

# BUAYANYUP RIVER ACTION PLAN



Prepared for the Geographe Catchment Council (GeoCatch)

*By Gemma Mincherton | December 2010*





## GeoCatch

72 Duchess Street  
Busselton WA 6280

Telephone + 61 8 9781 0111  
Facsimile + 61 8 9754 4335  
[www.geocatch.asn.au](http://www.geocatch.asn.au)

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For more information about this report, contact:  
The District Manager  
GeoCatch  
Busselton WA

Front cover photo Buayanyup River upper catchment by Gemma Mincherton

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# Summary

The overall goal of this river action plan is to set out ways to improve water quality, increase biodiversity and reduce the incidence of weeds and feral animals within the Buayanyup catchment.

It is hoped that the plan will increase awareness among land managers of the problems affecting the health of the catchment, and will encourage action to be taken to deal with them.

Water quality monitoring has revealed that excess nutrients from agricultural and urban sources contribute to problems such as toxic algal blooms, fish deaths, odours and increased mosquito populations. On-ground surveys throughout the catchment have identified areas where improvements can be made to help address these issues.

Foreshore condition assessments using methods developed by Luke Pen and Margaret Scott (Pen & Scott 1995) found that approximately 25% of the length of the waterway has been fenced from stock. A full summary of the foreshore condition rating and length of fencing of the waterways is presented in Table 2.

## Issues of concern

Ten issues of concern were identified during the foreshore assessments and community consultations. They were:

- limited understanding of waterway health issues
- poor water quality
- unrestricted stock access to waterways
- lack of riparian vegetation and destruction of habitat supporting rare or endangered flora and fauna
- tree decline
- erosion and sedimentation
- weed invasion
- dams and the lack of release of environmental flows
- feral animals
- slow progress in adopting ecologically sound management practices.



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# Recommendations

Recommendations for improving catchment health are as follows:

- Focus on raising awareness among land managers of how to address waterway health issues and improve management of riparian vegetation.
- Improve water quality by:
  - improving fertiliser and effluent management
  - excluding stock from waterways and drains and revegetating foreshores
  - using soil amendments that are high in iron and clay particles to increase the capacity for soils to retain phosphorus.
- Fence off waterways and drains and create off-stream stock watering points, particularly on properties where there are cattle.
- Protect existing riparian vegetation and re-establish it where it is absent.
- Conduct a study to determine the causes of tree decline and continue trials of phosphite and nutrients to establish which treatments aid in improving tree health.
- Engage engineers from the Department of Water for advice on designing erosion control measures.
- Control weeds using chemicals with modified surfactants (a product included in or added to herbicide to improve leaf penetration which is toxic to aquatic plants and animals). Focus on controlling declared plants and environmental weeds described in Appendix 3.
- Plan to construct dams off-stream to minimise the effects on flow regimes as well as on fish migrating up-stream to spawn. Where on-stream dams are present, ensure bypass valves are opened at the start of the wet season.
- Continue feral animal control, focusing on baiting foxes and rabbits. Also work with Murdoch University on raising public awareness about the importance of protecting native fish stocks by not releasing feral fish into waterways.
- Encourage the adoption of ecologically sound management practices by:
  - improving landholders' understanding of the value of riparian vegetation
  - addressing landholders' concerns relating to the perceived restrictions or loss of access to land because of funded projects.

# Priorities for on-ground works

The following table lists the goals of the plan, the reasons for setting each goal, the on-ground works needed to achieve them and the desired results.

**Table 1** Priorities for on-ground works

Goals	Why	How	Outcome
1. Improve water quality	<p>To maintain quality river water for agricultural use.</p> <p>To reduce algal blooms and fish deaths and to maintain quality water in receiving body (Geographe Bay) for fishing, swimming and biodiversity.</p>	Engage landholders with beef, dairy and horticulture properties in riparian management projects using the land-use map (Figure 6). Focus on excluding stock from waterways, rehabilitating riparian vegetation for nutrient buffers, upgrading dairy effluent systems and improving fertiliser management.	Reduced nutrients entering waterways from high risk land uses.
2. Protect and improve biodiversity	The Buayanyup catchment is part of a 'biodiversity hotspot' and supports threatened flora and fauna.	<p>Cross reference land-use map (Figure 6) with the Buayanyup River vegetation map (Figure 4) and work with landholders who have rare vegetation complexes on their properties (i.e. all Abba vegetation complexes).</p> <p>Conduct weed control and revegetation in coastal reserves such as Locke Nature Reserve as a way of maximising habitat for the western ringtail possum.</p> <p>Fence where necessary and rehabilitate riparian and in-stream habitat, particularly in the upper catchment in areas of known western minnow habitat. Use seeded matting for re-establishing in-stream habitat.</p>	<p>Protection of remaining rare vegetation complexes.</p> <p>Improving western ringtail possum habitat.</p> <p>Improving habitat for native fish.</p>
3. Reduce weeds and feral animals to allow natives to flourish	<p>Weeds compete with native plants.</p> <p>Feral animals compete for food and prey on small native animals.</p>	<p>Focus on controlling the priority weeds identified in Appendix 3: Common weed species.</p> <p>Work with Murdoch University (or other suitable organisations) on controlling mosquito fish and yabbies.</p> <p>Continue rabbit and fox control.</p>	Improved conditions for native flora and fauna.

**Table 2** Summary of foreshore condition

Condition	Length out of total of 100.2 km	
	km	%
A (pristine)	32.3	32
B (weedy)	12.2	12
C (erosion prone)	30.5	30
D (ditch)	24.7	25
E (dams)	0.5	0.5

# Introduction

## The catchment

The Buayanyup River is located in the Geographe Bay catchment and flows out to sea approximately 8.5 km west of Busselton. It is a sprawling waterway stretching down from the Whicher Scarp with a stream length of some 100 km. The four main tributaries, which make up its headwaters, begin in state forest which is abundant with declared rare flora and native fauna. The river then flows through agricultural land, the growing urban area of Vasse Newtown, and finally discharges into Geographe Bay at Abbey.

Many know the Buayanyup River only as the degraded drain passed over when travelling between Vasse and Carburnup. Although there has been significant alteration to sections of the river for flood mitigation purposes, drainage is not its only function. In a setting where much of the land has been cleared for agriculture and urban development, river corridors provide some of the most substantial areas of natural vegetation remaining and the Buayanyup River is no exception.

The river has a catchment area of 91 km<sup>2</sup> and supports a variety of agricultural production including annual horticulture, vineyards, dairy and beef cattle and sheep enterprises. The area has been farmed since 1834 when the Bussell family established a cattle station called 'Cattle Chosen' on the Vasse River. This prosperous station attracted many others to the area and now more than 50% of the catchment is farmed for dairy or beef.

Food producing land uses have obvious economic and social benefits to the community. However, collectively these farming systems can create significant pressure on the catchment's waterways. The condition of riparian vegetation has degraded over time due to unrestricted stock access and weed invasion, while water quality has declined due to runoff from urban sources, stock, dairy effluent and fertiliser. This river action plan is a step towards addressing these issues while continuing to allow the land adjoining the river to be used for productive purposes.

## 1.2 Background

Since 1997 the Geographe Catchment Council (GeoCatch) has led an ongoing program of river restoration, biodiversity and water quality improvement within the Geographe catchment in consultation with local landholders and community groups. The program has focused on the development and subsequent implementation of river action plans for individual waterways, with community involvement at all stages of the process. Waterway restoration has continued to be a priority action for GeoCatch and to date there are eight river action plans being implemented in the Geographe Catchment. These include plans for the:

- Capel River
- Gynudup Brook and Tren Creek
- Abba River

- Sabina River
- Ludlow River
- Vasse River
- Carburnup River
- Cape Naturaliste Streams.

The recently developed *Vasse Wonnerup Wetlands and Geographe Bay water quality improvement plan (Department of Water 2010)* identified riparian management as being essential for improving the quality of water discharging into these two significant features.

This river action plan was written because:

- The Buayanyup catchment has been identified as a nutrient hotspot, or 'intervention' catchment in the water quality improvement plan for the Vasse Wonnerup wetlands and Geographe Bay. Water quality monitoring shows that excess nutrients, particularly nitrogen from catchment runoff are delivered to Geographe Bay. Seagrass meadows are sensitive to nutrient enrichment and have been known to be lost from other marine ecosystems due to this process (Department of Water 2010).
- The Buayanyup system is large and drains a catchment with increasing development pressures, such as the expansion of the Vasse Newtown residential development, which are likely to increase the nutrients delivered to the river and bay.
- Little is known about the Buayanyup catchment in comparison to surrounding areas, so a river action plan was needed to fill these knowledge gaps.

### 1.3 Study aims

The specific aims of this river action plan are:

- to produce a detailed description of the current state of the Buayanyup River foreshore and identify actions to improve waterway health
- to engage landholders adjoining the river and the community to increase awareness of the importance of healthy waterways for improved water quality and improved biodiversity
- to provide a benchmark against which the local community's future work to protect and rehabilitate the waterway can be gauged
- to provide guidance on the use of funding and assistance available for addressing the issues identified within the plan
- to provide a sound technical basis for future funding submissions.

## 1.4 Structure of the report

Readers wishing to find the overall background and general recommendations should refer to sections 1 to 5.

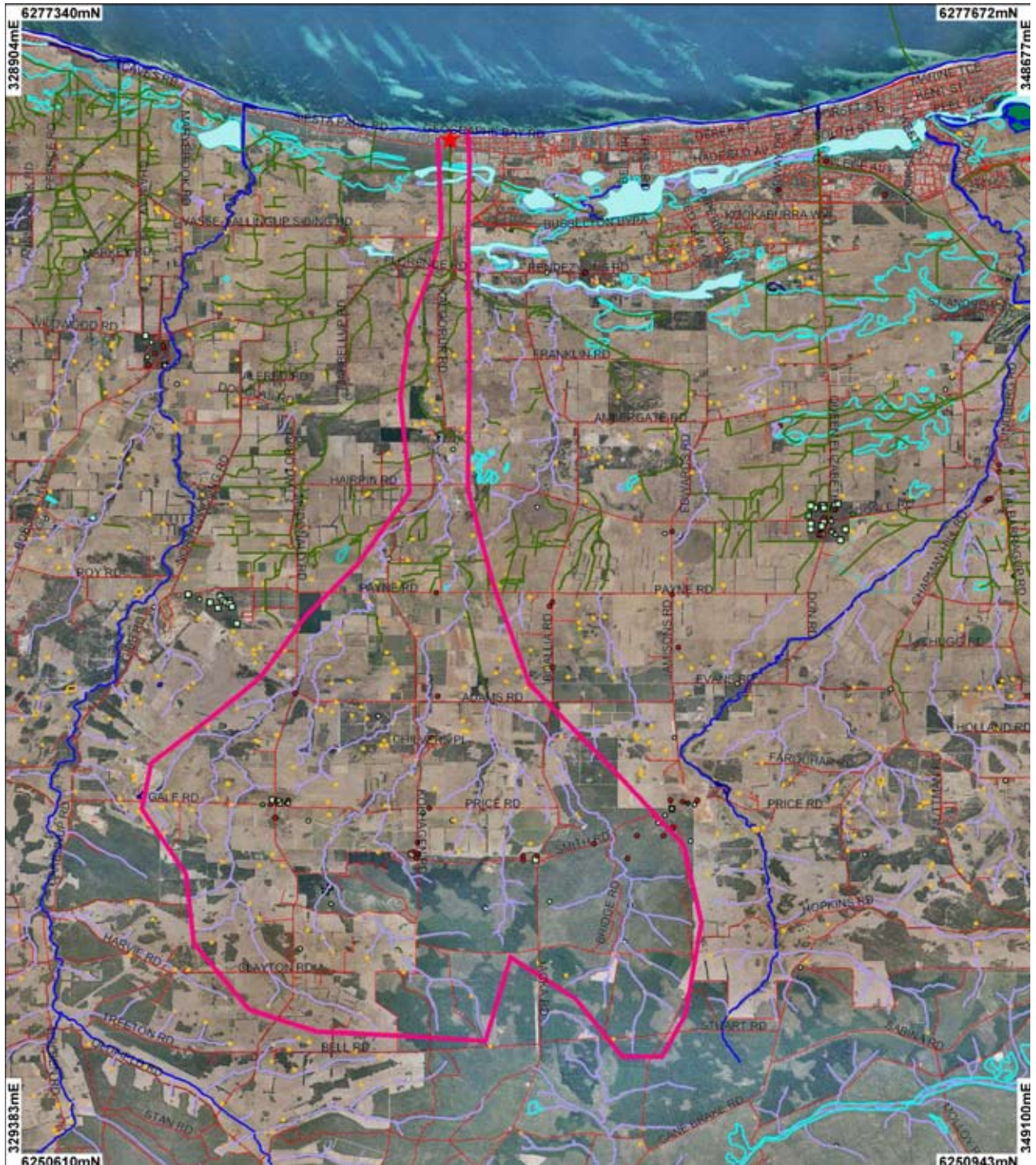
Readers wishing to find the detailed field observations on foreshore condition, and the specific recommendations on what should be done to improve it at the level of individual lots, should refer to Section 6. The key map, Figure 14, is the starting point.

The appendices contain:

- lists of vegetation complexes, flora and fauna
- background information about water ecology, erosion and revegetation
- the method used for assessing the condition of the foreshore
- advice on planning a project
- useful contacts and sources of information.



## 2 Catchment characteristics



**Figure 1** *The study area*

### 2.1 The waterway systems and catchments

The study area included the main channel of the Buayanyup River and three major tributaries – Dawson Gully, Ironstone Gully and an unnamed tributary. The most eastern tributary arising between Boallia and Jamisons Roads was not included in this study, nor were the farm drains in the lower catchment.

The four branches that make up the headwaters rise in the state forest. Collectively, these branches flow through 'A' Grade vegetation for 20 km.

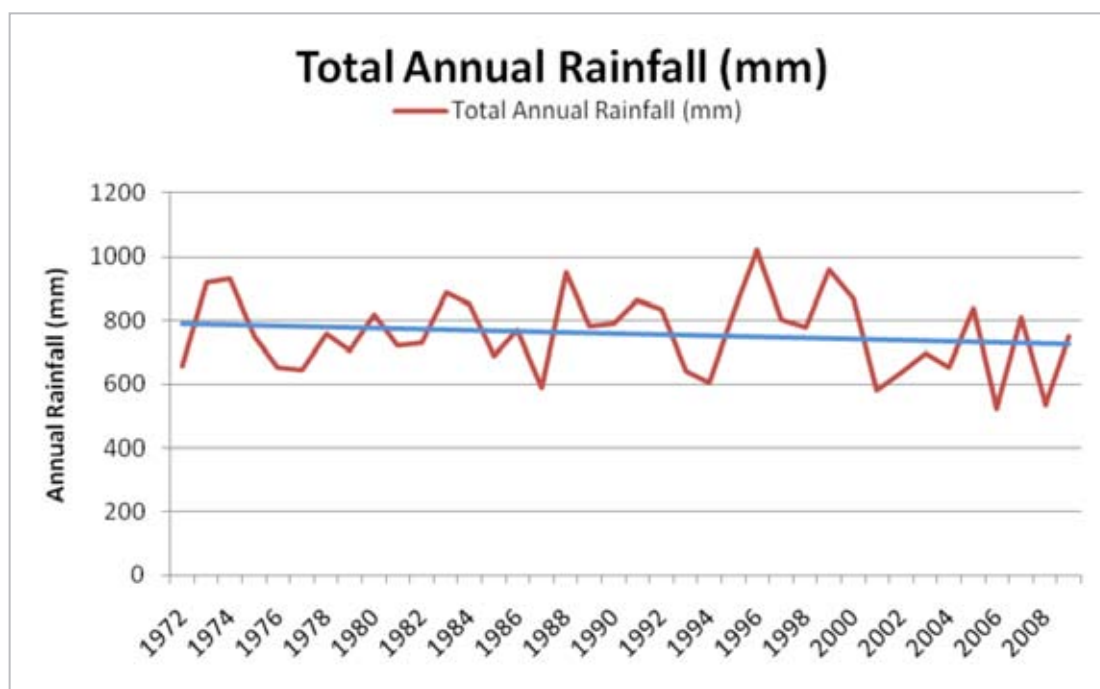
The middle of the catchment is dominated by agricultural pursuits ranging from annual vegetable crops, viticulture, dairy and beef cattle, plantations and a horse stud.

Within the lower catchment the land use becomes more urban and the waterway flows past a school and then into residential areas before discharging into Geographe Bay.

## 2.2 Climate

The Buayanyup catchment experiences a Mediterranean climate with hot, dry summers and mild, wet winters. The mean rainfall is approximately 814 mm (Bureau of Meteorology 2008).

The region has already been affected by climate change, experiencing a 10 to 15% decrease in annual rainfall since about 1975 which has resulted in runoff decreasing to less than half the earlier levels. The decline in autumn and early winter rainfall and a reduction in rainfall intensities is most marked. Climate modelling predicts that the climate in the South West region will become hotter and drier by 2030. Figure 2 below shows the total annual rainfall recorded from 1972 to 2009 just outside the Buayanyup catchment in Chapman Hill.



**Figure 2** Annual rainfall recorded in Chapman Hill from 1972 to 2009

## 2.3 Landform and soils

The Buayanyup River runs through a region that is separated into three distinct geological formations, the Swan Coastal Plain to the north and the Blackwood Plateau to the south with the Whicher Scarp forming a distinct separation between the two.

The rocks underlying the Swan Coastal Plain are sedimentary in origin and are relatively young. There are limestones, sandstones, sands, silts and clays. Rocks exposed at the surface are all younger than two million years and deposition is still occurring in some places. The oldest exposed geological unit is the Yoganup Formation, followed in age by the Guildford Formation, Bassendean Sand, Muchea Limestone, Tamala Limestone, Tamala Sand and the Safety Bay Sand.

The older sedimentary units underlying the area consist primarily of sandstone, siltstone, claystone and shales with minor coal beds, and contain significant groundwater reserves.

Within these land formations are several soil zones, starting at the coast with the Quindalup zone consisting of coastal dunes with calcareous deep sands and yellow sands (Figure 3). A brief description of each of the major soil zones is shown below in Table 3.

**Table 3**      *Major soil zones*

<b>Zone</b>	<b>Description</b>
Quindalup	Coastal dunes of the Swan Coastal Plain with calcareous deep sands and yellow sands. Coastal scrub is the principal vegetation.
Vasse	Poorly drained estuarine flats on the Swan Coastal Plain. Soils include tidal flat soil, saline wet soil and pale deep sand. The main vegetation types include samphire, sedges and paperbark woodland.
Spearwood	Dunes and flats overlying limestone on the Swan Coastal Plain with deep yellow sand, pale deep sand and yellow/brown shallow sand. The predominant vegetation is tuart forest and woodland.
Pinjarra	Poorly drained flats on the central coastal plain with grey deep sandy duplex soils, yellow loamy earth, cracking clay and sandy duplex. The vegetation consists of jarrah-marri-wandoo-paperbark forest and woodland.
Bassendean	Dunes, flats and swampy depressions of the Swan Coastal Plain with pale deep sand. Main vegetation types are banksia woodlands and heath on dunes and paperbark woodland in flats.
Whicher Scarp	Low scarp and raised platform on the northern edge of the Donnybrook Sunkland. Main soils include sandy gravel, pale deep sands, loamy gravel and non-saline wet soils. Principal vegetation consists of jarrah-marri forest (Rivers 2001, cited in Department of Agriculture 2003).



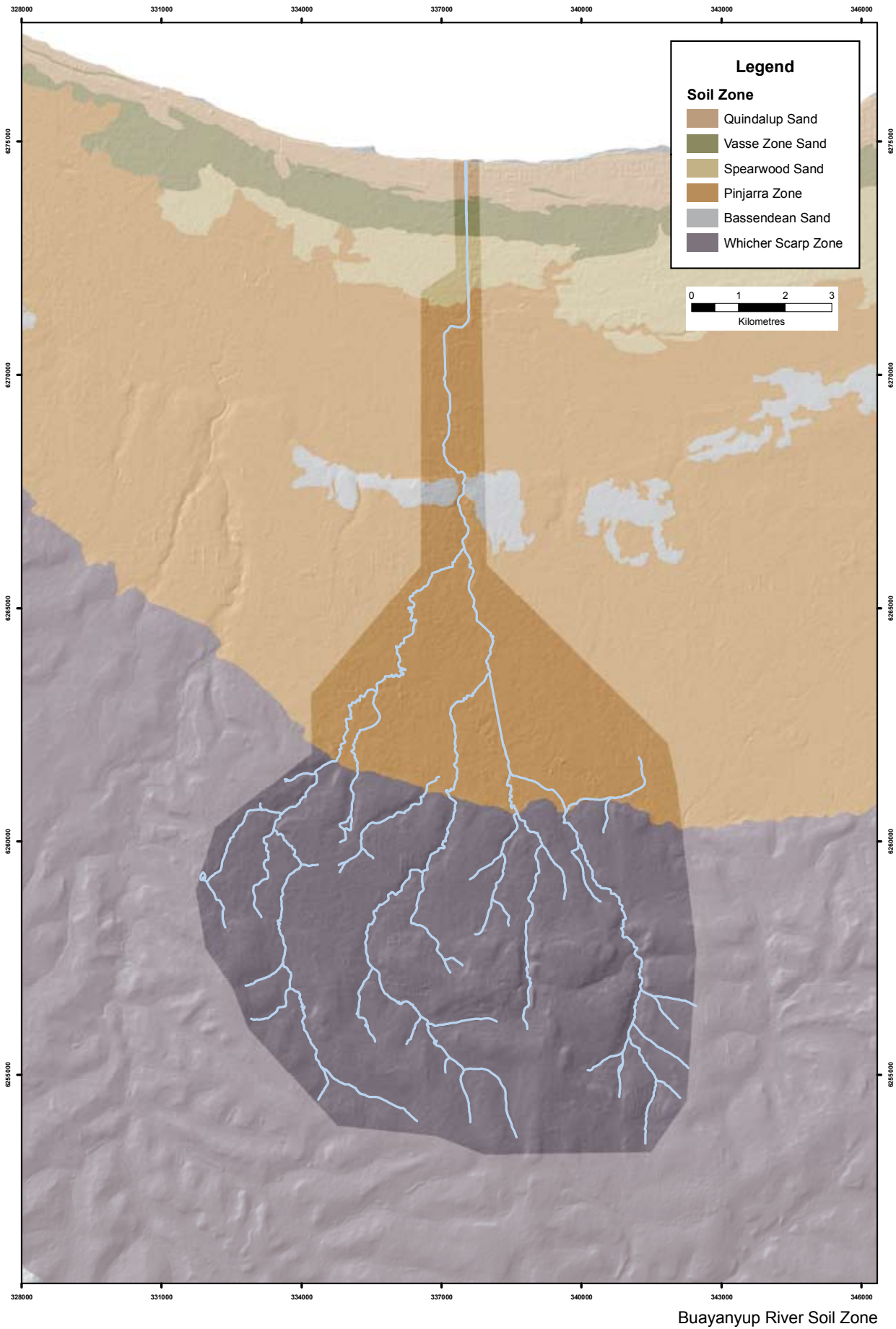


Figure 3 Soils of the Buayanyup catchment

Buayanyup River Soil Zone

## 2.4 Flora

Over 30% of the riparian vegetation within the Buayanyup catchment is in A grade condition, with high quality vegetation mostly limited to the upper reaches of the waterway found in state forest and private land where the waterway has been protected from stock access.

The predominant species found within this riverine landscape are overstorey of *Corymbia calophylla* and *Agonis flexuosa*, often with *Eucalyptus patens* and *Melaleuca preissiana* over an understorey of *Taxandria linearifolia*, *Astartea fascicularis* and *Mirbelia dilatata*. Dominant sedge species include *Lepidosperma effusum*, *Baumea vaginalis*, *Cyathochaeta avenacea* and some *Lepidosperma tetraquetrum*.

The river also supports species characteristically found on the Blackwood Plateau that are rarely seen on the Swan Coastal Plain such as the shrubs *Hovea elliptica*, *Mirbelia dilatata*, *Bosseaea linophylla*, *Dasyopogon hookeri*, *Hakea lasianthoides*, *Callistachys lanceolata* and *Hypocalymma cordifolium*; the herb *Lomandra pauciflora*; and the sedge *Lepidosperma effusum* (Webb et al. 2009).

### Vegetation complexes

Fourteen vegetation complexes are found within the Buayanyup catchment. The vegetation complexes are aligned with the soil types and tend to vary when the soil type changes. The percentage remaining, percentage protected and recommended action for the vegetation complexes found in each reach are given in Section 6. Appendix 1 has a full description of the vegetation complexes.

To ensure biological diversity is protected into the future, it is estimated that 30% or more of each ecological community needs to be retained (Commonwealth of Australia 2001). In the Buayanyup catchment, six of the 14 complexes have less than 30% remaining. These relate mostly to the Abba complexes found in the mid catchment which have less than 6% remaining, and so are a top priority for conservation.

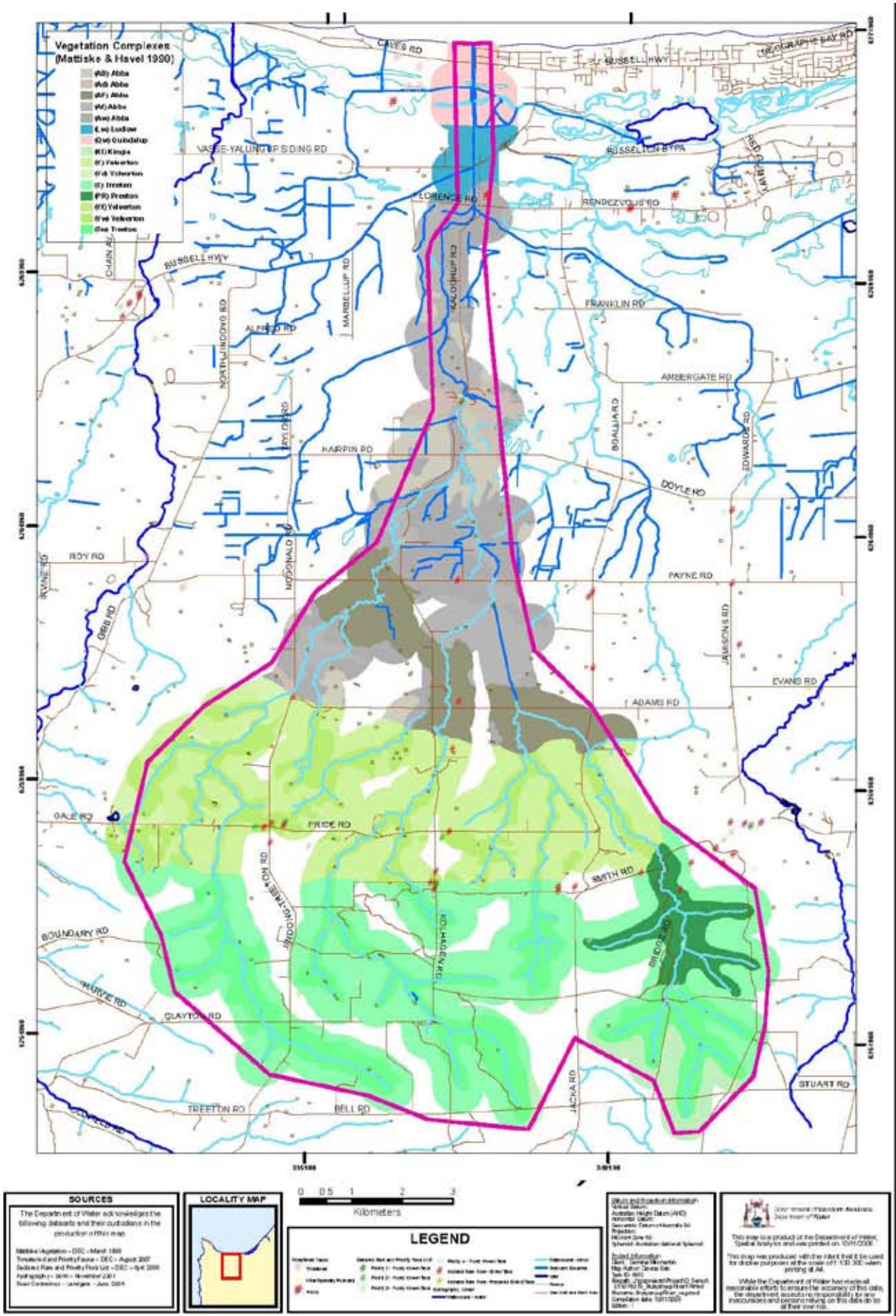





Figure 4 Vegetation complexes of the Buayanyup catchment






**Declared rare flora**

The study area supports a diverse range of flora species and many occurrences of declared rare flora, a number of which are orchids. The high prevalence of rare and endemic flora in the Buayanyup catchment emphasises the need to preserve remaining stands of intact vegetation communities, including those that occur along the foreshore of waterways. The declared rare flora known in the catchment are noted below. A list of all other known flora can be found in Appendix 2.

**Table 4** *Declared rare flora known within the Buayanyup catchment*

Declared rare flora	Photo
<p><i>Banksia nivea</i> subsp. <i>uliginosa</i></p> <p>Photographs by: JA Cochrane and M Pierone</p>	 <p><i>Banksia nivea</i> subsp. <i>uliginosa</i> Photos: J.A. Cochrane &amp; M. Pierone</p>
<p><i>Banksia squarrosa</i> subsp. <i>argillacea</i></p> <p>Photographs by: M Pierone</p>	 <p><i>Banksia squarrosa</i> subsp. <i>argillacea</i> Photos: M. Pierone</p>
<p><i>Chamelaucium roycei</i></p> <p>Photograph by: M Handock</p>	 <p><i>Chamelaucium roycei</i> Photo: M. Handock</p>

Declared rare flora	Photo
<p><i>Daviesia elongata</i> Benth. subsp. <i>Elongata</i></p> <p>Photographs by: K Brown and JA Cochrane</p>	 <p><i>Daviesia elongata</i> subsp. <i>elongata</i> Photos: K. Brown &amp; J.A. Cochrane</p>
<p><i>Grevillea brachystylis</i> subsp. Busselton</p> <p>Photographs by: AD Crawford</p>	 <p><i>Grevillea brachystylis</i> subsp. Busselton (D.J. Keighery s.n. 28/8/1985) Photos: A.D. Crawford</p>
<p><i>Verticordia plumosa</i> var. <i>ananeotes</i></p> <p>Photographs by: EA George and D Papenfus</p>	 <p><i>Verticordia plumosa</i> var. <i>ananeotes</i> Photos: E.A. George &amp; D. Papenfus</p>

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## 2.5 Fauna

Almost 300 species of fauna are known to occur in the Buayanyup catchment including 26 species of native mammals, 175 species of birds, 12 species of frogs, 36 species of reptiles and 25 species of aquatic fauna.

### Freshwater fish and crayfish survey

A survey of the freshwater fish and crayfish in the Buayanyup River was conducted by Murdoch University in November 2008. Listed below are the results.

*Freshwater fish*

- The western minnow
- Western pygmy perch
- Nightfish
- Mosquito fish (introduced species)

*Crayfish*

- Gilgie
- Smooth marron
- South-west shrimp
- Koonac
- Eastern Australian yabbie (introduced species)

*Estuarine fish*

- Black bream
- Australian salmon
- South-west goby
- King George whiting
- *Leptatherina presbyteroides*
- Western hardyhead
- Sea mullet
- *Palamonetes atrinubes*
- Blue spot goby
- Little scorpionfish
- Striped trumpeter
- Sandy sprat (whitebait)
- Yellowtail trumpeter

*Estuarine crayfish*

- Estuarine shrimp

The western pygmy perch was found to be the most widespread and abundant species and would be ideal for a proposed captive breeding program.

Native fish found in the Buayanyup River are considered good indicators of habitat change and water quality decline as they are generally found in areas where the vegetation is healthy and intact and seem to be absent from degraded areas, highlighting that protection and rehabilitation of both in-stream and riparian vegetation is critical to the survival of endemic fish populations (Beatty, Morgan & Allen 2009).

## Other fauna

The endangered western ringtail possum (*Pseudocheirus occidentalis*) depends upon habitat provided by peppermint woodland, which is common along the most northern extent of the Buayanyup River. Conservation of this type of habitat is essential to the survival of this species. Other significant fauna known to occur in the catchment and considered threatened are the brush-tailed phascogale, quenda, water rat, western brush wallaby and the carpet python. Appendix 3 provides a list of common fauna.

## 2.6 Heritage

### Aboriginal heritage

The Wardandi people are the traditional owners of the land within the Buayanyup catchment and their occupancy can be traced back for 55 000 years. Fresh water was essential to their quality of life as they relied on the fish, turtles, marron and ducks inhabiting the rivers. The riparian areas were also a rich source of other foods such as tubers, shoots, berries, eggs and the mammals they hunted for food and skins. Their practice was to take only what they needed at the time and they would often remove only one or two eggs from a nest, being careful not to disturb the others for fear that the mother may abandon the nest if the human smell was prevalent.

The Wardandi people value the rivers highly as they are significant to their culture as food sources, places for ceremony, campgrounds and spiritual tales. The rivers were also important burial grounds, particularly foreshore areas close to the sea as the Wardandi people often buried their dead by the riverside so that when the ocean came in and out of the river with the tide, it took the dead from their resting place and released them at sea.

Traditionally the Wardandi people would move from the coastal areas up through sacred places such as Kaloorup, Boallia and Jindong to camp in the Whicher Scarp during times of flooding (Pers. comm. Bill and Vilma Webb 2008).

There are three Aboriginal sites of significance registered with the Department of Indigenous Affairs within the Buayanyup catchment, but there is anecdotal evidence that there were more camps throughout the area. The registered Aboriginal sites of significance are:

- Busselton Fringe Camp in the lower catchment
- Busselton Camp towards Boallia Road in the mid catchment
- a site named the Vasse Drain, which is actually located on the Buayanyup Drain and is identified as a burial ground (Department of Indigenous Affairs 2008).

## European history and heritage

Busselton was settled by John Bussell and his family in the 1830s. The family moved from their property on the Blackwood River as the land around Busselton was considered more open, easier to fence and was accessible by water transport. The Bussells established a cattle station which they named 'Cattle Chosen' and still continue to farm in the district today. The prosperity of 'Cattle Chosen' attracted others to the area and it was from there that the settlement grew. Life was at times difficult for the settlers as they were isolated and supplies were irregular. The priority was to become self-sufficient and as the soil was good the focus was on clearing and cultivating the land (Busselton Bicentennial Community Committee 1999).

As time went on, the government encouraged further development in the South West, when a group of unemployed timber cutters and miners appealed for a chance to take up and farm land. Loans were offered to clear vegetation and establish agriculture on allocated land and men were recruited from England to turn the South West lands into dairy farms with the vision of rendering Western Australia self-sufficient in milk, butter and cheese (Blond 1987).

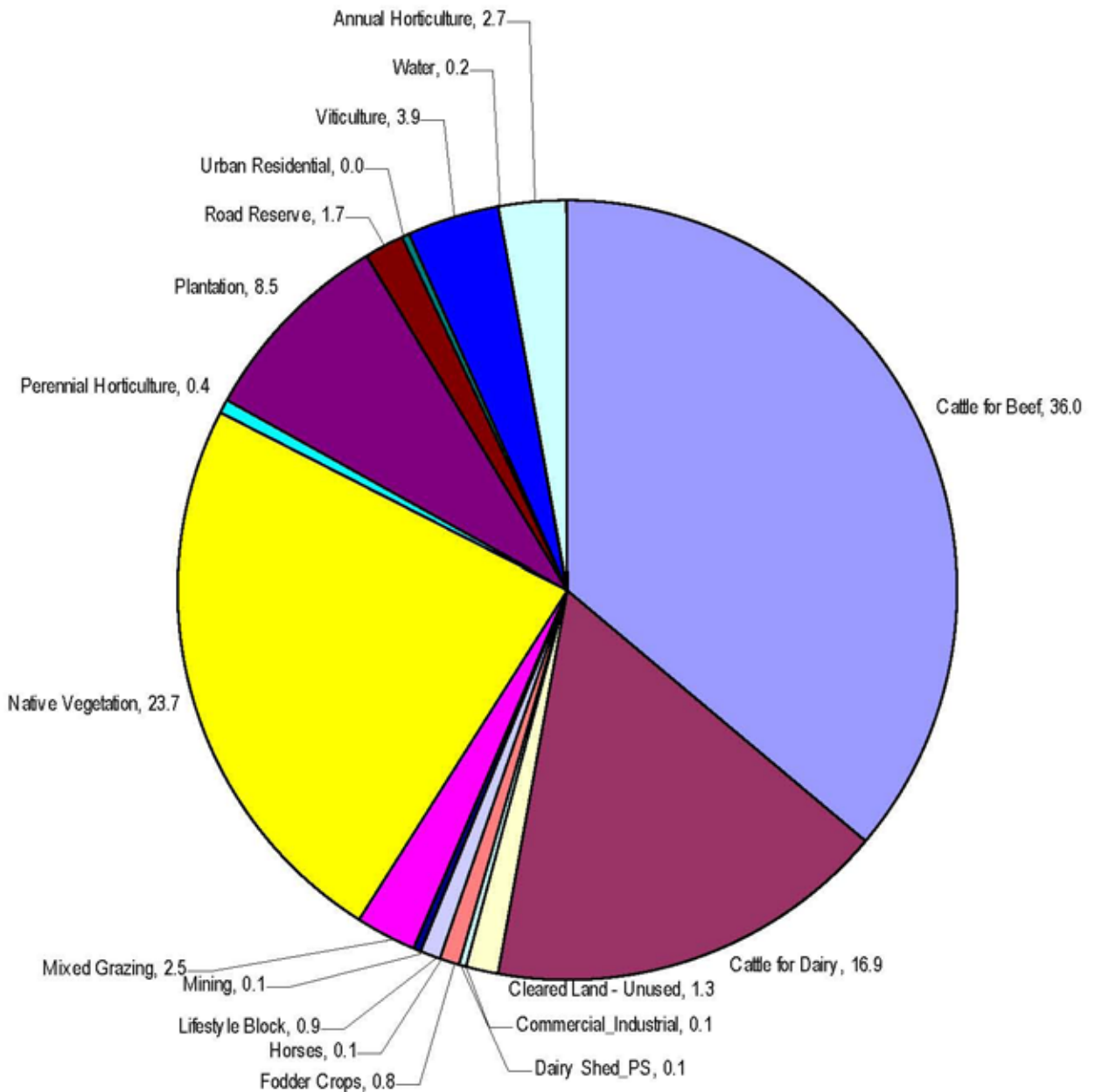
As the coastal plain was considered good productive land, but it was inundated with water for several months of the year, the Busselton drainage system was developed to allow the development of settlements, transport and infrastructure. The new settlers were not able to carry out the broadscale drainage they considered necessary on their own, so in 1894 requests were made to the government for drainage improvement. In 1900 the *Drainage Act* was passed and extensive drainage works began, involving the construction of new drains and the mounding and straightening of natural waterways.

After World War Two the government released land for war service settlement and conditional purchase schemes, to expand the agricultural sector with the intention of creating jobs and communities (Rijavec & Harrison 2002). It is understandable that there has been a reluctance to shift from this broadacre clearing approach to one where native vegetation is not only valued, but is considered a necessary component of sound land management.

This historical push to clear and cultivate land in the South West was a reflection of the collective values at that time. Native bush was seen as having no economic value and often just considered a home for vermin. There was little knowledge about sustainable farming practices, and the concept was hardly known.

## 2.7 Population and land use

As Figure 5 shows, the dominant land use within the Buayanyup catchment is cattle for both dairy and beef. However, the population within the wider Busselton area is increasing rapidly. Census data from 2006 shows that the Busselton shire is one of the fastest growing non-metropolitan local government areas in the state and achieved an annual growth rate of 2.9% between 2001 and 2006, well above the state average of 1.6% (Shire of Busselton 2007).

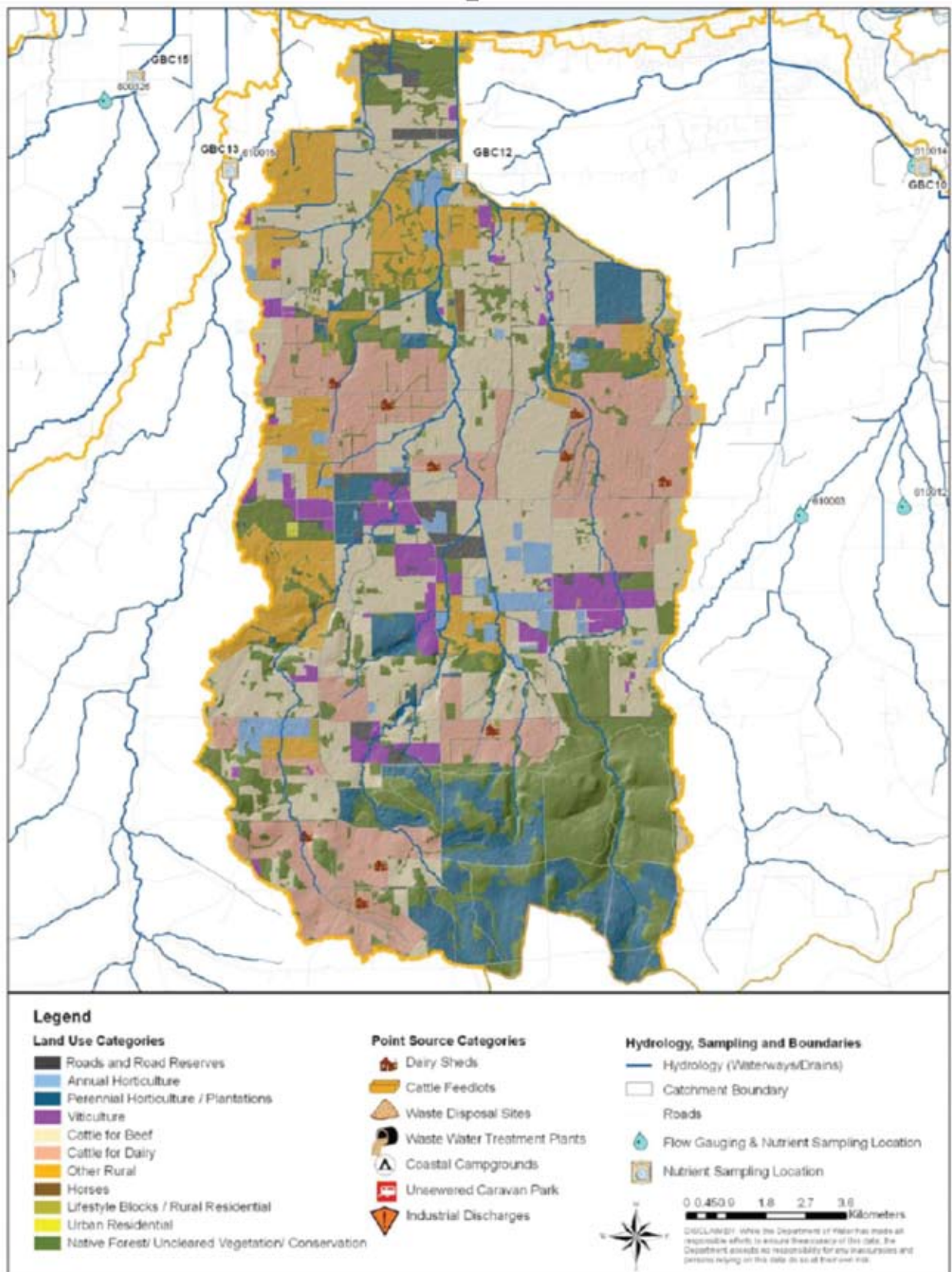


**Figure 5** Pie chart showing dominant land uses in the Buayanyup catchment

Other pressures mounting on the Busselton area and surroundings are the increase in tourism and the expansion of urban developments such as Vasse Newtown. All of these growing and changing land uses have the potential to degrade the natural environment and care must be taken to ensure the natural assets of this unique area are maintained.

The shire has a diverse agricultural sector and contributes considerably to the state's economy. Milk production has the highest gross value of agricultural production in the shire. The wine industry has also contributed to the gross value of agricultural production as over 50% of the wine producing members of the Margaret River Wine Industry Association are located in the Shire of Busselton (Shire of Busselton 2007). Figure 6 shows the land use in the catchment.





**Figure 6** Location of the main land uses

Note: This map was taken from Nutrient modelling in the Vasse Geographe catchment (Hall 2009) and shows a wider catchment than the study area shown in Figure 1.

## 3 Methodology

There were two components to collecting information for the plan: Community consultation and river health assessments.

### 3.1 Community consultation

Community involvement is an integral part of the development and implementation of river action plans. In the development of this plan the community were involved through several processes. They were:

- A postcard was sent to each landholder along the river explaining the purpose of the river action plan and the importance of community input to the plan.
- Informal interviews were conducted during the river foreshore surveys canvassing the issues facing landholders and gathering their historical knowledge of how the catchment developed. Out of approximately 100 properties, 85 were visited. Landholders provided important background information about the waterways and associated catchments. They also provided information on issues of concern to them relating to the health and management of the waterways.
- Phone surveys were completed for those unable to attend a site visit. Some 10 landholders were not able to be contacted.
- Aboriginal Elder Vilma Webb and her son Bill Webb were interviewed and provided information on Aboriginal heritage within the catchment.
- A spring bushwalk along the Buayanyup River was held where native flora was highlighted and the important role riparian vegetation plays in maintaining water quality and biodiversity was discussed.

## 3.2 River health assessment

The following methodologies were used to assess the foreshore condition and overall health of the Buayanyup River:

- The Pen–Scott method of riparian zone assessment was used by the Rivercare officer during site visits from July to November 2008. 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 can be found in Appendix 6.
- Flora species lists were compiled in August 2008 from plant samples taken on each landform the river traverses. Botanist Andrew Webb of the Department of Environment and Conservation assisted by completing surveys within the Whicher Scarp. Swan Coastal Plain species lists were compiled from plant samples taken on private locations by the Rivercare officer and identified by Andrew Webb. Additional species for the river were obtained from two quadrants (IRON01 and IRON02) in Ironstone Gully (a tributary of the Buayanyup River) as part of the 1994 survey of the Swan Coastal Plain (Gibson et.al. 1994).
- A freshwater fish and crayfish survey was undertaken by Dr Dave Morgan and Dr Steve Beatty of Murdoch University. Ten sites were sampled in November 2008 to establish the presence and abundance of native fish in the Buayanyup River with the aim of helping conserve and improve fish habitat.

## 4 Management issues

Ten main issues were identified by the Rivercare officer as a result of the survey work and are discussed below in order of importance.

### 4.1 Lack of awareness and appreciation of waterway health issues

Through landholder surveys undertaken on the Buayanyup River, it was identified that many landholders were not aware of the value of retaining and managing riparian vegetation for the benefit of improved water quality as well as biodiversity. This may be attributed to two causes:

- economic constraints, leading to a decreased value being placed on the retention of native vegetation
- landholders often not being aware of technical advice or financial assistance available to assist with the protection of native vegetation.

### 4.2 Water quality decline

Improving water quality has become a high priority within the Geographe Bay catchment due to the highly visible symptoms of poor water quality such as algal blooms and fish deaths, and to the high biodiversity, recreational and economic value the community places on waterways. Essentially, people value good quality water for:

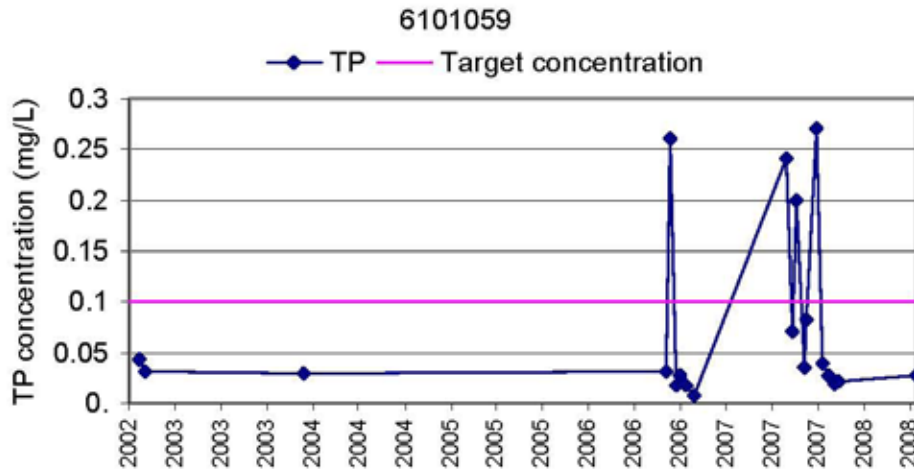
- irrigating crops
- watering stock
- supporting fish and crayfish stocks for recreational fishing
- water sports such as canoeing
- maintaining biodiversity in its own right
- the intangible value a healthy ecosystem has aesthetically.

The Department of Water has been monitoring the water quality in the Buayanyup River near the Florence Road bridge since 1998. The water at this location is very high in nutrients, particularly nitrogen.

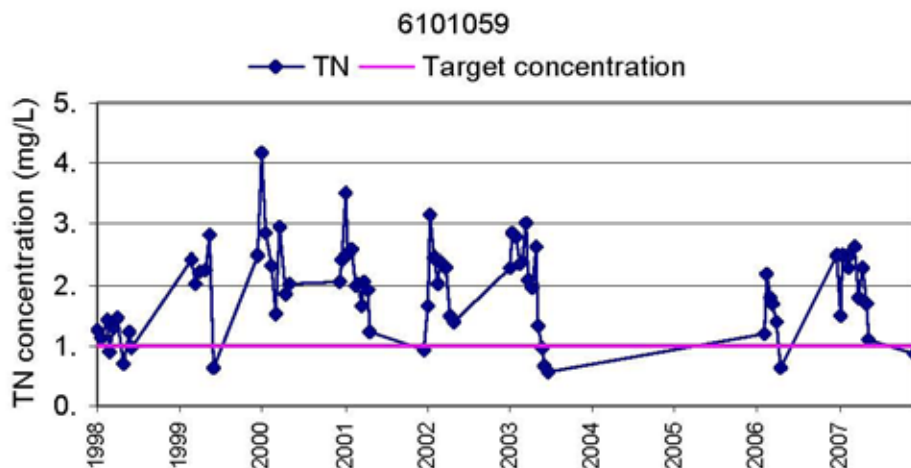
Nitrogen is a natural and essential part of an ecosystem and is the most limiting nutrient for plant growth. High concentrations of nitrogen, when combined with other factors, are often associated with:

- algal blooms (including toxic blue-green algal blooms) and dense aquatic plant growth
- sudden mass fish deaths attributed to low oxygen conditions
- odour problems
- reduction in estuarine seagrass, an important food source for waterbirds (Department of Water 2010).

The winter median concentration for total nitrogen (TN) for the Buayanyup catchment is 2.05 mg/L which is classified as 'very high', and 0.04 mg/L for total phosphorus (TP), which is classified as 'moderate' (based on figures in *the Vasse Wonnerup wetlands and Geographe Bay water quality improvement plan*). The following graphs show the monitoring results since 2002 for total phosphorus and 1998 for total nitrogen.

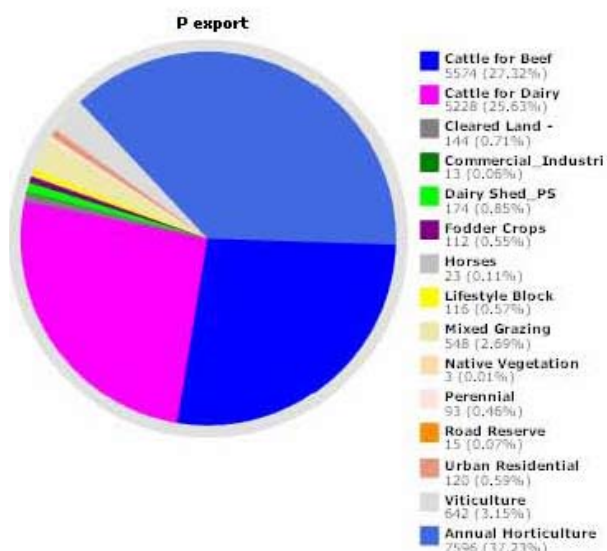


**Figure 7** Levels of total phosphorus in the Buayanyup catchment 2002 to 2008

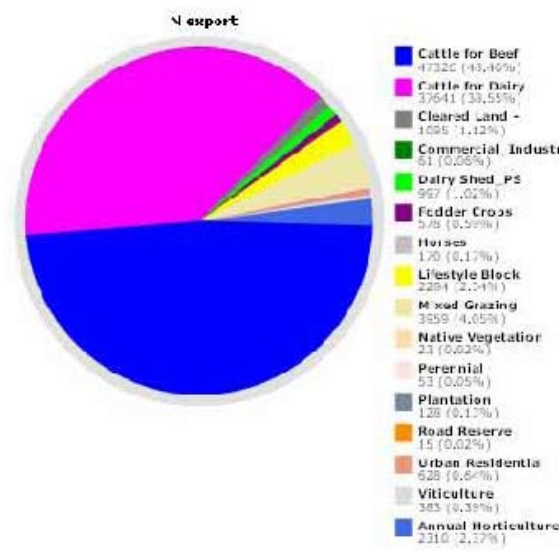


**Figure 8** Levels of total nitrogen in the Buayanyup catchment 1998 to 2008

Nutrient modelling undertaken by the Department of Water was used to determine the sources of nutrients in the waterways. As Figures 9 and 10 show, the largest sources of both phosphorus and nitrogen in this catchment are dairy farms, followed by horticulture and then beef cattle farms. Nutrient loads into the waterway are also predicted to increase due to the expansion of the Vasse Newtown urban development. Department of Water modelling suggests that phosphorus and nitrogen may increase by 40% and 10% respectively, primarily as a result of urban expansion (Hall 2009), although these predicted increases may be reduced by the implementation of water sensitive urban design in future developments.



**Figure 9** Pie chart showing land uses contributing to total phosphorus in the Buayanyup catchment



**Figure 10** Pie chart showing land uses contributing to total nitrogen in the Buayanyup catchment

### 4.3 Unrestricted stock access to waterways

In the upper catchment, there are long stretches of unfenced river foreshore adjacent to dairy and beef cattle operations. This represents a large proportion of the study area without foreshore fences in place to manage stock access. Unrestricted stock access to waterways contributes to:

- poor water quality – manure and urine pollutes fresh water, leading to algal blooms, fish deaths and reduced water quality for downstream users
- sedimentation – stock stirring up waterways reduce water quality by increasing nutrients and degrading aquatic habitats
- bank erosion – stock carve paths to the water’s edge leading to gully erosion and bank slumping
- compaction of the soil structure, limiting the capacity for regeneration
- loss of riparian vegetation through stock feeding
- spreading of weeds by hooves and manure.

### 4.4 Historical clearing of riparian vegetation and removal of large woody debris

Historical clearing of the river channel for flood mitigation purposes has resulted in the removal of riparian vegetation as well as large woody debris which is now understood to provide important habitat for aquatic organisms. Removal of large woody debris is sometimes undertaken by landholders trying to address minor erosion problems or to improve the flow of water through their properties. Unfortunately, the removal of this woody debris often exacerbates erosion problems since the absence of debris in the channel accelerates the water.

Riparian vegetation and large woody debris provide important habitat for in-stream fauna found in the Buayanyup River such as gilgies, the western minnow, the western pygmy perch and a variety of frogs and macroinvertebrates. The loss of habitat for such fauna ultimately leads to the loss of these species from the waterway ecosystem. Macroinvertebrates play an important role in breaking down organic matter from within the waterway and grazing on algal growth, so they can help to maintain better water quality. Also, a number of native fish species and macroinvertebrates such as dragonflies feed directly on the larvae of insects such as mosquitoes.

## 4.5 Tree decline

Throughout most of the catchment there are trees in decline, noted by the absence of healthy leaves. This may be the result of insect attack, changes in hydrology, chemical exposure, salinity, mechanical damage or pathogens such as *Phytophthora cinnamomi*. The most common species noted in the Buayanyup catchment suffering ill health were *Eucalyptus* species and some *Allocasuarina fraseriana*.

*Phytophthora* may be the cause of some of this decline. Often known as jarrah dieback, root rot, pox, PC or dieback, *Phytophthora cinnamomi* is a soil-borne water mould that affects many species including jarrah, banksia, grass trees, woolly bush and zamia palms. In fact, 40% of native plants in the South West are at risk and this pathogen can indirectly reduce populations of native animals by destroying their habitat. *Phytophthora* was introduced by the early European settlers and kills the plant by rotting the vessels that are responsible for both the uptake of water and nutrients and the downloading of sugars from photosynthesis. Essentially it 'ringbarks' the plant.

## 4.6 Erosion

The hard ironstone bed of the Buayanyup River in many locations has assisted in minimising bed erosion where it may have otherwise been extensive. However, erosion is still a major problem, particularly in the mid to lower catchment, and undercutting and bank slumping is clearly occurring where there is increased velocity due to channels having been straightened, or where the banks are bare and stock have access to the waterway. In some locations the hard bedrock has made the creek profile wider in response to increased flow rates.

Erosion causes a number of problems including:

- sedimentation of the waterways, which can result in loss of deep pools that provide important habitat for gilgies and other aquatic species
- reduced flood attenuating ability of the waterway channel, due to the loss of deep pools, which causes water to overtop the channel during high flows
- increasing the channel width
- in severe cases, loss of valuable agricultural land, fencing, infrastructure and riparian vegetation.



## 4.7 Weed invasion

Weed invasion of native vegetation is a major threat along the Buayanyup River and in the Geographe catchment as a whole.

A number of declared weeds under the *Agricultural and Related Resources Protection Act 1976* were found in the study area and their control is a high priority. They are:

- Pennyroyal: a weed of pastures and wet areas, strong in minty odour making it unattractive to stock. Ingestion by cattle has been associated with coughing. The oil is toxic and has been known to cause miscarriage in humans when ingested in large doses. It is often most prolific in flooded areas because it can germinate and survive under shallow water where most other plants die. It produces large amounts of seed and lasts in the soil for many years (Herbiguide 2009).
- Cape Tulip: native to South Africa, this weed of pastures and disturbed bushland is toxic to stock. Deaths generally occur when animals are hungry and have not previously been exposed to the plant. It can be difficult to control due to its many cormels (Moore & Wheeler 2008).
- Bridal creeper: an ornamental creeper common along creek lines, forming a dense mat that climbs up trees and limits revegetation of native species (Moore & Wheeler 2008).
- Arum lily: this South African lily is easily recognised by its large funnel-like flower, is common along waterways and tolerates waterlogging, sun and shade and a wide range of temperatures. It may be toxic to stock (Herbiguide 2009).
- Blackberry: these European perennial plants have dark leaves and arching prickly stems with white or pink flowers and red or black berries. The stems take root where they touch the ground and form dense thickets that smother native plants (Moore & Wheeler 2008).
- Broomrape: a brown, erect, single stemmed root parasite with scale like leaves. It is sticky to touch and has an underground bulb. It is a weed of pasture crops and gardens and is parasitic on the roots of other plants as it has no chlorophyll, so it is totally dependent on its host for nutrition (Herbiguide 2009).

According to legislation, the above declared plants need to be controlled or contained depending on their status (see Appendix 3), and reported to the local Agricultural Protection Officer. More information on the requirements for control and treatment is available from the Department of Agriculture and Food.

There are also a number of environmental weeds, not listed under legislation as plants needing to be controlled or contained, which quickly out compete natives within the catchment. They are:

- Blue periwinkle: a sprawling groundcover that has dark green opposite leaves with shiny surfaces and singular blue flowers with a white throat. Blue periwinkle is native to the Mediterranean region and is a common garden plant in Australia. The plant spreads rapidly by producing new roots where the stems have contact with the ground.



- **Watsonia:** a tufted bulbous species from South Africa with erect sword shaped leaves, tall and spike-like white, pink, yellow or orange flowering stems.
- **Fig:** a large tree with distinctive lobed leaves and fleshy fruit. A garden escapee that tolerates damp conditions. This tree takes root readily from cuttings and root fragments, and birds and animals disperse its seeds.
- **Myrtle-leaved milkwort:** a garden escapee native to South Africa and now invading coastal bushland areas. This is a shrub, about 2.5 m high with light green elliptic leaves and clusters of pea-like pink to purple flowers.

## 4.8 Dams, environmental flows and barriers to aquatic fauna migration

A number of on-stream dams occur along the Buayanyup River. On-stream dams are thought to contribute to reducing streamflow, thereby reducing the amount of water available for other users and for ecosystems downstream.

In a drying climate, water is a precious commodity and its use and management has become a contentious issue. Balancing water for personal use, industry, agriculture and the environment has proven to be challenging and the idea of releasing flows from dams has been met with some resistance.

Flows downstream of on-stream dams are delayed, and this effect is escalating with the increase in on-stream dams on our waterways. Where there are a number of dams on a system, the cumulative effect of these delays can be significant.

Poorly managed on-stream dams can have other effects on the environment such as:

- the destruction of riparian vegetation during dam installation
- increased erosion and sedimentation of waterways during construction and while the earth settles around the dam
- preventing the passage of aquatic fauna, thus preventing upstream migration for spawning.

## 4.9 Feral animals

Rabbits and foxes were evident in parts of the catchment, through the sighting of individuals as well as dens and burrows. Rats, feral cats, feral pigs and the house mouse have also been confirmed by staff from the Department of Environment and Conservation to be known in the wider catchment, but were not sighted during the surveys. The freshwater fish and crayfish survey completed by Murdoch University also found introduced mosquito fish and yabbies within the Buayanyup River.

## European red fox

The fox has played a major role in the decline of a number of native species and they are also known to prey on newborn lambs.

Introduced in the 1800s for sports hunting the fox is believed to have contributed to the extinction of up to 10 native species. The fox can survive in differing habitats and enjoys the lightly wooded landscapes often found in agricultural areas with degraded waterways. These areas offer shelter and an open hunting ground providing opportunity for foxes to attack mammals, birds and reptiles as well as newborn lambs, sick stock and poultry (Williams et al 1995).

## European rabbit

Rabbits severely damage agricultural crops and native vegetation and compete with native animals for food and shelter.

Twenty-four rabbits brought over from England were released in Victoria on Christmas day 1859 for sports hunting. These rabbits soon became a colony and by the 1900s they had reached Western Australia. Due to their potential to breed from 3 to 4 months of age, and give birth to 4 to 7 young, a pair of rabbits can produce 30 to 40 young a year making them one of the most widely distributed and abundant mammals in Australia.

Compared to Europe which has ferrets and weasels, rabbits in Australia have few predators (Williams et al 1995).

## Mosquito fish

Mosquito fish (*Gambusia affinis*) were recorded in the lower catchment where the waterway is little more than a degraded drain. They create problems in waterways as they out compete other fish, reducing native populations. In contrast to native fish, mosquito fish can survive in poor water quality conditions and give birth to fully developed, live young.

Mosquito fish are naturally more aggressive than the smaller South West native fish species and have been known to attack other species and even harass larger fish by fin nipping, causing infection and death. Native fish are easily out competed by the very hardy mosquito fish when a habitat has suffered some degree of degradation such as that in the lower reaches of the Buayanyup River.

Mosquito fish were introduced to Western Australia in 1934 into irrigation ditches in Nedlands, Perth with the intention of controlling mosquitoes. At a time when malaria, yellow fever and dengue fever were common threats to public health, they were considered an appropriate biological control for disease carrying mosquitoes. They are now the most widely distributed freshwater fish in the world and found on every continent except Antarctica (Department of Fisheries 1998).

## Yabbies

Yabbies are an invasive species now found in many aquatic systems in the South West. They inhabit a similar niche to the native marron but breed faster and out compete them. They undermine riverbanks by burrowing and can carry diseases affecting other native freshwater crayfish species.

## 4.10 Adoption of ecologically sound management practices

Having established that there is a need to improve the health of the catchment, the plan now looks at factors that may be slowing down the adoption of ecologically sound management practices. Identifying these factors is the first step in overcoming them. Much of this information provided came from the community consultation process. The points raised were:

- Some landholders are not aware of the value of healthy riparian vegetation and in-stream habitat and therefore see no need to maintain it. In some cases:
  - the vegetation is seen as a refuge for pests such as the silvereeye bird which often attack grapes
  - landholders view rare species (such as declared rare flora or the rare native fish found in the Buayanyup River) as a potential risk to the future development their land.
- The recent economic downturn has meant that:
  - landholders have tightened budgets and may not be able to invest in activities outside their core business
  - landholders are less inclined to voluntarily fence off riparian areas due to the escalating price of steel.
- Landholders are unwilling to fence riparian areas as:
  - they provide shade for stock and not all paddocks have stands of trees that provide alternative shade if the riparian zone is fenced
  - they are a source of water for stock and the expense of stock crossings and alternative watering points discourages landholders from fencing them out of the waterway
  - they are concerned that if they agree to be involved in a government funded project that it will limit their control over the works on their land.
- Landholders adjacent to reserves feel that the burden of management should be undertaken by the body vested with management and in some reserves it is not clear who the managing body is.
- Initial development approvals for the Vasse Newtown urban expansion were issued prior to water sensitive urban design becoming a prominent tool for managing water quality.

## 5 Management recommendations

The following management recommendations are provided for land managers within the Buayanyup catchment, including private landholders, GeoCatch, the Shire of Busselton, state government agencies and the Water Corporation. Some recommendations will be outside the scope of individuals or particular management bodies, so a coordinated approach is recommended to achieve maximum benefits with limited funding.

### 5.1 Raise awareness of waterway health issues

There is a need for management bodies to increase awareness of the value of riparian vegetation. Encouraging people to think about the issues and to realise the long-term benefits of improving river health is just as important as physically erecting fences along waterways and revegetating with native species. It's better to put effort into raising awareness because the physical activities have an ongoing cost, whereas the raised awareness will be self-perpetuating.

Understanding how a river restoration project will benefit a landholder helps to engage them in taking action on waterway health issues. For example, landholders who complete river restoration activities benefit because:

- It improves their land. Fencing, installing stock crossings, completing weed control and revegetating river banks improve the functions of a farm by reducing injuries to stock traversing unstable riverbanks and preventing weeds infesting crops.
- They are doing a service for themselves, and their community. Vegetation along waterways provides a filter to protect water quality, benefiting the overall quality of water available to that property, and their neighbours' properties.
- It can save them money. Stable river banks and crossing points reduce stock deaths and prevent the loss of land which can be eroded during times of high flow.
- Healthy rivers look better than degraded ones and can provide a place of recreation.

It is recommended that management bodies offer free education and awareness raising activities, as they are an effective way to reach the community and often attract a wider audience than just those interested in environmental issues. Wildflower walks, wildlife stalks and natural art and photography competitions attract the wider community and present an opportunity to highlight the natural assets in the catchment as well as to promote the funding incentives and programs available for landholders to become involved in biodiversity and water quality improvement.

Working with children is another way to effect behavioural change, but is a more long-term approach. Specific suggestions for raising awareness of waterway health issues and inspiring the community to take action are:

- create educational resources on topics of interest to rural landholders such as identifying native fish and crayfish or common fauna along waterways
- complete a breeding and release project with the western pygmy to encourage the re-establishment of native fish in local waterways

- support and work with conservation teams such as Green Corps to continue recruiting and training young environmental leaders and completing on-ground tasks.

## 5.2 Improve water quality

To address water quality problems, the Department of Water has prepared the *Vasse Wonnerup Wetlands and Geographe Bay water quality improvement plan* (Department of Water 2010) which describes prioritised nutrient reduction actions such as:

- Improving fertiliser and effluent management, particularly on dairy, beef and horticultural farms which have been identified as the highest contributors of nutrients within the Buayanyup catchment.
- Improving riparian management, including fencing waterways and drains, revegetating and installing off-stream watering points particularly on dairy, beef and horticultural farms. 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) but this is mostly restricted to areas where the soils contain clay. In the sandy soils on low lying areas like the Swan Coastal Plain, buffer zones seem to be less effective in the uptake of phosphorus, but effective in reducing sediment and nitrogen loads into water bodies (Steele 2006).
- Improving fertiliser management. Timing and application of fertiliser should be based on recommendations from regular soil testing to determine the required nutrients to meet crop, pasture or animal needs. Applying fertiliser only when nutrient levels fall below recommended agronomic thresholds will maximise economic and environmental benefits. Regular plant tissue testing during the growing season will help detect and correct any nutrient deficiencies. A low pH will often have a greater impact on pasture performance than fertiliser applications. Applying sufficient lime to ensure pH levels are above 5.5 in the top 10 cm of soil will maximise the utilisation of nutrients.
- Testing for mycorrhizal and soil bacteria is another useful 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. Contact the Department of Agriculture and Food's AgLine for more information (see Appendix 10).
- Using soil amendments high in iron and clay particles to increase the phosphorus retention of the soils.
- Converting to perennial pastures where possible.

Other ways to improve water quality within the Buayanyup catchment specifically are:

- To revegetate dams with local native plants, being careful not to plant deep rooted species in the dam wall as this can weaken its structure.
- To manage erosion by stabilisation works, construction of stock crossings and off-stream stock watering points.
- To work with the residents of Vasse Newtown to encourage native gardens, verge planting and correct fertiliser use.
- To incorporate water sensitive urban design in the Vasse Newtown expansion. Look at the installation of rain gardens (planted depressions that allow rainwater runoff, from impervious urban areas such as roofs, driveways, walkways, and compacted lawn areas, to be absorbed into the ground or filtered prior to entering waterways).

The Department of Water has specific targets for adoption of these practices and the engagement of the community and implementation of recommendations within river action plans are critical to reaching these targets.

### 5.3 Control stock access to waterways

Fencing waterways is the most cost-effective and time-efficient measure for protecting remaining areas of good vegetation. Priorities for fencing are areas of A and B grade riparian vegetation, as protecting these areas produces the greatest benefits to biodiversity. The next priority is fencing of first and second order streams as, even though they are often seen as small, degraded farm drains, there is a water quality benefit to excluding stock from them.

Restricting stock access to waterways is one of the quickest and easiest ways to improve waterway health. This is an important management tool particularly in the Buayanyup catchment which has a high proportion of stock related agricultural practices. Obviously in areas where stock are not present, there is no need to fence the waterway (Department of Water 2010).

It is very difficult to arrest existing erosion problems while stock still have access to the problem area. It was noted that there are some areas of good quality vegetation where stock have access. Fencing these to exclude stock is a priority as these areas are likely to have a seed bank and would regenerate naturally.

The benefits of fencing stock out of waterways are:

- Improved water quality. Excluding stock alleviates direct fouling of the waterway and allows the natural regeneration of native riparian vegetation.
- Increased farm productivity. When stock have access to clean water, it can help maintain their health, prevent disease and assist in improving milk and wool productivity. Stable banks will also help reduce stock deaths due to toppling on unstable slopes or being caught in the river during times of flood.
- Reduced sedimentation and erosion. Keeping hooved animals away from waterways will assist in maintaining the vegetation that binds the banks and filters the water entering the waterway.

- Regeneration of vegetation assists in improving water quality, stabilising banks and providing habitat for native fauna (Station and O’Sullivan 2006).

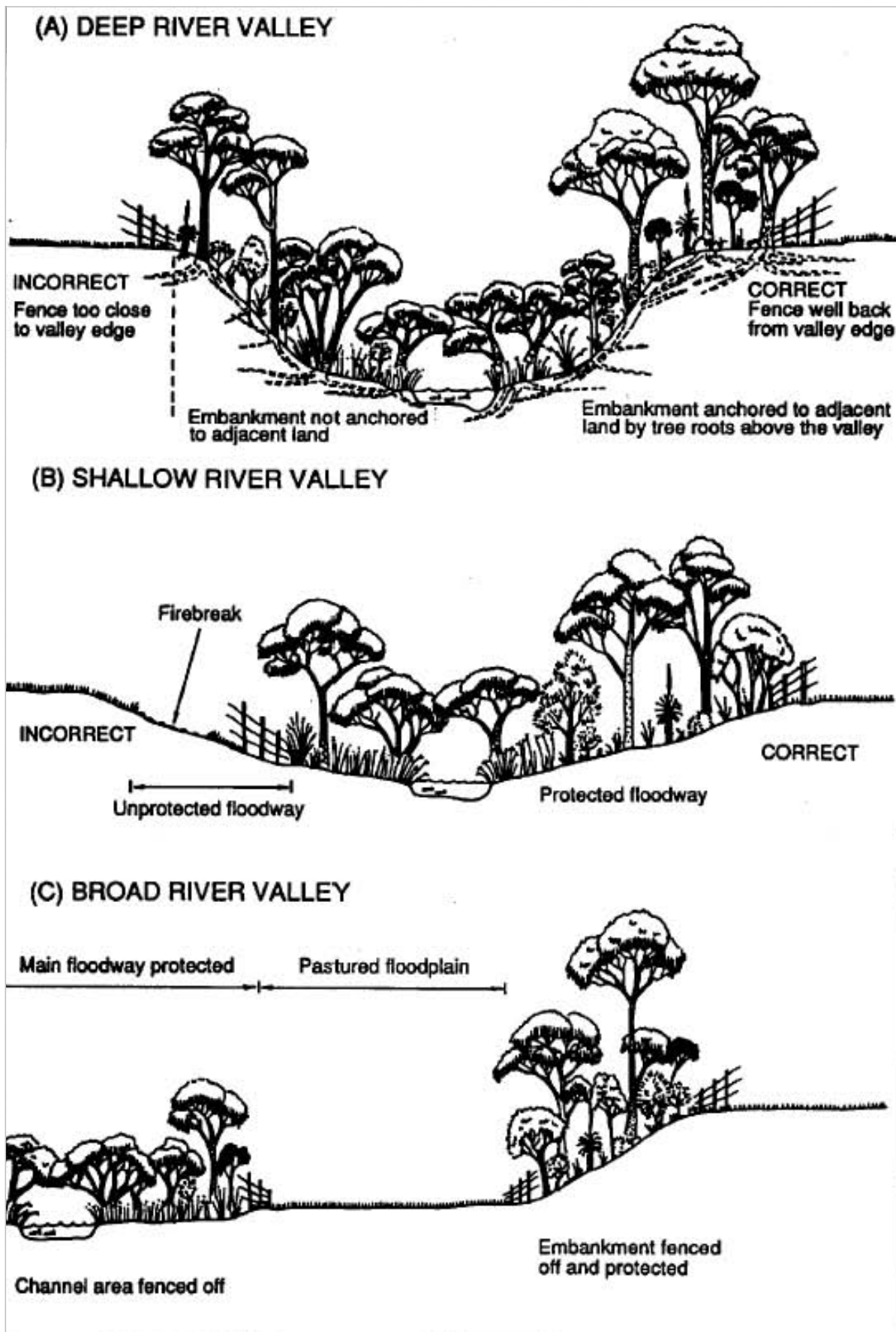
### **Fence placement**

Ideally, fences should be placed as far away from the waterway as possible. Recommended distances are at least 5 m from the top of the banks of small creeks and at least 30 m back from the top of the banks of major rivers.

The purpose of allowing a vegetated buffer between the fence and the top of the bank is to stabilise the land, and thereby prevent slumping. Figure 11 below shows the correct placement of fences in three situations.

- Deep river valleys. For valleys deeper than 5 meters it is recommended that the fence be placed 10m or more away from the bank to allow for the tree roots to anchor the banks to the adjacent land and prevent slumping (figure 11a).
- Shallow river valleys. In the case of shallow river valleys, there is little chance that embankments will slump. Nevertheless, fence-lines should be located above the river valley (see Figure 11b) as the fences and firebreaks located within the river valley can be damaged and eroded by floodwaters.
- Broad flood plains. If the river valley is particularly broad and flood plains 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 (see Figure 11c). 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.





**Figure 11** Recommended placement of fencing in a river valley  
 (a) the deep river valley, (b) the shallow river valley and (c) the broad river valley  
 (Water and Rivers Commission 2000)

## Controlled grazing

While completely excluding stock from waterways is the preferred approach to improving waterway health, controlled grazing can be beneficial in reducing the weed burden in riparian zones, providing the grazing pressure is not so heavy as to damage native plants.

In order to successfully use controlled grazing in a sustainable riparian management plan, stock need to be managed by:

- checking them regularly to assess damage to native plants
- reducing pressure on native plants by providing food supplements and salt licks
- keeping them out of areas where:
  - new seedlings have germinated
  - plants are in flower or setting seed
  - the bank is steep and sandy, or prone to collapse.

## Alternative stock water points

Some landholders were also concerned about closing off access to stock watering points by fencing off the waterway. To address this concern it is recommended that funding be offered to landholders for the installation of off stream stock troughs and rocky riffle stock crossings where applicable.

## 5.4 Protect and re-establish riparian vegetation and create habitat

### Protecting riparian vegetation

It is best to focus on protecting and conserving areas of A and B Grade riparian vegetation, particularly within the mid catchment where there are rare vegetation complexes, as it is almost impossible to recreate these ecosystems once they are gone. See maps 3, 6, 7, 8, 9 and 10.

It is important to educate and raise awareness about the values of maintaining riparian vegetation in order to encourage landholders and others to adopt good practices, and abandon the old ones which focused on stripping the riparian zone in favour of agriculture or a view to the river.

Financial incentives to assist land managers with fencing for waterways and drains, for off-stream watering points and for shelter belts for stock will reduce the need for stock to have uncontrolled access to riparian zones.

### *Clearing permits*

Land managers are reminded that the process for assessing and issuing clearing permits is managed by the Department of Environment and Conservation and a permit must be gained unless the clearing is for an exempt purpose (although these exemptions don't apply in environmentally sensitive areas) and equals no more than one hectare a year.

## Re-establishing riparian vegetation and creating in-stream habitat

Planting vegetation corridors and re-creating habitat is important for supporting the movement of wildlife from one feeding and breeding ground to the next. Of particular conservation significance is the western ringtail possum which is listed as threatened and relies heavily on coastal peppermint woodlands. Coastal reserves such as Locke Nature Reserve on the Buayanyup Drain support large populations. A dense arum lily infestation was noted in Locke Nature Reserve and it is recommended that this be controlled and the area revegetated with peppermint trees as a way of increasing habitat for the ringtail possum. Specific notes on techniques for revegetation can be found in Appendix 9.

Also of interest is the western minnow found in the upper reaches of Ironstone Gully. These native fish are generally only found where vegetation is healthy and intact, highlighting the need to conserve and rehabilitate riparian and in-stream habitat, particularly in the upper catchment and moving downstream from there.

### *Declared rare flora and threatened ecological communities*

It is recommended that properties with declared rare flora be given a high priority for fencing and revegetation projects.

## 5.5 Manage tree decline

In order to further understand how to best manage tree decline it is first important to understand why the trees are in decline. The suggested approach to assessing and managing tree decline is:

- choose several locations within the catchment where there are areas of trees in decline and undertake a study investigating the possible causes
- complete root tissue analysis to determine if the cause of the decline is *Phytophthora cinnamomi*
- look at other possible causes of decline such as extensive groundwater draw nearby which may be lowering the watertable or evidence of extensive insect attack
- conduct trials using phosphite and nutrient treatment kits and monitor over a period of several years to establish which treatments improve tree health.

Preventative measures can also be taken to prevent the spread of dieback once confirmed. This pathogen is spread by both natural and human assisted mechanisms and although it may be impossible to eradicate, there are precautions that can be taken to minimise its spread.

Following the general hygiene principles outlined below will assist in minimising the spread of phytophthora:

- wash down vehicles and equipment and brush off shoes when moving from one bush location to the next
- don't dump green waste in bush locations
- complete soil moving operations when the conditions are dry (November to March)
- use certified disease free suppliers of seedlings, gravel and mulch (Dieback Treatment Services 2008).

## 5.6 Control erosion

Erosion is an issue requiring attention in parts of the Buayanyup River, with areas showing signs of severe incision, undercutting and bank slumping.

A detailed river geometry survey and a hydraulic assessment are required for the correct design of engineering works. It is also important to remember that rivers are part of a dynamic system. They can change in response to changes in flow characteristics caused by removal of large woody debris and increased runoff from land clearing, and now possibly reduced runoff due to climate change. Care should be taken when attempting to predict the outcome of alterations to channel form and capacity, and it is very important to assess the upstream and downstream effects of localised engineering interventions. If inappropriately designed, erosion prevention works will result in moving the problem rather than resolving it. Site-specific technical advice should be obtained before beginning any form of physical modification to the river channel. GeoCatch and engineers from the Department of Water can assist with providing technical support.

Some approaches to erosion control outlined in the *Capel River action plan* (GeoCatch 1999) and *River restoration report: waterway stabilisation* (Water and Rivers Commission 2001) can be found in Appendix 7.

## 5.7 Manage weeds

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. It is important to choose a herbicide which has a modified surfactant to reduce its impact on waterways and wetlands. In surface or sheet erosion prone sites, spot rather than blanket spraying can help to reduce erosion from loss of weed cover while still providing opportunities for planting.

Fencing waterways and restricting stock access will result in the need for extra weed control. A coordinated approach across the whole catchment may be more effective, to tackle the seed base rather than attempt to implement localised spot controls which may become re-infested due to seeds travelling with the stream. Removing weeds in foreshore areas can lead to erosion, so care is needed.

Weed control principles to keep in mind include:

- weeds thrive in disturbed areas and on bare ground.
- if weed control is carried out, revegetation with natives will assist in preventing further weed invasion in the bare soil.
- some native plants look and act like weeds, so it is best not to begin weed control until the plants are positively identified.

Troublesome major weeds, particularly those identified as 'declared plants' by the Department of Agriculture and Food (see Appendix 3) should be identified at an early stage and eradicated immediately (Pen 1999).

## 5.8 Manage dams

### Dam construction

Gully wall or on-stream dams should only be constructed where there is no other alternative, since they often result in removal of riparian vegetation and may also block the passage of native freshwater fish on their annual migration upstream to spawn. It is vital that flows from the outlets of on-stream dams are managed appropriately.

The adverse effects of on-stream dams can be reduced by:

- Opening under wall bypass valves at the start of the wet season (as soon as water is flowing into the dam). The dam will still fill over the winter months and, once it is full to overflowing, the bypass valve can be closed. This ensures that the riparian ecosystem downstream of the dam receives water at the break of the wet season. The rest of the flows will safely dilute any salt or sediment that has built up in the dam over summer.
- Retrofitting a bypass system to an existing dam, which can be done by installing a channel or pipe which bypasses low flows around the dam and into the waterway.
- Installing fish ladders where native fish are known to be present so that they can continue to migrate upstream to spawn.
- Revegetating dam banks which will assist in improving water quality as well as creating a more diverse ecosystem and improving the aesthetic value of the dam area. Care should be taken to avoid planting deep rooted species on dam walls as they can weaken the wall. For more information see the *Converting dams to living wetlands brochure* (GeoCatch 2006).



## Water licensing

The Government of Western Australian declared the Whicher area to be proclaimed under the *Rights in Water and Irrigation Act 1914* and the order was gazetted on the 21 September 2007. This required the Department of Water to administer Part III of the Act, which includes the licensing of surface water use. If landholders are currently using surface water and/or have a dam it is possible they will require a licence. This applies to both new and existing dams. Part of the Buayanyup catchment falls within the proclaimed Whicher area and the dam approval process is managed by the Department of Water. Any proposals to construct a dam within a proclaimed area should be submitted to the department for comment. The department has published the *Whicher area surface water allocation plan* on its website <[www.water.wa.gov.au](http://www.water.wa.gov.au)> (Department of Water 2008).

The Whicher area is also situated within the proclaimed Busselton–Capel groundwater area under the *Rights in Water and Irrigation Act 1914* and any groundwater use may also require licensing (Department of Water 2008).

In some cases the construction of a dam requires approval from the Department of Water and the Shire of Busselton so it is important to contact both agencies when planning a new dam.

## 5.9 Control feral animals

### Rabbits, foxes and cats

Baiting using 1080 (sodium fluoroacetate) can be an effective way to control rabbits and foxes as most native animals have developed a resistance to it so there should be limited off target deaths. Domestic stock and pets however, are not resistant and must be kept away from baits as well as poisoned carcasses. Fumigation tablets can be used in rabbit warrens.

Baiting products can be purchased from rural suppliers after a baiting approval has been granted from the Department of Agriculture and Food.

### Mosquito fish

Mosquito fish are difficult to control because they are so widespread. Landholders are advised to dispose of them humanely if caught and are asked not to use them as live bait and to never release them in waterways or dams.

It is recommended that management agencies work with Murdoch University and the Department of Fisheries on containing and controlling the species.

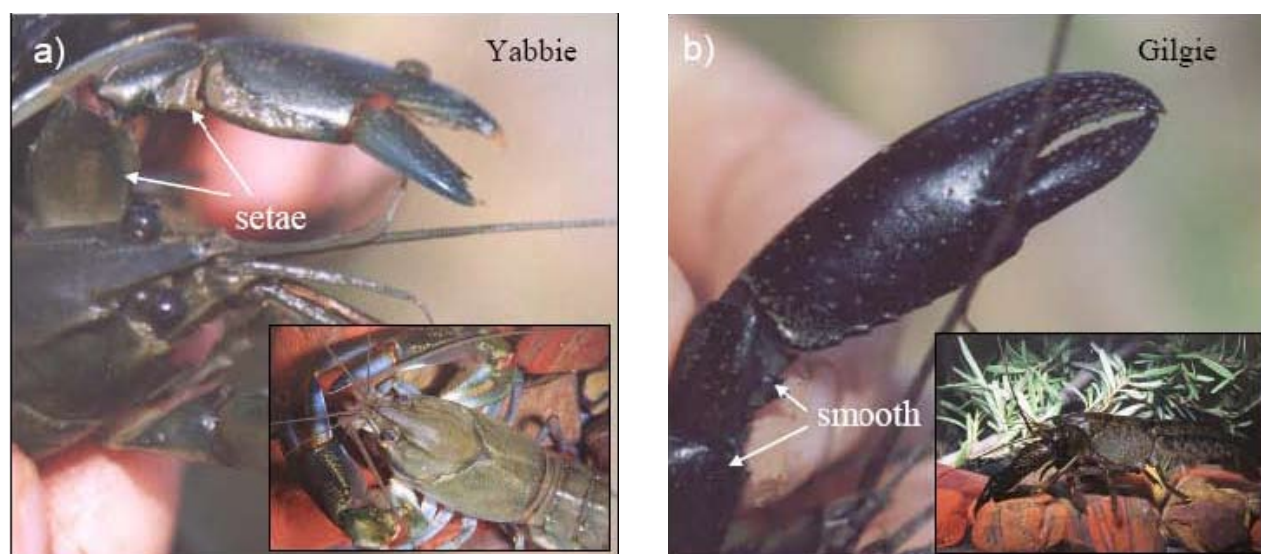
## Yabbies

Due to their ability to burrow, yabbies are extremely difficult to control once established, so preventing them spreading is important for maintaining native crayfish stocks.

Landholders are encouraged not to release yabbies into rivers or dams and if yabbies are caught during marron season keep them and don't throw them back. Yabbies and native gilgies can be hard to tell apart but can be distinguished by the features described below in Table 5 and Figure 12.

Feature	Yabbie	Native crayfish
Keel (ridges on their heads)	Yabbies have four ridges on the back of their heads, two of which are prominent.	Marron and gilgies have five ridges.
Claws	Yabbies also have fine hairs on the inner edge of their clawed limbs.	Marron and gilgies don't have these hairs. Marron and koonacs have a triangular piece on the inside of their claw.
Colour	Yabbies are usually a pale beige colour but can range to blue or dark brown.	Most native crustaceans are normally dark brownish black, but sometimes range to blue.

**Table 5** Features defining yabbies and native crayfish



**Figure 12** Comparison of a yabbie claw and gilgie claw

a) Yabbie claw showing the location of the fine hairs and b) Gilgie claw which is smooth as are all other native crayfish. If unsure, go to the link at <[www.fish.wa.gov.au/Identifying freshwater crayfish in South West WA](http://www.fish.wa.gov.au/Identifying_freshwater_crayfish_in_South_West_WA)>.

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## 5.10 Encourage the adoption of ecologically sound management practices

The following steps are recommended to help encourage landholders and others to adopt practices that will improve the health of the Buayanyup River system:

- Promote the benefits of riparian vegetation. This can be done by explaining the improvements to water quality and biodiversity and by promoting the added benefit of insect control if the waterway supports birds and fish. It is recommended that vignerons plant natives that flower when grape vines fruit to provide a food source other than the grapes for the silvereye birds that damage their fruit.
- Management bodies should keep up to date with the cost of fencing, stock troughs and the materials required to build stock crossings so that funds offered to landholders represent 50% of the cost of restoration projects
- Management bodies should offer native trees for paddock shade to replace shade lost when waterways are fenced.
- Where the waterway runs through a reserve managed by the shire or a government agency, these bodies should be involved in restoration projects within the reserve.
- Engage developers and the Shire in considering the installation of rain gardens as well as promoting native gardens within the estate.

Funding assistance and technical advice to help carry out the management recommendations may be available through GeoCatch. For more information, please contact GeoCatch. Appendix 10 has the contact details.

## 6 River foreshore condition and recommendations

This section contains the detailed field observations on foreshore condition and the specific recommendations on what should be done to improve it, at the level of individual lots. The key map, Figure 14, shows how the study area is covered by the 12 individual maps.

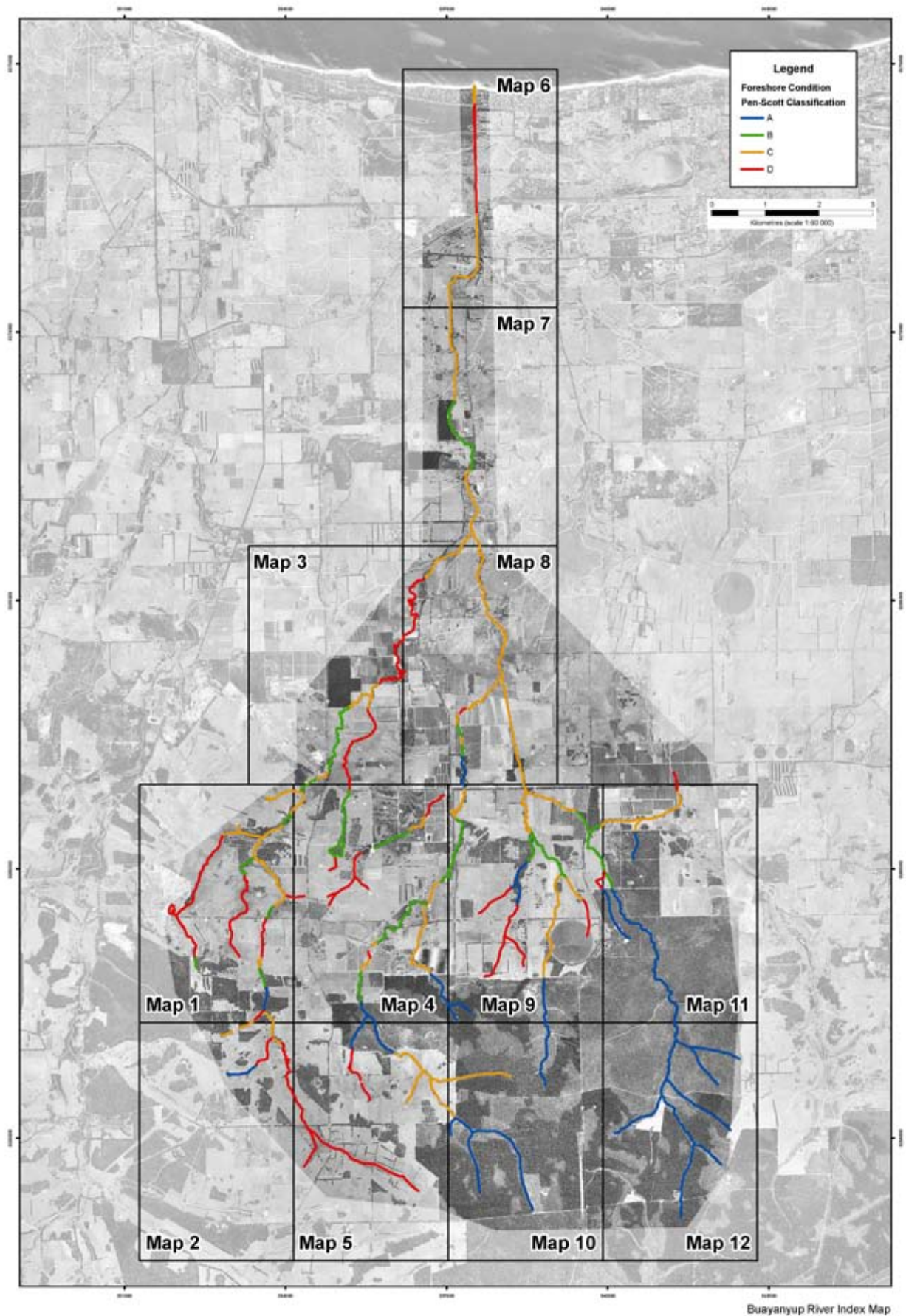
### Legend

Foreshore Condition

Pen-Scott Classification



**Figure 13** *Legend for waterway condition on maps*



**Figure 14** Key map for the study area



## 6.1 Map 1 Three tributaries of Dawson Gully

<b>Land use</b>	The land use is agriculture and the area is stocked with dairy and beef cattle. There are also vineyards and annual horticulture in this area.			
<b>Landform and soils</b>	The soils are characterised by extensive block laterite and ironstone gravels with some swamps. Chief soils on slopes and undulating areas generally are hard acidic yellow mottled soils containing small to very large amounts of ironstone gravels.			
<b>Native vegetation</b> (Appendix 1 for descriptions of vegetation complexes)	<b>Vegetation complex</b>	<b>% remaining</b>	<b>% protected in formal and informal reserves</b>	<b>Recommended action</b>
	Yelverton (Yw)	26	9	Refrain from clearing. Preferably locate developments in cleared areas as less than 30% of this vegetation complex remains (EPA 2006).
<b>Weeds</b>	Blackberry, cape tulip, capeweed, flatweed, guildford grass, <i>juncus microcephalus</i> , kikuyu, pennyroyal, thistle			

### Management recommendations and advice

**Lots 4437 & 2581** – Although the riparian vegetation has been degraded by stock, there is still some regeneration of sensitive understorey species such as orchids occurring. Fencing these areas is likely to result in successful natural regeneration. There is also an abundance of in-stream habitat such as woody debris that would offer habitat for native fish and crayfish. The stock have created erosion which if fenced off, could be stabilised with native rushes and sedges further improving the habitat for native fish. Installing a rock stabilised stock crossing would also be beneficial to the farmer and reduce erosion. One large blackberry bush is present on lot 2581. Recommend removing this before it spreads.

**Lot 82** – This unfenced waterway does not appear to have been heavily stocked in the past and the wide verge of riparian vegetation is healthy and intact and supports a variety of species including orchids. In the interest of protecting healthy habitat as a priority, fencing is recommended. Control pennyroyal with glyphosate when waterway ceases to flow.

**Lot 2574 & 1** – Much of the native riparian vegetation is absent at these locations and the banks have been eroded by stock. Recommend fencing the waterway to minimise further erosion and reduce the input of manure directly into the waterway. Algae was visible at this location and it is expected that the water quality may be poor. The construction of rock stabilised stock crossings may be beneficial.

**Lot 4436** – This lot contains the headwaters of the most western tributary of Dawson Gully and appears to be a broad wet depression supporting good vegetation. Recommend fencing to exclude stock.

**Lot 100** – The waterway is unfenced and stock have access. Recommend fencing to exclude stock.

**Lots 2573, 4201, 4202, 4205, 24, 25, 21, 7, 8 & 9** – These lots were not surveyed and have been assessed from aerial photography. General best management principles apply and it is recommended that the waterway be fenced off where stock have access, invasive weeds be controlled (see Appendix 3) and revegetation with native species be undertaken in degraded areas.



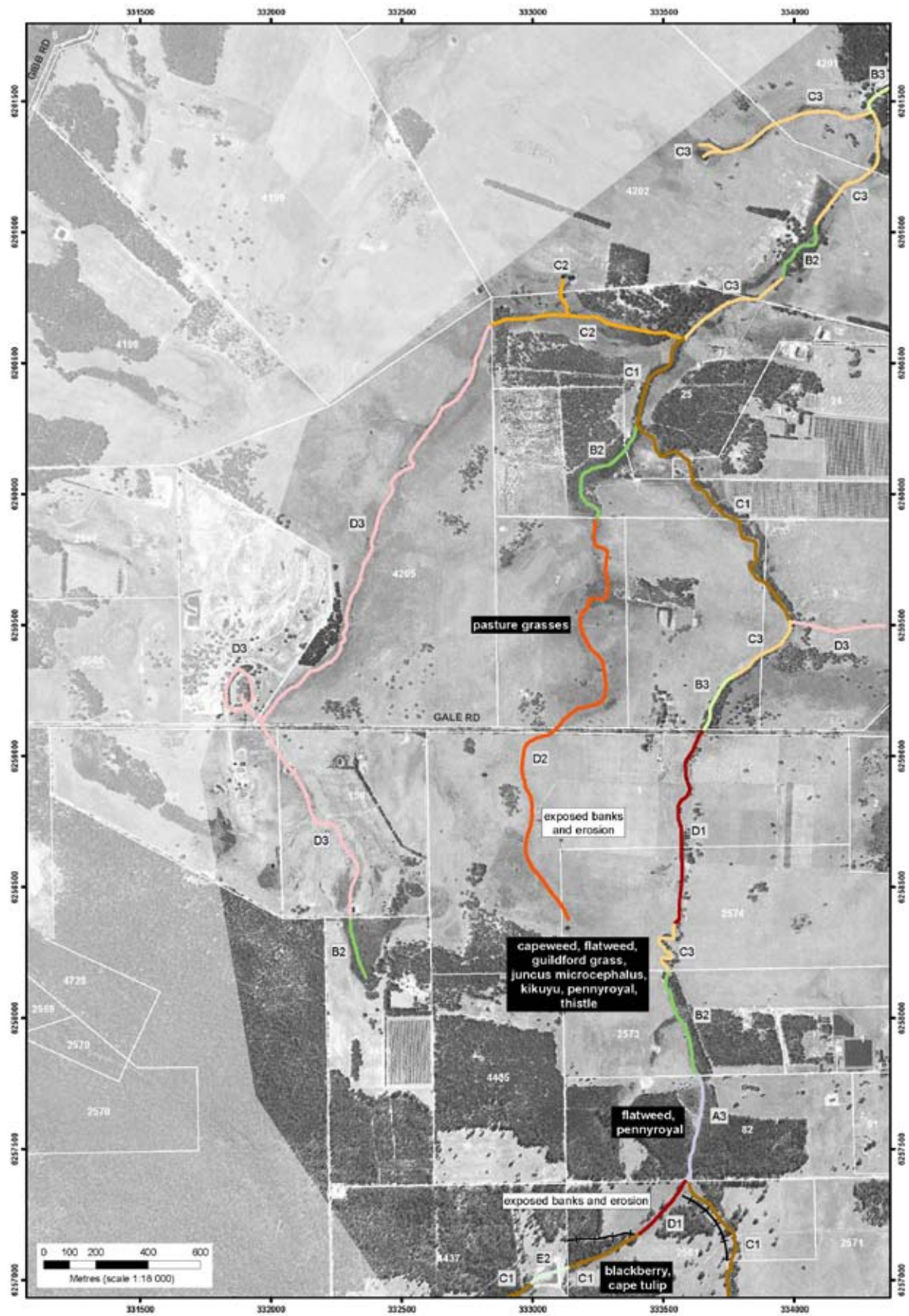


Figure 15 Map 1 – three tributaries of Dawson Gully

## 6.2 Map 2 South-western part of Dawson Gully

<b>Land use</b>	The land use is agriculture and the area is stocked with dairy and beef cattle.			
<b>Landform and soils</b>	The soils are characterised by extensive block laterite and ironstone gravels with some swamps. Chief soils on slopes and undulating areas generally are hard acidic yellow mottled soils containing small to very large amounts of ironstone gravels.			
<b>Native vegetation</b> (Appendix 1 for descriptions of vegetation complexes)	<b>Vegetation complex</b>	<b>% remaining</b>	<b>% protected in formal and informal reserves</b>	<b>Recommended action</b>
	Treeton (Tw)	35	9	Retain at least 30% of this vegetation complex (EPA 2006)
<b>Weeds</b>	Capeweed, dock, <i>juncus microcephalus</i> , kikuyu, pasture grasses			

### Management recommendations and advice

**Lot 2571** – Although stock have access to the waterway on this property and there are degraded and eroded areas, some stretches are in good condition and support healthy vegetation. Fencing off waterways that are still relatively healthy encourages natural regeneration from the seed bank in the soil and is an effective way to achieve a positive biodiversity and water quality outcome with minimal effort. Recommend fencing the waterway on this property as a priority.

**Lot 2239** – This lot contains a piece of A grade riparian bush. While the remainder of the waterways on the property are unfenced and in D grade condition, this highlights the benefit of fencing stock out of waterways. Although it is unlikely that there would be much natural regeneration if the D grade sections were fenced off, there would be a water quality improvement. Stock crossings are recommended to allow stock to cross the waterway safely without destabilising sediment on the way through.

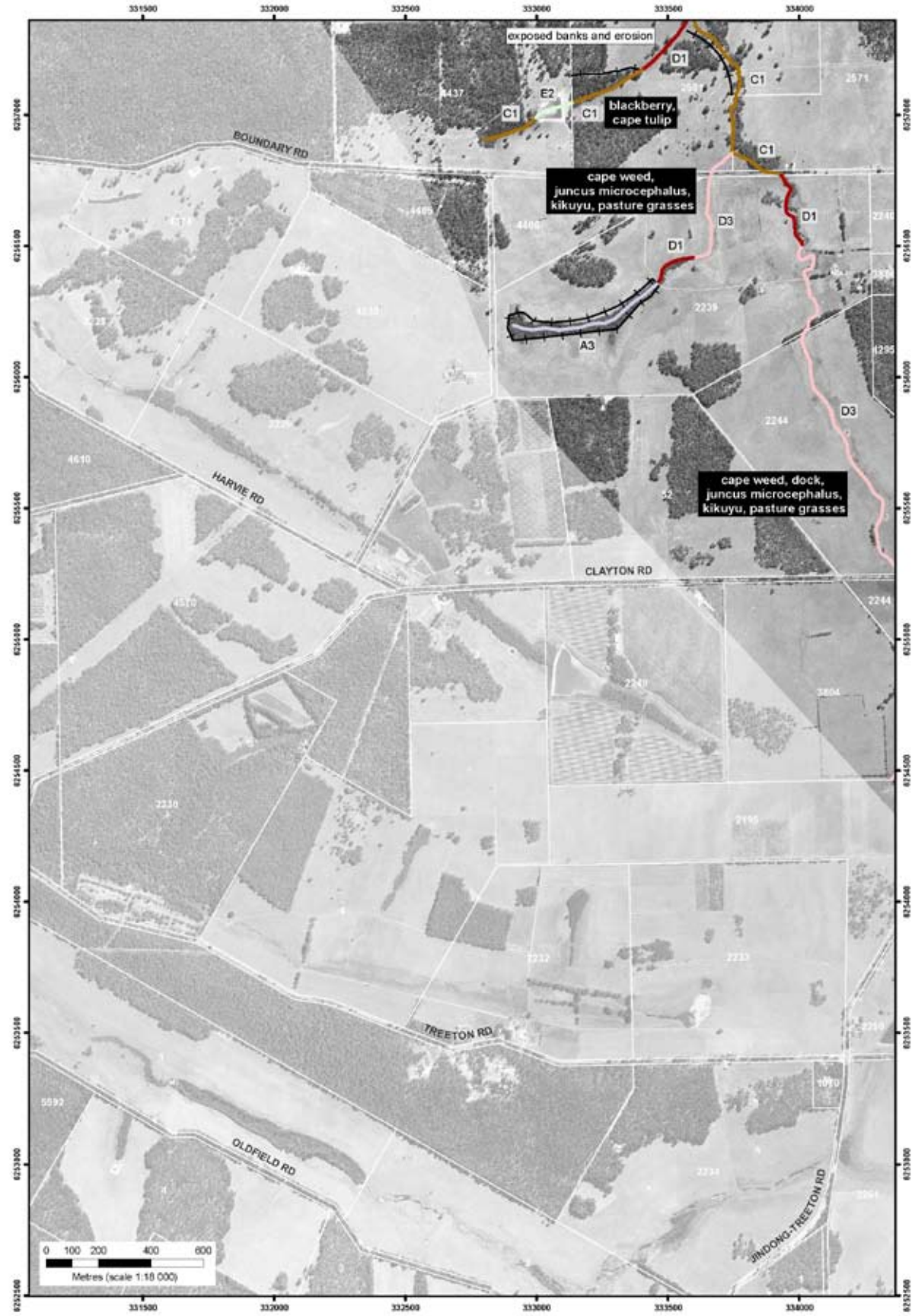


Figure 16 Map 2 – south western part of Dawson Gully



### 6.3 Map 3 Mid section of the catchment

<b>Land use</b>	The land use is agriculture, dominantly cattle grazing, annual horticulture and vineyards. Forestry also features in this area as there are pine plantations.			
<b>Landforms and soils</b>	The bed of the waterway in this section is ironstone and rock riffles are present. The soils on the south of the map are characterised by extensive block laterite and ironstone gravels with some swamps. Chief soils on slopes and undulating areas generally are hard acidic yellow mottled soils containing small to very large amounts of ironstone gravels. Towards the north the chief soils are acid Fey earths with leached sands that have a clay horizon at depths of 1 to 2.4 m.			
<b>Native vegetation</b> (Appendix 1 for descriptions of vegetation complexes)	<b>Vegetation complex</b>	<b>% remaining</b>	<b>% protected in formal and informal reserves</b>	<b>Recommended action</b>
	Abba (Aw),(Ad), (AF)&(Af)	6	0	These are rare vegetation complexes and should be retained and conserved (EPA 2006)
<b>Weeds</b>	Birdsfoot trefoil, blowfly grass, capeweed, couch, dock, guildford grass, <i>juncus microcephalus</i> , kikuyu, lotus, lupins, non-local eucalypts, oak trees, pennyroyal, rye grass, wild radish			

#### Management recommendations and advice

**Lots 3107 and 3105** – The most western waterway on this property supports some good quality vegetation. Many of the shrubs are still intact and the ironstone base of the waterway has prevented any major erosion. Most of this waterway has been fenced off and regeneration is likely which will be a good outcome for this area supporting a rare vegetation complex. Although the most eastern waterway is far more degraded and therefore less of a priority it is recommend that it be fenced off.

**Lot 3109** – This lot has some good quality vegetation at the most western end which has been fenced off. The most eastern waterway supports little native vegetation, but water quality would improve if fenced to exclude stock.

**Lots 3103 and 2387** – This section of the waterway runs through vineyards and has been diverted. It is now mostly a mounded drain dotted with degraded native vegetation and planted oak trees. Sheep have access so fencing is recommended to improve the water quality and minimise erosion. Some weed control and revegetation with native rushes and sedges is also recommended as these species are less likely to attract silvereyes (fruit loving birds) which can spread disease and destroy the grapes.

**Lot 3102 & 3104** – These lots were not surveyed and have been assessed by aerial photography. General best management principles apply and fencing is recommended if stock have access to the waterway.

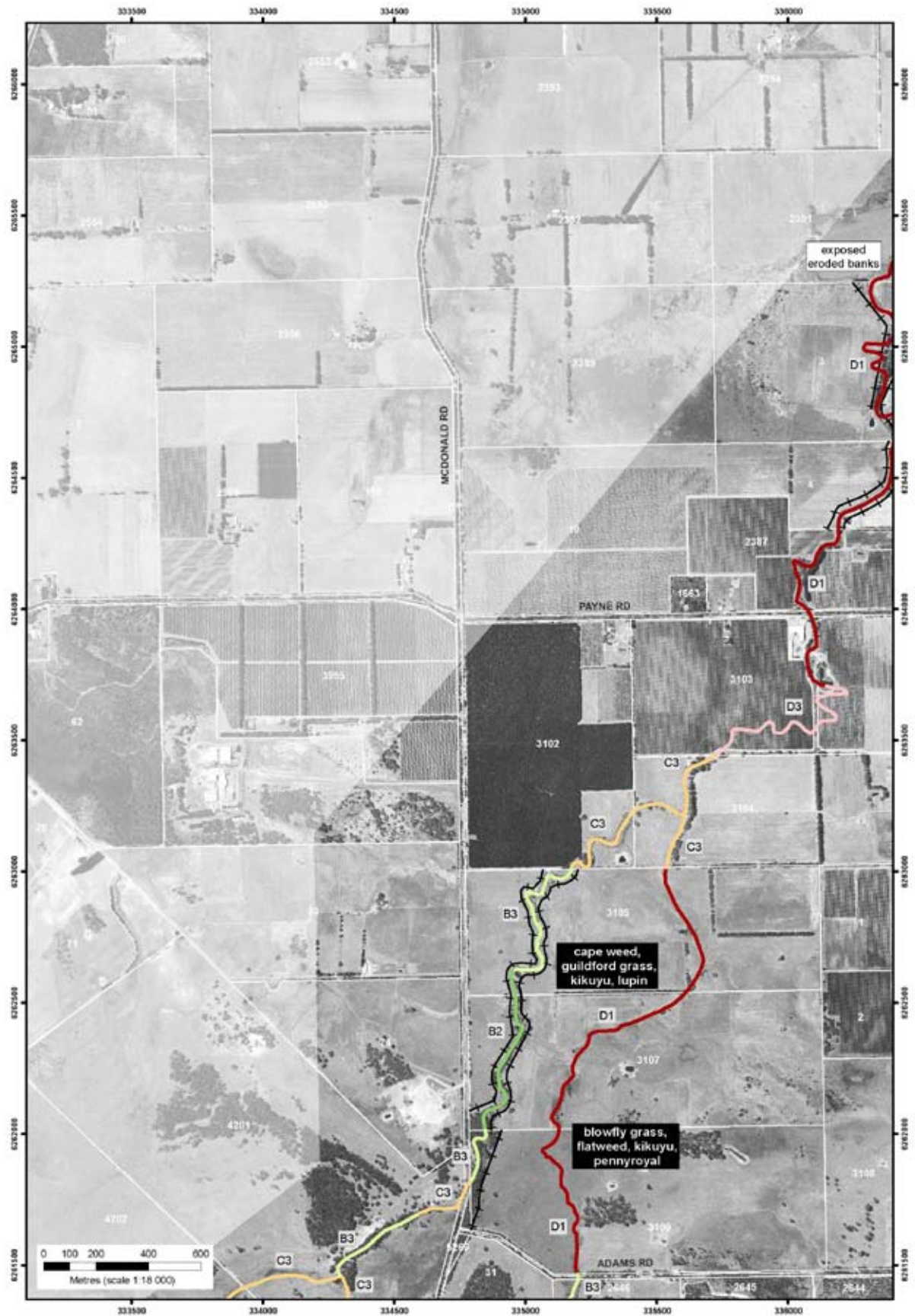


Figure 17 Map 3 – mid section of the catchment

## 6.4 Map 4 Upper section of Ironstone Gully

<b>Land use</b>	The land use is agriculture. There are vineyards, cattle grazing, annual horticulture and plantations.			
<b>Landform and soils</b>	Soils are characterised by extensive block laterite and lateritic (ironstone) gravels; some swamps: chief soils on slopes and undulating areas generally are hard acidic yellow mottled soils containing small to very large amounts of ironstone gravels.			
<b>Native vegetation</b> (Appendix 1 for descriptions of vegetation complexes)	<b>Vegetation complex</b>	<b>% remaining</b>	<b>% protected in formal and informal reserves</b>	<b>Recommended action</b>
	Yelverton (Yw)	26	9	Refrain from clearing. Preferably locate developments in cleared areas as less than 30% of this vegetation complex remains (EPA 2006).
<b>Weeds</b>	<i>Acacia</i> sp. <i>juncus microcephalus</i> , kikuyu, ryegrass, capeweed, flatweed, pennyroyal, typha, pine trees, freesia			

### Management recommendations and advice

**State forest 32** – This A grade vegetation supports a variety of declared rare flora and has few weeds. Pine trees are encroaching on the riparian zones from the nearby plantations and it is recommended that they are removed.

**Lot 2686** – This property supports some good quality vegetation and has wide waterway buffer that links to the state forest. Fencing the waterway to exclude cattle on the property would be a great outcome as understorey regeneration is likely and it is the start of a bushland corridor leading down from the scarp.

**Lots 2684 and 2682** – The land uses on these properties are predominantly vineyards with some stock. Parts of the waterway are fenced and if the properties continue to be stocked, it is recommended that the remainder of the waterway is fenced. On lot 2682 some weedy pine trees have become established and it is recommended that these be removed and natives planted in their place.

**Lot 2683** – The recent construction of a dam at this location has led to the removal of much of the riparian vegetation. Unrestricted stock access has also degraded the understorey species in the bushland that remains. Recommend fencing off the waterways and revegetating the recently disturbed riparian zone with native species.

**Lot 2653** – Although cattle have access to the riparian bushland on this property, their access is limited and the most western waterway supports some good quality B grade vegetation with plenty of in-stream habitat for native fish and for the rare freshwater mussel. Recommend fencing the western waterway as a priority. Also recommend removing weedy acacia species.

**Lot 2643** – This is a shallow weedy waterway. Recommend revegetating with native rushes and sedges.

**Lots 101, 100, 2644, 2645, 2648 & 2651** – These lots were not surveyed and have been assessed from aerial photography. General best management principles apply and it is recommended that the waterway be fenced off where stock have access, invasive weeds be controlled (see Appendix 3) and revegetation with native species be undertaken in degraded areas.



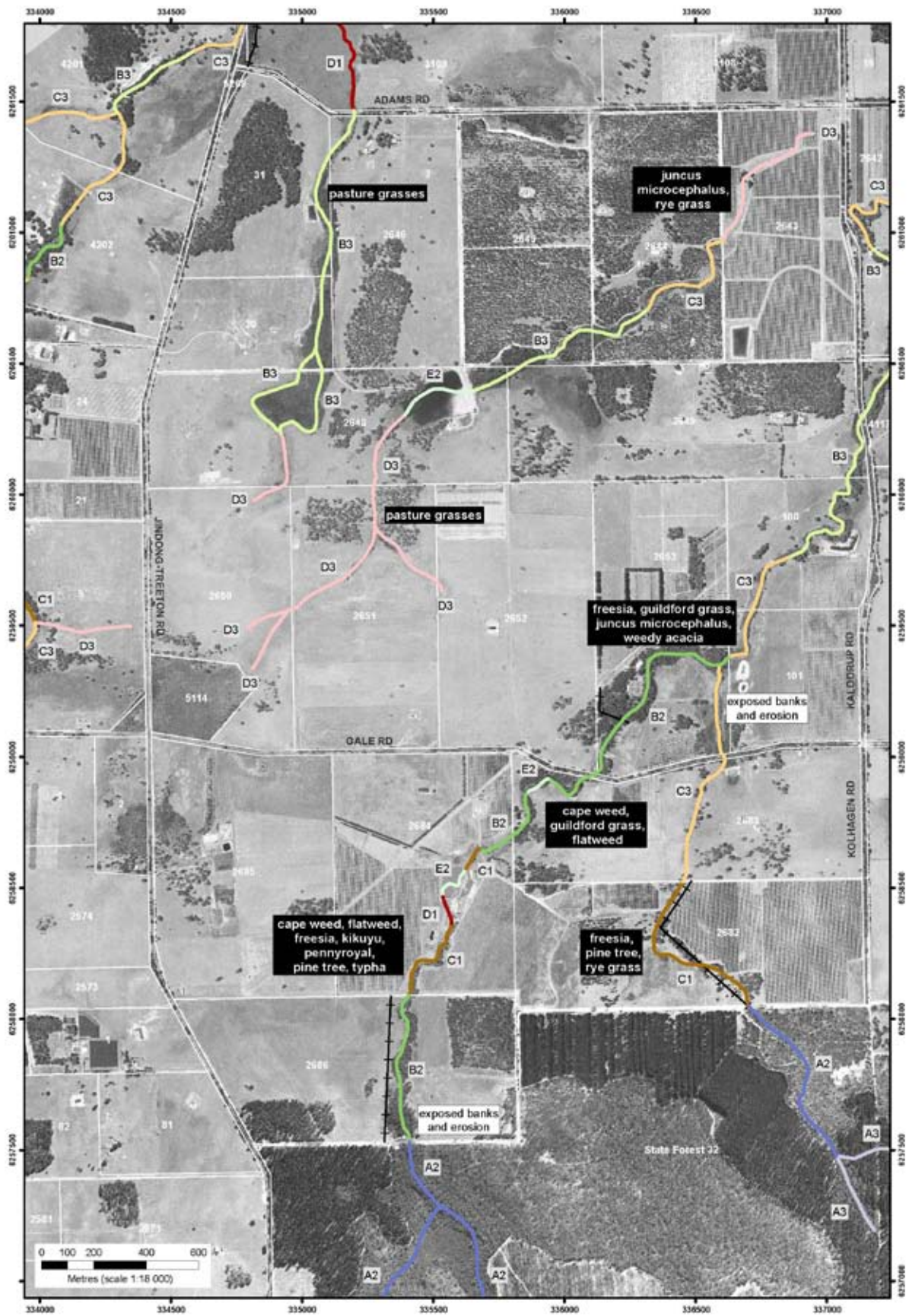


Figure 18 Map 4 – upper section of Ironstone Gully

## 6.5 Map 5 Southern tip of Ironstone Gully

<b>Land use</b>	The land use is agriculture, dominantly cattle grazing and state forest managed for timber and conservation.			
<b>Landform and soils</b>	Soils are characterised by extensive block laterite and lateritic (ironstone) gravels with some swamps. Chief soils on slopes and undulating areas generally are hard acidic yellow mottled soils containing small to very large amounts of ironstone gravels.			
<b>Native vegetation</b> (Appendix 1 for descriptions of vegetation complexes)	<b>Vegetation complex</b>	<b>% remaining</b>	<b>% protected in formal and informal reserves</b>	<b>Recommended action</b>
	Treeton (Tw)	35	9	Retain at least 30% of this vegetation complex (EPA 2006).
<b>Weeds</b>	Arum lilies, cape tulip, capeweed, <i>juncus microcephalus</i> , kikuyu, pasture grasses			

### Management recommendations and advice

**Lots 2244, 2245 and 2246** – The waterway on these lots mostly resemble drains vegetated with kikuyu, pasture grass and the odd native tree. Fencing these waterways off from stock would, however, encourage a water quality improvement as it would prevent stock from depositing manure directly into the water.

**Lots 3804 & 2244** – These lots contain the headwaters of Dawson Gully. The velocity of water is low and erosion is minimal even though much of the riparian vegetation is absent and stock have access to the waterway. Fencing these waterways would assist in improving water quality and reduce the input of manure directly into the waterway. The construction of rock stabilised stock crossings may be beneficial.

**Lots 2241, 2242, 2243 and 3954** – Although stock have access to the waterways on these lots, their access is limited and in some areas, the riparian vegetation has remained healthy and intact. The waterways on lots 2242 and 2241 also provide a bush corridor between two areas of state forest. Fencing the waterway on these lots is likely to encourage the regeneration of delicate understorey species and would facilitate the regeneration of a bush corridor. There are some areas of arum lily infestation as well as cape tulip. The landholder has begun controlling these weeds and it is recommended that the staged weed control continue.



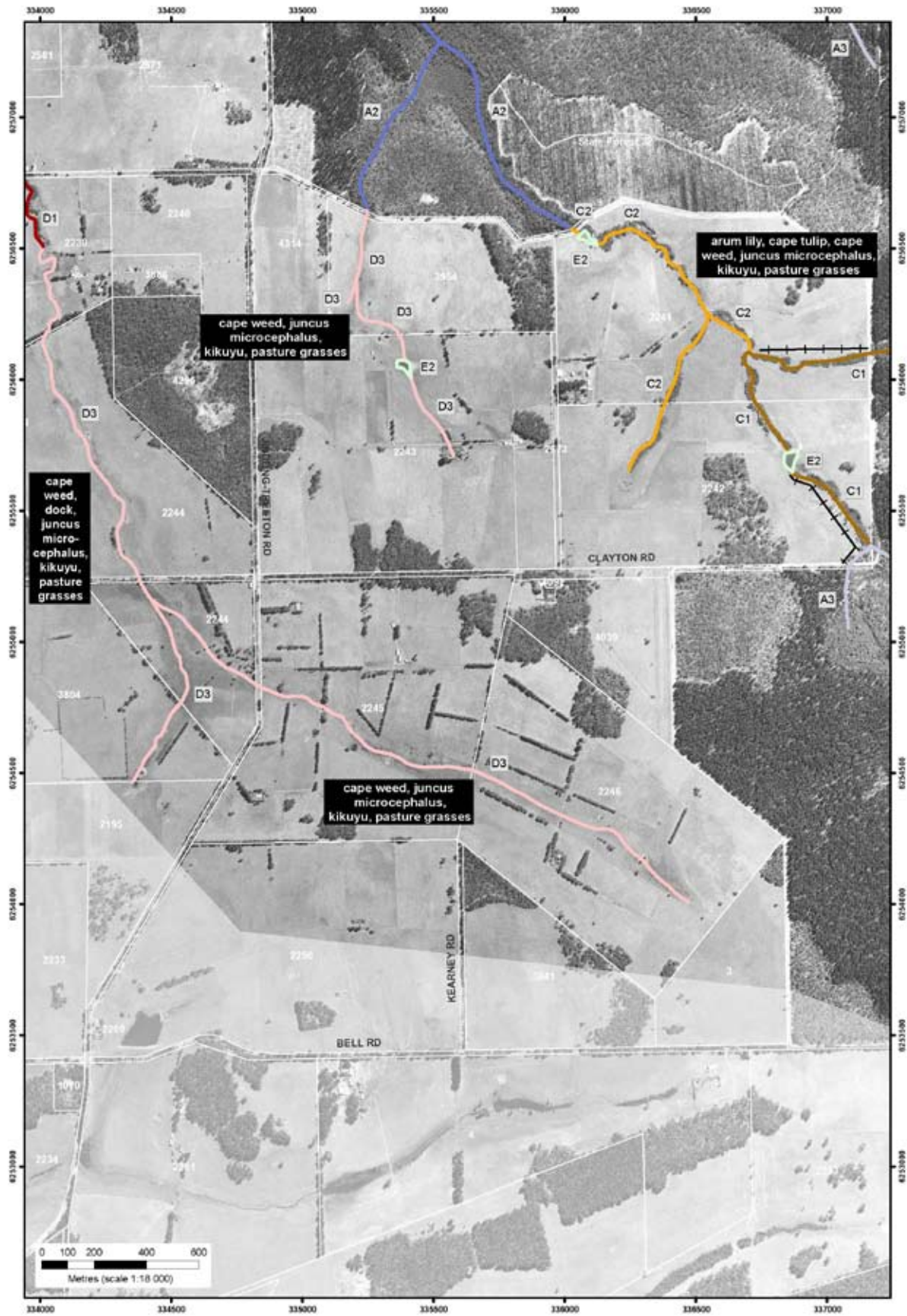


Figure 19 Map 5 – southern tip of Ironstone Gully

## 6.6 Map 6 Where the river meets the sea at Abbey

<b>Land use</b>	Much of this section of the waterway has been straightened and mounded for flood mitigation purposes. Adjacent land uses are a mixture of hobby farms with small orchards, residential lots as well as a nature reserve towards the mouth of the river/drain.			
<b>Landform and soils</b>	Close to the ocean are coastal dune formations backed by the low-lying deposits of inlets and estuaries. Chief soils are calcareous sands on the dunes. Associated are various, acid peat soils in the swale behind the coastal dunes.  Moving further inland is a gently undulating plain with low dunes: chief soils are brown sands with variable areas of siliceous sands, shallow dark sands and shallow yellow-brown sands. The area is underlain by fossiliferous limestone.			
<b>Native vegetation</b>	<b>Vegetation complex</b>	<b>% remaining</b>	<b>% protected in formal and informal reserves</b>	<b>Recommended action</b>
(Appendix 1 for descriptions of vegetation complexes)	Abba (Aw) (Af)	6	0	This is a rare vegetation complex and should be retained and conserved
	Ludlow (Lw)	Not determined	Not determined	Not determined
	Quindalup (Qw)	44	16	Retain at least 30% of this vegetation complex
	Quindalup (Qd) (Qwy)	Not determined	Not determined	Not determined (EPA 2006).
<b>Weeds</b>	African cornflag, African lovegrass, arum lily, blue periwinkle, bridal creeper, capeweed, couch, curled dock, flatweed, flaxleaf broom, fleabane, freesia, hare's tail grass, kikuyu, lupin, rose pelargonium, soursob, storkbills, typha, watsonia, wild gladiolus, wild radish			

### Management recommendations and advice

**Drainage reserve** – The length of the waterway on this map is contained within a drainage reserve and although the waterway has been altered and mounded on either side of its banks, there has been some natural regeneration of trees, understory species and herbs. There is however, some extensive erosion and there are significant weed infestations along the length of the drain.

There is significant undercutting occurring near the Florence and Kaloorup Road bridges. The drain is managed as a containment levee by the Water Corporation and the developers of Vasse Newtown also have a vested interest as they are developing the land either side, so it is recommended that the relevant stakeholders meet to discuss addressing the erosion as well as revegetating with species suitable for drains. A document called *Native plant species to be used in stabilisation and enhancement of Water Corporation rural main drains and in the South West draining districts* (Kabay Consultants 2002) provides a useful reference for selecting suitable species. As the drain is highly visible from Bussell Highway and Kaloorup Road, a partnership rehabilitation project is likely to set a good example for the community and encourage involvement in river rehabilitation projects.

A dense arum lily infestation within Locke Nature Reserve requires control. GeoCatch, in partnership with the Department of Environment and Conservation began control in 2008 and it is recommended that this continue. A patch of bridal creeper in the Florence Road reserve as well as the cape tulips a little further up-stream also require control.

**Adjacent landholders** are encouraged to maintain stock proof fences. Stock were noted in the drain reserve at the time of survey and some stretches of fencing were in disrepair. Recommend fencing to exclude stock.



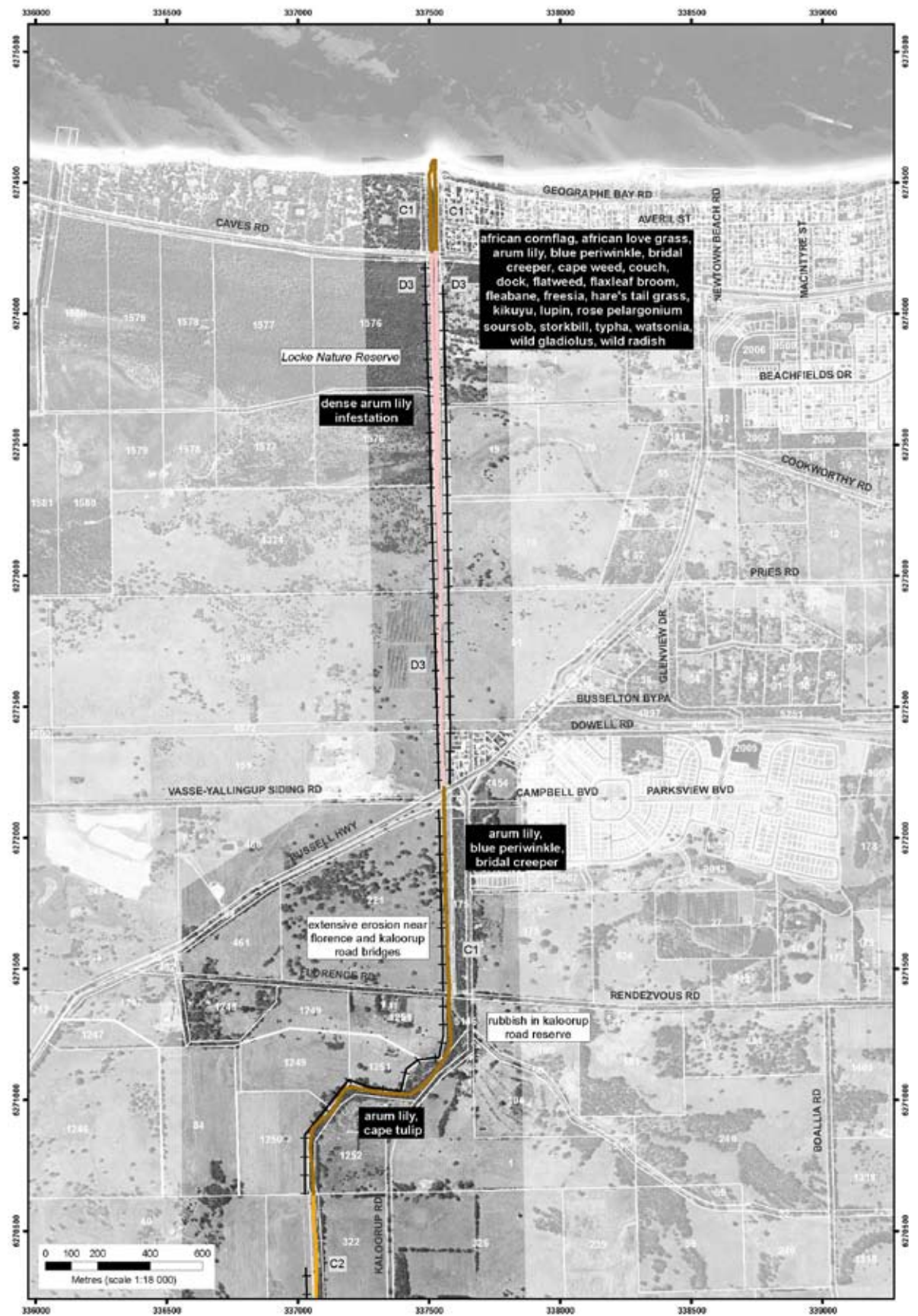


Figure 20 Map 6 – where the river meets the sea at Abbey

## 6.7 Map 7 Where the four up-stream tributaries meet

This map is towards the middle of the catchment where the four up-stream tributaries meet and the waterway often forms a deep and sometimes wide, defined channel.

<b>Land use</b>	Agriculture: cattle and sheep farming, horse stud			
<b>Landform and soils</b>	Chief soils are acid Fey earths often in fairly intimate association with leached sands that have a clay D horizon at depths of 1 to 2.4 m. Associated are small areas of soils containing ironstone gravels.  Further south on this map is subdued dune-swale terrain where the chief soils are leached sands.			
<b>Native vegetation</b>  (Appendix 1 for descriptions of vegetation complexes)	<b>Vegetation complex</b>	<b>% remaining</b>	<b>% protected in formal and informal reserves</b>	<b>Recommended action</b>
	Abba (Aw) (AB) (Af)	6	0	These are rare vegetation complex and should be retained and conserved (EPA 2006).
<b>Weeds</b>	African lovegrass, blowfly grass, clover, dock, flatweed, freesia, kikuyu, lesser broomrape, narrowleaf trefoil, pampas grass, pennyroyal, rye grass, wild oats, wild radish, willow trees.			

### Management recommendations and advice

**Lot 322** – Some sections of the waterway on this property have already been fenced off. Recommend fencing off the remainder. There are also several crossing points that may be suitable for the construction of rock stabilised stock crossing to reduce erosion.

**Lots 3866, 3867 & 3868** – These properties are dissected by a drainage reserve that is not actively managed by the state government or the Water Corporation. Lots 3866 and 3868 were not surveyed and have been assessed from aerial photography. The waterway in this part of the catchment is wide and reasonably shallow and erosion is minimal. Stock have access so it is recommended the waterway be fenced off to exclude them. Some revegetation has already begun on lot 3867 and it is recommended that this continue.

**Lot 3** – was not surveyed and has been assessed from aerial photography. General best management principles apply and fencing is recommended if stock have access to the waterway.

**Lot 2** – This property is fully vegetated and has a spectacular array of flowers including orchids. There is no requirement to fence the waterway as there is no stock on the property. Although the riparian zone is in good condition, there are some dense infestations of grassy weeds. Controlling these and revegetating with native rushes and sedges is recommended.

**65 & 66** – The full length of the waterway on this property has been fenced off and some erosion control work has been undertaken where scouring of the banks had occurred. Recommend revegetation of the banks with local native species, particularly native rushes and sedges and other understorey species as there are some existing trees (although not local) planted in the riparian zone. The willow trees, although recently planted can be considered weedy so replanting with peppermint trees (*Agonis flexuosa*) is recommended.



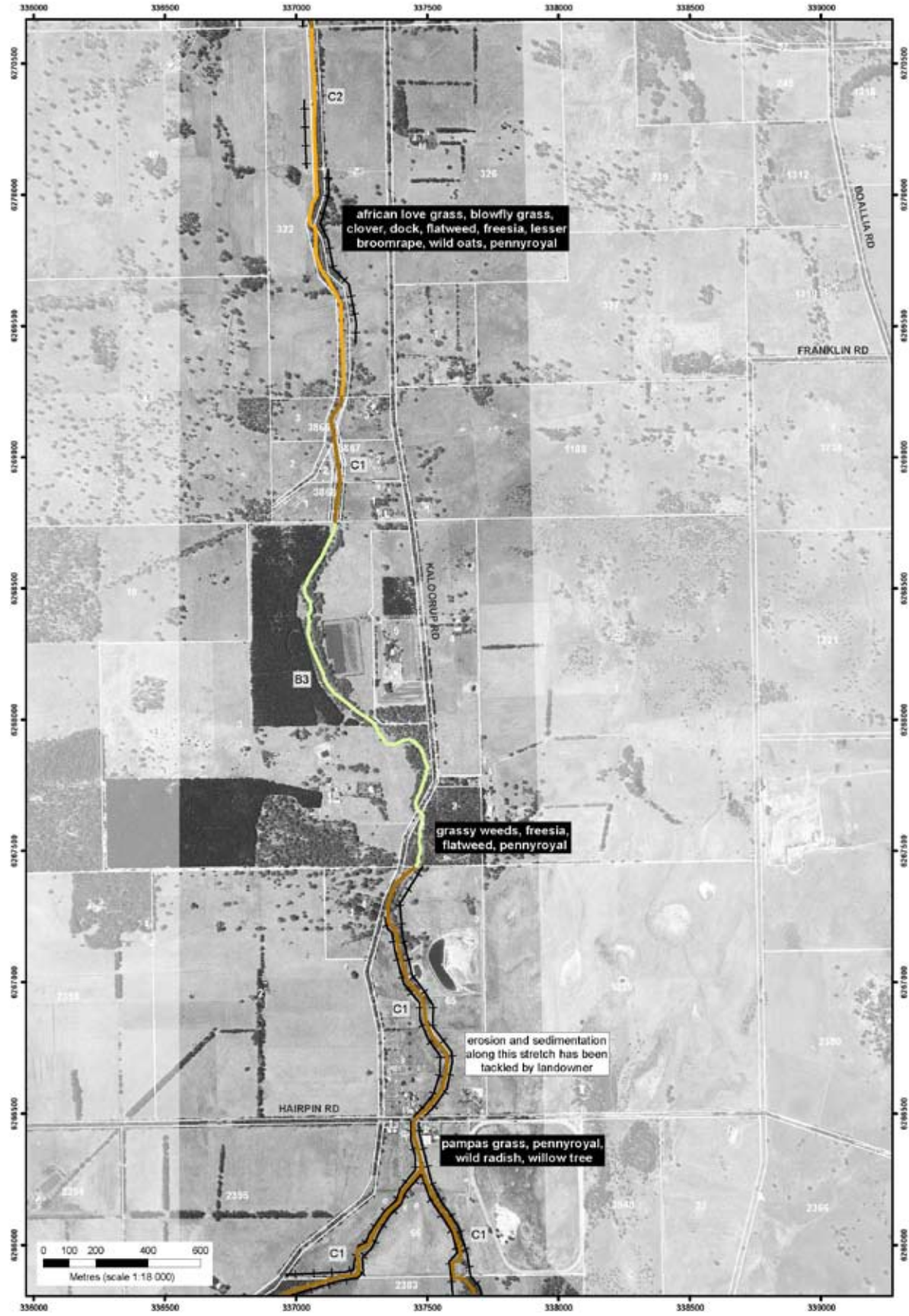


Figure 21 Map 7 – where the four up-stream tributaries meet

## 6.8 Map 8 Mid catchment

<b>Land use</b>	The land use is agriculture: horse, sheep and cattle grazing, vineyards and potato crops.			
<b>Landform, soils</b>	Chief soils are acid Fey earths often in fairly intimate association with leached sands that have a clay D horizon at depths of 1 to 2.4 m. Associated are small areas of soils containing ironstone gravels.			
<b>Native vegetation</b> (Appendix 1 for descriptions of vegetation complexes)	<b>Vegetation complex</b>	<b>% remaining</b>	<b>% protected in formal and informal reserves</b>	<b>Recommended action</b>
	Abba (AF) (Af) (Aw) (AB)	6	0	These are rare vegetation complexes and should be retained and conserved (EPA 2006).
<b>Weeds</b>	Blowfly grass, blue periwinkle, burr medic, capeweed, flatweed, <i>juncus microcephalus</i> , kikuyu, non-local eucalypts, pasture grasses, pennyroyal, watsonia			

### Management recommendations and advice

**Lot 2383 & 3948** – The length of the waterway on this property has been fenced off from stock and revegetated with native Australian species, although not all of them endemic to Western Australia. Stock still have access to the riparian area via a sandy stock crossing. A location further up-stream has been identified as a suitable location for a new bridge stock crossing which if installed will remove the stock access to the riparian zone. Recommend installation of stock crossing.

**Lot 22** – This lot was not surveyed but appeared to be fenced. Recommend some grassy weed control and revegetation with native species particularly rushes and sedges.

**Lot 21 & 52** – The full length of the waterway on these properties has also been fenced off and despite the fact that it is a mounded drain, there has been some good natural regeneration of natives in the riparian zone. The smaller waterway leading into the main channel on Lot 715 is not fenced. There is some undercutting and bank slumping occurring, particularly along the outside bends of the waterway. Recommend fencing and addressing the erosion by laying some matting and planting native rushes and sedges. Also, some grassy weed control and revegetation with understorey species on the upper banks would be beneficial as there are some well established overstorey species.

**Lot 3111** – Although some sections of the waterway on this property have been fenced off, the stock still have access and this has created lengthy erosion along the banks. Recommend fencing off the remainder to exclude stock as well as planting native rushes, sedges and understorey species to minimise erosion. Also recommend addressing the bank erosion.

**Lot 3115** – The waterway on this property is mostly in C grade condition with a healthy overstorey, but limited native shrubs and herbs and with some erosion along the outside bends of the waterway. Recommend grassy weed control and revegetation with native understorey species. Also recommend revegetating the D grade section in the middle of the property to provide for a bush corridor for native fauna as a priority.

**Lot 1, 3117, 3119 & 3120** – A drain reserve containing the waterway runs through the length of these properties. Although the waterway has been mounded and altered to form a linear drain, there has been some good regeneration of native species. The high velocity flows typical of linear drains have created undercutting and bank slumping throughout much of this area and lot 3117 also contains some eroding subsurface drains, which would benefit from being stabilised though matting, laying rocks of various sizes and planting with native rushes and sedges. Some sections of the waterway have been fenced off and it is recommended that at the locations where stock have access, the remainder is fenced off. Also, some grassy weed control and revegetation with native rushes, sedges and herbs would assist in stabilising the erosion and increase species diversity.

**Lots 3 & 14** – These lots contain some good quality bush and are likely to naturally regenerate if the riparian areas are fenced off from stock. There is a patch of blue periwinkle (*Vinca major*) which is recommended to be mown and or sprayed with glyphosate and replaced with local native species.

**Lot 15** – This lot contains a section of riparian vegetation with rock riffles and waterfalls and minimal erosion. These A grade sections are a priority for protection. Fencing is not currently required as there is no stock on the property. Recommend controlling a patch of *Watsonia* at the southern end of the property.

**Lots 4, 3 and 2391** – The landholder has fenced off much of the waterway on these properties. Recommend fencing off the remainder. Stock crossings would also be beneficial to the landholder for safe passage across the waterway for stock as well as reducing erosion.

**Lot 2** – The waterway on this property is unfenced but is not heavily stocked. There is limited erosion, but many weeds. The deep river pools were known to support marron. Some weed control and revegetation with native species would assist in improving the habitat for fish and marron.



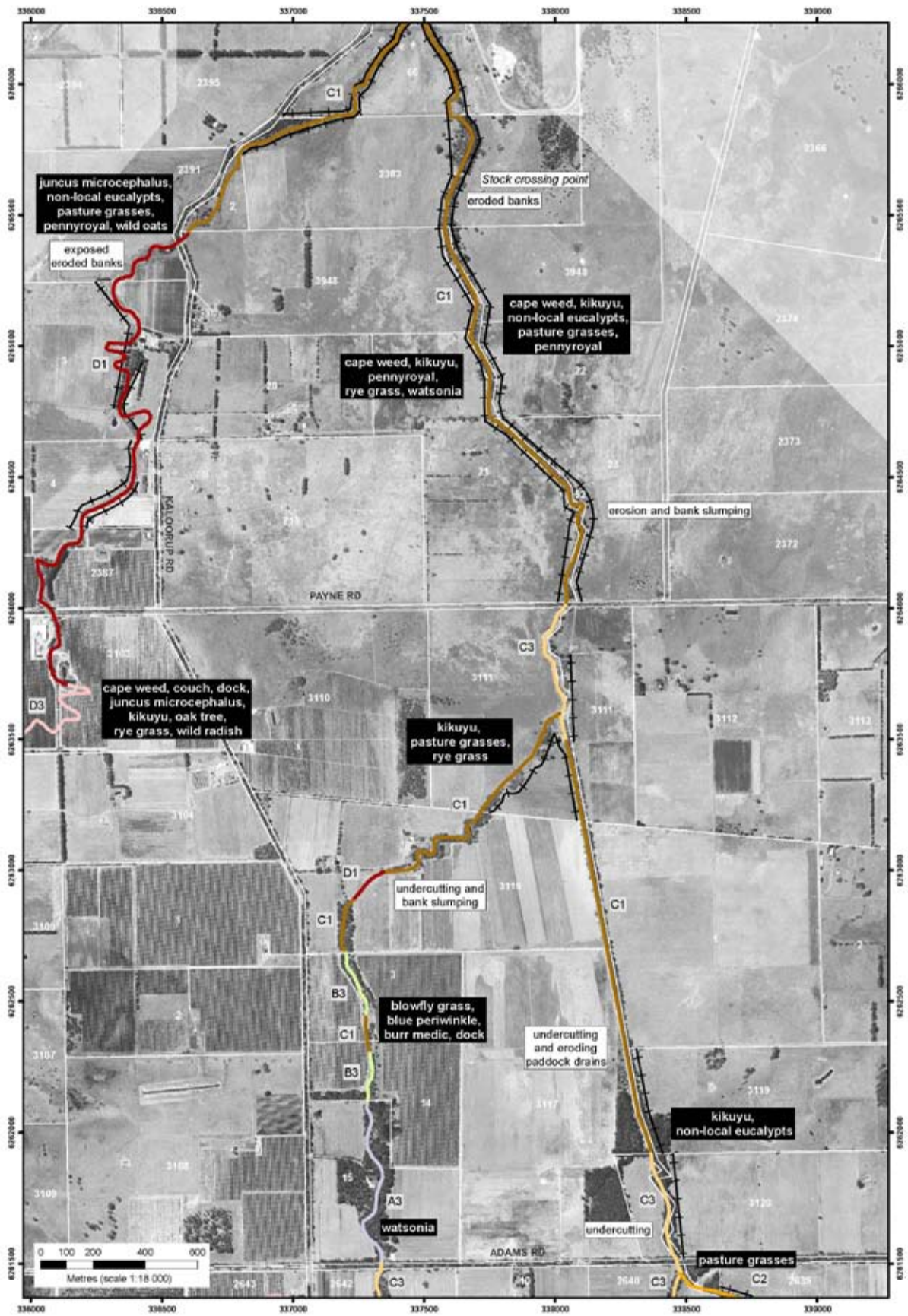


Figure 22 Map 8 – mid catchment, some sections altered to form a linear drain

## 6.9 Map 9 Upper reaches of an unnamed minor waterway

<b>Land use</b>	The land use is agriculture: dairy and beef cattle and vineyards, some sheep grazing.			
<b>Landform and soils</b>	<p>The northern half of this area contains strongly undulating lands often with granite outcrops on higher slopes. A range of loamy mottled yellow or grey earths occur. Moderately deep loamy duplex soils occur on lower slopes, with shallow sands common on higher slopes and adjacent to rock outcrops.</p> <p>Towards the southern half of the map is a dissected plateau at low elevation of gently undulating to low hilly relief and characterised by extensive block laterite and lateritic (ironstone) gravels. There are some swamps. Chief soils on slopes and undulating areas generally are hard acidic yellow mottled soils containing small to very large amounts of ironstone gravels. Associated are soils underlain by block laterite on the less dissected areas devoid of waterway channels.</p>			
<b>Native vegetation</b>  (Appendix 1 for descriptions of vegetation complexes)	<b>Vegetation complex</b>	<b>% remaining</b>	<b>% protected in formal and informal reserves</b>	<b>Recommended action</b>
	Yelverton (Yw)	2	9	Refrain from clearing. Preferably locate developments in cleared areas as less than 30% of this vegetation complex remains.
	Yelverton (Y)	38	6	Retain at least 30% of this vegetation complex
	Treeton (Tw)	35	9	Retain at least 30% of this vegetation complex
	Abba (AF)	6	0	This is a rare vegetation complex and should be retained and conserved (EPA 2006).
<b>Weeds</b>	Cape tulip, cape weed, dock, flatweed, fig trees, <i>juncus microcephalus</i> , kikuyu, lotus, guildford grass, pennyroyal, rye grass, thistle			

### Management recommendations and advice

**Lot 2460** – The most southern part of this property has a section of B grade bush so it would be beneficial to fence the waterway off from stock. There are also some steep, eroding banks which would benefit from the realignment of fallen logs to protect the banks from further erosion rather than direct the water into already eroding points.

**Lot 101** – was not surveyed and has been assessed by aerial photography. General best management principles apply and fencing is recommended if stock have access to the waterway.

**Lots 2632 & 2633** – Lot 2632 has a spectacular piece of A grade vegetation abundant with the majestic twine rush, Chinese puzzle (*Loxocarya Sp.*). This area has been fenced, but there are some weed infestations including fig trees. Recommend controlling the fig trees and completing some grassy weed control to maintain this area of high quality bush. The waterway in most southern section of lots 2632 and 2633 is in D grade condition. Although waterways in D grade condition provide little biodiversity value, excluding stock by fencing improves water quality, therefore they are recommended to be fenced off.

**Lot 2676, 2674 & 2675** – Most of the waterways on these properties are also in D grade condition. Recommend fencing to exclude stock for improved water quality.

**Lot 2630** – Fencing and rehabilitation of this property has begun and it is recommended that continued support is provided to the landholder to continue fencing the remainder of the two waterways traversing the property and continuing the staged weed control and revegetation program which began in 2007.

**Lot 2** – Lot 2 has also been fenced and some revegetation has occurred with both natives and eastern states eucalypts. Recommend continued revegetation with native species endemic to Western Australia.

**Lots 2639 & 2638** – A drainage reserve encompassing the waterway runs through the length of these properties. The landholder has revegetated this reserve with native species, although some of them are eastern states eucalypts and acacias. There are several crossing points that would benefit from being updated. Recommend the managers of the reserve work with the landholder on updating the crossings to minimise erosion and provide safe crossing points for the landholders and stock. Also recommend fencing the remainder of the reserve where stock have access as well as removing weedy eastern states acacias.

**Lot 3** – This lot contains high quality bush and has been fenced off in the locations where stock have access. It is linked to the state forest in the upper catchment and supports an abundance of flora and fauna including bandicoots, identified by their diggings. This lot is a priority for protection, but currently only requires minimal weed control.

**State forest 32** – Much of this area is densely vegetated and not easy to penetrate for conducting foreshore surveys. This A grade vegetation supports a variety of declared rare flora and has few weeds. Pine trees are encroaching on the riparian zones from the nearby plantations and it is recommended that the Department of Environment and Conservation remove these.

**Lot 2642** – This property supports some healthy B grade vegetation and has rocky riffles and some in-stream habitat. There are areas without understorey and there are no stock currently on the property. Recommend grassy weed control and planting native understorey.

**Lot 4117** – This lot was not surveyed and has been assessed from aerial photography. General best management principles apply and it is recommended that the waterway be fenced off where stock have access, invasive weeds be controlled (see Appendix 3) and revegetation with native species be undertaken in degraded areas.



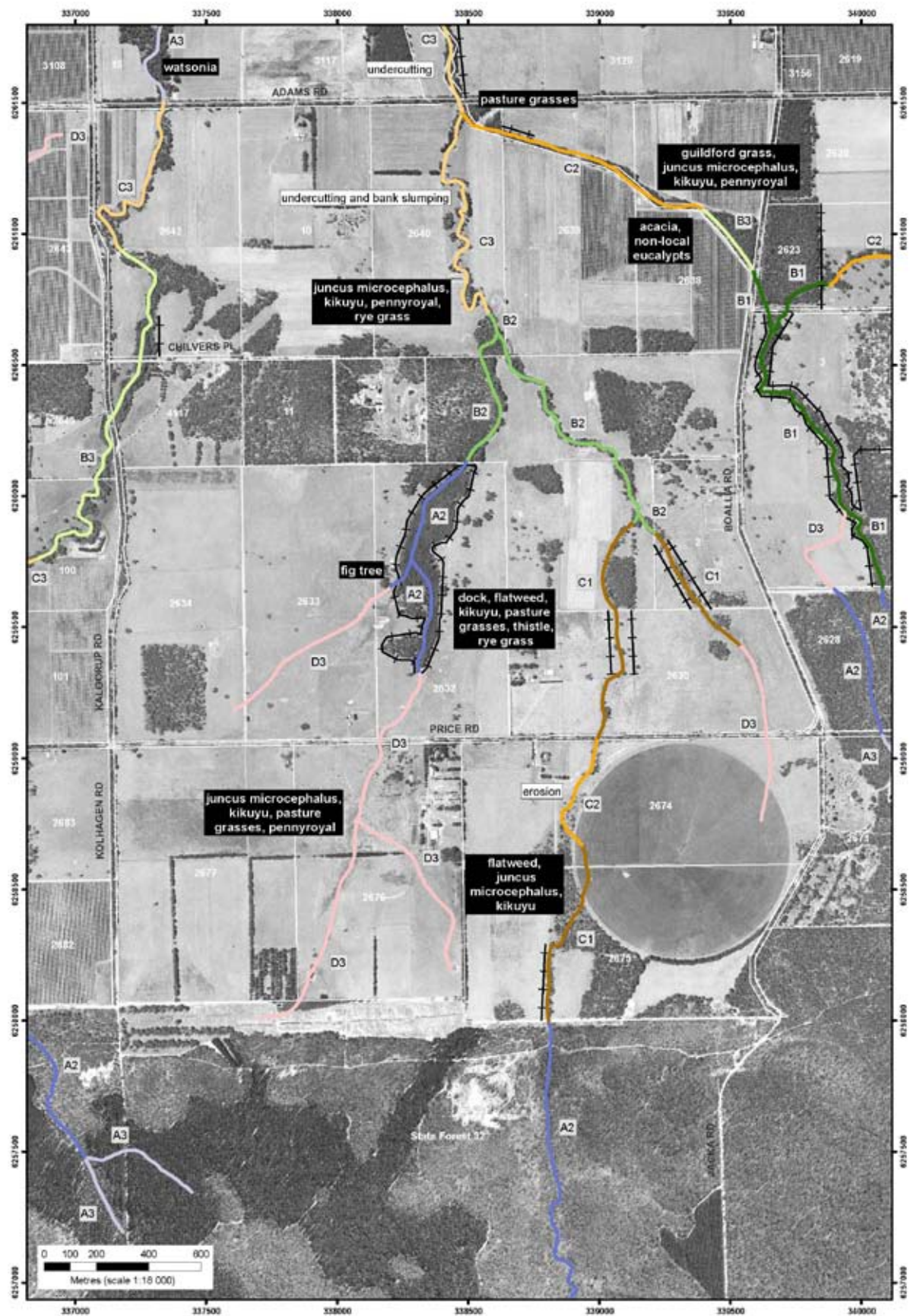


Figure 23 Map 9 – upper reaches of an unnamed minor perennial waterway



## 6.10 Map 10 Headwaters of the Buayanyup River

<b>Land use</b>	State forest 32 is managed for conservation and timber reserve by the Department of Environment and Conservation.			
<b>Landform and soils</b>	The landform is a gently undulating plateau characterised by extensive block laterite and lateritic (ironstone) gravels. Chief soils on slopes and undulating areas generally are hard acidic yellow mottled soils containing small to very large amounts of ironstone gravels.			
<b>Native Vegetation</b>	<b>Vegetation complex</b>	<b>% remaining</b>	<b>% protected in formal and informal reserves</b>	<b>Recommended action</b>
(Appendix 1 for descriptions of vegetation complexes)	Treeton (Tw)	35	9	Retain at least 30% of this vegetation complex (EPA 2006).
<b>Weeds</b>	Blowfly grass, budding club-rush, cape weed, common sowthistle, fescue, fleabane, freesia, <i>genista monspessulana</i> , guildford grass, <i>juncus microcephalus</i> , myrtleleaf milkwort, narrowleaf lupin, narrowleaf trefoil, radiata pine, shivery grass, smooth catsear, sticky bartsia, sweet vernal grass, wild gladiolus, wimmera ryegrass, yellow serradella, yorkshire fog			

### Management recommendations

As this area forms the headwaters of the waterway and is well vegetated, the flow velocity is low and therefore erosion is minimal. Although buffers of approximately 20 m either side of the waterways were left when the pine plantations were planted, seed from the radiata pine trees has encroached into the riparian zones and both mid sized and sapling pines can be found along most waterways in the upper catchment close to the pine plantations. It is recommended that these be removed.

There is also an abundance of declared rare flora in the forest in the upper catchment along with an extensive list of birds and mammals (see Appendix 4). Areas of state forest such as that found in the upper Buayanyup catchment represent refuges for native fauna and should be protected. It is recommended that the Department of Environment and Conservation review its fire management practices to ensure minimal clearing is conducted for fire management, unused gravel pits are revegetated and burns are conducted during times that have minimal impact on the native flora and fauna.



Figure 24 Map 10 – headwaters of the main channel of the Buayanyup River

## 6.11 Map 11 Upper catchment

<b>Land use</b>	The land use is agriculture: beef cattle and grape vines. Some lots are lifestyle properties managed for conservation. State forest dominates the upper catchment.			
<b>Landform and soils</b>	<p>The soils on the most northern part of this map are acid Fey earths often in fairly intimate association with leached sands that have a clay D horizon at depths of 1 to 2.4 m. Associated are small areas of soils containing ironstone gravels.</p> <p>Towards the southern half of the area is a dissected plateau at low elevation of gently undulating to low hilly relief and characterised by extensive block laterite and lateritic (ironstone) gravels; some swamps: chief soils on slopes and undulating areas generally are hard acidic yellow mottled soils containing small to very large amounts of ironstone gravels. Associated are soils underlain by block laterite on the less dissected areas devoid of waterway channels.</p>			
<b>Native vegetation</b>	<b>Vegetation complex</b>	<b>% remaining</b>	<b>% protected in formal and informal reserves</b>	<b>Recommended action</b>
(Appendix 1 for descriptions of vegetation complexes)	Yelverton (Yw)	26	9	Refrain from clearing. Preferably locate developments in cleared areas as less than 30% of this vegetation complex remains.
	Yelverton (Y)	38	6	Retain at least 30% of this vegetation complex
	Yelverton (Yd)	57	10	Retain at least 30% of this vegetation complex
	Preston (PR)	35	9	Retain at least 30% of this vegetation complex
	Abba (AF) (Aw)	6	0	This is a rare vegetation complex and should be retained and conserved (EPA 2006).
<b>Weeds</b>	Capeweed, <i>juncus microcephalus</i> , kikuyu, pasture grasses, wild radish, Yorkshire fog			

### Management recommendations and advice

**Lot 2621, 2622 & 2623** – The most western section of lot 2623 contains a healthy piece of B grade bush which has been fenced off. The remainder of the waterway would also benefit from being fenced as the stock access has created erosion along much of the bank. Recommend addressing this erosion and possibly a staged revegetation project to continue the vegetation corridor coming down from the scarp.

**Lot 4** – This lot was not surveyed but has been assessed from aerial photography as A2 grade and is a priority for protection.

**Lots 2628 & 2671** – These lots contain high quality bush and have been fenced off in the locations where stock have access. They are linked to the state forest in the upper catchment and support an abundance of flora and fauna including bandicoots, identified by their diggings. These lots are a priority for protection, but currently only require minimal weed control. Lot 2671 contains an old gravel pit and it is recommended that this area be revegetated.

**State forest 32** – Much of this area is densely vegetated and not easy to penetrate for conducting foreshore surveys. This A grade vegetation supports a variety of declared rare flora and has few weeds. Pine trees are encroaching on the riparian zones from the nearby plantations and it is recommended that these be removed.



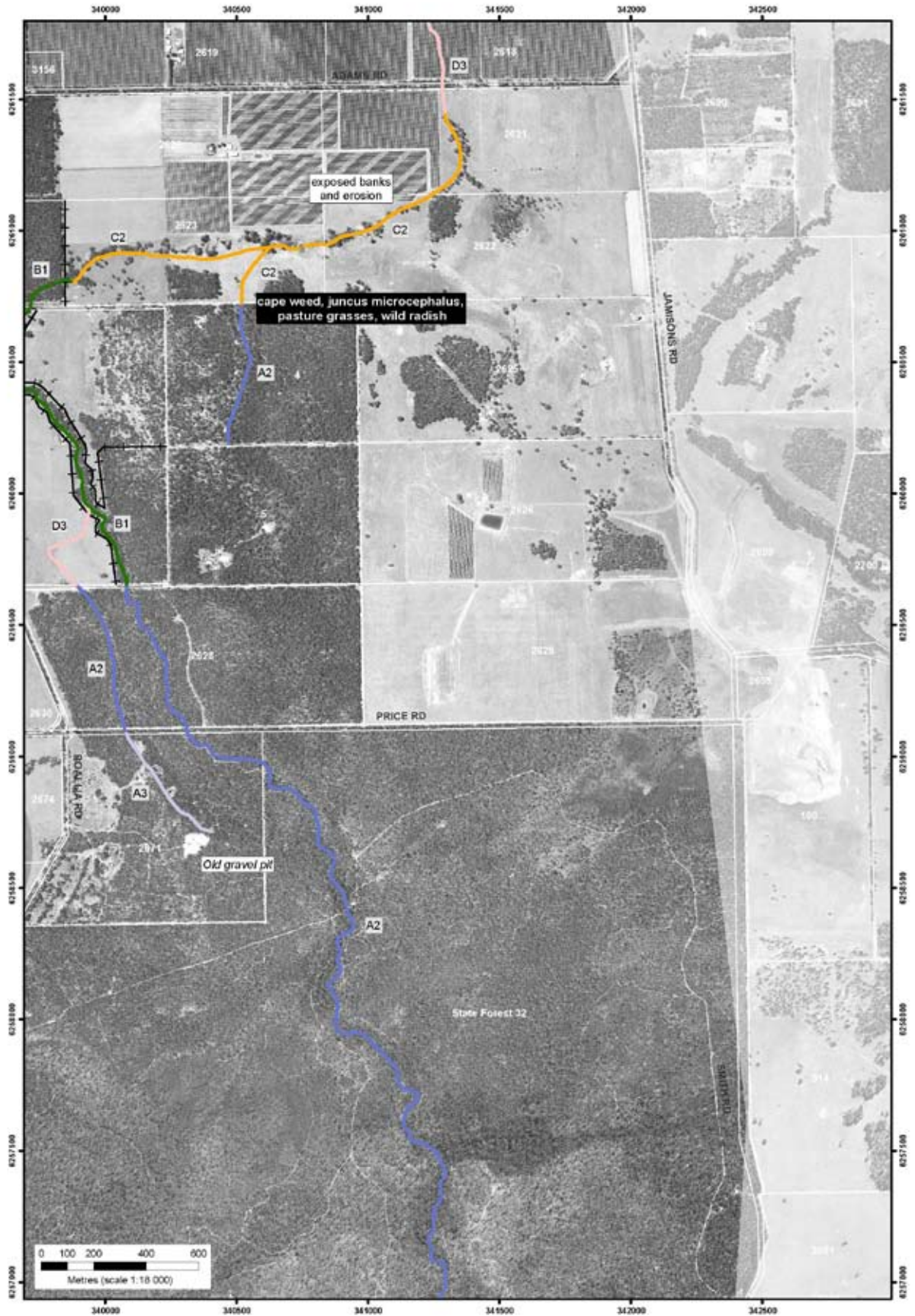


Figure 25 Map 11 – state forest and beginnings of agricultural land in upper catchment



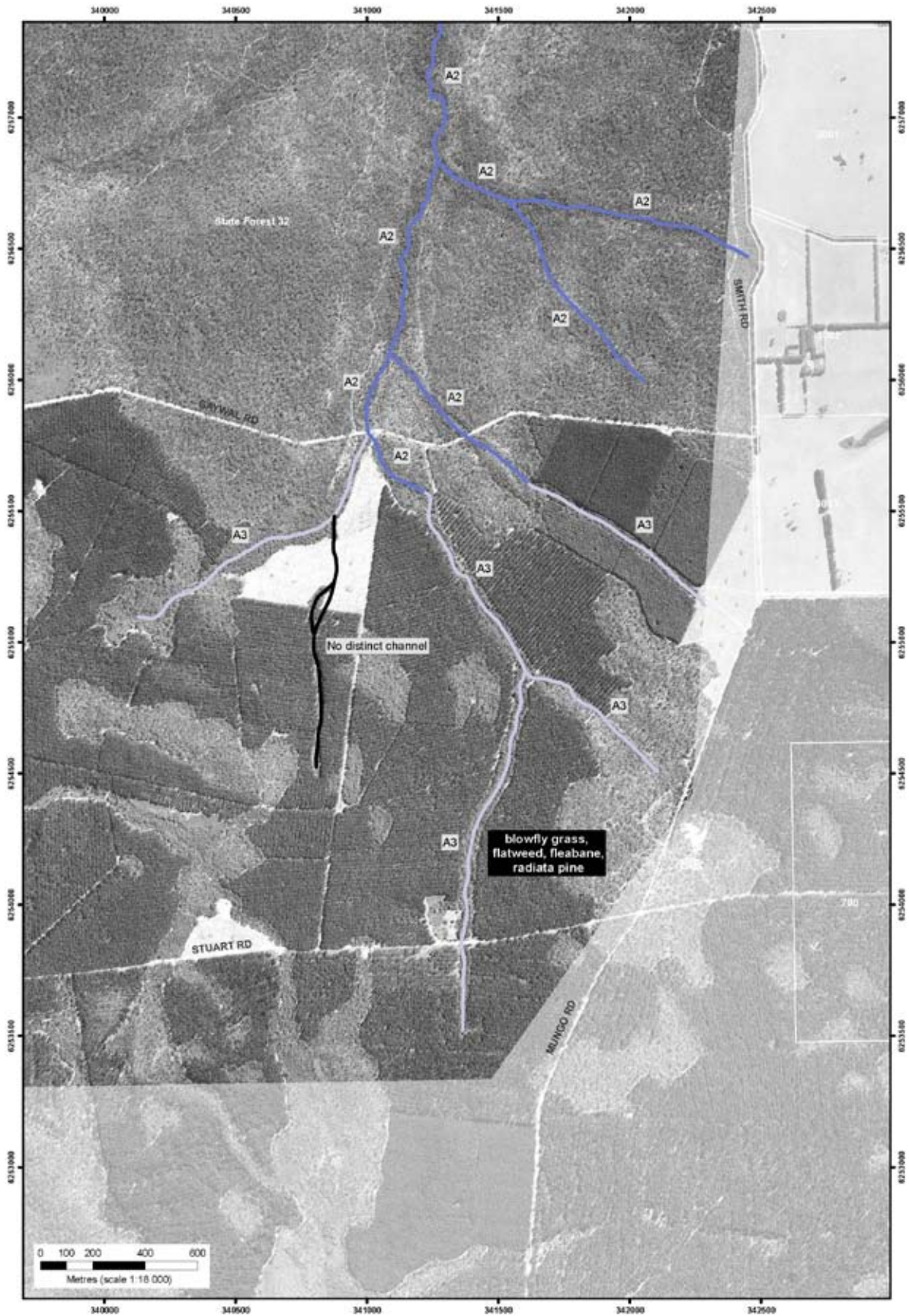
## 6.12 Map 12 Eastern headwaters of the Buayanyup River

<b>Land use</b>	State forest 32 is managed for conservation and timber reserve managed by the Department of Environment and Conservation.			
<b>Landform and soils</b>	The landform is a gently undulating plateau characterised by extensive block laterite and lateritic (ironstone) gravels. Chief soils on slopes and undulating areas generally are hard acidic yellow mottled soils containing small to very large amounts of ironstone gravels.			
<b>Native vegetation</b>	<b>Vegetation complex</b>	<b>% remaining</b>	<b>% protected in formal and informal reserves</b>	<b>Recommended action</b>
(Appendix 1 for descriptions of vegetation complexes)	Treeton (Tw)	35	9	Retain at least 30% of this vegetation complex
	Preston (PR)	54	21	Retain at least 30% of this vegetation complex (EPA 2006).
<b>Weeds</b>	Blowfly Grass, budding club-rush, capeweed, common sowthistle, fescue, fleabane, freesia, <i>genista monspessulana</i> , guildford grass, <i>juncus microcephalus</i> , myrtleleaf milkwort, narrowleaf lupin, narrowleaf trefoil, radiata pine, shivery grass, smooth catsear, sticky bartsia, sweet vernal grass, wild gladiolus, wimmera ryegrass, yellow serradella, yorkshire fog			

### Management recommendations and advice

As this area forms the headwaters of the waterway and is well vegetated, the flow velocity is low and therefore erosion is minimal. Although a buffer of approximately 20 m either side of the waterways were left when the pine plantations were planted, seed from the radiata pine trees has encroached into the riparian zones and both mid sized and sapling pines can be found along most waterways in the upper catchment close to the pine plantations. It is recommended that these be removed.

There is also an abundance of declared rare flora in the forest in the upper catchment along with an extensive list of birds and mammals (see Appendix 4). Areas of state forest such as that found in the upper Buayanyup catchment represent refuges for native fauna and should be protected. It is recommended that the Department of Environment and Conservation review its fire management practices to ensure minimal clearing is conducted for fire management, unused gravel pits are revegetated and burns are conducted during times that have minimal impact on the native flora and fauna.



**Figure 26** Map 12 – headwaters of main channel of the Buayanyup River in state forest.

## 7 Appendices

### Appendix 1 Vegetation complexes found along waterways in the Buayanyup catchment

The following vegetation complex descriptions were developed by Mattiske and Havel (1998) and Heddle, Loneragan and Havel (1980) and provide a brief explanation of the variety of vegetation complexes found within the Buayanyup catchment.

Vegetation complex	% remaining	Description
Abba (AB)	6	Woodland and open forest of marri ( <i>Corymbia calophylla</i> ) on flats and low rises in the humid zone.
Abba (Ad)	6	Woodland of marri ( <i>Corymbia calophylla</i> ), peppermint ( <i>Agonis flexuosa</i> ), sheoak ( <i>Allocasuarina fraseriana</i> ) and Christmas tree ( <i>Nuytsia floribunda</i> ) on mild slopes in the humid zone.
Abba (AF)	6	Woodland of marri ( <i>Corymbia calophylla</i> ), peppermint ( <i>Agonis flexuosa</i> ) and tall shrubland of Myrtaceae and Proteaceae species on terraces and valley floors in the humid zone.
Abba (Af)	6	Open forest of marri ( <i>Corymbia calophylla</i> ), peppermint ( <i>Agonis flexuosa</i> ), and golden wreath wattle ( <i>Acacia saligna</i> ) on lower slopes in the humid zone.
Abba (Aw)	6	Mosaic of tall shrubland of mohan ( <i>Melaleuca viminea</i> ) and woodland of flooded gum ( <i>Eucalyptus rudis</i> ), swamp paperbark ( <i>Melaleuca raphiophylla</i> ) with occasional marri ( <i>Corymbia calophylla</i> ) on broad depressions.
Ludlow (Lw)	Not determined	Open woodland of swamp paperbark ( <i>Melaleuca raphiophylla</i> ) and sedgelands of Cyperaceae and Restionaceae species on broad depressions in the subhumid zone.
Preston (PR)	35	Woodland of flooded gum ( <i>Eucalyptus rudis</i> ), peppermint ( <i>Agonis flexuosa</i> ), river banksia ( <i>Banksia seminuda</i> ) along waterways, open forest of marri ( <i>Corymbia calophylla</i> ), blackbutt ( <i>Eucalyptus patens</i> ) on slopes in the humid zone.
Quindalup (Qd)	Not determined	Coastal dune complex consisting mainly of two alliances, the strand and foredune alliance and the mobile and stable dune alliance.
Quindalup (Qw)	44	Tall shrubland of golden wreath wattle ( <i>Acacia saligna</i> ), peppermint ( <i>Agonis flexuosa</i> ) and open heath on depressions amongst recent dunes in the subhumid zone.
Quindalup (Qwy)	Not determined	Mixture of closed scrub of Melaleuca species and fringing woodland of flooded gum ( <i>Eucalyptus rudis</i> ).
Treeton (Tw)	35	Open forest of blackbutt ( <i>Eucalyptus patens</i> ), marri ( <i>Corymbia calophylla</i> ) and jarrah ( <i>Eucalyptus marginata</i> ) on lower slopes and on floors of minor valleys in the prehumid zone.
Yelverton (Y)	38	Woodland of jarrah ( <i>Eucalyptus marginata</i> ), marri ( <i>Corymbia calophylla</i> ), sheoak ( <i>Allocasuarina fraseriana</i> ), peppermint ( <i>Agonis flexuosa</i> ) and open woodland of marri ( <i>Corymbia calophylla</i> ) on low undulating uplands in the humid zone.

Vegetation complex	% remaining	Description
Yelverton (Yd)	57	Woodland of sheoak ( <i>Allocasuarina fraseriana</i> ), jarrah ( <i>Eucalyptus marginata</i> ), woody pear ( <i>Xylomelum occidentale</i> ), slender banksia ( <i>Banksia attenuata</i> ) on sandy slopes in the humid zone.
Yelverton (Yw)	26	Woodland of sheoak ( <i>Allocasuarina fraseriana</i> ), Christmas tree ( <i>Nuytsia floribunda</i> ), peppermint ( <i>Agonis flexuosa</i> ) slender banksia ( <i>Banksia attenuata</i> ) on slopes and open forest of marri ( <i>Corymbia calophylla</i> ), blackbutt ( <i>Eucalyptus patens</i> ), jarrah ( <i>Eucalyptus marginata</i> ) on the lower slopes and woodland of flooded gum ( <i>Eucalyptus rudis</i> ), swamp paperbark ( <i>Melaleuca raphiophylla</i> ) on valley floors in the humid zone.

## Appendix 2 List of local native plant species to aid in revegetation

This table provides a list of the native plants identified on the foreshore of the Buayanyup River during the foreshore assessments. The middle column indicates whether the species is available from local plant nurseries. For assistance in developing a species list for your rehabilitation project, please contact GeoCatch.

Species name	Common name	Form	In nurseries	Landform			
				Quindalup Dune	Spearwood/ Pinjarra Plain	Pinjarra Plain/Abba	Whicher Scarp/ Treeton Hills
				Map 6 (river mouth to Caves Rd)	Map 6 (Caves Rd to Florence Rd)	Maps 3, 7, 8, 9	Maps 1, 2, 4, 5, 9, 10, 11, 12
<i>Acacia applanata</i>		Shrub				✓	
<i>Acacia browniana</i>		Shrub	✓				✓
<i>Acacia cochlearis</i>	Rigid wattle	Shrub	✓	✓	✓		
<i>Acacia divergens</i>		Shrub	✓				✓
<i>Acacia extensa</i>	Wiry wattle	Shrub	✓			✓	✓
<i>Acacia flagelliformis (P4)</i>		Shrub					✓
<i>Acacia gilbertii</i>		Shrub	✓				✓
<i>Acacia littorea</i>	Shark tooth wattle	Shrub	✓	✓			
<i>Acacia mooreana</i>		Shrub				✓	✓
<i>Acacia myrtifolia</i>	Myrtle wattle	Shrub	✓			✓	✓
<i>Acacia pulchella</i>	Prickly Moses	Shrub	✓		✓	✓	✓
<i>Acacia saligna</i>	Orange wattle	Shrub	✓	✓	✓	✓	
<i>Acanthocarpus preissii</i>		Herb		✓			
<i>Adenanthos barbiger</i>		Shrub					✓
<i>Adenanthos meisneri</i>		Shrub	✓				✓
<i>Adenanthos obovatus</i>	Basket flower	Shrub	✓				✓
<i>Adriana quadripartite</i>	Bitter bush	Shrub		✓			
<i>Agonis flexuosa</i>	Peppermint	Tree	✓	✓	✓	✓	



Species name	Common name	Form	In nurseries	Landform			
				Quindalup Dune	Spearwood/Pinjarra Plain	Pinjarra Plain/Abba	Whicher Scarp/Treeton Hills
				Map 6 (river mouth to Caves Rd)	Map 6 (Caves Rd to Florence Rd)	Maps 3, 7, 8, 9	Maps 1, 2, 4, 5, 9, 10, 11, 12
<i>Allocasuarina fraseriana</i>	Sheoak	Tree	✓				✓
<i>Amperea simulans</i>		Herb					✓
<i>Amphipogon laguroides</i>		Herb					✓
<i>Anarthria prolifera</i>		Herb					✓
<i>Anarthria scabra</i>		Herb					✓
<i>Andersonia ferricola (P1)</i>		Shrub					✓
<i>Andersonia involucrate</i>		Shrub					✓
<i>Anigozanthos flavidus</i>	Tall kangaroo paw	Herb	✓			✓	✓
<i>Anigozanthos humilis</i>	Catspaw	Herb				✓	
<i>Aphelia cyperoides</i>		Herb					✓
<i>Astartea fascicularis</i>		Shrub	✓				✓
<i>Astroloma ciliatum</i>	Candle cranberry	Ground cover					✓
<i>Astroloma pallidum</i>	Kick bush	Shrub				✓	
<i>Austrodanthonia sp.</i>		Herb					✓
<i>Austrostipa compressa</i>		Herb					✓
<i>Banksia grandis</i>	Bull banksia	Tree	✓				✓
<i>Banksia nivea subsp. Uliginosa (R)</i>		Shrub					✓
<i>Banksia squarrosa subsp. Argillacea (R)</i>		Shrub					✓

Species name	Common name	Form	In nurseries	Landform			
				Quindalup Dune	Spearwood/ Pinjarra Plain	Pinjarra Plain/Abba	Whicher Scarp/ Treeton Hills
				Map 6 (river mouth to Caves Rd)	Map 6 (Caves Rd to Florence Rd)	Maps 3, 7, 8, 9	Maps 1, 2, 4, 5, 9, 10, 11, 12
<i>Baumea preissii</i> subsp. <i>laxa</i> MS		Sedge	✓				✓
<i>Baumea rubiginosa</i>		Sedge	✓				✓
<i>Baumea vaginalis</i>	Sheath twigrush	Sedge	✓			✓	✓
<i>Bacteria australis</i>		Herb					✓
<i>Beaufortia sparsa</i>	Swamp bottlebrush	Shrub	✓				✓
<i>Billardiera floribunda</i>	White-flowered Billardiera	Shrub/ climber					✓
<i>Billardiera variifolia</i>		Shrub/ climber					✓
<i>Boronia crenulata</i>	Aniseed boronia	Shrub					✓
<i>Boronia dichotoma</i>		Herb or shrub					✓
<i>Borya scirpoidea</i>		Herb					✓
<i>Bossiaea eriocarpa</i>	Common brown pea	Shrub	✓			✓	
<i>Bossiaea linophylla</i>	Golden cascade	Shrub	✓		✓		
<i>Bossiaea ornata</i>	Broad leaved brown pea	Shrub	✓			✓	✓
<i>Burchardia multiflora</i>	Dwarf Burchardia	Herb					✓
<i>Caladenia brownii</i>		Herb (orchid)					✓
<i>Caladenia flava</i>	Cowslip orchid	Herb					✓
<i>Callistachys lanceolata</i>	Wonnich	Tall shrub	✓			✓	✓
<i>Calothamnus sanguineus</i>	Silky-leaved Blood flower	Shrub	✓				✓

Species name	Common name	Form	In nurseries	Landform			
				Quindalup Dune	Spearwood/ Pinjarra Plain	Pinjarra Plain/Abba	Whicher Scarp/ Treeton Hills
				Map 6 (river mouth to Caves Rd)	Map 6 (Caves Rd to Florence Rd)	Maps 3, 7, 8, 9	Maps 1, 2, 4, 5, 9, 10, 11, 12
<i>Calothamnus</i> sp. Whicher (BJ Keighery and N Gibson 230) (P4)		Shrub				✓	
<i>Calothamnus</i> sp. Scott River (R.D.Royce 84) (P2)		Shrub					✓
<i>Carex inverse</i>	Knob sedge	Sedge					✓
<i>Cassytha glabella</i>	Tangled dodder laurel	Herb climber					✓
<i>Centrolepis aristata</i>	Pointed centrolepis	Herb					✓
<i>Centrolepis drummondiana</i>		Herb					✓
<i>Chamaescilla corymbose</i>	Blue squill	Herb				✓	✓
<i>Chamaescilla versicolor</i>		Herb					✓
<i>Chorizema carinatum</i> (P3)		Shrub					✓
<i>Chorizema cordatum</i>		Climbing Shrub	✓			✓	
<i>Chorizema glycinifolium</i>		Shrub					✓
<i>Comesperma virgatum</i>	Milkwort	Shrub					✓
<i>Conospermum paniculatum</i> (P3)		Shrub				✓	✓
<i>Conostylis aculeata</i>	Prickly conostylis	Herb	✓		✓		✓
<i>Conostylis setigera</i>	Bristly cottonhead	Herb				✓	✓
<i>Corymbia calophylla</i>	Marri	Tree	✓			✓	✓

Species name	Common name	Form	In nurseries	Landform			
				Quindalup Dune	Spearwood/ Pinjarra Plain	Pinjarra Plain/Abba	Whicher Scarp/ Treeton Hills
				Map 6 (river mouth to Caves Rd)	Map 6 (Caves Rd to Florence Rd)	Maps 3, 7, 8, 9	Maps 1, 2, 4, 5, 9, 10, 11, 12
<i>Corymbia haematoxylin</i>	Mountain marri	Tree	✓				✓
<i>Cryptandra arbutiflora</i>	Waxy cryptandra	Shrub			✓		
<i>Cyathochaeta avenacea</i>		Sedge					✓
<i>Cyathochaeta clandestina</i> subsp. <i>Carbunup</i>		Sedge					✓
<i>Cyathochaeta teretifolia</i> (P3)		Sedge					✓
<i>Dampiera alata</i>	Winged-stem Dampiera	Herb			✓		
<i>Dampiera hederacea</i>	Karri Dampiera	Herb					✓
<i>Dampiera linearis</i>	Common Dampiera	Herb				✓	✓
<i>Darwinia citriodora</i>	Lemon-scented Darwinia	Shrub	✓			✓	
<i>Dasypogon bromeliifolius</i>	Pineapple bush	Herb					✓
<i>Daviesia cordata</i>	Bookleaf	Shrub	✓			✓	
<i>Daviesia elongata</i> subsp. <i>Elongata</i> (R)		Shrub					✓
<i>Daviesia inflata</i>		Shrub				✓	
<i>Daviesia physodes</i>		Shrub				✓	
<i>Daviesia preissii</i>		Shrub				✓	✓
<i>Desmocladius fasciculatus</i>		Herb					✓
<i>Diuris corymbosa</i>	Donkey orchid	Herb (Orchid)				✓	
<i>Drosera gigantea</i> subsp. <i>gigantea</i>	Giant sundew	Herb					✓

Species name	Common name	Form	In nurseries	Landform			
				Quindalup Dune	Spearwood/ Pinjarra Plain	Pinjarra Plain/Abba	Whicher Scarp/ Treeton Hills
				Map 6 (river mouth to Caves Rd)	Map 6 (Caves Rd to Florence Rd)	Maps 3, 7, 8, 9	Maps 1, 2, 4, 5, 9, 10, 11, 12
<i>Drosera glanduligera</i>	Pimpernel sundew	Herb					✓
<i>Drosera macrantha</i>	Bridal rainbow	Herb/ climber		✓	✓	✓	✓
<i>Drosera neesii</i> (Pink flowered sthn form)(BJ Keighery & N Gibson 96)		Herb					✓
<i>Drosera pulchella</i>	Pretty sundew	Herb					✓
<i>Banksia dallanneyi</i>	Couch honeypot	Shrub					✓
<i>Empodisma gracillimum</i>		Herb					✓
<i>Epilobium billardioreanum</i>	Smooth willow herb	Herb					✓
<i>Eucalyptus marginata</i>	Jarrah	Tree	✓			✓	✓
<i>Eucalyptus megacarpa</i>	Bullich	Tree	✓				✓
<i>Eucalyptus patens</i>	Swan River blackbutt	Tree	✓				✓
<i>Eutaxia virgata</i>		Shrub				✓	
<i>Exocarpos odoratus</i>	Scented ballart	Shrub		✓			
<i>Gahnia decomposita</i>		Sedge					✓
<i>Gahnia trifida</i>	Coast saw-rush/sedge	Sedge	✓	✓			
<i>Gompholobium confertum</i>		Shrub	✓				✓
<i>Gompholobium cyaninum</i> MS		Shrub					✓
<i>Gompholobium knightianum</i>		Shrub				✓	✓



Species name	Common name	Form	In nurseries	Landform			
				Quindalup Dune	Spearwood/ Pinjarra Plain	Pinjarra Plain/Abba	Whicher Scarp/ Treeton Hills
				Map 6 (river mouth to Caves Rd)	Map 6 (Caves Rd to Florence Rd)	Maps 3, 7, 8, 9	Maps 1, 2, 4, 5, 9, 10, 11, 12
<i>Gompholobium tomentosum</i>	Hairy yellow pea	Shrub					✓
<i>Gonocarpus diffusus</i>		Herb					✓
<i>Goodenia eatoniana</i>		Shrub					
<i>Gratiola pubescens</i>		Herb					✓
<i>Grevillea brachystylis</i> subsp. <i>Brachystylis</i> (P3)		Shrub					✓
<i>Grevillea brachystylis</i> subsp. <i>Busselton</i> (R)		Shrub				✓	
<i>Grevillea diversifolia</i>	Variable-leaved grevillea	Shrub	✓				✓
<i>Grevillea manglesioides</i>		Shrub		✓	✓		✓
<i>Grevillea manglesioides</i> subsp. <i>manglesioides</i>		Shrub					✓
<i>Grevillea quercifolia</i>	Oak-leaf grevillea	Shrub					✓
<i>Grevillea trifida</i>		Shrub					✓
<i>Hakea amplexicaulis</i>	Prickly hakea	Shrub	✓			✓	✓
<i>Hakea ceratophylla</i>	Horned leaf hakea	Shrub	✓				✓
<i>Hakea cyclocarpa</i>	Ramshorn	Shrub	✓				✓
<i>Hakea lasianthoides</i>		Shrub	✓				✓
<i>Hakea linearis</i>		Shrub or tree	✓				✓

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				Map 6 (river mouth to Caves Rd)	Map 6 (Caves Rd to Florence Rd)	Maps 3, 7, 8, 9	Maps 1, 2, 4, 5, 9, 10, 11, 12
<i>Hakea lissocarpha</i>	Honey bush	Shrub	✓			✓	✓
<i>Hakea oldfieldii</i> (P3)		Shrub	✓				✓
<i>Hakea rusCIFolia</i>	Candle hakea	Shrub	✓				✓
<i>Hardenbergia comptoniana</i>	Native wisteria	Climber	✓		✓	✓	✓
<i>Hemiandra pungens</i>	Snakebush	Shrub	✓				✓
<i>Hibbertia cuneiformis</i>	Cutleaf hibbertia	Shrub	✓	✓			
<i>Hibbertia cunninghamii</i>		Shrub			✓	✓	✓
<i>Hibbertia glomerata</i>		Shrub					✓
<i>Hibbertia hypericoides</i>	Yellow buttercups	Shrub				✓	✓
<i>Hibbertia diamesogenos</i>		Shrub					✓
<i>Hibbertia sp.</i>		Shrub					✓
<i>Homalospermum firmum</i>		Shrub or tree					✓
<i>Hovea chorizemifolia</i>	Holly-leaved hovea	Shrub					✓
<i>Hovea elliptica</i>	Tree hovea	Shrub or tree	✓			✓	✓
<i>Hovea trisperma</i>	Common hovea	Shrub				✓	✓
<i>Hypocalymma angustifolium</i>	White myrtle	Shrub	✓				✓
<i>Hypocalymma cordifolium</i>		Shrub	✓				✓
<i>Hypocalymma robustum</i>	Swan River myrtle	Shrub					✓
<i>Hypolaena exsulca</i>		Herb					✓

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				Map 6 (river mouth to Caves Rd)	Map 6 (Caves Rd to Florence Rd)	Maps 3, 7, 8, 9	Maps 1, 2, 4, 5, 9, 10, 11, 12
<i>Isopogon formosus subsp. Dasylepis (P3)</i>		Shrub					✓
<i>Isopogon sphaerocephalus</i>	Drumstick isopogon	Shrub					✓
<i>Jacksonia furcellata</i>	Grey stinkwood	Shrub	✓		✓		
<i>Johnsonia lupulina</i>	Hooded lily	Herb					✓
<i>Juncus pallidus</i>	Pale rush	Rush	✓			✓	✓
<i>Juncus subsecundus</i>	Finger rush	Rush	✓		✓		✓
<i>Kennedia coccinea</i>	Coral vine	Shrub or climber	✓				✓
<i>Kennedia prostrata</i>	Scarlet runner	Shrub	✓		✓		✓
<i>Kingia australis</i>	Kingia	Tree like monocot				✓	✓
<i>Kunzea micrantha</i>		Shrub					✓
<i>Kunzea rostrata</i>		Shrub	✓				✓
<i>Lagenophora huegelii</i>		Herb					✓
<i>Lambertia rariflora (P4)</i>	Green honeysuckle	Small tree or shrub					✓
<i>Lasiopetalum floribundum</i>	Free flowering lasiopetalum	Shrub					✓
<i>Lechenaultia biloba</i>	Blue leschenaultia	Shrub	✓				✓
<i>Lepidosperma effusum</i>	Spreading sword-rush/ sedge	Sedge	✓				✓
<i>Lepidosperma squamatum</i>		Sedge			✓	✓	

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				Quindalup Dune	Spearwood/ Pinjarra Plain	Pinjarra Plain/Abba	Whicher Scarp/ Treeton Hills
				Map 6 (river mouth to Caves Rd)	Map 6 (Caves Rd to Florence Rd)	Maps 3, 7, 8, 9	Maps 1, 2, 4, 5, 9, 10, 11, 12
<i>Lepidosperma tenue</i>		Sedge				✓	✓
<i>Lepidosperma tetraquetrum</i>		Sedge	✓				✓
<i>Leptocarpus tenax</i>	Slender twine rush	Herb	✓				✓
<i>Leptomeria squarrulosa</i>		Shrub					✓
<i>Lepyrodia drummondiana</i>		Herb					✓
<i>Lepyrodia glauca</i>		Herb					✓
<i>Leucopogon australis</i>	Spiked beard-heath	Shrub					✓
<i>Leucopogon capitellatus</i>		Shrub				✓	
<i>Leucopogon parviflorus</i>	Coast Beard-heath	Shrub or tree		✓			
<i>Leucopogon propinquus</i>		Shrub			✓		
<i>Levenhookia pusilla</i>		Herb					✓
<i>Lindsaea linearis</i>	Screw fern	Herb					✓
<i>Lobelia anceps</i>	Angled lobelia	Herb	✓				✓
<i>Logania serpyllifolia</i>		Herb or shrub					✓
<i>Lomandra integra</i>		Herb					✓
<i>Lomandra nigricans</i>		Herb					✓
<i>Lomandra pauciflora</i>		Herb				✓	✓
<i>Lomandra purpurea</i>	Purple mat rush	Herb				✓	
<i>Lomandra sericea</i>	Silky mat rush	Herb					✓
<i>Lomandra sonderi</i>		Herb					✓

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				Quindalup Dune	Spearwood/ Pinjarra Plain	Pinjarra Plain/Abba	Whicher Scarp/ Treeton Hills
				Map 6 (river mouth to Caves Rd)	Map 6 (Caves Rd to Florence Rd)	Maps 3, 7, 8, 9	Maps 1, 2, 4, 5, 9, 10, 11, 12
<i>Loxocarya cinerea</i>		Herb				✓	✓
<i>Loxocarya magna (P3)</i>		Herb					✓
<i>Macrozamia riedlei</i>	Zamia	Tree			✓		
<i>Marianthus tenuis</i>		Twining Shrub					✓
<i>Meeboldina scariosa</i>	Velvet rush	Herb	✓				✓
<i>Melaleuca incana</i>	Grey honeymyrtle	Tree or shrub	✓			✓	
<i>Melaleuca preissiana</i>	Moonah	Tree or shrub	✓			✓	✓
<i>Melaleuca raphiophylla</i>	Swamp paperbark	Tree or shrub	✓	✓	✓		
<i>Melaleuca viminea</i>	Mohan	Tree or shrub	✓	✓			
<i>Mesomelaena graciliceps</i>		Tree or shrub					✓
<i>Mesomelaena tetragona</i>	Semaphore rush/sedge	Sedge				✓	✓
<i>Microlaena stipoides</i>	Weeping grass	Herb					✓
<i>Microtis atrata</i>	Swamp mignonette orchid	Herb					✓
<i>Mirbelia dilatata</i>	Holly-leaved mirbelia	Shrub	✓			✓	✓
<i>Neurachne alopecuroidea</i>	Foxtail mulga grass	Herb	✓				✓
<i>Olax benthamiana</i>		Shrub					✓
<i>Olearia axillaris</i>	Coastal daisybush	Shrub	✓	✓			
<i>Opercularia apiciflora</i>		Herb or shrub					✓



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				Map 6 (river mouth to Caves Rd)	Map 6 (Caves Rd to Florence Rd)	Maps 3, 7, 8, 9	Maps 1, 2, 4, 5, 9, 10, 11, 12
<i>Opercularia hispidula</i>	Hispid stinkweed	Herb					✓
<i>Opercularia vaginata</i> (Ironstone form)		Herb or shrub					✓
<i>Patersonia occidentalis</i>	Purple flag	Herb	✓				✓
<i>Patersonia umbrosa</i>	Yellow flags	Herb	✓			✓	✓
<i>Pentapeltis peltigera</i>		Herb					✓
<i>Pericalymma ellipticum</i>	Swamp tea tree	Shrub	✓				✓
<i>Persoonia elliptica</i>	Spreading snottygobble	Shrub or tree					✓
<i>Persoonia longifolia</i>	Snottygobble	Shrub or tree				✓	✓
<i>Petrophile diversifolia</i>		Shrub					✓
<i>Petrophile linearis</i>	Pixie mops	Shrub				✓	
<i>Petrophile squamata</i>		Shrub					✓
<i>Petrophile squamata</i> R.Br. subsp. <i>squamata</i>		Shrub					✓
<i>Philotheca spicata</i>	Pepper and salt	Shrub				✓	
<i>Philydrella pygmaea</i> subsp. <i>pygmaea</i>	Butterfly flowers	Herb					✓
<i>Phyllangium paradoxum</i>	Wiry mitrewort	Herb					✓
<i>Phyllanthus calycinus</i>	False boronia	Shrub	✓		✓		

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<i>Pimelea angustifolia</i>	Narrow-leaved pimelea	Shrub		✓			
<i>Pimelea argentea</i>	Silvery leaved pimelea	Shrub	✓				
<i>Pimelea imbricata</i> var. <i>imbricata</i>		Shrub				✓	
<i>Pimelea</i> sp.		Shrub			✓		
<i>Pimelea spectabilis</i>	Bunjong	Shrub				✓	
<i>Podocarpus drouynianus</i>	Wild plum	Tree or shrub				✓	
<i>Prasophyllum</i> sp.		Herb				✓	
<i>Pteridium esculentum</i>	Bracken	Herb			✓	✓	
<i>Pterostylis recurva</i>	Jug orchid	Herb (orchid)				✓	
<i>Pterostylis vittata</i>	Banded greenhood	Herb (orchid)			✓	✓	
<i>Pultenaea brachytropis</i> Benth		Shrub				✓	
<i>Pyrorchis nigricans</i>	Red beaks	Herb (orchid)				✓	
<i>Scaevola calliptera</i>		Herb				✓	
<i>Schoenus bifidus</i>		Sedge				✓	
<i>Schoenus efoliatus</i>		Sedge				✓	
<i>Schoenus odontocarpus</i>		Sedge				✓	
<i>Schoenus subflavus</i> subsp. <i>subflavus</i>	Yellow bog-rush	Sedge				✓	
<i>Selaginella gracillima</i>	Tiny clubmoss	Herb				✓	

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<i>Sowerbaea laxiflora</i>	Purple tassels	Herb		✓			
<i>Sporadanthus rivularis</i>		Herb					✓
<i>Spyridium globulosum</i>	basket bush	Shrub	✓	✓			
<i>Stenotalis ramosissima</i>		Sedge			✓		
<i>Stylidium barleei</i> (P3)	Tooth-leaved triggerplant	Herb					✓
<i>Stylidium bulbiferum</i>		Herb					✓
<i>Stylidium calcaratum</i>	Book triggerplant	Herb					✓
<i>Stylidium crassifolium</i>	Thick-leaved triggerplant	Herb					✓
<i>Synaphea gracillima</i>		Shrub					✓
<i>Synaphea petiolaris</i>	Synaphea	Shrub			✓		✓
<i>Synaphea petiolaris subsp. Simplex</i> (P2)		Shrub			✓		
<i>Taxandria fragrans</i> MS		Shrub	✓				✓
<i>Taxandria linearifolia</i>	Swamp peppermint	Small tree or shrub	✓				✓
<i>Taxandria linearifolia</i> MS		Small tree or shrub	✓			✓	
<i>Taxandria parviceps</i> MS		Shrub	✓				✓
<i>Tetrraria capillaris</i>	Hair rush/ sedge	Sedge			✓		✓
<i>Tetrraria octandra</i>		Sedge			✓		✓
<i>Tetrarrhena laevis</i>	Forrest ricegrass	Herb					✓

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				Map 6 (river mouth to Caves Rd)	Map 6 (Caves Rd to Florence Rd)	Maps 3, 7, 8, 9	Maps 1, 2, 4, 5, 9, 10, 11, 12
<i>Tetratheca hispidissima</i>		Shrub			✓		
<i>Thelymitra antennifera</i>	Lemon-scented sun orchid	Herb (orchid)				✓	
<i>Thomasia grandiflora</i>	Large flowered thomasia	Shrub				✓	
<i>Thomasia laxiflora (P3)</i>		Shrub				✓	
<i>Thomasia pauciflora</i>	Few flowered thomasia	Shrub				✓	
<i>Thysanotus sp.</i>		Herb		✓		✓	
<i>Thysanotus thyrsoideus</i>		Herb				✓	
<i>Trichocline sp. Treeton (P2)</i>		Herb				✓	
<i>Trichocline spathulata</i>	Native gerbera	Herb				✓	
<i>Tricoryne elatior</i>	Yellow autumn lily	Herb				✓	
<i>Trymalium odoratissimum</i>		Shrub	✓			✓	
<i>Trymalium ledifolium</i>		Shrub		✓	✓	✓	
<i>Utricularia multifida</i>	Pink petticoats	Herb				✓	
<i>Velleia trinervis</i>		Herb				✓	
<i>Verticordia plumosa var. ananeotes (R)</i>		Shrub				✓	
<i>Verticordia plumosa var. plumosa</i>		Shrub				✓	
<i>Viminaria juncea</i>		Shrub	✓			✓	
<i>Xanthorrhoea gracilis</i>		Tree like monocot			✓	✓	

Species name	Common name	Form	In nurseries	Landform			
				Quindalup Dune	Spearwood/Pinjarra Plain	Pinjarra Plain/Abba	Whicher Scarp/Treeton Hills
				Map 6 (river mouth to Caves Rd)	Map 6 (Caves Rd to Florence Rd)	Maps 3, 7, 8, 9	Maps 1, 2, 4, 5, 9, 10, 11, 12
<i>Xanthorrhoea preissii</i>		Tree like monocot	✓			✓	✓
<i>Xanthosia candida</i>		Herb					✓
<i>Xanthosia huegelii</i>		Herb				✓	
<i>Xylomelum occidentale</i>		Tree or shrub	✓			✓	✓
<i>Xyris laxiflora</i>		Herb					✓

### Key:

**R: Declared rare flora** – extant: taxa which have been adequately searched for, and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such, following approval by the Minister for the Environment, after recommendation by the state's Endangered Flora Consultative Committee. (= threatened flora = endangered + vulnerable).

**P1: Priority 1** – poorly known: taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, e.g. road verges, urban areas, farmland, active mineral leases, etc., or the plants are under threat, e.g. from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

**P2: Priority 2** – poorly known: taxa which are known from one or a few (generally less than 5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

**P3: Priority 3** – poorly known: taxa which are known from several populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in need of further survey.

**P4: Priority 4** – rare: taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5–10 years (Gibson et al. 1994).



## Appendix 3 Common weed species of the Buayanyup River catchment

This table provides a list of the weeds found on the foreshore of the Buayanyup River. Ideally, these should be replaced with local native plant species such as those presented in Appendix 2. Some of the species presented below are highly invasive and will require a number of years of follow-up control to achieve eradication.

Species name	Common name	Status
<i>Acacia mearnsii</i>	Black wattle	
<i>Anthoxanthum odoratum</i>	Sweet vernal grass	
<i>Arctotheca calendula</i>	Capeweed	
<i>Asparagus asparagoides</i>	Bridal creeper	P1
<i>Brassicaceae Sp.</i>	Wild radish	
<i>Briza maxima</i>	Blowfly grass	
<i>Briza minor</i>	Shivery grass	
<i>Carduus sp.</i>	Thistle	
<i>Chasmanthe floribunda</i>	African cornflag	
<i>Conyza sumatrensis</i>	Fleabane	
<i>Cynodon dactylon</i>	Couch grass	
<i>Ehrharta calycina</i>	Perennial veldt grass	
<i>Eragrostis curvula</i>	African lovegrass	
<i>Eucalyptus sp.</i>	Non-local Eucalypts	
<i>Ficus carica</i>	Fig	
<i>Freesia alba x leichtlinii</i>	Fresia	
<i>Genista linifolia</i>	Flaxleaf broom	
<i>Genista monspessulana</i>	Genista	
<i>Gladiolus undulatus</i>	Wild gladiolus	
<i>Holcus lanatus</i>	Yorkshire fog	
<i>Hypochaeris glabra</i>	Smooth catsear	
<i>Hypochaeris sp.</i>	Flatweed	
<i>Isolepis prolifera</i>	Budding club-rush	
<i>Juncus microcephalus</i>	Juncus microcephalus	
<i>Lolium rigidum</i>	Wimmera ryegrass	
<i>Lotus angustissimus</i>	Narrowleaf trefoil	
<i>Lupinus angustifolius</i>	Narrowleaf lupin	
<i>Lupinus sp.</i>	Lupins	
<i>Mentha pulegium</i>	Pennyroyal	
<i>Moraea sp.</i>	Cape tulip	P1, P4
<i>Ornithopus compressus</i>	Yellow serradella	

Species name	Common name	Status
<i>Orobanche ramosa</i>	Broomrape	P1, P2
<i>Oxalis corniculata</i>	Soursob	
<i>Oxalis purpurea</i>	Largeflower wood sorrel	
<i>Parentucellia viscosa</i>	Sticky bartsia	
<i>Paspalum dilatatum</i>	Paspalum dilatatum	
<i>Pelargonium capitatum</i>	Rose pelargonium	
<i>Pennisetum clandestinum</i>	Kikuyu	
<i>Pinus radiata</i>	Radiata pine	
<i>Polygala myrtifolia</i>	Myrtleleaf milkwort	
<i>Quercus sp.</i>	Oak tree	
<i>Romulea rosea</i>	Guildford grass	
<i>Rubus sp.</i>	Blackberry	P1, P4
<i>Rumex crispus</i>	Curled dock	
<i>Rumex pulcher</i>	Fiddle dock	
<i>Salix sp.</i>	Weeping willow	
<i>Sonchus oleraceus</i>	Common sowthistle	
<i>Sparaxos sp.</i>	Harlequin flower	
<i>Trifolium sp.</i>	Clover	
<i>Typha orientalis</i>	Bulrush	
<i>Vicia sativa</i>	Common vetch	
<i>Vinca major</i>	Blue periwinkle	
<i>Vulpia sp.</i>	Fescue	
<i>Watsonia bilbillifera</i>	Watsonia	
<i>Zantedeschia aethiopica</i>	Arum Lilly	P1, P4

### Key:

**P1:** Movement prohibited – the movement of plants or their seeds is prohibited within the state. This prohibits the movement of contaminated machinery and produce including livestock and fodder.

**P2:** Treat all plants to destroy and prevent propagation each year until no plants remain. The infested area must be managed in such a way that prevents the spread of seed or plant parts on or in livestock, fodder, grain, vehicles and/or machinery.

**P3:** The infested area must be managed in such a way that prevents the spread of seed or plant parts within and from the property on or in livestock, fodder, grain, vehicles and/or machinery.

**P4:** The infested area must be managed in such a way that prevents the spread of seed or plant parts within and from the property on or in livestock, fodder, grain, vehicles and/or machinery.

**P5:** Infestations on public lands must be controlled (Agriculture Protection Board 2007).

Information on the priority weeds in the catchment is provided below. It is 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 for landholders in the South West and provides information on weed identification and control. It is available from Department of Agriculture and Food offices. Also useful for weed identification is *Western weeds* (Hussey et al. 1997).

### **Pennyroyal *Mentha pulegium***

Chemical control using glyphosate when actively growing is effective. Single plants can be removed mechanically if all rooting material is collected. Sulfonyl urea herbicides are the most effective followed by triclopyr, glyphosate and the hormone herbicides. Useful control in legume pastures can be achieved with an annual 'spray graze' using 2,4-D amine. Caution should be used when applying glyphosate near waterways. Spray only when water flows have receded or stopped.

In bushland areas spray each year with 10 g chlorsulfuron plus 250 mL Pulse per 100 L water when the plants are actively growing in summer before flowering.

### **Cape Tulip *Moraea sp.***

Manual control can be difficult due to the cormels at the plant's base. Recommend digging individual plants out, including the surrounding soil and incinerating or drenching with diesel. For larger areas, cultivation to 150 mm will control if done after the old corm shrivels and before the new corms form (June – September). Plants can be dug up to check the stage of their corms.

### **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 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 GeoCatch for more information and release locations.

The rust appears to be spreading well, and was found on most bridal creeper infestations. In many places where previously bridal creeper was extremely thick, the rust has 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 implement other control methods such as wiping individual stems with a 1:2 Glyphosate solution as they emerge.

**Arum lily *Zantedeschia aethiopica***

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 chlorsulfuron or metsulfuron as flowers start to wither is most effective. Little effect will be noticeable immediately, but 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* sp.**

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.

**Broomrape *Orobanche ramosa***

Eradication strategies suggest removing the host plants and spraying with low rates of glyphosate.

**Blue periwinkle *Vinca major***

Effective control can be achieved in early to late spring by first raking the vine to lift it off the ground, and mowing or cutting the vine then spraying the regrowth with glyphosate or dicamba. Several applications every three months are required. The last remnants will need to be removed manually or by spot spraying, as these will start a new infestation. Some control is achieved with hot fires and solarisation.

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

These have been grouped together as growth form and control methods are similar. 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 worse 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.

### **Edible fig *Ficus carica***

Hand pull seedlings, inject larger specimens with 50–100% glyphosate in summer. Can be treated with the cut and paint method, but all branches, twigs and fruit must be removed and burnt.

### **Myrtle-leaved milkwort *Polygala myrtifolia***

Remove seedlings and small plants by hand. Larger plants can simply be cut off at the base and tend not to regrow. Burning can kill adult plants if hot enough but will result in larger infestations if there is not follow up control as the seeds will germinate. Glyphosate can also be used for effective control.

More information on weed identification and control is available from the Department of Agriculture and Food and GeoCatch.

## Appendix 4 Native and feral fauna within the Buayanyup River catchment

Below is a list of native and feral fauna found within the Buayanyup catchment. This information was obtained from Department of Environment and Conservation staff, *Birds of the Busselton area* (Birds Australia 2001) and anecdotal information provided by landholders within the catchment.

Common name	Scientific name	Conservation status
<b>Native mammals</b>		
Brush-tailed phascogale or wambenger	<i>Phascogale tapoatafa tapoatafa</i>	I: Near threatened S: Schedule 1 – vulnerable
Chocolate wattled bat	<i>Chalinolobus morio</i>	
Chuditch or western quoll	<i>Dasyurus geoffroii</i>	I: Near threatened N: Vulnerable S: Schedule 1 – vulnerable
Common brushtail possum	<i>Trichosurus vulpecula vulpecula</i>	
Dingo	<i>Canis lupus dingo</i>	
Great pipestrelle	<i>Pipistrellus tasmaniensis</i>	
Greater long-eared bat	<i>Nyctophilus timoriensis timoriensis</i>	
Grey-bellied dunnart	<i>Sminthopsis griseoventer</i>	
Gould's long-eared bat	<i>Nyctophilus gouldi</i>	
Gould's wattled bat	<i>Chalinolobus gouldii</i>	
Honey possum	<i>Tarsipes rostratus</i>	
Lesser long-eared bat	<i>Nyctophilus geoffroii</i>	
Mardo or yellow-footed antechinus	<i>Antechinus flavipes</i>	
Quenda or southern brown bandicoot	<i>Isodon obesulus fusciventer</i>	L: Priority species – Priority 5
Quokka•	<i>Setonix brachyurus</i>	I: Vulnerable N: Vulnerable S: Schedule 1 – vulnerable
Short-beaked echidna	<i>Tachyglossus aculeatus</i>	
Southern forest bat	<i>Vespadelus regulus</i>	
Southern freetail-bat	<i>Mormopterus planiceps</i>	
Tammar wallaby •	<i>Macropus eugenii</i>	L: Priority species – Priority 5
Water rat	<i>Hydromys chrysogaster</i>	L: Priority species – Priority 4
Western brush wallaby or black gloved wallaby	<i>Macropus irma</i>	L: Priority species – Priority 4
Western bush rat	<i>Rattus fuscipes fuscipes</i>	
Western grey kangaroo	<i>Macropus fuliginosus</i>	
Western pygmy possum or mundarda	<i>Cercartetus concinnus</i>	



Common name	Scientific name	Conservation status
Western ringtail possum or nguara	<i>Pseudocheirus occidentalis</i>	I: Vulnerable N: Vulnerable S: Schedule 1 – vulnerable
White-striped freetail Bat	<i>Tadarida australis</i>	
Woylie or brush-tailed bettong •	<i>Bettongia penicillata ogylybi</i>	S: Schedule 1 – endangered
<b>Introduced mammals</b>		
Black rat	<i>Rattus rattus</i>	
Brown rat	<i>Rattus norvegicus</i>	
Feral cat	<i>Felis catus</i>	
Feral pig	<i>Sus scrofa</i>	
Fox	<i>Vulpes vulpes</i>	
House mouse	<i>Mus musculus</i>	
Rabbit	<i>Oryctolagus cuniculus</i>	
<b>Birds</b>		
Australian white ibis	<i>Threskiornis molucca</i>	
Australasian bittern	<i>Botaurus poiciloptilus</i>	I: Endangered S: Schedule 1 – vulnerable
Australasian shoveler	<i>Anas rhynchos</i>	
Australian bustard	<i>Ardeotis australis</i>	L: Priority species – Priority 4
Australian hobby	<i>Falco longipennis</i>	
Australian magpie lark	<i>Grallina cyanoleuca</i>	
Australian owl-nightjar	<i>Aegotheles cristatus</i>	
Australian raven	<i>Corvus coronoides</i>	
Australian ringneck	<i>Barnardius zonarius</i>	
Australian shelduck	<i>Tadorna tadornoides</i>	
Australian spotted crake	<i>Porzana fluminea</i>	
Australian wood duck	<i>Chenonetta jubata</i>	
Australasian grebe	<i>Tachybaptus novaehollandiae</i>	
Baillon's crake	<i>Porzana pusilla</i>	
Banded lapwing	<i>Vanellus tricolor</i>	
Banded stilt	<i>Cladorhynchus leucocephalus</i>	
Barn owl	<i>Tyto alba</i>	
Bar-tailed godwit	<i>Limosa lapponica</i>	
Black swan	<i>Cygnus atratus</i>	
Black-faced cuckoo-shrike	<i>Coracina novaehollandiae</i>	
Black-fronted dotterel	<i>Elsyornis melanops</i>	

Common name	Scientific name	Conservation status
Black-shouldered kite	<i>Elanus axillaris</i>	
Black-tailed godwit	<i>Limosa limosa</i>	
Black-tailed native-hen	<i>Gallinula ventralis</i>	
Black-winged stilt	<i>Himantopus himantopus</i>	
Blue-billed duck	<i>Oxyura australis</i>	
Bridled tern	<i>Onychoprion anaethetus</i>	
Brown falcon	<i>Falco berigora</i>	
Brown goshawk	<i>Accipiter fasciatus</i>	
Brown honeyeater	<i>Lichmera indistincta</i>	
Brown quail	<i>Coturnix ypsilophora</i>	
Brown-headed honeyeater	<i>Melithreptus brevirostris</i>	
Buff-banded rail	<i>Gallirallus philippensis</i>	
Bush stone-curlew	<i>Burhinus grallarius</i>	L: Priority species – Priority 4
Caspian tern	<i>Sterna caspia</i>	
Cattle egret	<i>Ardea ibis</i>	
Chestnut teal	<i>Anas castanea</i>	
Collared sparrowhawk	<i>Accipiter cirrhocephalus</i>	
Common bronzewing	<i>Phaps chalcoptera</i>	
Common greenshank	<i>Tringa nebularia</i>	
Common redshank	<i>Tringa totanus</i>	
Common sandpiper	<i>Actitis hypoleucos</i>	
Crested pigeon	<i>Ocyphaps lophotes</i>	
Crested shrike-tit	<i>Falcunculus frontatus</i>	L: Priority species – Priority 4
Crested tern	<i>Sterna bergii</i>	
Crow	<i>Corvus corax</i>	
Curlew sandpiper	<i>Calidris ferruginea</i>	
Darter	<i>Anhinga melanogaster</i>	
Dusky moorhen	<i>Gallinula tenebrosa</i>	
Dusky woodswallow	<i>Artamus cyanopterus</i>	
Elegant parrot	<i>Neophema elegans</i>	
Emu	<i>Dromaius novaehollandiae</i>	
Eurasian coot	<i>Eurasian Coot</i>	
Fairy tern	<i>Sterna nereis</i>	
Fan-tailed cuckoo	<i>Cacomantis flabelliformis</i>	
Freckled duck	<i>Stictonetta naevosa</i>	
Galah	<i>Cacatua roseicapilla</i>	
Glossy ibis	<i>Plegadis falcinellus</i>	
Golden whistler	<i>Pachycephala pectoralis</i>	

Common name	Scientific name	Conservation status
Great cormorant	<i>Phalacrocorax carbo</i>	
Great egret	<i>Ardea alba</i>	
Great knot	<i>Calidris tenuirostris</i>	
Greater sand plover	<i>Charadrius leschenaultii</i>	
Great-winged petrel	<i>Pterodroma macroptera</i>	
Grey butcherbird	<i>Cracticus torquatus</i>	
Grey currawong	<i>Strepera versicolor</i>	
Grey fantail	<i>Rhipidura fuliginosa</i>	
Grey plover	<i>Pluvialis squatarola</i>	
Grey shrike-thrush	<i>Colluricincla harmonica</i>	
Grey teal	<i>Anas gracilis</i>	
Grey-tailed tattler	<i>Heteroscelus brevipes</i>	
Hardhead	<i>Aythya australis</i>	
Hoary-headed grebe	<i>Polyocephalus polyocephalus</i>	
Hooded plover	<i>Thinornis rubricollis</i>	
Hooded robin	<i>Melanodryas cucullata</i>	
Horsfield's bronze-cuckoo	<i>Chrysococcyx basalis</i>	
Inland thornbill	<i>Acanthiza apicalis</i>	
Laughing kookaburra	<i>Dacelo novaeguineae</i>	
Lesser sand plover	<i>Charadrius mongolus</i>	
Little bittern	<i>Ixobrychus minutus</i>	L: Priority species – Priority 4
Little black cormorant	<i>Phalacrocorax sulcirostris</i>	
Little eagle	<i>Hieraaetus morphnoides</i>	
Little egret	<i>Egretta garzetta</i>	
Little pied cormorant	<i>Phalacrocorax melanoleucos</i>	
Little wattlebird	<i>Anthochaera chrysoptera</i>	
Long-billed black cockatoo	<i>Calyptorhynchus baudinii</i>	
Long-toed stint	<i>Erolia subminuta</i>	
Marsh sandpiper	<i>Tringa stagnatilis</i>	
Masked owl	<i>Tyto novaehollandiae</i>	
Musk duck	<i>Biziura lobata</i>	
Nankeen kestrel	<i>Falco cenchroides</i>	
Nankeen night heron	<i>Nycticorax caledonicus</i>	
New Holland honeyeater	<i>Phylidonyris novaehollandiae</i>	
Pacific black duck	<i>Anas superciliosa</i>	
Pacific golden plover	<i>Pluvialis fulva</i>	
Painted button-quail	<i>Turnix varia</i>	
Pallid cuckoo	<i>Cuculus pallidus</i>	

Common name	Scientific name	Conservation status
Pectoral sandpiper	<i>Calidris melanotos</i>	
Peregrine falcon	<i>Falco peregrinus</i>	S: Schedule 4 – other specially protected
Pied cormorant	<i>Phalacrocorax varius</i>	
Pied oystercatcher	<i>Haematopus longirostris</i>	
Pink-eared duck	<i>Malacorhynchus membranaceus</i>	
Pintailed snipe	<i>Gallinago stenura</i>	
Purple swamphen	<i>Porphyrio porphyrio</i>	
Purple-crowned lorikeet	<i>Glossopsitta porphyrocephala</i>	
Rainbow bee-eater	<i>Merops ornatus</i>	
Red knot	<i>Calidris canutus</i>	
Red wattlebird	<i>Anthochaera carnunculata</i>	
Red-capped parrot	<i>Purpureicephalus spurius</i>	
Red-capped plover	<i>Charadrius ruficapillus</i>	
Red-capped robin	<i>Petroica goodenovii</i>	
Red-eared firetail	<i>Stagonopleura oculata</i>	
Red-kneed dotterel	<i>Erythronyctes alba</i>	
Red-necked avocet	<i>Recurvirostra novaehollandiae</i>	
Red-necked stint	<i>Calidris ruficollis</i>	
Red-tailed black cockatoo	<i>Calyptorhynchus banksii</i>	S: Schedule 1 – vulnerable
Red-winged fairy wren	<i>Malurus elegans</i>	
Regent parrot	<i>Polytelis anthopeplus</i>	
Restless flycatcher	<i>Myiagra inquieta</i>	
Rock parrot	<i>Neophema petrophila</i>	
Royal spoonbill	<i>Platalea regia</i>	
Ruddy turnstone	<i>Arenaria interpres</i>	
Ruff	<i>Philomachus pugnax</i>	
Rufous treecreeper	<i>Climacteris rufus</i>	
Rufous whistler	<i>Pachycephala rufiventris</i>	
Sacred kingfisher	<i>Todiramphus sanctus</i>	
Scarlet robin	<i>Petroica multicolor</i>	
Sharp-tailed sandpiper	<i>Calidris acuminata</i>	
Shining bronze-cuckoo	<i>Chrysococcyx lucidus</i>	
Short-billed black cockatoo	<i>Calyptorhynchus latirostris</i>	I: Endangered N: Endangered S: Schedule 1 – endangered
Silvereye	<i>Zosterops lateralis</i>	
Singing honeyeater	<i>Lichenostomus virescens</i>	

Common name	Scientific name	Conservation status
Southern boobook	<i>Ninox novaeseelandiae</i>	
Southern emu wren	<i>Stipiturus malachurus</i>	
Splended fairy wren	<i>Malurus splendens</i>	
Spotless crane	<i>Porzana tabuensis</i>	
Spotted nightjar	<i>Eurostopodus argus</i>	
Spotted pardalote	<i>Pardalotus punctatus</i>	
Square tailed kite	<i>Lophoictinia isura</i>	
Straw-necked ibis	<i>Threskiornis spinicollis</i>	
Striated pardalote	<i>Pardalotus striatus</i>	
Stubble quail	<i>Coturnix pectoralis</i>	
Swamp harrier	<i>Circus approximans</i>	
Tawny frogmouth	<i>Podargus strigoides</i>	
Tawny-crowned honeyeater	<i>Gliciphila melanops</i>	
Terek sandpiper	<i>Xenus cinereus</i>	
Tree martub	<i>Petrochelidon nigricans</i>	
Varied sitella	<i>Daphoenositta chrysoptera</i>	
Wedge-tailed eagle	<i>Aquila audax</i>	
Weebill	<i>Smicronis brevirostris</i>	
Welcome swallow	<i>Hirundo neoxena</i>	
Western corella	<i>Cacatua pastinator</i>	
Western gerygone	<i>Gerygone fusca</i>	
Western rosella	<i>Platycercus icterotis</i>	
Western spinebill	<i>Acanthorhynchus superciliosus</i>	
Western thornbill	<i>Acanthiza inornata</i>	
Western yellow robin	<i>Eopsaltria griseogularis</i>	
Whimbrel	<i>Numenius phaeopus</i>	
Whiskered tern	<i>Chlidonias hybridus</i>	
Whistling kite	<i>Haliastur sphenurus</i>	
White-tailed black cockatoo	<i>Caoyptorhynchus sp</i>	
White-breasted robin	<i>Eopsaltria georgiana</i>	
White-browed scrubwren	<i>Sericornis frontalis</i>	
White-cheeked honeyeater	<i>Phylidonyris nigra</i>	
White-faced heron	<i>Egretta novaehollandiae</i>	
White-fronted chat	<i>Epthianura albifrons</i>	
White-naped honeyeater	<i>Melithreptus lunatus</i>	
White-necked heron	<i>Ardea pacifica</i>	
White-winged tern	<i>Chlidonias leucopterus</i>	
Willy wagtail	<i>Rhipidura leucophrys</i>	

Common name	Scientific name	Conservation status
Wood sandpiper	<i>Tringa glareola</i>	
Yellow-tailed black cockatoo	<i>Calyptorhynchus funereus</i>	
Yellow-billed spoonbill	<i>Platalea flavipes</i>	
Yellow-rumped thornbill	<i>Acanthiza chrysorrhoa</i>	
<b>Frogs</b>		
Bleating froglet	<i>Crinia pseudinsignifera</i>	
Glauert's froglet / clicking froglet	<i>Crinia glauerti</i>	
Günther's toadlet / crawling frog	<i>Pseudophryne guentheri</i>	
Lea's frog	<i>Geocrinia leai</i>	
Moaning frog	<i>Heleioporus eyrei</i>	
Motorbike frog / western bell frog	<i>Litoria moorei</i>	
Nicholl's toadlet	<i>Metacrinia nichollsi</i>	
Pobblebonk / banjo frog/bullfrog	<i>Limnodynastes dorsalis</i>	
Quacking frog	<i>Crinia georgiana</i>	
Sand frog	<i>Heleioporus psammophilus</i>	
Slender tree frog	<i>Litoria adelaidensis</i>	
Whooping frog	<i>Heleioporus inornatus</i>	
<b>Reptiles</b>		
Bardick	<i>Echiopsis curta</i>	
Black-backed snake	<i>Parasuta nigriceps</i>	
Black-headed snake / Gould's snake	<i>Parasuta gouldii</i>	
Bobtail / shingle back	<i>Tiliqua rugosa</i>	
Burton's legless lizard	<i>Lialis burtonis</i>	
Carpet python	<i>Morelia spilota imbricata</i>	S: Schedule 4 – other specially protected
Chain-striped South-west Ctenotus	<i>Ctenotus catenifer</i>	
Common dwarf skink	<i>Menetia greyii</i>	
Common scaly-foot	<i>Pygopus lepidopus</i>	
Crowned snake	<i>Elapognathus coronatus</i>	
Dugite	<i>Pseudonaja affinis affinis</i>	
Fence skink	<i>Cryptoblepharus plagiocephalus</i>	
Glossy swamp skink	<i>Egernia luctosa</i>	
King's skink	<i>Egernia kingii</i>	
Marbled gecko	<i>Christinus marmoratus</i>	
Odd-striped Ctenotus	<i>Ctenotus impar</i>	
Red-legged Ctenotus	<i>Ctenotus labillardieri</i>	



Common name	Scientific name	Conservation status
Sand monitor / Gould's goanna / bungarra	<i>Varanus gouldii</i>	
Short-nosed snake	<i>Elapognathus minor</i>	L: Priority species – Priority 2
South-west crevice skink	<i>Egernia napoleonis</i>	
South-western orange-tailed slider	<i>Lerista distinguenda</i>	
South-western slider	<i>Lerista microtis</i>	
South-western spectacled rock skink	<i>Egernia pulchra</i>	
Southern blind snake	<i>Ramphotyphlops australis</i>	
Southern heath monitor	<i>Varanus rosenbergi</i>	
South-western cool skink	<i>Acritoscincus trilineatum</i>	
South-western mulch skink	<i>Hemiergus gracilipes</i>	
Square-nosed snake	<i>Rhinoplocephalus bicolor</i>	
Three-toed earless skink	<i>Hemiergus peronii tridactyla</i>	
Two-toed earless skink	<i>Hemiergus quadrilineata</i>	
West Coast four-toed lerista	<i>Lerista elegans</i>	
Western bearded dragon	<i>Pogona minor</i>	
Western granite worm lizard	<i>Aprasia pulchella</i>	
Western pale flecked Morethia	<i>Morethia lineocellata</i>	
Western tiger snake	<i>Notechis scutatus</i>	
Woodland Morethia	<i>Morethia obscura</i>	
<b>Freshwater fish/aquatic fauna</b>		
Dunsborough burrowing crayfish (to be confirmed)	<i>Engaewa reducta</i>	N: Critically endangered S: Schedule 1 – endangered
Freshwater mussel	<i>Westralunio carteri</i>	I: Vulnerable
Gilgie	<i>Cherax quinquecarinatus</i>	
Koonac	<i>Cherax preissii</i>	
Nightfish	<i>Bostockia porosa</i>	
Oblong turtle / long-necked turtle	<i>Chelodina oblonga</i>	
Smooth marron	<i>Cherax cainii</i>	
South-west shrimp	<i>Palaemonetes australis</i>	
Western minnow	<i>Galaxias occidentalis</i>	
Western pygmy perch	<i>Edelia vittata</i>	
<b>Estuarine aquatic fauna</b>		
Black bream	<i>Acanthopagrus butcheri</i>	
Australian salmon	<i>Arripis truttaceus</i>	
South-west goby	<i>Afurcogobius suppositus</i>	
King George whiting	<i>Sillaginodes punctata</i>	

Common name	Scientific name	Conservation status
Silverfish	<i>Leptatherina presbyteroides</i>	
Western hardyhead	<i>Leptatherina wallacei</i>	
Sea mullet	<i>Mugil cephalus</i>	
Blue spot goby	<i>Pseudogobius olorum</i>	
Little scorpionfish	<i>Maxillicosta scabriceps</i>	
Striped trumpeter	<i>Pelates sexlineatus</i>	
Sandy sprat	<i>Hyperlophus vittatus</i>	
Yellowtail trumpeter	<i>Amniataba caudavittata</i>	
<b>Introduced Aquatic fauna</b>		
Eastern mosquitofish	<i>Gambusia holbrooki</i>	
Yabbie	<i>Cherax destructor</i>	

**Key:**

**I:** International protection under the International Union for Conservation of Nature and Natural Resources (IUCN) Red List. Red list categories include:

- Extinct
- Extinct in the wild
- Critically endangered
- Endangered
- Vulnerable
- Least concern
- Data deficient
- Not evaluated

**N:** National protection under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) List of Threatened Fauna. The categories are:

- Extinct
- Extinct in the wild
- Critically endangered
- Endangered
- Vulnerable
- Conservation dependent

**S:** State protection under the Wildlife Conservation Act 1950. Categories include:

Schedule 1 – Species that are rare or likely to become extinct. This category is further divided into:

- Extinct in the wild
- Critically endangered
- Endangered
- Vulnerable

Schedule 2 – Species that are presumed to be extinct.

Schedule 3 – Birds protected under an international agreement.

Schedule 4 – Other specially protected fauna.

**L:** Locally managed through the Department of Environment and Conservation Priority species list.

If a species does not meet the criteria for listing as threatened fauna or declared rare flora (e.g. due to lack of information) and is poorly known and/or conservation dependent, it can be nominated as a priority species). Priority species are placed into one of five categories of priority and are managed by Department of Environment and Conservation accordingly.

Priority One: Taxa with few, poorly known populations on threatened lands.

Priority Two: Taxa with few, poorly known populations on conservation lands.

Priority Three: Taxa with several, poorly known populations, some on conservation lands.

Priority Four: Taxa in need of monitoring.

Priority Five: Taxa that are conservation dependent (i.e. their conservation status is dependent on ongoing active management).

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## Appendix 5 Waterway ecology

To increase understanding of the values, waterway function and condition of the Buayanyup River some information about waterway habitats is provided below.

### Habitat zones

There is a great diversity of habitat zones and elements in a natural waterway. This variety of habitats supports a diverse range of plants and animals. Flora of the Buayanyup River is listed in Appendix 2.

### *Waterway pools*

The geology of the Buayanyup River includes ironstone bedrock throughout much of its length and there is anecdotal evidence of groundwater discharge into the waterway, particularly in the upper catchment. These two features give rise to a number of permanent, rocky pools within the catchment. The pools provide an essential summer drought refuge for many waterway fauna, including waterbirds, turtles, water rats, fish and crayfish, and are integral to the survival of many aquatic animals. Undisturbed waterway pools are usually surrounded by dense fringing vegetation and are well shaded and have snags and woody debris along their edges.

### *Riffles, rapids and cascades*

These habitats occur where water flows swiftly over an irregular waterway bed, over and between rocks and from one rocky terrace to another. As well as providing habitat for particular macroinvertebrates, they have two very important functions. They help to oxygenate the water and the sound they make enables some species to find their preferred habitat.

### *Runs and low flow channels*

Long reaches of unobstructed waterway flow, where the flowing water has a flat surface, are often called runs. In the South West they are the low flow channels that wind their way across the flood plains between pools. The low flow channels are often well supported and overhung by fringing and in-stream native vegetation.

### *Flood plains and backwaters*

In terms of habitats, flood plains are generally broad areas of low flat land adjacent to the main floodway of the river. Each year flood plains are inundated to some degree by floodwater, creating a seasonal habitat, which may be used for feeding and breeding by a variety of animals such as tiny crustaceans, birds, frogs and fish. Flood plains may also be part of broader wetland systems, which in winter become very swampy through groundwater rise or the build up of rainwater over a clay layer. Flood plains are an integral part of the waterway ecosystem. There is an exchange of water, nutrients, and living creatures between the waterway and its flood plain, which is essential to the proper functioning of a healthy waterway ecosystem. When secondary channels become disused and form pools they are referred to as backwaters. The still or slow flowing water in the backwater is often the preferred habitat of species that are unable to cope with fast flow.

### **Habitat elements**

Habitat elements are found within the zones outlined above in differing combinations to provide a large variety of habitats.

### *Riparian vegetation*

Fringing native vegetation is an important part of habitat as it contributes tannin-rich leaves to fuel the food web, and provides shade throughout the year helping to keep water temperature low.

### *Snags and woody debris*

Snags are fallen trees and large branches lying in the waterway channel. They are important to the ecology of the waterway systems. Apart from generally helping to slow the flow of water, woody debris alters its flow, creating eddies and small isolated zones of turbulence or still water, which provides 'microhabitats' for a range of tiny animals and plants. Furthermore, tree trunks and branches add a huge surface area to a waterway environment, creating a woody habitat for certain species to use for all or part of their life cycle. Tree trunks lying close to or on the waterway bed provide cover or a sturdy roof for burrowing animals such as marron and gilgies.

### *Shade*

Shade provides an essential refuge for aquatic animals to escape the heat of the sun, as well as generally keeping the water temperature down.

### *Aquatic vegetation*

Aquatic vegetation includes plants that are found submerged in, floating on or emerging from water. It provides a specialist habitat for certain animals, such as fish and hunting spiders, as well as cover for fish, shrimps and crayfish, and valuable breeding and nursery habitat for fish during spring.

### *Leaf litter*

Leaves and twigs collect in pools or in areas of still or slightly flowing water and form an important microhabitat for a large range of aquatic organisms. These range from large crayfish to microscopic bacteria and fungi, which break down organic material and initiate the natural food web. Piles of leaves and twigs can also provide cover for certain fish species, aquatic insect larvae and juvenile crayfish, but only if there is a slight flow of water through the material to maintain well oxygenated conditions.

### *Rocks and stones*

Although vegetation dominates waterway habitats in the south west, rock and stone are important habitat elements. Rocks create a myriad of microhabitat elements in which a broad range of animals and plants can find a home. Rock also limits the growth of trees and shrubs over water and creates sunlit habitat. Finally, the water flow over rocky waterway beds helps to oxygenate the water, improving the quality of habitats downstream (Pen 1999).



## Appendix 6 Pen-Scott foreshore assessment method

The foreshore condition grades are illustrated in Figure 27 and the photos on the following pages. The Pen–Scott method allows comparisons of waterway health across the south-west of Western Australia. (Pen & Scott 1995; Water and Rivers Commission 1999).

### A grade foreshore

#### *A1: Pristine*

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

#### *A2: Near pristine*

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

#### *A3: Slightly disturbed*

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

### B grade foreshore

#### *B1: Degraded - weed infested*

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

#### *B2: Degraded - heavily weed infested*

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

#### *B3: Degraded - weed dominated*

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

### C grade foreshore

***C1: Erosion prone***

While trees remain, possibly with some large shrubs or grass trees, the understorey consists entirely of weeds, mainly annual grasses. Most of the trees will be of only a few resilient or long lived species and their regeneration will be 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***

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

***C3: Eroded***

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

**D grade foreshore*****D1: Ditch - eroding***

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

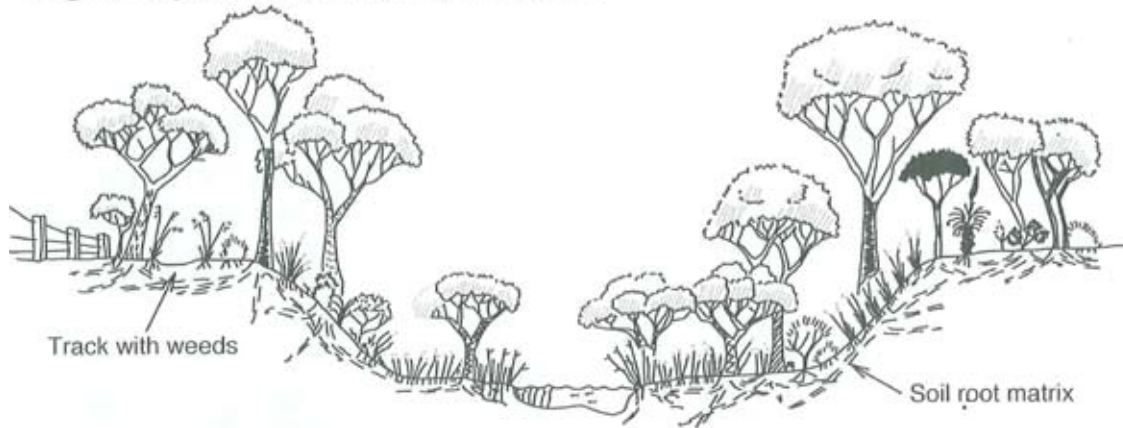
***D2: Ditch - freely eroding***

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

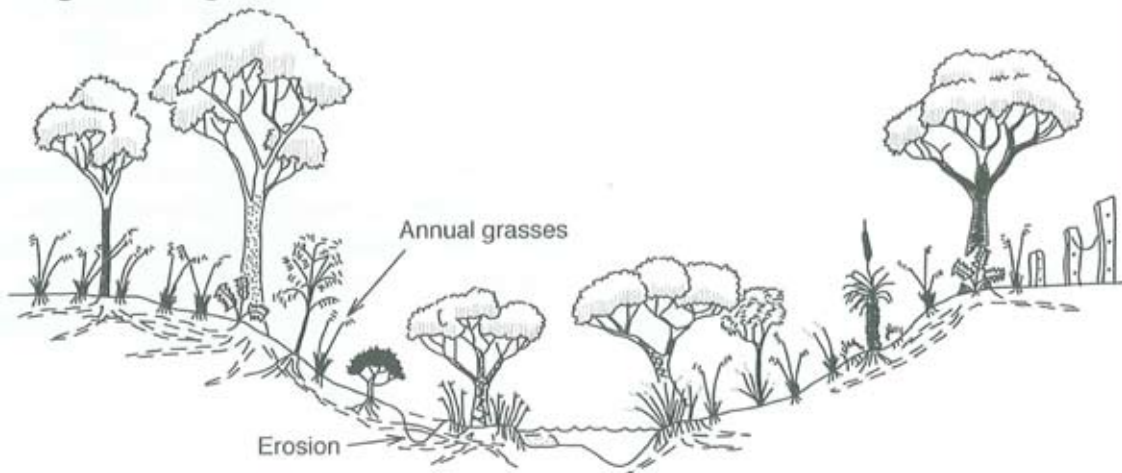
***D3: Drain - weed dominated***

The highly eroded river valley 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.

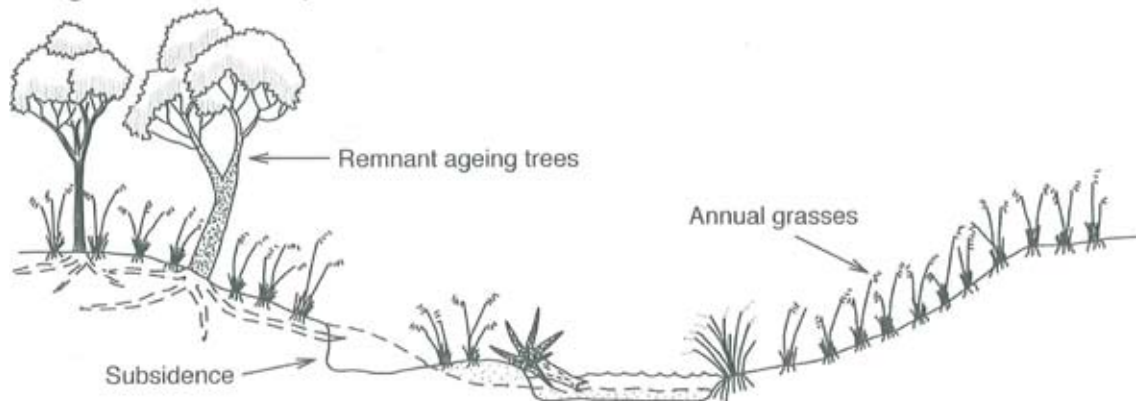
**A grade: pristine to slightly disturbed**



**B grade: degraded**

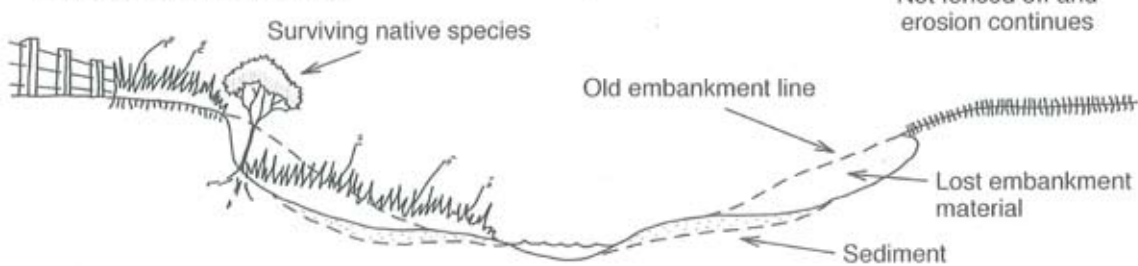


**C grade: erosion prone to eroded**



**D grade: ditch**

Fenced off and weed infested



**Figure 27** The grades of river foreshore (A to D)





**Photo 1**     *A2 grade foreshore*

A2 grade foreshore is near pristine with a few weeds. Riparian vegetation like this is as good as will be found today.



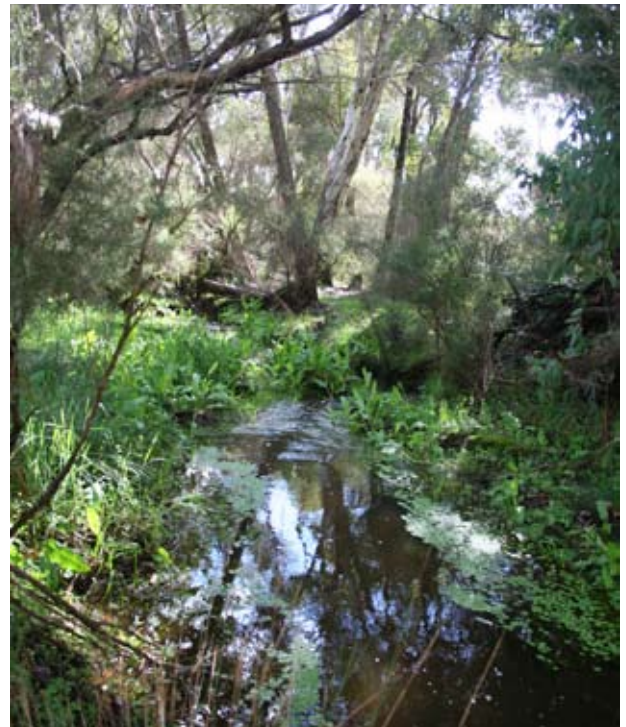
**Photo 2**     *A3 grade foreshore*

A3 grade foreshore shows the native vegetation is slightly disturbed with some dense patches of weeds.



**Photo 3**     *B1 grade foreshore*

B1 grade foreshore shows some of the natives in the understory have been displaced by weeds.



**Photo 4**     *B2 grade foreshore*

B2 grade foreshore shows heavy weed infestations in the understory.





**Photo 5** *B3 grade foreshore*

B3 grade foreshore shows a weed dominated understory with some decline in the trees and shrubs that may have once been present.



**Photo 6** *C1 grade foreshore*

C1 grade foreshore shows some trees and shrubs remain, but the understory is shallow rooted and erosion prone.



**Photo 7** *C2 grade foreshore*

C2 grade foreshore shows the older trees remaining, but the ground bare from livestock trampling.



**Photo 8** *C3 grade foreshore*

C3 grade foreshore shows the banks are being undermined by erosion.





**Photo 9** *D1 grade foreshore*

D1 grade foreshore shows a ditch with some vegetation keeping parts of the bank stable.



**Photo 10** *D2 grade foreshore*

D2 grade foreshore shows a freely eroding ditch.



**Photo 11** *D3 grade foreshore*

D3 grade foreshore shows a weed dominated ditch.

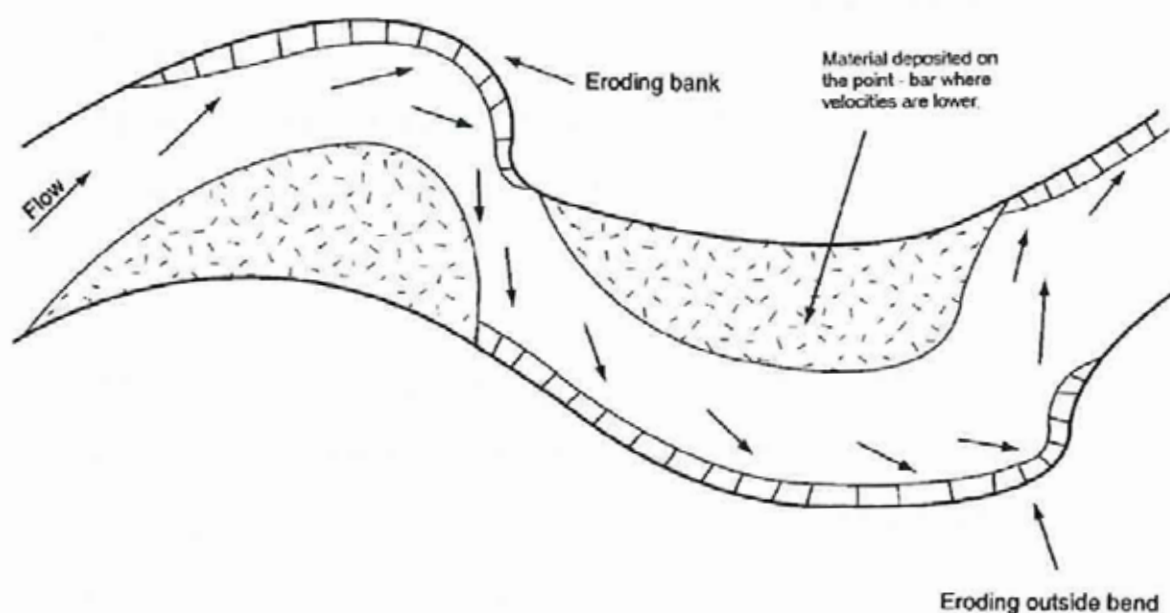


## Appendix 7 Common types of erosion

### Point bars

Once a riverbank becomes disturbed to the point where it is actively eroding, there is potential for this to create further erosion down-stream 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 down-stream, thus creating a new erosion point on the next outside bend. This cycle of erosion and deposition often continues down-stream, and is a classic sign of a river in which the hydrological balance has been disturbed (see Figure 28).

Removal of point bars may sometimes be needed in order to halt the progression of the erosion down-stream. 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.

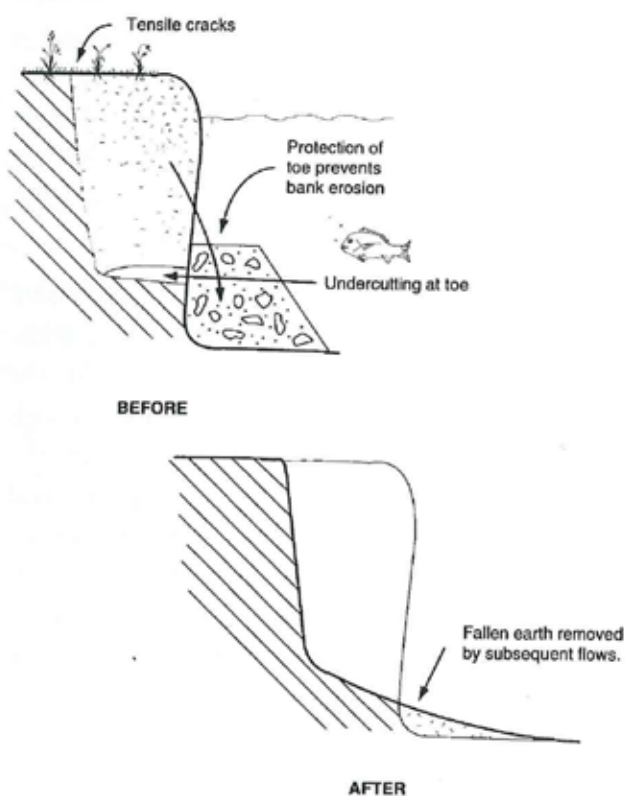


**Figure 28** *Outside bend bank erosion*

Arrows mark the direction of flow showing that outside bends have the greatest erosion potential, so the meanders migrate down-stream (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 slumping as illustrated in Figure 30 (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 29** *Undercut bank and rock toe*

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 30). This can occur with or without prior undercutting. It will often occur 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. In cases where the vegetation is missing, reducing the risk of slumping can be achieved with brushing, adding snags, sandbags and rock pitching. 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
- extend plantings from the toe to the flood plain. 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.

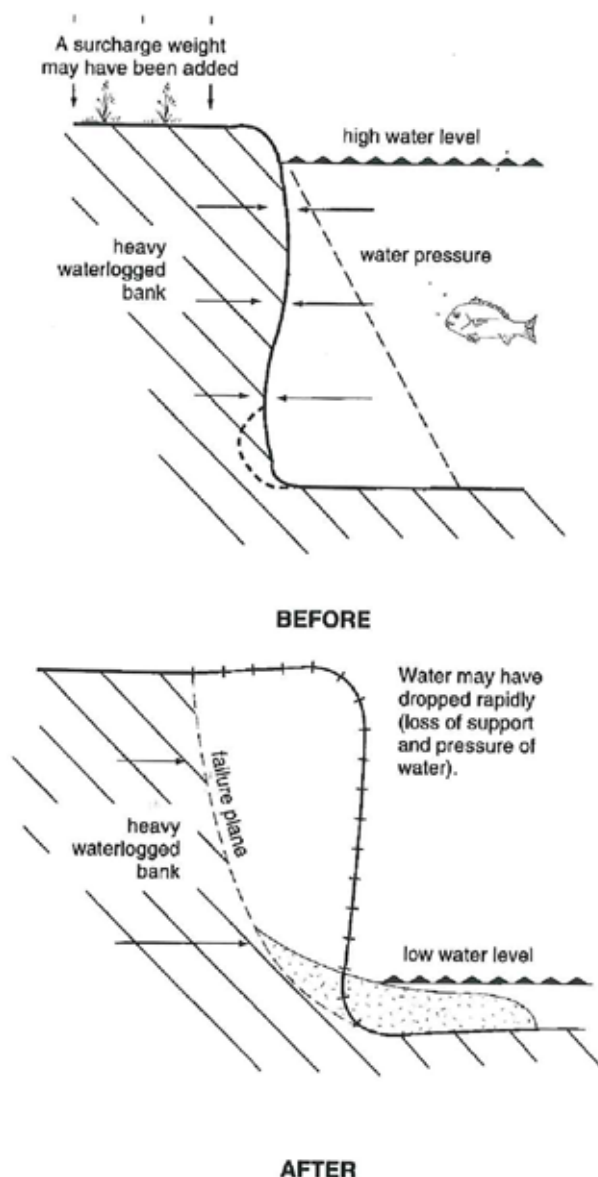


Figure 30 Bank slumping

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## Appendix 8 Advice for planning a project

### Planning a project

#### *Write down your objectives*

What will the work achieve, for instance, habitat creation, water quality improvement, aesthetic improvement?

What work will be done?

Who will do the work?

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
- 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 for a revegetation project should begin in the year preceding the proposed planting or seeding and should include researching the best approach.

Issues to be addressed include:

- Is erosion control required? If so:
  - Is the river on crown land? Contact the land manager to gain legal access to the land to undertake the proposed works.
  - Will it interfere with the bed and banks of a proclaimed waterway? Contact the Department of Water to check if a permit is required.
  - Is there any clearing required? Contact the Department of Environment and Conservation to check if a permit is required.
  - Does the site fall within a Site of Aboriginal Significance? Contact the Department of Indigenous Affairs to check if ministerial approval is required.
  - Do you have a suitably qualified professional to undertake the survey and hydraulic assessments? If not contact GeoCatch for assistance and advice.
  - Can the cause of the erosion be easily identified and how can it best be managed?
  - Will the proposed approach for repairing the erosion affect the up and/or down-stream reaches of the river channel?
  - Is machinery needed for earthworks or are big loads of materials required? If yes then is there good access?
- The selection of suitable plant species.
- How to propagate (by tube 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.
- Where to obtain funds if you intend applying for a grant.

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

- Existing native vegetation.
- Plants that are naturally regenerating.
- Seed sources.
- Potential problems, for example, rabbit activity, weed infestations, eroding banks and 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.

### *When to survey*

Late autumn to early winter is a good time to survey, when weed problems are apparent. The effects 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 waterway 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 waterway 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, suites of flowering plants go mostly unnoticed as they flower when few people are walking and looking. Some of these include *Astartea fascicularis* (a tea tree), *Taxandria linearifolia* (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.

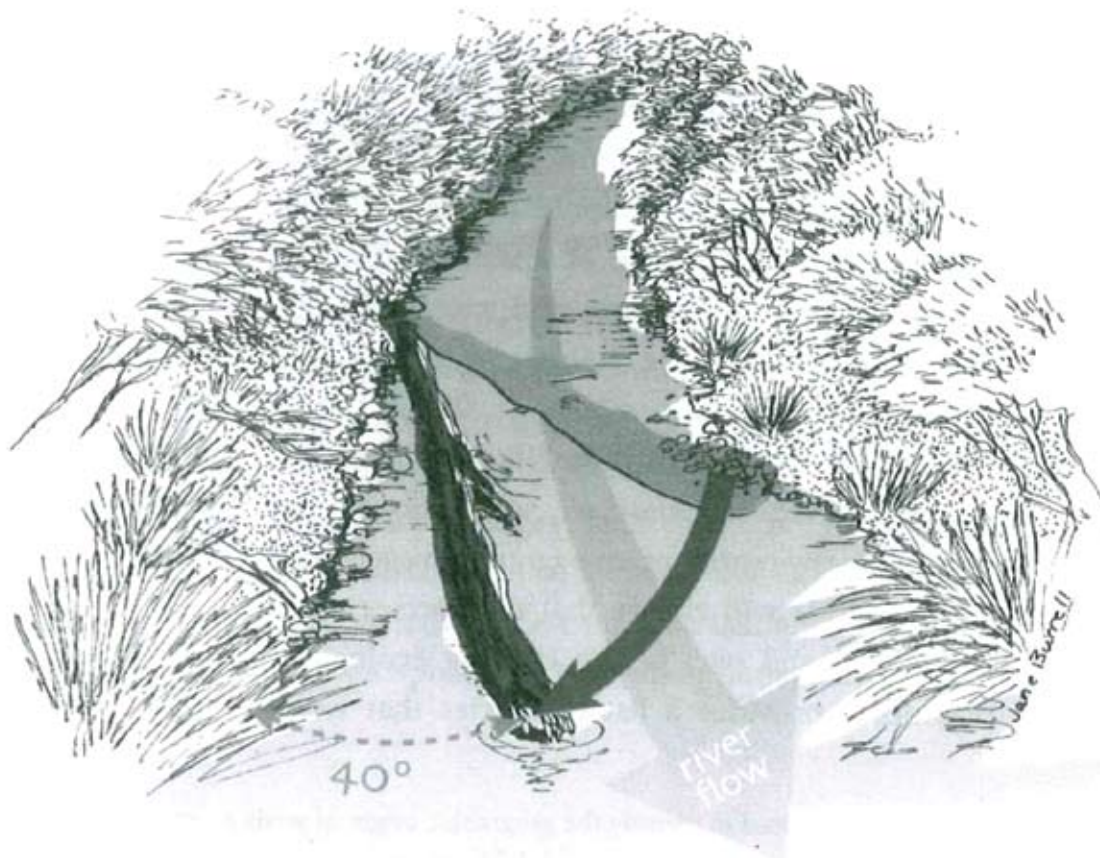
Where most understorey plants have been lost through clearing and grazing, selecting a vegetated site nearby with similar soil type and topography will assist in compiling a species list to use.

The Department of Conservation and Land Management publication *How to create a local herbarium* (Patrick 1997) is recommended for landholders who wish to collect and preserve their own set of field specimens.

## Appendix 9 Notes on revegetation

### Large woody debris

Snags, or large woody debris, are a natural component of the river system. They 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 waterway bank (see Figure 31 (Grippel et al. 1998)). 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.



**Figure 31** *Repositioning large woody debris*

### *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. Options for these areas include:

- direct seeding
- brushing with woody natives that contain seed
- pre-seeded matting
- planting of tube stock.

The riparian zone should be planted in a wide band with a diverse variety 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 representative remnant vegetation communities, as this will ensure that the species used are suitable, local and part of the existing ecological web. Appendix 2 provides a list of species that were found in the area. Species for revegetation projects in the catchment should be selected from this list. GeoCatch can assist with species selection.

### *Revegetation techniques*

Good site preparation is crucial to successful revegetation. Elements that need to be considered are:

- weed removal
- soil amelioration
- 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 increase the chances of success for 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<sup>1</sup> seed. More information on seed collection and propagation is available from GeoCatch.

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 ground-covers 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
- 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 unsuitable conditions. Direct seeding may not be possible when there are high winds or high water flow.

### *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 to 4 rushes per 1 m<sup>2</sup>, 1 shrub per 1 m<sup>2</sup>, and 1 tree every 3 m<sup>2</sup>. 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 watertable 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

<sup>1</sup> 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).

when removing from pots. Planting requires significant prior planning, as local seed can be collected and given to the community nursery to raise in time for planting in the following wet season. Seedlings can also be purchased from the Geographe Community Nursery in Busselton, which specialises in growing local native plants for revegetation purposes. For more information, contact GeoCatch.

### *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 appropriate 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 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 obtain 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.

## Appendix 10 Useful contacts for further information and assistance

### Community groups

#### *GeoCatch*

72 Duchess St, Busselton  
 PO Box 269  
 Busselton, WA 6280  
 Phone 9781 0111  
 Fax 9754 4335  
 Email [geocatch@water.wa.gov.au](mailto:geocatch@water.wa.gov.au)  
 Web [www.geocatch.asn.au](http://www.geocatch.asn.au)

### Government

#### *Department of Water (Busselton)*

72 Duchess St, Busselton  
 PO Box 269  
 Busselton, WA 6280  
 Phone 9781 0111  
 Fax 9754 4335  
 Web [www.water.wa.gov.au](http://www.water.wa.gov.au)

#### *Department of Agriculture and Food*

Verschuer Place  
 Bunbury, WA 6230  
 Phone 9780 6100  
 Web [www.agric.wa.gov.au](http://www.agric.wa.gov.au)  
 AgLine 1300 725 572.

#### *Department of Environment and Conservation*

14 Queen Street,  
 Busselton, WA 6280  
 Phone 9752 1677  
 Web [www.naturebase.com.au](http://www.naturebase.com.au)

#### *Shire of Busselton*

Southern Drive, Busselton  
 Locked Bag 1  
 Busselton, WA 6280  
 Phone 9781 0444  
 Fax 9752 4958

### Aboriginal Heritage

#### *The Wardan Aboriginal Cultural Centre*

55 Wyadup Rd,  
 Yallingup, WA 6282  
 Phone/fax 9756 6566  
 Email [wardan@westnet.com.au](mailto:wardan@westnet.com.au)  
 Web [www.wardan.com.au](http://www.wardan.com.au)

#### *Department of Indigenous Affairs*

PO Box 7770  
 Cloisters Square,  
 Perth, WA 6850  
 Phone 9235 8000  
 Fax 9235 8088  
 Email [info2@dia.wa.gov.au](mailto:info2@dia.wa.gov.au)

#### *South West Aboriginal Land and Sea Council*

HomeTown Centre  
 1490 Albany Highway  
 Cannington, WA 6107  
 PO Box 585  
 Cannington, WA 6987  
 Phone 08 9358 7400  
 Fax 08 9358 7499  
 Email [reception1@noongar.org.au](mailto:reception1@noongar.org.au)



## Local native plant suppliers

### *Geographe Community Landcare Nursery*

366 Queen Elizabeth Avenue,  
Busselton (2 km south of Busselton Bypass  
on the right)  
Monday and Tuesday  
Phone 9754 2049  
Ann Bentley 0429 644885

### *The Tube Nursery*

Lot 61 Blonde Street  
Cowaramup, WA 6284  
Phone 9755 5509  
Fax 9755 5954  
Mobile 0417 936 946  
Email tube\_nsy@bigpond.net.au

### *Everyday potted plants*

311 Sebbes Road  
Forest Grove  
PO BOX 51  
Witchcliffe, WA 6286  
Phone/fax 9757 7424  
Email everyday@reachnet.com.au

### *Margaret River Nursery and Irrigation*

48 Stewart St  
Margaret River, WA 6285  
Phone 9757 2691  
Fax 9757 3193  
Email info@summerworld.net.au

### *Nuralingup Gardens Nursery*

Lot 6 Sebbes Rd  
Forest Grove, WA 6286  
Phone 9757 7542†

### *Bandicoot Nursery*

7.5 km south of Mount Barker  
PO Box 240  
Mount Barker, WA 6324  
Phone 9851 1802  
Fax 9851 2802  
E-mail orders@bandicootnursery.com.au  
Monday to Friday 7 am – 4 pm

### *Leschenault Community Nursery*

PO Box 1741  
Bunbury, WA 6231  
Johnston Road off Estuary Drive  
Bunbury  
Phone 9791 4670

### *Boyanup Botanical*

Lot 14 South Western Hwy  
Boyanup, WA 6237  
Phone 9731 5470

### *The Native Nursery*

5 Possum place,  
Vasse, WA 6280  
Phone 9751 1427

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