River Action Plan for the Upper Preston River

2007

Leschenault Catchment Council

SOUTH WEST CATCHMENTS COUNCIL

GOVERNMENT OF WESTERN AUSTRALIA

Australian Government

How to use this RAP

This RAP (RAP) was prepared for the Leschenault Catchment Council and landholders within the Upper Preston River Catchment. It contains a detailed description of the current health of the waterway, provides information on current management issues, and recommends strategies to address these issues.

Landholders may find this a useful tool to manage their waterways, while community groups may find it helpful in prioritising actions to make the best use of limited resources. For others, it will provide background information to aid decision making.

For landholders

Landholders should turn to their relevant map in Chapter 6 and read the associated management issues and recommendations. They should then read Chapter 4 to determine why these issues are considered to be a priority for remediation, and Chapter 5 to determine the most appropriate actions to address the issues. Information on the general study area and methodology used to develop this action plan can be found in Chapters 1, 2 and 3.

For the Leschenault Catchment Council

Turn to Chapter 6 which contains detailed information on management issues for each stretch of the waterway. Chapter 5 provides technical advice on how to best address and manage these management issues. Relevant pages should be read carefully prior to implementing any actions.

Four appendices provide further information that may be useful to landholders and community groups.

- Native vegetation and community types that were found in the study area.
- Common weeds that were found.
- Advice for planning revegetation projects.
- Useful contacts for further information and assistance.

Acronyms

RAP	RAP
LCC	Leschenault Catchment Council
NHT	Natural Heritage Trust
DEC	Department of Environment and Conservation (formally CALM)
DoW	Department of Water
WRC	Water & Rivers Commission (now the Department of Water)
DAFWA	Department of Agriculture and Food Western Australia

Cover photo: Preston River views taken by Cathie Derrington, July 2006.

Acknowledgments

This RAP was developed in consultation with Leschenault Catchment Council, and thanks are extended to this community group for their assistance. Special thanks to Brendan Kelly, Cassandra Jury and Cameron Sutherland for their technical support.

All of the landholders who were involved in the project, especially those who took the time and effort to provide anecdotal and historical information, deserve a big thank you, as do those who attended the community workshop.

The Shire of Donnybrook-Balingup for providing information on land tenure, vesting and property owners. Aidan Power and Liesma Kukuls from the Regional Support Branch of the Department of Water for preparing the maps.

This RAP has drawn extensively from previous RAPs developed for rivers in the Geographe and Capes Catchments and Leigh Taylor's RAP for the Brunswick River. Special acknowledgement is extended to the Geographe Catchment Council for developing and sharing model used for RAPs.

The project was funded by the Natural Heritage Trust and National Action Plan for Salinity and Water Quality, these are joint initiatives of the State and Federal Government, which are administered by the South West Catchments Council.

Reference details

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Summary

The Preston River is located within the southern area of the Leschenault Catchment and has a total catchment area of 957.8 square kilometers. The Preston River is approximately 98km long, extending 61km inland from the coast.

The aim of this RAP (RAP) is to provide information to landholders, interested community members, and organisations on the health and current state of the Upper Preston River and recommends how to improve its management for the future. This report refers to the Upper Preston River, which is defined as the section of river from the eastern side of the Donnybrook Townsite to the Mumballup – Collie Road.

Foreshore assessments were carried out over the first two weeks of July 2006 using the Foreshore Condition Assessment method developed by Dr Luke Pen and Margaret Scott for rivers in the south west of Western Australia (Pen & Scott, 1995).

A summary of the foreshore condition ratings and length of fencing of the river is presented in Tables 1, 1b and 2.

Key issues identified

The key issues of concern identified during the foreshore assessment and community consultation were:

- Loss of native fringing vegetation and degradation of remaining vegetation;
- Poor health of the flooded gum (Eucalyptus rudis);
- Weed invasion and management;
- Erosion and sedimentation of the river;
- Log jams within the river;
- Water quality issues, including nutrient enrichment, pollution and salinity;
- Impacts of changing agriculture use (particularly horticultural land changing to cattle grazing);
- Need for assistance if landholders are to protect and enhance the foreshore by fencing or revegetating;
- Impact of feral animals;
- Government agencies – what are their roles and responsibilities, and
- Stock grazing on foreshores.

General recommendations to improve the health of the Upper Preston River

It is recommended that landholders consider the following:

- Retain and protect the remaining riparian vegetation of the Upper Preston River;
- Fence the river to enable control of stock access;
- Implement controlled grazing techniques as part of a rehabilitation plan to control grasses and fuel loads;
- Use available funding to contribute towards the costs of fencing and rehabilitation projects;
- Control weeds, particularly invasive species in the riparian zone;
- Implement best management practices that minimise soil erosion and nutrient loss to waterways such as soil testing and maximising vegetation cover on the soil.
- Revegetate waterways with local native species to provide habitat and enhance ecological function.
- Use available funding and resources to control feral animals.

It is recommended that the Leschenault Catchment Council (LCC) consider the following:

- Encourage and support community efforts to fence the River to restrict stock access;
- Apply for further funding to continue to subsidise the cost of revegetation projects and fencing;
- Provide educational opportunities to landholders on land management techniques;
- Clearly identify state and local government roles and areas of responsibility within the riparian zones.

- Encourage as a priority, the protection of areas of the rivers still retaining native fringing vegetation. (It is more cost effective to protect these areas now than to restore them later after further degradation has occurred);
- Provide encouragement and support to landholders to undertake revegetation using a diverse suite of local native species (including trees, shrubs, sedges, rushes, herbs and native grasses);
- Expand and continue to support weed and feral animal control projects in the catchment;
- Promote best management practices techniques that minimise soil erosion and nutrient loss to waterways, eg. buffer strips, soil testing, fertiliser management plans, and maximising vegetation cover on the soil;
- Work with landholders and engineers from the Department of Water to address serious erosion and sedimentation problems.
- Work with Department of Water to expand their water monitoring program of the Preston River to address community concerns about nutrient levels, contamination and salinity.
- Work with Ribbons of Blue and other community organisations to increase community awareness and knowledge of the Preston River catchment, focussing on natural assets, values, and threats.

Table 1a: Summary of foreshore condition rating of Upper Preston River

Condition	North Bank	North Bank %	South Bank	South Bank %	Total %
A (pristine)	0.097 km	0.3 %	0 km	0 %	0.15 %
B (weedy)	13.84 km	42%	15.454 km	47 %	44.5 %
C (erosion prone/eroding)	18.514 km	56.3 %	17.418 km	52 %	54.15 %
D (ditch)	0.459 km	1.4%	0.331 km	1 %	1.2%

Table 1b: Condition category summary of the foreshore conditions in the Upper Preston River

Condition	North Bank	North Bank %	South Bank	South Bank %	Total %
A3 (slightly disturbed)	0.097 km	0.3 %	0 km	0 %	0.15 %
B1 (degraded, understorey mainly natives)	0.199 km	0.6 %	0 km	0 %	0.3%
B2 (degraded, understorey 50% weeds)	2.873 km	8.72 %	2.724 km	8.2%	8.46%
B3 (degraded, understorey mainly weeds)	10.768 km	32.7 %	12.730 km	38.3%	35.5%
C 1 (erosion prone)	8.272 km	25.1%	8.754 km	26.36%	25.73%
C2 (soil exposed)	7.921 km	24%	6.007 km	18.09%	21.05%
C3 (Eroded)	2.321 km	7.05%	2.657 km	8.0%	7.53%
D1 (ditch, eroding)	0.459 km	1.4%	0.331 km	1 %	1.2 %

Table 2: Length of fenced areas on the Upper Preston River: Donnybrook to Mumballup

	Length Fenced	Percentage of Length
North Bank	14.33 km	43.5 %
South Bank	19.56 km	58.9 %
Total Fenced	33.89 km	51.2 %

1. Introduction

Background

The Leschenault Catchment Council (LCC) is an incorporated community-based body that works in partnership with government agencies, local government, industry and community groups to share awareness and responsibilities in determining natural resource management issues and their solutions within the catchment.

The Council was formed in 2000 through the membership of the former Leschenault Inlet Management Authority, and later amalgamation with the Leschenault Catchment Coordinating Group (LCCG). It has up to ten community, four local government, two industry and two State government representatives with links to many other groups throughout the region.

The Leschenault subregional boundaries encompass the Leschenault Estuary and the Preston, Collie, Ferguson, Wellesley and Brunswick River systems and the Wellington Dam Catchment (Upper Collie River).

Its charter is:
'To develop ways to achieve a sustainable, healthy and productive catchment in partnership with the community.'

In recognition of the need to address the poor state of the rivers in the Leschenault Catchment, the Geographe Catchment Council in partnership with the Leschenault Catchment Council submitted an application to the South West Catchment Council Investment Plan (funded by Natural Heritage Trust (NHT) and National Action Plan for Salinity and Water Quality (NAP)). The LCC was successful in obtaining funds for the Brunswick and Upper Preston Rivers. This funding has been used to survey river foreshore conditions, produce RAP's and introduce a number of management techniques with particular emphasis on weed control. The project was funded through the Improving Waterways Health Program of the SW Investment Plan, the basis of this program is:

"To bring about the improvement of the health of the Regions waterways."

Study aims

The primary aims of this RAP are:

- To produce a detailed description of the current state of the Upper Preston River and identify priority actions which guide works to help improve the health of these waterways;
- To help increase the community's awareness of the importance of healthy waterways and riparian vegetation;
- To provide a benchmark against which the local community's future catchment work (to protect and rehabilitate the waterways) can be gauged;
- To provide guidance on the possibility of funding and assistance available for fencing, weed and erosion control, and the planting and rehabilitation of native vegetation; and
- To provide a sound technical basis for future funding or project submissions.

2. Study area

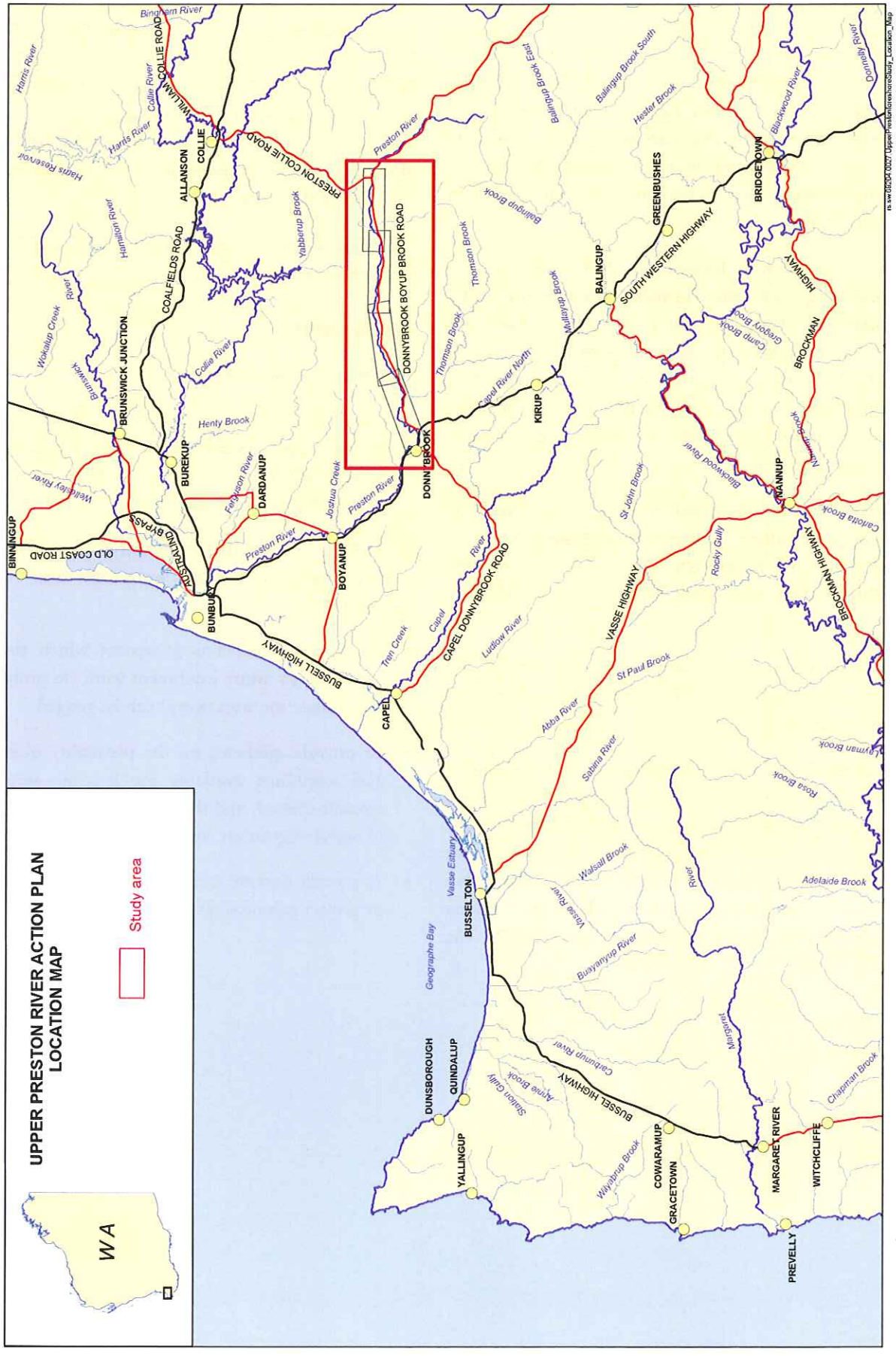

Figure 1: Study area.

Catchment description

There are 208 major waterways in Western Australia, with only 48 rivers being identified as "wild rivers" in recognition of their near pristine condition, the remaining rivers have some form of degradation due to changes in the environment (Department of Environment, 2004). The Preston falls into this latter category.

The Preston River is one of the six major rivers in the south west region. The Preston River ranges from a saline – brackish waterway in its lower reaches at the southern end of the Leschenault Estuary to a freshwater permanently flowing waterway in the higher rainfall areas on the Darling Scarp.

Thirty four kilometres of the Upper Preston River was surveyed from Donnybrook to Mumballup in July 2006. For the purpose of the study, the Upper Preston River is defined as the section of river from the eastern side of the Donnybrook Townsite to the Mumballup-Collie Road. The Preston River's main channel was only considered within this study, no tributaries have been included.

The location of the study area is shown in Figure 1. Background information on the study area is provided below.

The Preston River catchment and river system

The Preston River is located within the Leschenault Catchment and is the catchment's southern river. The Preston River has a total catchment area of 957.8 square kilometers and is approximately 98km long meandering to the southern end of the Leschenault Estuary from approximately 61km south-east inland (north of Wilga). Approximately 43% of the river catchment is cleared, with agriculture as the dominant land use (Department of Environment, 2004). Dryland grazing, orchards and forestry are the main agriculture uses.

The rainfall within this area ranges between 750 – 900mm. At Lowden, the Department of Water's river gauging station records an average annual flow of 19,980 ML (average from 1999-2006).

The Preston River is classified as a "T3" river type which means it is a medium to short river that originates in the higher rainfall zone of the jarrah/marri forest that descends through the darling scarp down to the coastal plain to the sea. (WRC 2/92)

Landuse description

Approximately 43% of the Preston River Catchment has been cleared. The major landuse in the Upper Preston River is beef and sheep grazing with smaller portions of land being used for orchards and forestry. The Preston River valley was once a major Australian horticultural area with apples as the key crop. Horticulture remains a prominent agriculture industry but the industry is in a decline (Jackson, 2006 pers comm).

The entire river foreshore within the RAP area is unvested crown land (foreshore reserves). The unvested foreshore reserve is entirely bound by freehold land which is primarily used for agriculture. Much of the unvested foreshore is used for grazing.

Water is released from the Glen Mervyn Dam, through Lyalls Mill Stream to the Preston River by the Preston Valley Irrigation Cooperative (PVIC), which actively licenses water users belonging to the cooperative. The Department of Water provides an annual water allocation to PVIC to provide a water supply service to users.

Climate

The area has a Mediterranean-type climate, characterised by warm, dry summers and cool, wet winters. The average yearly rainfall is between 750 and 900 mm and a mean annual evaporation of 1200 mm (BOM, Australia 2001). Rainfall and flow are highly seasonal with over 90% of rain falling between April and November (wet winter and dry summer).

Over the last 30 years climate data has clearly shown a decrease in annual rainfall, which has declined between 10% to 25% in the south west of Western Australia from the long-term climate mean (Hennessy, 2002). Figure 2 shows that since circa 1970 there has been a clear reduction in total annual rainfall, represented by a reduction in the mean number of rain days, and the mean number of heavy rain days during winter. The State Water Strategy (Government of Western Australia, 2003) determined that 'Climate change has contributed to a 10-20% reduction in rainfall in the south-west of the State over the last 28 years, a subsequent 40-50%

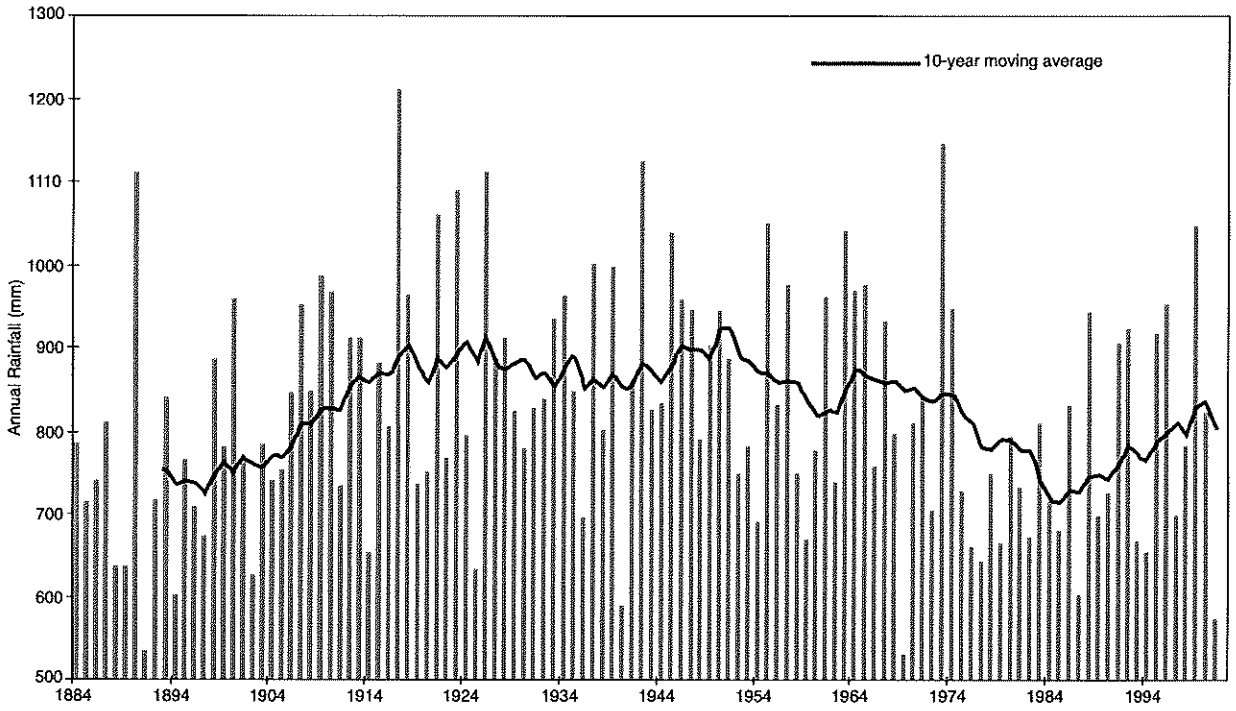

Figure 2: Annual total rainfall for south west Western Australia. Source Hennessy (2002).

reduction in run-off into our dams and reduced recharge of groundwater'.

Landforms and Soils

The Pinjarra System extends along the Swan Coastal Plain from Perth to Capel. This landform consists of a poorly drained coastal plain, where the geology is alluvium over sedimentary rock. The soils comprise either of semi-wet soils, grey deep sandy duplexes, brown loamy earths, pale sands and/or clays.

The landform and soils along the Upper Preston River Valley have been mapped and assessed by Department of Agriculture Western Australia. Tille (1996) determined that the Upper Preston River and associated riparian zone fall within the Mumballup sub-system (MLd), which has soils that are mostly alluvial brown loamy earths with some brown deep sands.

The landform consists of well drained flats, with good to moderate moisture nutrient retention, although some areas are subject to flooding and water-logging. The river banks are prone to erosion and there is a risk of nutrients leaching into the river from the sandy soils (Tille, 2006).

The adjacent landforms to the river valley are the Queenwood Subsystem (Qwf) and the Balingup Subsystem (BL3) (Tille, 2006).

Vegetation communities

Throughout the southwest region of Western Australia, vegetation communities are strongly associated with landform and soils (Keighery, 2006 pers. comm.). The vegetation community in the Preston River Valley, according to the Regional Forest Agreement Vegetation Complexes study, is the Mumballup (ML) community (Mattiske and Havel, 1998). This community is described as being the lower valley slopes and valley floor of the Preston River east of Donnybrook carrying open forest of yarri-marri (*Eucalyptus patens – Corymbia calophylla*) on slopes and woodland of flooded gum and paperbarks (*Eucalyptus rudis – Melaleuca rhaphiophylla*) on the valley floor.

Other major tree species that the author noted to be common within this community were the WA peppermint (*Agonis flexuosa*) and bullich (*Eucalyptus megacarpa*).

The Mumballup vegetation community is extensively cleared (96%), thus the remaining vegetation community of the Upper Preston River has high conservation values (Mattiske and Havel, 1998).

Two tree species are showing signs of dieback, being the flooded gum and WA peppermint. Dieback within the flooded gum community along the Preston River is thought to be related to the indirect effects of the

understorey dying or cleared, rather than the common belief of inadequate surface flows. Mortality of the gums appears due to an explosion in population of the leaf miners (repticulid moth species, a natural pest of flooded gums), following the decline in predator birds (LCCG, 1999). The high mortality of flooded gums along the Preston River is not a recent phenomenon, flooded gum dieback was noted amongst farmers along the Preston River in the early 1900's (Jackson 2006, pers comm). Across the length of the Upper Preston River the author suggests that about 70% of flooded gums were currently regenerating while 30% were dead.

The second species WA peppermint (*Agonis flexuosa*) was noted to be suffering from 'Peppy dieback'. Many mature trees looked either dead or had partial dead foliage. The Department of Environment and Conservation (DEC, 2006) have thought that this dieback is due to frost and that the trees should regenerate in the future.

Threatened and other Flora

The following information was provided by the Department of Conservation and Environment (DEC) office, Bunbury. The species listed below are obtained from the DEC Corporate and Regional databases and from general knowledge of species occurring in the area. Only those flora species within 100m of the Preston River are listed.

Threatened Flora

- *Acacia semitrullata* (DEC Priority 3).

Fauna

The following information was provided by the Department of Conservation and Environment office, Bunbury. The species listed below are obtained from the DEC Corporate and Regional databases and from general knowledge of species occurring in the area. Only those fauna species within 100m of the Preston River are listed.

Threatened and other Fauna

Mammals

- Southern Brown Bandicoot or Quenda *Isoodon obesulus fusciventer* (DEC Priority 5) within denser riparian habitat possibly including weedy areas.
- Western Ringtail possum *Pseudocheirus occidentalis* (Vulnerable) in pockets of peppermint and where eucalypt species with hollows are also present. Areas of blackberry and briar rose infestations have been known to be attractive to possums as they can provide food and extra protection from predators.
- Common Brushtail possum *Trichosurus vulpecula* (not threatened) outside and within riparian habitat where eucalypt species with hollows are present.
- Brushtail Phascogale *Phascogale tapoatafa* (DEC Priority 3) where eucalypt species with hollows are present.

Birds

- Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso* (Vulnerable) within adjacent forest.
- Baudins White-tailed Black Cockatoo *Calyptorhynchus baudinii* (Endangered) within adjacent forest.

Any rehabilitation of the riparian vegetation will help to enhance the suitability of all sites for native fauna habitat.

Fish and freshwater crayfish

During February 2006, four sites were sampled on the Preston River for fish, freshwater fish and crayfish within the RAP study area (Morgan and Beatty, 2006). Three freshwater species were found in the Upper Preston River, all of which are endemic to South Western Australia. They are the Western Minnow (*Galaxias occidentalis*), Western Pygmy Perch (*Edelia vittata*) and Nightfish (*Bostockia porosa*) (Morgan and Beatty, 2006).

One estuarine fish species was found in the Upper Preston River due to the Leschenault Estuary acting as a nursery ground for numerous fishes of marine origin (Potter *et al* 2000). Within the Upper Preston River the South Western Goby (*Afurcagobius suppositus*) was captured (Morgan and Beatty, 2006).

Two species of freshwater crayfish were captured during this study, the Gilgie (*Cherax quinquecarinatus*) and the Marron (*Cherax cainii*). While the Gilgie was extremely widespread, the Marron was less abundant (Morgan and Beatty, 2006). The Gilgie is a species that can occupy a range of habitats as it is able to burrow in to the soil to escape habitats that dry out. The Marron in contrast, only occupies permanent water bodies that have

adequate water quality, especially dissolved oxygen levels (Morgan and Beatty, 2006).

No introduced species were captured in this study within the RAP study area. However, Mosquito fish (*Gambusia holbrooki*) were found within smaller tributaries of the Upper Preston River (Morgan and Beatty, 2006). The introduced mosquito fish is of serious concern to all South West waterways, as the species is extremely tolerant of poor water quality and efforts should be made to reduce or eradicate the population if possible.

In general, the flows in the Upper Preston River support good populations of native fishes. There is a distinct correlation between in-stream habitat and fish/crayfish populations, therefore any rehabilitation works such as erosion control using large woody debris, or planting of emergent vegetation such as rushes and sedges will increase the habitat values of the Upper Preston River. Fish habitat creation should be considered when planning any rehabilitation or restoration projects.

Heritage

Indigenous heritage

It is recognised that rivers and wetlands, their surrounding landscapes and storey lines are integral to the cultural and spiritual beliefs of Aboriginal people. Prior to European settlement, Noongyar people would have moved seasonally along the Brunswick, Collie, Ferguson and Preston rivers systems to the Leschenault Estuary which provided a rich summer food resource.

The Preston River was a common tribal boundary used to separate the Kaneang (north of the Preston River) and Wadandi (south of Preston River) tribes (WRC, WN30 2002), and the Preston River would have provided important trading routes, camping sites and sources of food.

For Aboriginal people, rivers were more than a landscape feature or a natural resource, they were part of their 'body and soul'. What is done to the land and water is repeated and reflected in the souls of the people (WRC, WN30, 2002). Of special significance in the south west is the story of the serpent like creature that created rivers and wetlands, leaving a path of water and giving life as it journeyed across the land in the Dreamtime (WRC, WN30, 2002).

European heritage

Donnybrook was named after a town in Ireland by the first European settlers in the region. They arrived in 1842 (Hardiman, 1982), with the intent of establishing farms on a 130ha grant. Unfortunately, luck was not with them and they abandoned the settlement in February 1843 (Ausmade internet, 2006). In the 1860's the timber industry developed and was responsible for developing stable communities within Donnybrook and outlying localities along the Preston River. By the early 1900's timber processing mills were established at Donnybrook, Queenwood and at Lowden along the Preston River (Frost, 1976). Many of the workers engaged in the timber industry eventually took to agriculture as their livelihood (Frost, 1976). A short lived gold rush occurring in 1897 lasted for about four years. The attraction for gold lured many people to the area boosting township numbers (Frost, 1976).

Apple trees were first planted in Donnybrook in the 1890's. Orchards then sprung up from Donnybrook to Bridgetown and along the Preston River, and the region became known as the states premier apple growing area (Austmade internet, 2006).

3. Study methodology

River foreshore condition assessment

The Pen-Scott method of riparian zone assessment was used. This system provides a graded description of the river foreshore from pristine (A grade) through to ditch (D grade). A summary of the grades of the Pen-Scott system follows (Pen & Scott, 1995; Water and Rivers Commission, 1999a). These are illustrated in Figure 3 and photographs on the following pages. This method allows comparisons of waterway health across the south west of Western Australia, and can be used to prioritise actions.

A grade foreshore:
Pristine – near pristine

A1: Pristine

Embankments and floodway are entirely vegetated with native species and there is no evidence of human presence or livestock damage.

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.

A3: Slightly disturbed

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:
Weed infested understorey but tree cover still in tact.

B1: Degraded

Understorey mainly natives - 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

Understorey 50% weeds – understorey weeds are about as abundant as native species. The regeneration of some tree and large shrub species may have declined.

B3: Degraded

Understorey 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:
Erosion prone to eroded

C1: Erosion prone

Trees remain, possibly with some large shrubs or grass trees, but 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 almost negligible. In this state, where short-lived weeds support the soil, a small increase in physical disturbance will expose the soil and render the river valley vulnerable to serious erosion.

C2: Soil exposed

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:
Ditch to drain

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 will 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 may have 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.

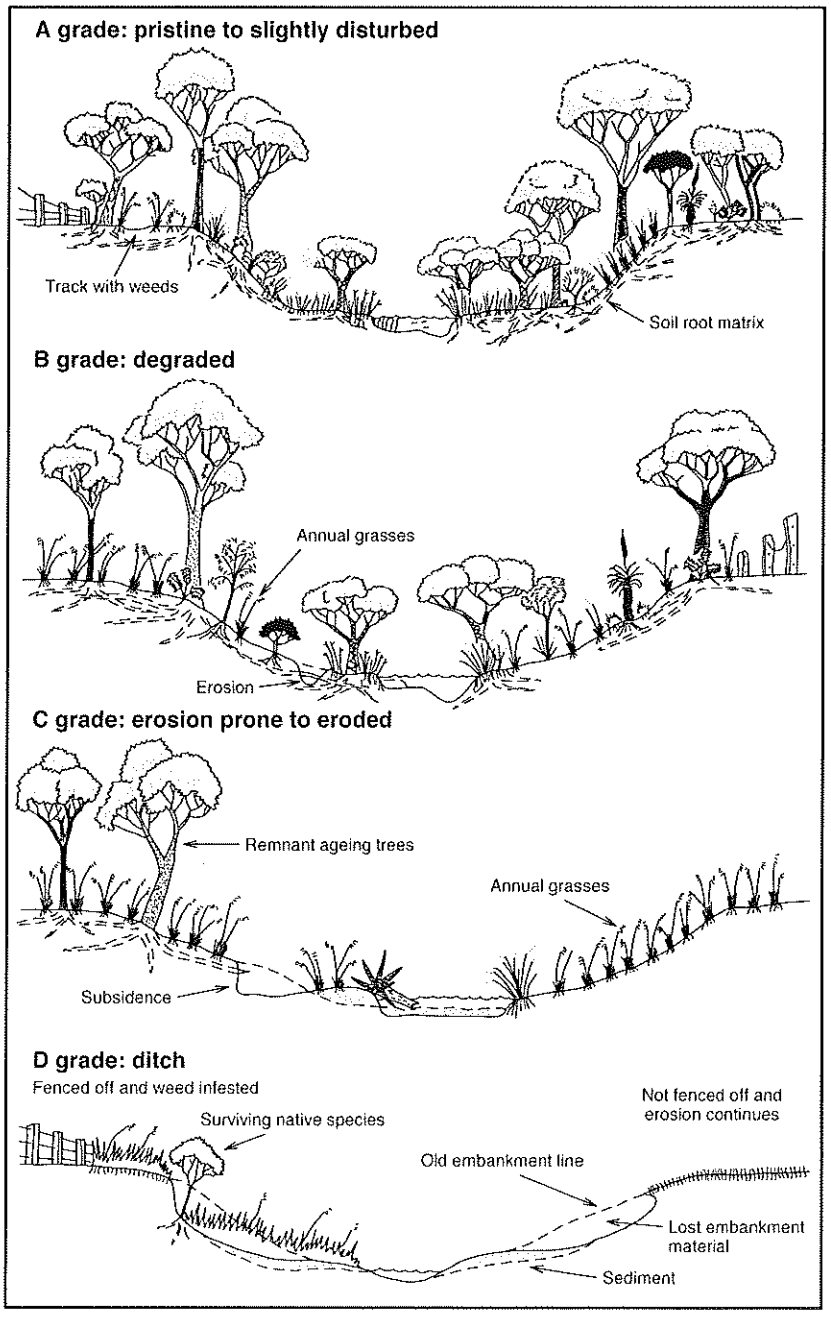

Figure 3: The four grades of river foreshore condition - (A) pristine to ditch (D).

A) A3 Grade foreshore: Note complete native vegetation cover which is essential to the health of the waterway. Localised weeds occurred in disturbed areas from small tracks and near the fence line from the edge effect from agriculture use adjacent to the river.

B) B1 Grade Foreshore: Understorey has large areas of weeds - pasture grasses, still healthy upper and mid storey structure of native vegetation.

C) B2 Grade foreshore: Weeds dominant in the understorey. Mid storey has a strong sign of disturbance within its structure.

D) B3 Grade Foreshore: The understorey is entirely dominated by weeds (pasture grasses) on top of the river bank, but many native mid storey species still remain as seen within the river channel.

E) C1 Grade Foreshore: Foreshore and within the river channel is trees over pasture. Recruitment levels of tree and understorey species is low due to stock access.

F) C2 Grade Foreshore: Foreshore and river channel consists of trees over pasture, there is evidence of erosion with deposition of sediment bars, exposed soil on river banks and cattle tracks.

G) C3 Grade Foreshore. Note the extensive bank erosion and the understorey consists entirely of annual weeds.

H) D1 Grade Foreshore: The channel has eroded away over time, leaving a weed (mainly annual grasses) infested drain. The occasional cluster of native shrubs and rushes occurs along the river edge.

Community involvement

Community involvement is an integral component of RAPs, and every effort was made to involve the community at each stage of this process from initial assessments to developing management recommendations.

Landholders adjacent to the Upper Preston River were sent letters inviting them to participate in the foreshore assessment. Ten landholders took part and they were able to provide invaluable historical and perceptive information about the river

Once the foreshore assessments were completed, a community workshop was held in November 2006 at the Donnybrook Hall to present findings and to seek feedback from the community about the project and management recommendations. Community representatives at the workshop were asked to provide information about what they felt were the major management issues on the Upper Preston River. The following points were raised by the community at the meeting and from phone calls:

- Loss of native vegetation and native animals;
- Weeds – including blackberry, watsonia, briar rose and bridle creeper;
- Erosion – erosion of river banks, loss of fencing and land;
- Water Quality – nutrients, pollution and salinity;
- Feral Animals – fox and rabbit numbers increasing and a lack of coordinated eradication management;
- Sedimentation – sediment in the river is being infested by couch grass which is blocking the natural flow of the river;
- Stock grazing on foreshores;
- Landholder apathy;
- Trees falling over in the river trapping sediment and causing changes in river flow;
- Mortality of *Eucalyptus rudis* (flooded gum), and
- Lack of government assistance and understanding of roles and responsibilities.

Using a three vote priority system at the meeting, the community was asked to prioritise each issue, the top 10 issues are listed in order of priority:

1. Weed Control;
2. Landholder apathy;
3. Stock grazing on foreshores;
4. Loss of native vegetation and native animals;
5. Flooded gum dieback;
6. Feral animal control;
7. Erosion;
8. Water quality;
9. Trees falling into river and
10. Government assistance and roles and responsibility.

In addition, it was unanimously agreed that financial assistance programs and links to the LCC were important to start restoration works. The workshop group further agreed that information should be distributed by developing:

- Pamphlets with focus on individual topics;
- Websites (web addresses so people know where to go to find information);
- One on one farm/site visits, and
- Demonstration sites (that have high community visibility).

These community concerns and management issues have been addressed in more detail in Chapter 4.

Previous Foreshore Assessment

In 1997 the Leschenault Catchment Coordinating Group (now LCC) surveyed the Preston River from Boyanup to the Glen Mervyn Dam. The goals of this early foreshore condition survey were to:

- Identify the priorities of the residents with respect to the river;
- Identify opportunities for cooperative action to improve the environmental management of the river, and

- Complete a base line study of river conditions and the condition of fringing vegetation identifying "good" and "bad" areas.

The project consulted and involved the community in the assessment of the foreshore of the Preston River. In general the Preston River was in reasonable condition with the following foreshore condition grades.

A Grade Foreshore	3%
B Grade Foreshore	52%
C Grade Foreshore	40%
D Grade Foreshore	5%

The project identified a number of significant threats and management issues which are still current, they were:

Threats

- The addition of sediment from agriculture, horticulture and orchard activities and digging pump holes;
- Clearing of fringing vegetation by fire and grazing, and
- Weed invasion.

Management Issues

- Learning how to work together;
- Using existing community organisations such as PVIC to support river repair work;
- Instituting a plan of revegetation and repair;
- Controlling stock access and fencing the river and
- Planning for fire management.

Why the need to do another survey?

The 1997 Preston River Survey was successful in providing a base line of foreshore conditions along the river but did not provide direction in the form of management advice and plans. The 1997 survey lacked technical direction and strategic information, and therefore was unable to develop community based projects in foreshore restoration which potentially could be funded through the federal and state governments. These factors along side a change in how the federal government drives the funding for natural resource management throughout Australia, lead to limited management of the river over the last ten years.

This new Upper Preston RAP provides a technical analysis and up to date assessment of foreshore condition grades that can be used by the LCC and the community to help identify future management strategies and projects for the Upper Preston River. This RAP will be a vital tool to managers to help meet the requirements for funding from the federal and state governments which will result in the much needed delivery of on the ground projects for the Upper Preston River.

The new RAP also provides a level of consistency with recent RAP's completed by Geocacth and the LCC, which aids in the equitable dispersal of funds for on ground works across the region.

4. Management issues

The Upper Preston River for the most part, is a highly degraded system and there are a number of management issues in the Upper Preston River Catchment, which vary according to landform, soils, past and current land use and management practices. These interrelated issues are summarised below.

Water extraction and allocation

The Department of Water (DoW) has the role of custodian and regulator of water in Western Australia. In 1946 the entire Preston River was proclaimed under the RIWI Act 1946. Within the RAP study area the river has two different allocation managers. The DoW licences the Preston River upstream of the confluence with Lyalls Mill Stream, thus irrigators are required to apply for a surface water licence from the DoW. Watering for stock and domestic use are considered a riparian right and not licensed.

Prior to 1998 the Water Corporation supplied irrigation water downstream of Glen Mervyn Dam (Lyalls Mill Stream) to Argyle on the Preston River (west of the study area). There after, this function was taken over by the irrigators through a formally constituted co-operative known as the (Preston Valley Irrigators Cooperative (PVIC). Typically irrigators are allocated a quota and authorised to pump water from Lyalls Mill Stream and the Preston River. In 2001 there were 66 allocations totalling 1,460ML. These allocations ranged from 2ML to 120ML (Halliburton, 2002).

The irrigators were surveyed in 2002 by Halliburton (2002) and the following issues were raised as their main concerns:

- Water availability (future supplies and irrigation practices);
- Water quality (fertiliser and other agriculture chemical management), and
- Riverine management (condition of the riparian vegetation and the lack of fencing and weed control).

Environmental and stream flows

Environmental flows are often referred to as Ecological Water Requirements (EWRs). EWR's are defined as the water regime needed to maintain ecological values of water dependent ecosystems at a low level of risk (WRC, 2001). In 2003, the Water Corporation commissioned a study of EWR's on Lyalls Mill Stream to the Preston River and downstream to Argyle (PVIC operating area). This study concluded that the EWR's were more than adequately maintained by the present flow regime, hence the current water flows are capable of sustaining ecological life within the Preston River.

However, a number of catchment management issues raised during the study identified the main causes of the current ecological degradation in the Preston River. They were:

- Riparian vegetation clearing;
- Uncontrolled livestock access to the river;
- Sedimentation;
- Bank instability;
- Weed invasion, and
- Many reaches were considerably incised (meaning the river bed has lowered) and the resultant sediment has filled in downstream pools (Water Corporation, 2002).

Overall the study concluded that the Preston River was "valuable", being one of the few remaining mid-sized river systems in south west Australia which has not been significantly impacted by secondary salinisation. As such, the river warranted a concerted restoration effort (Water Corporation, 2002).

Stream flows within the Preston River have been monitored by the Department of Water sporadically since 1939 and continuously since 1968 by a stream gauging network (Garbutt 2006, pers. comm.). Analysis of the gauging stations and hydrological records for the Upper Preston River by the Water Corporation (2002) showed an unregulated catchment, where rainfall and stream flows are highly seasonal and predictable. The peak flow occurs between June to October in every year and the river still maintains a natural flow state throughout the year, this is peak flow in winter and low flows in summer / autumn.

Since European settlement, stream flows have been shown to increase along the coastal plain. This increase in flow is considered to be due to widespread catchment clearing leading to rising water tables and consequently

more water being transmitted through the rivers (Water Corporation, 2002). Thus increased flows and poor catchment management practices have lead to the considerable channel incision (river bed lowering) which is widespread throughout the region. From a river flow perspective it will now require a substantial increase in water to attain a bankfull stage height compared to pre-European conditions. This means that the riverbanks now have breaches less often as the incised channels can carry a greater volume of water (Water Corporation, 2002).

Water Quality Issues

In the Upper Preston River water quality was sampled routinely from 1995 through to 2000 by the DoW. Since then water quality has only been sampled routinely by the DoW at Boyanup. Paice, (2000) reviewed the water quality data for the Upper Preston River, the results are shown in the following Table 3.

Paice, (2000) described the total nitrogen and phosphorus concentrations as being very low in the Upper Preston River, with the occasional peak value. These peak values were moderate to high levels indicating that significant amounts of organic matter were being transported in the catchment. Sedimentation levels were low with a consistent peak in levels during winter (up to 155mg/l). These results indicate an erosion problem in the Preston River associated with rising flows. The Upper Preston River was generally fresh, but records indicated isolated areas of elevated salinity in the river.

Within the water quality review blue-green algae was reported at low densities throughout most of the monitoring period between 1995 - 2000. A significant algal bloom of filamentous blue green algae at Lowden was recorded in December 1997 (67 000 cells/ml). The author while walking the Preston River found a macroalgae bloom of Rhizoclonium. The bloom was immediately downstream of a drain and would be the result of nutrient seepage from agriculture landuse.

Table 3: Summary of water quality data for the Upper Preston River taken from Paice (2002)

	Indicators for:	1996 -98	1997 - 99
Total nitrogen	Pollution		
	Eutrophication	Very low	Very low
Total phosphorus	Pollution		
	Eutrophication	Very low	Very low
Dissolved oxygen	Pollution		
	Important to sustain life	Life sustaining	Life sustaining
Salinity	Pollution		
	Agriculture farmimg limits		
	Ecological limits	Fresh	Fresh
Total suspended solids	Sedimentation	No data	Very low
Chlorophyll-a	Algal blooms		
	Eutrophication	Low	Low
Silica	Pollution	No data	Low
Dissolved organic carbon	Pollution	No data	Low

Macroalgal bloom (Rhizoclonium) Preston River July 2006

Water quality sampling is important for the future management of the Upper Preston River, as water quality data provides information to catchment managers and landholders about the condition of the waterway. In the Upper Preston River the key water quality issues are:

- Total suspended solids (detects sedimentation / erosion);
- Salinity (agriculture and ecological limits);
- Dissolved oxygen (life sustaining), and
- Total nitrogen & phosphorus, and dissolved organic carbon (detects enrichment of waterways).

Erosion & Sedimentation

While some level of erosion and deposition is natural in any waterway, the acceleration of these processes can cause management problems. As noted previously, wide-scale clearing of vegetation in the catchment has resulted in increased river flows causing significant incision and erosion. Disturbance from stock and clearing of fringing vegetation has led to erosion with undercutting and slumping of banks. Issues associated with erosion problems include:

- loss of valuable soil;
- loss of fences as the water course deviates;
- poor water quality resulting from increased turbidity and nutrients;
- loss of habitat areas due to the silting up of the channels/pools;
- filling of summer pools;
- increased channel width and loss of agricultural land;
- reduced visual amenity and recreational sites associated with the waterways, and
- further loss of native riparian vegetation as severe erosion problems cause subsidence.

Stock access

Stock have access to most of the Upper Preston Rivers riparian vegetation and the River. A number of problems can arise as a result of unrestricted stock access. They include:

- loss of native fringing vegetation;
- weed invasion;
- compacted soils;
- nutrient enrichment;
- erosion, and
- poor water quality.

Loss of native fringing vegetation

Although parts of Reach 1 in the Upper Preston River (between Donnybrook and Beelerup Road, page 23), have an intact vegetation structure, most of the vegetation is degraded to some degree through weed invasion, clearing, stock access or erosion. In many areas within the study area there is a healthy overstorey of mature trees but little else, while in some areas there is no native vegetation at all. It is important to retain and enhance riparian vegetation as it has many values including: erosion control, dissipating flow, sediment and nutrient retention and providing habitat for many species. The loss of the vegetation community along the Upper Preston River is of concern as only 4% of this vegetation community remains (Mattiske and Havel, 1998).

Weed invasion

Large numbers of weeds were found during the foreshore surveys. Most of these are shown on the maps in Chapter 6. Disturbance through clearing, grazing, erosion and modification of the channel provides ideal conditions for weed growth and spread. The main weeds of concern in the study area are blackberry, watsonia, briar rose, bridle creeper, arum lily, exotic trees, and grasses such as kikuyu and couch.

Weeds compete with native vegetation, restrict natural regeneration and have a high annual biomass which can increase fuel loads significantly in comparison to native vegetation. They are a significant factor in the degradation of remnant vegetation and are a major threat to biodiversity. In addition, they are a major economic cost to society. According to a recent study (Sinden et al., 2004) the economic cost of weeds in Australia is approximately $4,000 million annually. This includes the costs of control and losses in output in agricultural land ($3,927 million), the cost of control in the natural and built environment ($104 million) and the amount spent on research and development ($8 million). It does not include the considerable amount of volunteer time and labour donated by community groups and landholders in controlling weeds.

All revegetation activities need to include strategic weed management actions to increase the survival rate of plantings and to reduce long-term management activities. If grassy weeds infest a revegetation site, they will out-compete the native vegetation, and may lead to a fire hazard. For more information on weed control, refer to Chapter 5.

Fire

The use of fire was noted to be a common practice along the river. The information below is largely taken from the Wetlands and Fire Water Note WN2 (Water and Rivers Commission, 2000).

Fire needs to be carefully managed in order to maintain plant and animal communities, wetland functions and landscape character. Fire can be a useful management tool, indeed it is an essential factor in the ecology of south-west ecosystems. It is needed to stimulate regeneration and regrowth in native vegetation and create a diversity of fauna habitats. However, if it is used inappropriately (too much burning) it can lead to a loss of habitat and species diversity, native seed and peat soils and in some circumstances endanger human life and property. Frequent fires often contribute to weed invasion and the loss of native plant species. A good understanding of the impact of fire upon riparian ecology is required before considering using fire as a management tool.

Advantages of fire in the riparian zone

Fire:

- May trigger seed release and germination in some species;
- Stimulates the development of new green shoots, roots and rhizomes of grasses and sedges producing a food source for waterbirds;
- May create pools for nesting and feeding waterbirds, and
- Can provide favourable habitat for some waterbirds by eliminating impenetrable growth of plants such as sedges, rushes and weed infestations.

Disadvantage of fire in your wetland

Fire can lead to:

- Loss of seed as a consequence of inappropriate timing of fires;
- Degradation or loss of peats (organic rich soils);
- Increased predation of seed by insects;
- Fungal attack on seeds;
- Changes in vegetation composition and structure;
- Exposure of roots and rhizomes;
- Loss of vegetation, resulting in reduced biofiltering of incoming surface water flows;
- Erosion of soil and increased turbidity in the waterway;
- Increased weed invasion;
- Destruction of fauna habitat used for breeding, feeding and shelter, and
- Death of fauna, and an increase in water temperature as a result of the loss of vegetation and shade.

5. River foreshore condition and recommendations for management

Using the maps

The following page provides an index for the maps, and an overview of the conditions of the Upper Preston River. For a summary of the condition rating and%age of the Upper Preston River that is fenced to exclude stock, see Table 1 and Table 2 in the Summary.

Maps 1 to 4 show the Upper Preston River catchment, the main channel and the adjoining land titles.

The maps show the foreshore condition of the waterways as assessed using the Pen-Scott method (see Chapter 3 for details of the method of assessment). Weeds and management issues are also shown, and a legend is provided.

The background aerial photos of the map were taken in 2003 and these are available for purchase from the Department of Land Information (www.dli.wa.gov.au).

The photographs on the maps were taken from each of the corresponding sections of the river in July 2006.

Management recommendations

The notes accompanying each map contain background information, the current condition of the river and management recommendations. These management recommendations can be used by a range of organisations as well as landholders.

5. River foreshore condition and recommendations for management

Using the maps

The following page provides an index for the maps, and an overview of the conditions of the Upper Preston River. For a summary of the condition rating and%age of the Upper Preston River that is fenced to exclude stock, see Table 1 and Table 2 in the Summary.

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The photographs on the maps were taken from each of the corresponding sections of the river in July 2006.

Index Map

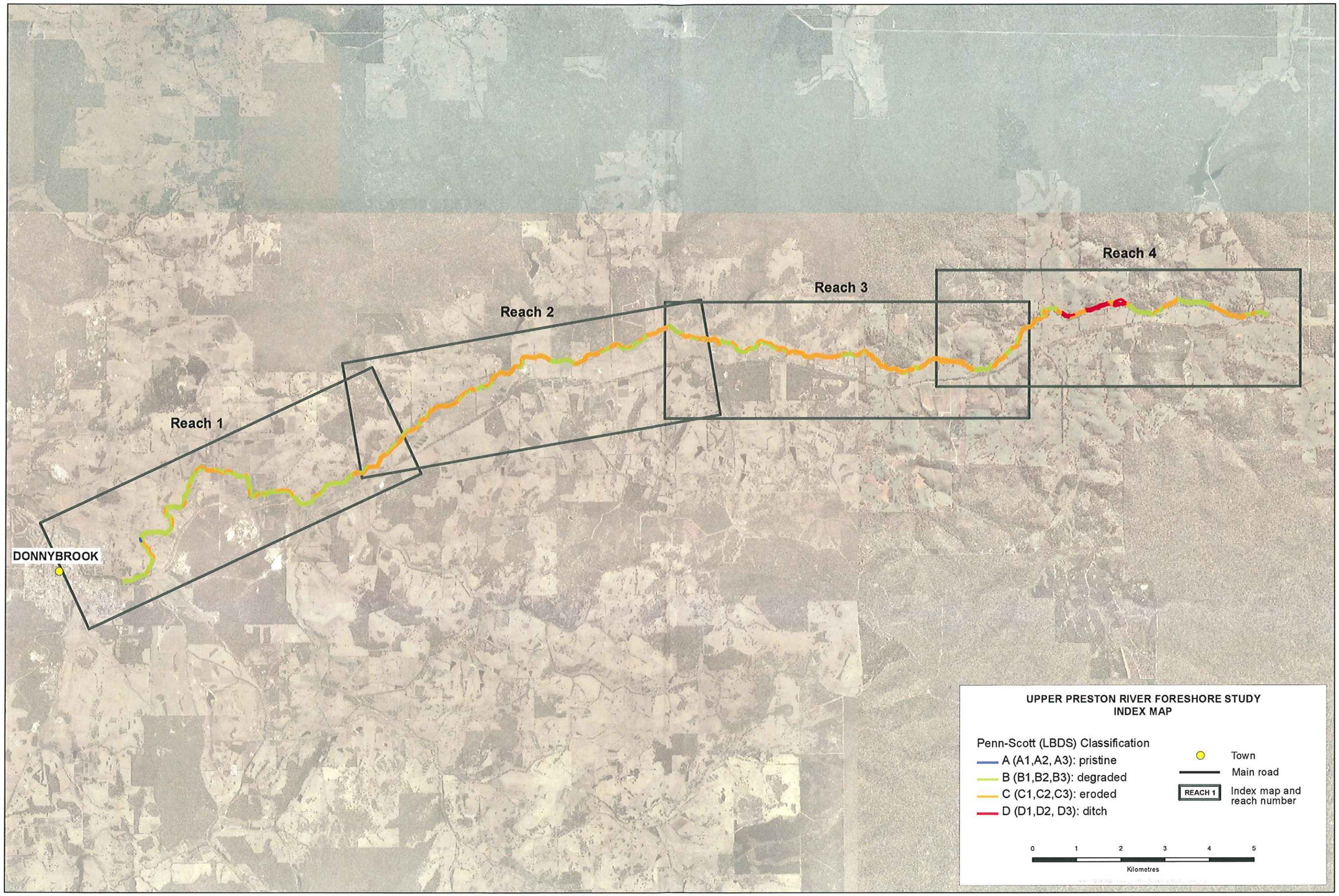
UPPER PRESTON RIVER FORESHORE STUDY

LEGEND

Foreshore condition

- A1: pristine
- A2: near pristine
- A3: slightly disturbed
- B1:degraded - weed infested
- B2: degraded - heavily weed infested
- B3: degraded - weed dominated
- C1: erosion prone
- C2: soil exposed
- C3: eroded
- D1: ditch - eroding
- D2: ditch - freely eroding
- D3: drain - weed dominated

- Reach start and end points
- Main road
- Other road
- Fencing along river bank
- Tributary
- blackberry — Weed
- riffle — Comment
- B3 — Foreshore condition marker


Reach 1
Reach 2
Reach 3
Reach 4
DONNYBROOK
UPPER PRESTON RIVER FORESHORE STUDY
INDEX MAP
Penn-Scott (LBDS) Classification
A (A1,A2, A3): pristine
B (B1,B2,B3): degraded
C (C1,C2,C3): eroded
D (D1,D2, D3): ditch
Town
Main road
REACH 1
Index map and reach number
0 1 2 3 4 5
Kilometres

Index Map

Reach 1

Reach 1

Reach 1 extends from Donnybrook Townsite to Charley's Creek.

Description

Feature	Comments
Landuse	Horticulture and grazing dominate both foreshores. Apple's are the main fruit grown. Beef is the main grazing animal, with some sheep.
Land tenure	There are crown reserves on the river which are classified as unallocated crown land, and are unvested and remain the responsibility of the Department of Land Information. The adjacent lots to the foreshore reserves are privately owned.
Fencing	Both sides of the river had some fencing. Some properties were completely fenced and had stopped grazing activities on the foreshore, while other properties were partially or not fenced allowing unrestricted access to the foreshore by cattle.

Condition

Feature	Comments
Vegetation	The foreshore in this reach was in the best condition overall. The vegetation consisted of a continuous upper canopy of flooded gums, marri, bullich and blackbutts. The main mid storey species was Astartea and swamp tea tree occurring within the channel and along the banks. Thick patches of sword sedge occurred at the top of the banks. The understorey had a high level of weeds with sparse clumps of native sedges and rushes.
Weeds	Blackberry, watsonia, pampas grass, feral trees, bridle creeper and sections of thick grass/ bracken fern infestations.
Bank stability & erosion	Bank subsidence occurred commonly throughout this reach. Causes for this were: 1. loss of vegetation to help bind the soil; 2. groundwater seepages causing instability in the soil structure; 3. cattle trampling vegetation, compacting the soil, cattle tracks causing banks to become exposed and unstable. There was little base flow protection in the main channel, exposing soil to high velocity flows. There were many sediment bars throughout the reach. (Sediment bars can cause erosion by deflecting high flow water onto the river banks causing scouring.) The high levels of sediment in the river were from an incising river bed and bank subsidence. Many log jams occurred throughout the reach. The majority of log jams were helpful, creating natural riffles and sections for the sediment bed load to be deposited. A few log jams were deflecting water into the bank causing erosion, if left unchecked the river will correct itself in most cases. Revegetation along these banks will assist in stabilising these areas.
Special features, other comments	Much of the foreshore in this reach has the potential to be rehabilitated as it is within the "B" foreshore condition and would provide an excellent wildlife corridor linking into the Donnybrook Townsite. Rabbit warrens were evident along this section and control is required. The practice of dumping old fruit trees and clippings along the foreshore occurred throughout the reach.


BEELERUP ROAD
BEELERUP ROAD
C2
B3
B3
C1
C2
Fire on foreshore
C1
B3
Steep bank erosion
C2
Bank erosion
B3
C2
feral trees
B3
Fire on foreshore
C1
Periodical bank subsidence
C2
B3
B2
C3
Fence in river, needs repairs
A3
B2
Rabbit warrens
B3
C1
pampas grass
B2
feral fruit trees
C2
Fences need repairing
PRESTON ROAD
DONNYBROOK-BOYUP BROOK ROAD
START OF REACH 1
River restoration site (toe protection and revegetation)
blackberry watsonia grasses
B3
Erosion area, some restoration
B3
B3
B2
B2
C2
B3
blackberry
B2
HIGHWAY
Subsidence top of bank (groundwater subsidence)
FROST ROAD
WESTERN
SOUTH

Feature	Comments
Restoration Sites	Restoration on both sides of the river occurred at the start of Reach 1 in 1997/98. Bank recontouring and stabilisation works took place using heavy machinery and plantings followed. Bank stabilisation occurred adjacent to Lot 10 on Diagram 80263, Queenwood. The banks were stabilised using rock pitching from the bank toe to bank full, although little revegetation has taken place.

Please note "encourage" and "support" can mean to; provide financial support, education or technical advice, depending on the resources available.

Management

Issue	Management Action/Advice
Weeds	• Currently, DAFWA is conducting weed management of blackberry in the area. Continuation and expansion of the program to include environmental weeds, such as watsonia and pampas grass is required. • The LCC could arrange a bridle creeper eradication day releasing the leaf hopper and rust. • Encourage Local Governments and State Governments to fulfil their obligations to properly manage declared weeds and priority weeds. • Provide support and education to landholders on how to properly manage their declared weeds. • Support local community groups and weed action groups in weed management. • Target blackberry, bridle creeper, pampas grass and watsonia as a priority in this area. • Encourage PVIC to become involved in weed management.
Loss of native vegetation	• Assist regeneration of native vegetation and expand the riparian zone through planting of local native species. Appendix 1 contains a list of local species suitable for planting. (See Chapter 5 for detailed techniques and information.) In particular, planting a variety of understorey species, including rushes and sedges, is a priority in areas degraded by weed invasion or have had past stock access. • Encourage PVIC to become involved in riparian management and revegetation programs.
Fish & macro - invertebrates	• Increase fish and macroinvertebrate habitats by encouraging rehabilitation works, such as erosion control using large woody debris or planting of emergent vegetation such as rushes and sedges.
Declining water quality	• Encouraging the use of best management practices (BMP) on farms to increase water quality and river health. The DAFWA, Water management BMP includes the management of on-farm issues such as, erosion, nutrient inputs, vegetation, grazing and water sources. See Appendix 6 for a comprehensive list of farm BMP. • Encourage the DoW and PVIC to sample for water quality parameters in the Upper Reaches of the Preston River and ensure the program monitors for sediment.

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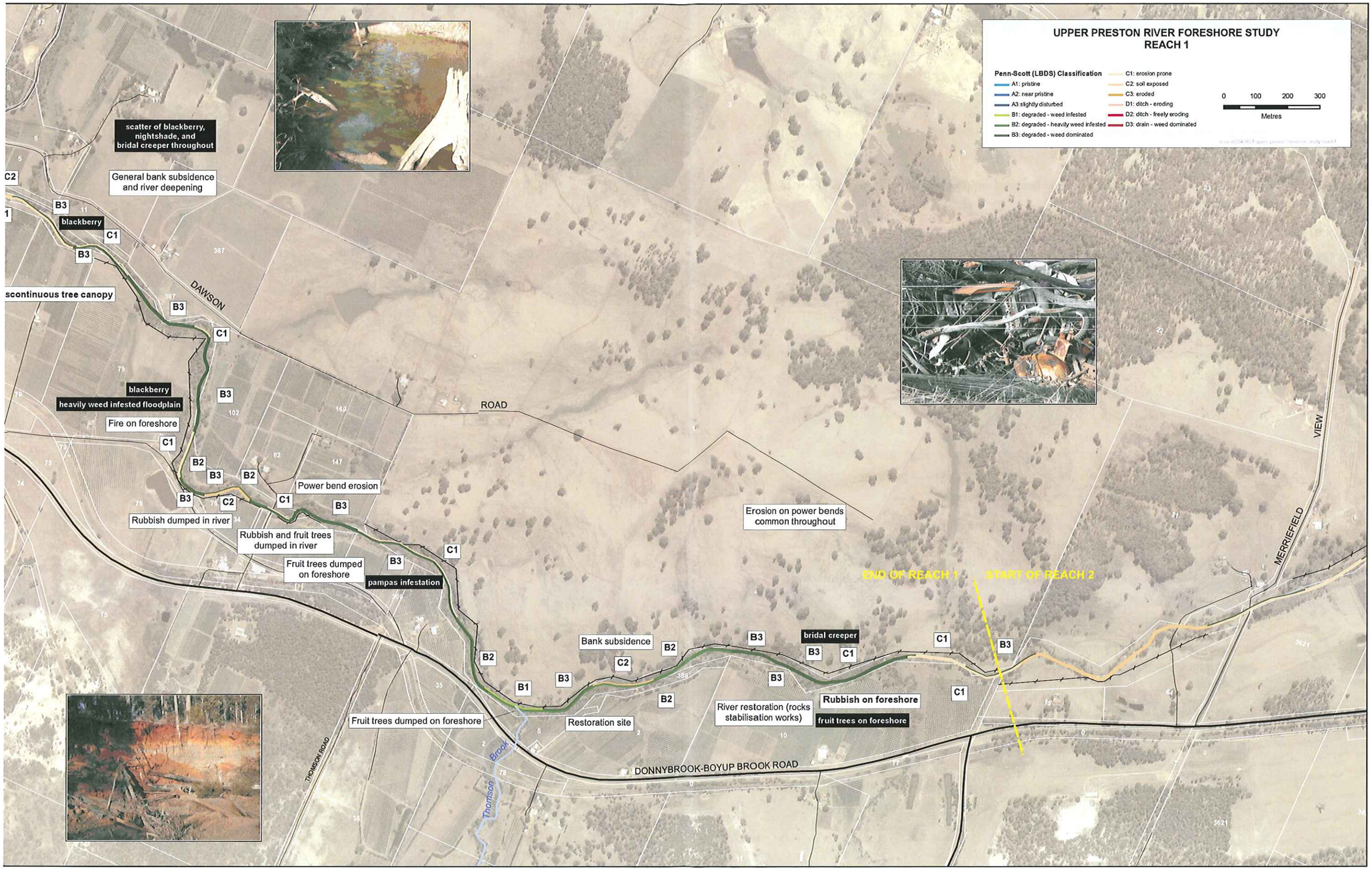

UPPER PRESTON RIVER FORESHORE STUDY
REACH 1
Penn-Scott (LBDS) Classification
A1: pristine
A2: near pristine
A3: slightly disturbed
B1: degraded - weed infested
B2: degraded - heavily weed infested
B3: degraded - weed dominated
C1: erosion prone
C2: soil exposed
C3: eroded
D1: ditch - eroding
D2: ditch - freely eroding
D3: drain - weed dominated
0 100 200 300
Metres
scatter of blackberry, nightshade, and bridal creeper throughout
General bank subsidence and river deepening
blackberry
scontinuous tree canopy
DAWSON
ROAD
blackberry
heavily weed infested floodplain
Fire on foreshore
Power bend erosion
Rubbish dumped in river
Rubbish and fruit trees dumped in river
Fruit trees dumped on foreshore
pampas infestation
Erosion on power bends common throughout
END OF REACH 1
START OF REACH 2
MERRIEFIELD
VIEW
Bank subsidence
bridal creeper
River restoration (rocks stabilisation works)
Rubbish on foreshore
fruit trees on foreshore
Fruit trees dumped on foreshore
Restoration site
THOMSON ROAD
Thomson Brook
DONNYBROOK-BOYUP BROOK ROAD

Reach 1

Reach 2

Reach 2

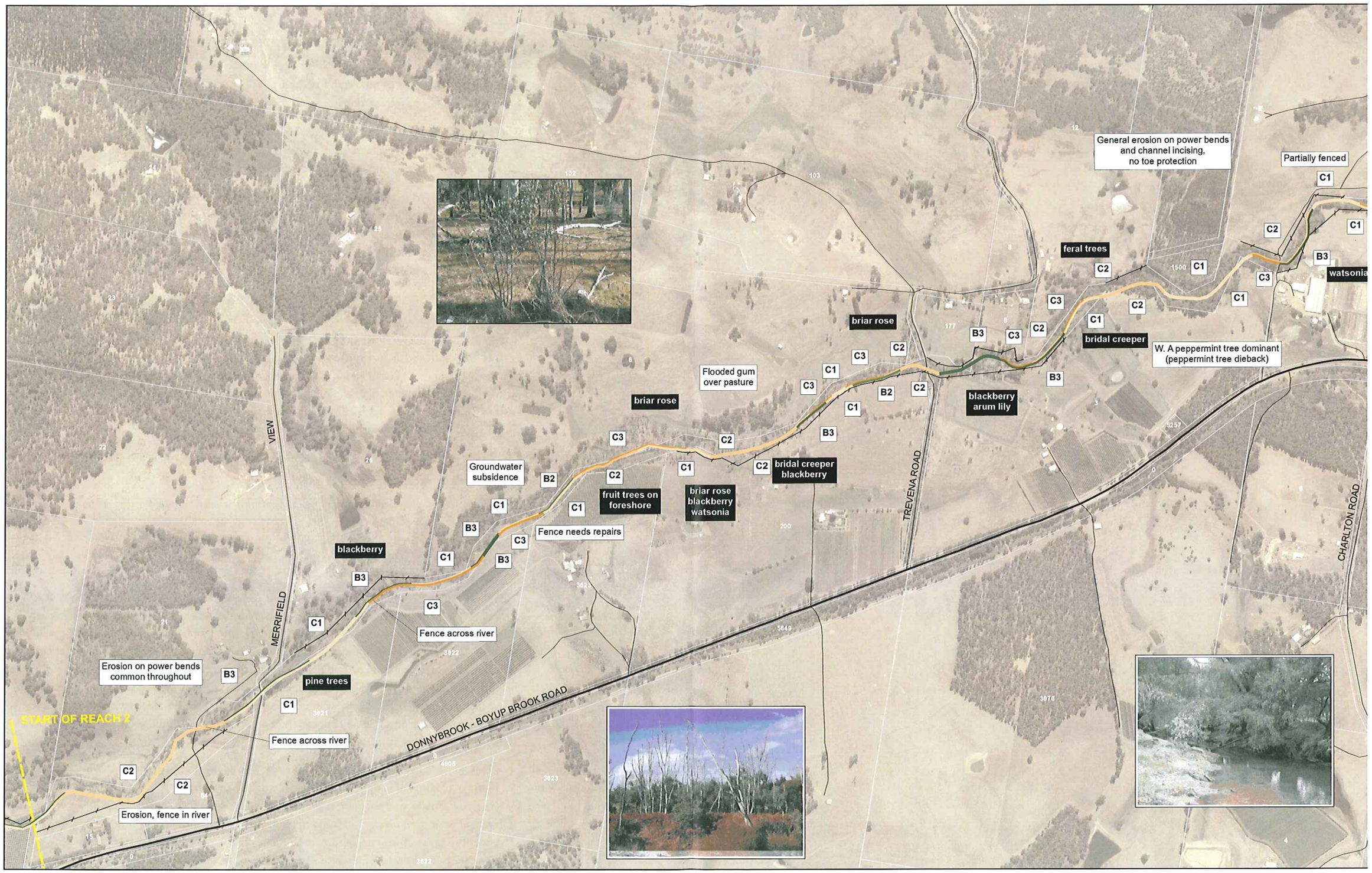
Reach 2 extends from Charleys Creek to west of Lowden Road

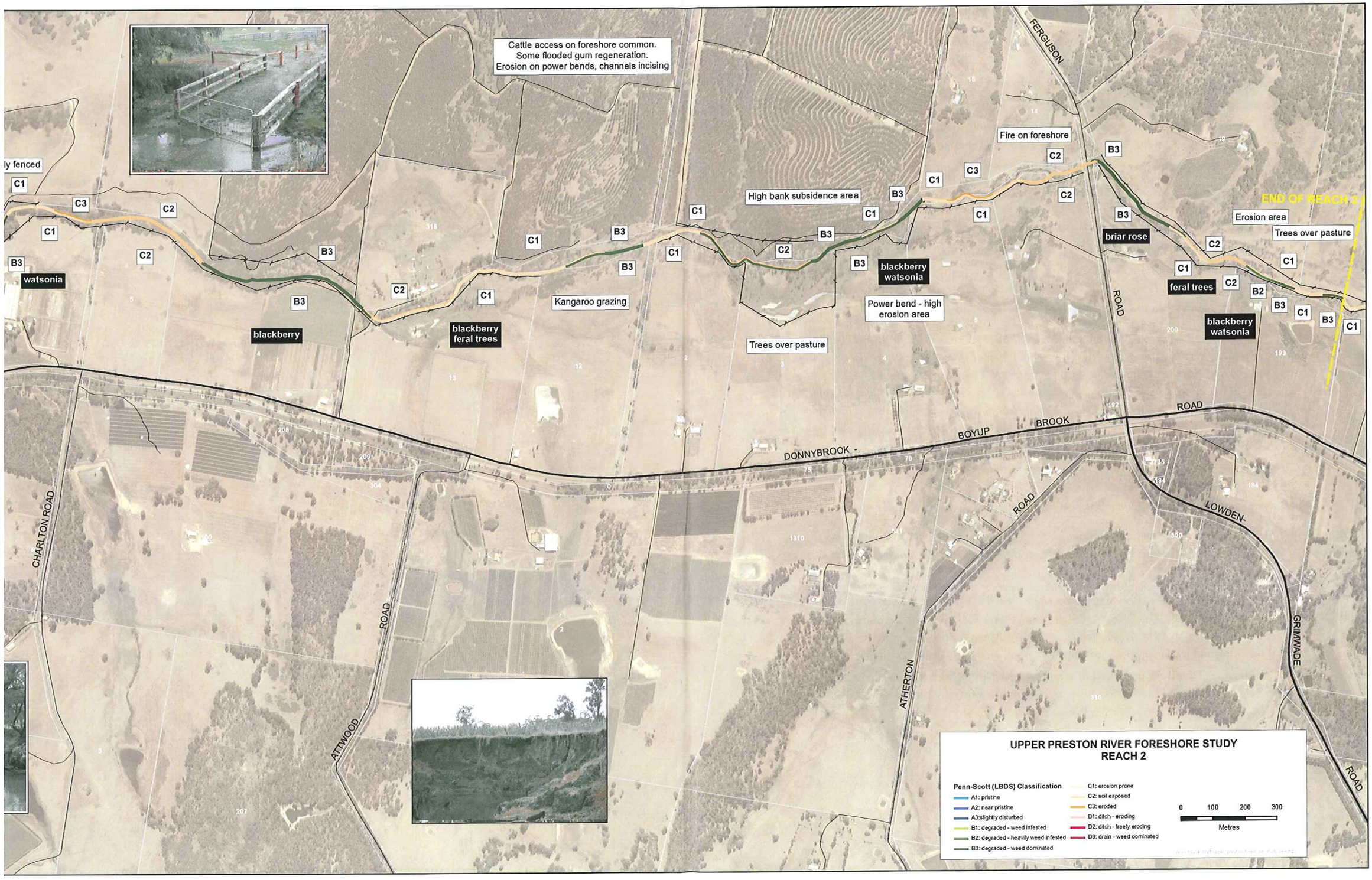
Description

Feature	Comments
Landuse	Agricultural land dominates both foreshores. Horticulture, beef and sheep grazing are dominate, two forestry plantations exist on the north side of the river.
Land tenure	There are crown reserves on the river which are classified as unallocated crown land, and are unvested remaining the responsibility of the Department of Land Information. The adjacent lots to the foreshore reserves are privately owned.
Fencing	Both sides of the river had some fencing. Some properties were completely fenced but still allowed grazing activities on the foreshore, while other properties were partially or not fenced allowing unrestricted access to the foreshore by cattle.

Condition

Feature	Comments
Vegetation	The foreshore in this reach was in poor condition. In some areas the foreshore vegetation was restricted to scattered trees over pasture. The vegetation consisted mainly of flooded gums, marri and blackbutts. The main mid storey species was Astartea and swamp tea tree, occurring within the channel and along the banks. The understorey had a high level of weeds. Sections of the river were dominated with WA peppermint tree that had 'peppy dieback' damage. Flooded gums were regenerating, however little recruitment was noted.
Weeds	Blackberry, briar rose, pine trees, fruit trees, watsonia, bridal creeper, arum lily, feral trees and sections of thick grass/ bracken fern infestation.
Bank stability erosion	Bank subsidence occurred commonly throughout this reach. Causes for this were: 1. loss of vegetation to help bind the soil; 2. groundwater seepages causing instability in the soil structure; 3. cattle trampling vegetation, compacting the soil, cattle tracks causing banks to become exposed and unstable. There was little base flow protection in the main channel, exposing soil to high velocity flows particularly on the power bends. There were many sediment bars throughout the reach. (Sediment bars can cause erosion by deflecting high flow water onto the river banks causing scouring.) The high levels of sediment in the river were from an incising river bed and bank subsidence. Many log jams occurred throughout the reach. The majority of log jams were helpful, creating natural riffles and natural barriers for the sediment bed load to be deposited. A few log jams were deflecting water into the bank causing erosion, if left unchecked the river will correct itself in most cases. Revegetation along these areas will assist in stabilising the banks, and preventing further land loss.
Special features, Restoration Sites	• A section had a large area of WA peppermint trees as the dominate species. This area could be a habitat area for the endangered ring tail possum. • Kangaroo activity was common throughout the foreshore. • Fire had been used on the foreshore to control the weed burden, this produced large sections of areas of soil exposed to potential erosion. All areas burnt provided stimulation for the weeds, no native vegetation recruitment was seen. • No active restoration works were evident.


General erosion on power bends and channel incising, no toe protection
Partially fenced
feral trees
watsonia
bridal creeper
W. A peppermint tree dominant (peppermint tree dieback)
briar rose
Flooded gum over pasture
blackberry arum lily
briar rose
Groundwater subsidence
fruit trees on foreshore
briar rose blackberry watsonia
bridal creeper blackberry
Fence needs repairs
blackberry
Fence across river
Erosion on power bends common throughout
pine trees
START OF REACH 2
Fence across river
Erosion, fence in river
VIEW
MERRIFIELD
TREVENA ROAD
CHARLTON ROAD
DONNYBROOK - BOYUP BROOK ROAD


Cattle access on foreshore common.
Some flooded gum regeneration.
Erosion on power bends, channels incising
ly fenced
C1
C3
C2
B3
watsonia
blackberry
blackberry feral trees
Kangaroo grazing
High bank subsidence area
Trees over pasture
blackberry watsonia
Power bend - high erosion area
Fire on foreshore
FERGUSON
ROAD
briar rose
END OF REACH 2
Erosion area
Trees over pasture
feral trees
blackberry watsonia
B2
DONNYBROOK - BOYUP BROOK ROAD
CHARLTON ROAD
ATTWOOD ROAD
ATHERTON ROAD
LOWDEN-GRIMWADE ROAD
UPPER PRESTON RIVER FORESHORE STUDY
REACH 2
Penn-Scott (LBDS) Classification
A1: pristine
A2: near pristine
A3:slightly disturbed
B1: degraded - weed infested
B2: degraded - heavily weed infested
B3: degraded - weed dominated
C1: erosion prone
C2: soil exposed
C3: eroded
D1: ditch - eroding
D2: ditch - freely eroding
D3: drain - weed dominated
0 100 200 300
Metres

Reach 2

Please note "encourage" and "support" can mean to; provide financial support, education or technical advice, depending on the resources available.

Management

Issue	Management Action/Advice
Weeds	• Encourage Local Governments and State Governments to fulfil their obligations to properly manage declared weeds and priority weeds on their land. • Encourage the DAFWA to continue with its blackberry control program. • Provide support and education to landholders on how to properly manage their declared weeds and use of fire on foreshores. • Support local community groups and weed action groups in weed management. • Target blackberry, briar rose, bridle creeper, watsonia, arum lily and feral trees as a priority in this area. • The LCC could arrange a bridle creeper eradication day releasing the leaf hopper and rust. • Encourage PVIC to become involved in weed management.
Fencing/loss of native vegtation	• Where stock is present, continue to fence off the creek to restrict stock access and provide off river watering points for stock to minimise bank damage and protect water quality. • Assist regeneration of native vegetation and expand the riparian zone through planting of local native species. Appendix 1 contains a list of local species suitable for planting. See Chapter 5 for detailed techniques and information. In particular, planting a variety of understorey species, including rushes and sedges, is a priority in areas degraded by weed invasion or past stock access. • Educate landholders on controlled grazing techniques to control weed burden and fuel loads within the foreshore. • Encourage PVIC to become involved in riparian management and revegetation programs.
Fish & macro-invertebrates	• Increase fish and macroinvertebrate habitats by encouraging rehabilitation works such as erosion control using large woody debris, or planting of emergent vegetation such as rushes and sedges.
Declining water quality	• Encourage the use of best management practices (BMP) on farms to increase water quality and river health. The DAFWA, Water management BMP includes the management of important on-farm issues such as, erosion, nutrient inputs, vegetation, grazing and water sources. See Appendix 6 for a comprehensive list of farm BMPs. • Encourage the DoW and PVIC to sample water quality parameters in the Upper Reaches of the Preston River and ensure the program monitors for sediment.

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Reach 3

Reach 3

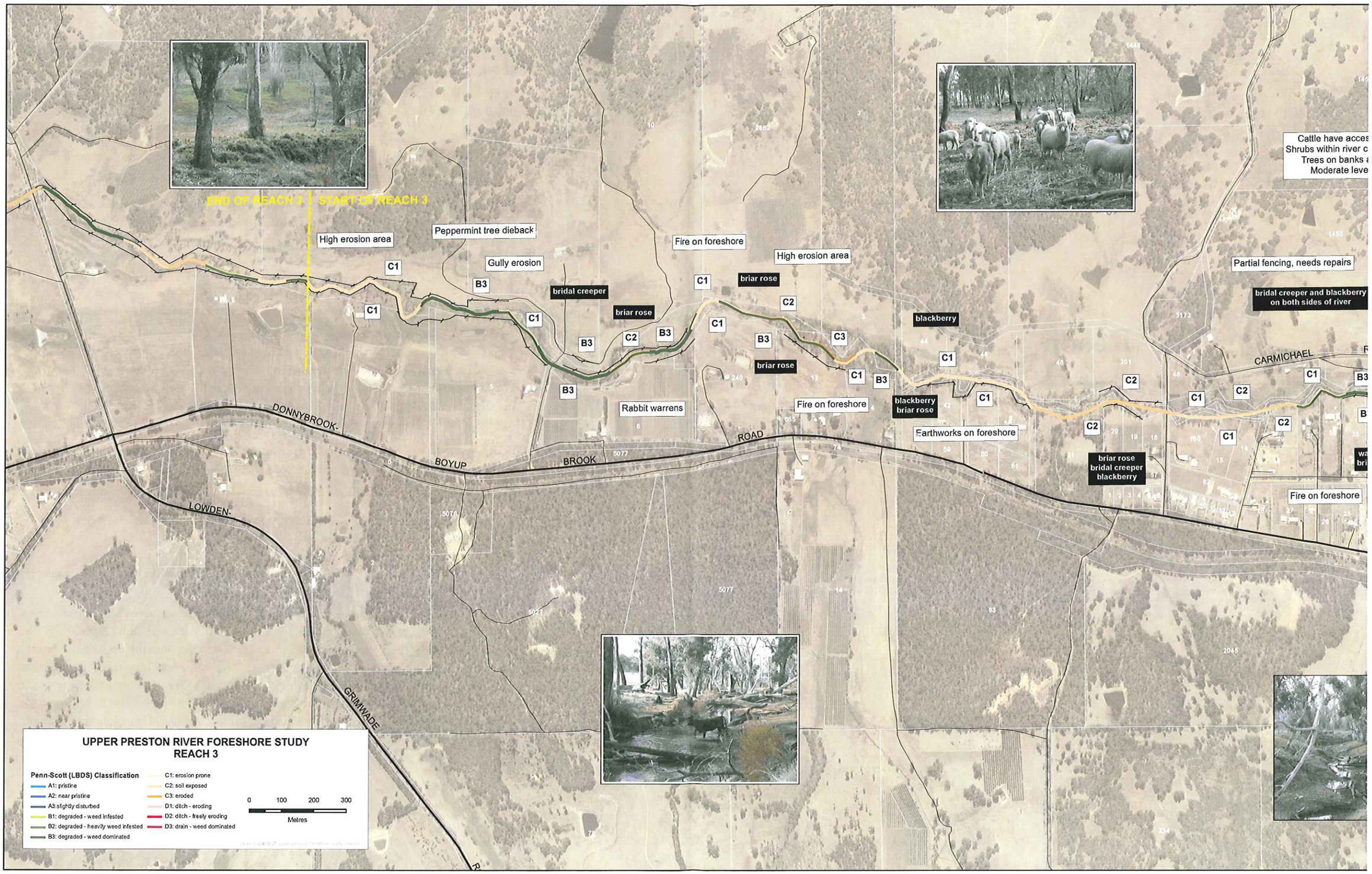
Reach 3 extends from west of Lowden Road to west of Nioka Drive

Description

Feature	Comments
Landuse	Agricultural land dominates both foreshores. Horticulture, beef and sheep grazing are dominate. A small rural residential area occurs at Lowden.
Land tenure	There are crown reserves on the river which are classified as unallocated crown land, and are unvested and remain the responsibility of the Department of Land Information. The adjacent lots to the foreshore reserves are privately owned.
Fencing	Both sides of the river had some fencing. Some properties were completely fenced and had stopped grazing activities on the foreshore, while other properties were partially or not fenced allowing unrestricted cattle access to the foreshore.

Condition

Feature	Comments
Vegetation	The foreshore in this reach was in poor condition. In some areas foreshore was restricted to scattered trees over pasture. The vegetation consisted mainly of flooded gums, marri and blackbutts. The main mid storey species was Astartea and swamp tea tree, occurring within the channel and along the banks. The understorey had a high level of weeds. Flooded gums were regenerating, however little recruitment was noted.
Weeds	Blackberry, briar rose, pine trees, fruit trees, watsonia, bridal creeper, arum lily, feral trees, bamboo and sections of thick grass/ bracken fern infestations. The LCC could arrange a bridle creeper eradication day releasing the leaf hopper and rust.
Bank stability & erosion	Bank subsidence occurred commonly throughout this reach. Causes for this were: 1. loss of vegetation to help bind the soil; 2. groundwater seepages causing instability in the soil structure; 3. cattle trampling vegetation, compacting the soil, cattle tracks causing banks to become exposed and unstable. There was little base flow protection in the main channel, exposing soil to high velocity flows particularly on the power bends. There were many sediment bars throughout the reach. (Sediment bars can cause erosion by deflecting high flow water onto the river banks causing scouring.) The high levels of sediment in the river were from an incising river bed and bank subsidence. Many log jams occurred throughout the reach. The majority of log jams were helpful, creating natural riffles and natural barriers for the sediment bed load to be deposited. A few log jams were deflecting water into the bank causing erosion, if left unchecked the river will correct itself in most cases. Revegetation along these banks will assist in stabilising these areas.


END OF REACH 2
START OF REACH 3
High erosion area
Peppermint tree dieback
Gully erosion
bridal creeper
briar rose
Fire on foreshore
High erosion area
briar rose
blackberry
Partial fencing, needs repairs
bridal creeper and blackberry on both sides of river
Cattle have acces
Shrubs within river c
Trees on banks a
Moderate leve
CARMICHAEL
Rabbit warrens
Fire on foreshore
blackberry
briar rose
Earthworks on foreshore
briar rose
bridal creeper
blackberry
Fire on foreshore
DONNYBROOK-
BOYUP
BROOK
ROAD
LOWDEN-
GRIMWADE
UPPER PRESTON RIVER FORESHORE STUDY
REACH 3
Penn-Scott (LBDS) Classification
A1: pristine
A2: near pristine
A3:slightly disturbed
B1: degraded - weed infested
B2: degraded - heavily weed infested
B3: degraded - weed dominated
C1: erosion prone
C2: soil exposed
C3: eroded
D1: ditch - eroding
D2: ditch - freely eroding
D3: drain - weed dominated
0 100 200 300
Metres

ttle have access to foreshore.
s within river channel, scattered.
ees on banks and foreshore.
Moderate level of erosion.

eds repairs

and blackberry
des of river

ROAD

Rabbit warrens

watsonia
briar rose

blackberry
watsonia
briar rose
bridal creeper

on foreshore

Partial fencing

watsonia
briar rose
bridal creeper

briar rose

blackberry

Partial fencing

Swamp paper bark
occuring on river

Area of good flooded gum
regeneration and recruitment

Incised channel area

bamboo infestation

END OF
REACH 3

START OF
REACH 4

River restoration: a riffle
and plantings

DONNYBROOK-
BOYUP
BROOK
ROAD

NIOKA
DRIVE

CHAPMAN
ROAD

Reach 3

Feature	Comments
Special Features, Restoration Sites	• Kangaroo activity was common throughout the foreshore. • Fire had been used on the foreshore to control the weed burden and this has produced large sections of exposed soil that have high potential for erosion. All the areas burnt provided stimulation for the weeds, no native vegetation recruitment was seen. • A small riffle allowing for pumping from the river and replanting was noted near Nioka Drive.

Please note "encourage" and "support" can mean to; provide financial support, education or technical advice, depending on the resources available.

Management

Issue	Management Action/Advice
Weeds	• Encourage Local Governments and State Governments to fulfil their obligations to properly manage declared weeds and priority weeds on their land. • Encourage the DAFWA to continue with their blackberry control program. • Provide support and education to landholders on how to properly manage their declared weeds and fire use. • Support local community groups and weed action groups in weed management. • Target blackberry, briar rose, bridle creeper, watsonia, arum lily and feral trees as a priority in this area. • Encourage PVIC to become involved in weed management.
Fencing/loss of native vegatation	• Where stock are present continue to fence off the creek to restrict stock access and provide off river watering points for stock to minimise bank damage and protect water quality. • Assist regeneration of native vegetation and expand the riparian zone through planting of local native species. (Appendix 1 contains a list of local species suitable for planting. See Chapter 5 for detailed techniques and information.) In particular, planting a variety of understorey species, including rushes and sedges is a priority in areas degraded by weed invasion or past stock access • Educate the landholders on controlled grazing techniques to control weed burden within the foreshore. • Encourage PVIC to become involved in riparian management and revegetation programs.
Fish & macro-invertebrates	• Increase fish and macroinvertebrate habitats by encouraging rehabilitation works such as erosion control using large woody debris, or planting of emergent vegetation such as rushes and sedges.
Declining water quality	• Encourage the use of best management practices (BMP) on farms to increase water quality and river health. The DAFWA, Water Management BMP includes the management of important on-farm issues such as, erosion, nutrient inputs, vegetation, grazing and water sources. See Appendix 6 for a comprehensive list of farm BMPs. • Encourage the DoW and PVIC to sample water quality parameters in the Upper Reaches of the Preston River and ensure the program monitors for sediment.

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Reach 4

Reach 4

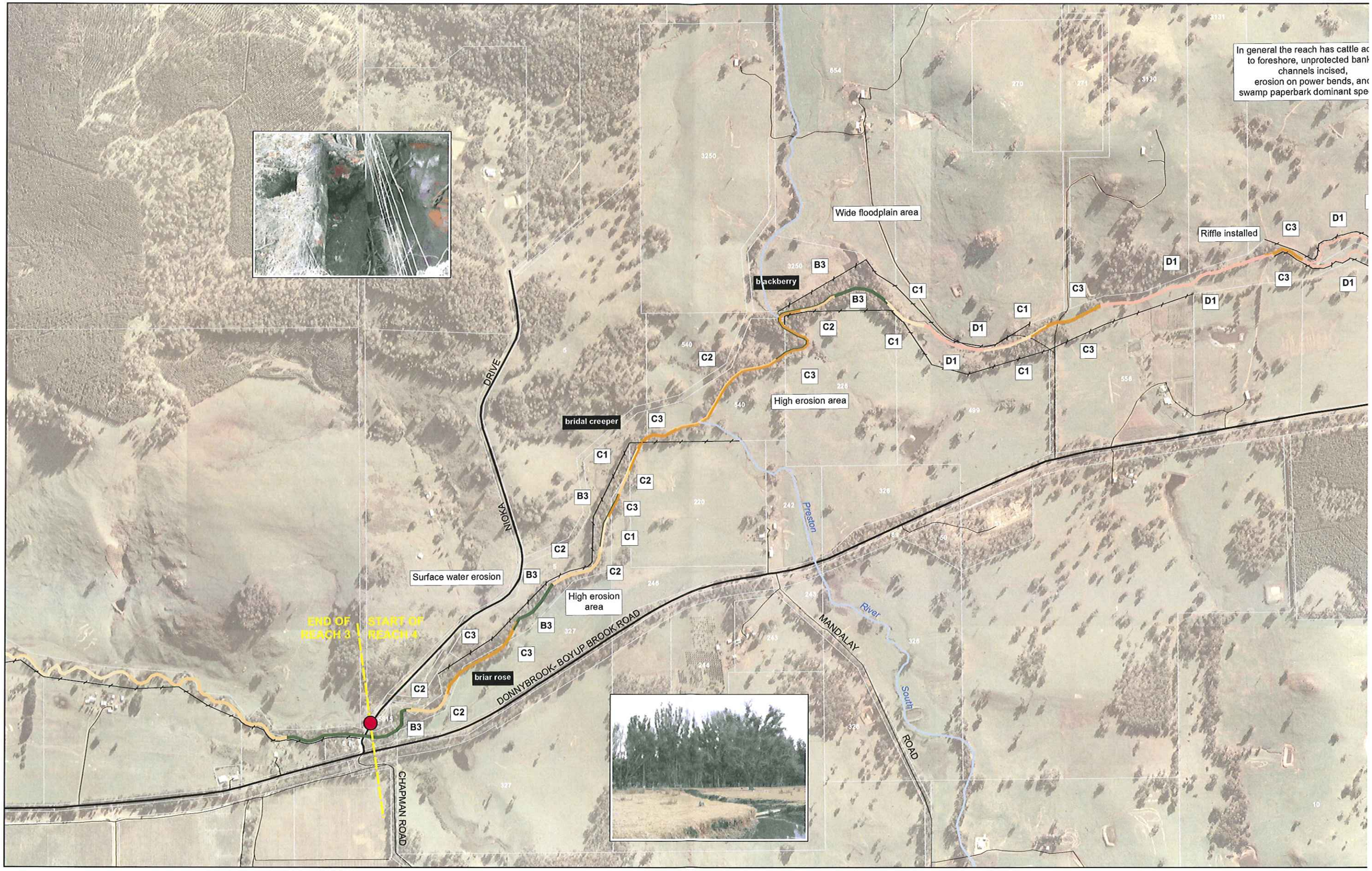
Reach 4 extends from west of Nioka Drive to Mumballup-Collie Road

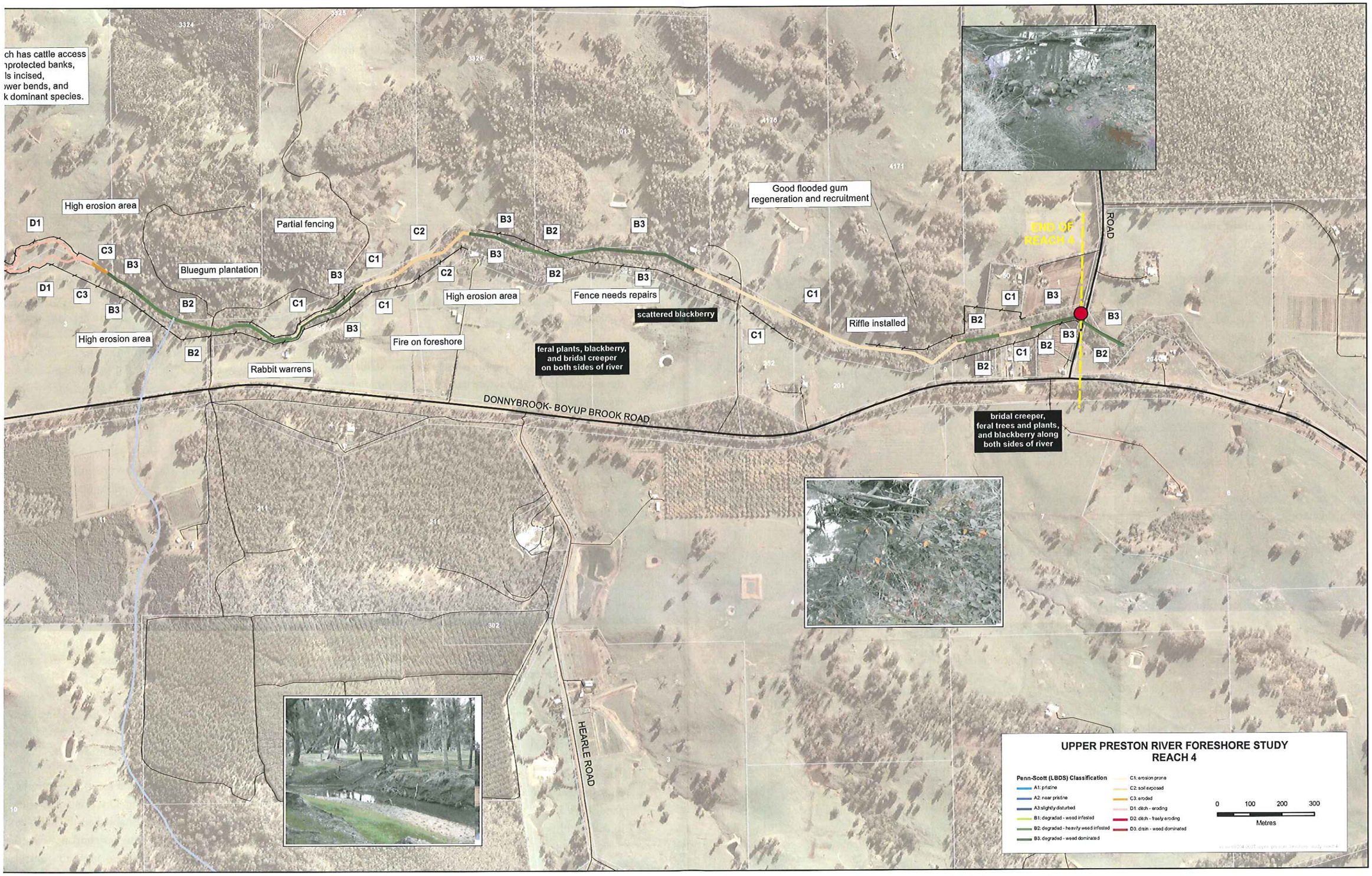
Description

Feature	Comments
Landuse	Agricultural land dominates both foreshores. Horticulture, beef and sheep grazing are dominate. A small rural residential area occurs at Mumballup.
Land tenure	There are crown reserves on the river which are classified as unallocated crown land, and are unvested and remain the responsibility of the Department of Land Information. The adjacent lots to the foreshore reserves are privately owned.
Fencing	Both sides of the river had some fencing. Some properties were completely fenced and had stopped grazing activities on the foreshore, while other properties were partially or not fenced allowing unrestricted cattle access to the foreshore.

Condition

Feature	Comments
Vegetation	The foreshore in this reach was in poor condition. This was the only reach that recorded a "D" grade foreshore condition. In many areas the foreshore was restricted to scattered trees over pasture. A major change to the vegetation community occurred within this reach, with the swamp paperbark (Melaleuca rhapiophylla) becoming dominant within the river channels and along the banks. The vegetation consisted of flooded gums, marri and blackbutts. The main mid storey species was Astartea and swamp tea tree, occurring within the channel and along the banks. A few good patches of sword sedge occurred, however most of the understorey had a high level of weeds. Flooded gums were regenerating, however little recruitment was noted.
Weeds	Blackberry, briar rose, pine trees, fruit trees, watsonia, bridal creeper, arum lily, feral trees, bamboo and sections of thick grass/ bracken fern infestations.
Bank stability & erosion	Bank subsidence occurred commonly throughout this reach. Causes for this were: 1. loss of vegetation to help bind the soil; 2. groundwater seepages causing instability in the soil structure; 3. cattle trampling vegetation, compacting the soil, cattle tracks causing banks to become exposed and unstable. There was little base flow protection in the main channel, exposing soil to high velocity flows particularly on the power bends. There were many sediment bars throughout the reach. (Sediment bars can cause erosion by deflecting high flow water onto the river banks causing scouring.) The high levels of sediment in the river were from an incising river bed and bank subsidence. Many log jams occurred throughout the reach with the majority of log jams being helpful, creating natural riffles and sections for the sediment bed load to be deposited. A few log jams were deflecting water into the bank causing erosion, if left unchecked the river will correct itself in most cases. Revegetation along these banks will assist in stabilising these areas.


In general the reach has cattle ac
to foreshore, unprotected bank
channels incised,
erosion on power bends, and
swamp paperbark dominant spe
Wide floodplain area
Riffle installed
blackberry
bridal creeper
High erosion area
Surface water erosion
High erosion area
briar rose
END OF REACH 3
START OF REACH 4
DRIVE
NIOKA
DONNYBROOK- BOYUP BROOK ROAD
CHAPMAN ROAD
MANDALAY ROAD
Preston River
South
B3
C1
C2
C3
D1


ch has cattle access
protected banks,
ls incised,
wer bends, and
k dominant species.
High erosion area
Partial fencing
Bluegum plantation
High erosion area
Rabbit warrens
Fire on foreshore
High erosion area
Fence needs repairs
scattered blackberry
feral plants, blackberry, and bridal creeper on both sides of river
Good flooded gum regeneration and recruitment
Riffle installed
END OF REACH 4
ROAD
bridal creeper, feral trees and plants, and blackberry along both sides of river
DONNYBROOK- BOYUP BROOK ROAD
HEARLE ROAD
D1
C3
B3
B2
C1
C2
UPPER PRESTON RIVER FORESHORE STUDY
REACH 4
Penn-Scott (LBDS) Classification
A1: pristine
A2: near pristine
A3:slightly disturbed
B1: degraded - weed infested
B2: degraded - heavily weed infested
B3: degraded - weed dominated
C1: erosion prone
C2: soil exposed
C3: eroded
D1: ditch - eroding
D2: ditch - freely eroding
D3: drain - weed dominated
0
100
200
300
Metres

Reach 4

Feature	Comments
Special Features, Restoration Sites	• Kangaroo activity was common throughout the foreshore. • Fire had been used on the foreshore to control the weed burden, which produced large sections of areas of soil exposed to potential erosion. All areas burnt only provide stimulation for the weeds, no native vegetation recruitment was seen. • Two small riffles allowing for pumping from the river was noted. • On the confluence with Lyalls Mill stream and the Preston River a wide floodplain and wetland system existed. The area was grazed and only a remnant patch of the swamp paperbark community remained.

Please note "encourage" and "support" can mean to; provide financial support, education or technical advice, depending on the resources available.

Management

Issue	Management Action/Advice
Weeds	• Encourage Local Governments and State Governments to fulfil their obligations to properly manage declared weeds and priority weeds on their land. • Encourage the DAFWA to continue with its blackberry control program. • Provide support and education to landholders on how to properly manage their declared weeds. • Support local community groups and weed action groups in weed management. • Target blackberry, briar rose, bridle creeper, watsonia, arum lily and feral trees as a priority in this area. • Encourage PVIC to become involved in weed management.
Fencing/loss of native vegetation	• Where stock is present continue to fence off the river to restrict stock access and provide off river watering points for stock to minimise bank damage and protect water quality. • Assist regeneration of native vegetation and expand the riparian zone through planting of local native species. Appendix 1 contains a list of local species suitable for planting. See Chapter 5 for detailed techniques and information. In particular, planting a variety of understorey species, including rushes and sedges, is a priority in areas degraded by weed invasion or past stock access. • Educate the landholders on crash grazing techniques to control weed burden within the foreshore. • Encourage PVIC to become involved in riparian management and revegetation programs.
Fish & macro-invertebrates	• Increase fish and macroinvertebrate habitats by encouraging rehabilitation works such as erosion control using large woody debris, or planting of emergent vegetation such as rushes and sedges.
Declining water quality	• Encourage the use of best management practices (BMP) on farms to increase water quality and river health. The DAFWA, Water Management BMP includes the management of important on-farm issues such as, erosion, nutrient inputs, vegetation, grazing and water sources. See Appendix 6 for a comprehensive list of farm BMPs. • Encourage the DoW and PVIC to sample water quality parameters in the Upper Reaches of the Preston River and ensure the program monitors for sediment.

6. Management advice

What can be done?

The information in this chapter is largely taken from RAPs for Margaret River and Ellen Brook (Cape to Cape Catchments Group, 2003 and 2005) and the Brunswick River (LCC 2006).

Where to start

The main principles for riparian management are:

- conserve the best areas first;
- move on to those reaches showing signs of recovery, and
- then treat the more degraded parts of the system.

This advice applies to both individual properties and the system as a whole.

It is most cost effective to protect areas still retaining native vegetation. These areas are the most stable and the most likely to regenerate naturally. Assisting natural regeneration is a lot cheaper and easier than restoring degraded areas.

Work on the more degraded parts will be easier if the river upstream is in good condition. Erosion and weed infestations impact on areas downstream.

Both the Cape to Cape Landcare Companion (Cape to Cape Catchments Group, 2004) and the Geographe Catchment Companion (GeoCatch, 2004) contain excellent advice on planning a restoration and revegetation project. These manuals are available free, or at very little cost, from CCG and GeoCatch. This advice and the lessons learnt from the implementation of other RAPs should be applied during the planning and prioritisation of individual on-ground activities. The Vasse RAP contains excellent advice on planning a restoration and revegetation project. Parts of this advice are included in Appendix 3 of this RAP.

Stock control

The control of livestock access is the most important management tool in the protection and restoration of waterways and vegetation. Fencing is the best method to achieve this.

APACE Green Skills & Pen (1997) provide good advice on the placement of fences alongside waterways:

'Ideally, fences should be placed above the river valley (Figure 9). Depending on the steepness of the embankment, the fence should be placed 5 m to 20 m back from the edge of the river valley (Figure 9 A). Five metres is sufficient for a shallow valley a couple of metres deep but a broader zone, greater than ten metres, is required for valleys deeper than five metres. The purpose of fencing off the shoulders of the river is to enable trees on the upper part of the embankment and those above the river valley to anchor the adjacent land, and thereby prevent subsidence.

In the case of shallow river valleys, there is little chance that embankments will subside. Nevertheless, fence-lines should be located above the river valley (Figure 9 B). This is because fences and firebreaks located within the river valley will be damaged and eroded by floodwaters. When they occur, firebreak washouts can be severe and contribute large quantities of sediment to the river system.

If the river valley is particularly broad and floodplains have been cleared for grazing, fencing them off may mean sacrificing good farmland. In this case it is necessary that only those areas that are prone to water erosion or stock damage, such as embankments and secondary river channels which only flow strongly at times of flood, need to be fenced off (Figure 9 C). Some of these fence-lines will be prone to flood damage, but this can be minimised if fences run, as much as possible, parallel to the direction of floodwaters.

In the flatter and broader valleys it may be acceptable to use fences to control the level of grazing rather than to exclude it altogether. A careful watch would need to be kept to ensure that the grazing is sustainable and is not so heavy as to prevent the regeneration of native trees, shrubs and sedges.'

Fencing may be used to exclude stock entirely from the river, or to allow restricted grazing. Once native species have regenerated or been re-established it may be appropriate to allow careful grazing for short periods to control weeds. Grazing may also be used to control weeds prior to planting. Heavy grazing that would

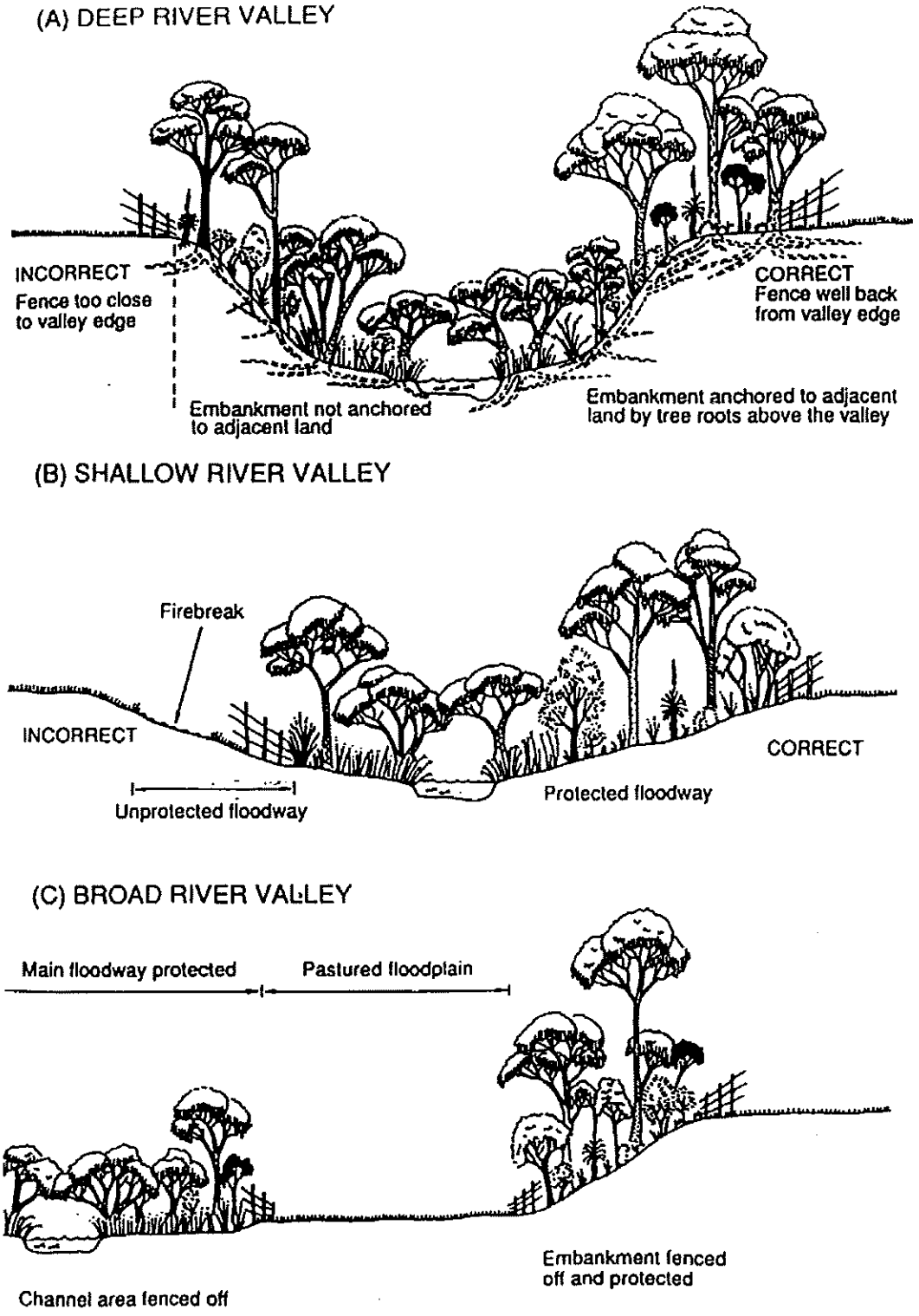


Figure 4: The correct placement of fences in relation to the river valley: (A) the deep river valley, (B) the shallow river valley and (C) the broad river valley with broad floodplain (APACE Green Skills & Pen, 1995).

degrade the riparian zone and ultimately eliminate native plant species should be avoided. Total exclusion of stock will be necessary where the bank is steep and sandy, or prone to collapse, or where the objective is to maintain high quality riparian habitat. It is important to note that there may be increased grassy weed growth if previously grazed areas are fenced off. A long-term weed management and revegetation plan needs to be developed prior to fencing off riparian land.

In areas where stock is not present, there is no need to fence. However on properties where stock is present, even for only part of the time, it is important to restrict stock access to the banks.

During the surveys and community consultations, a number of issues regarding restricting stock access arose, including the cost of fencing and the need for summer water. These are all valid concerns and at the time of writing this report, LCC had funds available to landholders to restrict stock access to waterways. These funds may be used to erect fencing, provide alternate watering points and construct stock and vehicle crossings. For more information, please contact LCC.

Useful references on stock control

- Water and Rivers Commission Water Note 18, Livestock Management: Fence Location and Grazing Control.
- Water and Rivers Commission Water Note 6, Livestock Management: Construction of Livestock Crossings.
- Water and Rivers Commission Water Note 7, Livestock Management: Watering Points and Pumps.
- Water and Rivers Commission Water Note 19, Flood Proofing Fencing for waterways.

Water quality

Waterways in agricultural areas receive large quantities of nutrients, either dissolved in water, adhering to small soil particles eroded from the land or in dead plant and animal material, including manure washed from paddocks. Outlined below are a number of ways improve water quality (Pen, 1999).

Vegetative buffers

Vegetated buffers alongside waterways can intercept and slow runoff and thereby trap suspended sediment, including organic material. Research has shown that vegetative buffers 10-50 m wide can achieve phosphorus and nitrogen filtration rates in the order of 50-100% (Pen, 1999). A vegetative buffer need not be of native vegetation and can be a simple grassy strip that is fenced off to control grazing. The nutrients assimilated by the vegetation can be utilised by crash grazing or preferably in hay production since the latter does not involve livestock returning nutrients to the grassy border as urine and manure.

Vegetation within the waterway itself forms a longitudinal buffer which, similarly, slows the flow rate, reduces erosion and traps soil, sediment and organic matter.

Farming practices (from Kingdon, 2000)

To reduce soil erosion, the key is to keep reasonably high levels of vegetation on the soil for as long as possible, and especially during times of high erosion risk. Achieving these conditions requires:

- use of reduced tillage and direct drilling;
- use of crop and pasture rotations that include well-managed perennial grasses and legumes;
- in row cropping, use of permanently raised beds and controlled traffic;
- managing organic matter by retaining stubble and including pastures in a crop rotation; and
- ensuring vigorous plant growth through appropriate soil, crop and water management.

Cultivation along the contours, rather than at right angles to them, will slow the rate at which water flows across the land, reducing soil erosion by as much as 50% (Pen, 1999).

Soil testing and fertiliser use

Fertiliser is generally applied according to traditional practice, usually some time before the winter/spring growing season. Today, we know that after a number of years of fertiliser application, many soils are rich in nutrients but may be deficient in a few trace elements (Pen, 1999). Soil should be tested to determine fertiliser requirements and avoid excess application of nutrients,

a portion of which will find their way into waterways. At the time of writing this report, LCC in partnership with GeoCatch, has a program called 'Nutrient Smart' which is designed to assist landholders to better manage their fertiliser use through soil testing. A paddock-scale fertiliser plan will be produced, allowing landholders to better target soil deficiencies and improve yields. For more information, please contact LCC.

Mycorrhizal and soil bacteria testing is another related tool. Past farming practices have led to the gradual sterilisation of soils. Soil organisms interact with the root hairs of pasture and native plants and assist with nutrient uptake. A number of landholders in the catchment are trialling the use of organic and biodynamic solutions to improve soil health, with an ultimate goal of reducing fertiliser, herbicide and pesticide use whilst maintaining or improving yields. Contact the Department of Agriculture & Food for more information.

Useful references for protecting water quality through farming practices

- Kingdon, B.K. (2000) *Fertiliser Use Guidelines for the Swan Coastal Plain of WA*. Vasse-Wonnerup LCDC, Busselton, WA
- Prosser, I., Karssies, L., Ogden, R. & Hairsine, P. (1999) *'Using buffers to reduce sediment and nutrient delivery to streams'. In: Riparian Land Management Technical Guidelines: Volume Two: On-ground Management Tools and Techniques*, Price, P. & Lovett, S. (eds). LWRRDC, Canberra.

Erosion control

Erosion is an issue requiring attention in many parts of the Upper Preston River, where areas showing signs of severe incision, undercutting and bank slumping.

It should be noted that a detailed river geometry survey and a variety of calculations are required for the correct design of engineering works. It is also important to remember that rivers are part of a dynamic system, that is, they are in a constant state of change. Care should therefore be taken when attempting to predict the outcome of alterations to channel form and capacity. Site-specific technical advice should be obtained prior to commencing any form of physical modification to the river channel. Engineers from the Department of Water can provide technical support.

A number of approaches to erosion control as outlined in the Capel RAP by Kirrily White and Sarah Comer (GeoCatch, 1999) are discussed below.

Point bars

Once a river bank becomes disturbed to the point where it is actively eroding, there is large potential for this to create further erosion downstream through the formation of point bars. Currents remove material from the outside banks of meanders and deposit it on the inside banks where water moves more slowly, forming a point bar (Raine & Gardiner, 1995). Over time these sand bars trap more sediment and continue to accumulate, to a point where they may even start to support in-channel vegetation growth. Some point bars are located and shaped in such a way that they actually divert the river flow onto the opposite bank further downstream, thus creating a new erosion point on the next outside bend. This cycle of erosion and deposition often continues downstream, and is a classic sign of a river in which the hydrological balance has been disturbed (Figure 10).

Removal of point bars may sometimes be needed in order to halt the progression of the erosion downstream. Generally, this should be undertaken in conjunction with other forms of restoration and care must be taken not to exacerbate the disturbance to the river channel. As discussed previously, a detailed river geometry survey of the problem areas is essential before this type of restoration procedure should be contemplated.

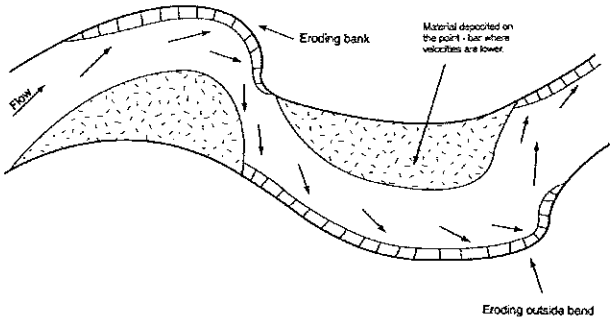


Figure 5: Outside bend bank erosion – Arrows mark the direction of flow showing that outside bends have the greatest erosion potential, so the meanders migrate downstream (Raine & Gardiner, 1995).

Undercutting

Undercutting often occurs in conjunction with the formation of point bars. Material is scoured from the toe of the bank, resulting in loss of bank support; this often results in subsidence as illustrated in Figure 11 (Raine & Gardiner, 1995). Previous experience has shown that supporting and protecting the toe of the bank can prevent undercutting. Generally undercutting will occur where there is a meander. If this is the case, only the outside bends need to be supported as the flow velocity on the inside bend is much lower. Once an outside bend is stabilised, the corresponding inside bend will usually adjust its width to cater for the change in flow.

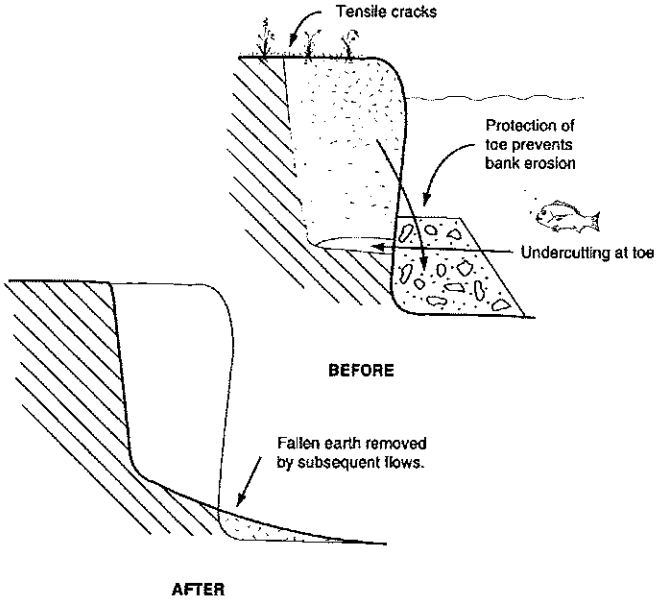


Figure 6: The use of structural works, such as a rock toe, will prevent the process of undercutting (adapted from Raine & Gardiner, 1995).

Bank slumping

Bank slumping can occur when poorly drained material within the bank becomes heavy with saturation and collapses into the river channel (Figure 12). This can occur with or without prior undercutting and often in response to the loss of native deep rooted riparian vegetation, which is critical to bank stability. The best way to manage this problem is to exclude stock with fencing set well back from the river channel, and revegetate the foreshore with suitable species. Raine and Gardiner (1995) provide the following advice on this process:

- Replant the toe with species that can withstand high flow velocities (e.g. native sedges). This replanting should be dense with spaces between plantings of less than 1 metre;
- Replant the middle to upper bank areas with fast growing, deep rooted trees and large shrubs. These will hold the bank together, enhance drainage and remove excess moisture through transpiration;
- Vary the species that are planted to ensure differing root structures; and
- Extend plantings from the toe to the floodplain. If a narrow band of trees is planted, this may serve only to add to the weight of the bank without providing the necessary network of root support.

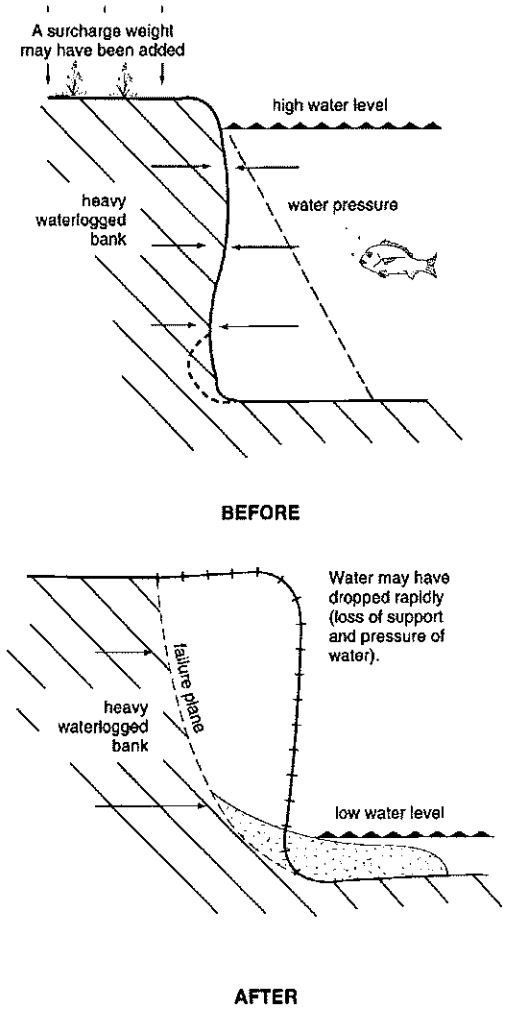


Figure 7: The process of bank slumping caused by excessive weight and lack of support (adapted from Raine & Gardiner, 1995).

Large woody debris

Snags, or large woody debris, are a natural component of the river system and play an important role in river ecology by providing a range of flow conditions within the channel and habitat for aquatic life forms. Occasionally snags can divert the flow onto the bank and subsequently cause erosion in areas lacking support from native vegetation. While de-snagging rivers has been a common practice in the past, the current management emphasis is to leave as much woody debris as possible. Rather than removing large woody debris from the channel, it should be repositioned at an angle of 20° to 40° to the stream bank (Figure 13). This action will minimise the effect of the snag on flow levels and direction, whilst maintaining the habitat available for plants and animals that benefit from low flow conditions. Large woody debris can also be added to deflect flows from unstable areas.

Repositioning LWD
The capacity of a river channel can be improved by rotating the LWD at an angle of 20° – 40° to the streambank.

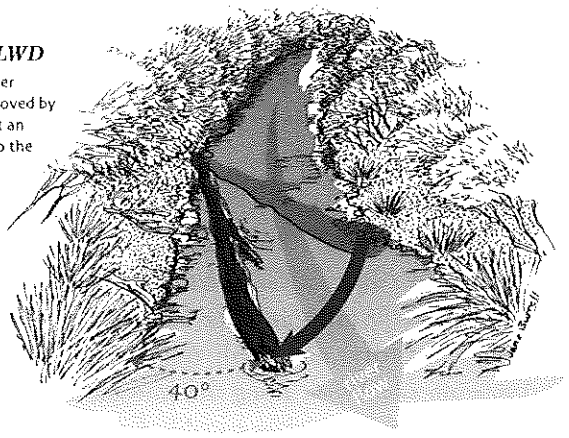


Figure 8: Repositioning large woody debris (Gippel et al., *1998).*

Useful references on erosion control

- Pen, L.J. (1999) *Managing Our Rivers.* Water and Rivers Commission, Perth.
- Water and Rivers Commission (2001) *Stream Stabilisation.* River Restoration Report No. RR 10.
- Raine, A.W. & Gardiner, J.N. (1995) *Rivercare — Guidelines for Ecologically Sustainable Management of Rivers and Riparian Vegetation.* Land and Water Resources Research and Development Corporation, Canberra.

Regeneration and revegetation

In areas that still retain native trees and understorey, natural regeneration is the cheapest and easiest management option. Control of stock access and invasive weeds is essential to this strategy, and should be the first step taken. Natural regeneration can be assisted by making small piles of branches and burning to promote germination through smoke and heat. Smoke water can also be applied to encourage germination. Another technique to assist regeneration involves laying the seed bearing parts of native plants directly onto the ground, allowing seeds to fall from them. This is called brushing, and works best after weed control measures such as spraying to reduce competition once the seedlings start growing.

Sections of riparian vegetation that have been heavily grazed and cleared generally contain more weeds and have a diminished seed bank. Regeneration options for these areas include: direct seeding; brushing with woody natives that contain seed; pre-seeded matting; and planting of tube stock. The riparian zone should be planted in a wide band with a diverse suite of species including trees, shrubs, sedges, rushes, herbs and native grasses. This not only improves the habitat value of the foreshore, but also provides a matrix of different root structures that will improve bank stability and assist in erosion control. Where possible, seed should be collected from nearby as this will ensure that the species used are suitable, local and part of the existing ecological web. Appendix 1 provides a list of species that were found in the area. Species for revegetation projects in the catchment should be selected from this list, choosing plants that are represented in nearby communities. Leschenault Community Nursery can assist with species selection.

Good site preparation is crucial to successful revegetation. Elements that need to be considered are weed removal; soil amelioration; and preparation of the soil surface for direct seeding or planting. Ongoing pest and weed control will need to be part of the project. Planting and sowing at the right time of year and at the appropriate depth will influence the success of the revegetation effort. Different revegetation techniques are outlined below.

Direct seeding

Direct seeding involves placing seeds directly on or into the soil on the site, either by hand or with machinery. For individual farm sized projects a mix of local seeds can be prepared in clean (weed free) sand and sown into lightly cultivated or raked soil. For an increased cost but higher success rate, tree bags can be placed over these areas to protect seedlings from dehydration, wind and predation. These bags will also help to identify and protect plants during follow-up spot spraying for weeds over the coming seasons. Several areas in the catchment have been identified as having good potential for the collection of local provenance[1] seed.

Direct seeding has a few distinct advantages over other revegetation methods:

- it is less time consuming and requires less labour than planting tube stock;
- a mixture of trees, shrubs, sedges and groundcovers can be planted at the same time, resulting in a plant community with a more natural look, and better resilience due to increased diversity and synergy;
- seeds will germinate over several years, giving a range of ages and growth forms, resulting in a more natural look;
- it is less expensive than using tube stock, and
- the natural root development of seedlings grown from seed usually results in plants developing deeper taproots, requiring less follow-up care.

However, direct seeding can be less reliable than planting, due to predation, specific germination requirements not being met, and poor conditions for direct seeding. Direct seeding may not be possible when high winds or strong water flow is present.

Planting

Planting is an appropriate technique for embankment and in-stream revegetation, and where direct seeding is difficult due to insufficient seed, excessive weed competition, or other factors. In these cases, nursery tube stock is ideally supplied from local provenance seed. A rule of thumb guide for planting densities is 3-4 rushes per 1 m^2, 1 shrub per 1 m^2, and 1 tree every 3 m^2. When selecting plants and designing the revegetation of an area, it is also important to take into account the budget for follow-up management; the availability of water over summer; the range of species available; existing vegetation cover such as tree canopy; soil types; and the intended weed management approach.

Rushes and sedges should be planted in spring, when the water table is beginning to fall and the soil is still moist. Other seedlings should be planted when the surrounding soil is moist and follow-up rain is likely (usually between May and July). Care should be taken to ensure that specimens are not root bound, and that minimal damage to the roots occurs when removing from pots. Planting requires significant prior planning, as it is best to collect local seed and contract a nursery to raise them in time for planting in the following wet season. The Leschenault Community Nursery specialises in growing local native plants for revegetation purposes.

Brushing

Brushing is an excellent technique for all zones apart from the channel bed. This technique can be used to spread seed and assist with erosion control simultaneously. Brush should be harvested from plants at seed maturity and laid immediately on the revegetation site. Brush along the embankment should be secured in place. Species suitable for this technique are those that retain seed on the plant, but shed it when the plant dries out. This includes many of the myrtaceous species (peppermints, tea trees, Melaleucas, and Eucalypts such as marri, jarrah and flooded gums). Brushing is easy to combine with other revegetation activities such as direct seeding, and provides shelter to plantings, increasing seedling survival rates.

Pre-seeded matting

Pre-seeded matting involves sowing seeds onto fibre mulch, and laying the mat on-site in early winter after germination. This technique is excellent for steep embankments, since it provides erosion control and revegetation in a single step. It is generally only suitable

[1] The term provenance is used to identify the geographic origin of seeds or parent plants. Often, genetically distinct local forms or varieties of a plant have evolved to suit a specific range of conditions, including soil, climate and water regimes. Direct seeding with local provenance seed ensures that the resulting plants will be suited to the localised environmental conditions and maintain the ecological integrity of existing native plant communities (GeoCatch, 1999).

for seeding with rushes and sedges, since matting usually requires rolling for transport to the site once seeds have germinated (like instant lawn). It can be difficult to source matting with seeds of local provenance.

Division and transplanting of rushes and sedges

Many rushes and sedges propagate very well by vegetative division – plants can be easily split into individual plants (ramets) every two months or so under good conditions. With planning the prior year and a small initial outlay, a large number of these difficult to propagate (from seed) species can be raised by division. Some species of rushes and sedges such as Juncus, Carex, Isolepis and Schoenoplectus are suitable for growing from seed, but others are difficult to propagate.

Farmers often grub out or spray rushes and sedges in paddocks as they may limit options for crop cultivation. In some circumstances, paddocks adjacent to restoration sites may contain large numbers of these rushes and sedges that could be transplanted with success. This can be a cheap, but labour intensive form of revegetation. Care must also be taken to minimise erosion and not spread dieback.

Useful references on natural regeneration and revegetation

- Bradley, J. (1988) Bringing Back the Bush: *The Bradley Method of Bush Regeneration*. Lansdowne Press, Sydney.
- Buchanan, R.A. (1989) *Bush Regeneration: Recovering Australian Landscapes*. TAFE Open Training and Education Network, Strathfield, NSW.
- Scheltema, M. (1993) *Direct Seeding of Trees and Shrubs. Greening Western Australia*, Perth.
- 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 (1999) *Revegetation: Case Studies from South-west Western Australia*. Water and Rivers Commission River Restoration Report No. RR5.
- Water and Rivers Commission (1999) *Using Rushes and Sedges in Revegetation of Wetland Areas in the South West of WA*. Water and Rivers Commission River Restoration Report No. RR8.
- Water and Rivers Commission (2000) Water Note 20; *Rushes and Sedges*.
- Geographe Catchment Council (2004) *Geographe Catchment Companion*.
- Cape to Cape Catchments Group (2004) *Cape to Cape Landcare Companion*.

Weed control

Weed invasion of native vegetation is a major threat along the Upper Preston River and in the greater catchment. Fencing the River and restricting stock access will result in the need for extra weed control. Weed control should be coordinated across the whole catchment for any action to be really effective. In foreshore areas, removal or control of weeds must take account of the erosive power of water. Clearing weeds in an unplanned manner could result in erosion in the river channel. Weed control principles to keep in mind include:

- Weeds thrive in disturbed areas and on bare ground.
- Fire promotes weeds. Burning a remnant that is weed infested can make the weeds worse, unless there is follow-up weed control and revegetation. Native plants cannot compete with the rapid regrowth of weeds, which then become a greater fire hazard.
- Aggressive perennial weeds that spread readily along riparian corridors should be eradicated first, eg. bridal creeper, blackberry and cotton bush.
- If weed control is carried out, revegetate to prevent further weed invasion in the bare soil.
- Some native plants look and act like weeds. Do not begin weed control until you are sure a plant is a weed.

Chemical control of weeds on waterways requires careful planning. Issues which must be considered prior to any type of chemical control include the effects of the herbicides on native flora and fauna, and on water quality. If you decide to use a herbicide, choose one that has a modified surfactant to reduce impact in waterways and wetlands, for example Roundup® Biactive. In surface or sheet erosion prone sites, spot spraying rather than blanket spraying can help to reduce erosion from loss of weed cover while still providing opportunities for planting.

In some cases it may be appropriate to use restricted grazing to control weeds. Where banks are steep and sandy or prone to collapse, or where the objective is to maintain high quality riparian habitat, grazing should be avoided. However, where the riparian zone has a history of grazing and the exclusion of stock would lead to an explosion of weeds, maintenance of the zone by light grazing is an option. The landholder should keep a careful eye on the riparian zone to see that it has an adequate cover of a mixture of native and pasture plant species and that erosion is not occurring.

Troublesome major weeds should be identified at an early stage and eradicated immediately (Pen, 1999).

Specific notes on certain weeds

A number of declared weeds (according to the Agricultural and Related Resources Protection Act 1976) were found in the study area. They are: apple of sodom, arum lily and blackberry. According to legislation, declared plants need to be controlled or contained depending on their status, and reported to the local Agricultural Protection Officer. More information on the requirements for control and treatment is available from the Department of Agriculture & Food.

Information on these weeds and other priority weeds in the catchment is provided below. This is sourced from Southern Weeds and Their Control (Moore & Wheeler, 2002), Bushland Weeds: A Practical Guide to their Management (Brown & Brooks, 2002), and Declared Plants Handbook: Recommendations for the Control of Declared Plants in Western Australia (Department of Agriculture, 2002).

Southern Weeds is a useful guide to landholders in the south west and provides information on weed identification and control. It is available from Department of Agriculture & Food offices. Also useful for weed identification is Western Weeds (Hussey et al., 1997).

Apple of Sodom (*Solanum linnaenum*)

An erect perennial shrub with deeply lobed prickly leaves, and prickly stems and branches. It has purple star shaped flowers often throughout the year and the fruits are bright yellow when mature. Introduced from South Africa, it is a serious problem in parts of the south west, especially in grazed paddocks and creek lines. Small plants may be grubbed out, however all root fragments must be removed. Chemical control using a 1:80 solution of Amitrole plus wetting agent is most effective.

Arum lily (*Zantedeschia aethiopica*)

A tufting perennial with dark green, shiny leaves arising from a tuberous root. Easily recognised by large white 'flower' with a central yellow column of minute male and female flowers. Toxic to stock. Berries are spread by birds and along watercourses. A serious threat to riparian vegetation. Slashing, if undertaken regularly (at least three times per season) over a long period, may be effective but is very time and labour intensive. Chemical control with low rates (0.5 grams per 10 L of water) of Glean® (Chlorsulfuron) or Metsulfuron as flowers start to wither is most effective. Little effect will be noticeable immediately, however the following year very few plants will come up. Glyphosate is not an effective control. Blanket or hockey stick wipers should be used near waterways to prevent spray drift or runoff. In areas with very dense infestations, multiple applications will be required to ensure any new seedlings are controlled.

Blackberry (*Rubus* spp.)

A perennial plant with arching prickly stems (canes) that were introduced from Europe as a fruit crop. Highly invasive, especially along creek lines. Mechanical control is difficult except for small infestations. Care must be taken to ensure that all root material is removed. Herbicide control is most effective, with Triclopyr and Triclopyr plus Picloram having good results, but care must be taken near waterways with the latter. Some success has been had with mixtures of Metsulfuron and Glyphosate. Further research is currently underway to develop effective biological controls with some trials in local areas expected to commence mid-2005.

Bridal creeper (*Asparagus asparagoides*)

A perennial climber with wiry stems that was introduced from South Africa as a garden plant. It is extremely invasive and spreads very rapidly, eventually smothering native vegetation. A variety of new bio-control methods seem to be having good results in the area. A small (2-3 mm long) leafhopper and a 'rust' (fungus) are available for release. Contact LCC for more information and release locations.

The rust appears to be spreading well, and no bridal creeper was found during the survey that was not infected with rust. It many places where previously bridal creeper was extremely thick, the rust have worked very well. However care must be taken not to become complacent about bridal creeper. Due to the nature of biological controls, the rust will never eradicate bridal creeper, it will just make it manageable. Now is the time to effect other control methods such as wiping individual stems with a 1:2 Glyphosate solution as they emerge.

Edible fig (*Ficus carica*)

A large tree with distinctive lobed leaves and fleshy fruit. A garden escapee that tolerates damp conditions. Takes root readily from cuttings and root fragments, with birds and animals also dispersing seeds. Hand pull seedlings, inject larger specimens with 50-100% Glyphosate in summer. Can be treated with the cut and paint method, however all branches, twigs and fruit must be removed and burnt.

Kikuyu (*Pennisetum clandestinium*), **Buffalo Grass** (*Stenotaphrum secundatum*), **Couch** (*Cynodon dactylon*) and **Water Couch** (*Paspalum distichum*).

These perennial introduced grasses all spread from runners or rhizomes and are very invasive. Manual control (except large scale scalping) is not effective. A spray-burn-spray regime using Glyphosate appears to work well in areas where water levels recede (allowing herbicide and fire use).

Victorian tea tree (*Leptospermum laevigatum*), **deciduous trees and other woody Weeds**

Woody weeds like Victorian tea tree and deciduous species like willows (Sailx spp.) and poplars (Populus spp.) can be controlled using stem injection or cut and paint with undiluted Glyphosate. To stem inject, holes should be drilled around the trunk and spaced no more than 5 cm apart into the sapwood (just beyond the bark, but not into the heartwood) and herbicide injected immediately. The tree may take up to 3 months to die and can then be felled or left as habitat. To cut and paint, the tree should be felled with a chainsaw as close to the ground as possible and painted immediately with undiluted herbicide. All material must be removed and monitoring for suckers should occur for at least 2 years.

Watsonia (*Watsonia* sp.), **Gladioli** (*Gladiolus* sp.) and **African cornflag** (*Chasmanthe floribunda*)

These have been grouped together as growth form and control methods are similar. All are tufted bulbous species from South Africa with erect sword shaped leaves, and tall spike-like white, pink, yellow or orange flowering stems. Manual control (digging out) of African cornflag and watsonia can be effective in small areas but is very labour intensive and requires many years of follow-up. Manual control of wavy gladioli should not be attempted as numerous cormels will break off and cause a more severe problem than before. Spraying with Glyphosate or 2,2-DPA just prior to flowering gives best results. In sensitive areas, using a sponge glove or a hockey stick wiper is best.

Feral Trees (woody plants)

Physical control – Best used when trees are under 2 metres in height. Cut tree down and dig out main roots.

Ring barking – Mature trees can be ring barked to avoid damage to other vegetation, however this method can only be used on non-sprouting trees. Ringbarking involves cutting away a strip of bark, at least 10cm wide all the way around the trunk. The strip must be deep enough to stop the flow of plant food between the growing points of the tree to be effective.

Chemical control – Mature trees can be treated effectively by two methods, either cut and paint or stem injection. Cut and paint involves cutting down the tree and painting the cut stump immediately with herbicide like gylsophate. If the painting process is delayed the uptake of the herbicide will be minimal. Stem injection involves drilling several holes into the trunk of a tree and injecting herbicide.

Pampas grass (*Cortaderia* spp.)

These plants are native to South America, where they are a large grass in tussocks with blades of up to 2.5m long. They have large plumes on the end of their long spikes, which are silvery white to grey in colour, they flower between summer to autumn. The seed heads produce up to 1000,000 seeds per plume thus on removal the seed heads should be bagged to contain seeds from spreading. In small infestations digging the plant out by hand is the most effective method. Manual removal involves cutting back all the long blades then mattock and lever the root mass from the ground,

ensuring that all rhizomes are removed. A number of chemical controls are available. The most effective method for larger infestations is to burn the plants then spraying glysophate on all the new shoots.

Briar Rose (*Rosa* spp)

There are two wild rose species that occurs along the river they are briar and sweet rose. Both roses are prickly deciduous shrubs that often sprawl in habit. These roses are scrambling shrubs that can form dense thorny thickets. Mechanical control is difficult except for small infestations. Care must be taken to ensure that all root material is removed. Herbicide control is most effective, with Triclopyr and Triclopyr plus Picloram having good results, but care must be taken near waterways with the latter. Some success has been had with mixtures of Metsulfuron and Glyphosate.

Thistle (*Carduus* spp.)

Two common thistles are slender and sheep thistle. The thistles germinate soon after autumn rains and flower in spring. Thistle seeds remain viable in the soil for over 10 years. Thistles tend to establish more readily in bare open ground so establishing a desirable vegetation cover can help reduce their impact. Hand removal of isolated plants through spring. Apply glysophate with a rope wick or spot spray Lontel 10ml in 10L water and 25ml of wetting agent. Best results control at rosette stage.

More information on weed control is available from the Department of Agriculture and Food or the LCC.

Useful references for weed identification and methods of control

Brown, K. & Brooks, K. (2002) *Bushland Weeds: A Practical Guide to their Management with Case Studies from the Swan Coastal Plain and Beyond.* Environmental Weeds Action Network, Greenwood, Western Australia.

Department of Agriculture (1999) *Wetlands not Weedlands.* Weed Note No. 1/99, Department of Agriculture, Perth, Western Australia.

Department of Agriculture (2002) *Declared Plants Handbook: Recommendations for the Control of Declared Plants in Western Australia.*

Dixon, B. & Keighery, G. (1995) 'Suggested methods to control weeds'. In: *Managing Perth's Bushlands*, Scheltema, M. & Harris, J. (eds). Greening Western Australia, Perth, WA.

Hussey, B.M.J., Keighery, G.J., Cousens, R.D., Dodd, J. & Lloyd, S.G. (1997) *Western Weeds: A Guide to the Weeds of Western Australia.* Plant Protection Society of Western Australia, Victoria Park, Western Australia.

Hussey, B.M.J. & Wallace, K.J. (1993) *Managing Your Bushland.* Department of Conservation and Land Management, Como, Western Australia.

Moore, J. and Wheeler, J. (2002) *Southern Weeds and Their Control Department of Agriculture*, Bulletin No. 4558. Perth, Western Australia.

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 Water Note 22, Herbicide Use in Wetlands.

Water and Rivers Commission Water Note 15, Weeds in Waterways.

Water and Rivers Commission Water Note 25, Effects and Management of Deciduous Trees on Waterways.

Feral animal control

Rabbits and foxes were evident throughout the catchment. The principle problem that foxes and rabbits cause on remnant vegetation has been taken from Hussey and Wallace (1993) they are as follows.

Rabbit

- Competes with native herbivores for food and habitat.
- Grazing damages many native plants.
- Prevents regeneration of native vegetation.
- Heavy grazing pressure can lead to soil erosion.
- Warren construction destroys plants.
- Warren construction and dung piles provide sites for weed invasion.

Fox

- Completes with native carnivore for prey.
- Reduces numbers of prey species – medium – sized mammals, reptiles, frogs, birds and insects.

Landholders and managers are encouraged to control rabbits through baiting, shooting, fumigation and destruction of warrens, Table 4 is a summary of rabbit control methods. Large numbers of landholders were concerned that foxes preyed on native fauna, which has limited habitat options in the area. Baiting and shooting can control foxes, with the most effective kill period in spring when the cubs are being reared (Hussey and Wallace 1993). The Department of Agriculture and Food has an on-going fox control program for local landholders. Advice and assistance is available from the Department of Agriculture and Food (DEFWA).

Table 4. Summary of rabbit control methods (Hussey and Wallace 1993).

Method	Time of year	Environmental hazard	Health hazard	Cost	Benefit
Fumigation	Best after opening rains before breeding	low	Care needed	Labour intensive	Use among bush and rocks
Warren destruction	Summer for sand, winter for clay	Soil erosion, damage to native vegetation	low	moderate	Effective for paddocks infestations
Rabbit-proof fencing	any	nil	nil	high	Long term effect permits regeneration
Conventional 1080	Best late summer/ early autumn	low	Care needed	low	Effective, cheap and safe for native fauna
Contract poisoning, 1080 one shot	Late summer/ early autumn	low	Care needed	low	Safe for native fauna, best for unskilled or busy landowner
Contract poisoning, pindone	Best late summer	Fatal to native animals	low	moderate	Safe for domestic animals
Shooting	any	nil	Care needed	moderate populations	Useful for very small

Fire Hazard

How to manage fires around the riparian zone.

Much of the following information has been taken from Wetlands and Fire Waternote WN 2 (Water & Rivers Commission 2000).

Fuel loads

Unless fuel reduction using a prescribed burning is identified as providing an ecological benefit it is undesirable to use it in the riparian zone. Any prescribed burning should ensure that all stakeholders have been consulted with and approvals received. Alternatives to burning in these areas include the thinning out of weedy undergrowth and litter using hand tools or machinery. Slashing should be timed to maximise fuel reduction (spring).

Weed control

Weeds contribute to an increase in fire hazard and fire intensity. Control of annual weeds using chemicals and hand tools during the early growth phase will help reduce subsequent fuel loads, fire frequency and the intensity of fire at ground level. Consult with the Department of Agriculture and Food, Western Australia for advice on the appropriate use of chemicals for weed control.

Fire breaks

Firebreaks should be at least 20m metres from the boundary of the riparian vegetation and have a maximum surface width of six metres. In some cases existing roads or steep rocky hills can be used as natural features instead. Biologically sensitive areas and steep inclines should be avoided with firebreaks being

constructed in already degraded or disturbed areas wherever possible. The construction of fire breaks must take into account the possibility of the spread of dieback, the Department of Environment and Conservation can be consulted for advice regarding techniques that prevent the spread of dieback.

Controlled grazing techniques

If fire or weed control are your management objectives, then controlled grazing can be useful tool within a sustainable riparian management plan. Controlled grazing depends on regular monitoring and the ability to manipulate grazing pressure to avoid damage to soil and vegetation. The following information has been taken from Stock & Waterways: A managers guide, by Land & Water Australia 2006.

The principles of controlled grazing on foreshores are as follows:

1. The timing of grazing. In the case for fire and weed control, the increased growth of weeds is the indicator for the need to graze. In the South West Region this is typically in spring between (September to November).
2. The Duration of grazing. Continuous grazing gives the riparian vegetation no chance of recovery, thus native vegetation will eventually die out and be replaced by weeds. Regeneration of foreshores through seed dispersal, trimming trees & shrubs and allowing light to penetrate for germination in weed infested areas can be achieved if riparian areas have short periods of grazing (less than 4 weeks) to control weed infestations and/or reduce fuel loads.
3. The intensity of grazing. Grazing young or lighter weight stock can be used to reduce both grazing intensity and the trampling effect. Conservative stocking rates and the ability to move stock out of the riparian area in response to signs of damage are critical for good riparian management.

Controlled grazing should only be used with a riparian management plan that is focussed on long term rehabilitation of native vegetation and sustainability of waterways. Controlled grazing techniques can be a useful tool to help with reducing weed burden and fuel loads in riparian areas.

7. Implementation

Implementation of Management Techniques on the Upper Preston River

Learnings, hurdles and successes of previous river restoration on-ground works

River restoration activities occurred along the Preston River (1998 – 2000) as part of the NHT federal funding program managed by the Water & Rivers Commission. This project funded on the ground activities including:

- Fencing (up to the value of $600/km);
- Erosion control;
- Revegetation – providing native plants;
- Weed Control, and
- Stock troughs (up to $300 per trough, unlimited troughs per property).

Some of the learnings, hurdles and successes experienced in implementing on-ground works along the Upper Preston River are outlined below in Table 5. These experiences will hopefully help others to learn from past mistakes and build on the successes of future projects.

Table 5. Outline of successes of past projects in the Upper Preston River

Location Name	Description of Activity
East of the Donnybrook Townsite. Foreshore both sides, unallocated crown reserve and Stoney Property	Engineering works • Bank battering and contouring (reduced the steepness of the banks) • Removal of point bars (removing sediment bars allowing the river to flow through the centre of the river) Revegetation Fencing the river from stock
Atherton Orchard, Lot 5 on Plan 69868.	Engineering works • Bank battering (contouring the banks and stabilising the banks with rocks) • Realigning the river channel to allow flow through the centre of the channel.
39 properties between Donnybrook and Mumballup including the Preston River Tributaries.	Providing a subsidy for fencing the rivers from stock. Providing a subsidy for herbicide for weed control Providing free plants from the Leschenault Community Nursery Providing free engineering advice from WRC engineers on restoration proposals.

Hurdles

The table above outlines some of the successes of the project. For the two engineering projects, the channel was stabilised preventing further erosion, however revegetation and subsequent weed control were lacking at both sites. The first site had good initial revegetation and many plants are evident, although follow up weed control and additional plantings did not occur. The second restoration site had no revegetation, thus restoration of the ecology of the riparian zone is still required.

The third set of restoration involved fencing, herbicide spray, revegetation and engineering advice. Fencing of these sections of rivers was good at reducing the damage done by stock on the waterway. However, the lack of management by landholders provided many fuel hazard areas on the foreshore, particularly the lack of weed management allowed high levels of fuel loads to accumulate and provided little opportunity for native vegetation to regenerate. In hindsight, fencing of the river must be done along side a foreshore management plan that deals with the long term weed management, fuel load and revegetation issues.

Work in other priority areas from the past funding program was not achieved due the following reasons.

Landholder Fencing

The land use along the Upper Preston River is dominated by agricultural land, mainly beef grazing. These reaches are also the most degraded in terms of erosion of the river banks. The priority for these reaches is to fence out stock and although some landholders have fenced part of the river, it was difficult to get remaining landholders on board for a number of reasons. Landholders concerns are listed below:

- Fencing the river would cause a weed issue along the riverbanks and lead to a major fire hazard.
- Stock would not have easy access to water. Off river stock watering points which involve pumping from the river require ongoing maintenance and can break down easily.
- Too much of their grazing land would be lost by fencing off the river.
- The maintenance of river fencing too costly, as they are susceptible to damage in times of flood.
- The incentive of $600/km was too low for it to be a financially viable option.

Time and resource constraints when dealing with erosion control techniques

Parts of the Preston River require erosion control works. However, in order to carry out such works a number of important steps are required;

- An engineer from DoW needs to be consulted with to ensure that the erosion control techniques will be successful. An engineering survey may also be required.
- Permits are required before you carry out such works, such as a permit to "interfering with bed and banks" under the *Right in Water and Irrigation Act 1914*. The Department of Indigenous Affairs should be contacted to see if the site is registered under the *Aboriginal Heritage Act 1972* . For a more extensive list of depts and permits required, see Appendix 4.
- The works must be carried out in summer when the river is at its lowest and the banks are dry and easy to work on.

Altogether these steps can be time consuming and costly, thus within a one year project it is extremely difficult to carry out a successful erosion control program. Time is not the only constraint in carrying out erosion control works; it can also be extremely costly and such works are often inadequately budgeted.

Learnings

Below are four points to remember when implementing on-ground works:

- Where possible the first work should be on the high grade foreshore the "best bits";
- Plan ahead, ensure you have the time and resources required to make the project successful. See Appendix 9 for a Landcare Project Timeline;
- Work with the willing, as they will ensure the work is successful into the future;
- Ensure that funding is allocated for maintenance and evaluation, and
- Landholder apathy is high within the community; the best resolution is to have key demonstration sites that "show and tell" to gradually influence the community's attitudes.

8. References

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Appendix 1. Native vegetation of the Upper Preston River

(This information has been adapted from the Brunswick River RAP)

Trees and large shrubs

Scientific name	Common name	Where to plant
Acacia saligna	Wattle	Dry foreshore
Agonis flexuosa	Peppermint	Dry foreshore
Taxandria linearifolia (Agonis)	Ti-tree	Within river, wet foreshore, wetlands, dry foreshore.
Taxandria juniperina (Agonis)	Ti-tree	Wet foreshore, wetlands, dry foreshore
Taxandria parviceps (Agonis)		Wet foreshore, wetlands, dry foreshore
Banksia litoralis	Swamp banksias	Wet foreshore, wetlands, dry foreshore
Calystachus lanceolata	Wonnich	Wet foreshore
Corymbia calophylla	Marri	Dry foreshore
Eucalyptus rudis	Flooded gum	Wet foreshore, wetlands, dry foreshore
Eucalyptus megacarpa	Bullich	Dry foreshore
Eucalyptus patens	Blackbutt	Dry and wet foreshores
Grevillea diversifolia	Valley grevillea /	Dry foreshore
Hakea lassianthoides		Dry foreshore
Kunzea baxteri		Dry foreshore
Melaleuca preissiana	Paperbark	Wet foreshore, wetlands, dry foreshore
Melaleuca raphiophylla	Swamp paperbark	Within river, wet foreshore, wetlands, dry foreshore.
Melaleuca viminea	paperbark	Wet and dry foreshores
Oxylobium lineare	River pea	Wet foreshore, wetlands, dry foreshore
Paraserithianthes lophantha	Albizia	Wet foreshore, wetlands, dry foreshore

Shrubs under 3m

Scientific name	Common name	Where to plant
Acacia alata, wildoweniana	Strappy wattles	Dry foreshore
Acacia extensa , pulchella, dentifera, urophylla, rostellifera, lasiocarpa	Wiry wattle	Dry foreshore
Astartia fascicularis	River myrtle	Within river, wetlands, wet and dry foreshores
Adenathos obovatus		Dry foreshore
Bossiaea linophylla		Dry foreshore
Boronia fastigata	Brown boronia	Wetlands, Wet and dry foreshore
Calathamus quadridus	One sided bottlebrush	Dry foreshore
Chorizema cordata / illicifolia		Dry and wet foreshores
Hakea varia		Dry foreshore

Shrubs under 3m (continued)

Scientific name	Common name	Where to plant
Hovea elliptica	Tree hovea	Dry and wet foreshores
Kunzea rostrata, recurva, micromera		Dry foreshore
Mealeuca incana, lateritia	Grey honey myrtle/ robin red breast	Dry and wet foreshores and wetlands
Pericalymma ellipticum		Dry foreshore
Pultanaea skinneri		Dry foreshore
Regelia cilliata		Dry foreshores
Viminaria juncea	Swish bush	Within river, wetlands and wet foreshore

Creepers and ground cover

Scientific name	Common name	Where to plant
Hardenbergia comptoniana	Native wisteria	Dry foreshore, wet foreshore
Angiozanthos flavidus	Tall kangaroo paw	Dry foreshore
Kennedia coccinea	Coral vine	Wet foreshore, dry foreshore, wetlands
Kennedia prostrata	Running postman	Dry foreshore
Clematis pubescens/ microphylla	Clematis	Dry foreshore
Chorizema diversifolia	Yellow pea	Dry foreshore, wet foreshore, wetlands
Brachysema praemorsa		Dry foreshore

Sedges, rushes and monocots

Scientific name	Common name	Where to plant
Baumea articulatum/rubignosa/juncea	Jointed twigrush	Within river, wetlands, wet foreshore
Dianella revoluta	Dianella blue flowers	Dry foreshore
Gahnia trifida	Saw sedge	Dry foreshore
Ficinia nodosa (Isolepis)	Knotted club rush	Dry foreshore, wet foreshore, wetlands
Juncus krausii/pallidus/subsecundus	Sea rush/pale rush/ finger rush	Within river, wet foreshore, dry foreshore and wetlands
Lepidospermum longitudinale	Sword sedge	Dry foreshore
Leptocarpus diffusus		Within river, wet foreshore, dry foreshore and wetlands
Lepyrodia glauca		Within river, wet foreshore, dry foreshore and wetlands
Orthrosanthus laxus	Morning iris	Dry foreshore
Pattersonia occidentalis	Native iris	Dry foreshore

Key for "Where to Plant" column:

Dry foreshore = Foreshore areas that occasionally get flooded, water dispersers within 24 hours.

Wet foreshore = Foreshore areas that get inundated several times a year, water can pool for a few days/weeks

Within River = Within the river channel on the river toe and bank slopes.

Wetlands = Seasonally wet areas set back on the floodplain.

Appendix 2. Common weeds found in the study area

Name	Common name
**Agapanthus praecox*	Agapanthus
**Amaryllis belladonna*	Easter lily
**Ammophila arenaria*	Marram grass
**Anagalis avensis*	Pimpernel
**Arctotheca calendula*	Capeweed
**Arundo donax*	Giant reed
**Asparagus asparagoides*	Bridal creeper
**Avena barbata*	Bearded oat
**Brassica tournefortii*	Mediterranean turnip
**Briza maxima*	Blowfly grass
**Briza minor*	Shivery grass
**Bromus* spp.	Brome grass
**Cakile maritima*	Sea rocket
**Carduus* spp.	Scotch thistle
**Cerastium glomeratum*	Mouse ears
**Conyza albida*	Fleabane
**Crepis* spp.	Hawksbeard
**Cynodon dactylon* var. *dactylon*	Couch grass
**Cyperus* spp.	
**Ehrharta longiflora*	Annual veldt grass
**Ehrharta villosa*	Pip grass
**Emex australis*	Doublegee
**Erythrina sykesii*	Coral tree
**Euphorbia paralias*	Sea spurge
**Euphorbia peplus*	Petty spurge
**Euphorbia terracina*	Geraldton carnation weed
**Ficus carica*	Edible fig
**Gladiolus undulatus*	Wavy gladioli
**Hedera helix*	Ivy
**Holcus lanatus*	Yorkshire fog
**Hordeum* spp.	Barley grass
**Hypochaeris glabra*	Flatweed
**Isolepis prolifera*	Budding club rush
**Juncus articulatus*	Jointed rush
**Juncus microcephalus*	
**Lagarus ovatus*	Hare tail grass
**Leptospermum laevigatum*	Victorian tea tree
**Lolium perenne*	Perennial rye grass

Name	Common name
**Lotus* spp.	Lotus
**Mentha diemenica*	Garden mint
**Mentha pulegium*	Pennyroyal
**Modiola caroliniana*	Red flowered mallow
**Monadenia bracteata*	South African orchid
**Morus nigra*	Mulberry
**Olea europa*	Olive
**Orbanche minor*	Lesser broomrape
**Oxalis pes-caprae*	Soursob
**Oxalis purpurea*	Mauve oxalis
**Paspalum dilatatum*	Paspalum
**Passiflora edulis*	Passionfruit
**Pelargonium capitatum*	Rose pelargonium
**Pennisetum clandestinum*	Kikuyu
**Petrorhagia velutina*	Velvet pink
**Phalaris aquatica*	Canary grass
**Physalis minima*	Chinese gooseberry
**Pinus* spp.	Pine tree
**Plantago lanceolata*	Ribwort plantain
**Psuedognaphalium luteoalbum*	Jersey cudweed
**Ranunculus muricatus*	
**Raphanus raphanistrum*	Wild radish
**Romulea rosea*	Guilford grass
**Rorippa nasturtium-aquaticum*	Watercress
**Rubus* spp.	Blackberry
**Rumex* spp.	Dock
**Samolus valerandi*	Water pimpernel
**Senecio elegans*	Purple groundsel
**Silene gallica* var. *gallica*	Silene
**Solanum linnaeanum*	Apple of Sodom
**Solanum nigrum*	Nightshade
**Sparaxis bulbifera*	Freesia
**Stellaria media*	Chickweed
**Stenotaphrum secondatum*	Buffalo grass
**Tetragonia decumbens*	Sea spinach
**Trifolium* spp.	Clover
**Vinca major*	Vinca
**Vitus* sp.	Grape
**Watsonia meriana*	Watsonia
**Zantedeschia aethiopica*	Arum lily

Appendix 3. Planning advice from the Vasse RAP

The following planning advice is taken from the Vasse RAP and was prepared by Marg Scott and Jenny Dewing (GeoCatch, 2003).

Planning a project

Write down your objectives:

- What work will be done?
- Who will do the work?
- What will the work achieve?
- Who and what will benefit from the work?

A written list of objectives:

- helps planners to stay within the goals;
- encourages recruitment of volunteers;
- helps volunteers to understand their roles; and
- provides benchmarks of progress and success.

Site selection:

- Choose a workable-sized site, small enough to complete the job.
- Select a site within easy travelling distance for volunteers.
- Favour a site which enables the volunteers, and if possible the general public, to view their achievements.

Organising a planning committee:

- Select a diverse group of people with various skills and interests.
- Choose leaders in the community.
- Draw on different groups of people within the community.
- Identify those people with supervising and planning skills.
- Enlist the local media to contribute their support.

Planning creek rehabilitation

Planning a revegetation project should commence in the year preceding the proposed planting or seeding and include researching the best revegetation approach.

Issues to be addressed include:

- the design of remedial work on the banks;
- the selection of suitable plant species;
- how to propagate (by green stock or direct seeding);
- where to obtain seed;
- who to get to propagate the seed;
- the position and design of fencing;
- identifying likely weed problems, developing a weed action plan; and
- where to access funds if you intend applying for a grant.

It is essential to study the project site thoroughly. A thorough site survey will provide an inventory of assets such as:

- existing indigenous vegetation;
- plants that are naturally regenerating;
- seed sources;
- potential problems, for example, rabbit activity, weed infestations, eroding banks, areas of sedimentation.

The survey may result in the decision to manage the area to encourage natural regeneration rather than to restore the native vegetation by planting or direct seeding.

A survey can also be used for monitoring the effectiveness of a particular management activity over time.

Bank erosion and/or sedimentation may require remedial action prior to revegetation. Advice should be sought from the Department of Water.

When to survey

Late autumn to early winter is a good time to survey when weed problems are apparent. Impacts of river activity can be easily seen – sections of eroding or slumping banks, and areas where sediment is being deposited. Later in winter, a survey of the river or stream in full flow is more likely to reveal the behaviour of the river rather than its impact.

What's growing on the creek or river bank

A list of existing native vegetation is useful for identifying suitable plant species for revegetation and potential populations of plants for obtaining seed. It is important to establish the position on the stream bank that each plant occupies and the type of soil in which it grows – sand, clay, loam etc.

Native plants are easier to identify when flowering. While different species flower in different seasons throughout the year, the peak season is spring. Fringing species flower later to coincide with falling water levels. They flower and produce seed after winter flooding, to complete their cycle before the next winter rains. It may take several visits from winter onwards to identify all plants.

In summer, flowering suites of plants go mostly unnoticed as they flower when few people are walking and looking. Some of these include Astartea fasicularis (a tea tree), *Taxandria linearfolia* (swamp peppermint) and Banksia littoralis (swamp Banksia).

There is a slightly different community of plants growing along the banks of each local creek. These variations reflect the topographical features of the landscape and the soil types unique to that site.

It is not difficult to compile a list of plants specific to a site. The revegetation is then tailored to suit local insects, reptiles, frogs, birds and small mammals, and looks similar to existing remnant vegetation.

Identifying plants

Native rushes and sedges are difficult for untrained people to identify, and are often excluded from revegetation plant lists. The easiest way to identify them is to collect samples, including the base of the plant, and compare them with specimens in the regional or state herbarium. Generally perennial grasses, including spear, wallaby and kangaroo grasses, flower from late spring to summer. Rushes flower at the same time, while sedges flower from late spring through to autumn, depending on the species. These are important plants that help to hold the bank together, acting as 'foot soldiers' to the trees.

Where most understorey plants have been lost through clearing and grazing, selecting a vegetated site nearby with similar soil type and topography will assist in compiling a species list to use.

The Department of Environment and Conservation (formerly Department of Conservation and Land Management (CALM) publication *How to Create a Local Herbarium* is recommended for landholders who wish to collect and preserve their own set of field specimens.

Appendix 4. Permits Required Prior to Commencing Works in Rivers

1. The riverbed and banks, which proposed works would affect, are located in a corridor of Crown Land. In order to undertake any work on this land, permission must be sought from and provided in writing by the Department of land Information (i.e. the landowner). Permission should be requested by sending a letter to the address given below, detailing the proposed works and the reasons for carrying out these works:

Department of Land Information Land Asset Management Services
Bunbury Tower
61 Victoria Street
Bunbury WA 6230

2. Under the *Rights in Water and Irrigation Act 1914* a permit to "interfering with bed and banks" must be obtained prior to undertaking work in a proclaimed waterway. This permit is applied for by completing and submitting a Form H, which can be obtained from:

Department of Water
South West Region
PO Box 261
Bunbury
WA 6231
08 9726 4111

Alternatively this form can be downloaded online from:
http://www.water.wa.gov.au
(Licensing and Industry Section)

3. Under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* a permit for "clearing of native vegetation" may be required for these works. It is only required if areas of native vegetation are to be cleared in addition to that affected by the proposed works (e.g. clearing required to gain access to the site or to stockpile materials). This permit is applied for by completing and submitting a Area Permit form, which can be obtained from:

Department of Environment & Conservation
Native Vegetation Protection Unit
South West Region
PO Box 261
Bunbury
WA 6231
08 9726 4111

Alternatively this form can be downloaded online from:
http://www.dec.wa.gov.au

Please Note: A letter from the landowner (DLI) stating that they agree for the project to occur and give permission for the works will need to be attached to the Area Permit application.

4. There are several other legal issues that may arise under the *Aboriginal Heritage Act 1972* and *Native Title Act 1993*:

   - Under the Aboriginal Heritage Act 1972, the Department of Indigenous Affairs should be contacted to:

     1. Advise them of the proposed project.
     2. Identify if your project is going to affect a registered Aboriginal site, and if so:
     3. Request the names and contact details for the relevant Aboriginal people for consultation purposes.

   - Under the *Native Title Act 1993*, the Department of Land Administration should be contacted to determine if the project area is subject to a native title claim. If there is a claim, the Department of Land Administration will be able to provide contact details of the claimants, as consultation with representatives from the Native Title Claimant groups will be required.

Appendix 5. Landcare Project Time Line Template

This information was provided by the Peel Harvey Catchment Council

This is a suggested plan for landcare projects in the region. Each specific site may have different problems and challenges. Climatic variations each season may affect the timing of some actions.

August	• Plan your landcare project. • Apply for funding assistance.
September to October	• Control weeds with Glyphosate spray. This early spray is important especially if couch or kikuyu are present. • Early fencing and spraying may discourage kangaroos from visiting the site and reduce damage when the seedlings are planted.
November to December	• Order seedlings from your preferred nursery. Early orders usually receive a discount so check the early order closing dates. • Control grasshoppers in the area by spraying or using bran baits. Check the high sandy areas for early hatchings and spray before the grasshoppers start to move.
January to February	• Plan your tree lines to follow the contours to prevent erosion. • Deep rip tree lines (minimum of 3 rows) to a depth of at least 50 – 70cm. Rows should be about 3m apart to allow for vehicle access while spraying and planting. • Monitor previous year's projects for pests and weeds. • Poison rabbits and rip warrens.
March to April	• Disc or rotary hoe along rip lines to help break up the soil and weeds. This will ensure a better-formed mound especially on clay sites or if there is a lot of persistent weeds like couch or kikuyu. • Fence off the project area before mounding the site to restrict access, as cattle will destroy unprotected mounds. • After the first rains mound along the rip lines in most soils. The mounds are essential in low-lying waterlogged areas but also provide a good growing environment for the seedlings in the higher areas. On deep sand sites it is better to furrow along the rip line to direct water to the roots which will improve survival rates.
May	• Good weed control is vital. Spray the weeds along the mounds/furrows. The use of a Glyphosate and Simazine mix has been found to give better weed control. (Glyphosate is a knockdown herbicide that kills on contact and Simazine is a residual chemical that will stop weeds germinating through winter and spring.) • Allow at least 2 weeks before planting out seedlings.3
June to July	• Plant seedlings, 2 – 3m apart and a mix of trees and shrub or you can make a more effective windbreak by planting one row of shrubs, then a row of tall shrubs and smaller trees and then a row of larger trees. • Monitor for pests – rabbits, kangaroos, ducks and black beetle to name a few. • Use tree guards if necessary. • Return your trays to the nurseries.
August to September	• Monitor weed growth – spot spraying may be necessary if initial weed control was not done properly. • Start planning for next year!!!!

Appendix 6. Best Management Practice (BMP)

Best Management Practice – 4.0 Water Management

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Definition

Management of important on-farm issues such as, erosion, nutrient inputs, vegetation, grazing and water sources, are all part of an integrated water quality management plan. This approach will have a greater cumulative effect than any one of these strategies used individually.

Description

The Western Australian dairy industry relies on a constant supply of fresh water for irrigation and stock watering. For this reason, production is usually located close to ground and surface water resources.

A major objective of this fact sheet is to maintain the high quality water resources that exist in most of Western Australia's dairy farming areas. These resources invariably have current or potential value for uses other than dairying.

Wetlands have nature conservation values. Dams on streams need to have 'environmental flows' that is, sufficient flowing water to maintain the natural biodiversity in the water and on the banks. Fresh groundwater aquifers may be required for potable water supplies in the future. Many estuaries are used for recreation and tourism activities and fisheries. The water quality of these resources must be maintained at levels suitable for all current and potential uses.

Pollution of water resources by agricultural nutrients and chemical are major issues for the industry. Excessive levels of phosphorus and nitrogen can cause algal blooms in surface water during summer. Groundwater maybe contaminated if management fails to prevent the downward leaching of fertilizers. In some parts of Europe and USA, agricultural activities are regulated because groundwater aquifers have become so badly polluted by nitrates from fertilisers and by the chemical atrazine that they are unfit for human consumption.

Whilst the impact on stream water quality and health is enormous, of equal importance is the impact of poor water quality on the health and happiness of both livestock and people in the community.

By following the water management practices discussed below, the expected environmental outcomes include:

- Water resource quality is maintained at levels acceptable for all of its beneficial existing and potential uses.
- Fertlisers and chemicals used for dairying do not pollute water resources.
- Stability and character of waterways are maintained and where possible enhanced.

Implementation

The first and most desirable strategy for erosion control is to prevent erosion and the subsequent transport of the sediment. Erosion management addresses sheet and rill erosion, wind erosion, stream bank erosion and erosion from construction and irrigation sites. Erosion and sediment control systems can and should be designed to protect against contaminating surface and ground water.

Erosion Management

Useful tools for erosion management;

- *Conservation*

Developing perennial cover will protect soil and water resources. Growing crops of grasses, legumes, or small grain will provide seasonal protection and soil improvement. Maintaining at least 30% soil surface cover by residue after planting will reduce soil erosion by water. Planting vegetation on high risk areas will help reduce erosion. Growing windbreaks will reduce wind erosion.

- *Contour farming*

Farming sloping land on the contour will help stop erosion and reduce sediment and nutrient flow. This includes following established grades of terraces or diversions. Growing crops in an arrangement of strips or bands on the contour also reduces water erosion.

- *Water management structures*

Developing grassed waterways, whether natural or constructed for the stable conveyance of runoff.

Planting a strip or area of vegetation for removing pollutants from runoff will reduce the amount of sediment reaching the waterways. Building grade stabilization structures and basins to collect and store debris or sediment will reduce sediment loss. Building sediment traps and water detention basins will also reduce the effects of erosion.

Nutrient Management

Nutrient management focuses on preventing nutrient loss. Efficient fertiliser use through nutrient management is important. Carefully planning nutrient applications is the key to controlling nutrient runoff.

Useful tools in nutrient management.

- *Testing*

Using soil surveys will help to identify nutrient loss sites. Soil testing for nutrients and plant leaf analysis helps identify the correct nutrient for each location and provides information on the right quantity to be applied.

- *Nutrient Inputs*

Using proper timing, formulation, and application methods for nutrients will maximise utilization and minimise loss. Split applications and banding of the nutrients, use of nitrification inhibitors and slow-release fertilizers will all help control nutrient loss. Use of gypsum instead of super phosphate as a sulphur source will help reduce the amount of phosphorous from either leaching into the soil or entering the waterways.

- *Buffer areas*

Use buffer areas around high-risk areas such as; land near surface water, areas at high risk of erosion or leaching soils and any irrigated land, to prevent nutrients entering the water flow or the water table. Buffer zones should include vegetation to filter nutrients.

- *Engineered water structures*

Developing grassed waterways, whether natural or constructed will help runoff control. Building grade stabilization structures and basins to collect and store debris or sediment will allow for nutrients to settle out. Building sediment traps and water detention basins will also reduce nutrient loss.

Vegetation management

Native vegetation intercepts rainfall and prevents rain splash erosion and also reduces gully, rill and sheet erosion by slowing runoff and binding soil together with root matter. It can take up nutrients and can be used in buffer strips for streams and surrounding nutrient intensive developments. Vegetation also acts to slow and filter sediment from runoff.

The focus of nutrient and sediment loss management is on the riparian zone. Erosion control from pastures and other grazing lands above wetland areas is vital. The key options to consider when planning a grazing management approach for a sensitive location, such as stream banks, wetlands, estuaries and riparian zones include:

- Limit livestock access, best management practice is to exclude livestock. Grazing should only be considered in extreme situations;
- Providing stream crossings or hardened watering access for drinking;
- Providing alternative drinking water locations;
- Locating additional shade, if needed, away from sensitive areas;
- Reducing the physical disturbance and reduce direct input of animal waste and sediment caused by livestock.

Available information shows that:

- Aquatic habitat conditions are improved with proper livestock management;
- Pollution from livestock is decreased by reducing the amount of time spent in the stream through the provision of supplemental water, and
- Sediment delivery is reduced through the proper use of vegetation, stream bank protection and planned grazing.

Water source management

Providing alternative water sources away from streams will help keep livestock away from sensitive stream banks and riparian zones. The establishment of alternate water supplies for livestock is an essential component of sediment and nutrient loss management.

Providing water can be accomplished through the following practices.

- *Pipelines*

Piping water to watering points away from streams decreases sediment and nutrient pollution from livestock. This will prevent bank destruction with resulting sedimentation, and will reduce animal waste directly entering the water.

- *Fencing*

Fencing acts as a barrier to livestock. Preventing livestock from being in the water or walking down the banks improves water quality. Fencing will protect wetland areas and riparian zones acting as sediment traps and filters along water channels and impoundment.

A controlled crossing or watering access point for livestock will control bank and streambed erosion.

- *Constructed wetlands*

Building dams, sediment basins, extending storage ponds or restoring existing wetlands will trap nutrients and sediments. Wetlands reduce the amount of water that flows downstream from the catchment.

Landholders working together, helping each other to plan and implement strategies not only on a farm by farm basis but in a whole catchment effort is the philosophical basis of the approach.

Advantages

Guarantees suitable water supplies will be available in the future for irrigation and stock watering.

The quality of water resources are maintained and enhanced to preserve all environmental, social, economic and recreational value.

Reference

Department of Agriculture (no date). Management strategies for nutrient and sediment loss in the Ellen Brook Catchment. Department of Agriculture, Western Australia.

The following BMP's are from the Department of Agriculture and Food. These Bulletins can be found on the Departments website and may provide landholders with additional information for improved land management.

- Bulletin 4573, Biosecurity for Small Landholders.
- Bulletin 4560, Code of practice for the use of agricultural and veterinary chemicals in Western Australia.
- Bulletin 4623, Common insect pests and diseases in fruit trees in the home garden.
- Bulletin 4624, Common insect pests and diseases on vegetables in the home garden.
- Bulletin 4689, Dairycatch: environmental best practice guidelines.
- Bulletin 4576, Dam design for pastoral stock water systems.
- Bulletin 4694, Farming for the future, self assessment tool.
- Bulletin 4577, Getting into sheep: An introductory guide to sheep management.
- Bulletin 4243, Management of agricultural weeds in Western Australia.
- Bulletin 4464. Natural resource management in Western Australia: catchment water management: guidelines for those considering drainage for waterlogging and salinity management.
- Bulletin 4596, Pome and stone fruit orchard spray guide 2003/04.
- Bulletin 4359, Soils of the Swan Coastal Plain.
- Bulletin 4547, Total grazing management field guide: self mustering system for cattle, sheep and goats.
- Bulletin 4490, Weed plan for Western Australia.
- Bulletin 4584, Zone management in precision agriculture by matching fertiliser input to crop demand.

Appendix 7. Useful contacts and phone numbers

Leschenault Catchment Council
35-39 McCombe Road, Bunbury
PO Box 261, Bunbury WA 6231
Ph: 9726 4111
Fax: 9726 4100
Email: cameron.sutherland@water.wa.gov.au
Web: http://www.leschenaultcc.com

GeoCatch
72 Duchess St, Busselton
PO Box 269, Busselton, 6280
Ph: 9781 0111
Fax: 9754 4335
Email: geocatch@environment.wa.gov.au
Web: http://www.geocatch.asn.au

Department of Agriculture and Food (Bunbury)
North Boyanup Road, Bunbury
PO Box 1231, Bunbury 6231
Ph: 9780 6100
Web: http://www.agric.wa.gov.au

Department of Environment and Conservation (Bunbury)
Native Vegetation Unit
35-39 McCombe Road
PO Box 261, Bunbury, 6231
Ph: 9726 4111
Fax: 9726 4100
Web: http://www.environment.wa.gov.au

All other sections
Cnr Dodson Road and North Boyanup Road, Bunbury
PO Box 1693, Bunbury WA 6231
Ph: 9725 4300
Web: http://www.naturebase.com.au

Department of Water (Bunbury)
35-39 McCombe Road
PO Box 261, Bunbury, 6231
Ph: 9726 4111
Fax: 9726 4100
Web: http://www.watert.wa.gov.au

Ribbons of Blue (Leschenault)
35-39 McCombe Road
PO Box 261, Bunbury, 6231
Ph: 9726 4111
Fax: 9726 4100

WA Museum
Perth Cultural Centre, James Street, Perth
Email: reception@museum.wa.gov.au
Web: http://www.museum.wa.gov.au

Leschenault Community Nursery
PO Box 1741, Bunbury, WA 6231
Ph: 97914670

Shire of Donnybrook – Balingup
PO Box 94, Donnybrook 6239
Ph: 9780 4200
Fax: 9731 1677
Email: shire@donnybrook.wa.gov.au
Web: http://www,donnybrook-balingup.wa.gov.au