Lower Warren River Action Plan

2006

SOUTHERN FORESTS LANDCARE

WARREN CATCHMENTS COUNCIL

GOVERNMENT OF

Natural Heritage Trust

Lower Warren River Action Plan

2006

Prepared for Warren Catchments Council- Southern Forests Landcare
and
the Manjimup Land Conservation District Committee

Funded by the Natural Heritage Trust and the National Action Plan
for Salinity and Water Quality

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How to use this river action plan

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This report was prepared for the Manjimup Land Conservation District Committee (LCDC) to assist landholders in the lower Warren River catchment. It is hoped that by providing this summary of lower Warren River foreshore condition and weed presence, future works in the area can be more focused on identified management priorities and issues.

The action plan is separated into eight sections. A brief overview of the river action plan and key findings is given in the summary. The lower Warren River has been divided into four sections for assessment and reporting purposes. A map accompanying the summary (Figure 1, p. vii) gives an indication of these sections. This overall map relates to smaller, section-specific maps in Section 7.

Section 1 provides background information on the river action plan, including aims and objectives of the study and involvement of various groups and persons.

Section 2 outlines the study area, covering issues such as landscape, climate, flora and fauna, as well as Indigenous heritage values.

Section 3 covers general river processes as well as water quality issues specific to the lower Warren River.

Section 4 provides an overview of the methodology involved in assessing foreshore condition. Section 5 outlines management issues identified as a result of the foreshore surveys.

Section 6 contains recommended management advice.

Section 7 contains section-specific maps, with information concerning general site description, foreshore condition rating, fencing status, management issues and weeds.

Section 8 is a summary of findings.

Section 9 lists references cited within this document.

Acronyms

CENRM	Centre of Excellence in Natural Resource Management
CALM	Department of Conservation and Land Management (now known as the Department of Environment and Conservation)
DAFWA	Department of Agriculture and Food WA
DEC	Department of Environment and Conservation
DIA	Department of Indigenous Affairs
DoE	Department of Environment (now known as the Department of Environment and Conservation)
DoW	Department of Water
LCDC	Land Conservation District Committee
NHT	Natural Heritage Trust
NRM	Natural resource management
SFL	Southern Forests Landcare
SWCC	South West Catchments Council
WRC	Waters and Rivers Commission

Cover photo: Lower Warren River, Lee Fontanini

Acknowledgments

Warren Catchments Council wishes to acknowledge the traditional owners of the south west region, the Nyungar[1] people. Nyungar people have a long-standing and continuing association with the south west area and are recognised as the traditional owners and custodians of the areas referred to in this document.

The Lower Warren River Action Plan was an initiative of Warren Catchments Council as part of a wider South West Catchments Council project to develop multiple river actions plans across the south west region. The project was funded by the Natural Heritage Trust (NHT) and the National Action Plan for Salinity and Water Quality (NAP). These funding bodies are joint initiatives of the State and Australian Federal Governments, which are administered by the South West Catchments Council. Thanks and acknowledgments go to GeoCatch for the planning that went into the current RAP method and RAP template. GeoCatch and Cape to Cape Catchments Group are further acknowledged for developing and managing the RAP project.

Previous river action plans developed for waterways in the south west provided guidance and direction in the development of the Lower Warren River Action Plan and these resources were extensively consulted during report preparation. Additional interaction with NRM officers developing river action plans was invaluable. The cooperation of landholders in undertaking foreshore assessments and attending project information meetings is greatly appreciated.

Erin Rice of the Department of Water Regional Support Branch, Perth, prepared the maps used in this document.

Reference details

The recommended reference for this publication is: Munro, J. (2006). *Lower Warren River Action Plan*. Manjimup Land Conservation District Committee.

[1]Alternative spellings are recognised.

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Summary of the Lower Warren River Action Plan

The Warren River is situated within the Warren subregion and is the sole river system within the Warren Drainage Basin. Situated in a high rainfall zone, the Warren River catchment covers an area of 4350 km^2 and is one of only five Water Resource Recovery Catchments in Western Australia. The lower Warren area is a much smaller subset of this larger Warren catchment. The Warren River flows through parts of the Bannister Uplands, Darling Plateau and Scott Coastal Plain physiographic units. The section of river assessed in this study, approximately 26 km, is part of the Scott Coastal Plain and passes through the Warren State Forest block and Greater Hawke and D'Entrecasteaux National Parks. Eight private landholdings are situated along 35 %, or approximately 9 km of the river surveyed.

The aim of developing the lower Warren River Action Plan was to assess the current condition of the lower Warren River, providing landholders and the Warren Catchments Council (Manjimup LCDC) with more accurate information regarding the condition of the waterway, to assist management decisions to be made. The lower Warren River was chosen for this study based on a number of factors including regional significance, community and landholder interest, existing blackberry biocontrol trials and the river's designation as a Water Resource Recovery Catchment.

Foreshore assessments were conducted from August-September 2006, during peak river flows. The surveys undertaken followed the Foreshore Condition Assessment methodology of Dr Luke Pen and Margaret Scott.

A summary of foreshore condition ratings for the lower Warren is contained in Table 1 below.

For the purposes of this report, the lower Warren River is defined as starting from 4.5 km upstream of Larkin Road Bridge. This point marks the transition onto the Scott Coastal Plain and the end of the Darling Plateau. The lower Warren River is in good condition for much of its length, owing to the fact that the majority of the river catchment flows through State Forest or national park areas.

The first section of the lower Warren River assessed runs through the Warren and Greater Hawke National Parks. Densely vegetated, the area has healthy native vegetation assemblages and plentiful natural regeneration. Dominant weed species include common blackberry *Rubus anglocandicans* and small leaf blackberry *R. ulmifolius*, which infest the waterline as impenetrable thickets, as well as kangaroo apple *Solanum laciniatum*. The area is largely undisturbed by humans as access is a limiting factor. In times of high water levels, water floods out across the adjacent floodplain flats and swamps.

The middle section of the river assessed moves downstream of Larkin Road Bridge into D'Entrecasteaux National Park, passing eight private properties. The area continues to be dominated by common blackberry *R. anglocandicans* thickets along the waterline. Other major weed species include golden dodder *Cuscuta campestris*, kangaroo apple *Solanum laciniatum*, small leaf blackberry *R. ulmifolius*, fruit trees including loquat *Eriobotrya jaoinica* and fig *Ficus carica*, geranium *Geranium* sp. and willow trees *Salix* sp. Scattered occurrences of thistle *Carduus* sp. and pennyroyal *Mentha pulegium* occur. A healthy native vegetation assemblage exists beyond these scattered and clumped weed infestations, with active natural regeneration.

Table 1: Summary of foreshore condition ratings for the Lower Warren River Action

Foreshore Condition	Total length (km)	Total length (%) of the Lower Warren River
A (pristine)	5	19.2
B (weedy)	20*	77
C (erosion prone)	1	3.8
D (ditch)	0	0

**includes sections marked as A3-B1 and B2-C1*

Several of the properties in the area run cattle, although in relatively small numbers. Free access to the river by stock is possible. Bank erosion and cutting is common throughout the section owing to natural, dynamic channel processes and sandy textured soils, exacerbated by historical and current stock access. The river channel in this section widens out and supports healthy in-stream vegetation with large woody debris. Significant flooded backwaters and billabongs exist on this section.

The final section of the lower Warren River to the river mouth passes through D'Entrecasteaux National Park; access is very limited. The river varies between approximately 40-70 m wide along the stretch and generally is in very good condition. Golden dodder *Cuscuta campestris* is the dominant weed species of concern. Other significant weed species that occur over a relatively widespread area include one-leaved cape tulip *Moraea flaccida*, sporadic common blackberry *R. anglocandicans*, briar rose *Rosa rubiginosa*, pennyroyal *Mentha pulegium*, typha *Typha* sp. and marram grass *Ammophila arenaria*. Weed species that occur in a restricted area (old hut site) include geranium *Geranium* sp., deadly nightshade *Solanum nigrum*, cape weed *Arctotheca calendula*, kikuyu grass *Pennisetum clandestinum* and purple groundsel *Senecio elegans*. This site is also the first recorded incidence of native *Mesembryanthemum* sp. ice plant in the area. Apart from these weed species a healthy native vegetation assemblage exists. The Warren River mouth is in a constant state of flux, depending on sand barriers and water movements.

Previous weed control efforts have been made in the area, including control trials for golden dodder and localised blackberry control regimes. The lower Warren region is being targeted for blackberry biocontrol (rust release) in late 2006.

Issues of concern:

- Unbroken infestations of common and small leaf blackberry along sections of river foreshore;
- Presence of golden dodder along the mid-lower reaches of the river;
- Spot occurrences of kangaroo apple *Solanum laciniatum*;
- Localised weed infestation in the lower reaches; and
- Uncontrolled stock access to some parts of the river foreshore.

Recommendations made in response to the above issues:

- Map occurrence of large and small leaf blackberry infestations along the length of the river. Target common blackberry infestations for biological control (rust release) over the course of a number of years, with continued monitoring of progress and to prevent re-establishment in controlled areas. Chemically control isolated plants;
- At this stage it appears that the new rust strains will have little effect on the small leaf blackberry. Management strategy is to contain and progressively chemically control the small leaf blackberry to ensure that it does not establish itself in areas where common blackberry has been affected by rust fungi;
- Map occurrence of and implement control of cape tulip along the river;
- Map other weeds along the lower Warren River, e.g. St. Johns wort. Implement multiple-property control systems to initially clear affected reaches of the weeds. Develop a monitoring regime to monitor for re-establishment of these weeds;
- Target localised weed infestation near the river mouth to achieve control before spread;
- Coordinate weed control activities with work conducted by other departments and groups e.g. DEC, DAFWA and
- Fence off riparian zones to exclude stock where appropriate.

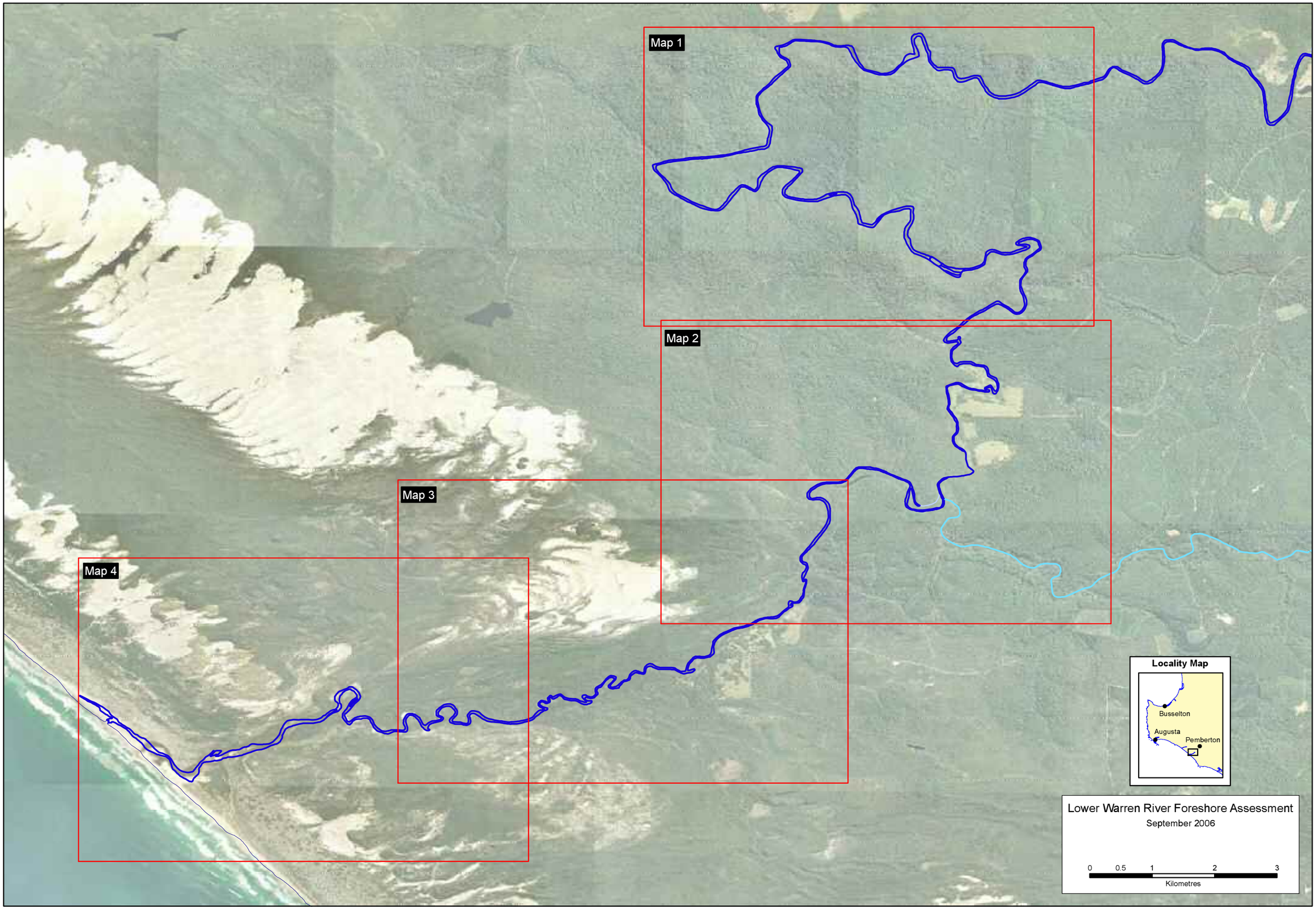

Figure 1: Warren River locality map

1. Introduction

Background

Riverine degradation has been exacerbated in recent years due predominantly to the effects of poor catchment management combined with the legacy of inappropriate agricultural regimes (WRC, 2000f). As a result, the impetus to gain a clearer understanding of the health and condition of river systems has increased. The removal of native fringing vegetation, erosion, declining water quality, encroachment of invasive weeds and feral animals are the main issues facing waterways managers as a result of agricultural practices (WRC, 1999). Most of these problems are mutually causative.

The lower Warren River Action Plan was developed as part of a wider program aimed at developing a suite of river action plans across the south west region. The project is funded by the Natural Heritage Trust (NHT) and the National Action Plan for Salinity and Water Quality (NAP); these are joint initiatives of the State and Australian Governments which are administered by the South West Catchments Council. Inaugurated in 1989, the Manjimup Land Conservation District Committee (LCDC) is a gazetted group of local farmers, landowners, professionals and interested community members working together to address natural resource management (NRM) issues in the region. The Warren Catchments Council is a committee of the Manjimup LCDC and represents the region in the South West Catchments Council (SWCC). Southern Forests Landcare (SFL) is a trading name formed under the auspices of the Warren Catchments Council. The group employs a number of full-time and part-time staff to coordinate both NRM projects that receive funding from the SWCC and other projects that receive external funding.

Study aims

The principal aims of the lower Warren River Action Plan are to maintain and enhance the long term ecological condition of the river. The action plan seeks to achieve these aims by firstly ascertaining the current condition of the lower Warren River; establishing management issues and prioritising restorative measures to deal with those issues. Community and landholder involvement and commitment to carrying out plan recommendations are crucial to the eventual effectiveness of the plan.

This action plan is not a statutory plan and does not represent government policy or regulation, nor does it have legal status. This action plan provides direction for future management and seeks to provide a benchmark against which any future works implemented by the Manjimup LCDC or local community to protect and rehabilitate the lower Warren River can be assessed. Associated objectives of the action plan are that it should be used as the foundation for further works and funding applications, and for the plan to act as an initial source of technical advice.

2. Study area

The lower Warren River was surveyed from the last set of rapids (approximately 4.5 km upstream of Larkin Road Bridge) to the river mouth, approximately 30 km south west of Pemberton. The location of the study area is shown in Figure 1 (p. vii). Background information regarding the study area is detailed below.

The Warren River

Lieutenant Preston was the first European to discover the Warren River in 1831 (CALM, undated). The river flows for approximately 137 km from the confluence of the Tone and Perup Rivers (locality of Murtinup) to the Southern Ocean. The river has a full catchment area of ~4350 km^2, which encapsulates the towns of Manjimup and Pemberton. The upper Warren catchment area is mostly cleared farmland and contributes a large amount of salt to the waterways from the Tone and Perup Rivers (Mayer *et al*. 2005; Smith *et al*. 2006). After passing through these cleared agricultural areas, the river then flows through a mixture of forested and cleared agricultural areas before reaching the section assessed and defined for the purposes of this action plan as 'the lower Warren River'.

The Warren is classed as a T8 river type, meaning that it is a "medium river originating in medium rainfall marri/wandoo woodlands, flowing through jarrah/marri forest and the high rainfall karri country to the coast" (Pen, 1997 p.54). It is the second largest river by streamflow in the Busselton-Walpole region. Tributaries of the Warren River include the Perup, Yerraminnup, Wilgarup and Tone Rivers, Quinninup, Lefroy and Dombakup Brooks. Although the main channel itself is not dammed, most tributaries are, and indeed the Warren River is one of the most dammed catchments in Western Australia (State of Western Australia, 2004). Previous survey work conducted by Water and Rivers Commission classed the majority of the Warren River as B1-B3 grade (see p. 14 for explanation of grading system), although the condition was recorded as ranging from A3-C3. Most of the tributaries were classed as of B1-C1 condition (Pen, 1997). Threats to the Warren River catchment include feral pigs and deer; blackberry, golden dodder and pasture weed species; recreational usage impacts; eutrophication and water diversion and storage upstream on freshwater tributaries and dams (CALM, 2002).

The lower Warren River

The lower Warren River has been defined for the purposes of the action plan as an approximately 26 km section of the Warren River, from the river mouth to approximately 4.5 km upstream of Larkin Road Bridge. The lower Warren River passes through the Warren, Yeagarup, Callcup and Dombakup State Forest blocks as well as Greater Hawke and D'Entrecasteaux National Parks and Dombakup Nature Reserve. Aside from forest reserves and national park, land uses within the catchment are grazing and rural residential blocks. There are a total of eight private landholdings with frontage onto the river. The small number of landholders combined with the relative isolation of much of the river within State Forest reserves and national park has meant that the lower Warren River has remained in good condition. Issues with the health and quality of the river are largely attributable to upstream processes, such as salinity and blackberry spread. The soil substrate of the foreshore area is sandy and natural, dynamic channel erosion and corresponding deposition processes are occurring along much of the river, exacerbated in places by stock access.

Only one tributary, Dombakup Brook, joins the part of the Warren River assessed in this study. Previously assessed as being of B1-C1 condition (Pen, 1997), Dombakup Brook is westerly oriented for approximately 26 km before entering the Warren River roughly 16 km from the river mouth. The river opens onto a long sandy beach, Warren beach, snaking in a north westerly direction for approximately 2 km before reaching the ocean. The mouth is closed over during periods of low flow, but this is not a common occurrence, as the river is not tidal (Hodgkin & Clark, 1989).

Climate

The climate of the south west region is warm temperate Mediterranean, with distinct seasons involving cool, wet winters and hot, dry summers. Median rainfall for the region ranges from 900-1400 mm on the coast and decreases to around 500 mm in the eastern upper Warren catchment. The wettest period of the year is from May to September, however prolonged summers are common. Median rainfall for the Warren River catchment is 850 mm, although in the lower Warren region this figure varies from 700 mm to 1000 mm. Winter mean temperatures in the region vary with

distance from the coast, whereas latitude has a greater effect on mean summer temperatures (DoE 2004a; Mayer *et al*. 2005; Pen 1997; Smith *et al*. 2006).

Landforms and soils

The south west of Western Australia is mostly located on the ancient Western Archaean Shield. The shield covers an extensive region and is underlain by Precambrian gneiss and granite rocks, which have been stable for the last 570 million years. The Warren River is situated on three main physiographic units. The Warren catchment begins (with Tone and Perup Rivers as headwaters) in the Bannister Uplands, where a lateritic duracrust exists beneath sandy, yellow mottled soils with varying amounts of gravel. The river then moves through the Darling Plateau, an uplifted (200-300 m above AHD), broadly undulating surface with laterite overlaying Precambrian crystalline rocks. Soils are typically gravelly ironstone over a hard lateritic duracrust. Generally found higher in the landscape, lateritic soils support jarrah or jarrah-marri vegetation associations (Pen 1997; V. & C. Semenuik Research Group 1997). Around the Pemberton area, soil type changes to predominantly heavy red, or karri, loams. This soil type is of significant horticultural value to the region, supporting high karri forest with jarrah or marri species. These tall karri forests are important timber and landscape character icons for the region and have proved to be a tourist drawcard (State of Western Australia 2004; V. & C. Semenuik Research Group 1997).

The mouth region of the lower Warren River, and the entire area of river assessed in this study, lies on the Scott Coastal Plain, characterised by generally low lying, swampy land with windswept parabolic dunes (State of Western Australia, 2004). High Pleistocence dune systems extend for approximately 8 km before the river discharges onto the narrow coastal plain. Vegetation generally comprises eucalypt, peppermint and wattle species on the slopes and heath and sedge species in lower areas (Hodgkin & Clark 1989; State of Western Australia 2004).

Water quality

Mean annual flow of the Warren River as recorded at Barker Road gauging station is 291 gigalitres, a figure mostly resulting from the high rainfall levels in the lower catchment (Smith *et al*., 2006). There is a commonly acknowledged relationship between clearing, mean annual rainfall and salinity. Prior to clearing, salinity was recorded as approximately 120-350 mg/L (<500 mg/L is considered fresh). The Wilgarup, Dombakup and Lefroy sub-catchments were initially cleared around 1925 as part of settlement schemes. Extensive clearing in the 1950s and 1960s resulted in a significant increase in stream salinity, with water quality no longer considered fresh. The Warren catchment was declared a clearing control catchment in 1978 after concerns were expressed at rising salinity levels. Following this declaration intensive revegetation efforts were undertaken within the Perup and Tone River sub-catchments, which account for 60% of the salt load entering the Warren River. The Warren River catchment was declared a Water Resource Recovery Catchment in 1996 owing to continuing salinity and resultant water quality concerns. Salinity levels now appear to be leveling off and clearing within the total catchment is estimated as approximately 35% (Pen 1997; Mayer *et al*. 2005; Smith *et al*. 2006; State of Western Australia 2004).

Clearing within the lower Warren River catchment is much less than in the entire Warren catchment, owing to the lower catchment's predominantly forested status. Monitoring of water quality along the Warren River has not been continuous for most sampling sites since the period 1971-1979 (DoE, 2004a). The most recently available snapshot water quality information obtained from Department of Environment data repositories were for the periods 1999-2001 and 2001-2003. The data indicate that the lower Warren River exhibits the following median values: low total nitrogen (0.607 mg/L), neutral pH (7.43), stained colour (50 TCU[2]), moderate turbidity (7.7 NTU)[3] and low dissolved oxygen levels (5.6 mg/L). The lower Warren River to the river mouth is considered slightly brackish, with a mean annual salinity of 990 mg/L for the period 1993-2002, measured at Barker Road gauging station just upstream of the river section surveyed. The Warren River below Pemberton is considered to be marginally brackish (440 – 1,375mg/L) due to the influx of brackish water from the largely cleared Perup and Tone Rivers (DoE 2004b; Pen 1997; Smith et al. 2006). Clearing of the area surrounding Dombakup Brook was recorded as 24% in 2000, down from 36% cleared in 1979 (Smith *et al*., 2006). Dombakup Brook is recorded as being fresh (< 440mg/L) (Mayer *et al*., 2005).

Flora

The south west of Western Australia has long been recognised as a biodiversity 'hot spot', connoting very high biodiversity values. The process of continental drift is in part responsible for this phenomenon. Palaeobotanical studies provide evidence of the existence of vast rainforests across much of the Australian continent approximately 50 million years ago. Climate change to a much drier environment resulted in adaptive changes among the flora and a reduction in the spread of rainforests across the continent. The south west corner was isolated as a result, and flora and fauna evolved unique adaptations to allow them to survive (Christensen, 1992). Native vegetation varies greatly over the south west and is largely determined by the rainfall in the area and soil type. The most important genera in the wider south west region include *Acacia, Stylidium*, *Caladenia*, *Leucopogon*, *Eucalyptus* and *Drosera*. The lower Warren River passes through three main vegetation formations: high open forest, woodlands and open shrubland (Christensen, 1992).

Iconic high, open karri *Eucalyptus diversicolor*, or karri/marri forests dominate along the section of the lower Warren River assessed. Understorey tree species include karri sheoak *Allocasuarina decussata*, Warren River cedar *Taxandria juniperina*, swamp willow (wonnich) *Callistachys lanceolata* and Western Australian peppermint *Agonis flexuosa*. Other understorey species include karri hazel *Trymalium floribundum*, ropebush (banjine) *Pimelia clavata* and sword sedges *Lepidosperma* sp. This type of forest association has developed on the most fertile soils in areas of annual rainfall exceeding 1100 mm.

Common species noted along the lower Warren foreshore once past the dominance of open karri forests include Western Australian peppermint *Agonis flexuosa*, yate *E. cornuta*, paperbark *Melaleuca raphiophylla*, Warren River cedar (wattie) *Taxandria juniperina* and river banksia *Banksia seminuda*. Shrub species noted included Dungyn *Hakea oleifolia*, ropebush (banjine) *Pimelia clavata*, coral vine *Kinnedia coccinea*, cutleaf hibbertia *Hibbertia cuneiformis*, sharks tooth acacia *Acacia acuminata*, *Astartea fascicularis*, prickly Moses *Acacia pulchella*, water bush *Bossiaea aquifolium* and albizia *Paraserianthes lophantha*. Sword sedges *Lepidosperma* sp. form dense thickets along much of the foreshore area.

Towards the coast, flora composition shifts as the underlying soils change to swampy flats and consolidated dune systems. Near the mouth of the river, the rush *Juncus krausii* forms dense swamps. Other rush species observed include *J. pallidus* and the weed species *J. microcephallus*, sedge species *Cyperus* sp. and coast sword sedge *Lepidosperma gladiatum*. The mouth is dominated by freshwater species and *Typha* sp. grows within 0.5 km of the river mouth (Hodgkin & Clark, 1989).

Fauna

Fish fauna

The Department of Freshwater Fish Research at Murdoch University was contracted to undertake a comprehensive study of past and present fish fauna in the lower Warren River. This information will be available as part of a separate report giving a biological snapshot of the lower Warren River.

Macroinvertebrate fauna

Comprehensive macroinvertebrate sampling was not undertaken for the lower Warren River Action Plan; however information regarding macroinvertebrate species occurrence was provided by the local Ribbons of Blue waterways education and community monitoring project. Macroinvertebrate species identified in the lower Warren River are listed below (Table 2). A more comprehensive study of macroinvertebrate populations is to take place and will be available as a separate report, as above.

[2]True Colour Units, Long term acceptable limits for potable water should not exceed 15 TCU.
[3] Nephelometric Turbidity Unit. Used to describe the amount of suspended solids in the water.

Table 2: Macroinvertebrate species occurring in the lower Warren River

Common name	Scientific name	Details
Copepod	*Subclass Copepoda*	Tolerant of changes in water quality, predator/ scraper/ shredder
Damselfly larvae	*Order Odonata*	Sensitive/ moderately tolerant to changes in water quality, predator
Dragonfly larvae	*Order Odonata*	Sensitive/ moderately tolerant to changes in water quality, predator
Freshwater prawn/ shrimp	*Order Decapoda*	Moderately tolerant of changes in water quality, collector
Mayfly	*Order Ephemeroptera*	Very sensitive to changes in water quality, collector
Non-biting midge larvae	*Family Chironomidae*	Very tolerant to changes in water quality, filter feeder
Scavenger beetle	*Family Hydrophilidae*	Moderately tolerant to changes in water quality, predator
Water boatmen	*Family Corixidae*	Very tolerant to changes in water quality, shredder/ predator
Water spider	*Order Araneae*	Tolerant of changes in water quality, predator

Ribbons of Blue involvement with the lower Warren River and other waterways within the Warren region is ongoing. Anyone interested in finding out more information on the local Ribbons of Blue program should get in touch with the organisation; contact details are given in Appendix 2.Ribbons of Blue involvement with the lower Warren River and other waterways within the Warren region is ongoing. Anyone interested in finding out more information on the local Ribbons of Blue program should get in touch with the organisation; contact details are given in Appendix 2.

Terrestrial fauna

Twenty-seven species of larger land fauna are known to occur in the region, of which six are endemic to the south west of Western Australia (Table 3). In addition, many species of birds have been recorded as occurring in the southern forests region. Generally, the highest numbers of species are supported within open woodland and low open woodland habitats. It is likely that some if not all of these species occur near to the lower Warren River or within the wider Warren River catchment.

Table 3: Fauna occurring in the south west of Western Australia (after Christensen, 1992)

Common name	Scientific name	Further details
Macropods		
Western grey kangaroo	*Macropus fuliginosus*	-
Western brush wallaby	*Macropus irma*	Endemic
Tammar wallaby	*Macropus eugenii*	-
Quokka	*Setonix brachyurus*	Endemic, rare/likely to become extinct
Brush-tailed bettong (woylie)	*Bettongia penicillata*	Threatened fauna
Possums		
Common brushtail possum	*Trichosurus vulpecula*	-
Western ringtail possum	*Pseudocheirus occidentalis*	Threatened fauna: rare/likely to become extinct
Western pygmy possum	*Cercartetus concinnus*	Endemic
Honey possum	*Tarsipes rostratus*	Endemic
Dasyurids		
Western quoll (chuditch)	*Dasyurus geoffroii*	Threatened fauna: rare/ likely to become extinct
Brush-tailed phascogale	*Phascogale tapoatafa*	
Yellow-footed antechinus (mardo)	*Antechinus flavipes*	Common on sites unburnt for >10 years
Grey-bellied dunnart	*Sminthopsis griseoventer*	Endemic
Bandicoots		
Southern brown bandicoot	*Isoodon obesulus*	Threatened fauna
Numbats		
Numbat	*Myrmecobius fasciatus*	Threatened fauna: rare/ likely to become extinct
Echidna		
Echidna	*Tachyglossus aculeatus*	-
Rodents		
Bush rat	*Rattus fuscipes*	-
Water rat	*Hydromys chrysogaster*	-
Bats		
Greater long-eared bat	*Nyctophilus major*	Common
Gould's long-eared bat	*Nyctophilus gouldii*	Common
Lesser long-eared bat	*Nyctophilus geoffryi*	Common
Gould's wattled bat	*Chalinolobus gouldii*	Common
Chocolate wattled bat	*Chalinolobus morio*	Common
MacKenzie's Bat	*Falsistrellus mackenziei*	Common, endemic
King River eptesicus	*Eptesicus regulus*	Common
White-striped mastiff-bat	*Tadarida australis*	Common
Little mastiff-bat	*Mormopeterus planiceps*	Common

Table 4: Exotic mammals present in the region (after Christensen, 1992)

Common name	Scientific name
Cat	*Felix catus*
Dingo	*Canis familiaris dingo*
Fox	*Vulpes vulpes*
Pig	*Sus scrofa*
Goat	*Capra hircus*
Horse	*Equus caballus*
House mouse	*Mus musculus*
Black rat	*Rattus rattus*
Rabbit	*Oryctolagus cuniculus*

Cultural heritage

Aboriginal heritage

Aboriginal association with the south west area of Western Australia stretches back approximately 50,000 years. Waterways and their associated landscape features are traditionally important foci for their customs, folklore and spiritual beliefs. Aboriginal people inhabiting the area are generally referred to as Nyungar people. Nyungar people utilised the Warren and other rivers in the area as food sources and trade routes among other uses (Crawford & Crawford 2003; WRC 2002a). Oral and written histories of the Nyungar people indicate that seasonal movements occurred, predominantly related to the availability of certain food and water resources as affected by seasonal fluctuations. The Nyungar people tended to move inland during the winter months and congregate around river and lake systems during the summer months (Crawford & Crawford, 2003).

The Department of Indigenous Affairs (DIA) maintains a register of officially recognised Aboriginal sites throughout Western Australia; predominantly these are classed as either archaeological or anthropological sites. There is one officially registered site along the lower Warren River, the Dombakup Archeological Sites, classed as an artifacts/scatter site containing archeological deposits. It is worth noting also that all waterways hold special significance for indigenous people. There may be further Aboriginal heritage sites in the lower Warren River area that are not officially recorded on the Aboriginal sites register. Laws are now in place to ensure that Aboriginal artifacts discovered during river assessment and restoration works are protected (Government of Western Australia, undated). Further information can be found on the DIA website at www.dia.wa.gov.au.

Of note is the late local personality Charlie Burns, born early in the century, raised and educated by the Brockman family on their property near the Warren River and cattle leases on the south coast. Well known in the area, he knew the coastline between Broke Inlet and Augusta intimately (Morris & Underwood, 1992).

European heritage

European association with the south west of Western Australia officially began in 1826, when the first British settlement was established at Albany. The settlement of the Swan River region in 1829 continued European colonisation of the area, with initial reports commenting on the helpful and productive relationship between the settlers and Aboriginal people. However interaction between European settlers and Aboriginal people turned into conflict as settlements and disputes over food sources displaced Aboriginal people. Disease brought by the Europeans also proved to be devastating to the Aboriginal people (Crawford & Crawford 2003; WRC 2002a).

In 1852, the banks of the Warren River were described by European surveyor Augustus Charles Gregory. The Pemberton area upstream of the lower Warren was settled in the 1860s. A number of historically important sites are located near to the Warren River, including Warren House, established in 1862 on the banks of the Warren River by Edward Brockman, son of one of the original Swan River Colony settlers. Near to Warren House, the bridge over the Warren River is also of historical significance. Both of these sites are upstream of the river section assessed in this study. The mouth of the Warren River was drilled for oil by the Westralian Mining and Oil Corporation in 1902 (WRC 1996). Also near the mouth of the river is a block known locally as 'The Colonels', settled by an ex-army officer Colonel Vialis. There are several sites of historical interest along Dombakup Brook. 'Brockman's sawpit' is one of the original sawpits in the area, used to saw timber for the original Brockman homestead. The sawpit has been restored as an historic site (Morris & Underwood, 1992). Dombakup Bridge, spanning the brook, is thought to be the only remaining wholly timber trestle bridge still in use in WA. Tourist tram rides are still

conducted over the bridge and along the Warren River (Pemberton Tramway Company, undated).

1916 saw the introduction of marram grass to the Callcup dune system in an effort to stabilise dune movement amid fears that the natural flow of the Warren River would be affected and forest overwhelmed. Initial planting was undertaken by the Forest Department and carried further by the efforts of Colonel Vialis and Mr W. Brockman (White, 1972).

Later, settlement in the region occurred as part of the Group Settlement Scheme. Under the scheme, dairy farming, orchards and potato and onion farming were emphasised. In the 1930s, the new crops of tobacco and hops were trialed in the area. The locally grown tobacco was of poor quality, and the industry folded after World War II. 'Bunns Hops Gardens' on Beedelup Brook flourished, and the hops were at one stage used to supply Swan and Emu beer production. A new owner, however, began importing hops from Tasmania at a lower cost and the gardens failed.

The lower Warren River has a number of local community groups associated with it and concerned about its protection and the protection of traditional anthropocentric rights regarding the river. Groups include the Warren Environment Group, D'Entrecasteaux Coalition, Warren Fishing Club, Freshwater Anglers and KOCO (Keep Our Coast Open).

Zoning

The lower Warren River is located within the Shire of Manjimup. As outlined by the *Warren-Blackwood Rural Strategy* (2004), land use within the Warren-Blackwood region is classed as one of three land use zones which seek to separate desired primary land usage: Agriculture, Priority Agriculture and Rural Landscape Protection zones. The Agriculture zone aims to protect the productive capacity of rural land, by promoting and facilitating the diversification and intensification of sustainable agriculture production. The Priority Agriculture zone provides an increased level of protection to the productive capacity of the land and the key land and water resources underlying it. The final zoning unit, Rural Landscape Protection, is used to denote areas where the primary objective is to protect and enhance intrinsic landscapes, environmental and cultural values (State of Western Australia, 2004). The lower Warren River does not fall into any of these zones, as it is wholly contained within National Park.

Economic issues

The economy of the Warren-Blackwood area, where the lower Warren River is located, rests upon three main industries: agriculture, forestry and tourism. Forestry is a major component of the local economy, from native forest logging operations and more recently from commercial timber plantations. In the Shire of Manjimup, annual and perennial horticulture provides more than half of the gross value of agricultural production. The Warren-Blackwood region is recognised as one of Western Australia's primary tourism zones, owing to the region's varied landscape, forests, remote coastlines and mild climate (State of Western Australia, 2004). Downturns and changes, particularly in the agricultural and forestry fields, have the potential to cause economic hardship for the region, as well as providing opportunities for diversification and growth. Principal land conservation issues with the potential to impact economically on the lower Warren River region include salinity, erosion, waterlogging and water quality, as well as protection of agricultural land, soil structure decline and soil acidification (State of Western Australia, 2004).

Existing plans and surveys

Much of the background information on the Warren-Blackwood region and the Warren River has been sourced from plans and policies already in existence. These include the *Warren- Blackwood Rural Strategy* (2004), *South West Regional Strategy for Natural Resource Management* (2005) and the *Warren Blackwood Regional Planning Study: Environmental and Landscape Assessment* (1995). Information was also been sourced from both the original *Shannon Park and D'Entrecasteaux National Park Management Plan* (1987) and the revised *Shannon and D'Entrecasteaux National Park Draft Management Plan* (2005).

Future planning proposals

When officially published, the revised *Shannon and D'Entrecasteaux National Park Management Plan* (2005) may have an impact on land and waterway management within the lower Warren River area.

3. River Ecology

To provide context to the issues discussed later in this document, the following section contains information on the fundamentals of river ecology and habitats, sourced from a variety of publications, details of which can be found at the end of this section. The majority of this information came from Pen (1997). More detailed information on river ecology can be found in these publications as well as other sources.

Habitats

Habitats exist in the environment as a continuum, with no clear demarcation between distinct 'zones'. However, for the purposes of illustration, different habitats are treated as discrete units. The variety of natural habitats in a waterway provides the opportunity for a diverse array of flora and fauna to exist. Major habitat zones include permanent river pools, riffles and runs, areas of terrestrial riparian vegetation on embankments and seasonal floodwaters. These zones are discussed in more detail below.

River pools

River pools in optimum condition are well shaded environments, surrounded by dense fringing paperbark and sedge vegetation and containing snags and woody debris. They perform an important refugia role during the drier summer months when they often represent the only source of permanent water in an area. As such they act as a haven for many aquatic fauna. However, conditions may be extreme during this time, with warmer water temperatures and correspondingly lower levels of dissolved oxygen available.

Riffles, rapids and cascades

These habitat types primarily serve to oxygenate the water column and also as a source of noise, enabling some species to locate their favoured habitat. The three habitats are defined as where water flows swiftly over an irregular stream bed, over and between rocks and from one rocky terrace to another, respectively. In the area, riffle zones characteristically are dominated by flooded gum, paperbarks, Warren River cedar and sedges.

Runs and low flow channels

Runs are commonly described as long reaches of unobstructed stream flow where the water surface is flat. In the south west, runs are further defined as the low flow channels that wind across the floodway between pools. Often the low flow channels are well supported and overhung by riparian vegetation.

Floodplains

In general terms, floodplains are broad areas of low flat land adjacent to the main floodway of the river. These areas are characteristically inundated by floodwater to some degree each year, creating a seasonal habitat utilised by a variety of organisms for feeding and reproduction. Floodplains may also form part of wider wetland systems, which become swampy in the winter months, either from rising groundwater or a buildup of rainwater over impervious clay layers. Often considered as distinct from the main river channel, floodplains are an important component of the river ecosystem, allowing for the exchange of water, nutrients and fauna between the two zones.

Habitat elements

Habitat elements are the components of the riverine ecosystem that combine to form different habitats. Some common elements are outlined here.

Riparian vegetation

Riparian vegetation is an important habitat element, providing shading throughout the year. Riparian vegetation in the south west area is commonly composed of eucalypt, peppermints and paperbarks over sedges and rushes, a mixture that serves to contribute oily, tannin-rich leaves and twigs to the water column. As such, riparian vegetation is an important source of energy for the waterbody in the form of organic debris and leaf litter.

Snags and woody debris

Woody debris and snags are collectively described as large pieces of wood (branches, whole limbs, trees) that are either submerged, semi-submerged or exposed within a waterway. Large woody debris serves to alter and slow the flow of water, thereby creating a range of micro-habitats based on eddies and isolated still/turbulent zones generated by altered flow regimes. The presence of woody debris further increases the surface area of the river ecosystem, adding to woody habitat used by certain species for all or part of their life cycle.

Shade

The shading provided by riparian vegetation is a significant habitat element, lowering water temperatures and providing respite from the sun for many aquatic animals.

Aquatic vegetation

Plants that are submerged in, floating on or emerging from the water are classed as aquatic vegetation. Dense riparian tree canopies mean that such vegetation is scarce in south west rivers, with overhanging vegetation shading out aquatic plants. Where present, aquatic vegetation provides a specialist habitat for certain fauna.

Leaf litter

Leaf litter becomes a habitat element in areas of still or slightly flowing water, forming an important microhabitat for a range of aquatic organisms.

Rocks and stones

While not as dominant as vegetation in south west rivers, rock and stone also form an integral habitat element. The presence of rocks and stones in a waterway creates a range of microhabitats, limits the growth of vegetation over the water column, thereby aiding in light penetration, and helps in oxygenation of the water.

The catchment

Waterways do not exist as isolated ecosystems. It is important when considering river ecology to remember the influence of external processes on waterway function. In this sense, the characteristics of the surrounding catchment are important. Inorganic sediment, dissolved organic matter, vegetable matter, salt and nutrients are carried from the wider catchment, ultimately to the waterway. The processes of salinisation and eutrophication are testament to this process.

Useful references

Pen, L.J. (1999). *Managing Our Rivers: A Guide to the Nature and Management of the Streams of South-West Western Australia.* Water and Rivers Commission, Perth.

Water and Rivers Commission (2002b). *Stream and Catchment Hydrology.* Water and Rivers Commission, River Restoration Report No. RR19.

Water and Rivers Commission (2000a). *Floodplain Management*. Water Facts 14. Water and Rivers Commission, Perth.

Water and Rivers Commission (2000f). *Stream Ecology.* Water and Rivers Commission River Restoration Report No. RR7.

Water and Rivers Commission (2000h). *The Value of Large Woody Debris (Snags)*. Water Notes 9. Water and Rivers Commission, Perth.

4. Study Methodology

Community involvement

Involving the local community in the development of the river action plan is instrumental in gaining community support for the project as well as for ease of assessment. Owing to the fact the majority of landholders along the lower Warren River are absentee landholders, only one of the properties was assessed with the landholder. Other community members provided factual and historical information. Landholders were contacted before the foreshore surveys took place, to inform them of the purpose of the project and discuss specific management issues. Each landholder received a personalised site report based on the site assessment of their property, which detailed individual management issues and recommendations.

River foreshore condition assessment

The Pen-Scott method of riparian zone foreshore assessment was used to evaluate the condition of the lower Warren River foreshore. The Pen-Scott method is a standardised rating technique for classifying foreshore areas along a gradient from pristine (A grade) through to D grade, connoting a ditch. The four grades are further divided into three sub-categories per grade, i.e. A1, A2 and A3. A description of these grades follows and they are represented pictorially in Figure 2 (Pen & Scott, 1995). Indicative sites representing each grade along the Warren River are also included in the following pages (Figure 3).

A grade foreshore

A1: Pristine

The river embankments and/or channel are entirely vegetated with native species and there is no evidence of human presence, or livestock damage. This category, if it exists at all, would be found only in the middle of large conservation reserves where the impact of human activities has been negligible.

A2: Near pristine

Native vegetation dominates but introduced weeds are occasionally present in the understorey, though not to the extent that they displace native species. Otherwise there is no human impact. A river valley in this condition is likely to be the highest quality river found today.

A3: Slightly disturbed

Here there are areas of localised human disturbance where the soil may be exposed and weed density is relatively heavy, such as along walking or vehicle tracks. Otherwise, native plants dominate and would quickly regenerate in disturbed areas should human activity decline.

B grade foreshore

B1: Degraded – weed infested

In this stage, weeds have become a significant component of the understorey vegetation. Although native species remain dominant, a few have probably been replaced or are being replaced by weeds.

B2: Degraded – heavily weed infested

In the understorey, weeds are about as abundant as native species. The regeneration of some tree and large shrub species may have declined.

B3: Degraded – weed dominated

Weeds dominate the understorey, but many native species remain. Some tree and large shrub species may have declined or have disappeared.

C grade foreshore

C1: Erosion prone

While trees remain, possibly with some large shrubs or grass trees, the understorey consists entirely of weeds, mainly annual grasses. Most of the trees will be of only a few resilient or long-lived species and their regeneration will be mostly negligible. In this state, where the soil is supported by short-lived weeds, a small increase in physical disturbance will expose the soil and render the river valley vulnerable to serious erosion.

C2: Soil exposed

Here, the annual grasses and weeds have been removed through heavy livestock damage and grazing, or as a result of recreational activities. Low level soil erosion has begun, by the action of either wind or water.

C3: Eroded

Soil is being washed away from between tree roots, trees are being undermined and unsupported embankments are subsiding into the river valley.

D grade foreshore

D1: Ditch – eroding

Fringing vegetation no longer acts to control erosion. Some trees and shrubs remain and act to retard erosion in certain spots, but all are doomed to be undermined eventually.

D2: Ditch – freely eroding

No significant fringing vegetation remains and erosion is completely out of control. Undermined and subsided embankments are common, as are large sediment plumes along the river channel.

D3: Drain- weed dominated

The highly eroded river valley has been fenced off enabling colonisation by perennial weeds. The river has become a simple drain, similar if not identical to the typical major urban drain.

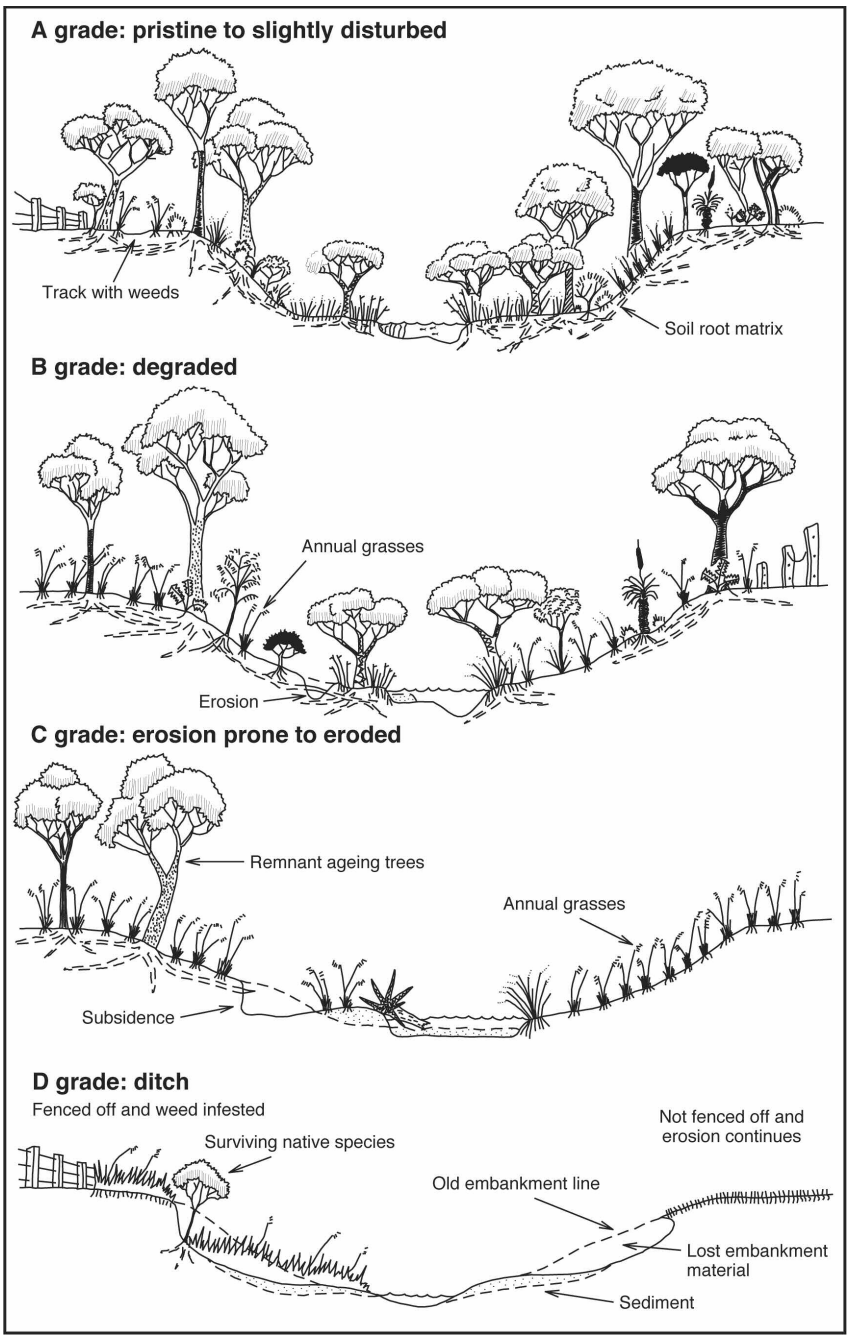

Figure 2: The four grades of river foreshore condition: A (pristine) to D (ditch) (after Pen & Scott, 1995)

A grade section

B grade section

C grade section

Natural bank cutting exposing underlying root systems

Figure 3: Foreshore condition of the lower Warren River (photos- Jenni Munro)

5. Management Issues

The lower Warren River area is varied in terms of landforms, soil types, past and current land use and livestock access. As such, there is a range of management issues pertinent to the area. These issues are presented below.

Loss of native riparian vegetation

Clearing of native riparian vegetation is not a major issue for the lower Warren River, as the majority of the river is within the D'Entrecasteaux National Park. Clearing is significant however in the wider Warren catchment, with predominantly heavily cleared areas located in the upper catchment. Clearing within the catchment is estimated at 35%, as previously noted. However, as the majority of the lower Warren River assessed passes through State Forest and D'Entrecasteaux National Park, the overall quality, quantity and diversity of riparian vegetation is extremely high and of excellent condition. The species composition changes as the river flows from the start of the survey to the mouth. Ecological disturbances arising from official fire management practices would also contribute to modifying the ecology and diversity of the area, affecting vegetation structure and water chemistry and quality within the lower Warren zone.

The emergent and terrestrial vegetation along the waterway banks essentially defines the riparian zone. The riparian zone serves several important ecological functions (CENRM 2004; Pen 1997; WRC 2000f):

- Woody debris provides both terrestrial and in-stream habitat. Riparian zones provide habitat for aquatic animals and food for native water birds and mammals;
- Acts as a corridor for fauna movements;
- Source of allochthonous (outside of stream) energy;
- Serves in bank stabilisation and aids in dissipating water velocity. The root systems of riparian vegetation increase and reinforce soil cohesion and provide matting to protect the soil from being transported downstream;
- Overhanging vegetation provides shade, influencing light penetration, which in turn lowers the water temperature. This action is beneficial in that high water temperatures act to decrease the level of dissolved oxygen content in waterways, which in certain circumstances can be harmful to aquatic flora and fauna; and
- Dense riparian vegetation acts as a buffer for pollution, sediments and nutrients which flow down the river, effectively stripping nutrients prior to entering the waterway. Grasses, rushes, sedges and shrubs are most effective at buffering.

Native vegetation also has a number of economic and social values, including eco-tourism potential, effects on property values, commercial products and recreation (LWRRDC, 1996). Clearing of riparian vegetation can have several far-reaching implications for a number of waterway processes. Clearing has altered the hydrological balance throughout the agricultural region of the south west: more rain filters into the soil, groundwater levels rise and streamflow (runoff) increases (WRC, 2002b). Bank stabilisation and erosion may become issues of concern, as may increased sediment loading in the waterway. Cleared sub-catchments upstream of major waterways are likely to contribute to high nutrient loads downstream (CENRM 2004; WRC 2002b).

Weed invasion

Several weed species of serious concern were identified during the foreshore surveys, predominantly blackberry *Rubus* sp. (both common and small leaf varieties), briar rose *Rosa rubiginosa*, golden dodder *Cuscuta campestris*, kangaroo apple *Solanum lanciniatum* and one-leaved cape tulip *Moraea flaccida*. Weeds are an issue for management as they compete with native vegetation, spread quickly and colonise new landscapes rapidly and with ease, preventing regeneration by native species. Blackberry and golden dodder pose the greatest threat to ecosystem health along the lower Warren River, occurring as dense infestations and being widespread along both banks for a significant proportion of the section surveyed. Blackberry in particular acts as a pioneer species which dominates disturbed and cleared areas.

Erosion and siltation

Natural, dynamic bank erosion processes occur freely on rivers and are evident along the length of the lower Warren River, where soils are sandy. The erosion process becomes exacerbated and cause for management

concern when supporting riparian vegetation is cleared and banks become further destabilised, leading to erosion and sedimentation downstream. As most of the erosion is a natural occurrence, bank cutting along the lower Warren River is not cause for significant concern, apart from areas where unrestricted stock access is compounding the erosion problem. Stock access to riparian zones also affects bank stability, vegetation cover and weed infestations and can enhance erosion concerns. For much of the section assessed, bank cutting is occurring on one side of the channel and deposition on the other, with the actual river channel being in a constant state of flux. Issues associated with erosion and subsequent siltation include loss of soil fertility, poor water quality, infilling of summer pools, increased channel width, further loss of native riparian vegetation, alteration of in-stream vegetation and flow dynamics, macroinvertebrate communities and the potential effects of reduced photosynthesis (WRC, 2000g).

Water quality

Water quality in the lower Warren River is generally high, due in large part to the limited proportion of the area that has been cleared and increased input of freshwater from rainfall in the lower catchment. As previously noted, continuous water monitoring has not been undertaken by the Department of Environment since the late 1970s; however, snapshot data from the periods 1999-2001 and 2001-2003 indicate that the Warren River has low nutrient and moderate turbidity levels. These water quality parameters may be impacted upon by a number of factors occurring in the Warren catchment, most notably further clearing of riparian vegetation, which can lead to increased erosion and bank destabilisation, in turn causing increased sedimentation and turbidity levels. Similarly, especially in the agricultural upper catchment, loss of riparian vegetation is cause for concern given that it allows free movement of excess nutrients into the waterway, increasing the possibility of nutrient enrichment, or eutrophication, and algal blooms. As noted, the Warren River catchment is one of the most dammed catchments in Western Australia. Of interest here is the increase in dam construction on Warren River tributaries within the upper catchment, which will have flow-on effects on water quality downstream.

Salinity

Stream salinity is caused in one of two ways: rising groundwater conveying salt to the surface, known as dryland salinity, or by the increased volumes of water carrying dissolved salts directly to waterways. The clearing of native, deep-rooted vegetation and replacement with shallow-rooted annual crops and pastures is a major cause of dryland salinity, with further risk factors being topography (i.e. flat, poorly drained land) and geology of the area (i.e. less permeable materials) (DoE 2004b; WRC 2000a). Stream salinity has steadily increased in many rivers over the last few decades. It is estimated that salinity has affected 80% of waterways in the south west region. Studies show that only 44% of streams analysed in the south west are still considered to be fresh (less than 500 mg/L Total Dissolved Solids, or TDS) (DoE 2004b; WRC 2000e). The Warren River is considered to be slightly brackish(between 1,500 mg/L and 5,000 mg/L) (DoE, 2004b) whereas the only tributary to enter the lower Warren River area surveyed, Dombakup Brook, is recorded as being fresh (Mayer et al., 2005). It should be noted that the Warren becomes very brackish with salinity levels of up to 5,000 mg/L after initial winter rains wash dryland salt into the waterway. This salinity load is diluted as the season progresses.

The effects of salinity on the landscape are serious. Saline water rising to the surface is harmful to both native vegetation and crops, disrupts soil structure and is unsuitable for stock or human consumption. In waterways, stream salinity increases, resulting in a change in associated ecosystem components, most notably replacement of native riparian vegetation with more salt-tolerant species. The effects of stream salinity are not localised and the repercussions of rising stream and dryland salinity may be evident for a long distance downstream from the initial salinised area (WRC, 2000e).

Sediment and nutrient retention

Nutrients such as nitrogen and phosphorus are naturally present in most waterways; anthropogenic sources include fertilisers, stormwater drainage and sewage. Problems occur when nutrient levels become elevated, as excess sediment and nutrient loading can be harmful to waterway health. Excess loading can be attributed to several processes, including clearing of

riparian vegetation, which leads to altered flow and in-stream vegetation dynamics, altered macroinvertebrate and fish communities, altered stream processes and infilling of natural riverine pools (WRC, 2000f). Excess nutrients in a waterway can cause eutrophication, leading to rapid growth of algae during optimum conditions. Death of algae may cause deoxygenation within the water column. A significant algal bloom of cyanobacteria, containing the gazetted toxic species *Microcystis* cf. *aeruginosa*, developed in 2004. Excess sediment can act to increase turbidity, reducing light attenuation, which in turn influences photosynthetic rates. Infilling of riverine pools may cause the loss of summer refugia for many aquatic fauna, and macroinvertebrate diversity is adversely affected by increased sedimentation levels which in turn has an impact upon fish community structure.

Pollution

Pollutants enter waterways either from point (localised) or diffuse (widespread) sources. Pollutants are often lethal or highly detrimental to aquatic life. Examples of waterway pollutants include excess nutrients, heavy metals, pesticides and herbicides. Arsenic sediments are known to occur in Lefroy Brook. Salt loads also constitute pollutants. Under the right circumstances, excess nutrient loading leads to increased growth of phytoplankton, macroalgae and submerged macrophytes. Algal blooms can cause deoxygenation, a condition that often causes loss of aquatic life (WRC, 2000f).

Stock access

Stock access to the lower Warren River is of concern, with free stock access possible along several landholder properties. In addition, much of the area was used historically as a cattle lease. In areas where stock access was historically or is currently possible, riverbank degradation is evident. No stock crossings were present. Problems associated with unrestricted stock access to waterways include damage to and loss of riparian vegetation, weed invasion, erosion, destabilisation and trampling of banks, compacted soil and poor water quality from faecal matter. The effects of stock access can be evident for many years after access has been restricted, and ongoing monitoring of fenced off areas is required to ensure that native vegetation is regenerating, weeds do not become established and erosion is not further exacerbated (WRC, 2000b).

Stock watering points

There were no dedicated stock watering points located on the lower Warren River; where present, stock were allowed free access to the river. This has had an adverse impact on bank stability, soil compaction and riparian vegetation in affected areas.

Landholder issues, interests and concerns

Landholders voiced several concerns regarding the lower Warren River, in relation to the spread of predominantly common, but also small leaf blackberry throughout the area. Blackberry plants have formed serious infestations in much of the area and landholders expressed frustration at what many consider to be a 'source and sink' scenario, with surrounding national park land harbouring blackberry populations. Other weeds of concern to landholders and government agencies along the river include one-leaved cape tulip, kangaroo apple, golden dodder, thistles, pennyroyal mint and purple groundsel. With the exception of the blackberry and golden dodder, which is present along a significant proportion of the study area, these weeds are not yet firmly established along the river and it is imperative to control their spread before it escalates.

6. Management Advice

In river management, priority is given to areas in best condition; attention is then given to areas showing promise of recovery and lastly, to degraded areas. This approach is cost-effective and beneficial to the entire river ecosystem as it is much more efficient to conserve better quality river areas than it is to restore degraded ones. There are a number of ways in which the health and overall integrity of river systems can be enhanced and maintained. How much emphasis is placed on each component is a function of the expected outcomes for that river or reach, i.e. revegetation of the riparian zone, improved water quality etc. Information was sourced from a variety of publications, details of which can be found at the end of the section. Further information on publications relating to this section can be found in the Greening Australia publication *Bush Tracks: Shortcuts to Vegetation Information for Natural Resource Management* (2004).

Protection and rehabilitation of native riparian vegetation

The riparian zone is a very important component of the river ecosystem. Obviously, it makes sense in terms of both finance and labour to conserve and protect existing riparian vegetation rather than to have to revegetate cleared areas. Limiting unnecessary access into the riparian zone is recommended, using fencing as required. Restricting access to the riparian zone will act to minimise damage from disturbance and allow natural regeneration to occur. It is important however to effect weed control and ensure stock access is controlled as fenced off areas are prone to weed invasion and stock access will undermine revegetation efforts. Natural regeneration will occur in areas where native trees and a healthy understorey remain. One technique for aiding natural regeneration is known as brushing, which constitutes laying seed-bearing parts of native flora directly onto the ground in revegetation sites, thereby allowing seeds to fall from the plant and germinate in the soil. This technique is appropriate for all habitats apart from the channel zone. However, for many stretches of river, riparian vegetation has been irreversibly damaged or lost, replaced by bare banks or dominated by invasive weeds. In these cases, it is necessary to revegetate the area back to its original state.

Revegetation of an area is commonly employed to achieve erosion control, enhance biodiversity, improve water quality and aid in rehabilitating saline-affected land, apart from inherent aesthetic and recreational benefits (WRC, 1999). Rehabilitation advice varies with each individual case and it is recommended that local environmental agencies and groups are contacted for advice; however some general rules apply when attempting to rebuild the area:

- Try and get a good understanding of the river system and determine the vegetation present before the damage occurred;
- Attempt to treat the cause of the problem, not just the symptoms;
- As mentioned, focus on rehabilitating or protecting areas of better quality before more degraded areas; and
- Weeds should be removed and replaced with native vegetation. In some cases however, it may be necessary to initially colonise an area with weeds to provide stabilisation and then introduce native species.

Site preparation is an essential precursor to revegetating a site. Preparation of the site involves adequately protecting the area to be revegetated, undertaking weed control and preparing the soil surface (e.g. ripping/mounding) prior to planting. Appropriate planting/seeding regimes will also have an effect on the success of revegetation. Ongoing monitoring of weeds is an integral part of the process, as weeds are quick to colonise disturbed habitats and compete with native plants for nutrients and water. There are a number of common revegetation techniques, including brushing (as above), direct seeding, planting of seedlings, pre-seeded matting and in certain cases, transplanting. These are described in more detail below.

Direct seeding

Direct seeding involves the sowing of native seed onto a prepared site. Relatively low cost, it allows for the establishment of a wide diversity of species for less labour investment than is involved in planting tube stock. Direct seeding can be less reliable than other methods due to specific germination requirements not being met and predation of seed. A very high investment in weed and pest control is also required. Direct seeding is best for floodplain and upland zones but is not recommended for embankments. On embankments, it is necessary to use matting or scallops, due to loss of seed from soil and water erosion.

Planting of seedlings

Planting of seedlings is appropriate for in-stream and embankment revegetation, as well as for areas unsuitable for direct seeding. Planting should be restricted to local endemic species, and a 500:50:5 planting density for herb/sedges to shrubs and trees should be followed. Planting within the channel and along the lower embankment should be undertaken in spring, whereas other areas are best planted in autumn.

Pre-seeded matting

This technique involves spreading seeds onto an appropriate fibremulch and then laying the mat on-site after germination in early winter. As this technique is effective in both revegetation and erosion control, it is appropriate for steep embankments. Matting usually requires rolling for transport to the revegetation site and hence is suitable for sedges and rushes only, unless matting is transported to the site before seeding, in which case any species may be used.

Transplanting

Transplanting becomes a viable revegetation option in instances where either an appropriate donor site is available or where engineering works require the removal of plants that can be transplanted at a later date to the restored site. Caution must be exercised so as not to transfer weed propagules or soil-borne diseases such as dieback. As a result, the process is labour intensive and costly. Transplanting is most effective for species with fairly shallow root systems and vegetative growth (e.g. sedges and rushes), and should be undertaken in winter to early spring.

Species composition

Species composition is an important part of any revegetation scheme. Composition of vegetation varies with topography and soil characteristics and the choice of species to be used in revegetation should be based upon those native species local to the area or botanic province (local provenance). Apart from matching revegetation species to soil type and hydrological requirements, other factors to consider may include commercial agriculture or floriculture considerations. A suggested list of appropriate species is given in Appendix 1 and further information can be obtained from agencies and groups including Southern Forests Landcare, DAFWA, DEC and Greening Australia (WA).

Useful references for revegetation and rehabilitation

Pen, L. (1999). *Managing Our Rivers: A Guide to the Nature and Management of the Streams of South-West Western Australia*. Water and Rivers Commission, Perth.

Water and Rivers Commission (2001b). *Using Sedges and Rushes in Revegetation of Wetland Areas in the South West of Western Australia*. Water and Rivers Commission, River Restoration Report No. RR 8.

Water and Rivers Commission (1999). *Revegetation: Revegetating Riparian Zones in South-West Western Australia*. Water and Rivers Commission River Restoration Report No. RR4.

Water and Rivers Commission (1997b). *Native Vegetation of Freshwater Rivers and Creeks in South Western Australia*. Water and Rivers Commission, Perth.

Weed control

Weeds are simply plant species that are able to take advantage of certain, usually human induced, conditions to regenerate at the expense of native flora. Furthermore, most weed species reproduce by highly viable seed, vegetative propagule, or both, which can make them very difficult to eradicate. As mentioned, follow up revegetation and monitoring is a crucial component of any weed control program. It is important to note that many weeds thrive on disturbance and are favoured by fire, and some native species may act in ways similar to weed species.

Weed invasion along the lower Warren River and within the catchment is a problem of increasing concern. For management purposes, weeds can be divided into three groups: true aquatic weeds, garden escapees and annual pasture species. It is important to correctly identify your weed and gain an understanding of its biology. Management of annual weeds is in many cases limited to preliminary spraying, while removal or poisoning of garden escapees is necessary to control their growth in the riparian zone. Most major tree, shrub, vine, bulbous, herb and tall grass weeds are classed as garden escapees. As the effort required to remove them is intensive, the emphasis should lie on prevention rather than cure of the problem, necessitating constant vigilance to avoid major infestations becoming established. A further problem in the removal of some garden escapees is that

the weed species may actually be supporting bank stability, and their removal would result in destabilisation. This situation highlights the necessity of always undertaking weed removal in conjunction with revegetation or stabilisation works. True aquatic weeds are less prevalent as major infestations but the consequences can be far more severe.

A coordinated and integrated approach is required to deal with invasive weed species, such as blackberry, cape tulip, pennyroyal and golden dodder present along the lower Warren River. Some information on weeds designated as priority species along the lower Warren River is given below. The weeds are classified by the Department of Agriculture as either declared plants or pest plants, both of which mean the species in question is both serious and invasive, and in need of immediate control and eradication. Declared plants are under the APB (Agricultural Protection Board) legislation and landholders are obligated to control the plant on their property. Pest plants are not included in the legislation, meaning that there is no legal obligation for the plant to be eradicated.

Common blackberry *Rubus anglocandicans*

Weed of national significance[4] and declared plant. Perennial, originally introduced from both Europe and America as a fruit crop. Spread by birds, other animals and vegetatively. Flowers white, sometime with a pink tinge in bud. Found intermittently but mostly in dense infestations along the length of the lower Warren River, although not yet in the lower reaches of the river. Manual control is possible if spread is localised, but larger infestations typically require chemical treatment. Regrowth can be treated with appropriate chemicals when plants are actively growing and before seed set; follow up treatment is usually necessary. Biological rust fungus is also in use; for further details contact Southern Forests Landcare.

Small leaf blackberry *Rubus ulmifolius*

As above; differs from common blackberry in that flowers are always pink. Found in dense thickets for approximately the first 6 km of the river surveyed, in isolated patches thereafter. Control methods are as for common blackberry; however small leaf blackberry is less susceptible to the biological rust fungus.

Golden dodder *Cuscuta campestris* spp.

Declared plant. Parasitic twining vine, grows on host plants. Native to North America. Located as infestations along much of the lower Warren River. Manual control of the golden dodder is not recommended as it is highly likely to spread the dodder further. Control involves removing the host plant/s for 3-5 years and revegetating with species that are not susceptible to attack by the dodder, e.g. grass or woody species. It is also important to control broadleaf weeds in these areas. If revegetation of controlled areas is not possible, then chemical control is an option although this also needs to be repeated annually for a period of 5 years.

One-leaved Cape tulip *Moraea flaccida*

Declared plant. Herb, short-lived pink to orange flowers. Native to South Africa. Located in small patches and scattered across selected areas of the lower Warren. Manual control difficult due to dormant corms in the soil; dig up the soil surrounding the plants, remove the plant and incinerate or soak with diesel. Chemical control is recommended, although care needs to be taken when dealing with sensitive riparian areas. A weed wiper as opposed to sprayer is suitable in these instances. Control will take several years and annual follow up is crucial. Control chemically in late winter to spring.

Briar rose *Rosa rubiginosa*

Shrub, native to Europe and western Asia. Spread by seeds, mostly by birds, foxes and water.
Flowers fragrant, late spring to summer. Established plants can be removed manually, taking care to remove all roots. Cutting or slashing is not effective as regrowth will occur from crowns and rootstock. Large infestations should be ploughed deeply, after mechanical removal of larger bushes, to bring roots to the surface for raking and burning. Follow up with further cultivation and pasture improvement or the planting of a crop. Dense pasture cover and stock grazing with goats and sheep restricts seedling establishment. Chemical control possible.

[4]Signifies that the weed has been identified as causing significant environmental damage in Australia. There are twenty weeds of national significance recognised in Australia.

Kangaroo apple *Solanum laciniatum*

Native to eastern Australia. Shrub, yellow to orange-yellow egg shaped berries. Sometimes confused with similar native species (to distinguish from the weed species, native species berries are green tinged with purple, black when ripe). Hand pull seedlings and young plants, grazing and mowing also provide control. Chemical control possible while plants are actively growing.

Pennyroyal *Mentha pulegium*

Native to western Asia. Perennial herb, highly aromatic (mint). Commonly naturalised on wet flats in agricultural areas. Flowers blue, purple, pink, spring to autumn. The oil is toxic/dangerous to humans and dogs and has been known to cause breathing problems in stock. Manual control very difficult. Chemical control possible when actively growing over summer, at the end of flowering. Important to control upstream infestations and recify drainage problems.

Thistle *Carduus sp.*

Native to Europe, Asia and North Africa. Several species have naturalised in WA. Small growths can be mechanically removed, before seed set. Chemical control is also an option, provided application occurs before flowering, during a phase of active plant growth.

As the weed species in question are located near water systems, physical control is the preferred method of removal, however the size of infestation and growth habit may make this option unviable. Chemical control should then be considered, subject to a number of provisions. Of importance are the possible effects of the chemical on native flora and fauna as well as on water quality. There are a few guiding principles to follow when using herbicides, namely:

- Always read the label and stick to the recommend usage;
- If possible try and spray the plants when the water table is low, as the herbicide will have a smaller chance of contaminating the water table;
- For optimal effectiveness, ensure that the plant is sprayed before seeds have set;
- It may be useful to mix coloured food dye into the spray as this will allow you to monitor progress;
- Where possible and appropriate inject the herbicide into the lower trunk to prevent runoff;
- Do not spray on windy or rainy days, as this will decrease the effectiveness and target accuracy of the chemical;
- Once the plant has died, remove and burn it to prevent any seed spread; and
- If unsure contact DAFWA.

For further information on weeds and their control, agencies and groups such as Southern Forests Landcare, DEC and the DAFWA may be contacted.

Useful references on weeds and weed control

Brown, K. and Brooks, K. (2002). *Bushland Weeds: A Practical Guide to Their Management*. Environmental Weeds Action Network (Inc.), Greenwood, Australia.

CSIRO (2006) (online). *Weedy blackberry and raspberry species in Western Australia and strategies for their management*. Unpublished report submitted to the Department of Agriculture, Fisheries and Forestry. Available World Wide Web: http://www.ento.csiro.au/weeds/blackberry/WABBManPlan2006_draft.pdf

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Moore, J. and Wheeler, J. (2002). *Southern Weeds and Their Control*. Department of Agriculture, Perth.

Water and Rivers Commission (2000i). *Weeds in Waterways*. Water Notes 15. Water and Rivers Commission, Perth.

Weeds Australia (undated) (online). *Weeds Australia*. Available World Wide Web: http://www.weeds.org.au.

Water quality

Any waterway in an agricultural catchment is potentially subject to elevated nutrient levels and increased sedimentation as a result of farming activities, impacting on water quality. As noted, water quality

within the lower Warren River does not currently pose a significant management issue, with salinity levels stabilising. However, the following techniques will help to maintain the current quality, avoiding the necessity of management intervention at a later stage.

Management of water quality can be achieved in a number of ways, including maintenance of vegetative buffers and appropriate agricultural practices. Maintaining a vegetative buffer between the waterway and surrounding land is beneficial in that the vegetation effectively acts as a biological filter, intercepting and trapping nutrients and sediment before they enter the river. Even a buffer of grass can be effective in areas where foreshore vegetation has been lost, and aquatic vegetation also serves in nutrient and sediment trapping. Agricultural practices in the surrounding catchment have a large bearing on the subsequent amount of sediment and nutrients transported into a waterway. Appropriate practices can reduce the amount of soil erosion and ensure adequate vegetative buffers are maintained. Cultivating along rather than perpendicular to soil contours will help to reduce soil erosion, as will fencing to keep stock away from waterways.

A snapshot biological survey is being conducted by Southern Forests Landcare in the lower Warren catchment to gain a better understanding of water quality issues. Parameters including dissolved oxygen, pH, turbidity, salinity, total nitrogen and phosphorus, colour, macroinvertebrates, phytoplankton, nitrates and nitrites will be tested. This data will enable comparisons to be made over time on the water quality of the river, and management actions to be decided accordingly.

Useful references on water quality

Pen, L. (1999). *Managing Our Rivers: A Guide to the Nature and Management of the Streams of South-West Western Australia*. Water and Rivers Commission, Perth.

Prosser, I., Karssies, L., Ogden, R. and Hairsine, P. (1999). Using buffers to reduce sediment and nutrient delivery to streams. *Riparian Land Management Technical Guidelines Volume Two: On-ground Management Tools and Techniques*. Price, P. and Lovett, S. (eds.), LWRRDC, Canberra.

Rose, B. (2002). *Best Environmental Management Practices for Environmentally Sustainable Vegetable and Potato Production in Western Australia: A Reference Manual*. Potato Growers Association of WA, Inc., Perth.

Water and River Commission (2001b). W*ater Quality and macroinvertebrates*. Water Facts 2. Water and Rivers Commission, Perth.

Stock control

Unrestricted stock access has a number of detrimental effects, such as impeding flora regeneration and compacting soil, increasing erosion and bank destabilisation, transportation of weeds and grazing and trampling of vegetation. Limiting access of stock to waterways is an extremely important management practice in waterway restoration and rehabilitation, achieved by fencing of riparian zones. However the idea of fencing is often negatively received by landholders. Fencing off the riparian zone is contentious for a number of reasons, mainly that the riparian zone often represents good grazing potential, fencing is an expensive undertaking and management of the fenced off area will often require intensive weed control efforts.

Fencing off the riparian zone does not have to be absolute; the quantity of land from which stock are excluded will depend on management objectives. If the aim of fencing is to protect high quality riparian vegetation to maintain habitat, landscape and ecological corridors, all stock should be excluded. However, if the riparian zone has a history of grazing and stock exclusion could lead to the proliferation of weeds and a fire hazard, allowing access for seasonal grazing is beneficial. Fences in this instance are used to control the level of grazing so that the dominant native vegetation is able to regenerate. Considerations when planning fence location include the form of the river, presence of riparian vegetation and frequent flood levels, in addition to land tenure and cadastral boundaries. Correct fence placement in relation to river valleys is illustrated in Figure 4.

Rehabilitation of old or ineffective stock watering points, which are devoid of vegetation and have compacted soil, may include soil amelioration, such as ripping prior to covering with matting to control erosion, or brushing to assist regeneration. Protection of the regenerating vegetation from predation may be required.

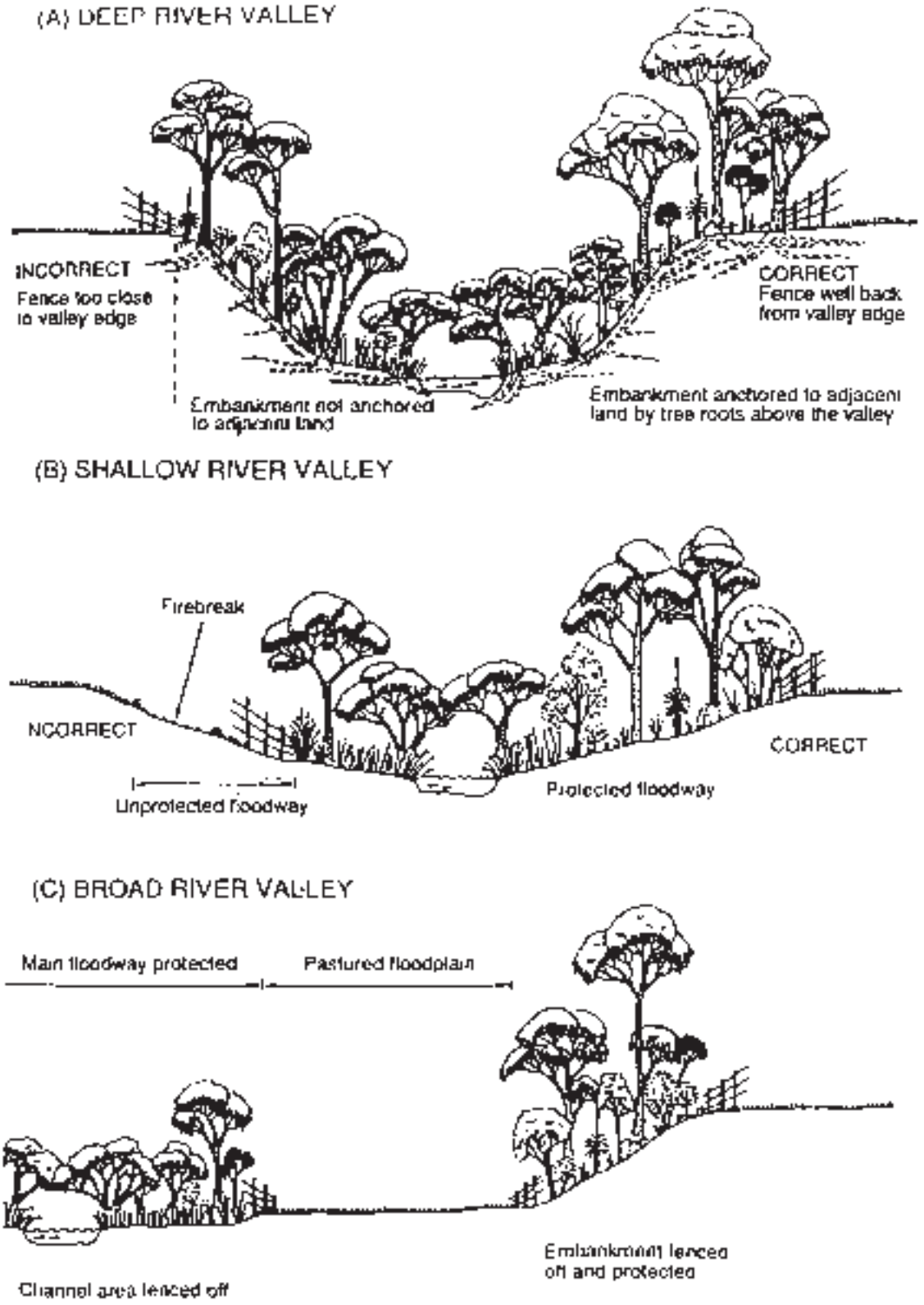


Figure 4: Placement of fences in relation to the river valley

Useful references on stock control

Pen, L. (1999). *Managing Our Rivers: A Guide to the Nature and Management of the Streams of South-West Western Australia*. Water and Rivers Commission, Perth.

Water and Rivers Commission (2000b). *Livestock Management: Construction of Livestock Crossings*. Water Note 6. Water and Rivers Commission, Perth.

Water and Rivers Commission (2000c). *Livestock Management: Fence Location and Grazing Control*. Water Note 18. Water and Rivers Commission, Perth.

Water and Rivers Commission (2000d). *Livestock Management: Watering Points and Pumps*. Water Note 7. Water and Rivers Commission, Perth.

Feral animals

Feral animals located within the lower Warren River catchment include foxes, rabbits, cats and pigs (see also Table 6). Invasive species cause management problems in that they compete with native species for habitat and resources. Feral pigs have been sighted in the nearby area and are likely to be found in the lower Warren River area. The presence of feral pigs is of concern, given evidence of the damage they can inflict on riparian areas. A large scale control program is recommended to minimise damage from the animals to the lower Warren River area. A coordinated approach to feral animal control is necessary for optimal effectiveness. Advice on feral animal control can be obtained from Southern Forests Landcare, DEC (formerly CALM) or DAFWA.

Erosion control

There are areas of potential concern along the lower Warren River where natural and dynamic erosion processes have become exacerbated. The lower Warren has a sandy soil substrate, making the banks more prone to erosion and slumping than heavier soils. Although much of the river retains a dense and supportive riparian zone, bank erosion is still significant and intensified in areas of stock access. Revegetation of unstable banks is the easiest way to combat erosion; however engineering solutions involving modification of channel flow may be necessary if revegetation proves inadequate. If deemed necessary, site-specific advice and relevant legal approvals should be obtained prior to instigating any physical modification works on a river and it is important to remember that a detailed river geometry survey and variety of calculations are normally required for the correct design of restorative engineering works. As any engineering works attempted will usually be on a larger scale, it is recommended that landholders approach the relevant authorities (e.g. DEC, DoW, Southern Forests Landcare, Department of Indigenous Affairs) for assistance and notify them of issues which are under their jurisdiction to determine. These agencies and groups can also be approached for general advice and expertise to aid in solving specific problems that may be encountered.

Large woody debris also known as snags, fulfills an important role in river ecology and is an integral and natural part of river systems. In the past, management practice has involved removing large woody debris from the water in instances where it may be diverting water flow onto the bank and subsequently causing erosion in vulnerable areas. Preferred management practice is to leave the greatest amount of large woody debris possible in situ, to provide habitat for aquatic flora and fauna. Large woody debris, instead of being removed, should be repositioned at an angle 20°-40° to the stream bank, which will diminish the effect on water flows and direction while maintaining habitat. Large woody debris can also be added to a river system to redirect flows from unstable areas.

Rocks can also help in the stabilisation of river dynamics and ecology. Rocks should be left in situ or in the case of restoration be placed to help provide habitat, decrease high flow impacts, increase oxygen levels and to stabilise eroded zones.

Of note here is the existence of marram grass Ammophila arenaria in the lower reaches of the Warren River. First introduced to Western Australia in 1982, from South Africa, marram grass is native to Europe. The grass was planted extensively throughout the lower Warren River area in an attempt to stabilise shifting sand dunes, which authorities were concerned would eventually impede the natural course of the river. The first plantings of marram grass occurred in 1916, on the Callcup dunes south of the river (White, 1972).

Useful references on erosion control

Pen, L. (1999). *Managing Our Rivers: A Guide to the Nature and Management of the Streams of South-West Western Australia*. Water and Rivers Commission, Perth.

Raine, A.W. and Gardiner, J.N. (1995). *Rivercare-Guidelines for Ecologically Sustainable Management of Rivers and Riparian Vegetation*. Land and Water Research and Development Corporation, Canberra.

Rose, B. (2002). *Best Environmental Management Practices for Environmentally Sustainable Vegetable and Potato Production in Western Australia: A Reference Manual*. Potato Growers Association of WA, Inc., Perth.

Water and Rivers Commission (2001). *Stream Stabilisation*. River Restoration Report No. RR 10. Water and Rivers Commission, Perth.

General recommendations

It is recommended that landholders along the lower Warren River consider:

- Controlling and managing weed species found on their properties;
- Prioritising the protection of their riparian land, protecting the river foreshore and restricting stock access by fencing the riparian zone to restrict or exclude stock permanently, utilising available funding to help minimise costs; and
- Rehabilitating their riparian zone by revegetation.

It is recommended that Southern Forests Landcare consider:

Weed control

- Encouraging an integrated community approach to weed control along the lower Warren River. Work cooperatively with other relevant agencies and departments, e.g. DEC, DAFWA, Shire of Manjimup and landholders to develop and implement a coordinated weed control strategy;
- Monitoring the occurrence of both common and small leaf blackberry along the length of the river. Target common blackberry growths for biological control (rust release) over the course of a number of years, with continued monitoring to prevent re-establishment in controlled areas along the river. Target isolated growths for chemical control; and
- Mapping, monitoring and implementing control regimes for other weeds along the lower Warren, e.g. cape tulip, golden dodder, kangaroo apple, briar rose, purple groundsel.

DEC and Shire managed land

- Liaising with DEC to coordinate and improve weed control and management of foreshore reserves vested with DEC; and
- Liaising with DEC and DoW to support water quality improvement projects both locally and in the upper catchment. Liaise with existing programs to reduce aquatic weed infestations.

Fencing and revegetation

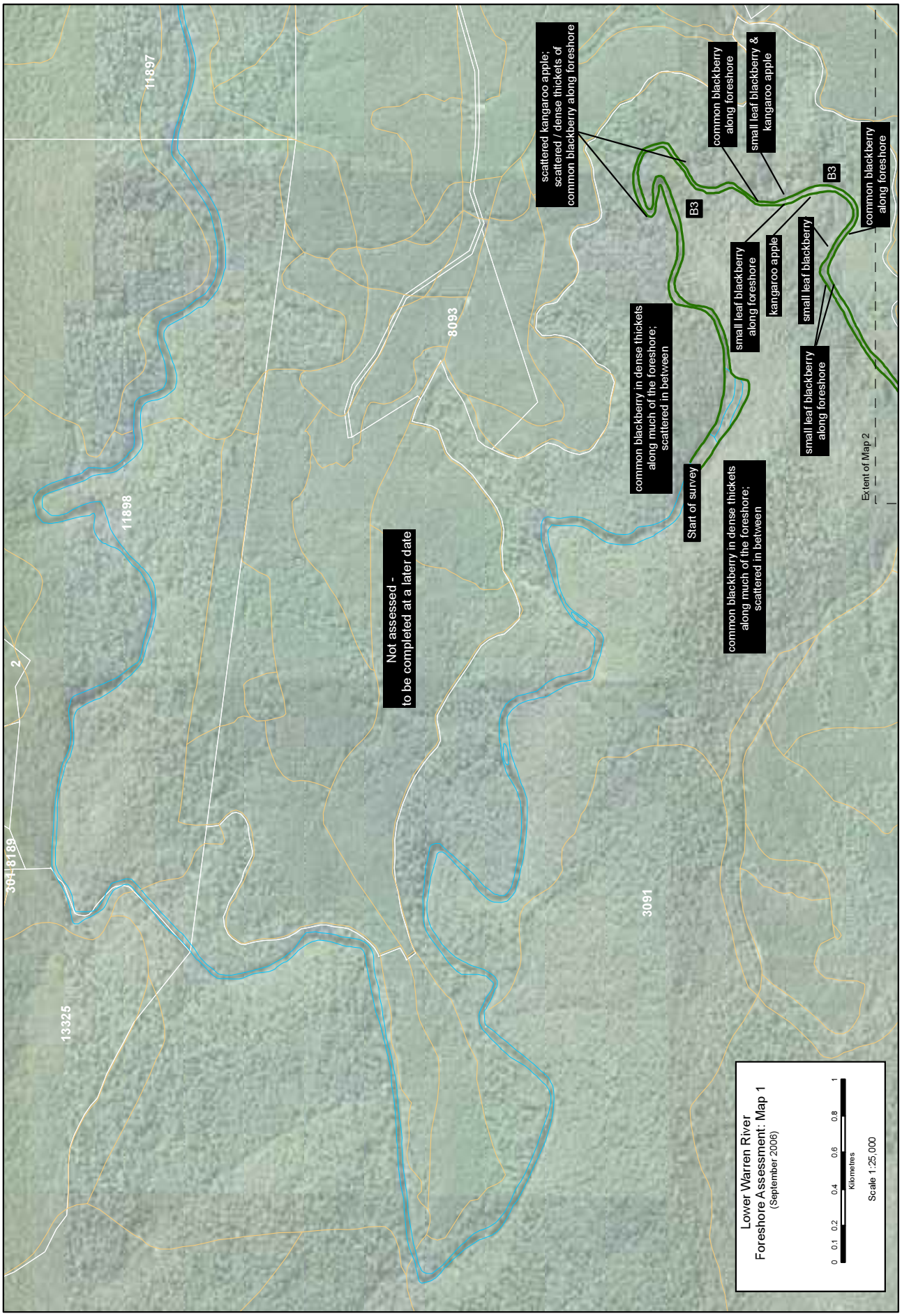
- Actively supporting and encouraging landholders/community groups to fence off areas of the river where stock access is possible and assisting with related funding applications; and
- Providing support and encouragement to landholders undertaking revegetation, using local provenance seedlings.

7. River Foreshore Condition and Recommendations for Management

Overview

The lower Warren River as represented on Figure 1 has been divided into four sections for the purposes of reporting and surveying. The information following should be considered along with Figure 1 and Maps 1- 4 for spatial reference and clarity. The summarised information includes foreshore condition ratings for the lower Warren River, information on land use, erosion and prevalent weeds, stock access and recommended management advice to address any issues of concern. The information was current at the time of assessment and initial mapping of weed species has been completed.

Southern Forests Landcare bases all information in this section upon personal site observations, interactions with landholders and supplementary weed presence information from the DAFWA. All foreshore assessments took place from August to September 2006, with the majority of sections assessed by canoe. Some landholder properties were also assessed with the landholder. Management advice and recommendations contained in this report are offered as an indicative guide only. Implementation of any recommendations would be entirely voluntary and represent a cooperative effort between interested landholders and Southern Forests Landcare. However, while this section contains recommendations only, implementation of the management advice is strongly recommended.



Lower Warren River Map 1

Map 1

The lower Warren River as covered by Map 1 runs through the Greater Hawke National Park, covering approximately 4.5 km, upstream from Larkin Road Bridge to the first set of rapids. The remainder of the river as depicted in Map 1 was not assessed in this study. The entire stretch is dominated by extensive thickets of both common and small leaf blackberry, though common blackberry dominates. Scattered kangaroo apples and thistles are located throughout the stretch.

Common native flora species noted along the stretch include: flooded gum *Eucalyptus rudis*, Warren River cedar (wattie) *Taxandria juniperina*, swamp willow (wonnich) *Callistachys lanceolatum*, river banksia *Banksia semindua*, albizia *Paraserianthes lophantha*, Western Australian peppermint *Agonis flexuosa*, karri sheoak *Allocasuarina decussata*, karri hazel *Trymalium floribundum*, sword sedges *Lepidosperma* sp., rushes *Juncus* and *Baumea* sp., *Billardiera floribunda*, karri *Eucalyptus diversicolor*, tassleflower *Leucopogon verticillatus*, *Astartea fasicularis*, mohan *Melaleuca viminea*, bracken *Pteridium escalatum*, swamp peppermint *Taxandria linearfolia*, clematis *Clematis aristata*, blackbutt *Eucalyptus patens*, dungyn *Hakea oleifolia*, zamia *Macrozamia reidlei* and weeping grass *Microlaenea stipoides*.

Summary Information	
Location/lot numbers of adjacent properties	National Park
Foreshore condition rating (as at Oct 2006)	B3 100%
Vegetation cover & health	Immediate foreshore area dominated by common and small leaf blackberry thickets. Beyond infestations, densely vegetated with native species, excellent vegetation health and diversity
Land use	Warren State Forest/ Greater Hawke National Park

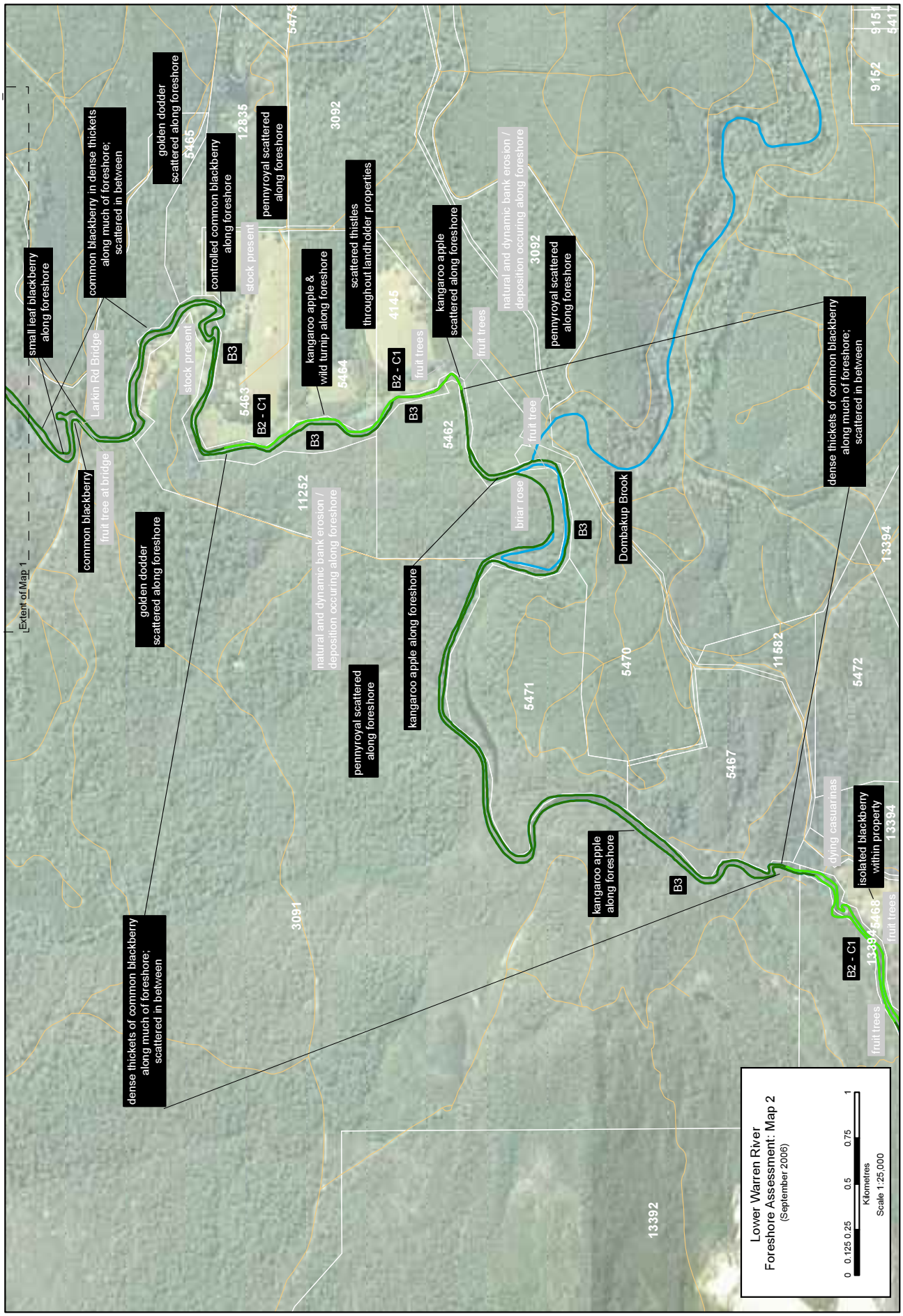
Issues	Comments
General foreshore condition	Channel width approx. 20-30 m. Riparian area dominated by thickets of common and small leaf blackberry which have excluded native vegetation; beyond this, a diverse and regenerative native vegetation assemblage exists. In-stream vegetation and large woody debris present
Fencing	Entire section is unfenced. No stock present, although the area is an historical cattle lease
Erosion/bank stability	Dynamic, natural channel erosion and deposition processes occurring along length of foreshore with sandy banks in some areas exacerbating cutting and active erosion. Historical stock access may also have contributed
Weeds	Serious common and small leaf blackberry infestations dominate both banks for the majority of the section. Weed density has excluded native vegetation growth on the immediate foreshore areas. Isolated kangaroo apples, thistles
Other comments	~ 90 % death of blackberry growths owing to previous blackberry biocontrol rust release. Access difficult

Prioritised management actions recommended

1. Release blackberry biocontrol rust fungi into common blackberry infestations as soon as available
2. Target isolated kangaroo apples for control/ removal

Long term management actions recommended

1. Monitor effect of blackberry biocontrol rust and further spread of common and small leaf blackberry
2. Monitor emergence and spread of other weed species



Lower Warren River Map 2

Map 2

Map 2 follows the river south from Larkin Road Bridge past the first few landholder properties, covering approximately 8.5 km. Again, the section is dominated by common blackberry thickets; golden dodder also becomes significant throughout the stretch. The area has sandy soils; dynamic channel erosion and deposition processes are freely occurring along the foreshore. Stock is present on two of the landholder properties, with free access to the foreshore which is contributing in some areas to bank destabilisation. Historical stock access occurred throughout the wider area.

Weed species in the section include common blackberry and golden dodder, which occur along much of the foreshore, as well as kangaroo apple, fruit trees, briar rose, pennyroyal and scattered thistles/ wild turnip. Common flora species throughout the section include: ropebush (banjine) *Pimelia clavata*, swamp paperbark *Melaleuca raphiophylla*, flooded gum *Eucalyptus rudis*, Warren River cedar (wattie) *Taxandria juniperina*, river banksia *Banksia semindua*, swamp willow (wonnich) *Callistachys lanceolata*, albizia *Paraserianthes lophantha*, Western Australian peppermint *Agonis flexuosa*, karri *Eucalyptus diversicolor*, karri sheoak *Allocasuarina decussata*, karri hazel *Trymalium floribundum*, sword sedges *Lepidosperma* sp., rushes *Juncus*, *Baumea* and *Isolepis* sp., dungyn *Hakea oleifolia*, grass tree *Xanthorrhoea preissii*, *Billardiera floribunda*, marri *Corymbia callophylla*, tassleflower *Leucopogon verticillatus*, *Astartea fasicularis*, mohan *Melaleuca viminea*, native maidenhair *Adiantum aethiopicum*, bracken *Pteridium escalatum*, swamp peppermint *Taxandria linearfolia*, native wisteria *Hardenbergia comptoniana*, clematis *Clematis aristata*, blackbutt *Eucalyptus patens*, zamia *Macrozamia reidlei*, weeping grass *Microlaenea stipoides* and kangaroo paw *Anigozanthos* spp.

Summary Information	
Location/lot numbers of adjacent properties	National park, NL 12835, NL 5463, NL 11252, NL 5464, NL 4145, NL 5462
Foreshore condition rating (as at Oct 2006)	B3 64 % B2-C1 36 %
Vegetation cover & health	Densely vegetated with native species, excellent health. Immediate foreshore area dominated by common blackberry thickets. Golden dodder also present
Land use	Private property, stock grazing, Greater Hawke/ D'Entrecasteaux National Park, Dombakup Nature Reserve

Issues	Comments
General foreshore condition	Channel width approx. 20 – 40 m. Riparian area dominated by thickets of common blackberry which have excluded native vegetation; beyond this, a diverse and regenerative native vegetation assemblage exists. In-stream vegetation and large woody debris present
Fencing	Discrete parts of landholder foreshore fenced, but essentially unrestricted stock access
Erosion/bank stability	Dynamic and natural channel erosion/ deposition processes occurring along length of foreshore. Sandy banks and historical/ current stock access in some areas exacerbating cutting and erosion
Weeds	Serious common blackberry infestations dominate both banks for the majority of the section. Weed density has excluded native vegetation growth on the immediate foreshore areas. Cleared parts of landholder properties predominantly blackberry-free. Golden dodder present along majority of foreshore area. Scattered kangaroo apples, thistles, wild turnip and pennyroyal; isolated briar rose, fruit trees. Willow trees present in-stream
Other comments	Access restricted

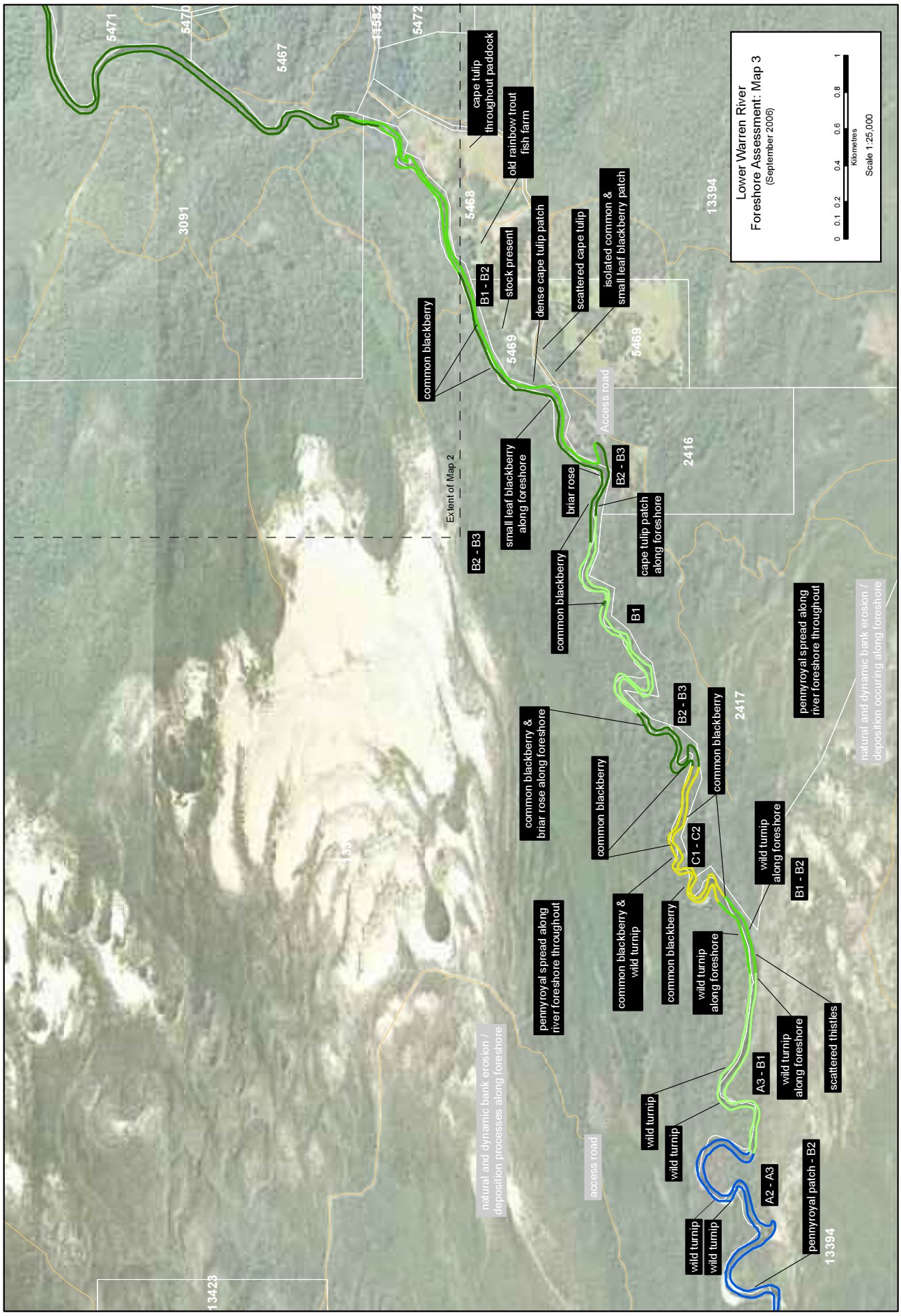
Prioritised management actions recommended
1. Release blackberry biocontrol rust fungi as soon as available
2. Remove willow trees from in-stream
3. Target isolated kangaroo apples for control/ removal
Long term management actions recommended
1. Monitor effect of blackberry biocontrol rust and further spread of common and small leaf blackberry
2. Monitor spread of golden dodder
3. Monitor emergence and spread of other weed species

Map 3

Map 3 covers approximately 8 km, from just above the second set of landholder properties in a south westerly direction towards the river mouth. The section includes three landholder properties; the remainder is within the Greater Hawke and D'Entrecasteaux National Parks. The area has sandy soils. Dynamic, natural channel erosion and deposition processes are freely occurring along the foreshore. Stock is present on two of the landholder properties, with free access to the foreshore which is contributing to bank destabilisation in some areas. Previous stock access in the form of coastal cattle leases occurred throughout the wider area. The section contains a disused rainbow trout fish farm, which was in operation from 1990-1998.

The section has scattered thickets of common blackberry and golden dodder, which occur along much of the foreshore, as well as one-leaved cape tulip, fruit trees, briar rose, pennyroyal and scattered thistles and wild turnip. Common flora species throughout the section include: ropebush (banjine) *Pimelia clavata*, swamp paperbark *Melaleuca raphiophylla*, Warren River cedar (wattie) *Taxandria juniperina*, river banksia *Banksia seminuda*, Western Australian peppermint *Agonis flexuosa*, karri *Eucalyptus diversicolor*, karri sheoak *Allocasuarina decussata*, sword sedges *Lepidosperma* sp., rushes *Juncus*, *Baumea* and *Isolepis* sp., dungyn *Hakea oleifolia*, *Billardiera floribunda*, marri *Corymbia callophylla*, tassleflower *Leucopogon verticillatus*, *Astartea fasicularis*, mohan *Melaleuca viminea*, swamp peppermint *Taxandria linearfolia*, native wisteria *Hardenbergia comptoniana*, clematis *Clematis aristata*, zamia *Macrozamia reidlei*, weeping grass *Microlaenea stipoides*, kangaroo paw *Anigozanthos* spp., Australian bluebell *Sollya heterophylla*, blue grass lily *Agrostocrinum scabrum* and *Kunzea* sp.

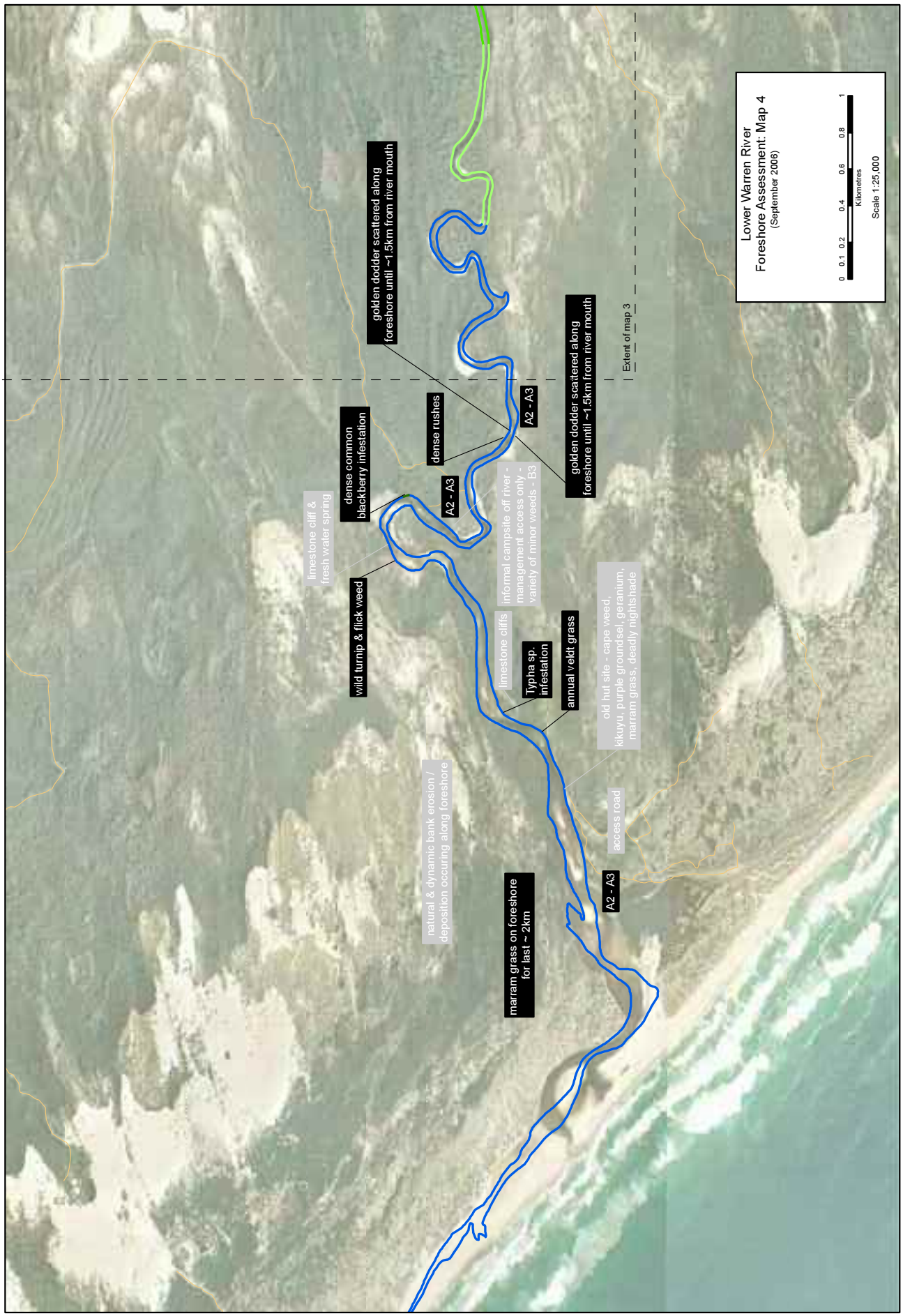
Summary Information	
Location/lot numbers of adjacent properties	National park, NL 5468, NL 5469, NL 2416, NL 2417
Foreshore condition rating (as at Oct 2006)	A3-B1 12.5 % B 60 % B2-C1 15 % C1-C2 12.5 %
Vegetation cover & health	Aside from common blackberry thickets and golden dodder growths, generally a very healthy and predominantly natural assemblage of plants. Foreshore vegetation has been removed in some parts of landholder properties
Land use	Private property, stock grazing, Greater Hawke/ D'Entrecasteaux National Park



Lower Warren River Map 3

Issues	Comments
General foreshore condition	Channel width approx. 20 – 50 m. Riparian area generally is in extremely good condition, apart from scattered thickets of common blackberry and golden dodder growths. In-stream vegetation and significant large woody debris present
Fencing	Discrete parts of landholder foreshore fenced, but generally unrestricted stock access where stock are present
Erosion/bank stability	Dynamic, natural channel erosion and deposition processes occurring along length of foreshore with sandy banks in some areas exacerbating cutting and erosion. Past stock access may also have had an impact as the entire area was once run as a coastal cattle lease
Weeds	Common blackberry infestations are scattered along the foreshore. In these areas, weed density has excluded native vegetation growth on the immediate foreshore area. Few small leaf blackberry sites. Cleared landholder properties are predominantly blackberry-free but all contain one-leaved cape tulip, also found further downstream. Golden dodder along majority of foreshore. Scattered thistles, wild turnip and pennyroyal. Isolated briar rose and fruit trees
Other comments	Access restricted

Prioritised management actions recommended
1. Control and eradicate weed infestations on private property, i.e. blackberry, one-leaved cape tulip
2. Eradicate isolated growths of blackberry (common and small leaf)
3. Release blackberry biocontrol rust fungi as soon as possible, and monitor outcome and progress
Long term management actions recommended
1. Monitor effect of blackberry biocontrol rust and further spread of common and small leaf blackberry
2. Monitor spread of golden dodder
3. Monitor emergence and spread of other weed species



Lower Warren River Map 4

Map 4

Map 4 covers the remaining 5 km to the river mouth at Warren Beach, approximately 30 km south west of Pemberton. The foreshore is in excellent condition, densely vegetated and well stabilised with a variety of native species as well as the introduced but naturalised marram grass Ammophila arenaria further towards the river mouth. Channel width is approximately 40-100 m wide, with the soils turning to coastal sand near the mouth. Golden dodder is still scattered along much of the foreshore although growth ends approximately 1.5 km from the river mouth. Other weeds are limited throughout the stretch, with isolated common blackberry growths, annual veldt grass, typha and scattered wild turnip. An old hut site is located approximately 1 km from the river mouth; although the hut no longer exists, the site contains several weed species in need of removal. A small infestation of purple groundsel Senecio elegans exists at the river mouth.

Native species characteristic of the section include: ropebush (banjine) *Pimelia clavata*, swamp paperbark *Melaleuca raphiophylla*, Warren River cedar (wattie) *Taxandria juniperina*, river banksia *Banksia seminuda*, dungyn *Hakea oleifolia*, coral vine *Kennedia coccinea*, cutleaf hibbertia *Hibbertia cuneiformis*, sharks tooth acacia *Acacia acuminata*, *Kunzea* sp., *Astartea fascicularis*, prickly Moses *Acacia pulchella*, water bush *Bossiaea aquifolium*, swamp willow (wonnich) *Callistachys lanceolata*, Western Australian peppermint *Agonis flexuosa*, sword sedges *Lepidosperma* sp., rushes *Juncus*, *Baumea* and *Isolepis* sp., *Billardiera floribunda*, tassleflower *Leucopogon verticillatus*, bracken *Pteridium escalatum*, swamp peppermint *Taxandria linearfolia*, native wisteria *Hardenbergia comptoniana*, clematis *Clematis aristata*, zamia *Macrozamia reidlei*, prickly acacia *Hakea amplexicaulis*, native dodder *Cusscuta australis*, kangaroo paw *Anigozanthos* spp., coastal/ red-eyed wattle *Acacia cyclops* and jacksonia *Jacksonia* sp.

Summary Information	
Location/lot numbers of adjacent properties	National Park
Foreshore condition rating (as at Oct 2006)	A2-A3 100%
Vegetation cover & health	Generally excellent condition, healthy and diverse native assemblage. Scattered weed occurrences along length
Land use	D'Entrecasteaux National Park

Issues	Comments
General foreshore condition	Overall extremely good foreshore condition, well vegetated and stabilised with native species. Channel width 40-100 m. Scattered weed occurrences
Fencing	0 km fenced. Historical stock grazing area
Erosion/bank stability	Well stabilised banks, some cutting occurring. Mouth region has shifting sand dunes, exact mouth location is in a constant state of flux
Weeds	Scattered common blackberry growths in the upper reaches of the section, golden dodder to within ~ 1 km of river mouth. Old hut site has a concentration of weeds. Marram grass is stabilising dunes near the mouth (introduced but now naturalised)
Other comments	Access restricted, difficult

Prioritised management actions recommended

1. Eradicate isolated common blackberry growths
2. Eradicate weed occurrences at old hut site

Long term management actions recommended

1. Monitor regrowth of weed species along the section
2. Investigate Typha sp. for possible removal options if necessary
3. Monitor for incursions of small leaf blackberry into the area and control

8. Summary of findings

The foreshore assessment surveys produced the following information for overall foreshore condition ratings along the lower Warren River (Table 5). Foreshore condition ratings have been averaged from both banks of the river.

As evident from Table 5, the majority of the lower Warren River foreshore is classed as B grade; representing 77 % of the entire river foreshore (this figure includes sections graded as A3-B1 and B2-C1). The B foreshore rating implies that although the bushland is of a generally good quality, some degradation, weed invasion or soil disturbance is occurring along the river. The fact that the majority of the lower Warren River was assessed as B grade is a positive, as B grade foreshores with weed issues are easier to manage than foreshore areas with serious erosion problems (i.e. C or D grade foreshores). Decisive action by both landholders and responsible government agencies to control weed occurrences will be instrumental in protecting B grade stretches of foreshore. Keeping these B grade foreshore areas in a B grade condition, or enhancing their condition, will require ongoing weed control measures and monitoring for any erosion issues that may emerge. The main management issue for these B grade sections concerns blackberry (predominantly common, but also small leaf) and golden dodder, which dominate much of the foreshore. As mentioned, biocontrol rust fungus is to be released in the area to help control blackberry infestations. Other weed species of concern include one-leaved cape tulip and kangaroo apple, levels of which are still controllable. An integrated management approach involving landholders and responsible government agencies is preferred for dealing with these B grade sections.

The next most common foreshore condition rating for the lower Warren River was A grade, representing 19.2 % of the river. Grading was either A2 or A3 meaning that there were either some weeds present but no soil disturbance (A2), or very localised weed infestations in areas with soil disturbance (A3). These areas, densely vegetated with native species, were found towards the mouth of the river within D'Entrecasteaux National Park. Weed incidences are scattered and predominantly localised; blackberry (as dense infestations) and golden dodder do not occur. The main management issues for these sections are localised weed infestations, mainly common blackberry and the old hut site. It will be relatively easy to control these weed occurrences and their removal has been prioritised as a means to protect the mouth area of the river.

Finally, a small proportion (3.8 %) of the lower Warren was classified as C grade, indicating the presence of an eroding and/or predominantly cleared foreshore. The foreshore in these C grade areas has in some cases experienced significant fringing vegetation loss, resulting in exposed soil and bank undercutting. Much of the C grade foreshore erosion recorded along the river sections assessed can be attributed to sandy soils; the bank erosion appears to be predominantly natural and of a dynamic nature, exacerbated by high velocity flows. Restricting stock access and restoring native vegetation along the channel would help to improve the ecological condition of C grade foreshores. The main management issue for these sections concerns the removal of stabilising foreshore vegetation and unrestricted stock access.

Table 5: Overall foreshore condition ratings for the lower Warren River (as at October 2006)

Foreshore Condition	Description of Grade	Total length (km)	Total as a percentage of the lower Warren River surveyed
A	Pristine to slightly disturbed	5	19.2
B	Moderately degraded, soil disturbance, weeds present	20*	77
C	Eroded, soil exposed, little foreshore vegetation	1	3.8
D	Ditch/drain	0	0

**includes sections marked A3-B and B2-C1*

No sections of the lower Warren River assessed were classed as D grade. The foreshore condition ratings recorded for each Map section of the lower Warren River are summarised in Table 6.

Table 6: Section foreshore condition ratings for the lower Warren River (as at October 2006)

Map Section	A Grade %	B Grade %	C Grade %	D Grade %
Map1	0	100	0	0
Map 2	0	100	0	0
Map 3	0	87.5	12.5	0
Map 4	100	0	0	0
TOTAL %	**19.2**	**77**	**3.8**	**0**
TOTAL km	**5**	**20**	**1**	**0**

Table 8: Works plan for each river section surveyed

Map Section	Works completed 2006	Future works
Map1	• Release of blackberry biocontrol rust fungi into infestations	• Monitor progress of blackberry biocontrol rust fungi • Control kangaroo apple • Monitor for other weed incursion • Assess upstream of section • Work with DEC to control and monitor existing and new weed incursions
Map 2	• Fruit tree removal at Larkin Rd Bridge • Release of blackberry biocontrol rust fungi into infestations • Willow tree removal	• Monitor progress of blackberry biocontrol rust fungi • Monitor effectiveness of weed control works • Work with landholders and DEC to control and monitor existing and new weed incursions
Map 3	• Release of blackberry biocontrol rust fungi into infestations • Control of one-leaved cape tulip in D'Entrecasteaux National Park, in concert with landholder control on private property • Removal of isolated common and small leaf blackberry growths	• Monitor progress of blackberry biocontrol rust fungi • Monitor effectiveness of weed control works • Work with landholders and DEC to control and monitor existing and new weed incursions • Assess Dombakup Brook
Map 4	• Release of blackberry biocontrol rust fungi into infestations • Control of isolated common blackberry growths • Control of localised weed growths at old hut site	• Monitor progress of blackberry biocontrol rust fungi • Monitor and if needed follow up control of isolated blackberry growths • Monitor and if needed follow up weed control at old hut site
Entire section	• Implement biological health snapshot survey data collection • (Also conducted upstream from the section of river assessed in this action plan)	• Monitor for new weed incursions • Continue biological health snapshot survey data collection • Revisit to collect data in approx. five years time

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Appendix 1: Suggested list of appropriate revegetation species

This information was sourced from a variety of reference material, including the online resource *Florabase*, a joint initiative of the Western Australian Herbarium and DEC, Wheeler *et al*. (2002) and WRC (1997) as well as from local 'in-house' knowledge. Further information regarding the species given below as well as other species can be found in these and other sources.

TREES			
Botanical Name	**Common name**	**Habit**	**Notes- propagation/uses/soil**
Agonis flexuosa	Western Australian peppermint	Tree or shrub, to 10m high	Flowers white, Jul-Dec. Sands and gravels (white or grey sand, sandy soils, laterite, limestone) with shallow fresh water table. Coastal sand dunes, granite outcrops, limestone areas. Direct seed/planting autumn or spring.
Taxandria juniperina	Warren River cedar/wattie	Small- medium to 25 m	Flowers white, much of year. Fringing plant for creeks, lakes & swamps. Can form dense thickets. Seed, brushing, cuttings.
Allocasuarina decussata	Karri sheoak	Monoecious tree shrub, to 15m high	Loam soils within karri forest. Craft timber.
Allocasuarina fraseriana	Sheoak	Dioecious, erect. tree, 5-15 m high, bark fibrous, reddish-brown	Flowers brown, May-Oct. Lateritic soils, white, grey or yellow sand. Valuable furniture timber.
Banksia ilicifolia	Holly-leaved banksia	Tree or shrub, 0.7-10m high, with epicormic buds.	Flowers white, cream, pink, yellow, red, Mar-Jan. Dry to damp white or grey sand soils. Consolidated dunes or low-lying flats.
Banksia littoralis	Swamp banksia	Tree to 12 m high, with epicormic buds	Flowers yellow, orange, Mar-Aug. Grey or black peaty sand. Low-lying, seasonally damp areas, along watercourses. Fire tolerant. Grown from seed in autumn, late winter. Good craft timber.
Banksia seminuda	River banksia	Tree to 20 m high	Flowers yellow, brown,(sub species = red) Feb-Jun. Slightly acidic or neutral soils. Fire sensitive. Grow from seed.
Corymbia callophylla	Marri	Tree to 40 m, bark rough, tesselated	Flowers white, pink, Dec-May. Wetlands, besides drainage lines, fringing salt marshes, flats, hills, breakaways. Grow from seed/direct seed.
Eucalyptus megacarpa	Bullich, bastard karri	Tree (mallee), 2–35m high, bark smooth	Flowers white, Apr-Nov. Sand, sandy loam, limestone. Hills, near swamps & streams. Clay subsoils.
Eucalyptus patens	Yarri/ WA blackbutt	Large tree to 50 m, bark rough, longitudinally furrowed.	Flowers white, cream, Nov-Feb. Gravelly soils, sandy clay, loam. Depressions, stream banks, valleys. Lower slopes, well drained soil, good timber tree, needs dense planting, heavy culling and form pruning to produce timber. Grow from seed/ direct seed.

TREES (continued)			
Botanical Name	**Common name**	**Habit**	**Notes- propagation/uses/soil**
Eucalyptus rudis	Flooded gum	Tree to 25 m, bark rough.	Flowers white, Jul-Sept. Sandy or loam soils. Wetter parts of south western WA, flats, hillsides. Seasonally waterlogged clays on floodplains, leaf miners attack it. Grow from seed/ direct seed, seedlings. Plant in spring.
Melaleuca priessiana	Moonah/ paperbark	Tree to 10 m.	Flower yellow, cream, white, Nov-Feb. Sandy soils, swamps. Less tolerant of prolonged inundation than *M. raphiophylla*. Direct seed.
Melaleuca raphiophylla	Swamp paperbark	Small to medium tree, to 10 m.	Flower white, cream, Aug-Mar. White or grey sand, clay soils, limestone. Saltmarshes, swamps, along watercourses. Withstands seasonal inundation. Direct seed, cuttings.
Paraserianthes lophantha	Albizia, Cape wattle	Tree or shrub, to 10 m.	Flowers cream, greenish yellow, Jun-Sept. Fringing watercourses and swamps. Grown from seed.

SHRUBS			
Botanical Name	**Common name**	**Habit**	**Notes- propagation/uses/soil**
Taxandria linearfolia	Swamp peppermint/rosa or coarse tea tree	Shrub to 5 m, spread to ~3 m,	Flowers white, most of year. Cut flower trade. Fringes swamps & watercourses-stream stabiliser. Direct seed, brushing, cutting in autumn.
Agonis parviceps	White/ fine leaf tea tree	Medium shrub	Cut flowers, commercial, stream stabiliser.
Astartea fascicurlaris	Astartea	Erect shrub to 3 m high, weeping branches.	Flowers white, pink, Jan-May/Oct-Dec. Sandy alkaline soils along watercourses, winter-wet depressions, granite outcrops. Direct seed, brushing, cuttings in autumn.
Banksia attenuata	Slender banksia	Lignotuberous tree or shrub, 0.4–10 m high, with epicormic buds.	Flowers yellow, Oct-Feb. White, yellow, brown or pale red sand, sometimes over laterite. Sand dunes, sandplains.
Beaufortia sparsa	Swamp bottlebrush	Shrub, 1–3 m high.	Flowers red, orange, Jan-Apr/Sept-Nov. Sand. Swampy areas (likes winter wet peaty sands), riverbanks. Cut flowers.
Bossiaea aquifolium	Water bush, netic	Shrub or tree, 0.6-8 m high. Legume.	Understorey to karri- marri Flowers orange, yellow, red, brown, Jul-Nov. Clay loam, laterite, granite.
Brachysema celsianum	Dark pea	Low spreading shrub/ground cover	Flowers pea shaped, red. Stock like it. Various habitats, fringing watercourses.
Callistachys lanceolata	Wonnich/ swamp willow/ greenbush	Erect shrub/ small open tree to 8 m	Flowers pea shaped, yellow-orange, Sept-Dec. Fringes watercourses, winter wet depressions. Thick middle storey shrub fringing watercourses. Grows from seed.

SHRUBS (continued)			
Botanical Name	**Common name**	**Habit**	**Notes- propagation/uses/soil**
Hakea oleifolia	Dungyn/olive-leafed hakea	Erect shrub or tree, 2-10 m high.	Flowers white, Aug-Oct. Grey or red/brown sand, peaty sand, sandy loam, clay, laterite, granite, limestone. Coastal sites. Ornamental, windbreak species.
Hakea varia	Variable–leaved hakea	Erect or spreading shrub to 4m, to 3m wide.	Flowers white, cream, yellow, Jul-Nov. White, grey red loamy sand, clay loam, laterite. Grows in seasonally wet flats. Seed.
Homalospermum Firmum	Common tea-tree	Shrub to 4 m	Forms thickets in permanently wet areas along watercourses.
Hovea elliptica	Tree hovea	Slender, erect shrub or tree to 3 m.	Flowers blue, purple, white, pea shape, Aug-Dec. Laterite, gravel, clay loam, sandy loam, sandy soils. Rocky slopes, granite outcrops, stabilised sand dunes, slopes, ridges.
Leucopogon propinquus	-	Erect shrub to 15 m.	Flowers white, Jan-July. Sandy, gravelly soils. Coastal heath, forest.
Leucopogon verticullaris	Tassel flower, native bamboo	Bamboo-like shrub to 4 m.	Flowers pink, red, Aug-Nov.Gravelly lateritic, granitic soils. Often in wet areas.
Macrozamia reidlei	Zamia palm	Palm like plant to 2 m.	Flowers cones, Mar-June. Widespread. Forests, woodland, heathland.
Persoonia longifolia	Snottygobble	Erect lignotuberous tall shrub or tree, to 5 m.	Flowers yellow, Nov-Mar. Grey/yellow sand, sandy loam or laterite. Difficult to propagate.
Podocarpus drouynianus	Emu bush/ wild plum	Shrub to 3 m. (conifer)	Flowers cones, Aug–Jan. White or grey sand, sandy loam or gravelly loam. Lower slopes or lowlands, near creeks. Edible fruit with external seed.
Trymalium florabundum	Karri hazel	Shrub to 9 m.	Flowers white, pale yellow, green July-Dec. Clay, sandy clay, gravelly soils, laterite, granites. Near watercourses and swamps.
Vimineria juncea	Swish bush	Shrub to 5 m, spread 2m.	Flowers pea shaped, yellow, orange, red-brown, Sept-Feb. Winter-wet depressions, near lakes. Grow from seed.
Xanthorrhoea gracilis	Graceful grass tree	Tufted tree-like monocot, to 2 m. No trunk.	Flowers white, cream, Oct-Jan. Lateritic loam, gravel, sand.
Xanthorrhoea preissii	Grass tree, balga	Tree-like monocot to 5 m. Trunk to over 3 m.	Flowers cream, white, Jan-Nov. grey sand, laterite. Grow from seed, transplant. Extract seeds from capsules with tweezers.
Mirbelia dilatata	Holly-leaved mirbelia	Erect prickly shrub to 3 m.	Flowers pea shaped, pink, purple, yellow centre. Gravelly, laterite, sandy soils.
Chorileana quercifolia	Karri oak	Shrub to 9m.	Flowers yellow, white, green, drooping heads, Apr-Jan. Sandy & loamy soils. Rocky coast & hillsides, granite & limestone rocks.

RUSHES, SEDGES, GROUND COVER			
Botanical Name	**Common name**	**Habit**	**Notes- propagation/uses/soil**
Baumea arthrophylla	Sparse twig rush	Sedge, spasely spreading to 1 m.	Flowers brown, Sept-Dec. Seasonally wet depressions, lakes. Tolerates partially sumberged conditions. Grow from seed or rhizome division.
Baumea articulata	Jointed twig rush	Sedge to 2.5 m, spreading. Often forms extensive colonies.	Flowers spike-like, greyish brown, Sept-Dec. Lake margins and watercourses. Fresh and brackish water, tolerates prolonged inundation (>1 m), wide tolerance Grow from seed/rhizome division in winter.
Baumea juncea	Bare twig rush	Sedge to 2 m, creeping under-ground stems. Often forms extensive colonies. Smooth cylindrical blue-green stems. Good colonising plant.	Flowers spike-like, brown, grey, Oct-Mar. Dark grey sand, waterlogged soils along rivers and winter- wet depressions. Tolerates seasonal water fluctuations up to 0.5 m, fresh-brackish- seasonally saline water. Rhizome transplantation, in-vitro culture of seed embryos.
Baumea preissii	Sedge	Sedge to 2 m. Rhizomatous, robust, colonising perennial.	Flowers purple, brown, grey, Jul-Dec. Silty sand, waterlogged soils. Waterlogged soils bordering lakes & watercourses. Rhizomatous division.
Baumea riparia	River twig rush	Sedge to 1.5 m.	Flower brown, Aug-Oct. Black peaty sand. Seasonal swamps, often brackish. Seasonally inundated areas. Rhizome division.
Baumea rubiginosa	Sedge	Sedge to 4 m, spread 2 m.	Flowers brown, Aug-Mar. Waterlogged soils bordering lakes & watercourses. Grow from seed, rhizome division.
Baumea vaginalis	Sheath twig rush	Sedge to 2.5 m, grows in large clumps. Circular stems 2-6 mm wide.	Flowers spike-like, brown, Sept-Dec. Fresh to semi-saline water, seasonally wet to permanaently inundated. Grows from rhizome division or tissue culture.
Bolboschoenus caldwellii	Marsh club rush	Sedge to 1.2 m, forms large colonies. Stems bright green, triangular in cross-section. Grass-like tufted plant.	Flowers spikelets, golden brown, Aug-Mar. White or grey sand, mud, saline silt, sandy clay. Seasonally damp to seasonally inundated habitat. Tolerates seasonal water fluctuation. Direct seed; seed germinates readily when fresh. Also in-vitro culture.
Carex appressa	Tall sedge	Sedge to 2 m, spread 0.5 m. Tufted, often forms large clump	Flowers spikelets, greenish brown, Sept-Dec. Seasonally inundated or shallow permanent water habitat, fresh or brackish conditions. Grow from rhizomes in early spring.

RUSHES, SEDGES, GROUND COVER (continued)			
Botanical Name	**Common name**	**Habit**	**Notes- propagation/uses/soil**
Carex fascicularis	Tassel sedge	Sedge to 1.5 m, spread 1m.	Flowers spikelets, green, Sept-Nov. Black peaty sand Freshwater to brackish conditions along seasonally inundated and partially waterlogged watercourses. Rhizomatous division.
Carex tereticaulis	Sedge	Sedge to 0.7 m. Tufted.	Flowers brown, Sep-Oct. Black peaty sand.
Chaetanthus aristatus (formerly *Leptocarpus aristatus)*	Bearded twine-rush	Densely tufted sedge to 0.8 m.	Flowers spikelets, May-Nov. Sand or clay soils in seasonally wet depressions. Grow from tissue culture.
Chorizema cordatum	Flame pea	Climber/ground cover to 1.5 m.	Flowers yellow, orange, July-Dec. Sandy gravelly soils, clay loam. Rocky hillsides, lateritic ridges, undulating places.
Chorizema ilicifolium	Holly-flame pea	Climber/ ground cover to 0.5 m.	Flowers yellow, orange with pink wings, July-Dec. Coastal limestone. Sand, sand over limestone.
Eleocharis acuta	Common spike rush	Creeping sedge to 0.7 m, tuffs arising along a slender rhizome.	Flowers spikelet, brown, Sept- Jan. Forms dense mass in seasonally waterlogged depressions, often partially submerged. Also fringes freshwater watercourses. Grow by division, in-vitro culture. Plant in clumps for increased stability.
Gahnia trifida	Coast saw-sedge	Sedge to 1.5 m, spread 1 m.	Flowers yellow, brown, Aug-Oct. Grey or white sand, clay, sometimes saline. Swamps, creeks.
Hardenbergia comptoniana	Native wisteria	Twining shrub or climber.	Flowers blue, purple, white, Jul-Oct. Sandy soils. Coastal limestone, sandplains, dunes.
Isolepsis nodosa	Knotted club rush	Tufted rush to 1 m. radiating rhizomes.	Flowers spikelets, brown, Sept-Mar. Sandy soils. Coastal dunes, winter-wet depressions and fringing watercourses. Direct seed.
Juncus kraussii	Shore rush/ sea rush	Rush. Tussock-forming, to 1.5 m. Dark green stems. Forms extensive compact clumps. Good colonising plant.	Flowers brown, red, Oct-Jan. White or grey sand, clay, alluvium. Swamps, brackish estuaries, saline flats, seashores. Grow from rhizome division or direct seed. Transplant while dormant (May-June).
Juncus pallidus	Pale rush	Rush. Tufted plant to 2 m. Good colonising plant.	Flowers green, Sept-Dec. Clay. Wet or seasonally damp soils around fresh to brackish watercourses and lakes. Seed viable around Jan, or rhizome division. Plant in clumps.
Juncus pauciflorus	Loose flower rush	Rush. Tufted plant to 1 m.	Flowers greenish brown, Sept-Dec. Permanently damp or seasonally wet soil. Fringes fresh watercourses. Direct seed.
Juncus subsecundus	Finger rush	Tufted sedge to 1 m.	Flowers straw-coloured, Sept-Dec. Moist or seasonally wet soils. Direct seed.

RUSHES, SEDGES, GROUND COVER (continued)			
Botanical Name	**Common name**	**Habit**	**Notes- propagation/uses/soil**
Kennedia coccinea	Coral vine	Twining or trailing shrub or climber. Climber/ground cover.	Flowers orange, pink, red, purple, Aug-Dec. Often on sandy soils. Grow from seed.
Lepidosperma effusum	Spreading sword-sedge	Tufted sedge to 3 m, spread 1 m.	Flowers spikelets, brown, dull grey, Sept-Dec. Sands and clay in seasonally moist or wet watercourses (occasionally tidal). Grow from rhizome division, tissue culture.
Lepidosperma gladiatum	Coastal sword-sedge	Sedge to 1.5 m, forms broad clumps.	Flowers spikelets, brown, Oct-Feb. Seasonally moist or wet sands, dry dunes. Grow from seed, transplant.
Lepidosperma longitudinale	Pithy sword-sedge	Creeping sedge to 2 m. Forms large colonies.	Flowers spikelets, brown, May-Aug. Sands/ peaty sands in winter-wet depressions and along watercourses. Rhizome transplantation, seed propagation difficult.
Lepidosperma tetraquetrum	Angle sword-sedge	Sedge to 3 m, spread to 2.5 m. Forms large colonies.	Flowers spikelets, brown, Aug-Mar. Black peaty sand. Seasonally moist or wet sands along watercourses and winter-wet depressions. Rhizome division, tissue culture.
Leptocarpus aristatus	Bearded twine-rush	Densely tufted sedge to 0.8 m.	Flowers spikelets, May-Nov. Sand or clay soils in seasonally wet depressions. Grow from tissue culture.
Leptocarpus laxus	Velvet rush	Tufted plant to 1.5 m.	Flowers red, spikelets, Apr-Nov. Moist to wet sand, saline soils, clay, laterite. Swamps, creeks, well-drained flats, seasonally wet sites.
Meeboldina kraussii		Rhizomatous, perennial, herb (rush-like) to 1 m high. Forms clumps.	Sandy & clayey soils. Fringing plant along swamps, creeks, granite outcrops, seasonally wet sites. Rhizomatous division.
Microlaena stipoides	Weeping grass	Clumping grass.	Flowers Sept-Jan. Widespread.
Reedia spathacea	Sedge	Robust, tufted perennial, grass like or herb (sedge), 2-3 m high, clumps 1.5-2 m wide.	Flowers brown, Nov–Jan. Peaty sand. Swamps, river edges. Propagation unknown, possibly rhizome division.
Schoenoplectus pungens	Sharpleaf rush	Erect sedge to 1 m.	Flowers spikelets, Sept-Dec. Fresh, brackish or semi-saline water in swampy conditions and standing water. Transplant rhizomes in winter, in-vitro culture.

RUSHES, SEDGES, GROUND COVER (continued)			
Botanical Name	**Common name**	**Habit**	**Notes- propagation/uses/soil**
Schoenoplectus Validus	Lake club rush	Erect sedge to 3 m. Forms clumps and at times extensive colonies.	Flowers spikelets, brown, Nov-Mar. Fresh, brackish or semi-saline water in winter-wet depressions and margins of watercourses. Transplant rhizomes in winter, in-vitro culture.
Schoenus subfascicularis	Bog rush Several other suitable varieties exist.	Rush to 1 m.	Flowers spikelets, brown, July-Dec. Seasonally wet depressions, fringing swamps and estuaries. Produces very little viable seed. Grow from rhizome division.

Appendix 2: Useful contracts

Contact	Location	Contact details
Southern Forests Landcare	Manjimup	Ph. (08) 9771 8180 Fax. (08) 9771 8108 E-mail: nrm-warren@southernforestslandcare.org.au
Ribbons of Blue- Andy Russell	Warren region	Ph. (08) 9776 1559 or 9771 8180 E-mail: andy@westnet.com.au
Manjimup LCDC/ Warren Catchments Council	Manjimup	As above for Southern Forests Landcare
DAFWA (inc. Biosecurity)	Manjimup	Ph. (08) 9777 0000 Fax. (08) 9777 0001 Web: www.agric.wa.gov.au
D'Entrecasteaux Coalition	Pemberton	Contact person- Andy Russell Ph. (08) 9776 1559 E-mail: pemhike@wn.com.au
Department of Environment and Conservation (DEC)	Donnelly District Manjimup	Ph. (08) 9771 7988 Fax. (08) 9771 2677 Web: www.dec.wa.gov.au
Department of Environment and Conservation	Bunbury	Ph. (08) 9726 4111 Fax. (08) 9726 4100 Web: www.dec.wa.gov.au
Department of Fisheries	Bunbury	Ph. (08) 97 212 688 Fax. (08) 97 911 862 Web: www.fish.wa.gov.au
Department of Indigenous Affairs	Albany	Ph. (08) 9842 3000 Fax. (08) 9842 3517 Web: www.dia.wa.gov.au
Department of Water	Manjimup	Ph. (08) 9771 1878 Fax. (08) 9771 8108 Web: www.water.wa.gov.au
Land for Wildlife- Julia Boniface	Nannup	Ph. (08) 9756 1465 Fax. (08) 9756 1242 Web: www.dec.wa.gov.au/landforwildlife.com
Manjimup Weed Action Group	Manjimup	Ph. (08) 9771 7988 Fax. (08) 9771 2677
Shire of Manjimup	Manjimup	Ph. (08) 9771 7777 Fax. (08) 9771 7771 Web: www.manjimup.wa.gov.au
SWCC	Bunbury	Ph. (08) 9780 6193 Fax. (08) 9780 6198 Web: www.swcatchmentscouncil.com.au
Warren Environment Group	Pemberton	Contact person- Andy Russell Ph. (08) 9776 1559 E-mail: pemhike@wn.com.au

Appendix 3: Bird species of the lower Warren River area

The following table lists some of the many bird species present in the lower Warren River area. The birds listed below are those that have been previously recorded (Hodgkin & Clark,, 1989) or observed by local ornithologist Dr Mees.

Common name	Scientific name	Common name	Scientific name
Australian kestrel	*Falco cenchroides*	Port Lincoln parrot	*Barnardius zonarius*
Australian little falcon	*Falco longipennis*	Purple-crowned lorikeet	*Glossopsitta porphyrocephala*
Australian little grebe	*Podiceps novaehollandiae*	Purple swamphen	*Porphyrio porphyrio*
Australian magpie	*Gymnorhina tibicen*	Quail	*Coturnix* sp.
Australian raven	*Corvus coronoides*	Red wattle bird	*Anthochaera carunculata*
Australian shelduck	*Tarnorna tadornoides*	Red wattlebird	*Anthochaera carunculata*
Australian white ibis	*Threskiornis moluccus*	Red-capped parrot	*Purpureicephalus spurius*
Black swan	*Cygnus atratus*	Red-capped plover	*Charadrius ruficapillus*
Black-capped sitella	*Neositta pileata*	Red-eared firetail finch	*Emblema oculatum*
Black-faced cuckoo shrike	*Coracina novaehollandiae*	Red-tailed black cockatoo	*Calyptorhynchus magnificus*
Brown falcon	*Falco berigora*	Red-winged wren	*Malarus elegans*
Brown goshawk	*Accipiter fasciatus*	Richard's pipit	*Anthus novaeseelandiae*
Brown honeyeater	*Lichmera indistincta*	Sacred kingfisher	*Halcyon sancta*
Brush wattle bird	*Anthochaera chrysoptera*	Scarlet robin	*Petroica multicolor*
Caspian tern	*Hydroprogne caspia*	Shining bronze cuckoo	*Chrysococcyx lucidus*
Collared sparrowhawk	*Accipiter cirrhocephalus*	Silver gull	*Larus novaehollandiae*
Common bronzewing	*Phaps chalcoptera*	Silvereye	*Zosterops lateralis*
Crested tern	*Sterna bergii*	Southern boobook	*Ninox novaeseelandiae*
Dusky woodswallow	*Artamus cyanopterus*	Splendid fairy-wren	*Malurus splendens*
Emu	*Dromaius novaehollandiae*	Spotted scrub-wren	*Sericornis maculatus*
Eurasian coot	*Fulica atra*	Square-tailed kite	*Lophoictinia isura*
Fan-tailed cuckoo	*Cacomantis flabelliformis*	Straw-necked ibis	*Threskiornis spinicollis*
Golden whistler	*Pachycephala pectoralis*	Striated pardalote	*Pardalotus striatus*
Great cormorant	*Phalacrocorax carbo*	Swamp harrier	*Circus approximans*
Grey currawong	*Strepera versicolor*	Tree martin	*Petrochelidon nigricans*
Grey fantail	*Rhipidura fuliginosa*	Wedge-tailed eagle	*Aquila audax*
Grey shrike-thrush	*Colluricincla harmonica*	Welcome swallow	*Hirundo neoxena*
Grey teal	*Anas gibberifrons*	Western rosella	*Platycercus icterotis*
Inland thornbill	*Acanthiza apicalis*	Western spinebill	*Acanthorhynchus superciliosus*
Kestrel	*Falco cenchroides*	Western warbler	*Gerygone fusca*
Kookaburra	*Dacelo novaeguineae*	Whistling kite	*Haliastur sphenurus*
Little black cormorant	*Phalacrocorax sulcirostris*	White-breasted robin	*Eopsaltria georgiana*
Little pied cormorant	*Phalacrocorax melanoleucos*	White-browed babbler	*Pomatostomus superciliosus*
Magpie-lark	*Grallina cyanoleuca*	White-faced heron	*Ardea novaehollandiae*

Common name	Scientific name	Common name	Scientific name
Maned duck	*Chenonetta jubata*	White-naped honeyeater	*Melithreptus lunatus*
Mountain duck	*Tadorna tadornoides*	White-necked heron	*Ardea pacifica*
Musk duck	*Biziura lobata*	Baudin's cockatoo	*Calyptorhynchus baudinii*
New Holland honeyeater	*Phylidonyris novaehollandiae*	Willie wagtail	*Rhipidura leucophrys*
Pacific black duck	*Anas superciliosa*	Wood duck	*Chenonetta jubata*
Pallid cuckoo	*Cuculus pallidus*	Yellow-rumped thornbill	*Acanthiza chrysorrhoa*
Peregrine falcon	*Falco peregrinus*		