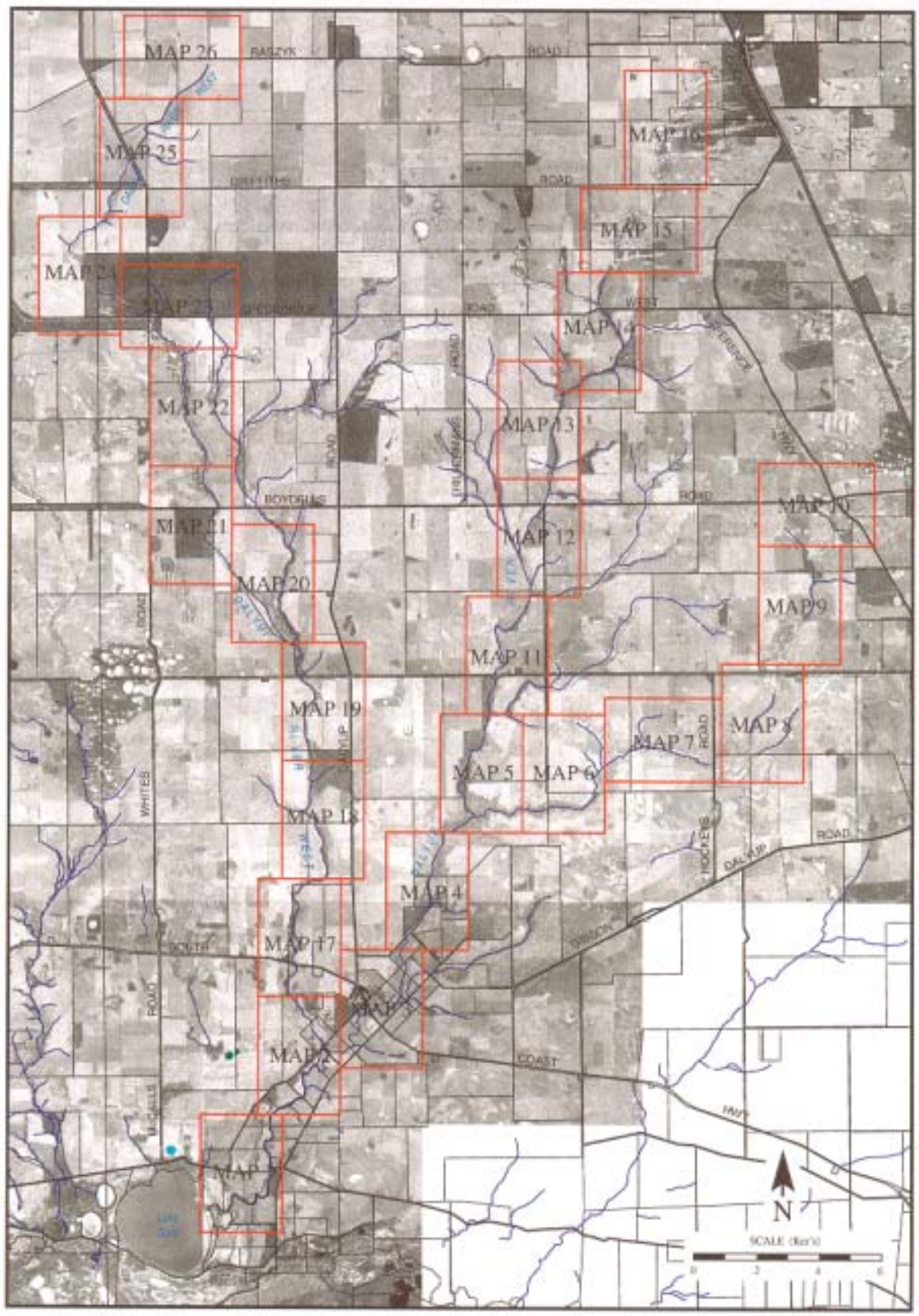
A Grade section of the Dalyup River – showing foreshore vegetation in excellent condition (photograph Catherine Field)

B Grade vegetation of the Dalyup River – note the odd weeds along the edge of the channel (photograph Kaylene Parker, WRC)

C grade – note the erosion and lack of understorey

D Grade vegetation condition – note the lack of vegetation and erosion.

7.2 Foreshore survey results
Specific maps and management recommendations for each section of the Dalyup River System



DALYUP RIVER FORESHORE SURVEY

Map 1 – DALYUP RIVER

Locations: D19, D18, D17, D16, D21, and D22, Reserve 38157
D48, 5, 6, 49, D25 (Lot2), D25 (Lot 51) 50, 27

Foreshore vegetation condition
Right Bank: average C3 (B1 – D3)
Left Bank: average D1 (B3 – D1)

The foreshore vegetation is showing extensive damage from the 1999/2000 flood events. There are small sections in good condition including the foreshore vegetation in locations D48, D18 and D 19. Many sections of the river are extremely degraded and weeds have colonised flood-damaged areas. Natural regeneration has occurred since the flood, however, supplementary planting is required in most locations. The width of foreshore vegetation needs to be increased along this section of the river to ensure the banks and floodplains of the river are protected from future flood events.

Fencing

Many fences were lost in this section during the 1999/2000 floods. Many land managers have re-fenced sections, with the fences placed further out to incorporate flood damage. Fences have been replaced in locations D19, D48, D5 and D17. Fencing tributaries draining into the river on location D17 is suggested as this would slow the water sheeting of the adjacent farmland and minimise the risk of paddock erosion. Better fencing is needed between location D25 (Lot 2) and adjoining nature reserve as cattle currently have access to and are degrading the reserve.

Erosion control

The flood has highlighted the instability of the Dalyup River, with massive undercutting, bank subsidence and sedimentation evident along this section of the river. Fencing and revegetation will help to encourage stability of the river channel, particularly in sections of the river where it is graded D1, D2 or D3. Sedges and rushes are the best option to help stabilise the river channel, however some engineering solutions may be required to stabilise headcuts and secondary channels, and to remove sediment plumes. Massive undercutting and subsidence is occurring on steep left bank along Location D17 (across from Dalyup Pioneer Reserve). The bank is in danger of further erosion and is only being held by a few trees.

Crossing design

A more suitable crossing for location D48 is a straight section of river just upstream from the wetland on location D48. The current crossing on D17 is located on a bend in the river and will continue to erode. This should be relocated to a straight stretch of river with a firm base – preferably rock. The land manager has sought funds from NHT to help redesign and relocate this crossing.

Weed control

Lovegrass is dominant and control will need to be carried out prior to revegetation. Bridal Creeper, Nightshade, Lovegrass and Afghan weed needs to be controlled on this stretch of river. Bridal Creeper control is the most urgent as this will choke all existing and planted vegetation along the river if not controlled. A few Easter Lily plants exist on the left bank across from location D25 (Lot 2). Early control will stop these spreading.

Other

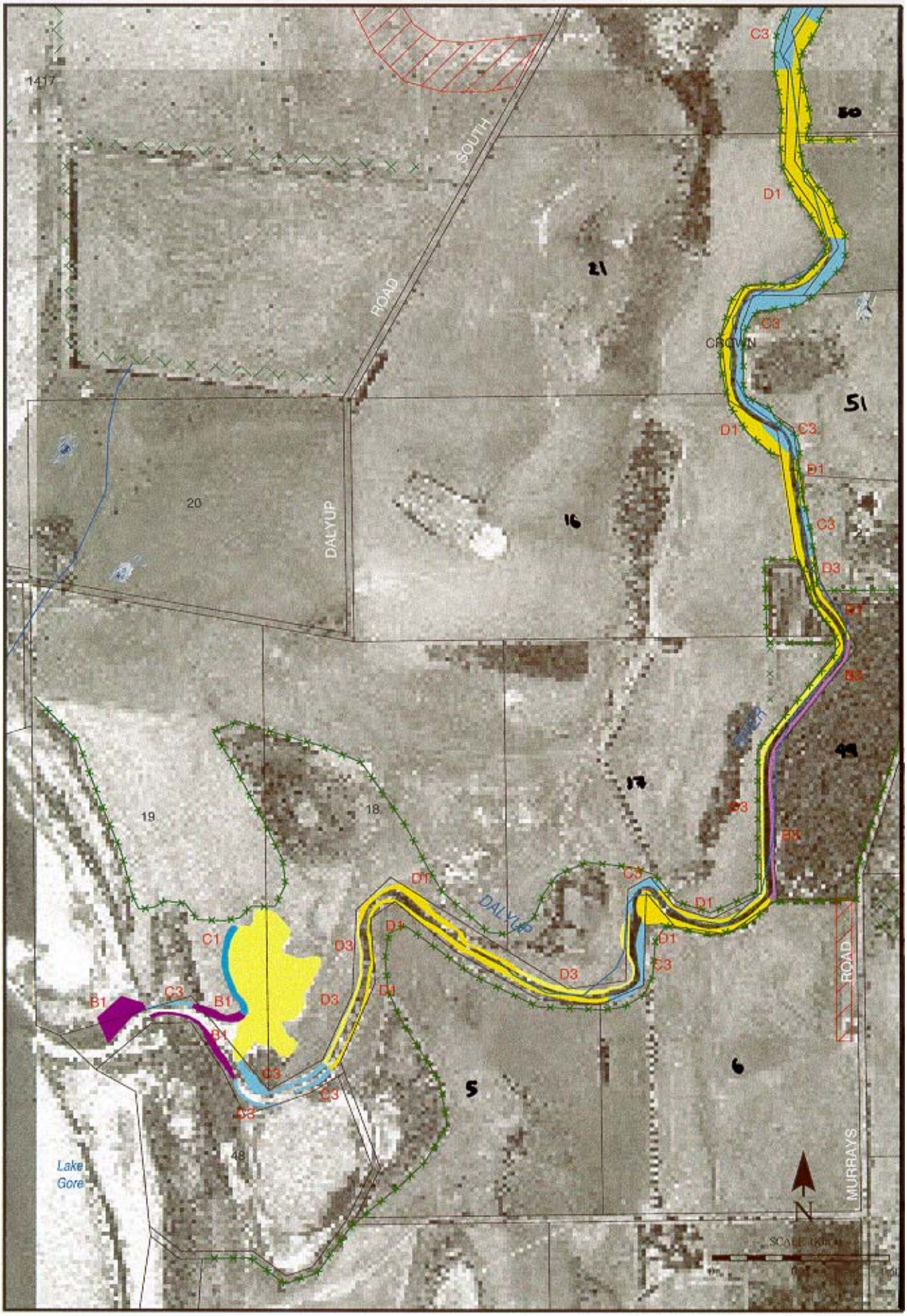
Location D48 is adjacent to Lake Gore Nature Reserve and forms an important component of the lake's riparian vegetation. CALM should consider buying this property back and incorporating in into the Lake Gore Nature Reserve – particularly considering Lake Gore's recent RAMSAR status. This would ensure a significant buffer of vegetation between Lake Gore and adjoining agricultural land to protect it during times of flood and provide important habitat for wading birds. CALM have no fencing assistance available to re-fence sections of Lake Gore (CALM, pers. comm.).

There are problems with illegal camping and lighting of fires in reserve 23570 or the Pioneer Reserve, which is causing degradation to the existing vegetation. The Shire of Esperance should be approached to better manage this reserve.

The house on Location D25 (Lot 2) is in danger of being damaged in future floods. The land in front of the house should be revegetated. A levee bank should also be constructed to protect the house.

It is recommended that any future subdivisions or development proposals for this section of the river redraw boundary locations so they do not cross the river. These locations were drawn up in the late 1890s and did not take into account the change in water flow and volume that is now experienced since the clearing of the catchment over the last 100 years. The locations are too small and therefore land managers are trying to farm both sides of the river, resulting in numerous river crossings. Economically it is not feasible to not farm the flood plain however boundary re-alignment is necessary to encourage protection of the Dalyup and West Dalyup rivers.

	Suggested actions
D48	• Approach CALM to buy back land surrounding Lake Gore, as this is an important vegetative buffer. • Redesign and relocate crossing.
D18	• Stablise banks and increase the width of the vegetative corridor along the river. • Fence the tributary draining into the Dalyup River.
D17	• Stablise banks and increase the width of the vegetative corridor along the river. • Fence the tributary draining to the Dalyup River. • Redesign and relocate crossing.
D19	• Stablise banks and increase the width of the vegetative corridor along the river.
D16	• Increase the width of the vegetative corridor along the river.
D5	• Stablise banks and increase the width of the vegetative corridor along the river.
D6	• Stablise banks and increase the width of the vegetative corridor along the river. • Remove or control deadly Nightshade in the river corridor and Bridal Creeper.
D25 (Lot2)	• Repair the fence between location D25 (Lot 2) and the adjoining nature reserve. • Construct flood levee banks to minimise future damage from floods.
Reserve 23570	• Approach the Shire of Esperance to advise of problems with illegal camping and lighting of fires in reserve 23570 (Pioneer Reserve), which is causing degradation to the existing vegetation.
D50	• Increase the width of the vegetative corridor along the river.
D51	• Increase the width of the vegetative corridor along the river.
D21	• Increase the width of the vegetative corridor along the river.
Other	• Ensure future landuse planning applications realign lot boundaries to protect the Dalyup River.



DALYUP RIVER MAP 1

MAP 2 – DALYUP RIVER

Location No: D22, D23, D24, 1027, D27, D28

West Dalyup River – Locations: D29, E853, 1027, 405 (West Dalyup River)

Foreshore vegetation condition
Left Bank: C3 – CD3 (average D2)
Right Bank: D2 – B3 (average D1)

The vegetation condition is degraded, mainly from the impact of stock grazing and weed invasion. Many sections of riparian vegetation were lost and damaged in the 1999/2000 flood events. There are many sections with little or no remaining vegetation and as a result were more susceptible to flood damage. There is a good Mallee community on location 22 and a *Banksia speciosa* community on location 853. There are good sections of bush adjacent to the river in locations 22, 23, 405, 1027 and 853 that could be linked to form a vegetative corridor.

Revegetation

Many sections of the river need to be revegetated with local species – particularly rushes and sedges in unstable river channels. Some natural regeneration is occurring since the flood however supplementary planting may be needed in some locations. Some sections along the river should be managed differently from usual agricultural practices. This may include planting of perennial crops or fodder trees to help stabilise the floodplain during flood events.

Fencing

Fences need to be replaced along the left bank of locations D22, 23, 24 and a section on D28. In addition to the fences in location 29, 853 1027 and 405 that were washed away by floods.

Flood or sacrificial fencing is recommended. Replacement fences need to incorporate flood levels recorded in the 1999/2000 flood. In addition, fences should be placed further away from unstable or actively eroding banks. The area of swampy bush on location D22 and D23 could be fenced. If fences need to cross the river to delineate a boundary, it is recommended to use sacrificial fencing (two-strainer posts) to minimise fence loss.

Erosion control

Massive undercutting, bank subsidence and sedimentation are occurring along this entire section of the river. Revegetation and fencing is the first step in helping to stabilise the river channels. Rushes and sedges can be used to stabilise the river channel. Brushing will also help to stabilise some banks, however steep banks may need leveling prior to revegetation.

Crossing design

A crossing did exist on the boundary between location D29 and E853. The location of this crossing is not suitable, as it was located on a bend. On location D30, the crossing point is also starting to cause erosion up-slope. The crossing on location E853 should be relocated further upstream or downstream where the river is straighter, or where the actively eroding sections stabilised.

Weed control

Weed proliferation in this area is extensive, particularly lovegrass and other weeds washed down from the flood. Weed control would be required prior to any revegetation.

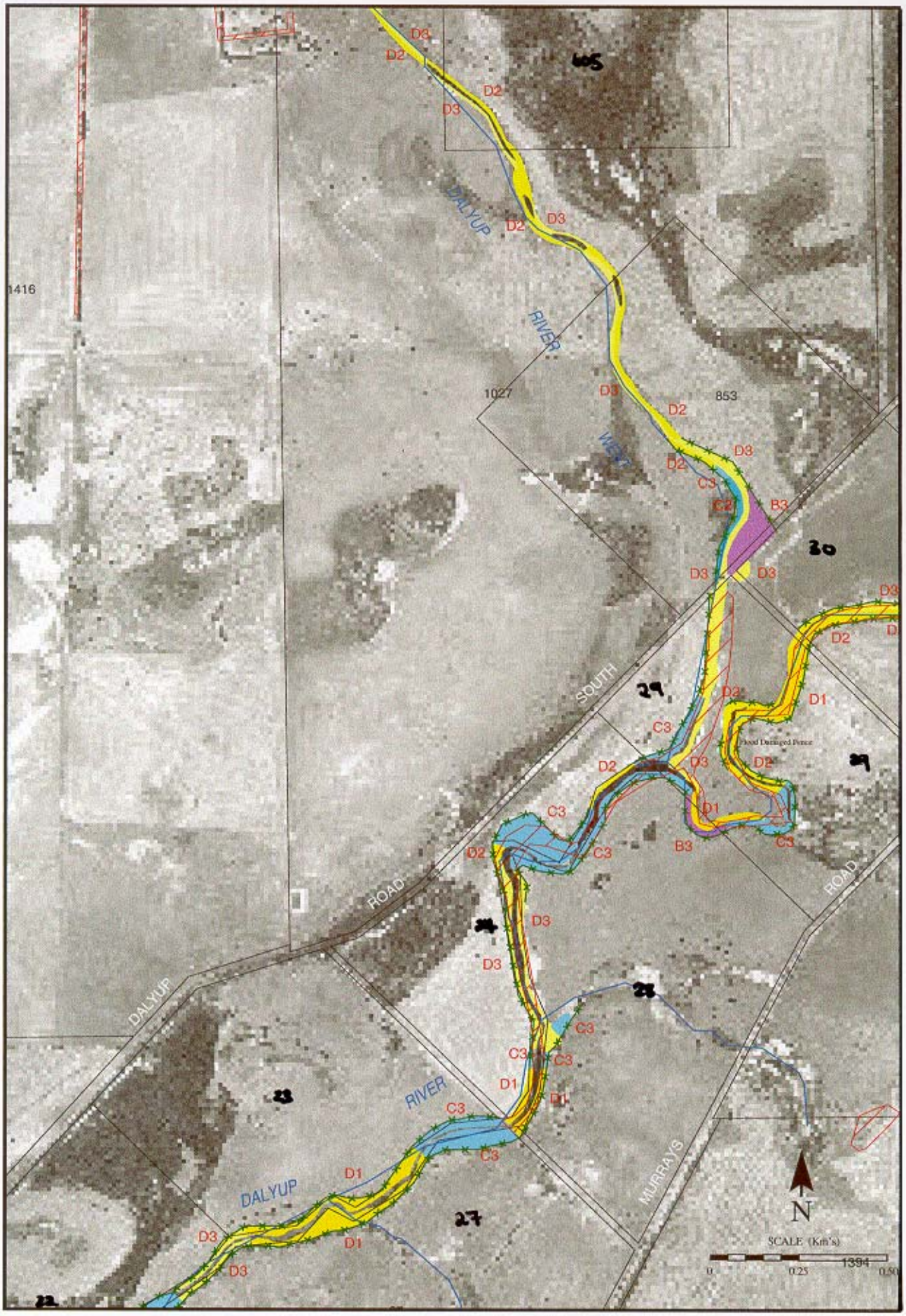
Other

Realigning location boundaries is needed in this area to protect the Dalyup and West Dalyup rivers. Suggestions would be to:

- change the boundaries of properties 853, 1027, D30 and 405 to reflect the river alignment – in particular, the small triangle on Location 405 could be joined with location 1027 to make farming the land more practical. In addition, Location 1027 could, in the future, be subdivided to form two separate locations.
- investigate whether owners of location E1027 or D23 are interested in purchasing the land on locations D24 and D29 north of the West Dalyup Branch of the river and having this land either as a new location or adding it onto an existing location.
- amalgamate location D28 and D29 south of the West Dalyup River into one location.

These locations were drawn up in the late 1890s and did not take into account the change in water flow and volume that is being experienced over 100 years later as more of the catchment was cleared.

	Suggested actions
D22	• Fence remnant bush adjacent to the river. • Replace flood damaged fences.
D29	• Replace flood damaged fences. • Increase the width of the riparian buffer with native species. • Stabilise actively eroding banks. • Relocate the crossing on the boundary D29 and E853 or stabilise to prevent further erosion.
D23	• Replace flood damaged fences. • Increase the width of riparian vegetation. • Fence left hand side of the river. • Fence remnant bush adjacent to the river. • Stabilise actively eroding areas.
D24	• Replace fences damaged by floods. • Fence right hand side of the river. • Increase the width of riparian vegetation. • Stabilise actively eroding areas.
1027	• Fence tributary draining to the West Dalyup River. • Fence the West Dalyup River. • Stabilise the eroding crossing (see section on crossing design). • Increase the width of the riparian buffer with native species. • Stabilise actively eroding banks.
D27	• Replace flood damaged fences and increase the width of riparian vegetation. • Stabilise actively eroding areas with sedges, rushes and brush with Melaleuca branches.
D28	• Replace flood damaged fences, particularly on right hand side of the river. • Increase the width of riparian vegetation.
D29	• Replace flood damaged fences. • Increase the width of riparian vegetation. • Stabilise actively eroding areas with sedges, rushes and brush with Melaleuca branches. • Where the West Dalyup and the Dalyup meet – the middle area should be revegetated with native species or some other perennial tree species to stabilse the area in future floods. • Fence the right hand side of the Dalyup River.
D30 (pt)	• Replace flood damaged fences. • Increase the width of riparian vegetation. • Stabilise actively eroding areas with sedges, rushes and brush with Melaleuca branches.
853	• Fence remnant bush adjacent to the river on both sides of the river. • Replace flood damaged fences on both sides of the river. • Increase the width of the riparian buffer with native species. • Stabilise actively eroding banks.
405	• Fence remnant bush adjacent to the river. • Fence the West Dalyup River. • Widen the buffer corridor.
Other	• Ensure that future landuse planning changes realign lot boundaries to take into account the river.



DALYUP RIVER MAP 2

MAP 3 – DALYUP RIVER

Location: D31, D32, D33, D34, D37, D38, D40 (pt)
Location D32 was not surveyed.

Foreshore vegetation condition
Left Bank: D3-B3 (average – D1)
Right Bank: D1-B3 (average – C3)

The foreshore vegetation condition is extremely degraded in most locations due to extensive flood damage, stock access and weed invasion. Location 37 has a section of vegetation graded as B Grade condition, with a variety of native species present.

Revegetation

Revegetation is urgently required on locations D31, D33, D38, D40 (pt) as the vegetation buffer along the river is not wide enough to cope with high flows and floods. Limiting stock access and revegetating the river with a wider strip of vegetation will help stabilise the riverbanks and prevent future undermining of buildings and further loss of productive land.

It is recommended degraded areas be revegetated with local native species, including rushes and sedges, *Melaleuca cuticularis, Melaleuca brevifolia, Thryptome saxicola, Gahnia trifida, Acacia saligna*. All are salt tolerant, can withstand being inundated during flooding and are good colonising plants. Rushes, sedges and Native Couch (*Sporobolus virginicus)* should be used at the toe of steep banks. Steep banks can also be stabilised by brushing with *Melaleuca* species. D34, 37 and 38 have been successfully revegetated with local, native species.

Fencing

Considerable kilometres of fences in locations D31, D33, D37, D38 and D40 were lost or damaged during the 1999/2000 flood events. Prior to fencing, it is recommended that the landholder re-evaluate the fencing location and the fencing type, to help protect these areas from future flood events. Fencing must take into account flood levels and the stability of the banks. If an area is actively eroding, then the fence should be placed further out. Sacrificial flood fencing is recommended where land managers are not willing to give up too much land, however are prepared to risk the fences during floods. Sacrificial fencing has been erected between D33 and D34 as a demonstration project.

Erosion control

Extensive stabilisation and revegetation work is required along this entire section. Planting with rushes and sedges will help to stabilise the banks of the river and also to stop the river continuing to widen. Leveling steep bank slopes will assist in vegetation establishment. Also a few small headcuts on the left bank need to be stabilised.

The area north of the highway location33 is extremely unstable. Main Roads WA previously excavated the site to help the water flow through the bridge. The excavated channel has since been filled in. The area has also been extensively grazed by stock hence there is little vegetation to stabilise this area. It is likely that this sediment will wash downstream in future high flow or flood events. This area needs to be addressed as an absolute priority. These paddocks adjacent to the main river stream are part of the flood plain, therefore the planting of perennial pastures and fodder trees is recommended.

A sediment plume on location 34 needs to be removed, or the river will continue to erode the bank close to the house.

Crossing design

The crossing present on location D33 is incorrectly designed and as a result the river has diverted around the crossing. This site needs to be either relocated to a straight stretch of the river, and smaller rocks used. Suggestions for management of the existing crossing site can be obtained by contacting Steve Janicke of the Water and Rivers Commission, Albany. An example of a good river crossing is on location D34.

The crossing on location D30 and D31 is located in a good spot along a relatively straight stretch of river, however the design of the crossing needs improvement. Placement of some small rocks on the crossing where the water flows across would help stabilise the crossing.

The crossing on location D37 is in an appropriate position, however the crossing needs to be lowered a little with a better mix of rock sizes used. A crossing

previously existed on location D40 but has been scoured out. This is a very difficult stretch of river on which to locate a crossing. Possibly the best site would be right against the boundary fence with location D38. The approach towards the crossing should be on the contour leading down to the river (not straight down the slope) to stop erosion.

Weed control

There is heavy weed infestation along this section of the river, particularly where little or no native vegetation remains. Bridal Creeper urgently needs control on this stretch of river otherwise it will choke the remaining and planted vegetation.

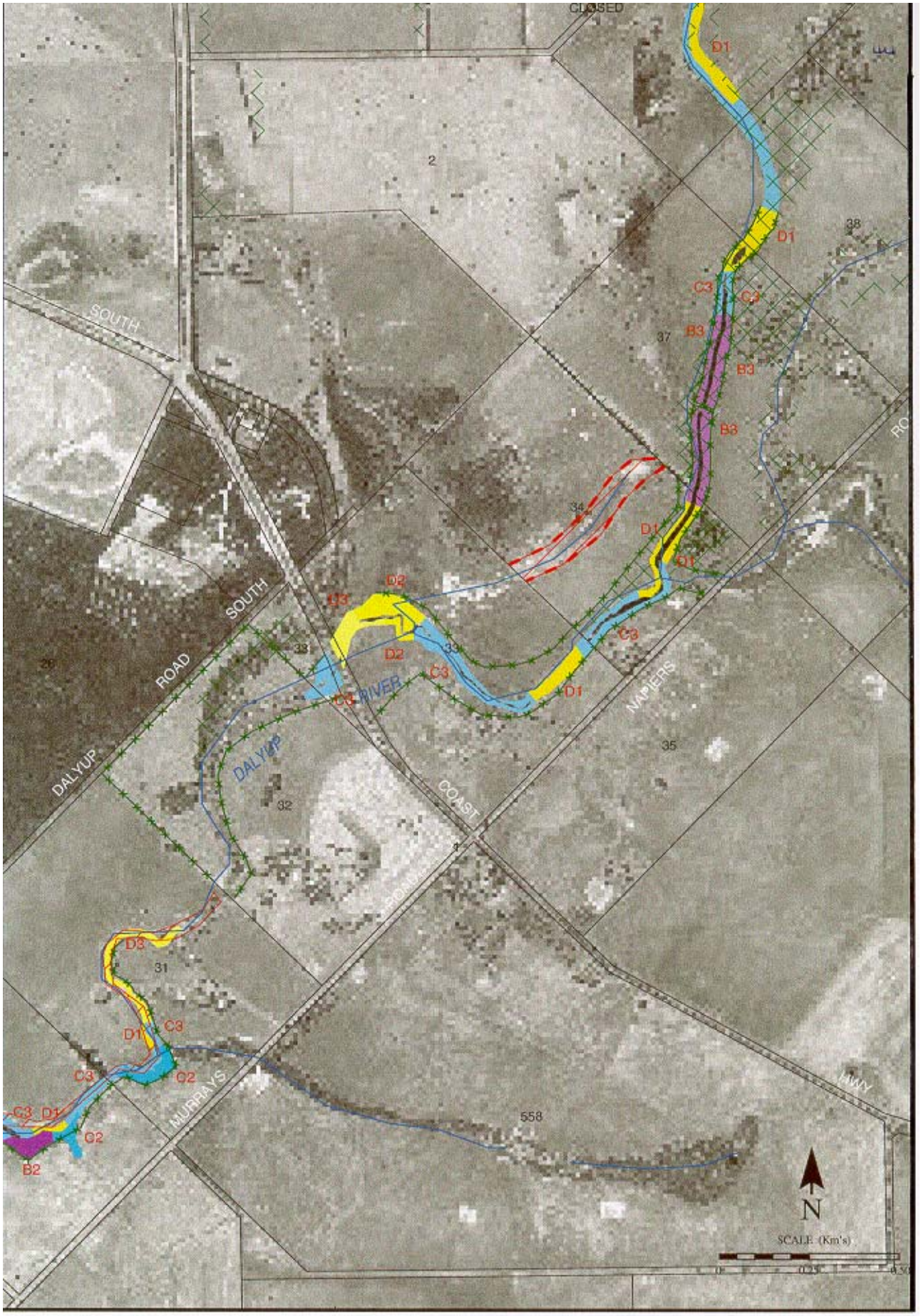
Other

It is recommended that lot boundaries be realigned to exclude the river. For example in lot 38, there is a small corner section of the block across the river. This makes management challenging and would require constructing many river crossings.

Many areas of the river are not fenced wide enough to cope with flood events. It is recommended that land managers re-evaluate the current farming practices in the flood plain, and grow perennial pastures or long-term crops such as commercial tree species. This would help the floodplain to withstand future flood events. The vegetation will also slow the water and hence minimise its erosive power.

The houses on locations D33 and D34 are dangerously close to the river. It is recommended that levee banks be constructed, in addition to the land managers moving the fences further out and revegetating the riparian zones.

Suggested actions	
D31	• Re-fence flood damaged fence and revegetate with native species. • Stabilse actively eroding banks. • Encourage growth of perennial fodder crops on the flood plain to stabilise flood-damaged areas.
D32	• Encourage growth of perennial fodder crops on the flood plain to stabilise flood-damaged areas. • Revegetate low-flow channel with native species to encourage further stability of the banks. • Exclude stock from main river channel. • Fence the remnant vegetation and link it to the main channel.
D33	• Remove stock and allow vegetation to stabilise the floodplain, particularly the area repaired by Main Roads WA. • Re-locate and redesign the crossing to a straight section of the river. • Revegetate main river channel with native species. • Stabilise actively eroding banks. • Exclude stock from the main river channel. • Encourage growth of perennial fodder crops on the flood plain to stabilise flood-damaged areas.
D34	• Remove the sediment plume and stabilse actively eroding banks. • Revegetate riverbanks with native understorey species – particularly on the bank between the river and the house. • Increase the battering on the riverbanks of the established crossing.
D37	• Revegetate flood damaged areas with native understorey species.
D38	• Infill revegetated sections of the river with native understorey species.
D40 (pt)	• Re-locate and redesign the crossing to a straight section of the river. • Re-fence flood damaged fences.· Revegetate the river corridor with native species. • Stabilise actively eroding banks.
Other	• Ensure future landuse planning changes re-align lot boundaries to exclude the river.



DALYUP RIVER MAP 3

MAP 4 – DALYUP RIVER

Location 40 (pt), E1379-1, E1379-2, E1379-5, D1431

Foreshore vegetation condition
Right hand side: D1 – A3 (average B3
Left hand side: D1 – A3 (average B3)

The condition of the vegetation along this section of the river is considerable better than some sections of the river, particularly in locations D1379-2, and D1431. The average condition of the vegetation is B Grade, with remnant vegetation associated with the river graded as A Grade. It is recommended that areas of bush linked to the river be fenced as an absolute priority.

Revegetation

Revegetation is needed on the right-bank of location E1379-2 to stabilise the banks and minimise further erosion. Old Ford Road is at risk of being undermined and washed out if the area between the river and the road is not stabilised. Already the culvert has had to be replaced on this road. Revegetation is also needed along location E1379-1 and E1379-5 to stabilise the banks and minimise further erosion. If further high flows or floods occur along this section, the vegetation may not be able to hold the banks together because the buffering strip is not wide enough.

Some infilling of vegetation is needed in location 1431 to improve the foreshore condition on the sections of the river where it is C Grade. This should mostly include understorey species and rushes and sedges. Rabbit control is also needed to increase natural regeneration of the existing vegetation.

Fencing

There is no fence along the left bank of location E1379-2 but may not be required as there is no stock access to that side of the river. The Right Bank is mostly fenced except a small area near the boundary with location E1379-5 where it was washed out. It is recommended to replace and widen the fence at this point.

The whole section of the river is fenced in location E1379-1 and E1379-5 although the fences may need to be wider where the riverbanks are actively eroding. It is also recommended that the remnant vegetation associated with the river is fenced to increase the width of the riparian corridor. Location 1431 appears fenced however riparian vegetation width and fencing needs to be widened – particularly on the river bends, as the riverbanks are unstable.

Erosion control

Urgent erosion control is needed along this section of the river. The banks are extremely steep and likely to widen if not protected. Use rushes and sedges and possibly matting or brushing to stabilise the banks of the river. Leveling off of the banks on this stretch of the river is not possible due to the narrowness of the river and inaccessibility due to remaining vegetation. Matting may be needed along both sides of the river where the banks are almost vertical. Alternatively, natural revegetation may gradually stabilise the banks.

Erosion control is needed on location 1431 – on the approach road to the crossing. Ideally this road should be revegetated and a new road created at an angle (not a right angle) to the direction of the river.

Crossing design

The crossing on location D40 is not in an ideal location as it is between two sharp bends in the river and would easily be eroded. To build a stable crossing on location E1379-2 would be difficult due to the steepness of the banks and depth of the river. A possibility would be to negotiate an alternative, permanent access to the land from the Dalyup North Road via adjoining location E1411. The crossing should be constructed on a straight section of the river.

The southern crossing on location 1431 is a good example of a well-located and constructed crossing on a straight stretch of river. The upper crossing is badly washed out, as it is located on a river bend. Relocating this upstream may be an option.

Weed control

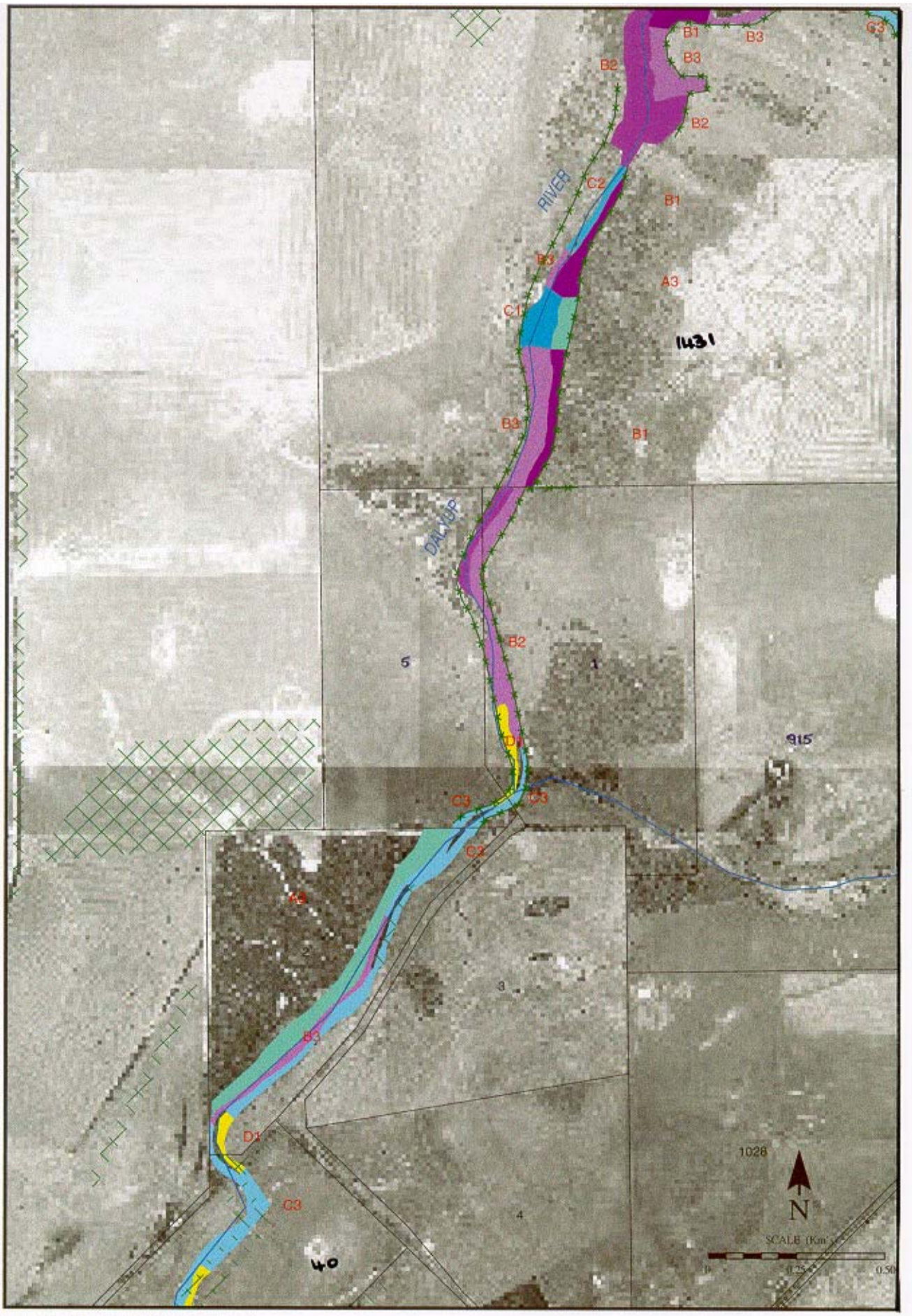
Weed control needed along all sections of the river, particularly on the right bank. There is evidence of rabbit damage, which is stopping the natural regeneration of riparian vegetation in location 1431.

Other

The dwelling on location E1379-1 is too close to the river and may be at risk of being damaged in future floods. A levee bank may help to protect the house from future flood events.

The boundary locations in this section are inappropriate. An option would be to realign locations E1379-1 and E1379-5 along the edge of the river. With owners of location E1379-1 owning all land east of the river and owners of location E1379-5 owning all land west of the river.

Suggested actions	
40 (pt)	• Redesign and relocate crossing on the northern boundary. • Stabilise actively eroding banks. • Fence the main channel to exclude stock.
E1379-1	• Erect a levee bank between the house and the river. • Fence remnant vegetation associated with the river.
E1379-2	• Revegetate the right bank of location to stabilise the banks and minimise further erosion – unless natural regeneration is adequate.
E1379-5	• Re-fencing a section of the fence. • Revegetate the right bank to stabilise the banks and minimise further erosion. • Fence remnant vegetation associated with the river
D1431	• Redesign and relocate crossing in northern section of the property. • Fence remnant vegetation associated with the river
Other	• Ensure future landuse planning changes realign lot boundaries to account for the river, particularly on locations E1379-1 and E1379 – 5. • Stabilise the headcut forming near Old Ford Road.



DALYUP RIVER MAP 4

MAP 5 – DALYUP RIVER

Location: 1431 (pt) E1514
The major tributary that was assessed as part of this survey branches to the right in this section of the river. Maps 5 – 10 show the condition of this tributary.

Foreshore vegetation condition
Right hand side: D2 – B3 (average B2)
Left hand side: D1 – B1A3 (average B3)

The foreshore vegetation condition in location 1514 and 1431 is in good to excellent condition. There are considerably wide buffers of riparian vegetation linked to river corridor. This section of the river is one of the better sections of the river. Part of the river vegetation has been burnt during a recent bushfire. There are some great river pools in location 1514 where the river cuts through granite rock.

Fencing and revegetation

Entire section of the river appears to be fenced, except possibly the beginning of the major tributary in location 1431. The vegetation is still in good condition and it is recommended that this is fenced. Revegetation is needed in small sections graded C and D Grade in locations 1514. This has been fenced, however supplementary planting of seedlings could help natural regeneration.

Erosion control

Generally this section of the river is much more stable due to the amount of vegetation associated with the river. There is some undercutting of banks and erosion just below the crossing on the right bank of location 1514.

Crossing design

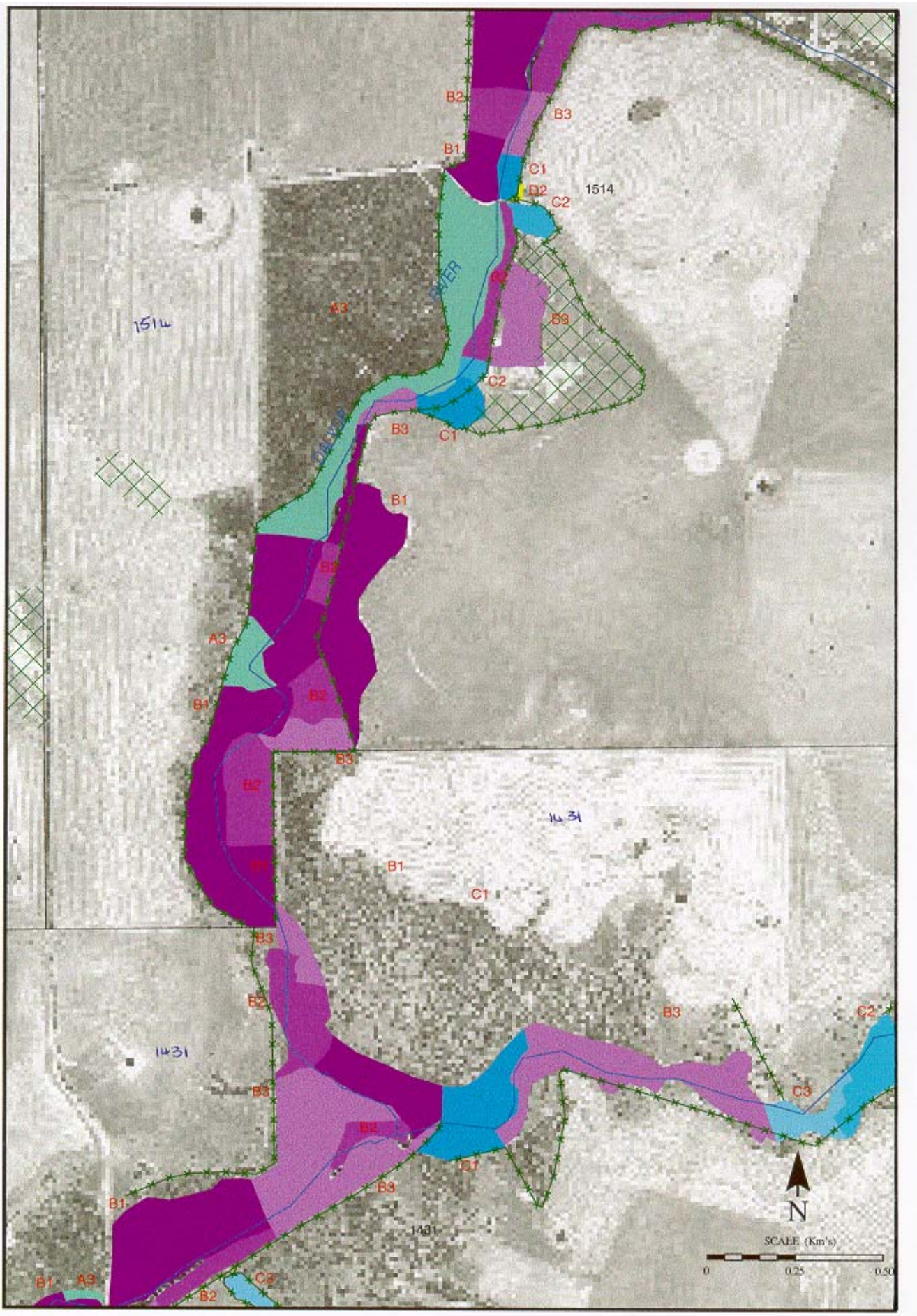
The crossing in location 1514 is in a suitable position, however would be more stable if the design followed contours of the channel bed more and is made of smaller rocks.

Weed control

Little weed control is needed except in an area where fire has burnt the vegetation. Hand spraying may be needed in this area.

Other
There are small outbreaks of salinity on the right bank. This could be minimised by surface water control and using water higher up in the catchment (see *Dalyup Catchment Report*, AgWest 2001).

Suggested actions	
1431	• Fence remnant vegetation associated with the river corridor.
1514	• Revegetate small sections of vegetation graded C and D Grade condition. • Infill the crossing on location 1514 with smaller rocks and ensure the crossing follows the contours of the channel bed.



DALYUP RIVER MAP 5

MAP 11 – DALYUP RIVER

Location: E1514 (pt) E1513

Foreshore Vegetation Condition
Left Bank: B2 – D1 (average – B3)
Right Bank: B1 – C2 (average – B2)

The vegetation condition in location 1514 is in excellent condition with considerable sections of remnant vegetation associated with the river. Location 1513 has vegetation in good condition, however there are sections that are degraded due to stock access and secondary salinity.

Fencing and revegetation

The river corridor in location 1513 is too narrow and may need to be widened on both sides of the river to cope with flood flows. This section needs to be revegetated with salt tolerant, native species. It also requires fencing or the exclusion of stock to ensure the long-term protection of the river.

The salt scald north of Brownings Road in location 1513 needs to be revegetated to control the headcuts, which threaten Brownings Road. Some suitable species for salt scalds include *Gahnia trifida*, Native Couch and tolerant ground covers. The neighbouring property below Brownings Road on the Dalyup River had no significant property damage during last two floods due to the width of the vegetation buffer along the river.

Erosion control

Erosion control is needed in location 1513 on the left bank where the river is graded as C or D Grade condition. Rushes and sedges can be used to stabilise the toe of the bank and the slopes. A number of headcuts exist on this stretch of river including those starting in the salt scald, one on the left bank at the sharp bend in the river and one again on the left bank further upstream. Headcuts should be stabilised by diverting or using the water in the upper catchment. In addition, the active part of the headcut should be stabilised by placing smaller rocks in a rockchute formation. Revegetation may help and it is recommended to use salt tolerant rushes and sedges e.g. *Juncus krausii* and colonising plants such as *Acacia saligna*.

Crossing design

A crossing is present in location 1513 however it has been washed out. The crossing is not stable, as it is located after a large bend in the river. A better location would be further downstream on a straight stretch of river.

Weed control

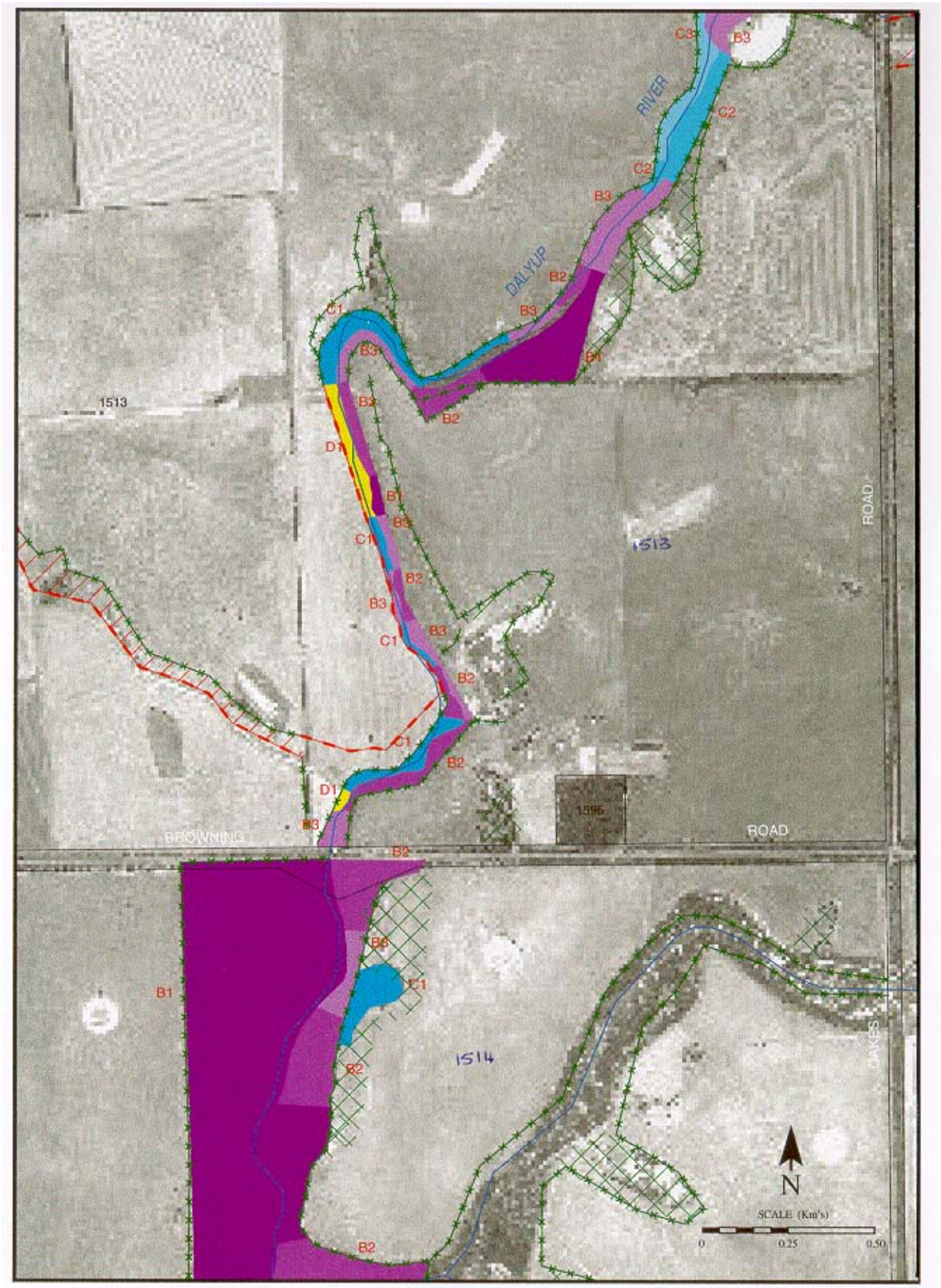
Lovegrass is a major problem on this stretch of river, that can be controlled by grazing and slashing.

Other

Parts of this section have a pool-riffle sequence indicating a fairly stable functioning river although the pools are starting to fill with sediment from bank erosion further upstream. Two large salinity outbreaks exist on the right bank.

Suggested actions

E1513	• Fence and revegetate the salt scald on the right bank with salt tolerant species. • Fence the Dalyup River ensuring an adequate width of foreshore vegetation. • Control actively eroding banks (areas graded as C or D Grade). • Stabilise active headcuts.



DALYUP RIVER MAP 11

MAP 12 – DALYUP RIVER

Location: E1512

Foreshore vegetation condition
Right Bank: C2 – B3 (average B3)
Left Bank: C3 – B1 (average C1)

There are sections of foreshore vegetation in good condition (B Grade condition). There are also sections graded as C Grade due to the impacts of previous stock access and secondary salinity.

Fencing and revegetation

There is a high probability that salinity will increase along this stretch of river and a wider buffer of vegetation between the river and farmland is needed. It is recommended that salt tolerant native species be used for revegetation where possible. The entire section of the river is fenced, however the fences may need to be widened in the future if the salinity starts to spread outwards.

Erosion control

A headcut has started from the end of a surface water drain on the left bank close to the river. The surface water drain did not cope with the flood event, and does not allow for the safe disposal of water into the river. The drain needs to be redesigned or filled in. Until this is done the headcut will continue to get worse because of the sheer volume of water it carries.

The bank of the river graded as C Grade condition is unstable. These can be stabilised by revegetating with salt tolerant native species.

Crossing design

A crossing exists where the main channel and a tributary meet. It was largely washed away in floods. This may need redesigning to help it survive future flood events. The flood also damaged the roadcrossing present on Boydells Road. The Shire of Esperance has since repaired the bridge.

Weed control

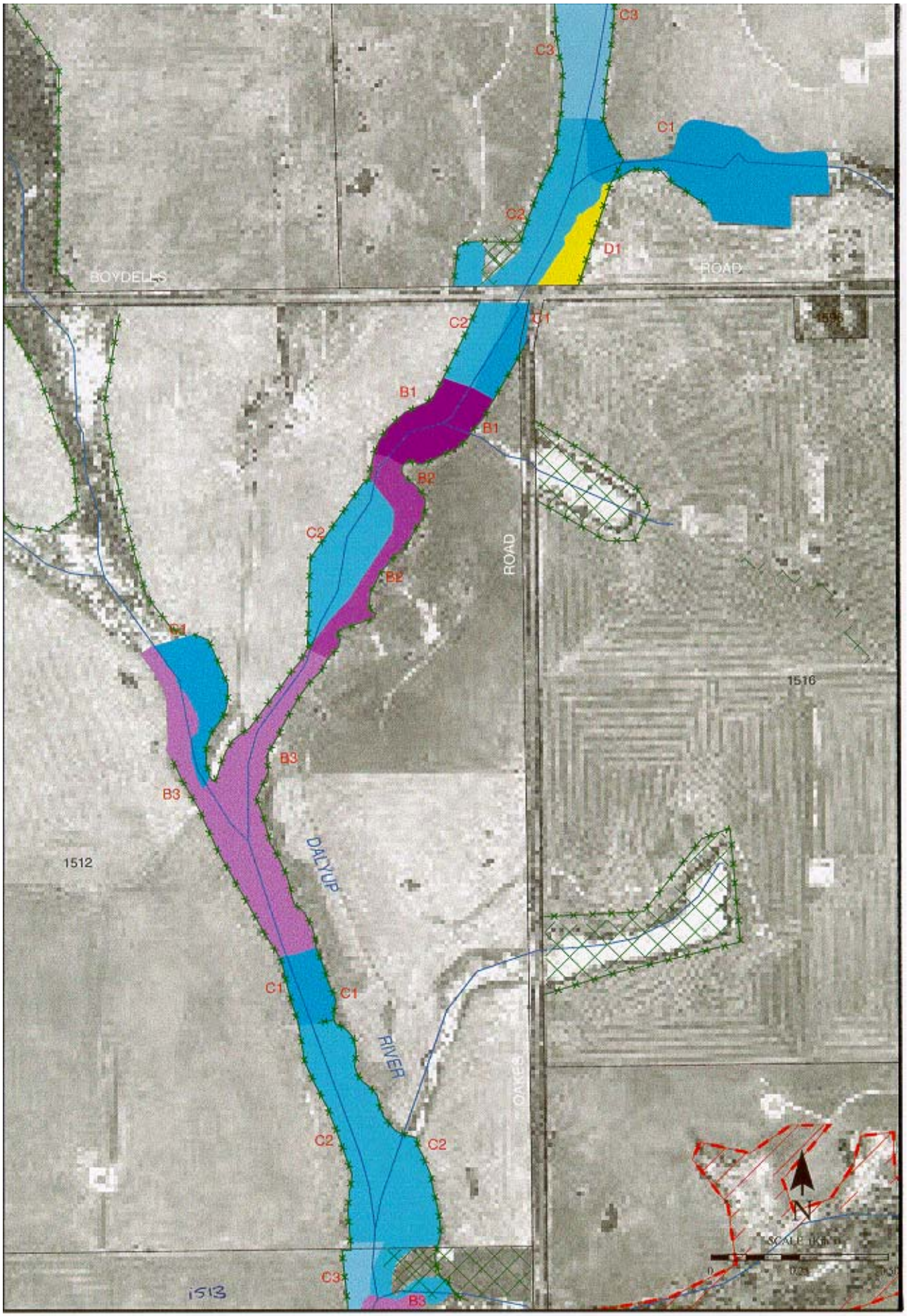
No significant weeds present in the lower salinity part of the river due to the high salinity but radish and African Lovegrass dominates the stretch of river upstream from the crossing. Crash grazing, slashing and spraying is recommended to control these weeds.

Other

Refuse disposal is occurring very close to and in the river. This is an illegal practice. It is recommended to relocate the existing refuse site to an area with more clay soils and away from the river. The Drum Muster program enables recycling of spray containers.

Suggested actions

1512	• Revegetate the river corridor with salt tolerant species. • Stabilise the headcut forming from a surface water drain. • Stabilise actively eroding areas graded as C Grade. • Relocate the refuse site to a more suitable location further from the river.



DALYUP RIVER MAP 12

MAP 13 – DALYUP RIVER

Location: E1511- 11 (1762 is described in map 14).

Foreshore vegetation condition
Left Bank: A3 – B2 (average B1)
Right Bank: B2 – D1 (average B3)

The foreshore vegetation in location E1511- 11 is graded as B Grade condition. The width of the foreshore vegetation is wide enough in most sections. Some excellent quality vegetation remains along the left bank. Some sections appear to have been burnt in recent decades and there has been good regeneration since the fire.

Fencing and revegetation

Entire section of the river is fenced in E1511- 11, although the floods damaged some sections. These sections could be fenced wider to ensure they survive future flood events. Revegetation with salt tolerant natives is needed in a small sections graded as C Grade.

Erosion control

Erosion control and bank stabilisation is needed where the river is in C Grade condition on the right bank in location E1511- 11. Revegetation with salt tolerant sedges such as *Gahnia trifida* could be used to stabilise the salt scald. Gully erosion is also occurring on the left bank close to the boundary of location 1762. Recommend revegetating this area and fencing from stock to slow the velocity of the water. Water should be diverted away from the headcut in the upper catchment. There is also a deep drain that enters the river. This also should be fenced and revegetated, to help minimise further sedimentation of the Dalyup River.

Crossing design

Two creek crossings occur on location E1511- 11. The crossing on the boundary location with 1762 is satisfactory, however the other crossing is located where the main channel and a tributary meet. This crossing was largely washed away in floods. A more stable location would be further downstream on a straight section of the river.

Weed control

Some weed control is needed along this section, however generally the B Grade condition means that there are fewer weeds to control.

Suggested actions	
E1511-11	• Revegetate the small section in location E1511- 11 graded as C Grade with salt tolerant species. • Stabilise the headcut near the boundary of location 1762. • Examine options to relocate the crossing on location E1762 to a straight section of the river.

DALYUP RIVER MAP 13

MAP 14 – DALYUP RIVER

Location: E1762, 1800 (pt)

Foreshore Vegetation Condition
Left Bank: A3 – D2 (average – B1)
Right Bank: A2 – C1 (average – A3)

The foreshore vegetation condition in location 1762 is in good to excellent condition (A and B Grade). There is only one small section graded as D Grade condition. The vegetation condition in location 1800 is in excellent condition.

Fencing and revegetation

The entire section of the river in location 1762 and 1800 is fenced. It is recommended that the fence be taken further back where the river condition is D Grade condition. Revegetation and erosion control is also recommended to help stabilise the river channel.

Some fencing exists across the river in location 1762 at crossing points. A suggestion would be to replace ringlock fencing with plain wire or flood fencing to protect the fencing from future damage – as ringlock impedes water flow and allows debris to catch on the fence wires pulling the fence down. Widening the width of vegetation along the eroded section south of Speddingup West Road would help to further protect the river. Otherwise the river corridor is in excellent condition.

Erosion control

A headcut has formed on location E1762 in a salt pan on the left bank of the river just upstream from the lower crossing. Salt tolerant species such as *Gahnia trifida* or other salt tolerant species could be grown there. A series of small headcuts also occur between the two crossings on the left bank. It is recommended to fence and revegetate this area. A new channel has also formed where the river has moved out and flowed along the fence line. This needs to be stabilised or the fence is at risk of being damaged.

Crossing design

Two crossings exist on Loc. E1762. The downstream crossing may be more stable if it was lowered and smaller rocks were used (about 5 – 10 cm in size). The upstream crossing appears to be stable.

Weed control

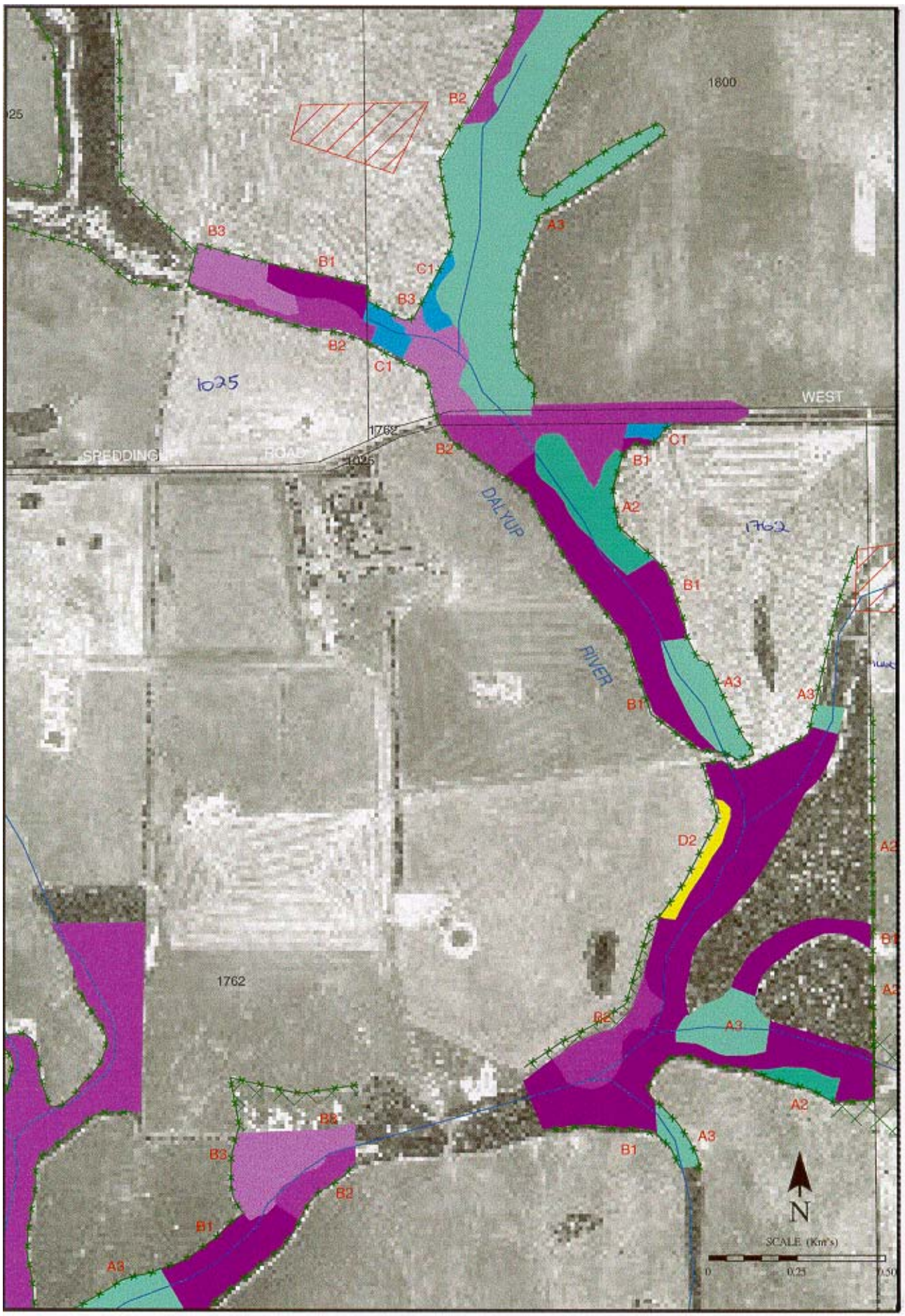
Very few weeds are present in sections that are A2 or A3. Some weed control needed in other areas.

Other

Refuse and grain dumping has been occurring near the downstream crossing on location E1762. Dumping grain near the river is going to increase the number of weed species growing in the river vegetation, however it may help stabilise salt pans if some seedlings germinate. An alga bloom was occurring near the downstream crossing when surveyed in early June. The river corridor is also showing signs of secondary salinity.

Suggested actions

1762	• Widen the section of the river graded as D Grade condition and revegetate with native species. • Stabilise headcuts located in a salt pan on the left bank and between the two crossings. • Fence and revegetate salt scalds and areas graded as C Grade condition with salt tolerant, native species. • Stabilise the downstream crossing by using smaller rocks (about 5 – 10 cm in size) and lower the height of the crossing to follow the contours of the channel.



DALYUP RIVER MAP 14

MAP 15 – DALYUP RIVER

Location: 1800 (pt), 530, 1343, 1760.

Foreshore vegetation condition

The foreshore vegetation in this section of the river ranges from A Grade in locations 1800 and 1760, to D Grade as found in locations 530 and 1343. Areas graded as D Grade have little or no remaining foreshore vegetation due to stock access and secondary salinity.

Fencing and revegetation

The river in location 530 needs to be fenced and revegetated and stock access limited. The area fenced should also include a headcut forming in this location. The landholder has planned to revegetate this area. Areas graded as C and D Grade in locations 1800and 1343 also should be revegetated with salt tolerant native species. Any areas to be revegetated would require mounding first. The boundary fence between location E530 and 1800 was damaged by the flood event and the fence may need replacing.

Erosion control

Extensive erosion problems exist on E530 especially on the left bank with headcuts up to 2 m deep. To stabilise headcuts it is recommended to fill them with small rocks and build a diversion bank so water cannot flow into the gully. Revegetating the headcut with rushes and sedges will also help stabilise the area.

Crossing design

The crossing on location E530 is in a suitable position. Placement of small rocks is recommended to help stabilise the crossing.

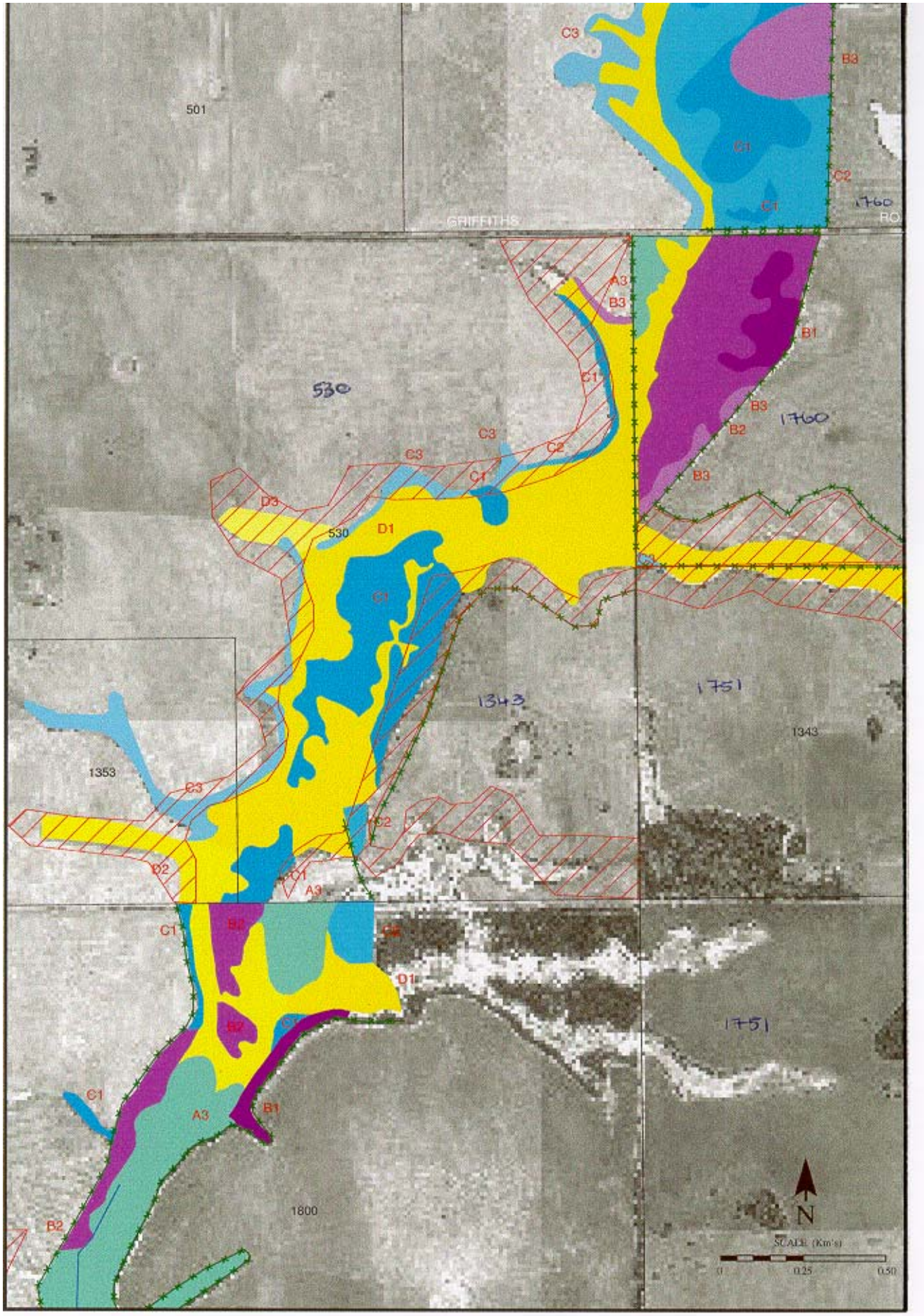
Weed control

Some weed control is needed on the edge of the vegetation where the river is graded B1 or lower. Generally little weed control needed due to high salinity of river.

Other

There is a concern that salinity is going to continue expanding into the surrounding paddocks and there are many places where there is insufficient vegetation between the paddock and the river channel. The land manger must address water use on farm to minimise the amount discharge to the river. Planting the area to fodder crops may be recommended to try to stabilise the bare salt scalds.

Suggested actions	
1800	• Replace boundary fence between location 1800 and E530. • Revegetate areas graded as C and D Grade.
1343	• Revegetate areas graded as C and D Grade with salt tolerant, native species. • Replaces fences that are falling down, and widen the width of the vegetative corridor.
530	• Fence and revegetate with salt tolerant, native species. • Realign the fences to incorporate the headcut. • Stabilise headcuts forming. • Revegetate areas graded as C and D Grade with salt tolerant, native species. • Replace falling down fences on the tributaries draining to the river.
1760	• Revegetate salt effected areas with salt tolerant, native species. • Replace fence along the road. • Fence sections of the river that are not fenced.



DALYUP RIVER MAP 15

MAP 16 – DALYUP RIVER

Location: E1760, 1052, 581, 506.

Foreshore vegetation condition

The foreshore vegetation condition ranges from B grade to D grade. The main impacts on the condition of the vegetation are salinity and stock access. There are sections of vegetation in this section of the river in very good condition, with a high biodiversity value.

Fencing and revegetation

Fencing is recommended in location 1760, 581 and 1052. Some sections of the right hand bank on location 1760 is fenced, however it may need to be relocated further back if the area of secondary salinity continues to grow. There are some areas of vegetation associated with the river corridor still in good condition; hence fencing these will help to ensure the long-term protection of the vegetation.

Erosion control

A minor headcut exists on E506. Construction of a diversion bank around the major headcut in addition to revegetating the area with rushes and sedges may help stabilise the headcut. Further revegetation with tree and shrub species may also be needed.

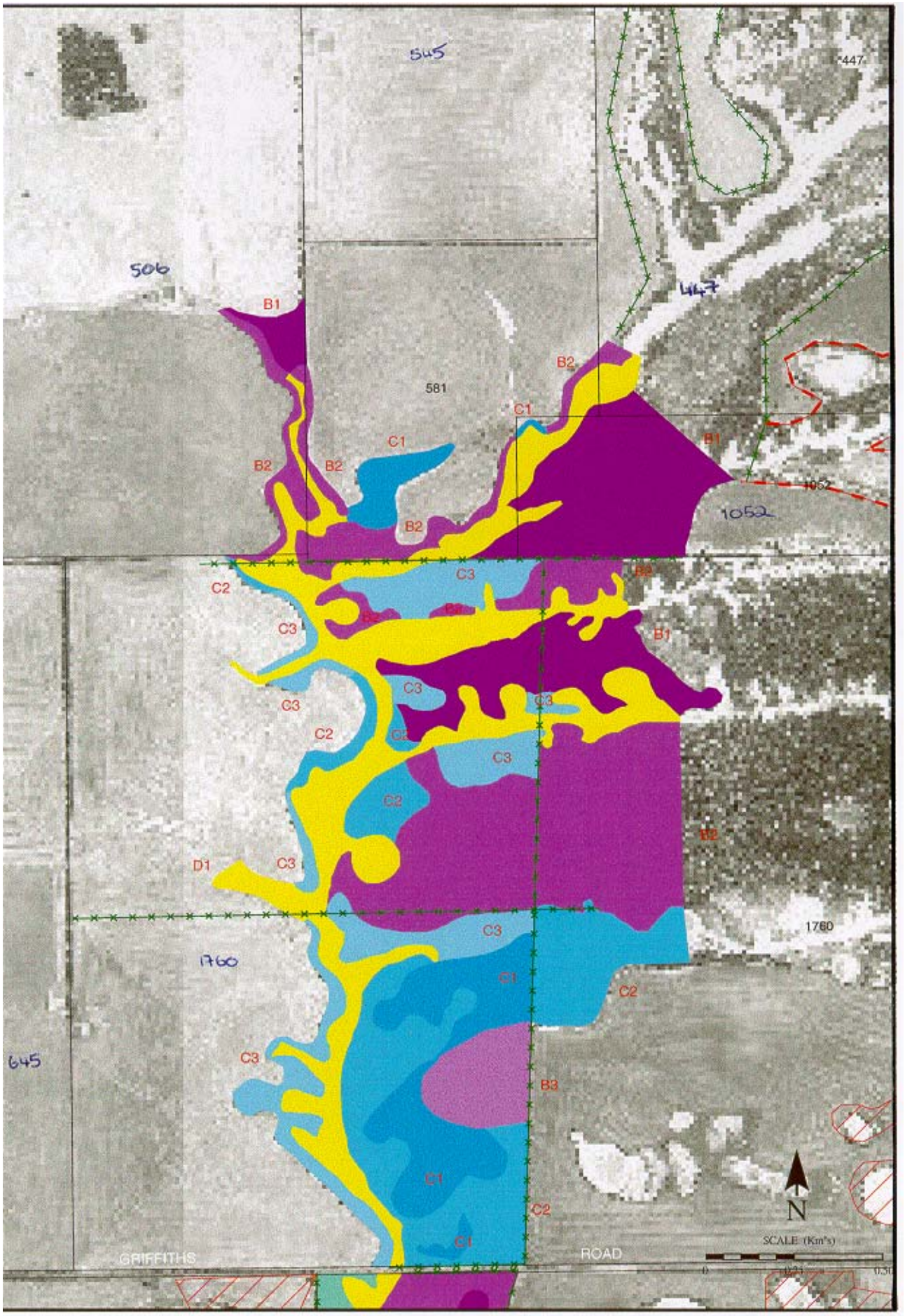
Weed control

Little weed control needed due to higher salinity values in the river valley.

Other

Salinity appears to be increasing along the streamlines. The land manager may need to try to increase water usage in the upper catchment to minimise discharge to the river environment. Monitoring groundwater levels may indicate the rise of groundwater levels.

Suggested actions	
E1760	• Revegetate areas graded C Grade with species able to tolerate high salinity levels. • Fence the river with an adequate buffer allowing for potential groundwater rise.
1052	• Fence sections of the waterway not fenced.
581	• Revegetate areas graded C Grade in locations 1760 and 581 with species able to tolerate high salinity levels. • Fence the river with an adequate buffer allowing for potential groundwater rise.
506	• Stabilise the headcut on location E 506. • Replace fences between the tributary and the river with plain wire to minimise potential risk of loss from floods. • Fence the tributary draining to the river.



DALYUP RIVER MAP 16

WEST DALYUP RIVER (MAPS 17 – 26)

The assessment of the foreshore for the West Dalyup River begins at location D29 (south of South Coast Highway) and passes Brownings Road, Boydells Road, Speddingup West Road and Griffiths Road. The foreshore condition assessment ends on location E607 just below Raszyk Road. Locations D29, E853, 1027, 405 (West Dalyup River) are described in Dalyup River Map 2.

MAP 17 – WEST DALYUP RIVER

Location No: E1416, E1412-3, E1016-2, and E1437

Foreshore vegetation condition

Left Bank: B3 – D3 (average – B3)
Right Bank: C3 – D3 (average – C2)

The vegetation condition in this section of the river ranges from B to D Grade. There are sections extensively damaged by the flood events, particularly those areas south of the bridge. There are some sections of B Grade condition north of the highway. Location 1416 has sections of vegetation in good condition, with a range of *Melaleuca*, *Hakea* and *Casuarina* and *Acacia* species. Location 1437 has a significant remnant vegetation bush that is in excellent condition. This is linked to the river corridor of location E1016-2.

Revegetation

Some revegetation has been completed in location 1416, however further planting is needed in sections graded as D Grade condition unless natural regeneration is not adequate.

The foreshore width also needs to be widened on locations E1016-2 on both sides of the river. Revegetation is needed on the river bend on location E1437 to combat wind erosion, which could turn into deep gully erosion in times of flood. Banks in this section of the river should be revegetated using native local species with rushes or sedges in the creekline; and *Eucalyptus* and *Melaleuca* species and smaller understorey species further up the slope.

The landholder on 1412-3 has re-fenced and revegetated this section of the river. The site is a direct seeding trial part funded by the Water and Rivers Commission and Bushcare. The banks of the river are also naturally regenerating since the floods as the stock have entirely been excluded from the river.

Fencing

Most fences were lost along the West Dalyup River south of the Highway in the 1999/2000 flood events. Replacement fences need to take into account the flood levels and be placed further back where the river is actively eroding.

Fencing is needed along almost the entire length of the river on location E1016-2. Some fencing exists on the right bank up from the highway and along the boundary with location E1437. This is actually the ideal place for a fence as it is out of the river valley. The pocket of land between the river and the higher fence would need to be revegetated and Lovegrass controlled. An alternative for this area would be to plant some commercial species adjacent to the river channel, to help ensure a stabile floodplain during high flow events, but to gain further productivity from the land.

Erosion control

Erosion needs to be addressed along this entire section of the river, particularly locations E1416, E1412-3 and on the river bends on locations 1437 and 1412-2 where there is massive undercutting, bank subsidence and siltation. Sedges and rushes are the best option in the river channel. Brushing would also be suitable on the banks although they are very steep.

Crossing design

Ideally only one river crossing should be needed along location E1027. A better position to locate the crossing would be downstream about 200 m where the crossing is present. This is because the river is straighter and less prone to erosion. A rock base in the river would be more suitable.

A crossing on location E1016-2 enables access to a small area of land on the left bank of the river. This is a very difficult stretch of river on which to locate a crossing. This may be better located across the river from the house or try to find a more suitable site with a rocky base.

Weed control

Weed control is needed especially where vegetation condition is graded as C or D Grade.

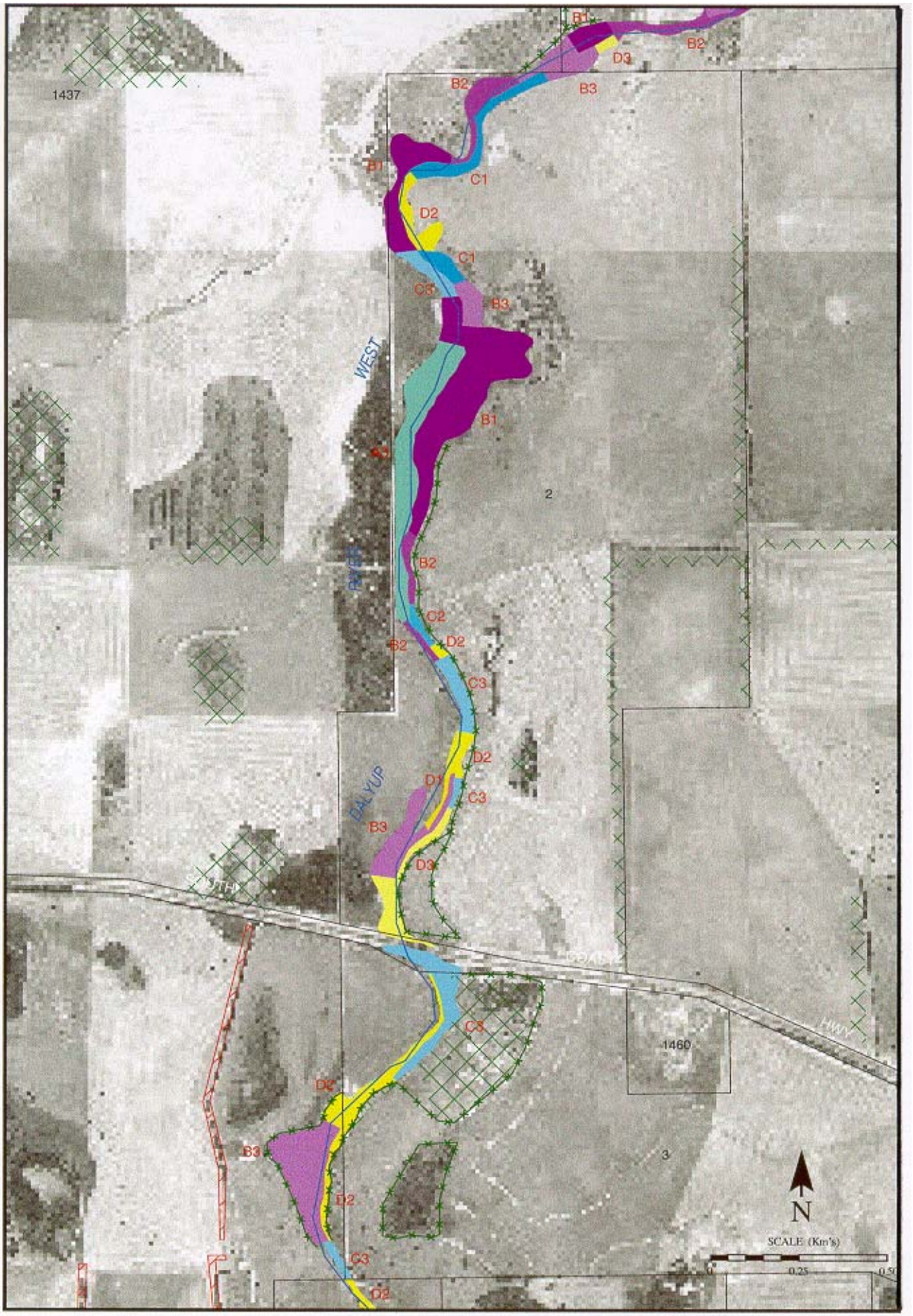
Other

Realignment of locations E1416 and E1412-3 is needed to better manage the river, reduce loss of fences and number of crossing points. A suggestion would be that the owners of location E1416 manage the west side of the river, while owners of location E1016 manage the east side of the river.

Two small pockets of land exist between the boundary of E1437 and E1016-2. These may be ideal sites for a long-term crops such as commercial trees or pines depending on the soil and suitable rainfall. This would also assist in using some of the excess water in the catchment and further protecting the river. Access could be gained when needed via the neighbour's fenceline. The other option might be to realign the location boundaries to ensure property boundaries do not cross the river.

A shed and other buildings are at risk of being undermined or damaged on location E1016-2 if upstream management of the river and adjoining bushland is not undertaken. A shed is located less than 100 m from the main river channel, which is too close to a river of this size and catchment area. Downstream of this property the river has widened from 100 – 350 metres. A construction of a levee bank between the sheds and the river may help protect the house.

Suggested actions	
E1416,	• Revegetated areas graded as D Grade. • Stabilise actively eroding banks.
E1412-3	• Monitor success of direct seeding trial. • Ensure the vegetation stabilises the headcuts.
E1016-2	• Widen the river corridor on both sides of the river. • Construct a levee bank between the sheds and the river to minimise risk of loss of shed and other building.
E1437	• Revegetated areas graded as D Grade. • Stabilise actively eroding banks on the river bends.
Other	• Realign lot on locations E1416 and E1412-3.



DALYUP RIVER MAP 17

MAP 18 – WEST DALYUP RIVER

Locations 1019 – 1, 1506

Foreshore Vegetation Condition
Left Bank: B1 – C1
Right Bank: A3/B1 – D3

The majority of the foreshore vegetation on the left bank of location 1506 is graded as B Grade condition except for small sections of C1 and a stretch of D3 where the section joins location E1019-1. There is a considerable patch of remnant bush adjoining the river that is in excellent condition.

In location 1019-1 the majority of the vegetation associated with the river is B Grade condition, with small patches of C and D Grade towards the south of this location. Overall the vegetation in this section is in excellent condition, with a good diversity of species, with an adequate buffer width, with minimal weed invasion. There are also nice granite pools.

Revegetation

Revegetation is recommended in sections graded as C or D Grade condition. Rabbit control is needed prior to any revegetation.

Fencing

Fencing needed almost along this entire section of the river in loc. 1019 – 1. This would be a high priority project, particularly due to the good condition of the remaining riparian vegetation.

The river in Location 1506 appears fenced, and the width is adequate except possibly where the left bank joins location E1019-1. Fencing of a small tributary that runs down to the river on the left bank and is well vegetated with Swamp Yates *(Eucalyptus occidenta*lis) is recommended.

Erosion control

Large gullies have formed on location E1019-1. These need rehabilitating with rushes and sedges and possibly a contour bank to divert the water from running into the gully. The gully on the right bank seems to be caused by a salt scald, therefore water management in the upper catchment is recommended.

There is also a washout on the left bank near the top of location E1506 and an area of erosion on a bend in the river along the right bank just above the boundary with the lower location. This should be revegetated with trees, rushes and sedges plus widening the fence at these points.

Crossing design

Two crossings are present along this section of the river. The location of these is not ideal, as they are located on a bend in the river where the erosive forces are greatest. These crossings may need to be relocated upstream where the river is straighter and the vegetation is in good condition. An excellent example of a crossing exists on location 1506. It is located on a straight stretch of river with a rocky base.

Weed control

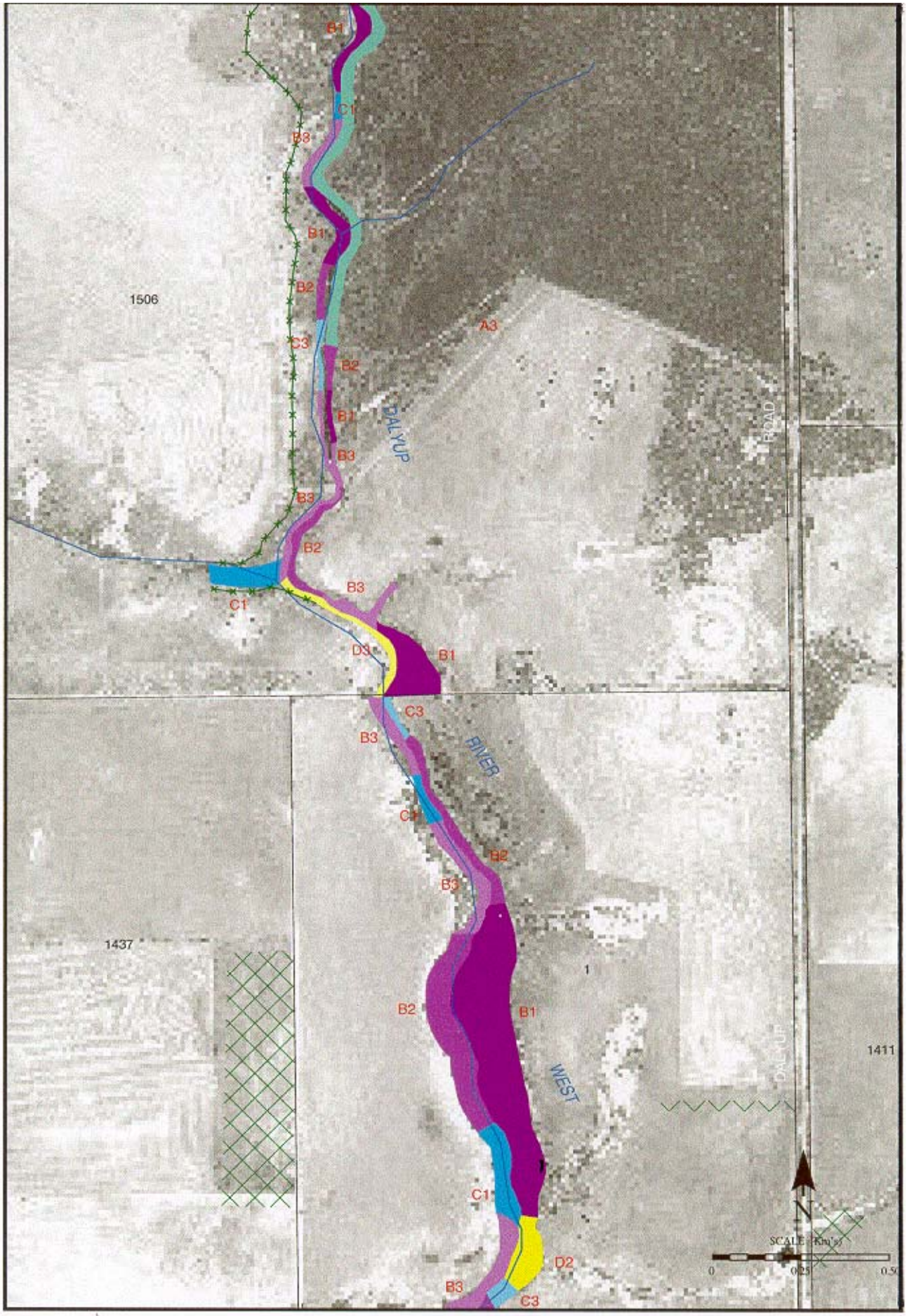
Weed control needed along the majority of the river where the condition is less than B Grade.

Other

Rabbits appear to be a significant problem along the river. Recommend continuing rabbit control and revegetating degraded areas.

Salinity problems are arising within three small tributaries that join the river on the right bank. High water-use farming is recommended in the upper catchment to use more water. Monitoring groundwater is recommended in these sites to measure groundwater rise. Salt scalds should be revegetated with salt tolerant plants including *Halosarcia* sp., *Melaleuca cuticularis* (Saltwater Paperbark). There are some nice granite pools in location 1506 showing an excellent pool, riffle sequences along the river.

Suggested actions	
1019-1	• Revegetate and stabilise the banks above property boundary of 1019-2, and where the river is graded as C or D Grade condition. • Fence the river. • Stabilise large gullies with rushes and sedges and establish contour banks above the gullies to manage water. • Fence tributaries draining into the river.
E1506.	• Revegetate and stabilise the washout on the left bank near the top of location with trees, rushes and sedges. • Fence any section of the river not fenced. • Fence the tributary draining into the river. • Revegetate and widen the fences where the river is graded as C or D Grade condition.



DALYUP RIVER MAP 18

MAP 19 – WEST DALYUP RIVER

Location No: E1505, E1504 –1 (pt)

Foreshore vegetation condition
Location 1505 has sections of riparian vegetation along the river that is in very excellent condition. There is a small section of D Grade vegetation that shows extensive flood damage from the 1999/2000 floods.

Location 1504 –1 has vegetation in excellent condition, and the riparian buffer is wide. There are some sections graded as C Grade.

Revegetation

Revegetation is needed on the upper section of the left bank in location 1505 where the condition is graded as D Grade condition. The site has been re-fenced since the 1999/2000 floods, however the site may need to be revegetated to stop further erosion if natural regeneration is not adequate. Sections graded as C Grade in location 1504-1 should be revegetated.

Fencing

The river in location 1506 is fenced, although the fences may need to be wider in the sections graded as C and D Grade. If further high flows or floods occur along this section, the vegetation may not be able to hold the banks together because the buffering strip is not wide enough. The river in location 1504-1 is fenced.

Erosion control

Stabilisation of the banks is needed on location 1505 where the river is D1 to D3. Rushes and sedges can be used to stabilise actively eroding banks, with native trees and shrubs on the banks.

Crossing design

The crossing in location 1505 is on a bend in the river, which has the most erosive power. It is likely that this crossing will continue to wash out at because the force of fast flowing water has a higher erosive energy on river bends than on straight sections of river. A better location for the crossing would be in the lower half of the section where the river is straighter.

Suggested actions

Location 1506

- Revegetate the upper section of the left bank of location 1506 where the river vegetation is graded as D Grade condition.
- Widen sections of the fences where the vegetative width is not adequate, particularly on the river bends and upstream of the crossing point.
- Relocate the river crossing in location 1505 to a straighter section of the river.

Location 1504-1 (Pt)

- Revegetate areas graded as C Grade.

DALYUP RIVER MAP 19

MAP 20 – WEST DALYUP RIVER

Location: E1504 – 11503 pt)

Foreshore vegetation condition
Left Bank: B3 – C2 (average C grade), right bank: B1 – D2. (Average: C Grade).

The majority of the foreshore vegetation along location 1504-1 is graded as C Grade condition. There is a major tributary that joins the river that is in good condition, and is entirely fenced.

In location 1503 there is a long section of vegetation in D Grade condition on the right bank, however on the left bank it is mainly D Grade. There is a section of remnant bush associated with the river that is in good condition. A fire has been through the bush recently as it has been colonised by weeds, *Acacia saligna* and small *Melaleuca* species. There are also *Melaleuca brevifolia, Melaleuca cuticularis, Banksia speciosa* present. The tributary adjacent to the river in location E1504-1 is graded as B Grade condition and is entirely fenced.

Revegetation

A reasonable amount of revegetation has already been undertaken on location 1504-1 and location 1503, however further revegetation are required in areas graded as C or D Grade. A small island of land exists between the two tributaries. The top part of this area probably needs to be revegetated as it is currently eroding and during times of floods is underwater. Maybe commercial tree species could be utilised e.g. oil mallees, *Melaleucas* for tea tree oil.

The width of the river vegetation needs to be wider between location E1503 and where the river joins location E1504-1. With the increasing salinity occurring on this stretch of river a wider barrier between agricultural land and the river needs to be maintained. It is recommended to revegetate this area with local native vegetation such as *Melaleuca cuticularis, Eucalyptus angustissima, Gahnia trifida* (close to the water) and the more salt tolerant species.

Fencing

The entire section of the river is fenced although some fences were lost or damaged in the 1999/2000 flood events. These may need to be moved further out to ensure they survive future flood events.

Erosion control

A headcut exists at the bottom of location E1503. The headcut could be stabilised by diverting water around the gully with a contour diversion bank and stabilising the active headcut with either small rocks or vegetation.

Weed control

Some weed control is needed particularly for Lovegrass.

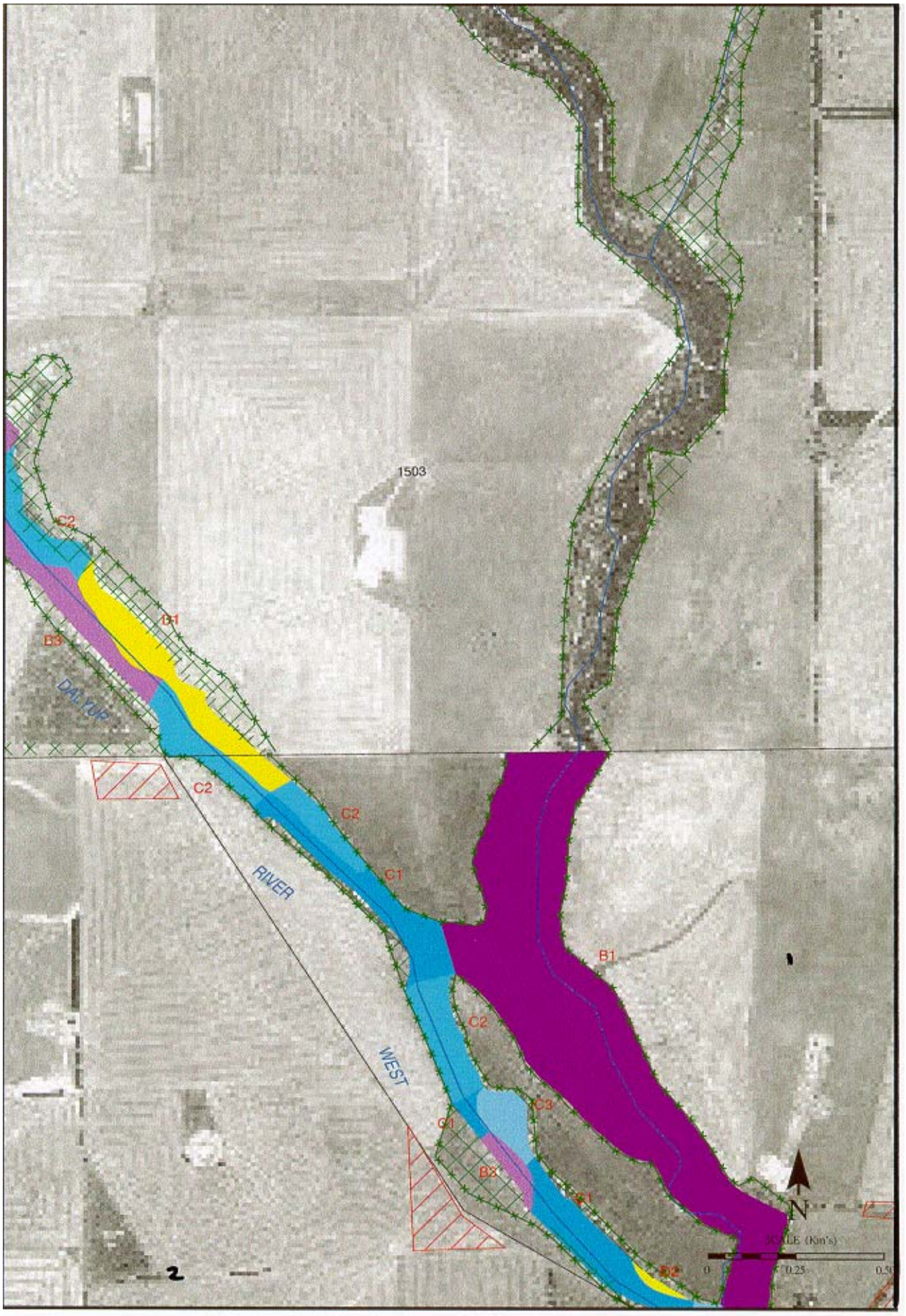
Suggested actions

Location 1504-1

- Revegetate areas graded as C or D Grade with salt tolerant, native species.
- Stabilise the newly formed channel with rushes and sedges at the toe of the eroded bank and native local trees and understorey further back.

Location 1503 (pt)

- Revegetate areas graded as C or D Grade with salt tolerant, native species such as *Melaleuca cuticularis, Eucalyptus angustissima, Gahnia trifida* (close to the water) and the more salt tolerant species.
- Stabilise the active headcut.
- Widen the width of riparian vegetation between location E1503 and where the river joins location E1504 -1and.



DALYUP RIVER MAP 20

MAP 21 – WEST DALYUP RIVER

Location: E1503 (pt), 1500 1499 (pt)

Foreshore vegetation condition

The northern section of E1503 is mainly in C Grade condition on the left bank and B Grade on the right bank, with a section of D Grade. Location 1500 has riparian vegetation graded in A Grade condition (excellent condition) and there is a considerable sized remnant associated with the river. Location 1499 also has riparian vegetation in good condition (B Grade). Vegetation species found in this section of the river include: *Calothamnus quadrificus*, spiny acacia, *Eualyuptus augustissima, Banksia speciosa, Melaleuca cuticularis, Melaleuca brevifolia,* serated leaf grevillia, *Hibbertia* sp., *Conospermum* sp., and Candlestick banksia. There is also a good pool riffle sequence towards the top of the location 1500.

Revegetation

Location 1503 and location 1499 has extensive areas alongside the river that has been revegetated. Species used for revegetation includes River Gums, Flat topped Yate and *Eucalypus spathula*, slat bush and tall wheat grass. Some implanting with salt tolerant species may be required where salinity and waterlogging has impacted on the condition of the vegetation. Recommend that future revegetation consist of local native species – particularly understorey species. This will encourage regeneration as native animals use the vegetation and spread the seeds. Species could include *Melaleuca cuticularis, Eucalyptus angustissima, Gahnia trifida* (close to the water) and other similar salt tolerant species.

Fencing

The entire section of the river is fenced, except for location 1500 where the river does not need fencing, as it is located in a block of remnant vegetation.

Erosion control

Numerous points of erosion exist along this stretch of river, as a result of the 1999/2000 flood. These are likely to stabilise through natural regeneration, as the vegetation is in good condition, which will gradually encroach and stabilise the banks.

A severe gully has formed in the 1999/2000 flood in location 1499 where the river becomes narrower, and has forced the river out of the main channel. The built up levee bank and the road culverts on Boydells Road are forcing excess water sideways into the paddock. Revegetation is needed along the left bank where the river meets Boydells Road and erosion has occurred in the adjoining paddock. Recommend using rushes and sedges on the toe of the bank and local native species.

A headcut has formed on the left bank above the upstream crossing. The headcut could be stabilised with rushes and sedges in the headcut and the surface water diverted to a stable dispersal point.

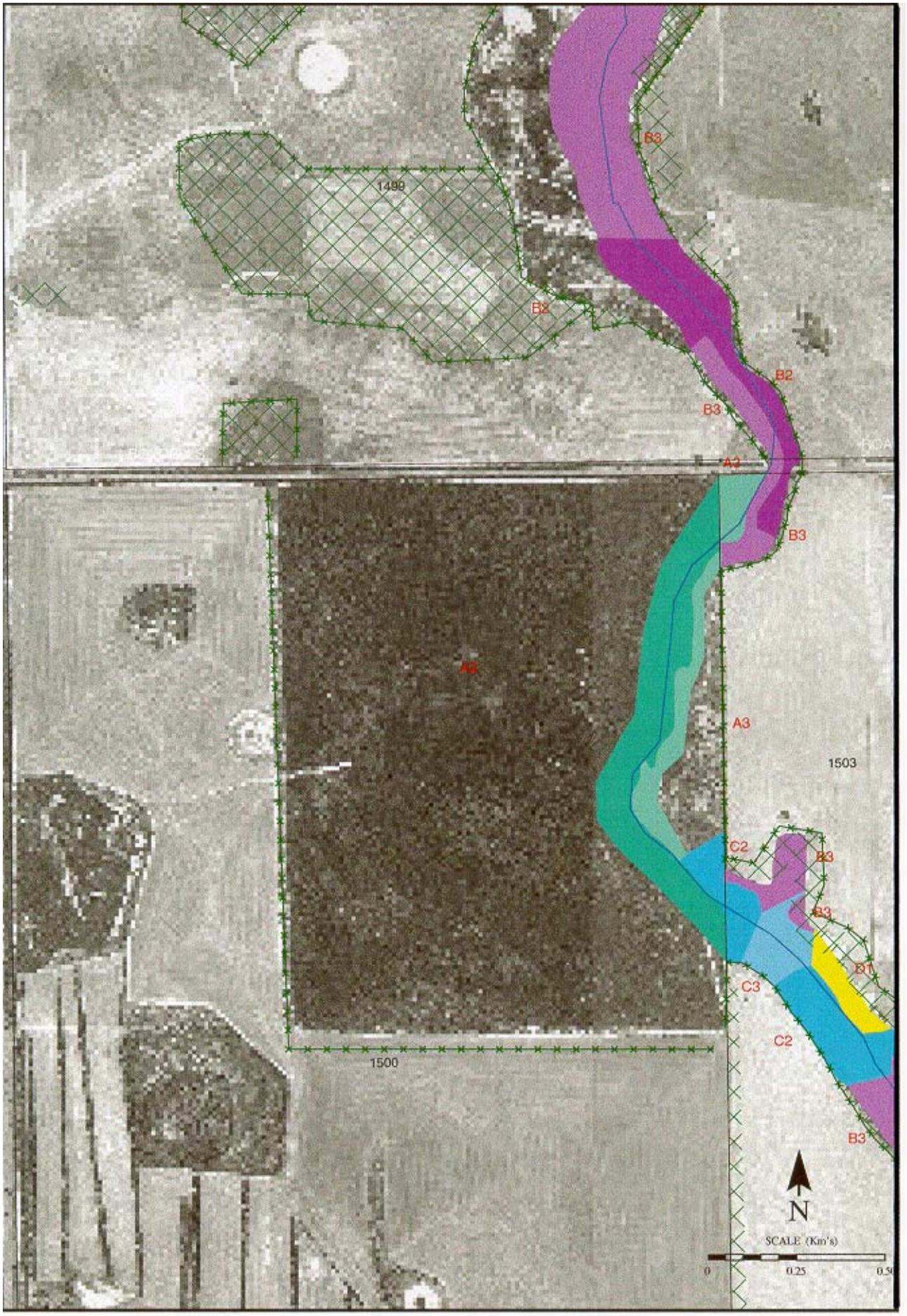
Weed control

Some weed control is needed particularly in the area burnt by fire, however as the area regenerates this should shade out the weeds.

Other

The river on location E1503 is obviously suffering from waterlogging and secondary salinity. Higher water use in the upper catchment is recommended, including perennial pastures and surface water management. Widening of the river vegetation and replanting with salt tolerant natives may help improve the condition of the waterway.

Suggested actions	
1503	• Implement high water-use farming in the upper catchment. • Widen the river corridor and replant with salt tolerant natives.
1499	• Stabilise the headcut and lateral erosion using rushes and sedges, and native understorey species.



DALYUP RIVER MAP 21

MAP 22 – WEST DALYUP RIVER

Location: 1499 and 681 (pt)

Foreshore Vegetation Condition
Location 1499 – average B Grade
Location 681 (pt) – average B Grade

Location 1499 has vegetation in good condition, with considerable sections graded as B Grade, and only a small section graded as C2 where salinity has attacked the overstorey and only salt tolerant understorey remains. An area graded as A3 is found where location 1499 joins location E681. Location E1499 has been well maintained and is in good condition considering the salinity problems. Vegetation species include *Eucalyptus occidentalis, Eucalyptus spathulata, Melaleuca homulosa, Eucalyptus grossa, and Eucalyptus kordinesis.*

Location 681 (pt) is currently in excellent condition with sections graded as A Grade condition. The buffer width is adequate, and natural salt lakes are found throughout the river corridor.

Revegetation

Considerable hectares of revegetation have been completed along both sides of the river in location 1499. This may need to be supplemented with local native species – particularly understorey species to encourage further regeneration of the site. Further areas of revegetation have been proposed by the landholder in location 1499.

Fencing

The whole section of river is fenced.

Crossing design

Two crossings exist on location 1499. The upstream crossing is well located and built. Possibly the middle section given more slope on the sides so water does not pond on the crossing. Even smaller rocks could be utilised at this crossing. The downstream crossing also is in a good location, but it is recommended that rocks be used as the base.

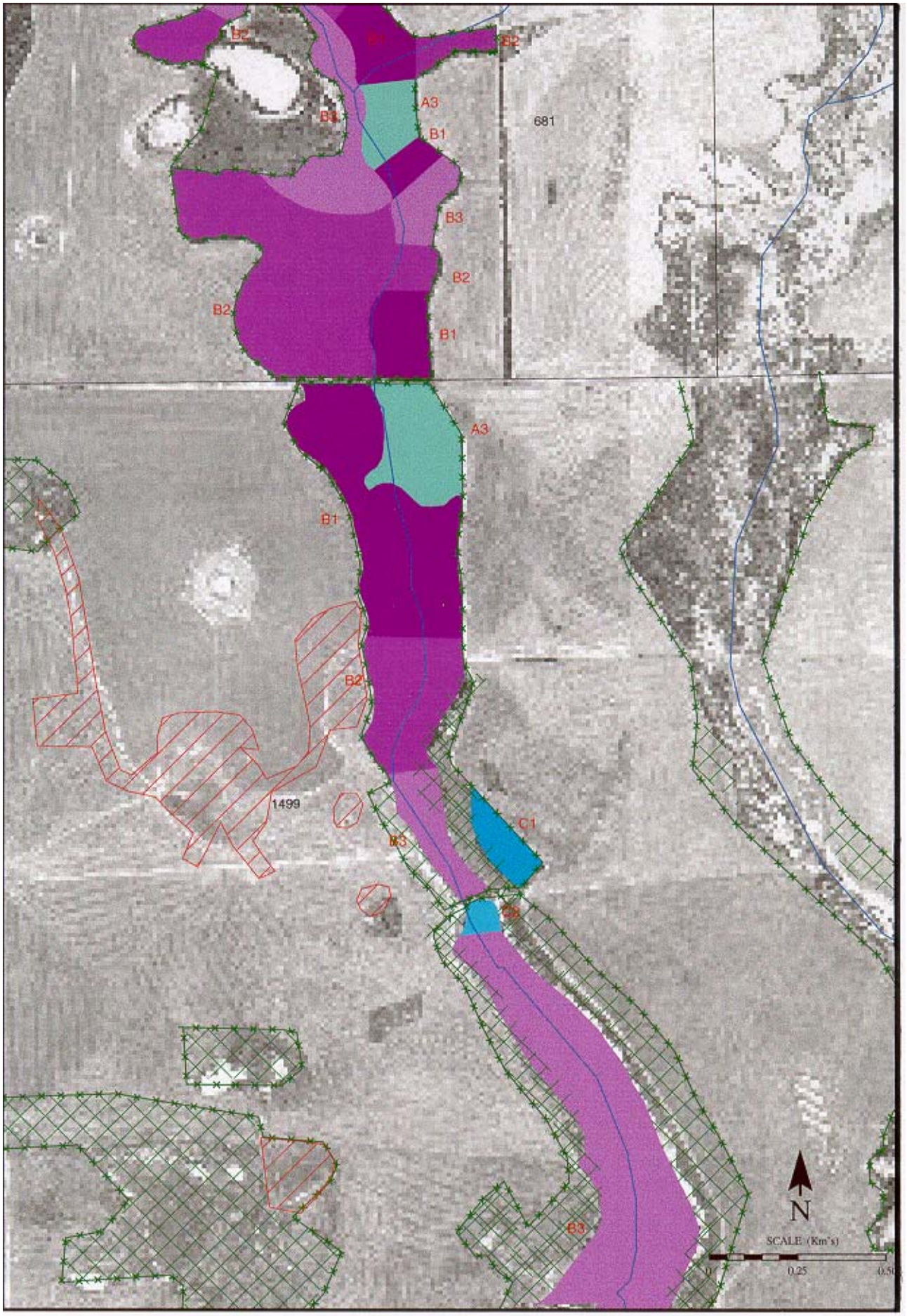
Weed control

Some weed control is needed particularly in areas where revegetation has taken place.

Other

A refuse site is located close to the river. This should be relocated to an area with more clay soils and is further away from the river.

Suggested actions	
1499	• The revegetated section could be supplemented with local native species to encourage further regeneration of the site.



DALYUP RIVER MAP 22

MAP 23 – WEST DALYUP RIVER

Location: E681, E782, 2085

Foreshore vegetation condition
Left Bank:
Right Bank:

The vegetation in locations E681, E782 and 2085 is in excellent condition.

Location E681 has vegetation graded as A and B Grade condition. In location 782 and 2085, the river traverses large sections of remnant vegetation and is graded as mainly in A Grade condition.

Revegetation

A suggestion would be to extend the fence in location 681 around an adjacent wetland. This appears to have been stocked and the vegetation degraded. It is likely with increased flows down this river that the lake will increase in size and salinity will start to spread into this cleared area making it unproductive. Possibly using commercial species could also be options e.g. oil mallees (*E. angustissima*). There is a concern with the spread of Sugar Gum into the surrounding paddocks.

Fencing

The river in location 681 is fenced. No fences are required in location 782 and 2085 as the river traverses remnant vegetation however the boundary fence between 782 and 681 could be plain wire to ensure it stands up to floods better.

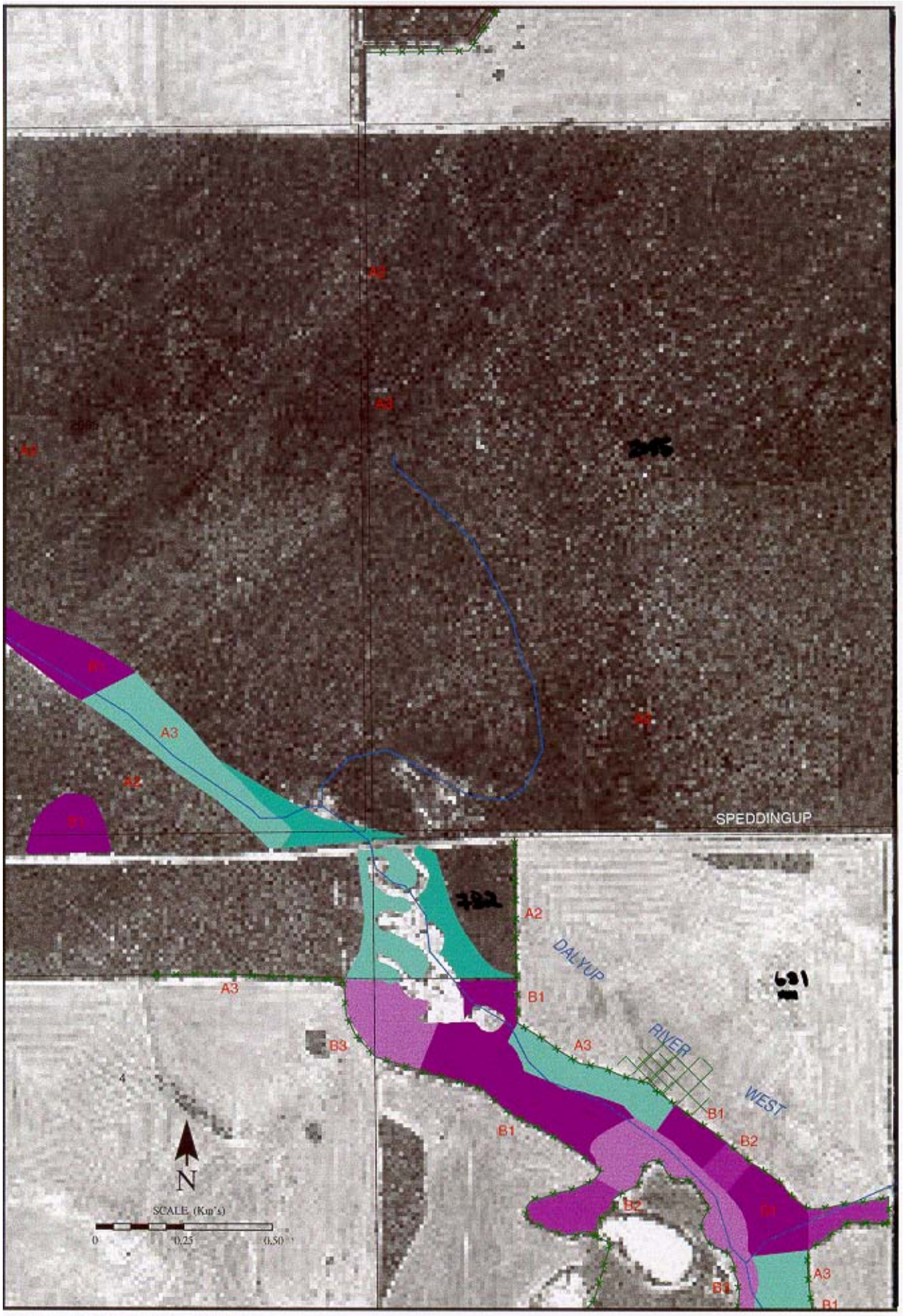
Crossing design

The crossing at the top of location E681 is suitable, however a rocky base and lowering the height of the crossing will help to ensure it survives high flow events.

Other

This river vegetation is serving as a wildlife corridor for numerous birds – especially close to Speddingup West Road. Rabbit control is needed in some areas along the right bank as they are starting to degrade the vegetation and create open areas that are filling with weed species.

Suggested actions	
681	• Extend the fence in location 681 around the adjacent wetland.



DALYUP RIVER MAP 23

MAP 24 – WEST DALYUP RIVER

Locations (pt 2085), E1822, E1812 (pt).

Foreshore vegetation condition
Location 1822:
Left Bank: D2 – D3
Right Bank: D2 – D3

Location 2085 is entirely vegetated; hence the river corridor is in excellent condition. There are however, sections of vegetation in the reserve that appears to be impacted by rising groundwater levels and waterlogging from the surrounding catchment.

The foreshore vegetation in location 1822 and 1812 is extremely degraded. There are few remaining native species along the river with areas of bare salt scald in the middle of the channel. The landholder has done considerable works to address the problems and the river has been fenced and revegetated.

Revegetation

Revegetation has been carried out along the entire section of river in location 1822 and 1812, mainly with *Acacia saligna*, saltbush and tall wheat grass. Recommend some infilling of vegetation with salt tolerant understorey species in areas with native local species such as *Gahnia trifida* and *Halosarcia* sp., *Melaleuca cuticularis* and *Melaleuca brevifolia*. The landholder has planned to revegetate some sections with salt bush and other native trees.

Fencing

The entire river section is fenced, however with the likelihood of rising groundwater levels; the fencelines may be too close to the river as salinity is now creeping back into adjoining paddocks. Recommend fencing small section of river on the right bank just above the reserve and possibly revegetating this using commercial species.

Recommend removing fence across the river at the first crossing upstream of the reserve and locating gateways on either side of the river to keep stock out. Also on location 1812 the fence needs to be moved further out where the river channel is very close to the fence. There is also a patch of salinity starting to form here.

Erosion control

There is a headcut forming from a tributary draining in from the paddock of Location 1822. This may need to be addressed by improving surface water drainage and by stabilising the headcut.

There is also a large sediment plume where location 1822 joins the reserve 2085. The river has been modified into a drain and large amounts of sediment are being dumped at this point. It is recommended to revegetate the drain with native rushes and sedges across the channel to slow down the water, filter out sediments and stop erosion of the river channel. The river has also begun to re-form its original form and is beginning to meander. Revegetating the low flow channel is the most effective way of enhancing water movement in natural waterways.

Crossing design

Three crossings are located on this stretch of river. The first crossing upstream from the reserve has been washed out in the last floods and had large amounts of sediment has built up.
A low, rocky crossing would be more suitable and more likely to survive high flow periods. The crossing between location 1822 and 1812 is not located in a good position. Stock has access to the river and the fences have washed out. It is recommended that only plain wire fences across the rivers be used to help ensure they survive flood flows.

Weed control

Some weed control is needed where location E1822 adjoins reserve.

Other

Severe salinity problems are occurring in this area. Watertable levels were recorded as less than 1 m below the surface in June 2001. Implementing high water-use farming is recommended in the upper catchment to minimise water discharging into the lower environment. This may include planting lucerne, summer crops, kikuyu and tree crops (oil mallees).

Suggested actions	
E1822	• Implement high water-use farming in the upper catchment to minimise water discharging into the lower environment. • Remove weeds where location E1822 adjoins reserve. • Infill the river corridor with salt tolerant understorey species including *Gahnia trifida* and *Halosarcia* sp., *Melaleuca cuticularis* and *Melaleuca brevifolia.* • Remove the fences across the river at the first crossing upstream of the reserve and locate gateways on either side of the river to keep stock out. • Revegetate the drain in the river channel with native rushes and sedges to help stabilise the drain.
E1812 (pt)	• Implement high water-use farming in the upper catchment to minimise water discharging into the lower environment. • Infill the river corridor with salt tolerant understorey species including *Gahnia trifida* and *Halosarcia* sp., *Melaleuca cuticularis* and *Melaleuca brevifolia.* • Relocate the fence further out where the river channel is very close to the fence. • Re-design the crossing between location 1822 and 1812 to ensure it survives high flow events.

DALYUP RIVER MAP 24

MAP 25 – WEST DALYUP RIVER

Locations: 1812 (pt), 1870, 1872, 995, 1024 (pt).

Foreshore Vegetation Condition
Left Bank: D2 – D3
Right Bank: C3 – D3

The entire length of this river section has almost no remaining native species. The land managers have completed considerable works and the entire section of the river has been fenced and revegetated with *Acacia* species, saltbush, *Casuarina* and *Eucalyptus* species. Almost all the river is graded as D2 or D3 condition but a very small patch of remnant vegetation remains that is graded C3. Location 1870 has a patch of native pasture (windmill grass) and some native *Eucalyptus* species. The channel has been cleared out and laser levelled in some sections.

Revegetation

Revegetation has been undertaken along the entire section of river. Species planted include saltbush, *Casuarina* and *Eucalyptus* species. Some infilling of vegetation with salt tolerant local, native understorey species is recommended – including *Gahnia trifida* and *Halosarcia* sp. and more *Melaleuca cuticularis* and *Melaleuca brevifolia* (paperbarks).

Fencing

The entire section of river is fenced. The fence may need to be wider on the northern boundary of location 1872 as there is flood debris evident on the fence and in the paddock.

Erosion control

No erosion control needed. There are problems with erosion and deposition in some sections of the river, however increasing the amount of native vegetation into the river channel will encourage the re-forming existing river channels.

A drain has been constructed in location 1024 in the river channel. The land manager advised that a scraper in 1986/87 constructed this, and that he planned to conduct further deep drainage.

Crossing design

Two crossings present and both are in a relatively good location. In particular, the crossing on 1870 is located on a straight section of the river and has a rocky base.

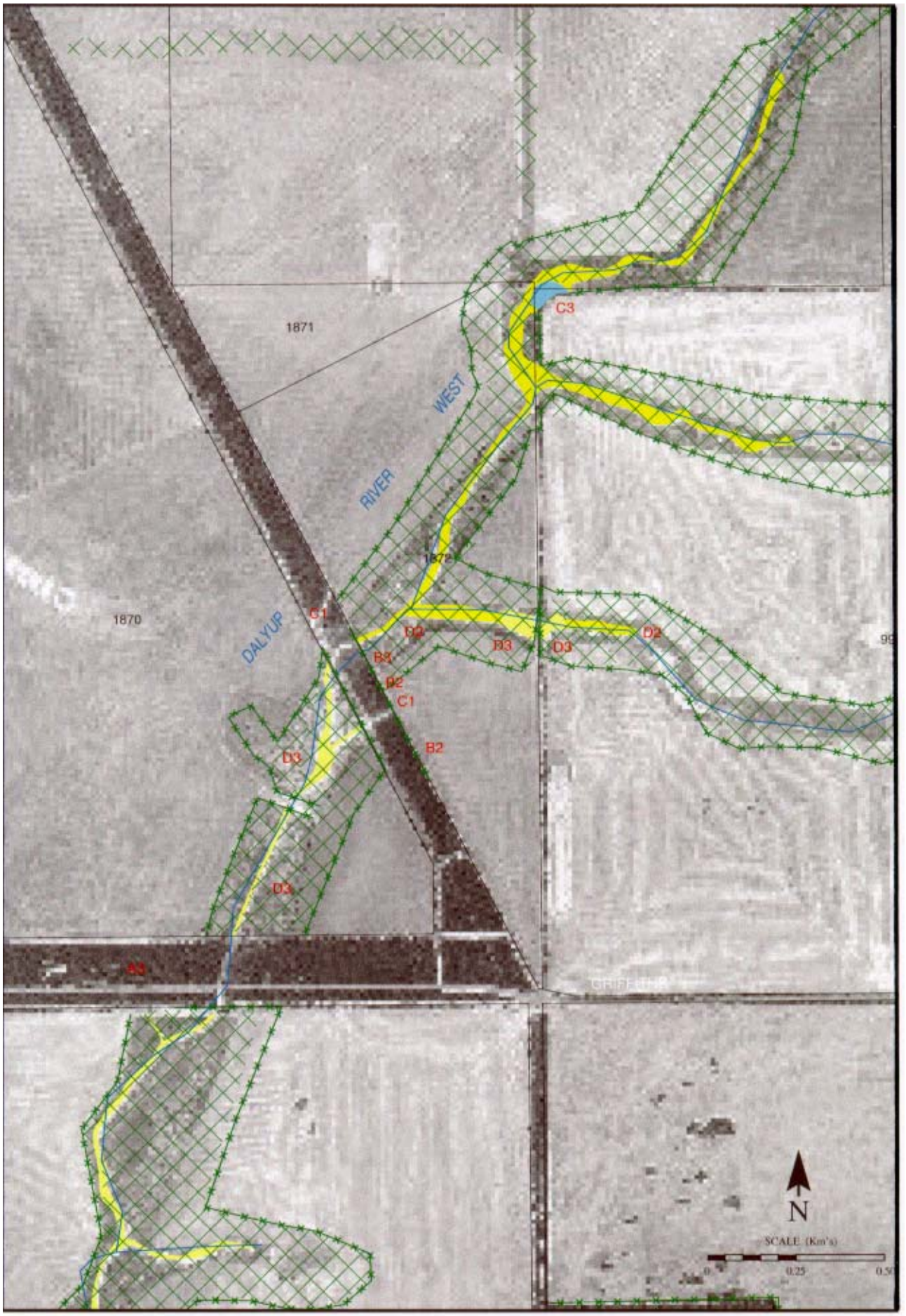
Other

There are severe salinity problem is occurring along this section of river. Shallow bedrock is evident and is possibly forcing the watertable to the surface. It is recommended to consult the Department of Agriculture's hydrologist to help locate these bedrock highs to better target where to focus efforts. Possible options for high water-use farming include planting oil mallees, lucerne, kikuyu and tall wheat grass.

Further advice on drainage design is required – in particular addressing the economics of the drain and the most suitable design of these. A 'Notice of Intent' is required prior to draining. Further groundwater monitoring is required to assess groundwater rise.

Water management on a farm scale needs assessing – in particular managing surface water. This will reduce paddock runoff and loss of topsoil, in addition will reduce the amount of water discharging into the receiving environment.

Suggested actions	
1812 (pt)	• Infill the riparian corridor with salt tolerant, native understorey species including *Gahnia trifida, Halosarcia* sp., *Melaleuca cuticularis* and *Melaleuca brevifolia* (paperbarks). • Implement high water-use farming in the upper catchment to minimise water discharging into the lower environment.
1870	• Infill the riparian corridor with salt tolerant, native understorey species including *Gahnia trifida, Halosarcia* sp., *Melaleuca cuticularis* and *Melaleuca brevifolia* (paperbarks). • Implement high water-use farming in the upper catchment to minimise water discharging into the lower environment.
1872	• Infill the riparian corridor with salt tolerant, native understorey species including *Gahnia trifida, Halosarcia* sp., *Melaleuca cuticularis* and *Melaleuca brevifolia* (paperbarks). • The fence may need to be wider on the northern boundary of location 1872 as there is flood debris evident on the fence and in the paddock. • Implement high water-use farming in the upper catchment to minimise water discharging into the lower environment.
995	• Infill the riparian corridor with salt tolerant, native understorey species including *Gahnia trifled, Halosarcia* sp., *Melaleuca cuticularis* and *Melaleuca brevifolia* (paperbarks).
1024	• Infill the riparian corridor with salt tolerant, native understorey species including *Gahnia trifida, Halosarcia* sp., *Melaleuca cuticularis* and *Melaleuca brevifolia* (paperbarks). • A drain has been constructed in location 1024 in the river channel. The land manager advised that a scraper in 1986/87 constructed this, and that he planned to conduct further deep drainage. • Implement high water-use farming in the upper catchment to minimise water discharging into the lower environment.



DALYUP RIVER MAP 25

MAP 26 – WEST DALYUP RIVER

Locations: 1024 (pt) and 607.

Foreshore vegetation condition
The entire length of this river section has almost no remaining native species along it. Almost all the river is D2 or D3 but a very small patch of remnant vegetation remains that is graded C3. A patch of native pasture (windmill grass) is found in location 1870.

Fencing and revegetation

The entire section of the river has been fenced and revegetated with *Acacia* species, saltbush, *Casuarina* and *Eucalyptu*s species. The entire section of river has been revegetated. Some infilling of vegetation with salt tolerant local, native understorey species in areas where the watertable is less than 1 m below the surface is recommended – including *Gahnia trifida* and *Halosarcia* sp. and *Melaleuca cuticularis* and *Melaleuca brevifolia*.

Erosion control

No erosion control needed. There are problems with erosion and deposition in some sections of the river. The channel has been cleared and lazer levelled in some sections. This practice is not recommended as it may increase further instability of the river channel, and therefore further reduce its efficiency in moving water.

Crossing design

The two crossings are in a good location and have a stable rocky base.

1024 (pt) Some infilling of vegetation with salt tolerant local, native understorey species in areas where the watertable is less than 1 m below the surface is recommended – including *Gahnia trifida* and *Halosarcia* sp. and more *Melaleuca* (paperbarks).

607 Some infilling of vegetation with salt tolerant local, native understorey species in areas where the watertable is less than 1 m below the surface is recommended – including *Gahnia trifida* and *Halosarcia* sp. and more *Melaleuca* (paperbarks).

Other Severe salinity problems are occurring along this section of river. Shallow bedrock is evident and is possibly forcing the watertable to the surface. Consult the Department of Agriculture's hydrologist to help locate these bedrock highs to better target where to focus efforts. Recommend focusing on water use across the farm and implementing more high water-use crops and pastures i.e. lucerne, summer crops, kikuyu and tree crops (oil mallees).

DALYUP RIVER MAP 26

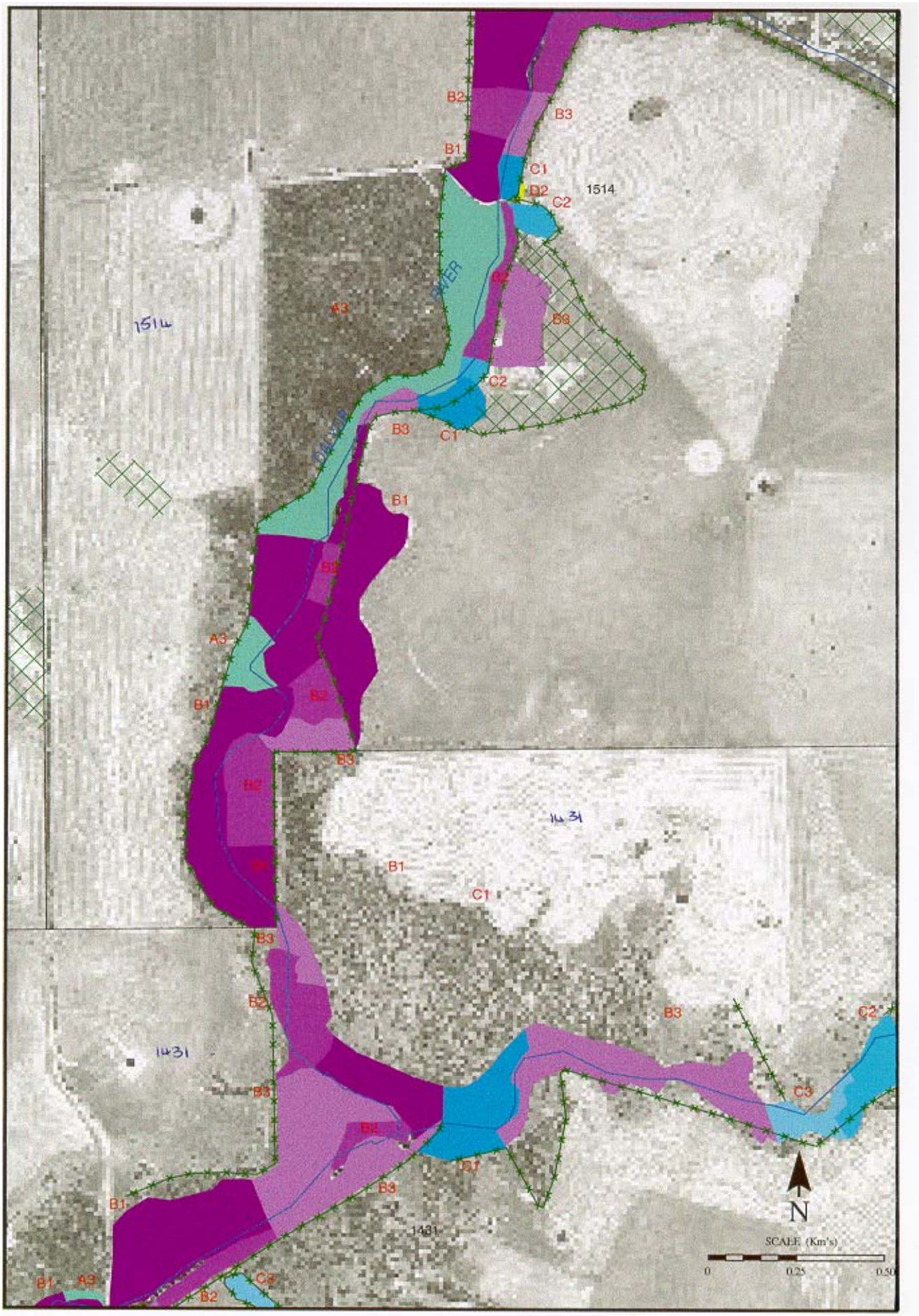
DALYUP RIVER TRIBUTARY 1

Map 5 – TRIBUTARY

Location: E1431

Foreshore Condition
Left bank: B3 – C2
Right bank: C1 – B3

The foreshore vegetation condition in this section is in relatively good condition. The understorey has been lost due to previous grazing by stock. Currently there is adequate vegetation to allow natural regeneration, however some supplementary re-planting may be needed. There are some minor headcuts forming on the southern side of the tributary. The tributary is not fenced in some sections. It is recommended that these sections are fenced.



DALYUP RIVER MAP 5

Map 6 – TRIBUTARY

Location: 1431 (pt), 1444 and 1518

Foreshore condition
Location: E1444 (Left Bank: B2 – C1, Right Bank: B1 – B3)
Location: E1518 (Left Bank: C2 – D2, Right Bank: C1 – C3)

The vegetation is in good condition, especially in location 1444. The buffer width is adequate, however there are some patches graded as C Grade condition.

Fencing and revegetation

Location 1444 is entirely fenced and the vegetation is in good condition. The section graded as C Grade could be supplemented with native species to encourage regeneration. Location 1518 is almost entirely fenced and considerable revegetation has been undertaken in location 1518.

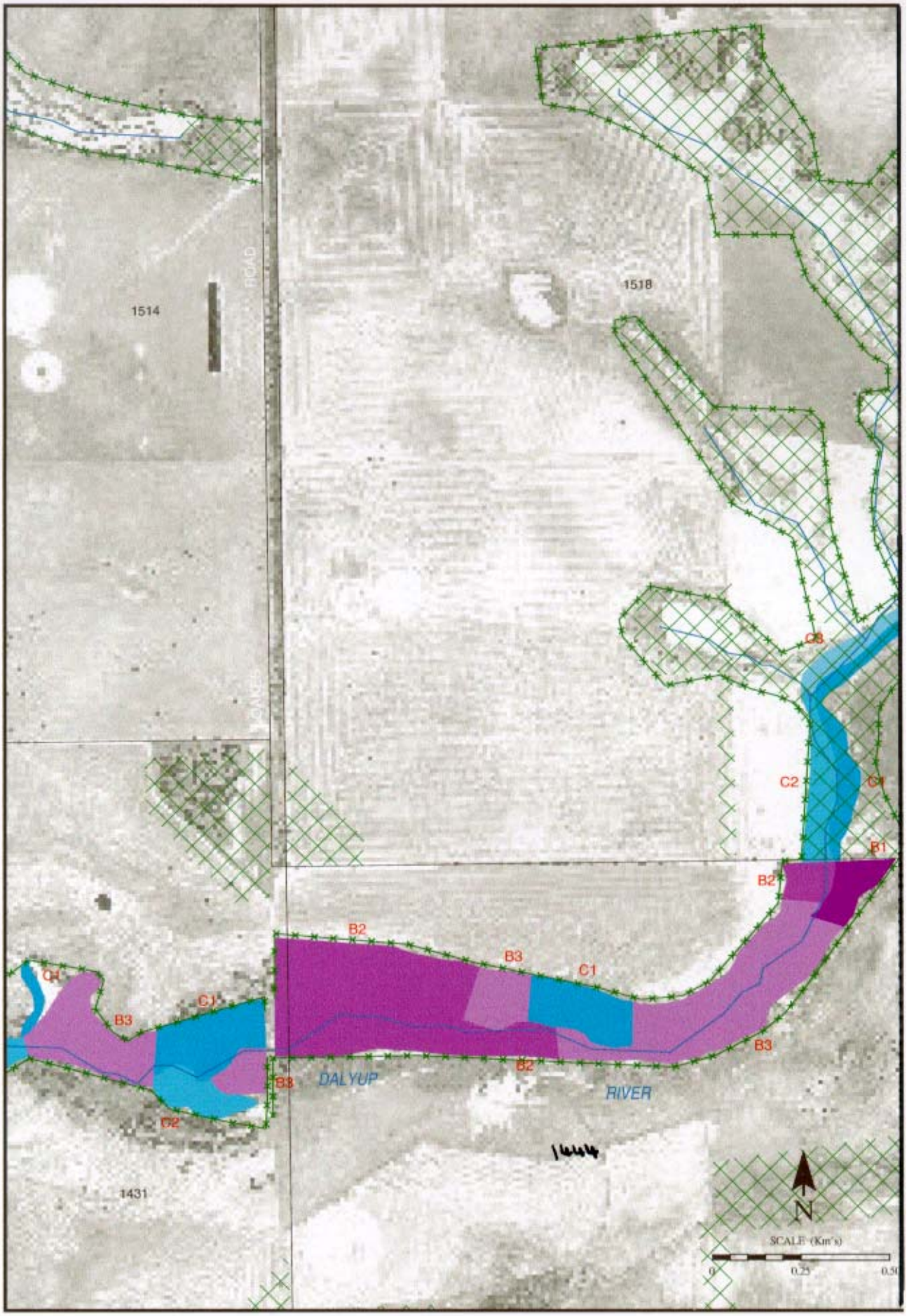
Erosion

There are major headcuts found along this section of the river. These can be stabilised by placement of rocks and vegetation in the actively eroding area, in addition to addressing surface water management.

1431 (pt)
- Revegetate sections graded as C Grade with salt tolerant, native species.
- Stabilise the minor headcut.

1444
- Revegetate sections graded as C Grade with salt tolerant, native species.
- Stabilise headcuts, particularly the major headcut that is forming on the south side of the tributary, near location 1518.

1518 (pt)
- Revegetate sections graded as C Grade with salt tolerant, native species.
- Fence waterways draining into the major tributary.
- Use rushes and sedges to stabilise actively eroding bank.



DALYUP RIVER MAP 6

Map 7 – TRIBUTARY

Location: 1518 (pt), 1522

Foreshore Condition
Left Bank: C2 – D1
Right Bank: B2 – C3

The entire right bank is graded between C1 and C3 except a small section graded in B2 condition. The left bank is graded on average C Grade, with some sections of D Grade where there is little or no vegetation.

The river has been entirely fenced and the buffer width is adequate. It may require some supplementary planting with native species to encourage regeneration. The landholder has done considerable amounts of work to protect this section of the tributary as the entire section has been fenced and revegetated.

DALYUP RIVER MAP 7

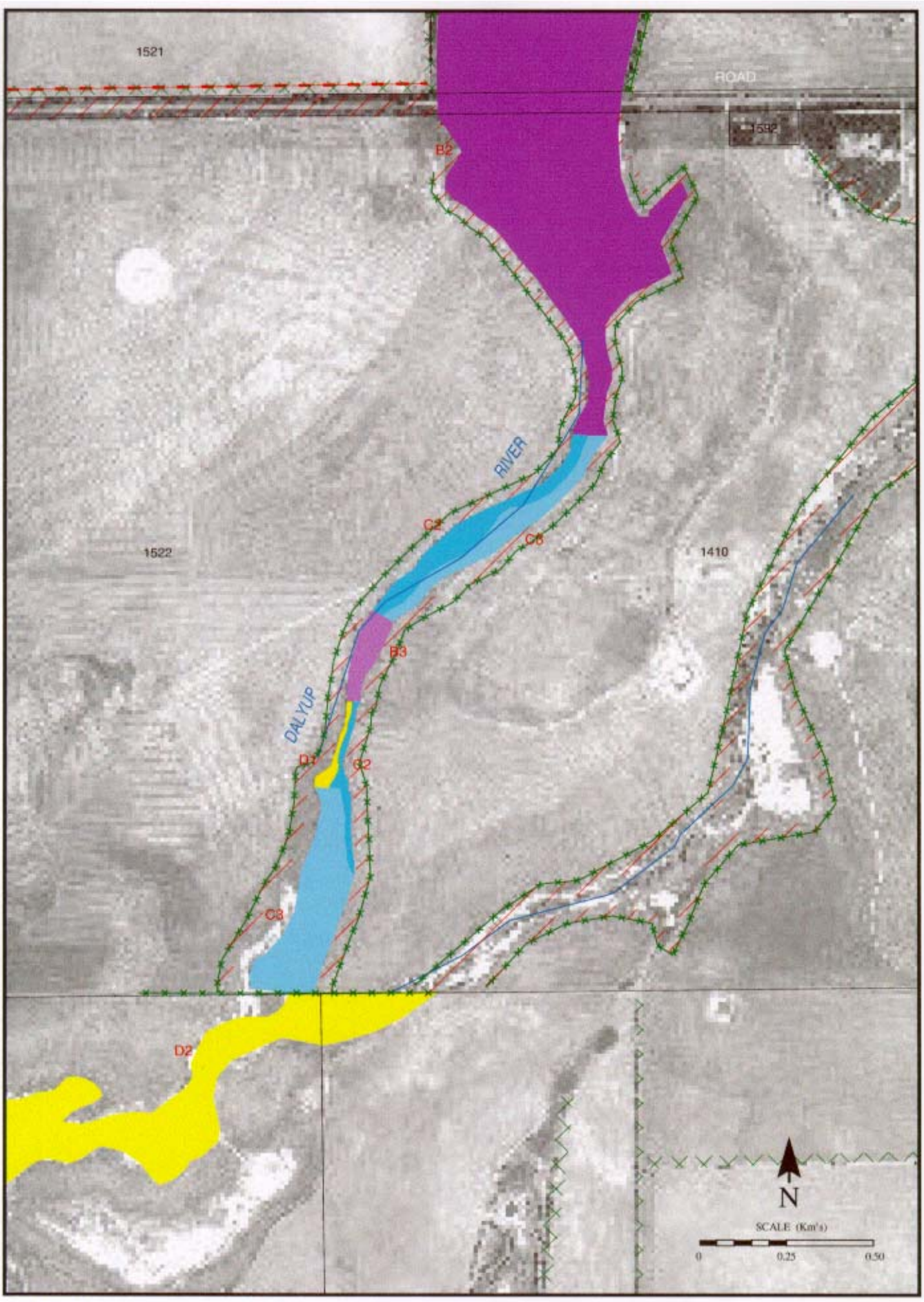
Map 8 – TRIBUTARY

Location: E1397-1, 1410, 1522

Foreshore Condition
Location E1397-1 (Left Bank: D2, right bank – D2)
Location E1410 and 1522 (Left bank: B3 – D1, Right bank: B2 – C3)

Location E1397-1 is extremely degraded from stock access and salinity, and there is little or no remaining native vegetation along the waterway. Many sections of the tributary are eroded and there is erosion and sedimentation along the channel. It is recommended that this section of the river is fenced and revegetated with local, native species. This site would be a priority area to rehabilitate.

Location 1410 and 1522 has sections of vegetation in good condition (B Grade) and the tributary has been entirely fenced. There are however, sections where the vegetative corridor is not wide enough, and fences may need to be moved further out to minimise risk of loss from future high flow events. Areas graded as C or D Grade may also require further revegetation with local, native species. The landholder has done considerable works to protect the waterways in these locations.



DALYUP RIVER MAP 8

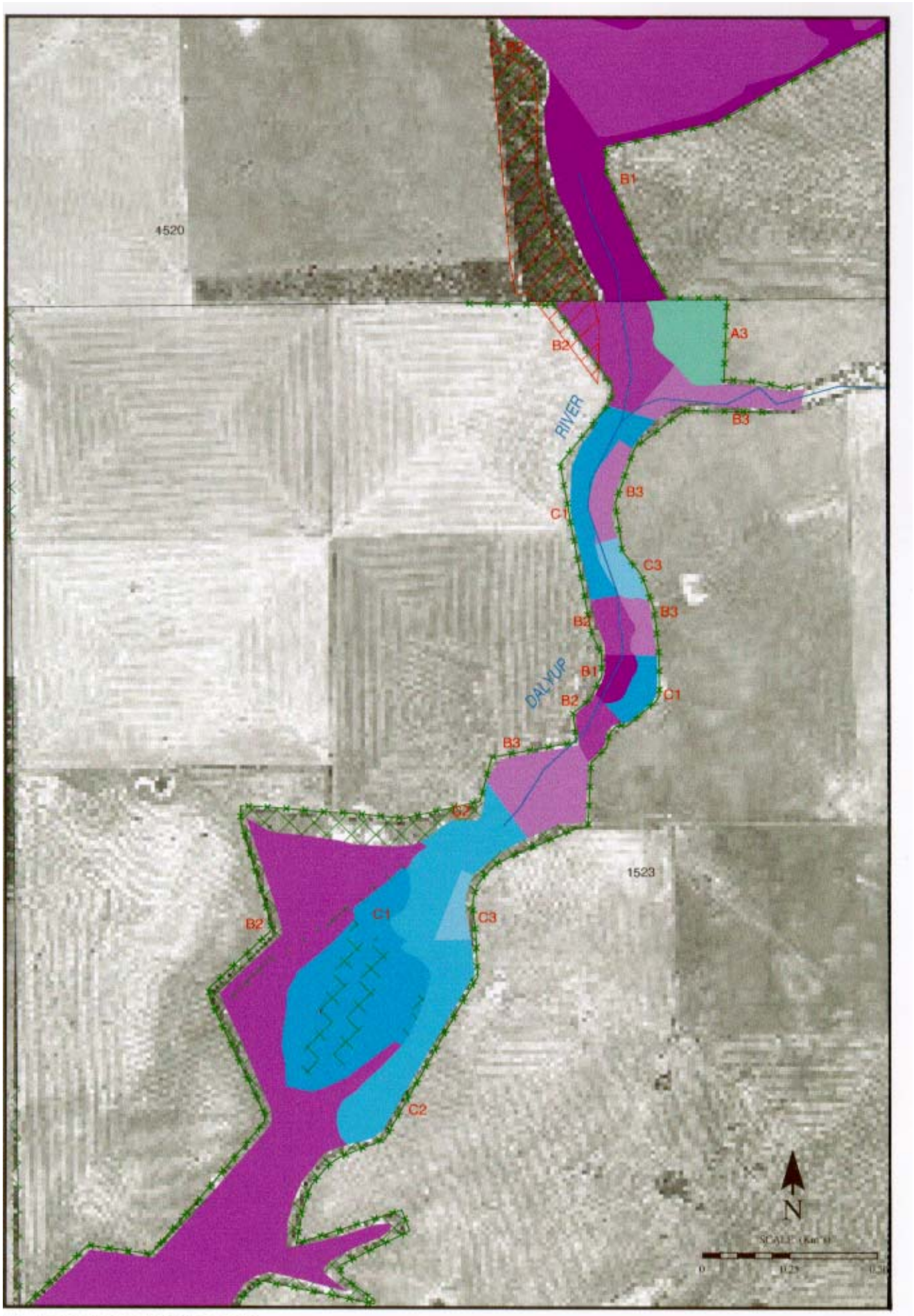
Map 9 – TRIBUTARY

Location: E1523, 1520 (pt).

Foreshore Condition
Left Bank: B1 – C2
Right Bank: A3 – C3

The river in location 1523 has been entirely fenced, and has been revegetated in some areas. Replanting further salt affected areas may be required to minimise the risk of further erosion. There are some sections of vegetation in very good condition. There is a crossing point that has been partly washed out. It is recommended to re-design the crossing to ensure it survives future high flow events.

Location 1520 has vegetation in good condition and the tributary has been fenced. The vegetation includes *Acacia saligna, Lechanaultia formasa, Melaleuca cuticularis, Eucalyptus occidentalis, Templetonia retusa, Hakea corymbosa and Acacia pritzeliana.*



DALYUP RIVER MAP 9

Map 10 – TRIBUTARY

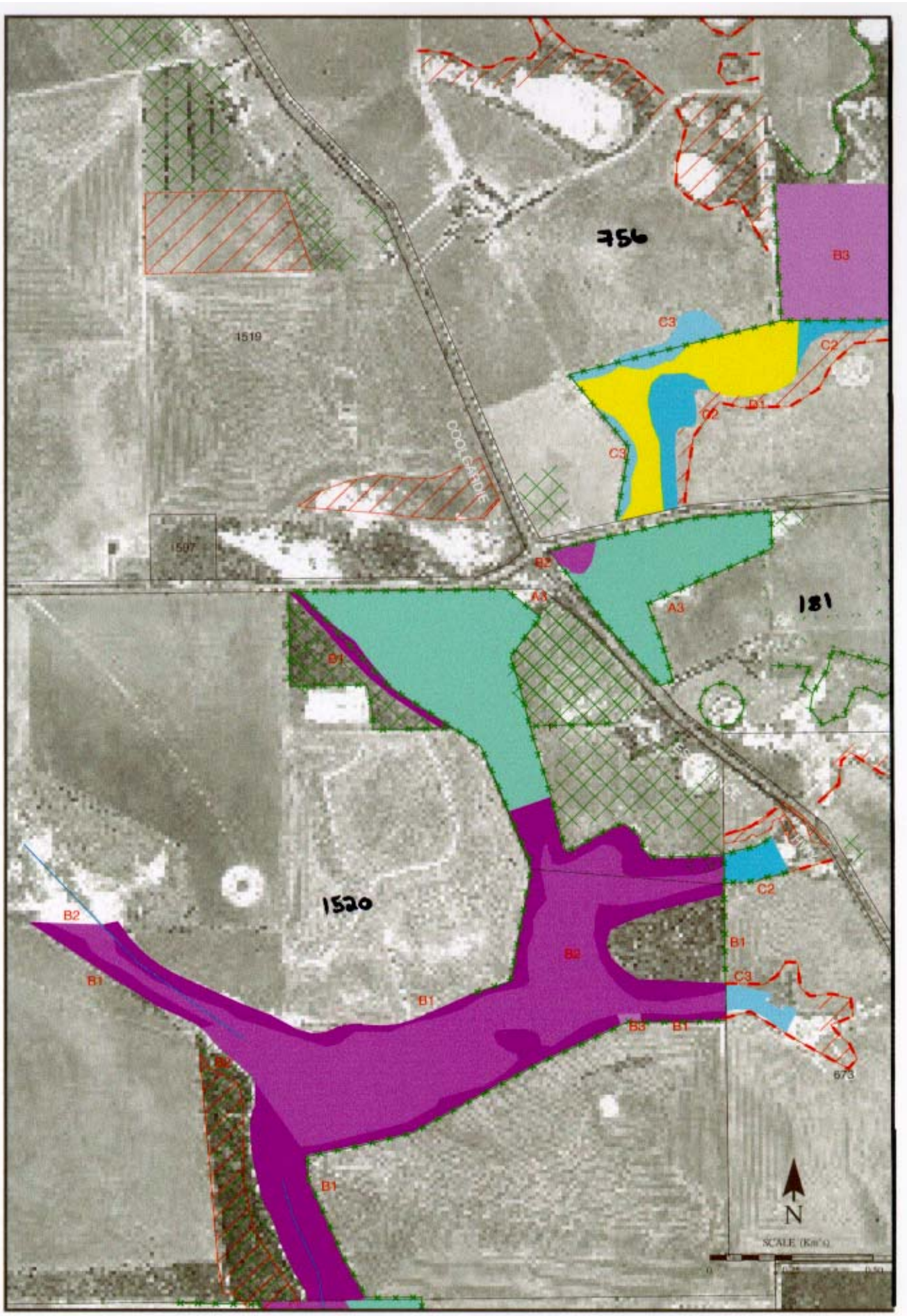
Location: E1520, E756 and E 181.

Foreshore Condition
E1520 - B1 – B2
E181 – A Grade
E 756 – C Grade and D Grade in the lower section of the location, but B Grade in the upper section.

The vegetation condition in 1520 is in excellent condition. There are signs of salinity in the centre of the riparian vegetation, however generally this section of the river is in really good condition.

Location 181 is a good example of riparian vegetation that has always been fenced. This is in excellent condition.

Location 756 has had stock access hence the understorey species are grazed. The landholder is planning to fence this section of the waterway over the next year. Stock has not had access since April 2001, and already many native species have been naturally regenerating, including orchids. The proposed section of revegetation west of the Coolgardie Road was completed in September 2001. This is part of a direct seeding trial being coordinated by Bushcare.



DALYUP RIVER MAP 10

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Appendix 1

List of plant species in the Dalyup River catchment

	Dalyup River			West Dalyup River	Upper West Catchment	Upper West Catchment
	Lake Gore to Brownings Rd	Brownings Rd to Boydells Rd	Boydells Rd to Speddingup West Rd	Loc D29 to Brownings Road	Indigenous Lands Trust Reserve Speddingup West Rd	Speddingup Wildflower Sanctuary Speddingup East Rd
Acacia acuminata	9	9	9			
Acacia assimilis			9			
Acacia bidentata			9		9	
Acacia cupularis (to be confirmed)?		9				
Acacia curvata			9			
Acacia cyclops	9	9	9		9	
Acacia dermatophylla					9	
Acacia (?)diminuta					9	
Acacia glaucoptera	9	9			9	9
Acacia merrallii					9	
Acacia mutabilis subsp. incurva		9	9			
Acacia patagiata					9	
Acacia pinguiculosa / teretifolia?			9			
Acacia pritzeliana (Priority 3 taxon)					9	9
Acacia pulchella			9			
Acacia pycnantha *		9				
Acacia saligna	9	9	9	9		9
Acacia sp.			9	9		
Acacia tetanophylla		9				
Adenanthos cuneatus	9					9
Agrostocrinum scabrum		9	9			9
Allocasuarina lehmanniana		9				
Allocasuarina huegeliana	9			9		
Allocasuarina thuyoides		9				
Allocasuarina sp.		9				9
Alyogyne hakeifolia		9				
Alyogyne huegelii		9	9			9
*Amaranthus albus**		9				
Amaryllis belladona *	9					
Amphipogon turbinatus		9				
*Anagallis arvensis**		9				
Anarthria laevis	9	9			9	
Angiosanthos rufus						9
Anthotium humile					9	
?Aotus procumbens					9	
*Arctotheca calendula**	9	9				
Asparagus asparagoides *	9					
?Astartea ambigua					9	
Astartea fascicularis						9

Appendix 1 (cont)

	Dalyup River			West Dalyup River	Upper West Catchment	Upper West Catchment
	Lake Gore to Brownings Rd	Brownings Rd to Boydells Rd	Boydells Rd to Speddingup West Rd	Loc D29 to Brownings Road	Indigenous Lands Trust Reserve Speddingup West Rd	Speddingup Wildflower Sanctuary Speddingup East Rd
Astroloma pallidum?						9
Astroloma sp.			9			
Atriplex nummularia		9				
Atriplex semibaccata		9			9	
Atriplex sp.		9				
Avena sp.*	9					
Baeckea crassifolia var. icosandra						9
Banksia media					9	9
Banksia nutans						9
Banksia pilostylis					9	9
Banksia pulchella						9
Banksia speciosa	9	9		9		9
Banksia sp.	9					
Baumea sp.	9					
Beaufortia schaueri?		9				
Beaufortia sp.						9
Beyeria leschenaultii?			9			
Boronia inornata					9	
Burnettia nigricans						9
Caladenia discoides						9
Caladenia flava						9
Calothamnus gracilis		9				
Calothamnus quadrifidus	9	9	9	9		9
Calytris decandra						9
Calytrix leschenaultii		9				9
Carpobrotus sp.					9	9
Cassytha melantha		9			9	
Cassytha racemosa		9			9	
Centaurium erythraea					9	
*Chamaecytisus palmensis**				9		
Chamelaucium ciliatum		9				
Chamelaucium megalopetalum						
Cheilanthes sp.			9			
Cheilanthes tenuifolia		9				
Cheiranthera filifolia					9	
Chloris sp.	9					
Chloris truncata		9				
Choretrum glomeratum					9	
Chorizema aciculare						9
*Cirsium vulgare**		9				

Appendix 1 (cont)

	Dalyup River			West Dalyup River	Upper West Catchment	Upper West Catchment
	Lake Gore to Brownings Rd	Brownings Rd to Boydells Rd	Boydells Rd to Speddingup West Rd	Loc D29 to Brownings Road	Indigenous Lands Trust Reserve Speddingup West Rd	Speddingup Wildflower Sanctuary Speddingup East Rd
Comesperma sp.			9			
Comesperma polygaloides					9	
Comesperma scoparium		9				
Conospermum distichum						9
Conospermum teretifolium						9
Conostylis bealiana						9
Conostylis setigera						9
*Conyza bonariensis**		9				
Coopernookia strophiolata			9		9	
?Crassula sp.		9				
Cryptandra sp.		9				
Cyanicula caerulea ssp. aperatala?						9
Dampiera sp.		9	9			
Dampiera ffin Alata						9
Dampiera linearis?stenophylla? parvifolia		9				
Darwinia vestita		9				
Daviesia benthamii subsp acanthoclona		9			9	
Daviesia lancifolia			9			
Daviesia sp.			9			
Daviesia teretifolia		9				9
Desmocladus flexuosus						9
Dianella revoluta		9	9			
Dianella revoluta subsp. brevicaulis					9	
Disphyma crassifolium		9				
Dodonaea concinna			9			
Dodonaea microzyga					9	
Drosera menziesii						9
Drosera sp.		9				9
Dryandra armata		9				
Dryandra obtusa						9
Dryandra quercifolia						9
Dryandra sp.				9		
*Ehrharta calycina**		9				
*Ehrharta longiflora**		9				
Elythranthera brunonis						9
Enchylaena tomentosa		9				
*Eragrostis curvula**	9	9		9		
Eriochilis sp.			9			
Erodium sp.*		9				
Eucalyptus anceps					9	

Appendix 1 (cont)

	Dalyup River			West Dalyup River	Upper West Catchment	Upper West Catchment
	Lake Gore to Brownings Rd	Brownings Rd to Boydells Rd	Boydells Rd to Speddingup West Rd	Loc D29 to Brownings Road	Indigenous Lands Trust Reserve Speddingup West Rd	Speddingup Wildflower Sanctuary Speddingup East Rd
Eucalyptus angulosa?	9		9			
Eucalyptus angustissima					9	
Eucalyptus densa		9			9	
Eucalyptus flocktoniae					9	
Eucalyptus forrestiana					9	
Eucalyptus kersellii	9				9	
Eucalyptus occidentalis	9	9	9			
Eucalyptus redunca					9	
Eucalyptus sp. *(mallee)*			9			
Eucalyptus tetragona	9	9		9	9	9
Eucalyptus transcontinentalis					9	
Eucalyptus uncinata	9	9	9		9	
Exocarpos sparteus			9		9	
Frankenia sp.	9					
Frankenia tetrapetala		9				
Gahnia sp.			9		9	
Gahnia trifida	9	9		9		
Gastrolobium parviflorum		9	9			
Glischrocaryon sp.			9			
Gompholobium confertum ?						9
?Gompholobium marginatum					9	
Goodenia affin filiformis					9	
Goodenia tripartita			9			
Grevillea baxteri						9
Grevillea nudiflora						9
Grevillea oligantha					9	
Grevillea paniculata		9	9			
Grevillea pauciflora	9	9				
Grevillea pectinata		9	9		9	9
Grevillea teragonoloba						9
Guichenotia ledifolia	9	9				
Haemodorum paniculatum		9				
Haemodorum spicatum						9
Hakea adnata			9		9	
Hakea cinerea					9	
Hakea clavata						9
Hakea commutata			9		9	
Hakea corymbosa						9
Hakea laurina		9	9		9	9
Hakea lissocarpha	9	9	9	9		9

Appendix 1 (cont)

	Dalyup River			West Dalyup River	Upper West Catchment	Upper West Catchment
	Lake Gore to Brownings Rd	Brownings Rd to Boydells Rd	Boydells Rd to Speddingup West Rd	Loc D29 to Brownings Road	Indigenous Lands Trust Reserve Speddingup West Rd	Speddingup Wildflower Sanctuary Speddingup East Rd
Hakea marginata		9				
Hakea nitida	9	9		9		9
Hakea trifurcata		9				
Hakea varia						9
Halgania preissiana		9	9			
Halosarcia indica			9			
Halosarcia indica subsp bidens		9				
Halosarcia sp.			9			
Hibbertia cuneiformis						9
Hibbertia racemosa?						9
Hibbertia sp.		9	9			
Hypochaeris sp.*		9				
Hypolaena humilis		9			9	
Hypolaena sp. *(exsulca)*	9					
Isolepis nodosa	9	9				
Isolepis sp.		9	9			
Isopogon buxifolius var. spathulatus						9
Isopogon polycephalus		9				
Jacksonia sp.	9					
Juncus sp.		9				
Juncus kraussii subsp.australiensis?		9				
Juncus pallidus	9	9				
Kennedia eximia		9	9			
Lambertia inermis	9	9				9
Lasiopetalum rosmarinifolium					9	
Lechenaultia formosa			9			9
Lechenaultia tubiflora						9
Lepidosperma aphyllum					9	
Lepidosperma squamatum	9	9			9	
Lepidosperma viscidum					9	
Lepidosperma sp.		9				
Leporella fimbriatus		9				
Leptomeria presissiana					9	
Leptospermum sp.		9				
Leucopogon rubicundus					9	
Leucopogon sp.		9	9			
Lomandra micrantha		9				
Lomandra sp.			9			
Lyginia imberbis?		9				
Lyginia sp.			9			

Appendix 1 (cont)

	Dalyup River			West Dalyup River	Upper West Catchment	Upper West Catchment
	Lake Gore to Brownings Rd	Brownings Rd to Boydells Rd	Boydells Rd to Speddingup West Rd	Loc D29 to Brownings Road	Indigenous Lands Trust Reserve Speddingup West Rd	Speddingup Wildflower Sanctuary Speddingup East Rd
Lysinema ciliatum						9
Macrozamia dyeri	9	9		9		
Melaleuca acuminata					9	
Melaleuca brevifolia	9	9	9	9	9	
Melaleuca bromelioides					9	
Melaleuca calycina					9	
Melaleuca cardiophylla	9	9	9		9	
Melaleuca carrii					9	
Melaleuca cucullata					9	
Melaleuca cuticularis	9	9	9	9	9	
Melaeuca elliptera	9		9			
Melaleuca glaberrima		9	9			
Melaleuca pulchella		9	9		9	9
Melaleuca ?rigidifolia					9	
Melaleuca striata						9
Melaleuca subfalcata					9	
Melaleuca tuberculata?		9	9			
Melaleuca uncinata	9	9	9		9	
Melaleuca undulata					9	
Melaleuca sp.	9	9		9		
Melaleuca sp. (Mt Ragged)						9
Microcorys virgata					9	
Micromyrtus elobata			9			
Micromyrtus imbricata						9
Micromyrtus sp.		9				9
Microtis media ssp. *Media*						9
Muehlenbeckia adpressa		9				
Myoporum sp.			9			
Nematolepis phebalioides					9	
Neurachne minor?		9				
Nuytsia floribunda	9	9		9		9
Oenothera sp.*	9			9		
Olearia sp.			9			
Opercularia vaginata		9				
Patersonia lanata						9
Patersonia occidentalis	9		9		9	
Patersonia sp.*?*		9				
Pelargonium littorale			9			
Pelargonium sp.		9				
Persoonia teretifolia		9				

Appendix 1 (cont)

	Dalyup River			West Dalyup River	Upper West Catchment	Upper West Catchment
	Lake Gore to Brownings Rd	Brownings Rd to Boydells Rd	Boydells Rd to Speddingup West Rd	Loc D29 to Brownings Road	Indigenous Lands Trust Reserve Speddingup West Rd	Speddingup Wildflower Sanctuary Speddingup East Rd
Petrophile fastigiata		9				9
Petrophile teretifolia						9
Phebalium microphyllum						9
Phymatocarpus maxwellii						9
Pimelea ?brachyphylla					9	
Pimelea cracens			9			
Pimelea sp.			9			9
Pimela suaveolens						9
Pinus sp.*	9					
Phyllanthus calycinus		9				
Phymatocarpus maxwellii					9	
Platysace effusa		9				
Podolepis micrantha		9				
Podolepis sp.			9			
Polygala sp.*				9		
*Polygonum aviculare**		9				
Prasophyllum sp.					9	
Pterostylis decurva						9
Ptilotus polystachyus		9				
Pultenaea neurocalyx						9
*Raphanus raphinstrum**	9					
Rumes sp.*	9					
Samolus repens	9					
Santalum acuminatum		9				
Sarcocornia quinqueflora	9					
Schoenus brevifolia	9					
Schoenus sp.*?*		9				
*Solanum nigrum**	9	9		9		
Sollya heterophylla	9				9	
*Spergularia salina**		9	9			
Sporobolus virginicus	9	9				
Stackhousia monogyna						9
Stackhousia pubescens						9
Stirlingia tenuifolia						9
Stypandra glauca		9		9		
Suaeda australis	9					
Synaphea sp.		9				
Templetonia retusa		9				
Templetonia sulcata			9			
*Thinopyrum elongatum**		9				

Appendix 1 (cont)

	Dalyup River			West Dalyup River	Upper West Catchment	Upper West Catchment
	Lake Gore to Brownings Rd	Brownings Rd to Boydells Rd	Boydells Rd to Speddingup West Rd	Loc D29 to Brownings Road	Indigenous Lands Trust Reserve Speddingup West Rd	Speddingup Wildflower Sanctuary Speddingup East Rd
Thryptomene saxicola	*9*	*9*				
Velleia trinervis			*9*			
Viminaria juncea	*9*	*9*				
Westringia rigida					*9*	
Wilsonia rotundifolia		*9*				
Xanthos sp.	*9*					
Aquatic plant in stagnant water		*9*				

* exotic weed species

Sources of Information:

- Lake Gore to Brownings Road (Dalyup River): Survey 4th and 5th April 2000 C.Field, K.Parker & S.Janicke (Water and Rivers Commission).
- Location D29 to Brownings Road (West Dalyup River): Survey 6th April 2000 C.Field, K.Parker & S.Janicke.
- Brownings Road to Speddingup West Rd (Dalyup River): Survey 19th April 2000, C.Field, C.Turley and L.Grant.
- Aboriginal Lands Trust Reserve Speddingup West Road: Survey 20th January 2000 C.Turley and V.Mischker.
- Speddingup Wildfower Sanctuary Speddingup East Road: Survey by Esperance Wildflower Society and Sylvia Leighton.

Appendix 2

Birds recorded in the Dalyup River catchment

Common Name	Scientific Name	Observer
Emu	*Dromaius novaehollandiae*	AH, KW, AR
Australiasian Grebe	*Tachybaptus novaehollandiae*	KW, AR
Hoary-headed Grebe	*Podiceps poliocephalus*	AH, KW, AR
Great Crested Grebe	*Podiceps cristatus*	KW
Little Black Cormorant	*Phalacrocorax sulcirostris*	AR
Little Pied Cormorant	*Phalacrocorax melanoleucos*	AH, AR
Darter	*Anhinga melanogaster*	KW
Pacific Heron or White-necked Heron	*Ardea pacifica*	AH, KW, AR
White-faced Heron	*Ardea novaehollandiae*	AH, AR
Great Egret	*Ardea ibis*	AR
Cattle Egret	*Ardea ibis*	AR
Nankeen Night Heron	*Nycticorax caledonicus*	AR
Australian White Ibis	*Threskiornis molucca*	AR
Straw-necked Ibis	*Threskiornis spinicollis*	AH, KW, AR
Yellow-billed Spoonbill	*Platalea flavipes*	AH
Black Swan	*Cygnus atratus*	AH, KW
Australian Shelduck	*Tadorna tadornoides*	AH, KW, AR
Black Duck	*Anas superciliosa*	AH, KW, AR
Grey Teal	*Anas gracilis*	AH, KW, AR
Chestnut Teal	*Anas castanea*	KW, AR
Australasian Shoveler	*Anas rhynchotis*	AR
Pink-eared Duck	*Malacorhynchus membranaceus*	AH, KW, AR
Hardhead	*Aythya australis*	KW, AR
Wood (maned) Duck	*Chenonetta jubata*	AH, KW, AR
Musk Duck	*Biziura lobata*	AH, KW, AR
Black-shouldered Kite	*Elanus notatus OR Elanus axillaries*	AH, KW, AR
Whistling Kite	*Haliastur sphenurus*	AR
Brown Goshawk	*Accipiter fasciatus*	AR
Little Eagle	*Hieraaetus morphnoides*	AR
Wedge-tailed Eagle	*Aquila audax*	AH, KW, AR
Spotted Harrier	*Circus assimilis*	AH, KW, AR
Swamp Harrier	*Circus approximans*	KW, AR
Peregrine Falcon	*Falco peregrinus*	AR
Australian Hobby	*Falco longipennis*	AR
Grey Falcon	*Falco hypoleucos*	AH
Brown Falcon	*Falco berigora*	AH, KW
Australian Kestrel or Nankeen Kestrel	*Falco cenchroides*	AH, KW, AR
Mallefowl (upper river)	*Leipoa ocellata*	AR
Stubble Quail	*Coturnix pectoralis*	KW
Brown Quail	*Coturnix ypsilophora*	AR
Painted Button-qauil	*Turnix varia*	AR
Little Button-Quail	*Turnix velox*	AH
Purple Swamphen	*Porphyrio porphyrio*	AH, KW, AR

Appendix 2 (cont)

Common Name	Scientific Name	Observer
Black-Tailed Native Hen	*Gallinula ventralis*	KW, AR
Dusky Moorhen	*Gallinula tenebrosa*	KW
Eurasian Coot	*Fulica atra*	AH, KW, AR
Australian Bustard	*Ardeotis australis*	AH, KW, AR
Banded Lapwing	*Vanellus tricolor*	AH, KW, AR
**Hooded Plover	*Charadrius cucullatus ORThinornis rubricollis*	AH, KW, AR
Red-capped Plover	*Charadrius ruficapillus*	AH
Black-fronted Dotterel	*Charadrius melanops*	AH, KW, AR
Inland Dotterel	*Peltohyas australis*	AH, KW
Common Greenshank	*Tringa nebularia*	*AR*
Banded Stilt	*Cladorhynchus leucocephala*	KW
Red-necked Avocet	*Recurvirostra novaehollandiae*	AH, KW
Common Bronzewing	*Phaps chalcoptera*	AH, KW, AR
Brush Bronzewing	*Phaps elegans*	AR
Crested Pigeon	*Ocyphaps lophotes*	AH, KW, AR
Purple-crowned Lorikeet	*Glossopsitta porphrocephala*	AH, KW, AR
Regent Parrot	*Polytelis anthopeplus*	KW, AR
Ring-necked Parrot or Australian Ringneck	*Platycerus zonarius*	AH, KW, AR
Red-capped Parrot	*Platycercus spurius*	AR
Western Rosella	*Platycercus icterotis*	AR
Elegant Parrot	*Neophema elegans*	AR
Carnaby's Cockatoo OR	*Calyptorhynchus latirostris*	KW, AR
Short-billed Black Cockatoo		
Galah	*Cacatua roseicapilla*	AH
Pallid Cuckoo	*Cuculus pallidus*	AH, AR
Fan-tailed Cuckoo	*Casomantis flabelliformis*	AR
Horsefield's Bronze-Cuckoo	*Chrysococcyx basalis*	AR
Shinning Bronze-Cuckoo	*Chrycococcyx lucidus*	AR
Barn Owl	*Tyto alba*	AH, KW, AR
Southern Boobook	*Ninox novaeseelandiae*	AR
Tawny Frogmouth	*Podargus strigoides*	AH, KW, AR
Australian Owlet Nightjar	*Aegothelis cristatus*	AR
Spotted Nightjar	*Eurostopodus argus*	AR
Fork-tailed Swift	*Apus pacificus*	AH, AR
Sacred Kingfisher	*Todiramphus sancta*	AH, AR
Rainbow Bee-eater	*Merops ornatus*	AH, AR
Welcome Swallow	*Hirundo neoxena*	AH, KW, AR
Tree Martin	*Hirundo nigricans*	AR
Richard's Pipit	*Anthus novaeseelandiae*	AH, KW, AR
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	AH, AR
White-winged Triller	*Lalage sueurii*	AR
Jacky Winter	*Microeca fascinans*	AR
Scarlet Robin	*Petroica multicolour*	AR
Hooded Robin	*Melanodryas cucullata*	AR
Western Yellow Robin or Yellow Robin	*Eopsaltria griseogularis*	AH, AR
Golden Whistler	*Pachycephala pectoralis*	AR
Grey Shrike-Thrush	*Colluricincla harmonica*	AH, AR

Appendix 2 (cont)

Common Name	Scientific Name	Observer
Crested Bellbird	*Oreoica gutturalis*	AR
Western Whipbird	*Psophodes nigrogularis*	AH
Grey Fantail	*Rhipidura fuliginosa*	AH, AR
Willie Wagtail	*Rhipidura leucophrys*	AH, KW, AR
Restless Flycatcher	*Myiagra inquieta*	AR
Southern Scrub-Robin	*Drymodes brunneopygius*	AH, AR
White-browed Babbler	*Pomatostomus superciliosus*	AH, KW, AR
Western Gerygone	*Gerygone fusca*	AR
Weebill	*Smicrornis brevirostris*	AH, KW, AR
Inland Thornbill	*Acanthiza apicalis*	AR
Brown Thornbill	*Acanthiza pusilla*	AH
Yellow -rumped Thornbill	*Acanthiza chrysorrhoa*	AH, AR
White-browed Scrubwren	*Sericornis frontalis*	AR
***Shy Heathwren	*Sericornis cautus orHylacola cautus*	AH
Rufous Fieldwren	*Calamanthus campestris*	AR
Blue-breasted Fairy Wren	*Malurus pulcherrimus*	AH, AR
Southern Emu-wren	*Stipiturus malachurus*	AR
Brown Songlark	*Cinclorhamphus cruralis*	AH, KW, AR
Varied Sittella	*Daphoenositta chrysoptera*	AR
Spotted Pardalote	*Pardalotus punctatus*	AR
Striated Pardalote	*Pardalotus striatus*	AH, KW, AR
Brown Honeyeater	*Lichmera indistincta*	AH, AR
Singing Honeyeater	*Lichenostomus virescens*	KW, AR
Purple-gaped Honeyeater	*Lichenostomus cratitius*	AR
White-eared Honeyeater	*Lichenostomus leucotis*	AH, AR
Brown-headed Honeyeater	*Melithreptus brevirostris*	AH, AR
White-naped Honeyeater	*Melithreptus lunatus*	AH, AR
New Holland Honeyeater	*Phylidonyris novaehollandiae*	KW, AR
White-cheeked Honeyeater	*Phylidonyris nigra*	AR
Tawny-crowned Honeyeater	*Phylidonyris melanops*	AH, AR
Western Spinebill	*Acanthorhynchus superciliosus*	AH, AR
Yellow-throated Miner	*Manorina flavigula*	AH, KW, AR
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	KW
** Little Wattlebird	*Anthochaera lunulate OR*	AH, AR
	Anthochaera chrysoptera	AH, AR
Red Wattlebird	*Anthochaera carunculata*	
White-fronted Chat	*Ephthianura albifrons*	AH, KW, AR
Red-eared Firetail	*Stagonopleura oculata*	AR
Magpie Lark	*Grallina cyanoleuca*	AH, KW, AR
Dusky Woodswallow	*Artamus cyanopterus*	AR
Grey Butcherbird	*Cracticus torquatus*	AH, KW, AR
Pied Butcherbird	*Cracticus nigrogularis*	AH
Australian Magpie	*Gymnorhina tibicen*	AH, KW, AR
Grey Currawong	*Strepera versicolor*	AH, KW, AR
Australian Raven	*Corvus coronoides*	AH, KW, AR
Silvereye	*Zosterops lateralis*	AR

Source of information: Anne Henderson (AH), West Speddingup, Kay Walter (KW), West Speddingup, Alan Rose (AH), Esperance Bird Observers Group and also the West Australian Museum (1999).

Appendix 3

Waterbirds recorded on the Lake Gore Wetland System

Common Name	Scientific Name
Blue-billed Duck	*Oxyura australis*
Musk Duck	*Biziura lobata*
Freckled Duck	*Stictonetta naevosa*
Marsh Harrier	*Circus aeruginosus*
* Black Swan	*Cygnus atratus*
* Australian Shelduck	*Tadorna tadornoides*
Australian Wood Duck	*Chenonetta jubata*
* Pacific Black Duck	*Anas superciliosa*
* Australasian Shoveler	*Anas rhynchotis*
* Grey Teal	*Anas gracilis*
* Chestnut Teal	*Anus castanea*
* Pink-eared Duck	*Malacorhynchus membranaceus*
*Hardhead	*Aythya australis*
Australasian Grebe	*Tachybaptus novaehollandiae*
Hoary-headed Grebe	*Poliocephalus poliocephalus*
Great Crested Grebe	*Podiceps dristatus*
Little Pied Cormorant	*Phalacrocorax melanoleucos*
Pied Cormorant	*Phalacrocorax varius*
Little Black Cormorant	*Phalacrocorax sulcirostris*
Great Cormorant	*Phalacrocoras carbo*
Australian Pelican	*Pelecanus conspicillatus*
White-faced Heron	*Egretta novaehollandiae*
Little Egret	*Egretta garzetta*
Great Egret	*Ardea alba*
Straw-necked Ibis	*Threskiornis spinicollis*
Black-tailed Native-hen	*Gallinula ventralis*
Black-tailed Godwit	*Limosa limosa*
* Eurasian Coot	*Fulica atra*
Marsh Sandpiper	*Tringa stagnatilis*
Common Greenshank	*Tringa nebularia*
Wood Sandpiper	*Tringa glareola*

Appendix 3 (cont)

Common Name	Scientific Name
Common Sandpiper	*Actitis hypoleucos*
Ruddy Turnstone	A*renaria interpres*
Great Knot	*Calidris tenuirostris*
Red Knot	*Calidris canutus*
Sanderling	*Caladris alba*
Red-necked Stint	*Calidris ruficollis*
Long-toed Stint	*Calidris subminuta*
Pectoral Sandpiper	*Calidris melanotos*
Sharp-tailed Sandpiper	*Calidris acuminata*
Curlew Sandpiper	*Calidris ferruginea*
* Black-winged Stilt	*Himantopus himantopus*
Banded Stilt	*Cladorhynchus leucocephalus*
Red-necked Avocet	*Recurvirostra novaehollandiae*
Pacific Golden Plover	*Pluvialis fulva*
* Red-capped Plover	*Charadrius ruficapillus*
Greater Sand Plover	*Charadrius leschenaultii*
Black-fronted Dotterel	*Elseyornis melanops*
Hooded Plover	*Thinornis rubricollis*
Red-kneed Dotterel	*Erythrogonys cinctus*
Banded Lapwing	*Vanellus tricolor*
Silver Gull	*Larus novaehollandiae*
Caspian Tern	*Sterna caspia*
* Fairy Tern	*Sterna nereis*
Whiskered Tern	*Chlidonias hybridus*

* = breeding recorded

Source: Alan Rose, Esperance Bird Observer Group

Appendix 4

Water quality monitoring results – Dalyup River catchment

3.1 Dalyup River snapshot monitoring results

Site	Date	Time	Temp(°C)	EC(mS/cm)	Comments
Speddingup West Road (Dalyup River)	11/7/00	9:00am	9.6	51.7	Moderate flow, fairly clear water
Spedingup West Road (West Dalyup River)	11/7/00	9:15am	10.6	70.3	Moderate flow, dark tannins in water
Brownings Road (Dalyup River)	11/7/00	9:40am	11.9	53.9	Fast flow, sediment in water
Brownings Road (West Dalyup River)	11/7/00	9:5 am	11.1	50.3	Fast flow, sediment in water
South Coast Highway-West Dalyup Bridge (West Dalyup River)	11/7/00	10:10am	12.8	35.4	Very fast flow, sediment in water
South Coast Highway-Dalyup Bridge (Dalyup River)	11/7/00	10:22am	12.5	39.7	Very fast flow, sediment in water
Dalyup Pioneer Reserve-Murrays Road (Dalyup River)	11/7/00	10:35am	12.5	31.5	Moderate flow, very dark tannins in water, depth >2m
The Oaks, Location E1431 (Dalyup River Tributary 1)	11/7/00	11:25am	13.1	25.3	Fast flow, clear, freshwater spring upstream

Appendix 5

Water quality monitoring data collected by Water and Rivers Commission

Sample Date	Dalyup River Site DRPE-A 07-08-1987	Location D31 07-08-1987	Quallilup LakesSth Shore 07-08-1987
BOD (mg/L) Biochemical Oxygen Demand 5 day	4	4	6
DOC (mg/L) Dissolved organic carbon	24	23	99
NOX (mg/L)Total oxidised nitrogen - sum of nitrite and nitrate nitrogen)	< .005	0.005	0.012
TKN (mg/L)Total Kjeldahl nitrogen - sum of ammonia- and organic-nitrogen	1.3	1.3	5.6
TN (mg/L) Total nitrogen - sum of TKN and TON	1.3	1.3	5.6
TP (mg/L) Total phosphorus	0.08	0.06	0.14

Appendix 6

Water quality monitoring data from Esperance Research Station

Site	Date	Time	Total P mg/L	Total N mg/L	Conductivity mS/m	Stage Height cm	Flow Rate m^3/h
1	25-May-95	10.00	0.93	1.7	79		
1	11-Jul-95	11.00	0.1	0.77	1920		
1	17-Jul-95	9.30	2.7	11	125	3	31
1	19-Jul-95	10.00	0.1	1.1	2080		
1	31-Jul-95	8.48	0.62	4	86.4	2	16
1	14-Aug-95	9.10	0.29	3	405	2	16
1	18-Oct-95	11.00	1.6	6.3	68.3	2	16
2	25-May-95	10.00	0.31	1.1	60		
2	26-Jun-95	13.30	0.3	1.8	78.9	1.5	11
2	17-Jul-95	9.30	0.95	5	559	4	59
2	31-Jul-95	8.48	0.05	1.1	1850	7	151
2	14-Aug-95	9.10	0.14	2.6	718	5	86
2	28-Sep-95	8.30	0.19	3.5	776	2	18
2	18-Oct-95	11.00	0.18	0.78	102	3	36
3	25-May-95	10.00	2.2	3.3	92		
3	26-Jun-95	13.30	0.14	1.6	24.2	1	5
3	17-Jul-95	9.30	0.4	1.9	165	2	15
3	31-Jul-95	8.48	0.13	2	484	5	69
3	14-Aug-95	9.10	0.17	2.4	639	4	47
3	28-Sep-95	8.30	0.5	5	1720	1	5
3	18-Oct-95	11.00	0.51	1.6	151	1	5
4	25-May-95	10.00	0.38	2.2	28		
4	26-Jun-95	13.30	0.35	1.1	2500	1	4
4	17-Jul-95	9.30	0.69	1.8	70	1	4
4	31-Jul-95	8.48	0.87	3.9	206	2	12
4	14-Aug-95	9.10	0.36	4.1	394	1	4
4	18-Oct-95	11.00	0.1	0.7	104	2	12
5	17-Jul-95	9.30	3.5	7.6	33	0.5	2
5	31-Jul-95	8.48	2.3	3.7	135	1.5	11

Source: Steve Gee, Department of Agriculture, Esperance, unpublished

Appendix 7

Lake Gore water quality data collected by Esperance Senior High School Ribbons of Blue program

Date	Sampling Time	Conductivity (uS/cm)	Temperature (oC)	Depth (m)	Turbidity (NTU)	pH	PO4 (mg/L)	NO3 (mg/L)
22-08-1994	14:15	69500	18		70	7.5	0.12	0.62
16-11-1994	8:00	3100	26		-25	8	1.34	0.066
?-04-1995	9:45	99500	14	0	40	7.5	0.14	0.141
?-06-1995	11:30	75000	15		30	8.5	0.56	0.158
?-08-1995	9:15	44000	12		90	8.6	0.02	0.079
?-11-1995	11:00	63000	17		500	7.8	0	0
27-03-1996	9:45	108000	16.5		60	7.3	0.14	0.106
30-08-1996	11:30	88700	18		-25	7.9	0.28	0.352
07-11-1996	12:00	81000	23		90	7.8	0.04	0
26-03-1997	?	10200	26	below	45	7.9	0.17	0.12
04-07-1997	am	83000	13	0.9	25	8	0.38	0.11
31-08-1997	am	49000	18	2.6	55	8.1	0.02	0.07
?-?-1997	am	69000	26	1.6	70	7.9	0.04	0.06
?-04-1998	?	14300	17	0.8	175	7.9	0.06	0
?-07-1998	?	135000	15	1.92	600	7.8	0.22	0.092
?-09-1998	?	62800	17	1.65	120	8	0.1	0.29
?-11-1998	?	73500	22	1.4	70	8	0.025	0.042
15-04-1999	9:15	32000	19	1.71	32	7.8	0.22	0.968
22-06-1999	14:45	12500	15	1.9	25	7.9	0.12	0.066
23-09-1999	14:55	1400	21	1.8	25	8.7	2.4	0

Source: Dennis Smith, Esperance Senior High School

Appendix 8

Lake Gore water quality data

Date of Survey	Salinity	Depth (m)	pH
08-11-1979	24.2	1.72	
15-01-1980	32.3	1.42	
15-03-1980	41.9	1.2	
17-05-1980	49.6	1.1	
16-07-1980	41	1.98	
17-09-1980	42	1.47	
08-11-1980	49.6	1.35	
14-01-1981	61	1.1	
14-05-1981	91	0.68	
16-07-1981	62.5	1.1	9
13-09-1981	50	1.45	
14-11-1981	59	1.32	
11-01-1982	96	0.99	7.7
15-03-1982	148	0.71	7.7
13-05-1982	193	0.61	8.4
13-07-1982	120	0.75	8
16-09-1982	90.3	0.95	8.4
11-11-1982	102	1.04	
14-01-1983	164	0.68	7.2
14-03-1983	166	0.67	7.8
20-05-1983	208	0.66	7.8
14-07-1983	193	0.65	7.3
14-09-1983	160	0.68	7.5
05-11-1983	250	0.58	7.9
16-01-1984	342	0.5	7.1
11-03-1984		0	
16-05-1984		0.1	
16-07-1984	136	0.69	
11-09-1984	41.3	1.8	8.4
06-11-1984	49.2	1.67	9
16-01-1985	71	1.28	8.1

Appendix 8 (cont)

Date of Survey	Salinity	Depth (m)	pH
14-03-1985	92	1.07	8.3
14-05-1985	109	0.93	
18-09-1985	66	1.37	8.1
04-11-1985	64.4	1.5	8.4
17-09-1986	18.2	2.02	8.7
02-11-1986	20	1.68	8.7
15-09-1987	30.7	1.62	8.7
08-11-1987	35.8	1.55	8.5
12-09-1988	39.6	1.53	8.5
10-11-1988	55.6	1.34	8.3
12-09-1989	6.5	1.89	8.1
08-11-1989	8.8	1.73	8.5
13-09-1990	22.1	1.46	9
07-11-1990	40.6	1.42	8.8
19-09-1991	58	0.95	9.4
08-11-1991	79	0.85	8.5
17-09-1992	19.3	2.1	9
12-11-1992	16.2	2.84	8.6
16-09-1993	22.5	1.8	8.7
10-11-1993	23.8	1.75	8.8
15-09-1994	69.3	0.95	8.3
10-11-1994	84.8	0.87	8.1
13-09-1995	43.5	1.21	6.8
09-11-1995	53.3	1.15	8.3
20-09-1996	69.9	1.01	8.5
07-11-1996	73.9	1.02	8.4
18-09-1997	38.2	1.79	8.8
08-11-1997	42.1		8.5
15-09-1998	47.9		8.5

Source: Jim Lane, CALM