



Vasse River Action Plan



2000



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Prepared for Geographe Catchment Council - GeoCatch
and the Vasse Wonnerup LCDC

by

Margaret Scott

Paper Daisy Environmental Services

in conjunction with

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and Banksia Environmental Mapping

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How to use this river action plan

The summary gives you a brief overview of what was studied and the recommendations that have been made.

In the introduction you will then find the background to the Study: who was involved, the brief upon which it was based and the aims it set out to achieve.

Chapter 2 describes in considerable detail the Study Area, its climate, vegetation, fauna, history and population.

Chapters 3 and 4 explain how the Study was carried out and the management issues it revealed.

In Chapter 5 you can read about individual properties, including specific issues relating to each one and recommendations on what actions need to be taken. There are maps, with a key at the end of the report which explains how to read them.

Figure 1 indicates the Study Area and the 13 sections into which it has been divided. Each section is covered by one of the maps.

Once the needs of a particular property are understood, Chapter 6 explains how those responsible for the property can go about planning and carrying out the remedial actions that are required.

Chapter 7 concludes the recommendations section of the report with discussion of a broader range of issues which need to be addressed by the community as a whole and by the various agencies who have a responsibility for or an interest in specific areas.

Chapter 8 and the appendices contain contact details, recommended reading and other useful information.

Acronyms used:

AGWEST	Agriculture Western Australia
APB	Agriculture Protection Board
CALM	Department of Conservation and Land Management
DOLA	Department of Land Administration
GeoCatch	Geographic Catchment Council
LCDC	Land Conservation District Committee
NHT	Natural Heritage Trust
OWR	Office of Water Regulation
PWD	Public Works Dept
RoB	Ribbons of Blue
Sh. Bsn	Shire of Busselton
WC	Water Corporation
WRC	Water and Rivers Commission

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Summary

This Action Plan covers the foreshore condition of the Vasse River from the Whicher Scarp to Fairlawn Road.

Clearing and grazing have removed much of the low protective vegetation and in some places even the tall trees along the riverbanks. Many adjoining paddocks are devoid of trees and stock rely on vegetation along the river banks or the road reserves for shade and shelter.

For too long the river has been regarded as a drain and treated like one in many ways. The Drain Reserve is too narrow to sustain all the processes of a healthy river.

The function of the estuary has changed with the installation of floodgates and check boards and the construction of the Vasse Diversion Drain.

The river catchment is in dire need of broad-scale revegetation strategies that also maintain

and sustain farming enterprises and practices. Water must be used and controlled within the catchment before it reaches the waterways. The river foreshore requires wider zones of vegetation to buffer nutrient and sediment run-off from the adjoining land and to stabilise eroding embankments.

There are parts of the river that are still beautiful, special, important and vital, and others that could become so again given the will of their custodians and practical assistance in the form of expertise and funding.

Table 1 presents a summary of the condition rating of the Vasse River developed during the Study. It is based on the Pen-Scott system of rating (1995), which is widely used across the State.

Table 1: Summary of foreshore condition rating of the Vasse River

Condition Rating	West Bank		East Bank	
	Total Length	Total %	Total Length	Total %
A (pristine)	4.6 km	16%	4 km	13%
B (weedy)	11 km	37%	11 km	37%
C (erosion prone)	11.9 km	40%	11.1 km	38%
D (ditch)	2.1 km	7%	3.5 km	12%

Table 2: Length of fenced and unfenced areas on the Vasse River

	Length Fenced	% of Length	Length Unfenced	% of Length
West Bank	20.5 km	69%	9.1 km	31%
East Bank	18.1 km	61%	11.5 km	39%

For the purposes of the Study the river was divided into 13 sections with specific recommendations developed for remedial action to be taken on each property.

Typical recommendations include improvements to fencing, construction of stock crossings, watering points and troughs, repairs to eroded and degraded areas, weed and pest control, re-establishing native species and widening the vegetation buffers.

In some cases it is identified that problems are starting upstream or in the broader catchment area and co-operation with other landholders and appropriate authorities is recommended.

Many landholders are already carrying out remedial action and this is commended and ways to improve upon it suggested.

Using the information provided about their properties, landholders are advised to select the areas most likely to respond to treatment and address these first, following progressively with the more difficult areas.

At each stage of the remedial programme a project plan should be developed which identifies what has to be done and how it can be achieved.

It is recommended that groups of people should work together, sharing skills and resources.

Specific advice and recommendations are provided on how to plan and carry out revegetation projects, including site preparation, identifying existing plant species and selecting appropriate species for planting.

There are also recommendations on stock control, creating effective buffer zones, preventing erosion, chemical use, weed management and water quality monitoring.

Other catchment strategies recommended include seeking funding to employ a part-time coordinator and conduct further studies, forging closer links between local bodies and with others outside the area, developing data banks of appropriate information and establishing a demonstration site of rehabilitated foreshore.

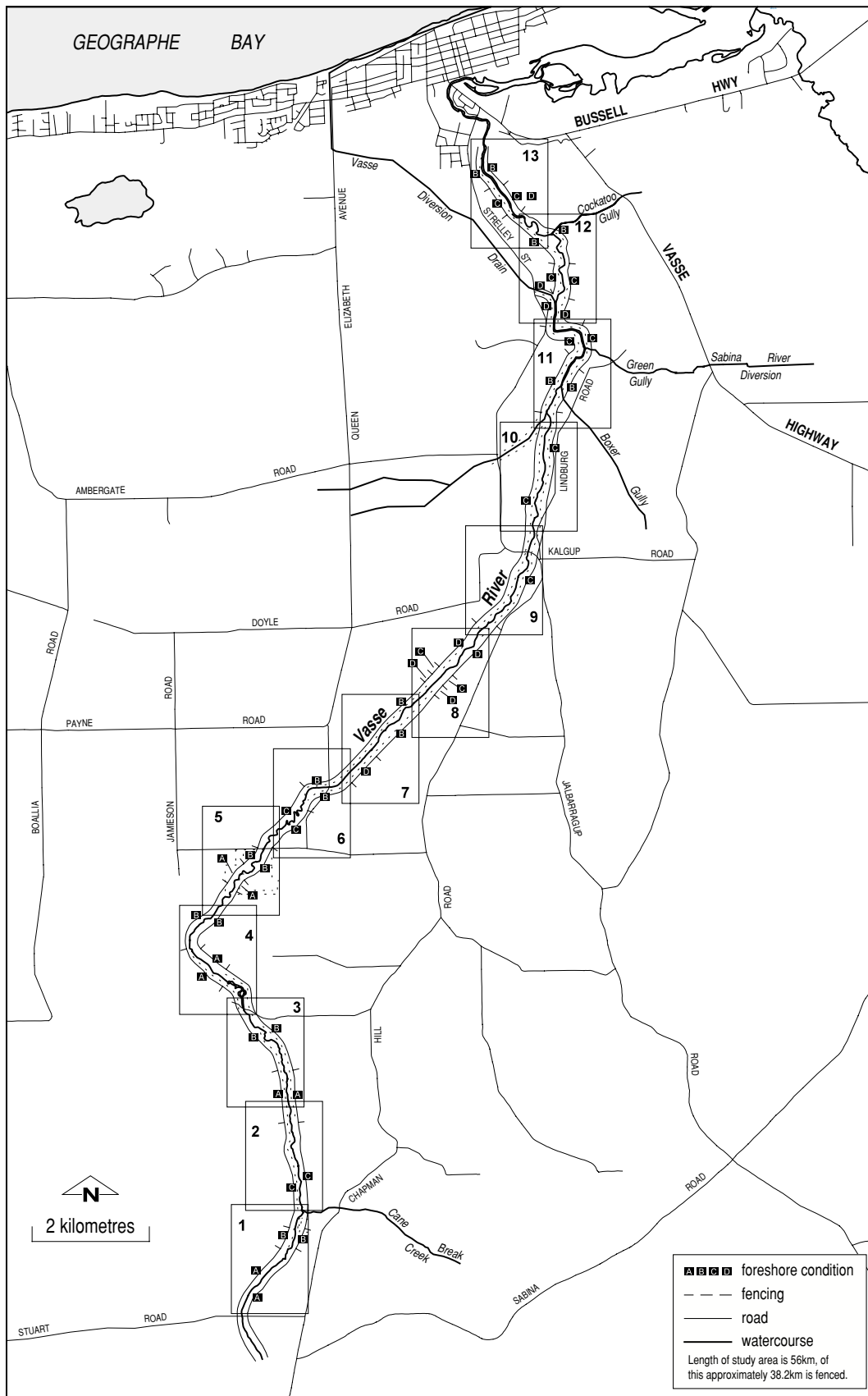


Figure 1: Location map for the Vasse River Catchment shows thirteen outlined inserts that correspond with surveys and interpretations. Condition ratings and fencing status are also displayed.

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1. Introduction

1.1 Background

The Geographe Catchment Council (GeoCatch) was established in 1997 with a strong community base and significant community input reinforced by multiple agency expertise. Its charter is:

'To work with the community and management agencies to manage the catchment of Geographe Bay and its marine environment so that natural systems, people and their activities coexist in a healthy, productive and sustainable way.'

The Vasse-Wonnerup LCDC provides a key link between community and government agencies. It has been involved in drainage control, river fencing projects and nutrient management to produce guidelines for on-farm fertiliser management.

Both groups recognised a need to address the poor state of health of the Vasse River.

The project was managed by GeoCatch in partnership with the LCDC and funded with a grant through the 'National Rivercare' component of the Natural Heritage Trust.

'Water is the driving force of all nature'

Leonardo da Vinci

1.2 Project brief

The brief for the project was in two parts:

- To assess the current state of the Vasse River.
- To recommend associated remedial action.

The primary purpose is to improve local knowledge of the condition of the Vasse River and to provide a prioritised Action Plan to guide coordinated management.

Drainage and flood control, although issues of concern to landholders, are not the primary focus of the project.

The Lower Vasse River and estuary are also not included as other projects, groups and agencies are addressing them under the Lower Vasse River Clean-up Program.

1.3 Aim of the study

This Action Plan describes the current state of the Vasse River and provides recommendations and management advice to address river degradation.

Public consultation has been particularly important with community meetings held and river inspections conducted with adjoining landholders.

Specific objectives are to provide:

- a benchmark against which the future work to protect and rehabilitate the river can be gauged;
- a tool to guide the limited resources available for weed control, erosion control, tree planting and rehabilitation;
- a sound technical basis for future funding or project submissions;
- an assessment of the river foreshore using the Pen-Scott technique with the information presented primarily through a Geographic Information System of mapping.

An Action Plan:

is not a statutory plan;
is not a government policy;
is not a government regulation;
has no legal stature.

This Action Plan:

records what is along the river;
indicates problem areas;
provides management guidance;
establishes benchmarks;
provides comparisons for the future;
seeks to improve local knowledge;
prioritises action planning;
produces resource guidance;
offers technical advice.

Every day one tree 'inhales' carbon dioxide and 'exhales' enough oxygen for a family of four.

American Forests

2. Study area

The area investigated extends from the headwaters just beyond Stuart Road in the Whicher Ranges near Chapman Hill through agricultural and horticultural areas north to Fairlawn Road (formerly Fairlawn Lane) in the Busselton light industrial area.



Dense bush protects the headwaters of the river (Whicher Ranges)

2.1 Catchment Physiography

Within the Geopraphe Bay Catchment are four zones or physiographic regions which are further sub-divided into soil-landscape units (SLUs). The Vasse River flows through the Donnybrook Sunkland Zone and the Swan Coastal Plain Zone.

The SLUs form irregular bands across which the river flows from the Whicher Scarp to the coast at Busselton. The watershed is along the edge of the Blackwood Plateau System.

The Vasse River traverses a number of different soil types with specific vegetation associations. Through the Donnybrook Sunkland Zone there is a combination of loams, deep sand and sandy gravel which support primarily jarrah-marri forest. On the Swan Coastal Plain Zone are low swampy flats comprised of pale deep sand, shallow loamy duplex and clay and yellow sands which support banksia and paperbark woodland, heath, tuart forest and finally samphire and sedges at the coast.

'Rivers (so called) in Western Australia are generally slight depressions in the undulating country along which water flows in winter.... In summer they are known only by those depressions being generally more thickly wooded than the surrounding country, and, at long intervals, beds of salt, pools of brine, and brackish water. There are exceptions but very few...'

Hargreaves, 1863

2.2 Climate and moisture balance

The area has a Mediterranean climate with dry, warm summers and cool winters. The rainfall ranges from 800 mm to 1000 mm per year.

Maps drawn by the Bureau of Meteorology (Tapp, 1999) and graphs of historical annual and winter rainfall from Busselton and Cowaramup (the two nearest recording stations), indicate a winter rainfall decline of 2% per decade over the past few decades (Appendices 1 & 2). Graphs for Cowaramup indicate a large decline in rainfall from the late 1960s which is consistent with other sites in the south western part of WA (Foster, pers. comm, 1999).

2.3 The river system

The Vasse is broadly classed as a 'T5 short river', or 'major creek' and is further generally classified by Water and Rivers Commission (Pen, 1997) as a 'C1 to C3'.

T5s are coastal plain rivers flowing through tuart-marri woodlands in medium to high rainfall areas.

'C1 - Landscape River - Heavily impacted by upstream and adjacent land use to the extent that most native plants and animals are extinct. However, important landscape components remain, such as river form (deep valleys, undulations), native trees and bodies of water, contributing to the character of the local area' (Pen, 1997).

'C2 - Multi-use enhancement: Highly degraded streams in rural, rural/residential or residential

land which have been or have some potential to be rehabilitated as part of the provision of local parkland or open space. In other words the stream retains its natural form, though it is highly degraded' (Pen, 1997).

'C3 - Drain - The stream has little value other than to convey water. It may be part of a drainage or irrigation scheme, it may be heavily eroded or completely channelised, lined with concrete or not and supporting a few remaining native trees and abundant weeds' (Pen, 1997).

The river begins in undulating country along the northern edge of the Blackwood Plateau in the Whicher Ranges, some 149 metres above sea level, and flows north through mixed farming and horticultural country across the Swan Coastal Plain to Geographe Bay. Most of the farmland drains into the Vasse which in turn drains into the Broadwater and Vasse-Wonnerup Estuaries behind the coastal dunes.

The Vasse Diversion Drain is leveed for 7.5 km in the lower catchment and accepts water from 65% of the Sabina River Catchment and 90% of the Vasse River catchment, diverting it away from the Vasse-Wonnerup Estuary and directly into Geographe Bay west of the Busselton township.

River training, diversion and levee banks have all assisted to change the river ecology and flow patterns. Floodgates on the estuary and in Busselton township have greatly impacted upon the flow regime of the river, assisting the accumulation of nutrients, chemicals and sediments in river pools and reducing the normal flushing effect. Drainage schemes at Vasse and Wonnerup in 1907 were part of an extensive government network of drainage channels from Perth to Busselton.

The adjoining land has problems which compound those of the river. The hydrology is out of balance due to the extensive removal of large, deep-rooted native vegetation and its replacement with low, shallow-rooted annual crops which do not use as much groundwater as the original vegetation. The water table has risen, salinity is appearing in places (during summer dried salt encrusts rocks in the river channel in the lower catchment) and waterlogging, flooding, inundation and erosion are more prevalent.

Wildlife habitats have been lost, degraded and isolated, and much of the remaining natural vegetation is unfenced from stock, grazed and not managed. The river's riparian zone is very narrow for most of its length and in some places non-existent.

Some excellent conservation fencing and revegetation work has taken place along the river using Streamlining Funding. Some landholders have contributed time and money in a conscious commitment to protect the landscape and implement best management practices in their farming enterprises. Some are keen to plant trees along their river banks and conserve remaining native species, but grazing by neighbours' stock makes this difficult.

'Damage caused by livestock to river banks of the south-west is so widespread and has occurred for so many years that it goes largely unnoticed'

Lane & McComb, 1988

2.3.1 Water quality and flow

The Vasse River has not historically attracted much attention in water monitoring terms. Its propensity to inundate agricultural land and the Busselton township has been, and remains, the focus of most attention.

Two WRC gauging stations are located in the catchment - one on the Vasse Diversion Drain near Strelly Street, and the other on the flat, alluvial plain upstream of the Vasse Research Station. Records from January 1972 to August 1998 give information on the total monthly discharge and instantaneous discharge monthly maximum.

This data is particularly relevant in light of comments from many landholders that the height and speed of delivery of peak flows has increased. Surface water flows are increasing in volume, floods move more rapidly down the catchment, water flows across roads for longer or where it has not flowed before, yet rainfall is decreasing. It is important to account for these changes.

Landholders have observed that in the 1950s, flood peaks would take 10 to 12 hours to move down the catchment. WRC confirms flood peaks now arrive in 6 hours (Pickett, R., 1999, pers comm.).

Landholders have also noted rising watertables, more frequent flooding, and longer inundation of paddocks.

In summary the community has observed:

- more surface water is moving off the catchment more quickly;
- less rain is falling on the catchment;
- less water is being used across the catchment;
- wetlands that once held water and released it slowly to the river have been drained;
- deep-rooted perennial vegetation has been removed from 80.5% of the catchment;
- soil compaction over many years reduces water absorption and increases run-off;
- Streams in the very upper catchment are fresh and overall average 200 mg/L (ppm) of salt (up to 1500 mg/L is potable water). However, dryland salinity is beginning to appear in the mid-to-lower catchment and dried salt encrusts rocks in the main river channel just upstream of Chapman Hill Road Bridge.

Lloyd Whisson, a Busselton resident, contributed notes and observations about the Vasse River, recalling his childhood experiences and his adult observations. From these it may be concluded:

- there are now greater volumes of surface water in the lower catchment and estuary;
- the increasing volume of water takes longer to dissipate from the area;
- flooding and inundation is increasing;
- fish populations are decreasing;
- river pools have filled with sediment;
- the river's integrity has been irreparably altered;
- remnant native vegetation is unable to cope with greater inundation periods;

- introduced grasses have slowed the river flow, held sediments and choked the natural flow;
- coordinated management of the whole system is badly needed.

2.3.2 Nutrient status

WRC, WC, Vasse-Wonnerup LCDC and more recently RoB have undertaken monitoring of water quality in the Vasse River. Data collected by WRC over the past three years indicates that nutrient levels (Total Nitrogen and Total Phosphorus) are moderate to high (Pickett, R. [WRC] 1999, pers. comm., 21 Dec.). The samples were predominantly above the Australian and New Zealand Environment and Conservation Council (ANZECC) freshwater guidelines (1992) of 0.1 mg/L for Total Phosphorus and 0.75 mg/L for Total Nitrogen. High nutrient levels are an indicator of poor ecological health.

As part of the National Waterwatch Program, the rivers of the Geographe Catchment were sampled in October 1999 to gain a "snapshot" of the health of our waterways. This involved nine sites across the catchment and one site on the Yallingup Brook. Total Phosphorus levels at all sites were below recommended ANZECC guidelines, except in the Sabina and Vasse rivers. In contrast, Total Nitrogen concentrations were relatively high across the catchment, with seven of the ten sites, including the Vasse River, being above ANZECC guidelines.

'The practice of river protection should aim at preventing the entrance of ecologically detrimental compounds into rivers and not impose on them a self-purification capacity which they never had as clean streams.'

Wurhamm, 1972

2.4 Vegetation structure

WA's South West is divided into Natural Resource Zones which relate to a combination of vegetation type, the drainage/catchment management system and rainfall.

The Vasse Catchment falls within two botanical subdistricts: Menzies 11 (Southern Jarrah Forest) and Drummond 44 (Swan Coastal Plain) with 700 to 1100 mm rainfall.

Menzies 11 - The low plateau of the Whicher Scarp is an undulating mosaic of pale, orange gravelly lateritic soils and sands which was at one time capped extensively with laterite. Tall forests of jarrah and marri trees prevail with bullich (*Eucalyptus megacarpa*) in the higher valley floors and areas of high open shrubland over clay. Blackbutt stands grow in the deeper lower valleys and moonah and low banksia woodland are found on damp sites.

The understorey of smaller trees and shrubs includes:

Sheoak - *Allocasuarina fraseriana*
 Bull banksia - *Banksia grandis*
 Snottygobble - *Persoonia longifolia*
 Woody pear - *Xylomelum occidentale*
 Zamia - *Macrozamia reidlii*
 Grasstree - *Xanthorrhoea preissii*
 Kingia - *Kingia australis*
 Tree hovea - *Hovea elliptica*
 Pineapple bush - *Dasypogon hookerii*
 Pepper and salt - *Eriostemon spicatus*
 Prickly Moses or
 Blackwood curse - *Acacia pulchella*

The lower, sandier slopes of the escarpment grow low open forest with candle and holly-leaved banksias (*Banksia attenuata* and *B. ilicifolia*) and Christmas tree (*Nuytsia floribunda*).

Drummond 44 - There are three distinct landforms: foothills, alluvial plains and coastal dune systems. Water forms are a feature with swamps, wetlands, meandering rivers and streams and coastal estuaries. The foothills are the remains of the shelf of the Blackwood Plateau where the Vasse River begins. These give way to an alluvial plain with long open views and pale soils through which the river and its tributaries meander.

The original vegetation consisted of lush, towering forests, remnants of which remain and include:

Marri - *Corymbia calophylla*
 Jarrah - *Eucalyptus marginata*
 Blackbutt - *Eucalyptus patens*
 Flooded gum - *Eucalyptus rudis*
 Swamp paperbark - *Melaleuca rhapsiophylla*
 Peppermint - *Agonis flexuosa*
 Christmas tree - *Nuytsia floribunda*

The understorey includes:

Sheoak - *Allocasuarina fraseriana*
 Grasstree - *Xanthorrhoea preissii*
 Kingia - *Kingia australis*
 Candle banksia - *Banksia attenuata*
 Holly-leaved banksia - *Banksia ilicifolia*
 Zamia palm - *Macrozamia reidlii*

2.5 Vegetation cover

Using satellite imagery, the total native vegetation cover in 1995 was assessed at 19.5 % of the total area of the Vasse River Catchment (Fig. 2). This figure is based on the area of vegetation on private land and the total area of public land, not all of which is vegetated.

Comparisons may be made with native vegetation remaining in the following Shires of the Blackwood Catchment:

Broomehill	7.2%
Wickepin	8%
Wagin	8.5%
Katanning	9%
Woodanilling	11.2%
Narrogin	15.25%
Kojonup	15.5%
Vasse River Catchment	19.5%
West Arthur	29%
Kent	30%
Williams	32%

(Grein, 1994)

It is the intention of several Vasse landholders to continue to clear parts of their properties in the near future.

Results from the National Agricultural Land Cover

Change Project 1990 - 1995

Vasse River Catchment

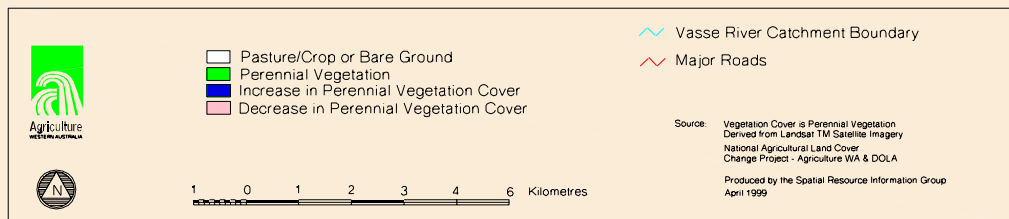
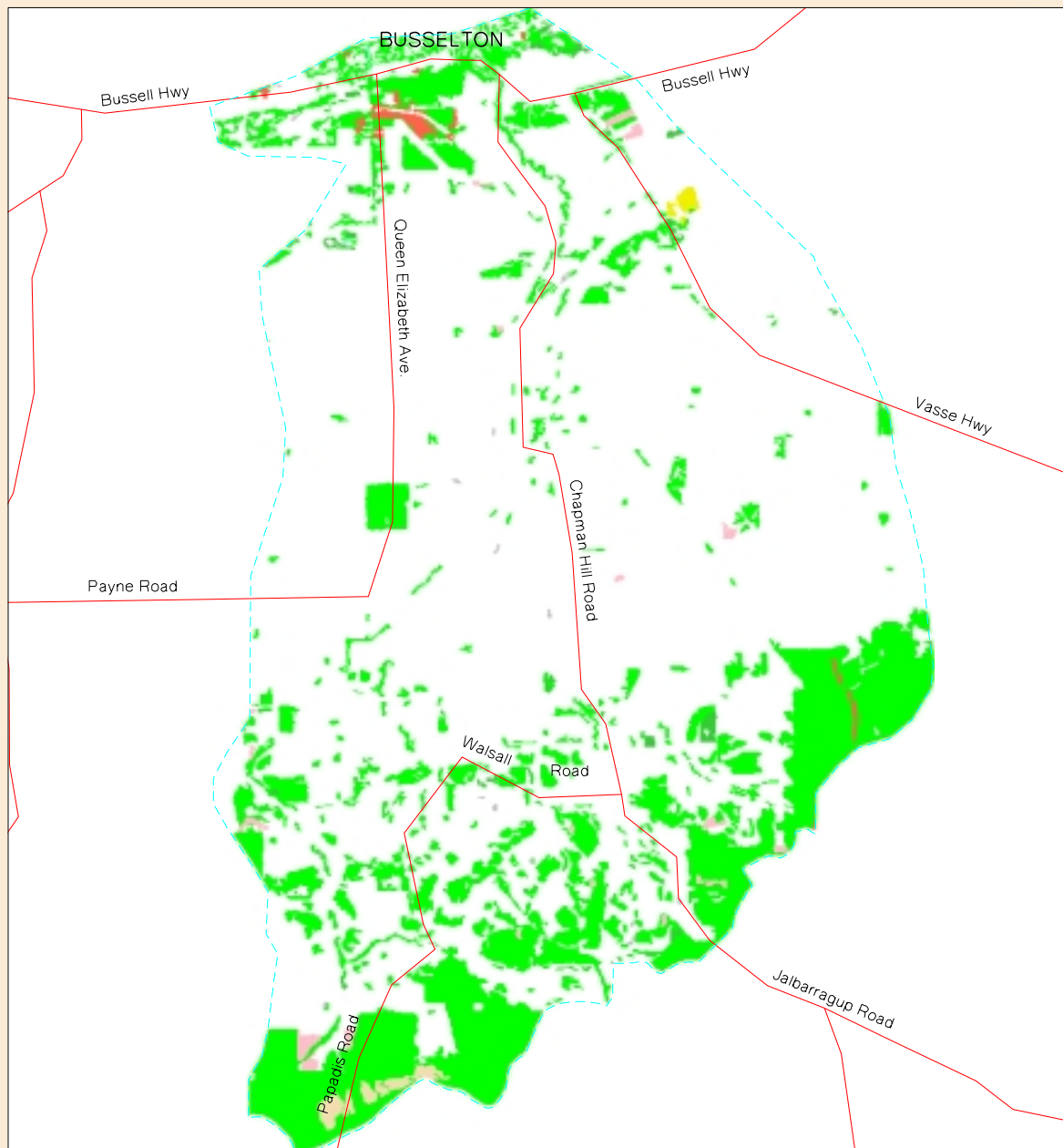


Figure 2: Native vegetation remnants of the Vasse River Catchment: National Agricultural Land Cover Change Project 1990 - 1995.

2.6 Fauna

Landholders have observed the following species, often due to cat kills rather than observations in the wild:

Brush-tailed phascogale - *Phascogale tapoatafa*

Bush rat - *Rattus fuscipes*

Chuditch - *Dasyurus geoffroii*

Common brush-tailed possum - *Trichosurus vulpecula hypoleucus*

Native water rat - *Hydromys chrysogaster*

Ring-tailed possum - *Pseudocheirus occidentalis*

Southern brown bandicoot - *Isodon obesulus*

Western grey kangaroo - *Macropus fuliginosus*

Dugite - *Pseudonaja affinis affinis*

Tiger snake - *Notechis scutatus occidentalis*

Freshwater mussels - *Westralunio carteri*

Frogs – approximately 12 species

Lizards - *Ergenia luctuosea* and *pulchra*, and *Leiopisma trilineata*

Turtles - *Chelodina oblonga*

Dusky moorhen - *Gallinula tenebrosa*

Eurasian coot - *Fulica atra*

Pacific black duck - *Anas superciliosa*

Port Lincoln parrot - *Barnardius zonarius*

Robins - *Peteroica* spp. and *eopsaltria* spp.

Wedge-tailed eagle - *Aquila audax*

White-tailed black cockatoo - *Calyptorhynchus latirostris*

Wrens - *Malurus* spp.

Introduced European feral species:

Black rat - *Rattus rattus*

Brown rat - *Rattus norvegicus*

Feral cat - *Felis catus*

Feral pig - *Sus scrofa*

Fox - *Vulpes vulpes*

House mouse - *Mus musculus*

Rabbit - *Oryctoagus cuniculus*

Kookaburra - *Dacelo gigas* – is an introduced predator from the Eastern States.

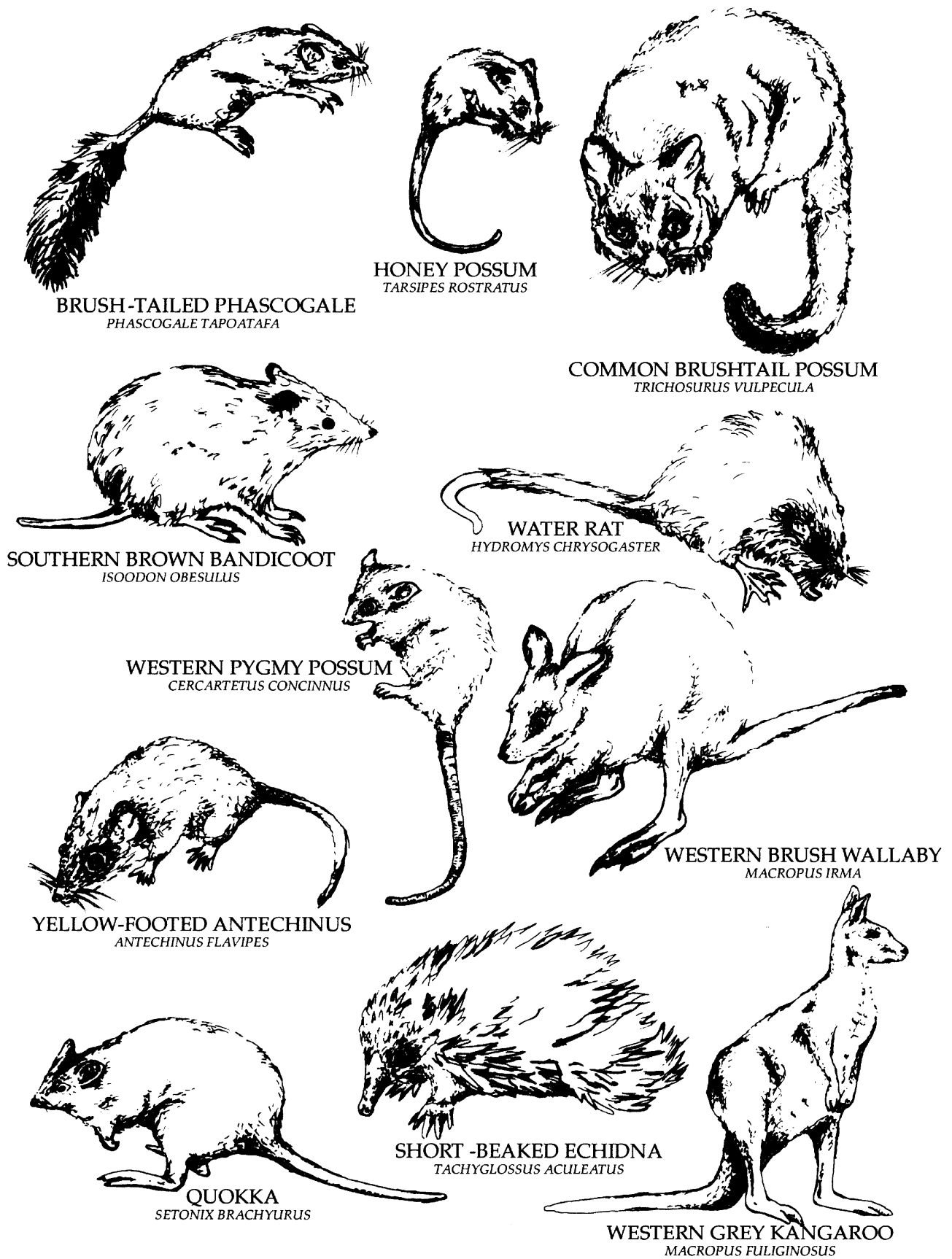


Figure 3: Major fauna species likely to be found in the catchment. Many of these animals have been sighted by landholders along sections of the Vasse River. Drawings courtesy of P. Taylor; Pawl Productions.

2.7 Heritage

2.7.1 Aboriginal heritage

While there are no Aboriginal sites currently listed along the Vasse River, it is possible that there are sites that have not yet been entered on the Aboriginal Sites Register.

George E Webb of Busselton, Aboriginal Elder of the Wardandi Tribe, and his wife Vilma Webb, provided the following recollections:

'My job for sixteen years was clearing the rivers and drains of blockages. We had some five to six hundred kilometres of waterways to maintain along roadway verges, through farms, and sometimes through thick and grassy woodlands.

"A lot of Aboriginals used to camp on either side of the Vasse Estuary and River, right up to where the Vasse Diversion Drain begins and flows to the sea north west of Busselton. Along the river, just upstream of the Strelley Street bridge, was where the Aboriginals used to camp facing east. Another camp site was where the river turns south about two hundred yards - halfway to the old Dutch house (New Holland) by the Vasse River.

"Our Aboriginal Nyungar people used to spear and trap fresh water fish - mullet, bream, eels, pilchards, cobblers - and get lots of mussels and turtles, and turtle eggs to eat from the Vasse River."

George's memories are included in a book by J Kinsella (1990) *Southern Enterprise: The Story of Henry John Yelverton and his Sawmills*.

2.7.2 European heritage

Vasse was the name of a French sailor who disappeared in the region in 1801 from an expedition sent to explore the coast of 'New Holland'.

A small colony of settlers was established at Augusta in 1830, the understanding being that they were to fend for themselves and establish subsistence farming enterprises. The Molloys and the Bussells later relocated along the Vasse River to Cattle Chosen and Fairlawn. The forest there was easier to clear and the settlers followed

the Aboriginal pattern of burning to promote grasslands for grazing. They described the land as having a 'park-like appearance' and being covered by 'fields of grass'.

Running parallel to the river for much of its length, is the Augusta-Busselton Heritage Trail which is part of a statewide network of trails established to commemorate the Bicentenary in 1988. Approximately 100 km long, the trail retraces the pioneer route from Augusta to the Vasse and incorporates:

- the historic Augusta site of Georgiana Park - site of Molloys' first house in 1830;
- the Adelphi house site of 1831 near Alexandra Bridge;
- Chapman Brook where the original track crossed near the existing bridge;
- the rapids where the original track crossed the Margaret River;
- Crossing the watershed between the Margaret and Vasse Rivers;
- Chapman Hill camp site of the pioneer travellers;
- Canebreak Pool picnic site;
- Cattle Chosen and Fairlawn;
- Busselton Jetty and beach where settlement was established in 1834.

Over the years, wide-scale clearing, broad-acre cropping, fertilising, draining, filling wetlands and irrigation placed huge demands upon the environment. Expectations of the land were high and sometimes two or more crops were expected per year.

Town settlement cleared more of the land as did railways, roads, bridges, mining, dams and weirs. Fresh drinking water was plentiful and taken for granted. Dams and weirs were constructed to give continuous supplies.

During the immediate post World War 1 period (1924), the English and Australian Governments settled U.K. residents in forest areas in the south west of WA. Families were given assisted passage and 12 months experience on an area of uncleared land. After the 12 months suitable families were selected to continue on the scheme. (Roberts, 1944 cited in Olsen and Skitmore, 1991).

2.8 Population

Geographe Bay Catchment, which includes the Vasse River Catchment, has a population of approximately 25,000 and a population growth rate of approximately 5% (Sh Bsn, 1999), one of the highest nationally.

The bay is very popular with tourists; some 1.5 million visit the area annually making tourism a growth industry with important economic and employment benefits for the catchment as a whole, and increasing the pressures upon a fragile environment (GBAC, 1994).

The pressures of urban residential development now extend to the farming lands nearest the town, increasing land values and rates and reducing farm viability.

Small rural holdings replace larger enterprises, mineral sand mining extracts the natural resources prior to the inevitable subdivision. Horticultural crops have begun to replace traditional stock and broadacre crops, and the remaining farmers are facing a major paradigm shift to remain on the land.

2.9 Land tenure

'Soil is the most fundamental resource, and its loss, the most serious of all losses. The day will come, when ownership of land will carry with it the obligation to so use and protect it with respect to erosion that it is not a menace to other land owners and the public.'

Aldo Leopold

Land tenure varies along the Vasse River. 'Old' titles extend to the centre of the river and a few of these still exist in the lower reaches including those of the historical properties known as

Cattle Chosen (P0014199 41) and Fairlawn (P004589 164, 166, 168). Further upstream the river either passes through privately owned titles or flows within a surveyed drain reserve vested in the Water Corporation. There is one Crown Reserve (D042478 24) below the penstock.

P004065 16 is a roadway surveyed in early days from Lindberg Road to allow a farmer with no river frontage to access water. This narrow strip has its own title and maps indicate it crosses to the far side of the river. Green Gully (the Sabina Diversion Drain) has also been surveyed and has its own title number P005398 0.

2.9.1 Drain Reserve

In some areas the river is contained within the surveyed Drain Reserve and in other places it wanders from it. Sometimes this has occurred since the original survey, the river having changed its course naturally over time.

The properties that either border or contain the Reserve are as follows:

P021150 6, P004065 4, P004065 16, P005398 0,
00283, 00126, 00282, 00333, 00337, 00872,
02063, 02064, 02065, 02069, 02070,
02115, 02116, 02117, 02120, 02121, 02122,
02123, 02124, 02321,
03000, 03005, 03693, 03858,
04935, 04945,
05074,
D062211 2, D060223 3, D082442 1, D048466 1,
D055936 26, D086539 4.

The following properties neighbour the river but neither adjoin, nor contain, a surveyed Drain Reserve:

P004065 4, P004589 168 166 164, P014199 41,
00515, 00635,
01321,
02691, 02692, 02698, 02699, 02700, 02992,
02994,
03004,

D050242 25, D051513 26, D055936 26, D059185 1, D060223 5, D065705 60, D068582 42, D068582 43, D071543 6, D084895.

Drain Reserves along the Vasse River are vested in the Water Corporation, which has the following powers under the Land Drainage Act, 1925:

'Any person who shall deface, damage or injure in any way, or without lawful authority use or occupy any land, work, or property whatsoever owned by, vested in, or under the care, control, or management of the Corporation shall be liable to a penalty not exceeding \$500, and may be ordered by the convicting justices to pay to the Corporation in addition to such penalty, the cost and expense of making good any damage or replacing any property destroyed: Provided that this section shall not protect or exempt any such person from the provisions of any law relating to injuries to property.'

2.10 The community

Along the river the adjoining land is mostly used for grazing beef and dairy cattle with some sheep and horses. Pasture is cut for hay and some fodder crops are grown. The river's riparian zone is grazed for most of its length despite good fencing and Drain Reserve regulations.

Adjacent to the river in the upper catchment are two viticultural enterprises and a large gravel extraction site. In past years potatoes were grown on the flats below the gravel mine.

In the lower catchment are the Busselton Golf Club, mineral sand mining leases and urban developments such as the new housing estate and the proposed Busselton Bypass Road across the river with accompanying nutrient and sediment stripping ponds.

Drains to alleviate flooding and inundation of farming lands and the Busselton township have impacted heavily on the river for many decades. The first work to drain land for group settlement around Vasse and Wonnerup began in 1907 (Olsen & Skitmore, 1991).

'Whilst it would be unrealistic to suggest that flow regulation and diversion be done away with so as to regain nearly pristine river conditions, it is quite feasible to suggest that our planners who seek to regulate river levels at least attempt to develop better programs of environmental flows down our rivers'

Moore, 1989

Future developments may include a variety of agroforestry projects, fodder tree plantings, and commercial tree plantations.

2.10.1 Vasse-Wonnerup Land Conservation District Committee

Land Conservation District Committees are voluntary statutory bodies established under the Soil and Land Conservation Act. They are empowered to report on local soil and land conservation issues to the Commissioner of Soil Conservation. Representation includes farmers, farmer organisations, relevant government agencies, and community groups.

The Vasse-Wonnerup LCDC has been particularly active over the years it has operated, and the following list of their activities and initiatives bears testimony to their endeavours for, and commitment to, the Vasse River Catchment:

- Nutrient management - bus trip, study tour, developing fertiliser management guidelines for the Swan Coastal Plain;
- Farm trees - bulk ordering;
- Farm planning;
- Education;
- Arboretum establishment;
- Salinity survey;
- Dairy effluent;
- Soil survey - soil testing for more efficient fertiliser use;
- Fertiliser trials - analysing the benefits of alternative sulphur sources;
- Pest control - grasshoppers, foxes, rabbits;
- Drainage control;
- Stream water monitoring 1995;
- Fencing river – Vasse;

- Farm planning demonstration;
- Vegetation corridor establishment;
- Ruabon Tutunup Rail Reserve Preservation Group - assisted the formation of the group;
- Weed control - arum lily, bridal creeper, prickly pear;
- Streamlining river – Vasse;
- Vasse River Catchment Survey 1997;
- Wildlife Vegetation Corridors Workshop 1998;
- Vasse River Action Plan 1999.

The LCDC put in place two experimental biofilters to manage dairy waste. Results showed up to 90% reduction of nutrients in water leaving the dairies.

In 1992 the LCDC began field trials to test the sources of sulphur other than superphosphate as an agricultural fertiliser. Results showed coarse gypsum to be suitable.

Stream monitoring began in 1991 (continuing into 1992 and 1993) when the Vasse was

sampled at three locations in the upper, middle and lower catchment. The aim of the sampling was to test the levels of phosphorus and highlight where the nutrient was entering the system. It showed that the upper catchment had low nutrient levels, which increased downstream as the river flowed through the sandy soils of the agricultural areas along the coastal plain.

In 1997 the Vasse River Group conducted a survey amongst landholders to assess the scale and diversity of work needed in the catchment, to identify the support needed for the work to be done, and to assist landholders in obtaining support to commence the work.

Key issues for the Geographe Bay Catchment have been identified by local LCDCs as communication, water management and weed control.



Catchment and community members at the Vasse River Action Plan Workshop, 20 May 1999

3. Study methodology

3.1 Community involvement

The River Action Plan was developed largely through public consultation.

Community meetings were held and river inspections conducted with adjoining landholders.

There are 65 titles adjoining the river (Fairlawn Road to the Whicher Ranges watershed) involving 36 owners (plus partners and associates). Twenty-two owners assisted directly in surveying their part of the river, giving their views, explaining their concerns, and offering information. The remaining owners were all contacted by phone, letter or visits. Most assisted in the completion of the survey form and selected the appropriate grading for their river reach.

In consultation with the landholders, a streamline assessment system was used to prepare maps which describe foreshore conditions over large areas.

Further public consultation took place at a workshop presentation of the Draft River Action Plan.

3.2 Assessment technique

The river foreshore or riparian zone was assessed using a technique developed by Dr Luke Pen.

River conditions are classified into one of four grades, A to D, and further into sub-levels 1 to 3. The gradings cover pristine, weedy, erosion prone and ditch. The levels within each grade are easily recognised from the descriptions and diagrams in *Stream Foreshore Assessment in Farming Areas* (Figure 2, Pen & Scott, 1995).

Other information collected included fencing status, fauna and weed observations, historical information and landholders' concerns and opinions.

The grading system is outlined below and represented in Figure 4, while Figure 5 depicts the immediate river valley and the terms used to describe its form.

A grade foreshore: Pristine to near pristine

A1 Pristine - embankments and floodway are entirely vegetated with native species and there is no evidence of human presence or livestock damage.

A2 Near pristine - native vegetation dominates but introduced weeds are occasionally present in the understorey, though not to the extent that they displace native species.

A3 Slightly disturbed - areas of localised human disturbance where soil may be exposed and weed density is relatively heavy, such as along walking or vehicle tracks. Otherwise, native plants dominate and would quickly recolonise disturbed areas should human activity decline.

B grade foreshore: Weed infested but tree cover still largely present

B1 Degraded, understorey mainly natives - weeds have become a significant component of the understorey vegetation. Although native species remain dominant, a few have probably been replaced or are being replaced by weeds.

B2 Degraded, understorey 50 per cent weeds - understorey weeds are about as abundant as native species. The regeneration of some tree and large shrub species may have declined.

B3 Degraded, understorey weed dominated - weeds dominate but many native species remain. Some tree and large shrub species may have declined or disappeared altogether.

C grade foreshore: Erosion prone to eroded

C1 Erosion prone - trees remain, possibly with some large shrubs or grass trees, but the understorey consists entirely of weeds, mainly annual grasses. Most of the trees will be of only a few resilient or long-lived species and their regeneration will be at most below replacement level or at worst negligible. In this state, where the soil is supported by short-lived weeds, a small increase in physical disturbance will expose the soil and render the river embankments and floodway vulnerable to erosion.

C2 Soil exposed - annual grasses and weeds have been removed through heavy livestock damage and grazing or as a result of recreational activities. Low level soil erosion has begun by the action of either wind or water.

C3 Eroded - soil is washed away from between tree roots, trees are being undermined and unsupported embankments are subsiding into the river valley.

D grade foreshore: Ditch to drain

D1 Ditch, eroding - fringing vegetation no longer acts to control erosion. Some trees and shrubs remain and act to retard erosion in certain spots but will be undermined eventually.

D2 Ditch, freely eroding - no significant fringing vegetation remains and erosion is completely out

of control. Undermined and subsided embankments are common, as are large sediment plumes along the river channel.

D3 Drain, weed dominated - the highly eroded river valley has been fenced off, enabling the colonisation of perennial weeds. The river has become a simple drain, similar, if not identical, to the typical major urban drain.

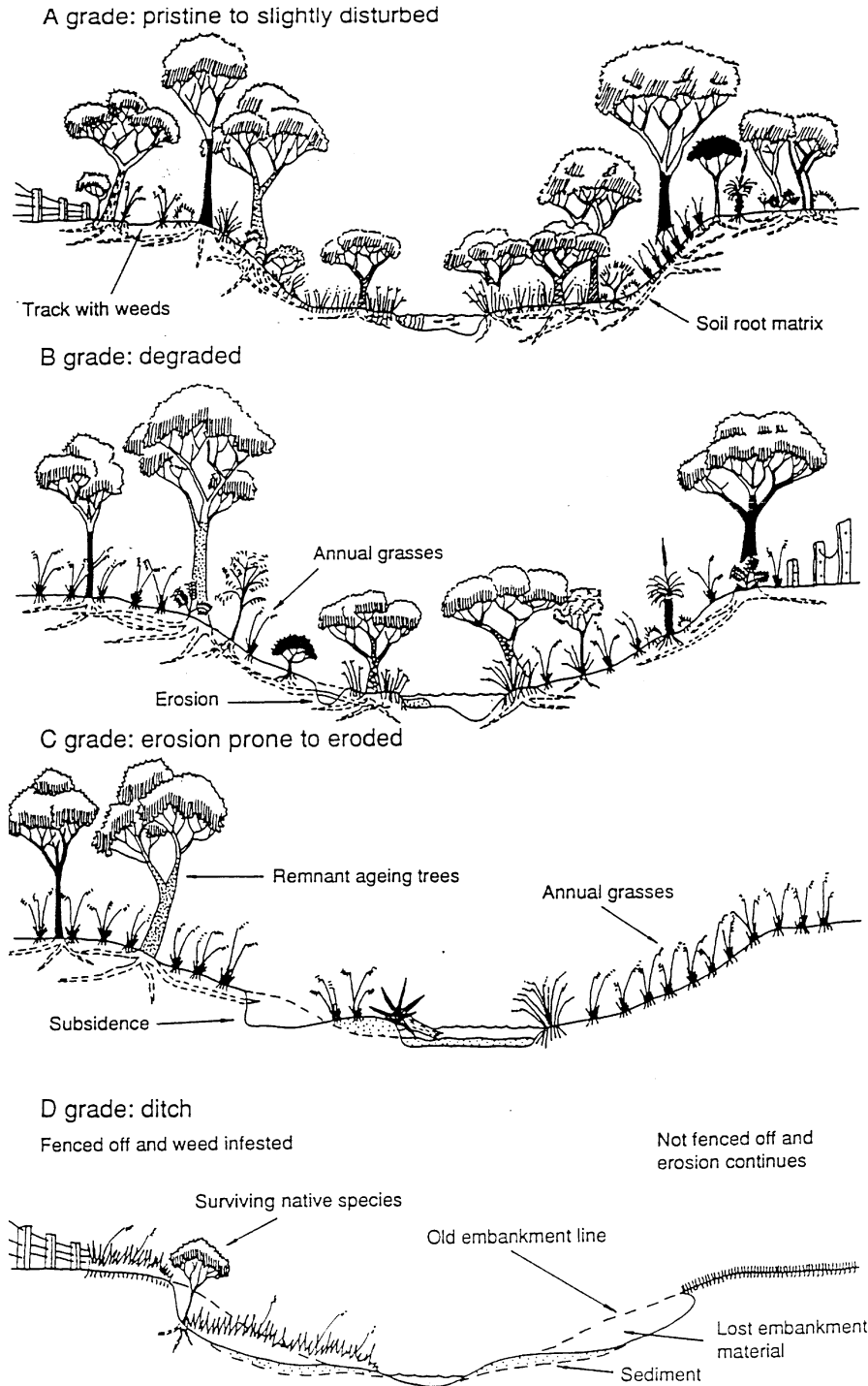


Figure 4: River foreshore stages of degradation - A (pristine) to D (ditch)

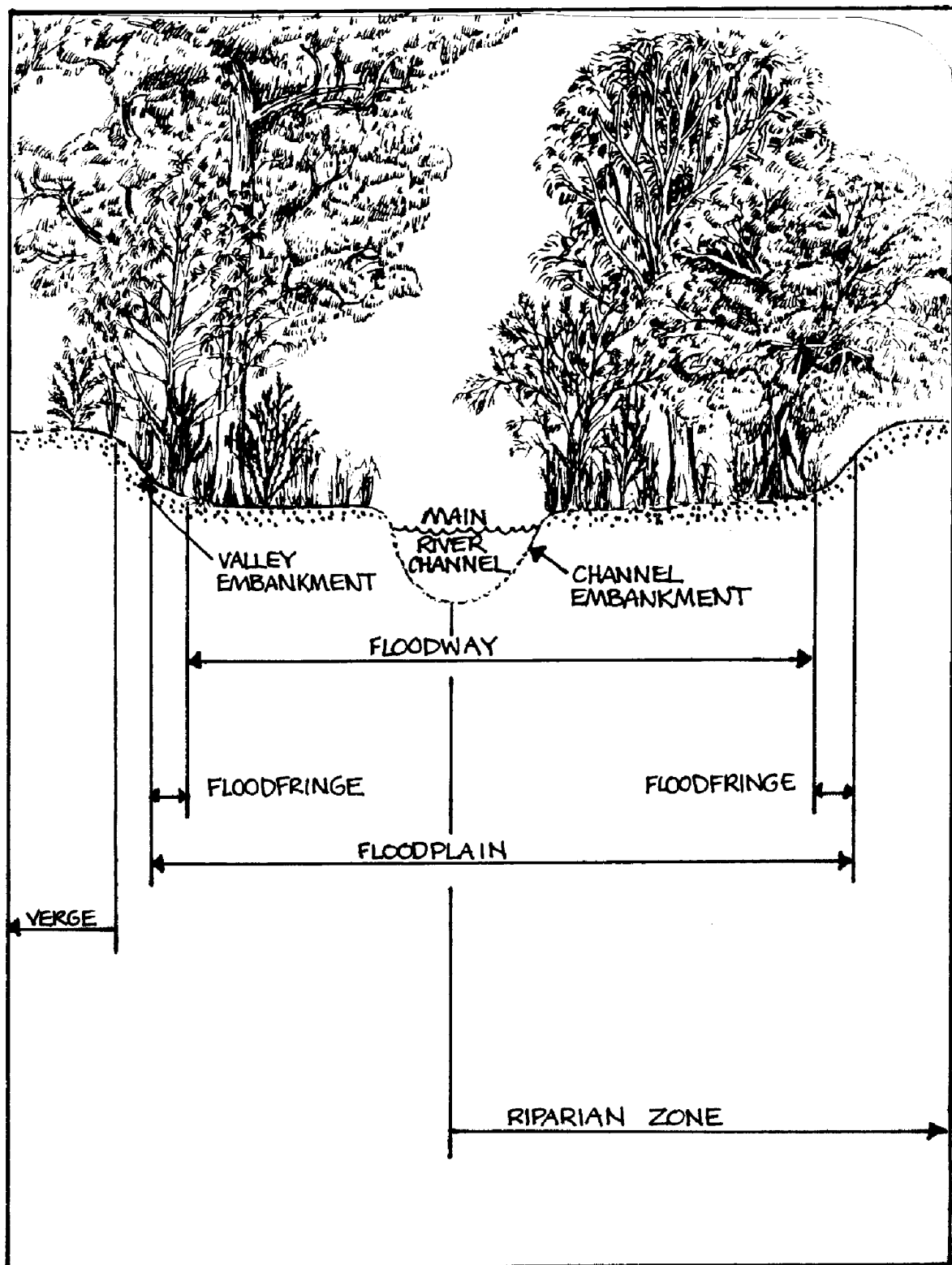


Figure 5: The immediate river valley and the terms used to describe its form.

4. Management issues

4.1 Landholder issues, interests and concerns

The following issues, interests and concerns were expressed by landholders.

- Unchecked upstream weed infestations. Who has or should have eradication responsibilities? Need for a weed management strategy, weed identification books, weed eradication information and funding assistance.
- Unwanted grazing and watering from the riparian zone - control of stock grazing across the river, stock grazing revegetation areas, overgrazing and severe bank erosion threatening fencing, grazing as a management tool for the reduction of fire risk, achieving a balance between grazing and flora and fauna communities, enriching nutrients.
- Property boundary disputation - definition and resolution.
- Revegetation - establishment techniques, pest control (rabbits, grasshoppers, parrots, kangaroos), local seed collection techniques, growing seedlings, smoked water technique for direct seeding establishment, direct seeding techniques, plant species to hold the river banks, understory species to use, commercial species to establish, fodder species to establish, information on revegetation funding schemes, free tree supplies, the loss of filtering vegetation from the riparian zone along the river's edge.
- Hydrology - increasing peak flows, increasing paddock inundation, identifying groundwater recharge areas, impacts of slowing water flow.
- Channel management - impacts of sedimentation of the river channel, impacts of vegetation blocking the river channel, defining responsibilities for maintaining a free flowing channel, impacts of bank erosion, sediment deposits from the erosion of tributaries and river banks.
- Water management - defining management of the penstock, the check boards and the floodgates, defining responsibilities for and coordination of these features.
- Erosion of firebreaks and gullies - strategic placement, alternatives to cultivation, review of the shire firebreak policy, roads as firebreaks, techniques for the repair of gully erosion.
- Fire risk in riparian zones - native vegetation hazards versus weed hazards.
- Fencing - options for types of stock crossings, fencing options, funding for fencing.
- Need for better communication on funding and other information - available funding, funding criteria, funding sources, accessing funding, accessing information.
- Chemicals - correct chemical selection advice, safe chemicals to use near waterways, availability of chemicals in small quantities, protective clothing instructions, effects of chemicals on animals, humans, wildlife and vegetation, correct application rates, polluting chemicals washed into the river from various rural and urban sources.



Debris from upstream creates a problem for downstream landholders when it diverts flow away from the main channel.

4.2 Channel stability and soil conservation

The river channel has changed due to natural flow patterns, alterations in the volume of water and sediment, human modification and stock management.

Vegetation along the waterway has significant roles - stabilising banks, filtering sediments, slowing floods, reducing flood peaks, dissipating the erosive energy of flowing water, reducing erosion and sediment build-up, binding soil, promoting better infiltration of rain and helping to reduce sub-surface water levels.

Understorey vegetation stabilises river banks by forming a deep root mat along the surface of the banks, while the trees provide the deep anchor points. Together they utilise the water infiltrating the banks and keep them from becoming saturated and slumping into the river channel due to the bulk weight of water in the soil.

Removal of vegetation exposes the soil to direct impact from rain drop shatter and to erosion where roots no longer bind it together. It also increases the sediment load within the river. Sedimentation has filled summer pools and caused reduced channel depth, increased channel width, flooding, inundation, bank erosion, bank collapse and loss of agricultural land and fencing.

4.3 Loss of soil and nutrients

The sandy soils in the catchment do not hold nutrients well and allow them to leach quickly into the high water table. They also efficiently drain the enriched and polluted underground water into the river, estuary and bay. Nutrient loads in the Vasse-Wonnerup wetlands system are the largest measured in any waterbody in south west WA (McAlpine et al 1989).

Vegetation along the river channel acts as a buffer to sediment, nutrients and other pollutants entering the water. The effectiveness of the zone is dependent upon its width, other on-site impacts such as grazing, and the volume and type of pollutants.

Grasses in the riparian zone are particularly efficient at holding sediment particles and using attached nutrients that would otherwise pollute

the river. Sedges and rushes are valuable along the river's edge for this reason and for their capacity to bind the soil within their root mat. Riparian vegetation can completely remove nitrogen by altering nitrates to nitrogen gas. It may also bind and sequester heavy metals (Mitch and Gosselink, 1986, cited in Odum, 1990).

Grazing stock trample and consume vegetation which severely reduces the efficiency of grasses and thick understorey vegetation to minimise surface water run-off, filter water into the soil and make maximum use of excess nutrients. It is estimated that nitrate may be removed in sub-surface flows at the rate of 45 kg per hectare (Peterjohn & Correll, 1984). Effective absorption of nutrients from riparian vegetation can be limited by growth requirements and later by plant decay when the nutrients are recycled back into the water.

4.4 Water quality

Phosphorus occurs naturally in most waterways in tiny concentrations. High levels can often be measured at high water flows, particularly the first flows of the season. There are many sources including sewage, fertilisers, industrial effluent and stormwater drainage. Nitrogen has similar sources to phosphorus and can cause similar problems when in excess.

Nutrient-rich water flows from catchments promote the excessive growth of algae during spring and early summer until the supply of nutrients is exhausted or until conditions supporting algal growth deteriorate. The algae then die and are consumed by aquatic organisms. In the process, the water's oxygen levels are reduced which can lead to the death of fish and crustacea.

Decaying algae can also smother the channel bed and cause the death of other micro-algae and aquatic flora, causing putrid and noxious gases to be released with decomposition. Blue-green algae produces a powerful toxin that can poison aquatic and terrestrial fauna. Stock drinking from water contaminated by blue-green algae may fail to thrive, and in some cases may even suffer liver damage.

Conditions improve with winter flows of fresh oxygenated water, but the cycle begins again in spring.

River pools also suffer from nutrient enrichment and algal growth during late summer where water levels are low and the water column is warm. Water condition can improve within hours of fresh winter rains falling, but impacts on aquatic fauna are not visible until macro-invertebrate and phytoplankton sampling is undertaken. Recovery at this level, if it occurs at all, is very slow.

Community water monitoring can accurately monitor changes. Professional guidance from the WRC can assist in developing an appropriate monitoring regime conforming to Australian Standards of Water Quality Monitoring.

4.5 Loss of fauna

Indigenous vegetation and wildlife habitats have been lost and fragmented throughout the catchment due to clearing, grazing, burning and land degradation. Domestic and feral animals, people and changed burning regimes have all contributed to the decline of native wildlife.

All cats, even pets, hunt by instinct, and most wildlife is killed by roaming pet cats, often not far from home. They reduce wildlife populations by predation, disease and competition. Cats' mouths are full of bacteria, and one bite to a native animal leads to rapid spread of infection. Cats carry toxoplasmosis, a protozoan disease which can devastate wildlife populations. Often a captured bird or animal will appear undamaged, but almost certainly will die within thirty six hours from shock or infection.

Infestations of rats and mice are more efficiently eradicated by traps and household poisons containing anti-coagulants, than by cats. Cats are not a deterrent to snakes. Snakes are native wildlife, protected by law, and can kill cats (Conservation and Environment Victoria, 1992, *Protect your Cat, Protect your Wildlife*).

One third of Australian households have at least one cat.

If a cat ate only native animals it would need about 3,600 a year to survive.

Bureau of Rural Resources Information Kit

4.6 Degradation of the riparian zone

Approximately 80% of natural vegetation has been removed from the Vasse River Catchment, mostly for farming, but also for roads, railways, power lines, urban and rural living, industry, mining and recreation.

Remnant vegetation is fragmented, denying flora and fauna the linkages for dispersal and movement required for changes in their range. Vegetation loss drastically reduces the surface area on which rain falls and, in consequence, evaporation from those surfaces. It increases the volume of water reaching the river and reduces the time it takes to flow there.

Vegetation along streams is vital to recycle and store nutrients and other pollutants. It is a critical factor in soil conservation and, in the context of the wider catchment, helps to maintain rainfall patterns. Within the vegetation may be rare plant, animal, insect and reptile species important to retain for genetics, biodiversity and ecosystem maintenance. Successful water conservation and management is dependent upon its continued and increased presence.

52% of Australia is classified as degraded and in need of repair.

Department of Environment, Sports and Territories

4.6.1 Uncontrolled grazing

Many landholders along the Vasse River continue to graze their stock along and in the river. This causes loss of vegetation which leads to the erosion of the banks and of farming land. This in turn creates areas of sedimentation downstream for other landowners to resolve. Stock contribute weeds and nutrients which also add to the problems downstream, including that of spreading disease.

The following grazing estimates have been calculated by the Vasse Research Station to assess the grazing value of the riparian zone in their adjoining Drain Reserve based on the information opposite.

“It is estimated that the reserve contains 3 ton per hectare of dry matter. A 400 kg steer eats 12 kg of dry matter per day. Therefore 100 steers will have 2 days grazing per hectare.

“Given the shading effect of the trees along the reserve, the usual 21 day grazing cycle would need to be extended to 40 days.

“If only couch and kikuyu grow below the trees, their protein value is low at 7 - 8%. Clover-based pasture would increase the protein levels to 10 - 11%.”

F Coupar, unpublished 1999

The grazing value of that small strip of land along the river is minimal - a very small sacrifice to make for the future of the river and for the improved health of the animals.

4.6.2 Stock watering

When stock drink directly from a stream the water is contaminated by the animal's excrement. There is a greater risk of the transfer of disease, particularly Leptospirosis and Bovine Virus. Silt, manure, algae and other substances make the water less attractive and less palatable. Stock tend to drink less and produce less beef and less milk.

Some farmers maintain their stock do better when the water is oxygenated and will pump water up to a tank letting it gravity feed down again simply to achieve greater oxygenation of the water.

4.6.3 Weed invasion

The list of weeds below was compiled from information supplied by landholders from observations during the Vasse River Assessment. Some landholders use chemicals, grazing, slashing and burning to control these weeds, while others do not control the weeds at all. Many of the landholders have expressed their concern about the necessity for good weed management along the river and have related their frustration at trying to control weeds that continue to flow down to them from upstream.

Various tributaries contribute different weeds to the main river channel confirming the need for a coordinated weed management strategy across the whole catchment for any eradication and control methods to be really effective.

The weeds are listed in prioritised groups for eradication and control. For more detailed descriptions of the weeds refer to *Western Weeds - A Guide to the Weeds of Western Australia* (Hussey et al, 1997).

Declared plants: Serious, invasive weeds needing immediate control and eradication.

Arum lilies (*Zantedeschia aethiopica*) - declared plant from Africa

Blackberry (*Rubus fruticosus*) - declared plant from Europe

Cape tulip (*Homeria flaccida*) - declared plant from Africa

Pest plants: Serious, invasive weeds needing immediate control and eradication

Bridal creeper (*Asparagus asparagoides*) - extreme pest plant from Africa - ‘...one of the State's most urgent environmental problems.’

Pampas grass (*Cortaderia selloana*) - pest plant from South America

Significant weeds needing control and eradication.

Afghan melons (*Citrullus lantanus*) - pest plant from Africa

Bracken (*Pteridium esculentum*) - serious weed plant from WA - colonises well on disturbed sites.

Dock (*Rumex bucephalophorus* and *R. crispus*) - pest plant from Europe & Asia; control when revegetating.

Prickly paddy melons (*Cucumis myriocarpus*) - pest plant, South Africa

Cumbungi bulrush (*Typha orientalis*) - invasive wetlands/river bank coloniser from E Australia

Variiegated thistles (*Silybum marianum*) - an agricultural/forestry weed from Southern Europe

Castor oil plant (*Ricinus communis*) - poisonous seeds from Africa

Others: Serious invasive weeds needing control and eradication.

Giant reed (bamboo) (*Arundo donax*) - wasteland coloniser from Southern Europe and Asia

Watsonia (*Watsonia bulbifera*) - serious weed for wetlands and rivers from South Africa

Nuisance weeds

Nightshade (*Solanum americanum* and *S. nigrum*) - common weed, America and Europe

Baby's tears (*Soleirolia soleirolii*) - low, spreading, wet area weed from S Europe

Plants requiring control when establishing new vegetation

Couch grass (*Cynodon dactylon*) - invasive tropical plant from Kimberleys and worldwide

Kikuyu grass (*Pennisetum clandestinum*) - invasive plant from tropical America, India, Africa

Pasture grasses

Lovegrass (*Ehrharta calycina*) - serious weed invader, South Africa

Woody weeds requiring control with a chemical 'cut and dab' method. (While they may not be spreading, they contribute nothing to the river ecosystem.)

Fig trees (*Ficus carica*) - invasive plant from Mediterranean and the Middle East

Weeping willow tree (*Salix babylonica*) - serious creek line weed from China

Yorkshire Fog (*Holcus lantanus*) - common weed from Europe, NW Africa, temperate Asia

Yukka (*Yucca aloifolia*) - garden escapee from SE USA

Weeds cause an estimated loss of \$3 billion each year to primary production.

Information for Landcare Month, 1994

4.7 Fire hazard

While a balance has yet to be struck between burning for fire protection and maintaining bush for habitat and species conservation, some general principles are well recognised.

Frequent burning of bush denies most plants the opportunity to reach maturity, seed and continue the species. Many plants need five to seven years or more to produce their first seeds.

Consequently, the most resilient species (usually trees) survive, but even these are seldom replaced by young seedlings in a regime of annual burns.

Any reduction of the understorey, or disturbance of the leaf litter mulch below trees and shrubs, allows weed invasion. Weeds out-compete most native species and annual burning promotes their seeding. With an understorey of flash fuels like wild oats, lovegrass or veldt grass, roadsides, reserves and drains catch fire easily, burning fiercely and spreading quickly.

Currently the Fire and Emergency Services Authority are producing a manual which seeks to address the complexities of all of these issues (FESA, 1999). In 1998 the Ruabon Tutunup Rail Reserve Preservation Group drafted a concise Fire Management Plan for the Reserve. The plan aims to demonstrate fire management techniques, including aspects of human safety, property protection, and environmental perspectives on retaining native fauna and flora populations.

4.8 Pest control - foxes, feral cats, feral pigs, rabbits

Along the Vasse River, these animals pose the greatest problems for landholders undertaking revegetation projects whether for biodiversity or commercial ventures.

Many LCDCs encourage landholders to participate in fox baiting each spring. Collection points are nominated for the distribution of baits to landholders who must produce a locked metal box into which the baits are placed and kept until they are placed around the farm. As the baits are extremely toxic, safety precautions are strict and no children or dogs are permitted to be present at these gatherings.

The baiting supports CALM's Western Shield Program of aerial baiting of the State Forest which aims to reduce fox numbers and then reintroduce thirteen native animal species to their original bush habitats. The woylie and chuditch are two such species. Foxes (*Vulpes vulpes*) not only pose a great threat to small mammals, reptiles, frogs, birds and insects, but they compete with other native carnivores for prey.

CALM's program also supports landholders with properties adjoining State Forest who have greater difficulty eradicating foxes than those further away. Foxes may also be shot, fumigated, trapped in humane cages, and excluded from domestic poultry by fencing. Genetic methods of control are under investigation.

Feral cats (*Felis catus*) pose similar problems to foxes and may be controlled by shooting, poisoning or trapping in humane cages.

Feral pigs (*Sus scrofa*) have been observed just over the watershed of the Vasse River in the Margaret River and Blackwood Catchments. Pigs are difficult to shoot in dense cover where they prefer to live, poisoning must be done in consultation with an AGWEST APB Officer, and trapping by building a trap around a bait station is costly and time consuming.

Pigs compete with native animals for food and habitat, and their soil disturbance can lead to erosion and greater sedimentation of waterways. They may also spread *Phytophthora* dieback. Landholders may find they damage pastures, orchards, crops and vineyards.

Revegetation projects and existing native plants both suffer from rabbits (*Oryctolagus cuniculus*) grazing and from their introduction of more weeds. Native herbivores have to compete with rabbits for food and habitat, while grazing pressure from rabbits can become so great that it can result in soil erosion.

Control measures include shooting, poisoning, fumigation of warrens, and exclusion fencing, which has begun around sections of vineyard in the upper Vasse Catchment. Genetic control is under investigation.

Rabbit control within suburban areas is much more difficult due to restrictions on the methods listed previously. AGWEST should be approached for advice. The best time to start rabbit control programs is the middle to the end of summer. Rabbit numbers start increasing with the availability of green feed. Seedlings can be protected by using tree guards which are available in many designs.

In-depth information on these pests and others is available from *Managing Your Bushland* (Hussey & Wallace, 1993).

4.9 Chemical use near waterways

A report in 1995 describing the acute toxicity to Western Australian frogs by the glyphosate based product Roundup®, Herbicide was published by the Western Australian Department of Environmental Protection (DEP).

Consequently 84 glyphosate based herbicides had restrictions placed on their use in aquatic environments by the National Registration Authority for Veterinary and Agricultural Chemicals (NRA). The active ingredient is suspended in a surfactant or detergent solution to improve the penetration of chemical past the waxy leaf surface.

A study evaluated the toxicity of a new product, Roundup®, Biactive Herbicide - on the tadpoles of four species of WA frogs. It was found to be 'virtually non-toxic' while Roundup, Herbicide had its high toxicity confirmed as did Agral, 600 and BS 1000®.

The *Special Review of Glyphosate* (NRA, 1996) states: 'Where a need exists to control weeds growing in or over water, a formulation with a superior margin of safety (no toxicity to fish, daphnids and tadpoles at a concentration of at least 100 mg/L whole formulation) should be used.'

Using Roundup[®], Herbicide away from waterways but in areas that can become wet still poses a great threat to frogs which live beyond open water. A final report published in 1998 expressed further concerns about surfactants and was unable to recommend using nonyl phenol ethoxylate or alcohol alkoxyate based products in frog habitats until further information is available (Mann, 1998).

Extreme caution should be exercised when using any herbicides and pesticides. It is essential to wear protective clothing at all times, to take all recommended safety precautions, to read the labels on the container extremely carefully, and to follow instructions for use accurately.

5. Findings and recommendations for specific areas along the river

Findings and recommendations for specific areas along the river

'It is time to scale up our efforts and think long term'

(H Alexander, National Landcare Facilitator)

Maps 1 to 13 depict the Vasse River and adjoining land titles from the Whicher Ranges to Fairlawn Road.

With the notes accompanying them they summarise the river surveys and assessment,

include historical notes and landholders' observations of weed infestations and wildlife, and identify specific areas of degradation, erosion and sedimentation title by title (corresponding with paddocks), and make recommendations for future riparian management.

A fold-out legend is provided which enables each map to be viewed alongside the legend for ease of interpretation.

Map 1

The Vasse River originates in the Whicher Ranges as a tiny stream adjacent to the watershed of the Margaret River Catchment. It travels through CALM's pine forest within a dense strip of native forest in excellent condition, flowing under Stuart Road and continuing to the first farming lands. Firebreak/access tracks follow both sides of the river through the plantation allowing good access. It then meanders and braids its way through a slender but excellent remnant of native forest to which cattle and sheep have access for watering and grazing. Clearing in recent years has removed most other vegetation leaving the river zone and the road reserves to retain the last remnant vegetation.

Issues	Comments
Fencing	The downstream title is part fenced on both the east and west banks, the upstream titles have no fencing and all are grazed.
Soils and banks	High in the catchment are laterite ridges with good clayey loams that give way to sandy clays over laterite. Soil cohesion in the river zone appears good, aided by slightly sloping banks and a very shallow river channel. Serious erosion is evident above the river along a boundary firebreak.
Vegetation	Healthy vegetation prevails in this area but understorey species will decline in direct relation to grazing pressures. As the vegetation thins and receives more light and higher temperatures plant species decline in number and are overtaken by opportunistic Melaleucas - shading and crowding out smaller species and seedlings. Half a hectare of excellent Blackbutt about 15 years old regenerated naturally after excavations for a farm water supply. A short avenue of Eucalyptus globulus borders part of a farm track downstream.
Weeds	The few weeds apparent in this area consist of pine seedlings, thistles, and pennyroyal which are controlled by hand grubbing, spraying and some grazing.
Special features	The river's first small tributary joins it with water of excellent drinking quality. A 10 hectare viticulture development is a more recent innovation here with the water for the vines being provided from a small soak adjacent to the river.

Map 1: Management advice

1. Fence the riparian zone to exclude stock and allow the understorey to re-establish.
2. Construct stable stock crossings or bridges and watering points or troughs.
3. Repair firebreak erosion and negotiate an alternative solution with the Busselton Shire Council.
4. Continue present weed control measures.
5. Plant a nutrient/sediment buffer of low natural vegetation and native grasses below the vineyard.
6. Extend the riparian zone with commercial plantings of local species eg. blackbutt, banksia etc.

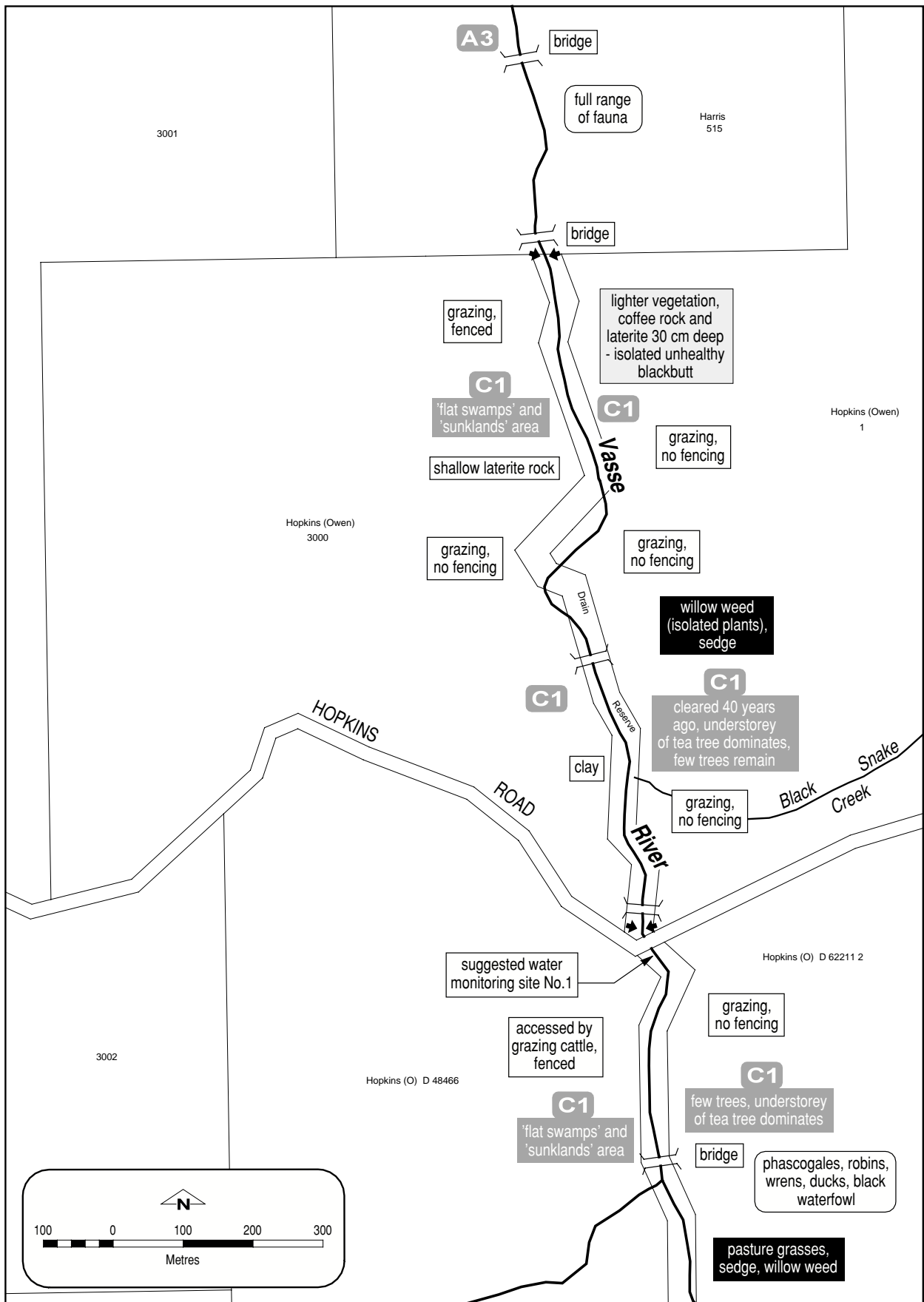
Map 2

The river continues into 'flat swamps' and 'sunklands' where the valley base widens and flattens, and the river is joined by two more tributaries - Canebreak Creek from the east contributing water from a large area bounded by Molloy, Seismic and Sabina Roads, and a smaller unnamed creek from the west. Within these next titles is a surveyed drain reserve in which the river is mostly contained, crossing under Hopkins Road. The river has flowed across the road for several months of winter each year for the last few years indicating increasing surface flows. Cattle have access to all of the river which was cleared completely forty years ago, but has mostly regenerated, albeit with a changed plant regime. Although much of the tea tree is very dense and appears impenetrable, one farmer at least maintains 'The cattle always manage to get in there when you want them!'

Issues	Comments
Fencing	All of these titles are grazed but good fencing exists along the western titles. The fencing is set back some 20 to 50 metres from the river and cattle access the western banks from the eastern side.
Soils and banks	Upstream the river flows through clay loams and onto a rocky laterite section of coffee rock about 30 cm deep. The banks slope slightly and the channel is very shallow. The mid-east bank of the river increases in steepness to a moderate slope while the west bank remains slightly sloping. The cattle cross the river at three places over a hard rock channel base. While the soil is quite cohesive and no erosion is present, continued grazing and trampling of bare banks and crossings by heavy animals will ultimately break them down and contribute fine silt and nutrients to lower reaches of the river, particularly at peak flow events from the well-cleared catchment.
Vegetation	Upstream a few marris and blackbutt stand above dense thickets of melaleucas, while downstream this understorey becomes more sparse and a few isolated blackbutts struggle to survive.
Weeds	Most weeds and pasture grasses like paspalum and kikuyu are kept well-grazed through this area and rush/sedge dominates one swampy area in particular. Species identification needs to be confirmed. Isolated plants of willow weed and pennyroyal are spot sprayed with chemical. Where the river is joined by the next tributary, Black Snake Creek, more pennyroyal appears.
Special features	In several places the river contains deep holes which have proven dangerous to grazing cattle which have slipped into them - but they also provide watering points through summer.

Map 2: Management advice

1. Complete fencing and reduce stock access to the river.
2. Continue present weed control measures.
3. Construct stable stock crossings or bridges and watering points or troughs.
4. Track the source of weed infestations up the tributaries and eradicate.
5. Identify the rush/sedge with assistance from CALM's botanist in Busselton, and the WA Herbarium.



Vasse River Map 2

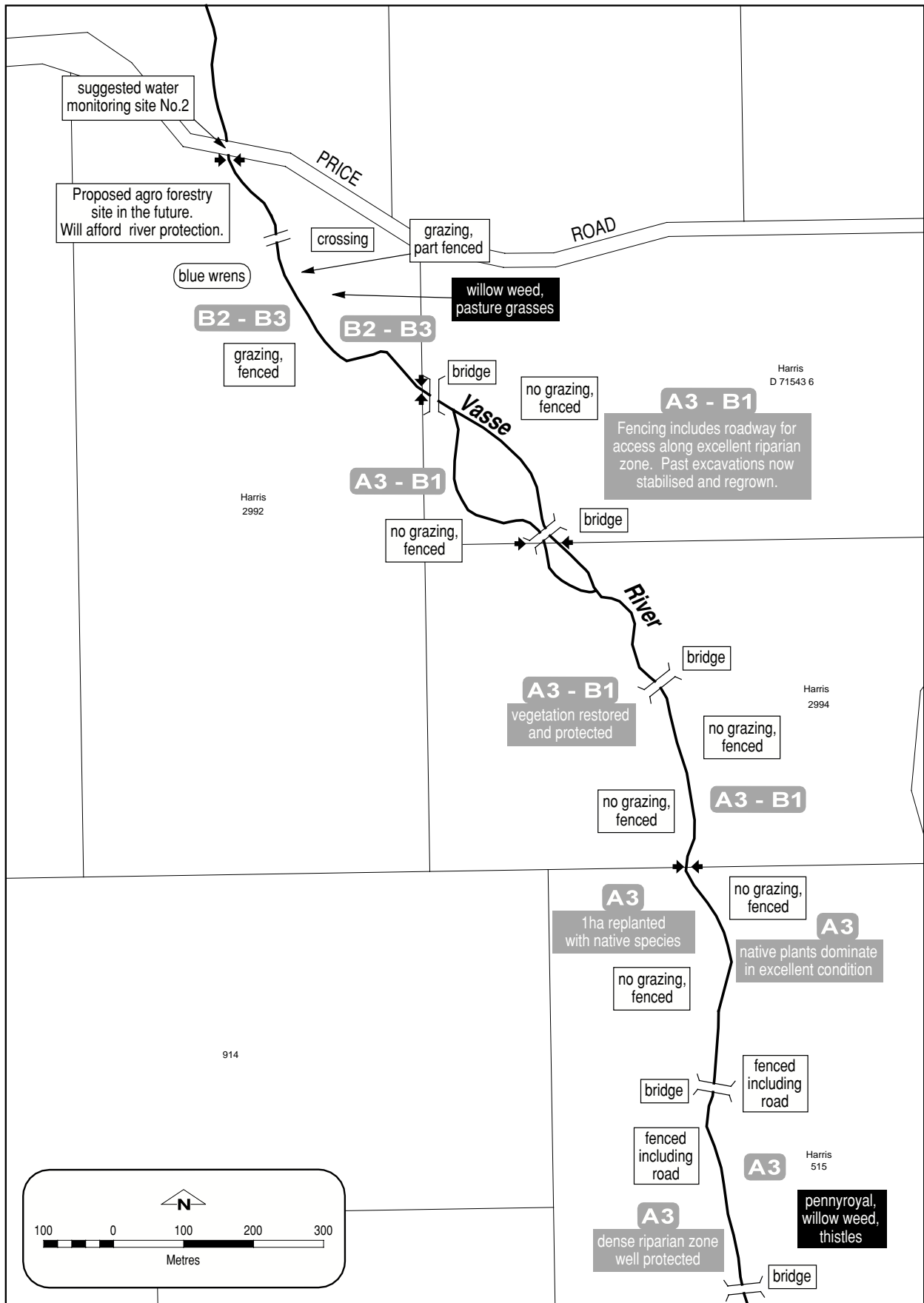
Map 3

Still within the Whicher Ranges, the next section of the river is in excellent condition and protected from stock grazing. Fencing is set back from the river and includes a continuous access road along both banks for maintenance, inspection and fire control, and several small bridges made from the base of old railway carriages. The corridor created through the property promotes unrestricted movement of both wildlife and people. Much of this area was excavated about six years ago by the previous owner for a proposed tourist development and involved deepening the river channel and creating a small lake complete with island and jetty. Its condition is now excellent due to vigorous natural regeneration encouraged by fencing the area generously, hand-planting native species in the gaps, and removing grazing stock completely.

Issues	Comments
Fencing	The downstream title is only part fenced for 400 metres on the eastern side. The rest of the river is completely fenced 20 to 80 metres wide.
Soils and banks	Although still quite shallow, the excavations have created a steep-sided channel and occasional minor points of undercutting can be observed along the banks and around the deeper pools and lake. Reeds and rushes recolonising the area are providing the stability needed to address the problem. Further downstream cattle access to the river is reducing the stability of the banks as they graze the pasture weeds in amongst the melaleucas and cross through the river zone to the other side of the paddock.
Vegetation	Marri, blackbutt and bullich form a forest with a dense understorey of melaleucas, reeds and rushes stabilising the banks. The diversity of the understorey has been reduced by grazing downstream but upstream the variety of plants and their condition is excellent. About one hectare of hand-planted native species are replacing pasture grasses. Future plans for the area downstream may include some form of commercial tree plantings.
Weeds	Pasture grasses are still evident in some sections but should disappear as the new native plants vigorously reclaim the area. Pennyroyal, willow weed and thistle are removed chemically. Downstream the same weeds predominate but are controlled by grazing.
Special features	In the paddock to the west, on the slope above the river, are many deep holes which appear to be created by water rising through the laterite, saturating the clay and causing the area to subside.

Map 3: Management advice

1. Continue present weed control measures.
2. Continue replanting and extending the riparian zone with indigenous species - trees, shrubs, groundcovers.
3. Use this area as a seed source of local provenances for local revegetation projects.
4. Complete fencing the river and investigate commercial timber options for indigenous species such as blackbutt and marri.
5. Limit stock access to the river downstream.



Vasse River Map 3

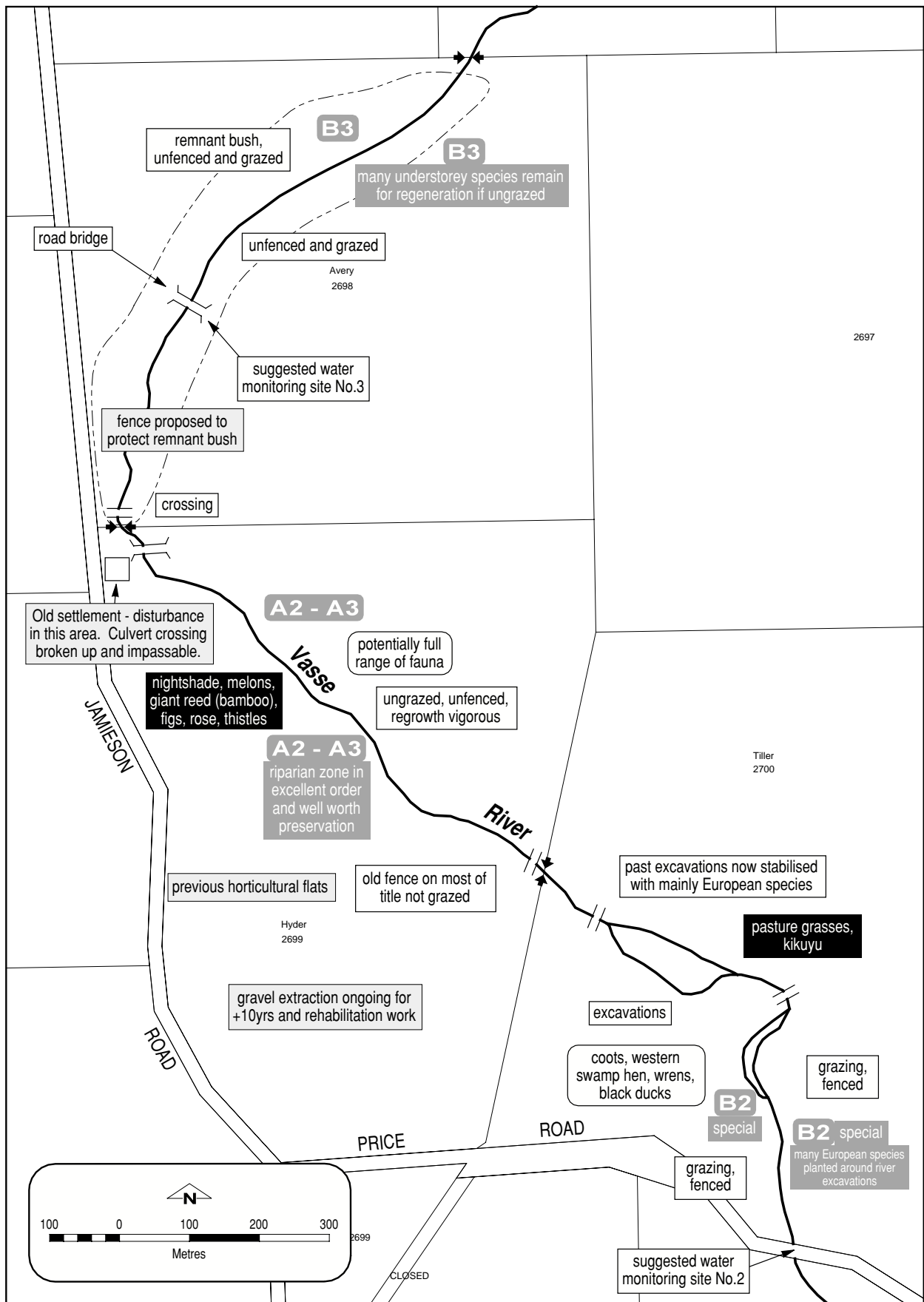
Map 4

The river flows under Price Road and through the last foothills of the ranges in a wider, deeper channel. Excavations to create a series of pools and waterfalls began in 1977 to 1982, again for tourism proposals. From 1980 onwards an area along the river reserve was planted with many European exotic plants. Downstream is an excellent riparian zone with vigorous regrowth along a title where gravel extraction will continue for at least the next 10 years. Below the mining area are flats where in past years cattle have grazed and horticultural crops such as potatoes have been grown. At the downstream boundary is evidence of past settlement with remnants of a garden, and a river crossing with concrete culverts in disrepair.

Issues	Comments
Fencing	Property 02700 fenced to 2 metres high and intermittently grazed to reduce pasture weeds and grasses below exotic trees and shrubs. 02699 - west bank poorly fenced and needing replacement, east bank unfenced, both presently ungrazed. 02698 - presently unfenced and grazed but under consideration for funding to fence and conserve the remnant bush along the river.
Soils and banks	Revegetation and natural regeneration of reeds and rushes along the banks has stabilised the extensive excavations. The banks are steep and the channel deep but the clayey loam soils are sufficiently cohesive and fertile to hold together and encourage regrowth of native plant species. Downstream the channel reverts to a shallower stream with banks moderately to very steep.
Vegetation	The exotic vegetation upstream includes many species - oaks, willows, liquid ambers, elms, cotton palms, sequoias, wattles. Downstream the trees remain in good condition with seedlings and understorey still evident.
Weeds	Pasture weeds and kikuyu are kept in check by intermittent grazing. The steepness of the banks discourages cattle from grazing reeds and rushes along the river channel. At the downstream boundary of the middle title are a rose, some distance back from the river, but more importantly two large fig trees and a clump of giant reeds (bamboo). Other weeds here include melons, nightshade and a large patch of thistles.
Special features	As the mining of gravel progresses on 02699 there is a rehabilitation requirement for the topsoil to be stockpiled then progressively used to cover the excavated areas to promote regrowth, reduce dust and address soil erosion. These requirements are being observed.

Map 4: Management advice

1. Remove exotic European tree species such as willows and fig from the immediate vicinity of the river.
2. Undertake control of thistles and 'bamboo' and the other weed species.
3. Fence the riparian zone to exclude stock and allow the understorey to re-establish.
4. Construct stable stock crossings or bridges and watering points or troughs.
5. Plant a wide nutrient/sediment buffer of natural vegetation below the mining site or generously increase the riparian zone width.
6. Extend the riparian zone with commercial plantings of local species eg. blackbutt, banksia etc.
7. Use this area as a seed source of local provenances for local revegetation projects.



Vasse River Map 4

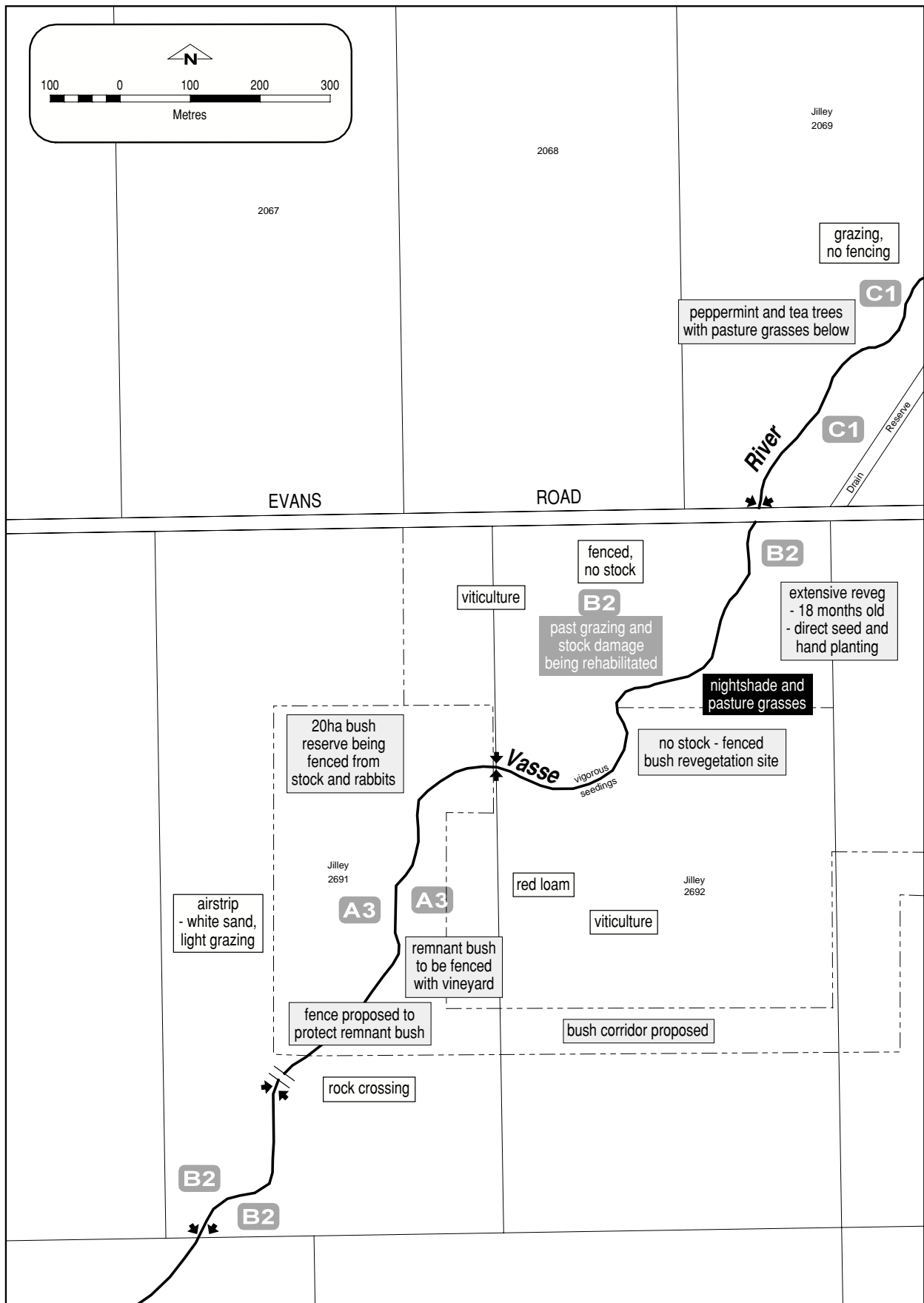
Map 5

The river leaves the foothills and moves on through a different landscape. Initially the soils remain good clayey loams with some rock and stone along the channel, but the soil types on adjoining land change dramatically from red loam to white sands. The sand area will be maintained as an airstrip with only light grazing in future and a stable crossing will be retained at rocks in the river channel. In years past cattle have contributed to substantial degradation of the creek bed and banks, which are now under repair and have continuous protection from a rabbit-proof fence surrounding the adjacent vineyard. The results of hand planting, direct seeding and natural regeneration are very rewarding and future generations living in the nearby homestead will be amongst the beneficiaries of these endeavours.

Issues	Comments
Fencing	The combined bush and viticulture area is soon to be fenced with rabbit proof mesh and steel posts as has been done further downstream on 02692 where the river is included in the vineyard area and no longer grazed. 02069 is unfenced and fully grazed.
Soils and banks	Although the soils are cohesive and grazing has been light, there has been loss of understorey species, and downstream the river channel has widened, deepened and eroded due to constant cattle access in past years. Degradation has been reversed in the last 18 months with stock excluded and rehabilitation with thousands of seedlings and reeds along the river banks and channel. The slope of the banks changes from very steep to moderate as the river travels downstream and some points of cutting and undercutting are evident.
Vegetation	Most of the trees in this section of the river are healthy and upstream the new seedling growth is vigorous. Rushes assist in stabilising the banks and channel. Downstream, cattle graze the kikuyu and pasture grasses amongst peppermints and melaleucas which hold the red loam. Grazing will not permit regeneration and these trees will not be replaced as they die in future years. Adjacent to the house a variety of exotics have been planted in a parkland style but it is unlikely they will impact directly upon the river.
Weeds	Arum lilies, thistles and pasture grasses along the river are kept in check chemically and by slashing in the newly revegetated area to allow the seedlings their best chance of survival. In the downstream area the kikuyu, nightshade and pasture grasses in and along the channel are grazed.
Special features	A wildlife corridor will be created when approximately 20 hectares of remnant bush is conserved. The river's inclusion in the viticulture development provides excellent protection from rabbits and gives young understorey seedlings the optimum chance of survival.

Map 5: Management advice

1. Maintain the new plantings of natural vegetation by excluding stock and maintaining present weed control measures.
2. Keep nearby exotic species from colonising closer to the river and becoming a future problem.
3. Maintain a shrub and groundcover nutrients/sediments buffer between the vineyards and the river.
4. Check the remnant vegetation areas for weed invasions.
5. Restrict stock access to the river downstream to allow natural regeneration of species to continue.
6. Use this area as a seed source of local provenances for local revegetation projects.



Vasse River Map 5

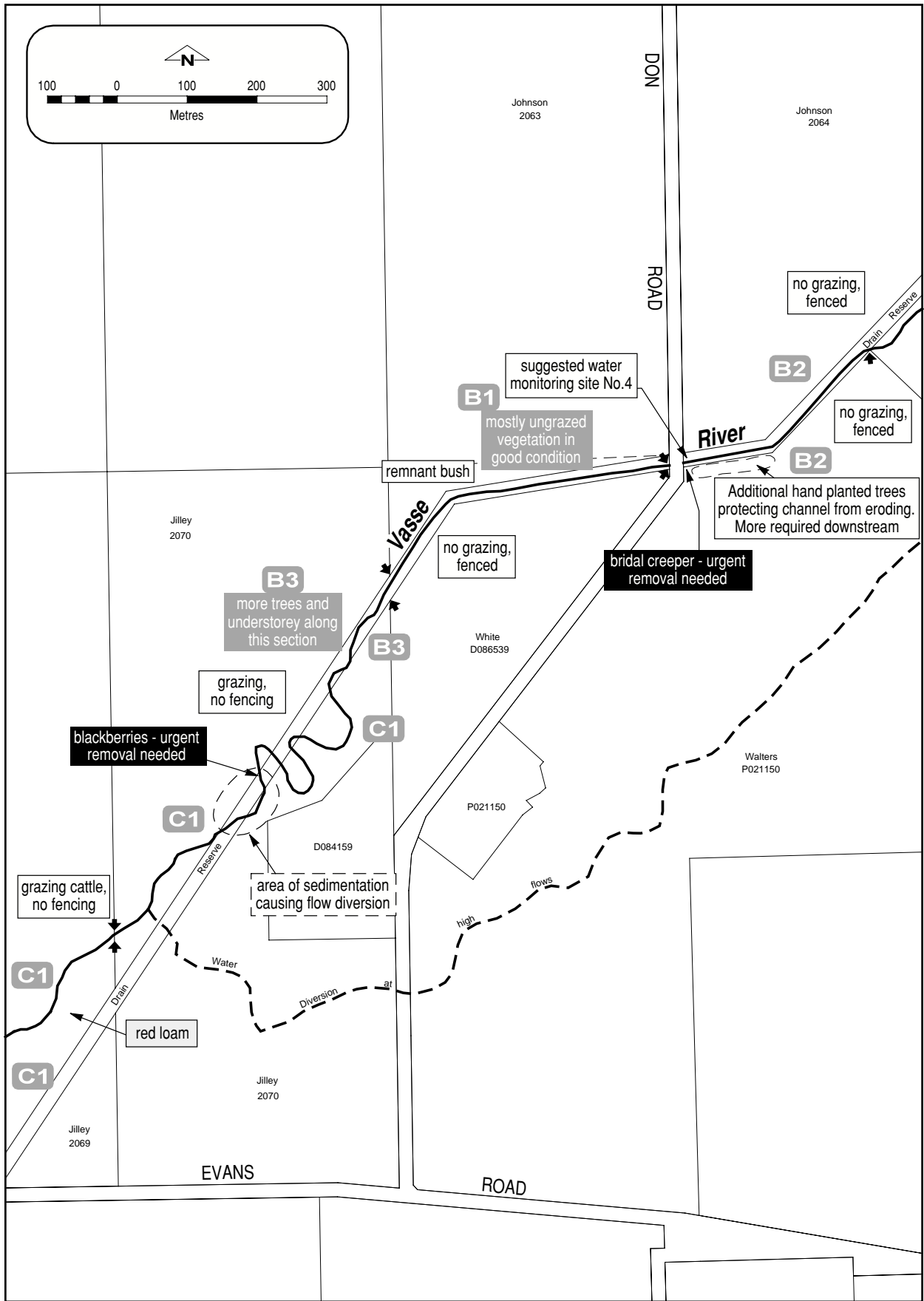
Map 6

The river meanders through the next title largely outside the surveyed Drain Reserve, then within the Reserve and under Don Road. Upstream it has deposited sediment over the years, reducing the channel depth and promoting flooding and inundation at high flows. On these occasions water diverts east over Don Road and on through P021150, linking into a tributary and eventually the main river much further downstream. Fenced remnant bush adjoining the fenced Drain Reserve through D086539 extends and enhances the riverine habitat and riparian zone, affording the river channel excellent protection.

Issues	Comments
Fencing	The river in the upstream title is unfenced and grazed, while downstream it flows within the fenced surveyed Drain Reserve. Intermittent grazing of the next titles reduces the understorey and increases the fire hazard by introducing and promoting more weeds. Fencing continues along the Drain Reserve.
Soils and banks	From the shallow area of sediment deposition the river flows into a steep-banked and well-defined channel through clayey loam. In one small section scrub builds up and contributes to minor bank erosion. The channel is stabilised by vegetation along the riparian zone. Erosion of a bend is threatening to undermine fencing, and requires a small planting of trees and understorey beyond the surveyed reserve to protect and preserve this area.
Vegetation	The vegetation is healthy and diverse and downstream of 02070 the understorey is in good condition and dense. Any disturbance allows weeds to flourish and greatly increases the fire hazard.
Weeds	Large blackberry bushes thrive on the upstream banks. Further downstream at Don Road is an extensive infestation of bridal creeper. Both species constitute a serious threat to any river system. Urgent action is required. Arum lilies are chemically treated.

Map 6: Management advice

1. Construct stable stock crossings or bridges and watering points or troughs.
2. Fence the riparian zone to exclude stock and allow the understorey to re-establish.
3. Conserve the small planting of trees just downstream of Don Road for the protection they afford the fencing and embankments by holding the soil and preventing it eroding away.
4. Remove blackberry and bridal creeper immediately and maintain the eradication program annually.
5. Maintain weed control in the remnant vegetation adjoining and also along the Drain Reserve.
6. Liaise with WC and WRC to resolve the sedimentation of the river channel the ensuing flooding and inundation problem and downstream impacts.
7. Ensure no stock have access to the surveyed Drain Reserve downstream.
8. Widen the riparian zone of the drain reserve downstream with indigenous species to combat erosion of the channel beyond the surveyed boundary.
9. Rabbits pose a serious problem for revegetation attempts and need a coordinated eradication program. Use commercial tree guards to protect seedlings from rabbits.



Vasse River Map 6

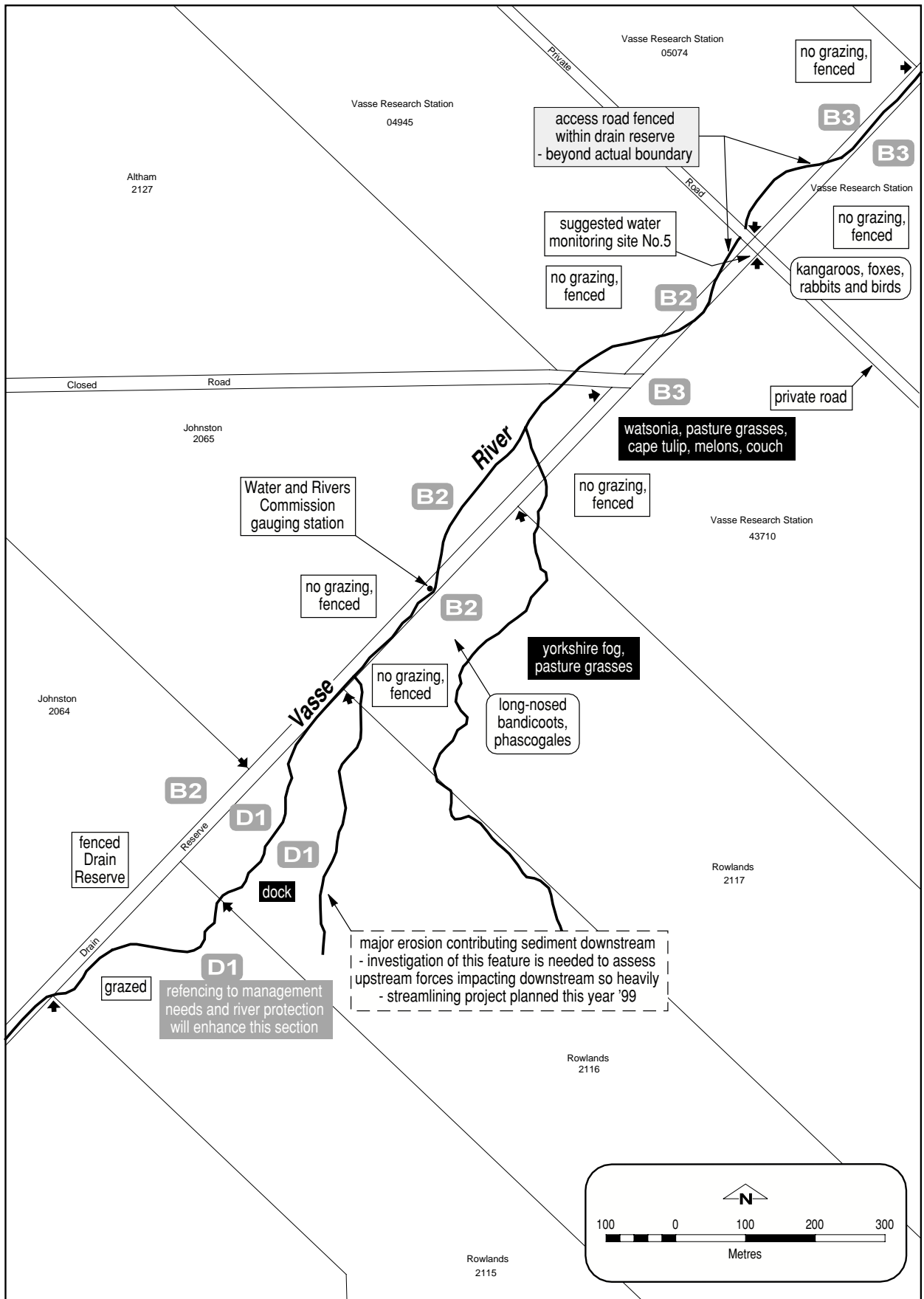
Map 7

The river again leaves the surveyed Drain Reserve and meanders through remnant trees then on through bare grazed paddocks with no protection from grazing stock. A tributary has eroded substantially in recent years and contributed to sedimentation of the channel downstream. The Drain Reserve is well vegetated but is intermittently grazed for fear of fire. Stock introduce weeds and pasture grasses which become flash fuels and a much greater fire hazard beneath the trees than the native understorey with its damp layer of mulch. Weed infestations increase downstream, competing strongly with indigenous understorey species. Vehicle tracks are fenced inside the Drain Reserve downstream to allow ease of access to paddocks for different owners.

Issues	Comments
Fencing	The Drain Reserve is well fenced but not the actual river.
Soils and banks	Apart from the tributary 'blow-out', the banks and channel are reasonably stable. Small, isolated sediment deposits are evident and these are quickly colonised by kikuyu. Should they become much larger they may slow the flow and cause more sediment deposition and more active erosion. Isolated points of undercutting are present as in a natural system.
Vegetation	While the canopy is diverse and many understorey species flourish downstream, there are many weeds.
Weeds	A wide range of weeds has invaded the understorey. <i>Watsonia</i> is particularly prevalent and cape tulip, melons, Yorkshire fog, couch and kikuyu all require eradication. Weeds mean more work, more expense, more time and a greater fire hazard than a complete forest system. Many spread downstream causing more problems for owners of land in the lower reaches.
Special features	The WRC Gauging Station is situated along 02065 and records flow data, continuously checking it every 20 seconds. This information is vital when assessing loads of sediment, nutrients and salinity. A second gauging station operates further along the Vasse Diversion Drain.

Map 7: Management advice

1. Prevent kikuyu colonising sediment deposits within the river channel.
2. Stabilise the river banks and tributaries with indigenous vegetation.
3. Exclude stock from the Drain Reserve and the waterways.
4. Use commercial trees and shrubs to extend and protect the riparian zones of the river and tributaries.
5. Reduce the fire hazard by restoring the natural species and eradicating flash fuels in the form of weeds.
6. Liaise with WC and WRC to determine the upstream reason for the major 'blow-out' of the downstream tributary which has contributed large amounts of sediment further down river.
7. Use direct seeding techniques with smoked seed or water to re-establish natural riparian vegetation.



Vasse River Map 7

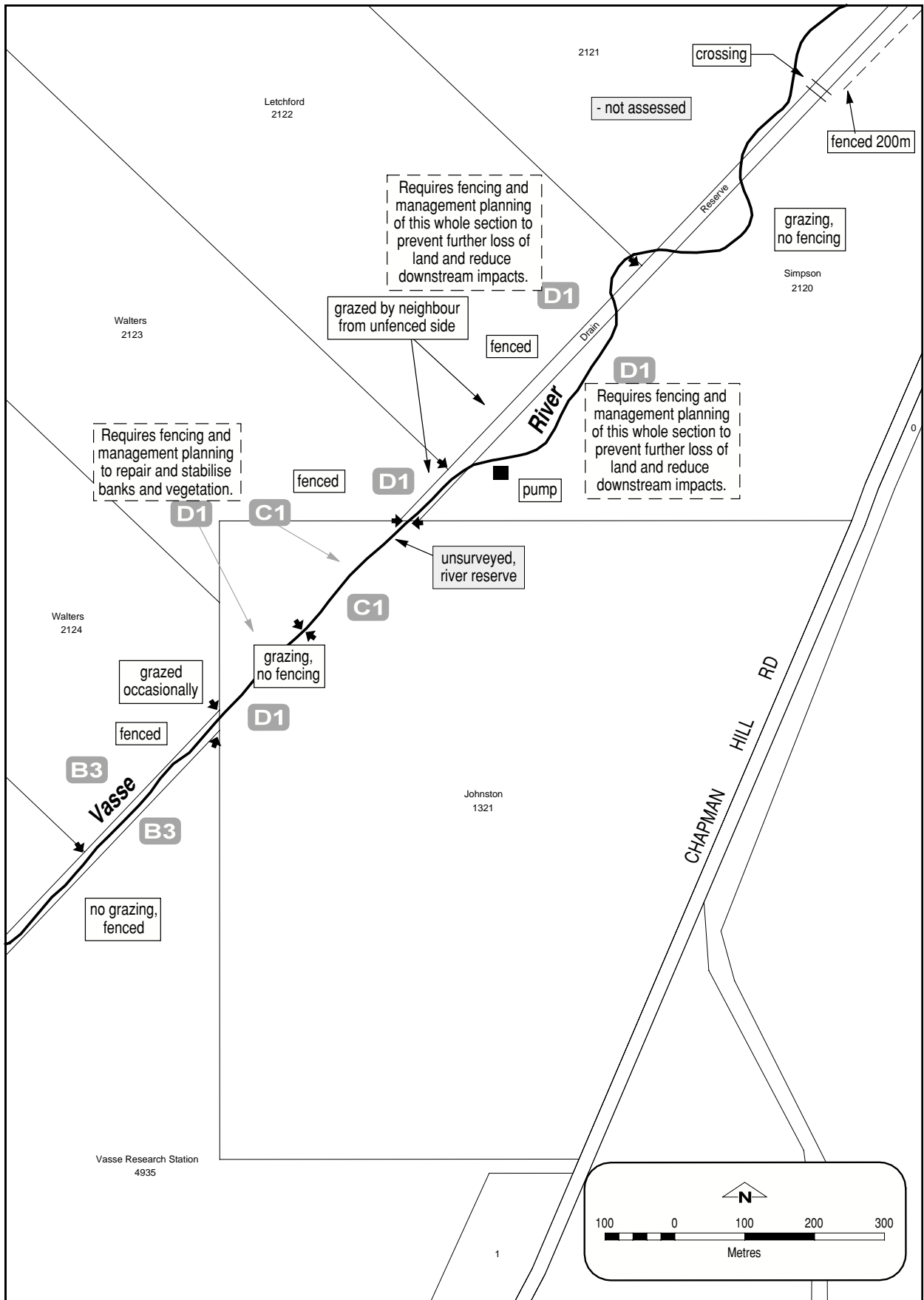
Map 8

The river flows across the flat alluvial plain to an area of great concern from environmental and agricultural viewpoints where stock have grazed and damaged the banks. The surveyed Drain Reserve is interrupted briefly at 01321 then resumed for the remaining titles, but the boundary markers have been lost with time and are a point of contention amongst landholders. Maps and air photos exist that could achieve consensus on the boundaries. Bank erosion is contributing sediment downstream, land is being lost from the holdings, and fence posts and isolated trees are unstable as water and stock erode soil from their roots. The system here urgently requires a plan of management to avoid further loss of agricultural land.

Issues	Comments
Fencing	Upstream is fenced to 01321, and downstream on 02120 is fenced for 200 metres. The downstream west banks are fenced but are under threat from erosion.
Soils and banks	The soil varies from good, clayey loam to poor, sandy, loose loam and has lost much of the cohesion of the upper catchment, leaving its banks more vulnerable. Throughout all titles are areas of undercutting, cattle crossings and track wash-outs, bank subsidence and sediment deposits. The banks are almost completely devoid of vegetation.
Vegetation	Stream cover has been lost from most of this area and no plant diversity remains –apart from a few marris and a lone banksia. The remaining trees will soon fall once the soil has been washed from their exposed roots. A small tree planting was attempted with disappointing results. Some landholders would like to replant the riparian zone but continued grazing by neighbouring stock makes this impossible.
Special features	In spite of its severe degradation, this is an area that could be stabilised by all the neighbouring landholders. Their stock would benefit from the shade and shelter, grasses could filter sediment and nutrients, and studies show that stock would benefit from watering at troughs instead of the polluted river. (refer: 5.6.2 Degradation of the Riparian Zone - Stock watering)

Map 8: Management advice

1. Exclude stock from the river banks to avoid further loss of agricultural land and fencing and allow stabilisation and recovery of the area.
2. Extend and repair the riparian zone with commercial plantings of local species.
3. Reach consensus on property boundaries with assistance from the Agricultural Practices Board. (refer: GeoCatch & AGWEST)
4. Water stock from troughs to improve their health and prevent further land erosion.
5. Prevent kikuyu colonising sediment deposits in the river channel.
6. Use direct seeding techniques with smoked seed or water to re-establish natural riparian vegetation.
7. Reduce the fire hazard by restoring the natural species and eradicating flash fuels in the form of weeds.



Vasse River Map 8

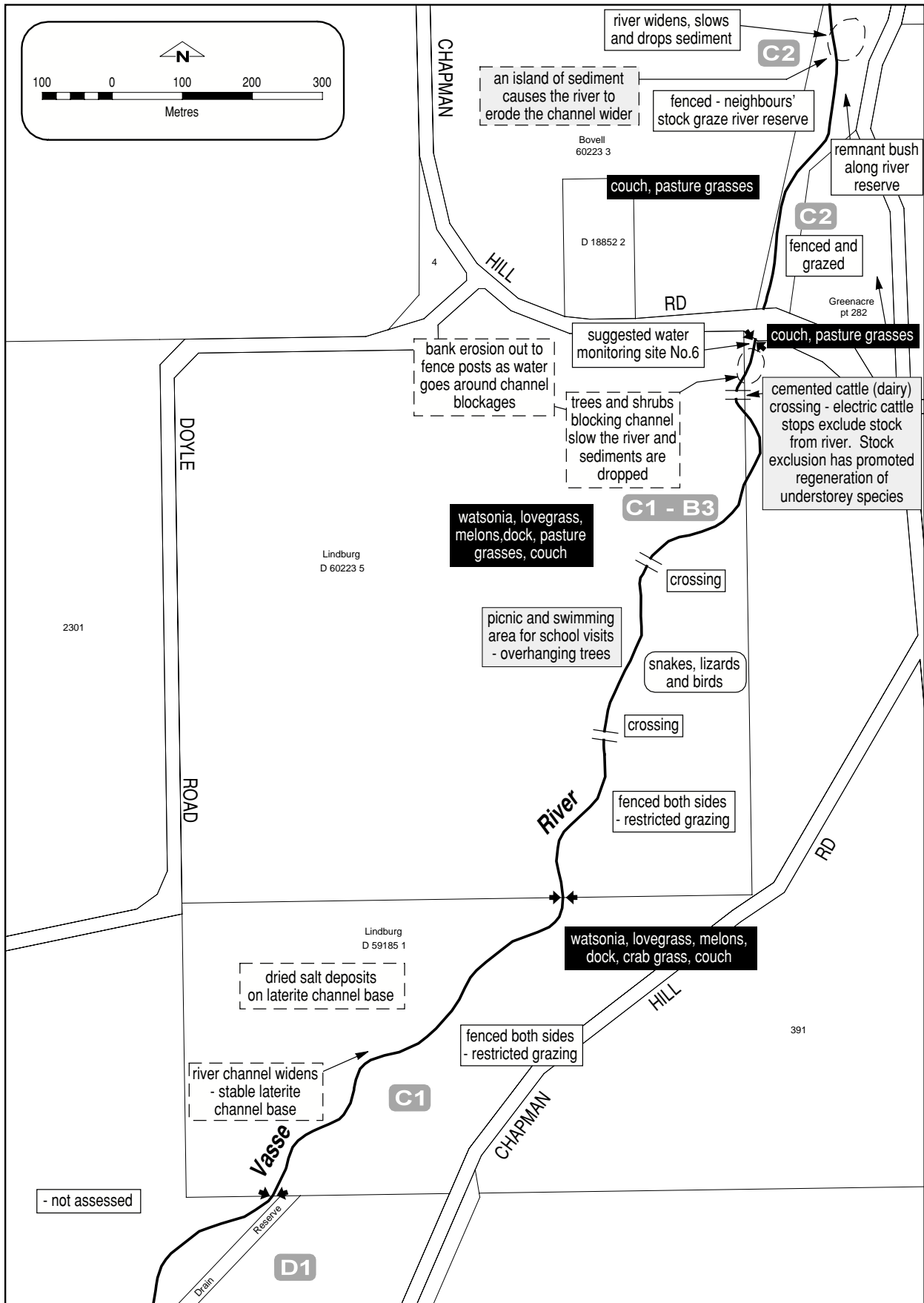
Map 9

The river channel widens and rocky laterite makes a stable base and a good riffle area adding oxygen to the water. Trees overhang the water from sandy banks where classes of school children enjoy summer picnics and swimming. In summer dried salt lightly encrusts rocks in the river channel (this is dryland salinity, not estuarine or marine). Below Chapman Hill Road the river flows within a surveyed reserve which widens briefly on the east bank to include a small area of bush. Past channel excavations have raised embankments to the east to protect the land and houses behind them from flooding. They are sandy, grazed and easily eroded. When the river level is high the septic systems have difficulty functioning.

Issues	Comments
Fencing	All titles are fenced but intermittent grazing still occurs, particularly downstream.
Soils and banks	Some embankments are intermittently grazed to control the couch grass. Vegetation growing in the channel collects debris and sediment from upstream, blocking the channel. Judicious pruning has been recommended following a WRC inspection. Removal of the accumulated debris and some of the sediment is advised as the water now flows around the obstacles, widening the channel by eroding the banks back to the fence line. The wider channel slows the water further, promoting more sediment deposition.
Vegetation	Paperbarks, marris, melaleucas, rushes and sedges dominate the vegetation in good condition. Downstream less understorey survives with more continuous grazing. The embankments are not cohesive and are eroding, threatening fences with collapse if the banks and trees fail to hold. There is encouraging natural regeneration where stock have been excluded.
Weeds	Paperbarks, marris, melaleucas, rushes and sedges dominate the vegetation in good condition. Downstream less understorey survives with more continuous grazing. The embankments are not cohesive and are eroding, threatening fences with collapse if the banks and trees fail to hold. There is encouraging natural regeneration where stock have been excluded.
Special features	Above Chapman Hill Road a dairy cattle crossing has been covered with concrete as a demonstration site and the cattle confined to that point by electric wires across the river. The benefits are easily visible, as small seedlings are able to grow, ungrazed and untrampled by stock. The laterite was too rough for the cattle to walk over, but concreting over the base has been very successful. Streamlining Funding was utilised for some of the fencing.

Map 9: Management advice

1. Restrict stock access to the river to allow natural regeneration of species to continue.
2. Control weed infestations and prevent kikuyu colonising sediment deposits in the river channel.
3. Water stock from troughs to improve their health and prevent further land erosion.
4. Implement advice from WRC to remove debris from the channel and judiciously prune key instream vegetation.
5. Use direct seeding techniques with smoked seed or water to re-establish natural riparian vegetation.
6. Establish indigenous reeds, rushes and sedges along the river banks to assist with bank stabilisation and nutrient and sediment stripping.



Vasse River Map 9

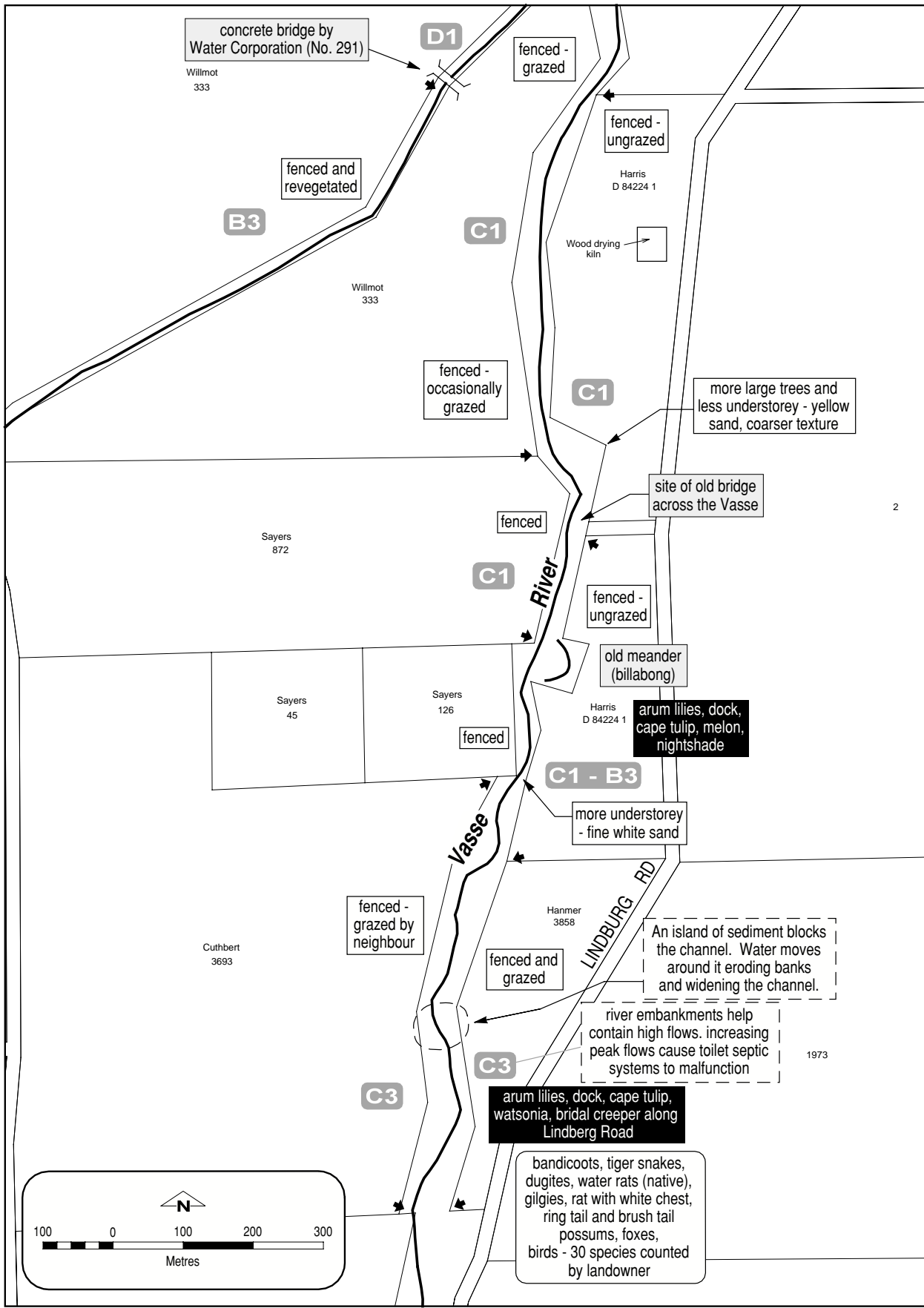
Map 10

The river continues through sandy soils, past embankments dug to prevent inundation and flooding in past years and over the rough laterite channel base. Bypassing a small billabong, it flows past the site of an old bridge into a wider and much deeper excavated channel. Kikuyu infestations make survival of any riverine species difficult and cattle get into the reserve at times. Downstream the sand becomes coarser and changes from fine, white to yellow. The weeds persist and need constant vigilance.

Issues	Comments
Fencing	All titles are well fenced both sides - some through Streamlining Funding.
Soils and banks	The embankments on the east side are above the river bank level. Large rocks were placed along part of the east bank to prevent further bank erosion. A small groyne effect was created but is diverting too much water towards the opposite bank causing undercutting. Major sediment deposition has created an island, around which the river flows making the channel wider and slowing the water.
Vegetation	The remaining trees along the embankments are under threat of collapse if more soil is removed from their roots. Small clumps of rushes still line parts of the channel. Understorey species have all but disappeared with grazing. Some attempts at revegetation have been made unsuccessfully, rabbits also making establishment very difficult.
Special features	Thirty species of animals have been noted along this stretch of the river.

Map 10: Management advice

1. Limit stock access to the river and riparian zone to allow natural regeneration of species to continue.
2. Establish indigenous reeds, rushes and sedges along the river banks to assist with bank stabilisation and nutrient and sediment stripping.
3. Implement advice from WRC in consultation with WC on removing the island of sediment to the sides of the river channel to prevent the water flowing wider around the present flow obstruction, and undercutting the embankments further.
4. Ask WRC and WC to advise on the re-positioning of large rocks in the channel to prevent water deflecting across the channel, causing undercutting to the opposite bank.
5. Use direct seeding techniques with smoked seed or water to re-establish natural riparian vegetation.
6. Prevent kikuyu colonising sediment deposits in the river channel.
7. Eradicate bridal creeper immediately from the road reserve along Lindberg Road.
8. Rabbits require a coordinated eradication program. Use commercial tree guards to protect seedlings from rabbits.



Vasse River Map 10

Map 11

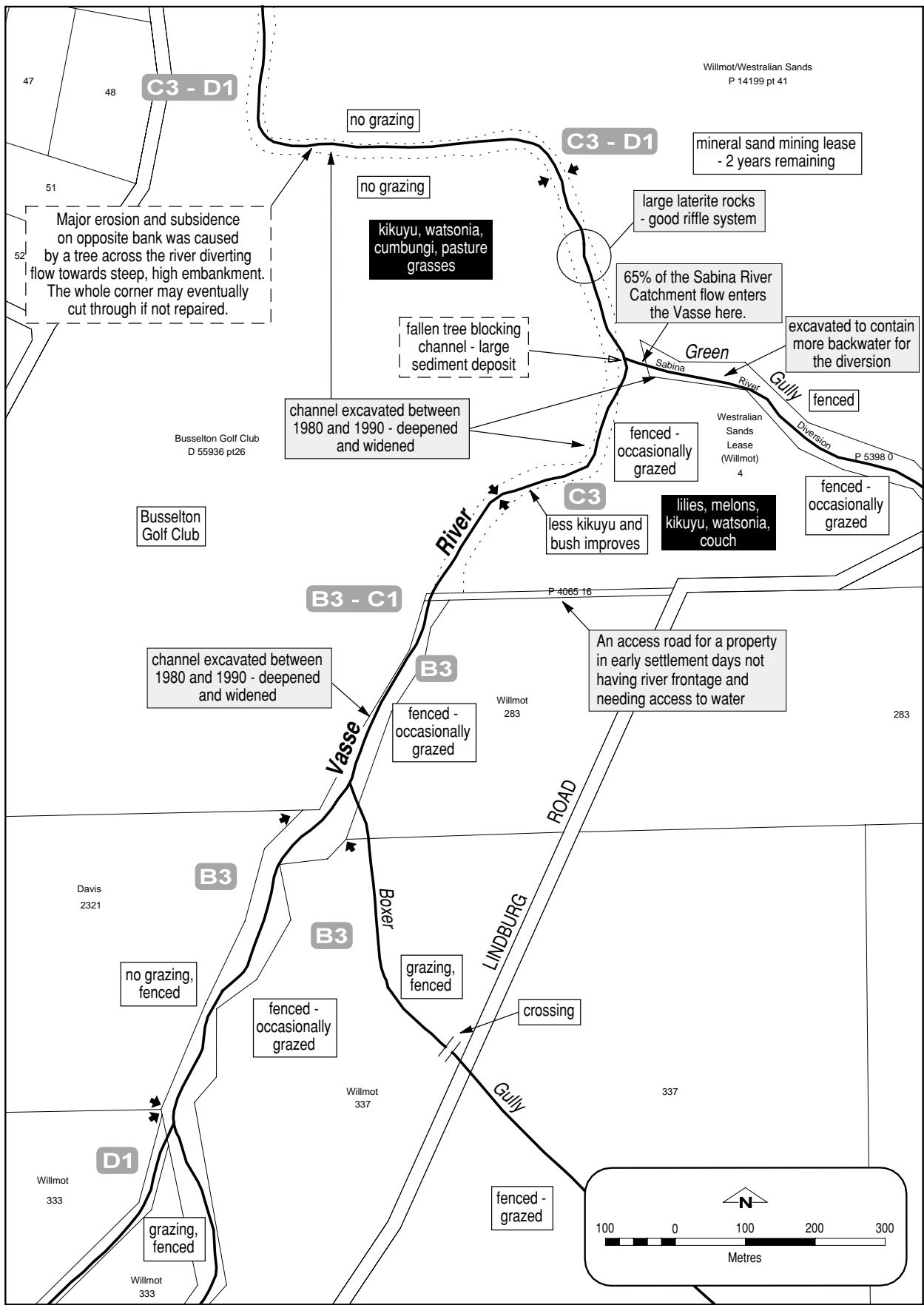
This part of the river is very different as it approaches the Vasse Diversion Drain. The backwaters for the Drain are where the first permanent summer river pools begin, maintained by underground seepages. Large deposits of sediment line the channel, particularly where two fallen trees have slowed and diverted water - in one case causing major bank subsidence and threatening to cut the corner of the channel. This tree was recently removed. WC Officers have requested that blockages of this nature be reported to them immediately before greater damage occurs requiring more expensive and extensive repairs to the banks.

The golf links and the mining lease share most of the river frontage and this is possibly the least attractive part of the river due to engineering works of past years. This part of the river is very public and a prime site to rehabilitate with a broad community base and corporate support.

Issues	Comments
Fencing	The farming land is well fenced, some with assistance from the Streamlining Fund. This fencing program has continued across the entire property protecting all tributaries and drains as well as the river. The mineral sands mining lease is partly fenced and ungrazed at present. In two years it will revert to the owner who intends to complete the fencing and resume grazing. All but 200 metres of the golf club is fenced.
Soils and banks	Excavations for the Vasse Diversion Drain backwaters occurred in this area between 1980 and 1990 when the river reserve was substantially widened and deepened. Green Gully was also excavated at this time. The soils are sandy, loose loams with poor cohesion while the channel base is laterite. An extensive section of large laterite rocks forms a good riffle system.
Vegetation	Dominance by kikuyu has excluded much of the understorey but sections remain that could become the focus of rehabilitation work. Remnant trees and understorey plants are in good condition. Substantial revegetation is required along these embankments to stabilise them, as they are subject to the greatest volumes of water of any part of the river.
Weeds	Cumbungi bulrush is a new weed species in this section. Kikuyu dominates but watsonia, melons, lilies, couch and other pasture grasses are well entrenched. With the exclusion of grazing stock the weeds will become more evident, and the need for active weed management will be made more urgent.
Special features	Boxer Gully and Green Gully flow into the river here. Both are large tributaries, with Green Gully diverting water from 65% of the Sabina River Catchment to bypass the Vasse-Wonnerup Estuary.

Map 11: Management advice

1. Limit stock access to the river and riparian zone to allow natural regeneration of species to continue.
2. Continue fencing the river channel with available funding.
3. Control rabbit populations to allow successful regeneration programs and use tree guards.
4. Use direct seeding techniques with smoked seed or water to re-establish natural riparian vegetation.
5. Control weed infestations and prevent kikuyu colonising sediment deposits in the river channel.
6. Establish indigenous reeds, rushes and sedges along the river banks to assist with their stabilisation and nutrient and sediment stripping.



Vasse River Map 11

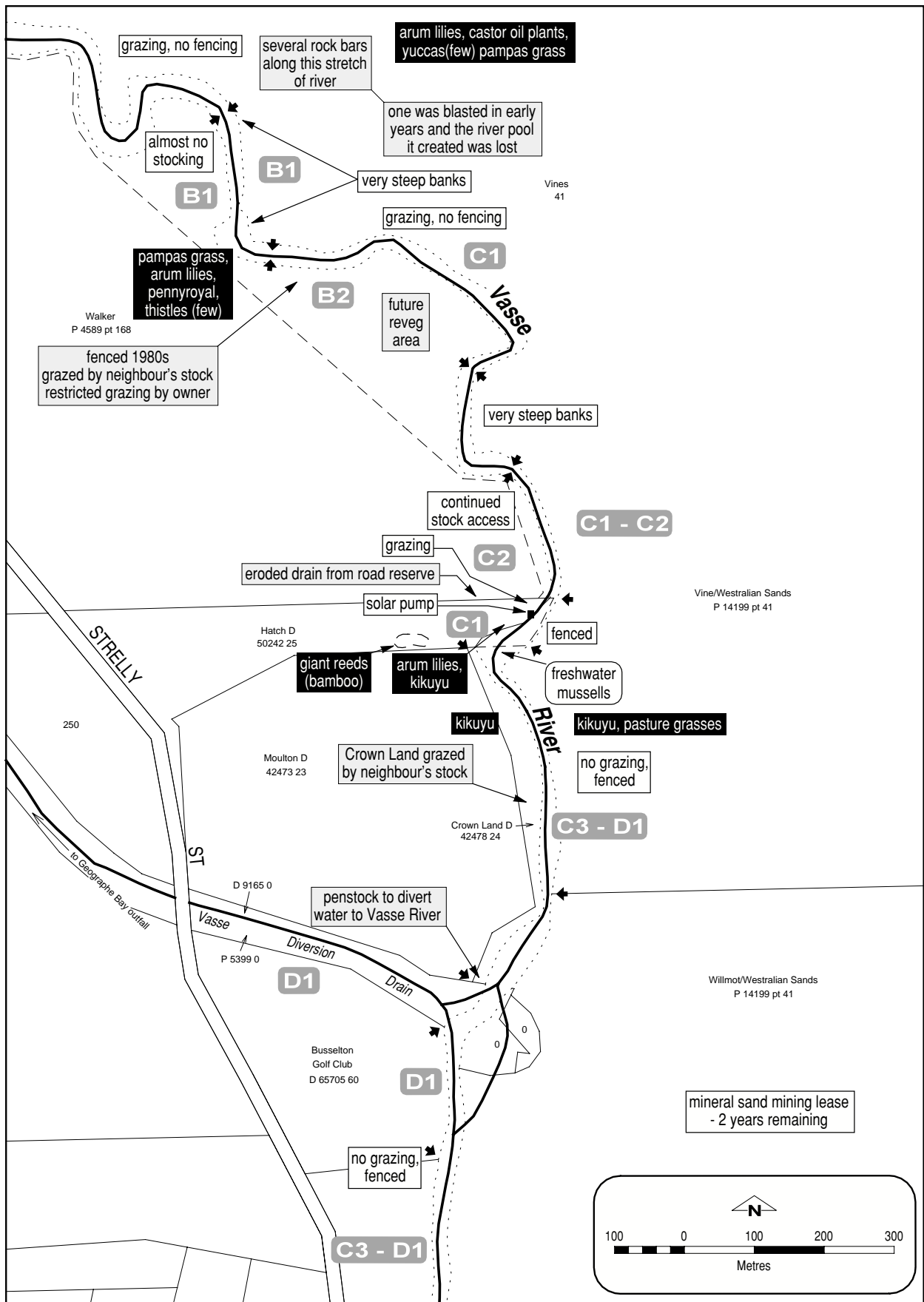
Map 12

The Vasse Diversion Drain is a major influence upon the river. Water to the lower Vasse is restricted by a penstock while nearly 90% of the Vasse Catchment's water flows to Geographe Bay. Mineral sands mining continues to the east and a strip of Crown land borders the west bank. Most of the river reserve is grazed to some degree but some areas may be used for commercial agroforestry in future years.

Issues	Comments
Fencing	All the west bank in this section is well fenced, some through Streamlining Funding. Most of the east bank is unfenced. Below the Diversion, stock graze the east bank and sometimes the west bank.
Soils and banks	Most of the banks are stable but there are points of undercutting and sediment deposits. Reduced flows have meant lesser impact, but river pools created by rock bars have filled with sediment. One bar was blasted many years ago, draining the river pool completely. Parts of the embankments are very steep but rocky and stable. A drain from Strelley St along one sandy property boundary fence is actively eroding.
Vegetation	Most of this area is marri/paperbark/peppermint forest with an understorey of grazed pasture grasses. Downstream is a section with understorey species - very valuable for obtaining seed of local provenances for future rehabilitation of this area. Some revegetation is planned for sections of land included in the river fencing where it has been easier to run a straight fence than negotiate large meanders.
Special features	Freshwater mussels can still be found along the lower river. Cockatoo Creek enters the Vasse along this reach providing fresh winter flows from a swampy area beyond the Vasse Highway through the 'red culvert' and across Cattle Chosen. Although only a small stream it contributes substantial volumes of fresh water to the lower Vasse River.

Map 12: Management advice

1. Pampas grass needs total eradication.
2. Control of weeds upstream would be beneficial to weed reduction efforts here.
3. Remove a clump of giant reeds (bamboo) near the river.
4. Fence the riparian zone to exclude or restrict stock and allow the understorey to re-establish.
5. Establish indigenous reeds, rushes and sedges along the river banks to assist with bank stabilisation and nutrient and sediment stripping.
6. Water stock from troughs to improve their health and prevent further land erosion.
7. Control rabbit populations to allow successful regeneration programs, and use tree guards.
8. Request an analysis of the management of the penstock in conjunction with the estuary floodgates and check boards at the Butter Factory to define responsibilities and functions.
9. Use commercial trees and shrub to extend and protect the riparian zone of the river and tributaries.
10. Liaise with the Busselton Shire Council for assistance in repairing and maintaining the eroded drain from the Strelley St road reserve.



Vasse River Map 12

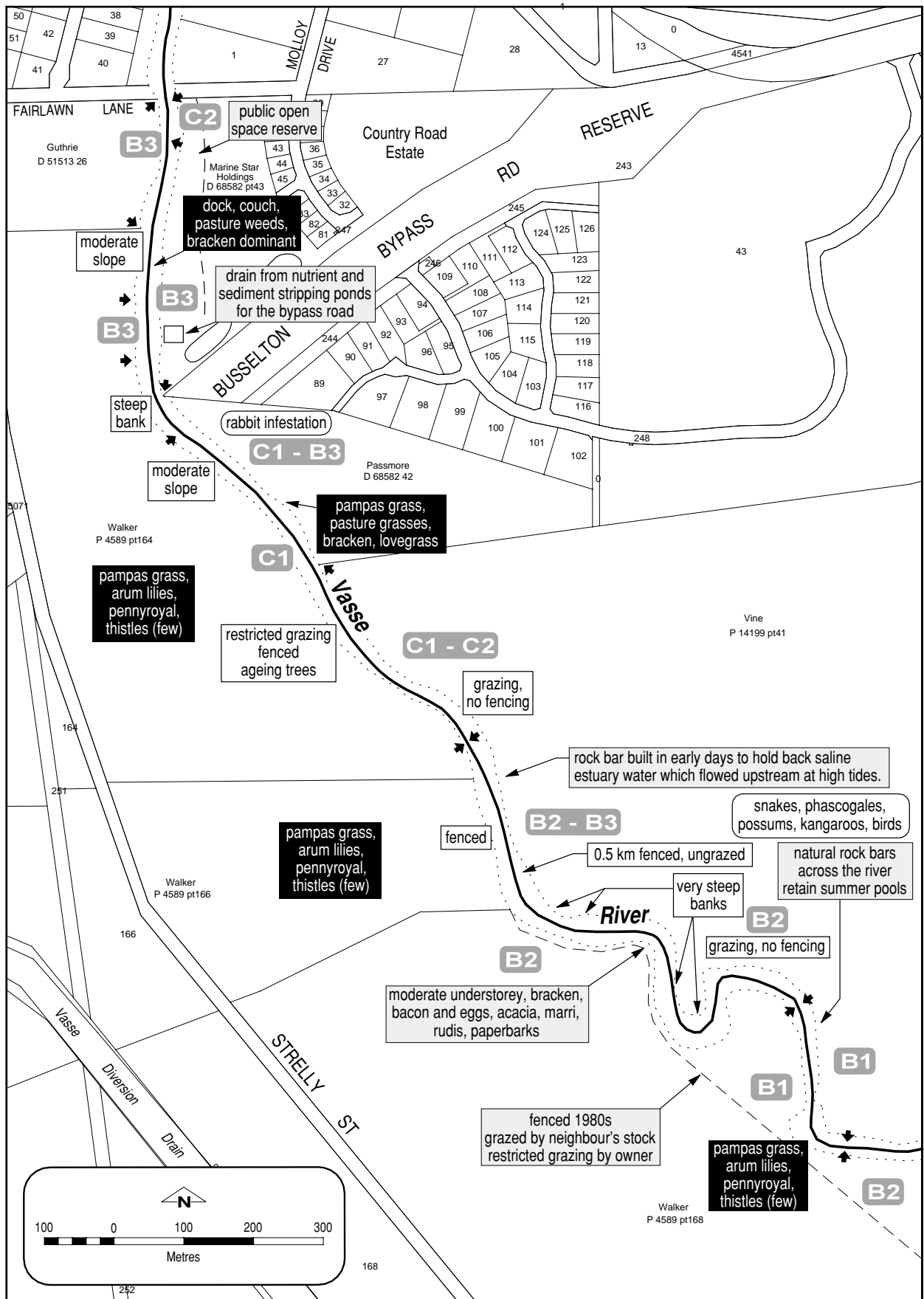
Map 13

The final part of the river for the purposes of this survey ends at Fairlawn Road near the Busselton industrial area. Urban developments are rapidly encroaching upon the historic farms of Fairlawn and Cattle Chosen. The new Busselton Bypass Road will cross the river here. Sediment and nutrient stripping ponds have been built to accommodate run-off from the new housing subdivision. These ponds will require future regular monitoring by the Shire Council for heavy metals and nutrients, as they will overflow into the river. The new subdivision will feature public open space along the river and the re-establishment of riparian vegetation utilising a pathway to buffer grasses. It may also become an opportunity to passively educate the public about riverine values and guide them along the river vegetation. Other proposed drainage from Bovell Park and the Bypass Road will also impact upon this reach of the river.

Issues	Comments
Fencing	All but the last title along the west bank is fenced and only a short section of fencing exists along the east bank. The farming land along the river is grazed to the east and intermittently grazed to the west. The subdivision does not require fencing.
Soils and banks	Banks range from steep to moderate and are stable. Sediment deposits have filled the river pools by one to two metres. A rock bar was built across the river in the early days of settlement to hold back saline estuary water at high tides and keep the river pools fresh. Natural rock bars create other summer pools.
Vegetation	Some understorey remains in isolated patches below aging trees. Revegetation along the urban estate is planned for this year, consisting of indigenous understorey species that will stabilise the banks and provide an attractive area of passive recreation. Attempts in the past at tree planting along other properties have proved difficult because of rabbits.
Weeds	Downstream the weeds are controlled chemically or by slashing and mowing. Bracken is more dominant in this area, dense patches excluding other vegetation. Pasture grasses are grazed upstream.
Special features	Encroaching urban development has the potential to impact heavily upon the river affecting water bird habitats and breeding sites. Every attempt should be made to prevent this and promote coexistence.

Map 13: Management advice

1. Control rabbit populations to allow successful regeneration programs and use tree guards.
2. Water stock from troughs to improve their health and prevent further land erosion.
3. Fence the riparian zone to exclude or restrict stock and allow the understorey to re-establish.
4. Establish indigenous reeds, rushes and sedges along the river banks to assist with their stabilisation and nutrient and sediment stripping.
5. Encourage wider plantings of indigenous plants along the river to buffer the impact of more people.
6. Control weed infestations.
7. Liaise with Busselton Shire Council and their Environmental Officer to promote the establishment of a 'Friends' group to assist with the maintenance and protection of the river and its fauna and flora.



Vasse River Map 13

6. General management advice

6.1 Where to start

Using the information provided in this River Action Plan, identify the best of the river reaches: those recovering naturally, those most likely to respond to rehabilitation and those with the greatest chance of recovery. In these areas work will be the most cost effective and require a minimum of future maintenance. The work should move progressively outwards from the best areas to the most degraded parts.

There are three principles to follow: Conserve the best pieces first, move on to those reaches showing signs of recovery, and then treat the more degraded parts of the system (RipRap Edition 12, 1999).

The A grade reaches should become the focus for the river's restoration. From them should extend the revegetation and the river corridors - they provide valuable seed sources of the local provenances so vital to retain. Aim to gradually link them together into a continuous reach.

The most degraded parts of the Vasse are in the mid to lower section. They will require a stable, conserved and rehabilitated system above each of them to influence their recovery. Unless the upstream areas are in good condition, those downstream will be influenced by the degraded areas above them and will prove much more difficult to rehabilitate.

This principle can be applied to many types of work and problems, on a whole river or whole catchment scale, or on a farm or paddock scale. Do the best bits first and work towards the worst bits.

6.2 Planning a project

Write down your objectives:

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

A written list of objectives

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

Site selection:

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

Organising a planning committee:

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

6.3 Planning creek rehabilitation (Dewing, 1999)

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

Issues to be addressed include:

- the design of remedial work of the banks;
- the selection of suitable plant species;
- how to propagate (by green stock or direct sowing);
- 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 access funds if you intend applying for a grant.

It is essential to study the project site thoroughly. The Stream Foreshore Assessment (Pen & Scott, 1995) survey used on the Vasse River and many other waterways is designed for landholders to use. It helps identify the stability of the stream bank, soil types, vegetation condition, the conservation value of the stream and priority areas for restoration.

A thorough site survey will provide an inventory of assets such as:

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

It will also identify indigenous and weed plants which may result in a decision to manage the area to encourage natural revegetation rather than to restore the native vegetation by hand planting.

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

Bank erosion may require remedial action prior to revegetation such as 'rocking' or other 'soft' engineering approaches.

6.4 When to survey (Dewing, 1999)

Late autumn to early winter is a useful time to survey when weed problems are apparent. Herbaceous perennials such as watsonia, bridal creeper and annual pasture species will have germinated with early rains. Impacts of river activity can be easily seen - sections of eroding or slumping banks, and areas where sand is being deposited. Later in winter, a survey of the river or stream in full flow is more likely to reveal the behaviour of the river rather than its impact (Pen & Scott, 1995).

In late autumn, deciduous exotics are apparent by their autumn colours eg. desert ash - clearly visible by its yellow colour against the evergreen native vegetation. eg. *Acacia decurrens* (Eastern States black wattle) is a woody weed that flowers early and is easily seen. These weeds can be treated or removed before seed set in the year prior to the rehabilitation program, allowing time for follow-up treatment in the second year.

6.5 What's growing on the creek or river bank (Dewing, 1999)

A list of existing native vegetation is useful for identifying suitable plant species for revegetation and potential populations of plants for obtaining local seed material. It is important to establish the position on the stream bank that each plant occupies and the type of soil in which it grows - sandy, clay loam, shallow rock etc. The thin green line of fringing vegetation along the stream banks is often overlooked, as the plants can be difficult to identify.

Native plants are easier to identify when flowering. While different species flower in different seasons throughout the year, the peak season is spring. Fringing vegetation (paperbarks, rushes and sedges) 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 on to identify all the plants.

In summer, flowering suites of plants go mostly unnoticed as they flower when few people are out walking and looking. Some of these include *Astartea fascicularis* (a tea tree), *Agonis linearifolia* (narrow-leafed 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. The general structure of the vegetation (trees, shrubs, ground covers, herbs, grasses, rushes and sedges) are common to each area, but individual species may differ.

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 the existing remnant vegetation.

6.6 Identifying plants (Dewing, 1999)

Native grasses, 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 which help to hold the bank together, acting as 'foot soldiers' to the flooded gums (*Eucalyptus rudis*). Rushes and sedges spread by rhizomes - creeping underground stems. By identifying populations of these plants, the stream banks can be managed to encourage their natural regeneration.

Where most understorey species 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 in planning the rehabilitation of the denuded site.

CALM's publication *How to Create a Local Herbarium* is recommended for landholders who wish to collect and preserve their own set of field specimens.

6.7 Stock control

Providing fencing, alternative shelter and a water supply away from the river or stream is one of the most effective means of assisting with river restoration. These strategies reduce the time stock spend in the river channel, reducing grazing pressure on the embankments and nutrient inputs to the water. Stability of the river channel is also achieved. This is regarded as critical to successful riparian zone restoration.

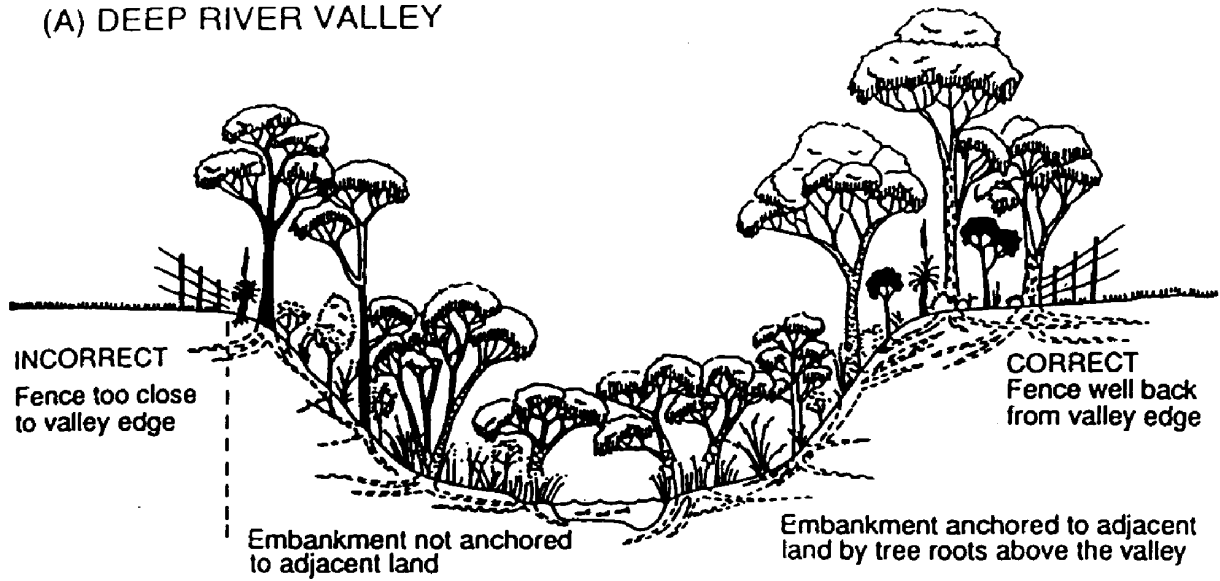
Fence placement is an important factor for sustaining the riparian zone and is well illustrated in Figure 6: The correct and incorrect placement of fences in relation to the river valley - the deep river valley, the shallow river valley, and the broad river valley and flood plain (Pen, 1995).

Fencing may be used to exclude stock entirely from the river, or to allow restricted grazing. The zone need not be lost to agricultural enterprises but can contribute towards them by sheltering stock, improving water quality and reducing erosion. Environmental and economic benefits need not exclude one another.

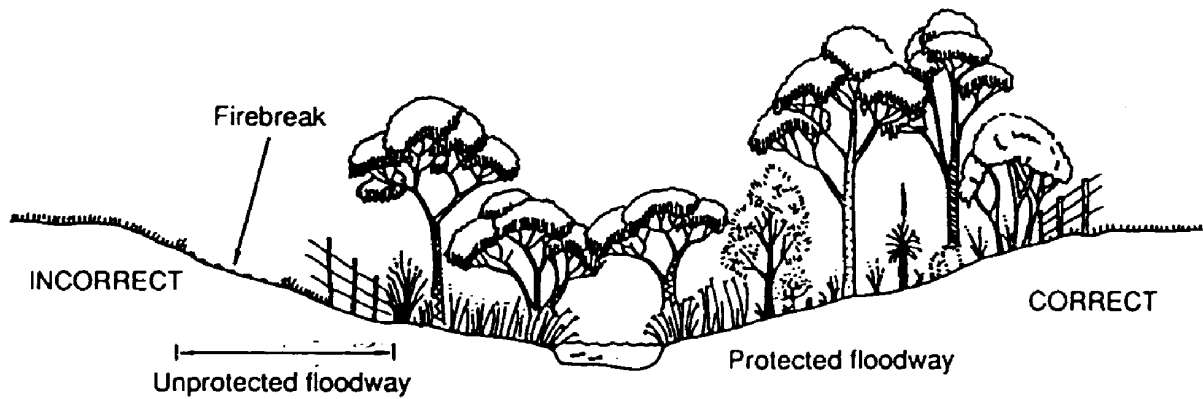
Electronic fencing is being developed in the USA specifically to control livestock access to riparian areas. Receiver ear tags worn by stock and one or more transmitters form an electronic boundary.

If an animal moves into the exclusion area, the audio warning signal is activated followed by an electrical stimulus to the ear, causing the animal to move out of the exclusion zone.

(A) DEEP RIVER VALLEY



(B) SHALLOW RIVER VALLEY



(C) BROAD RIVER VALLEY

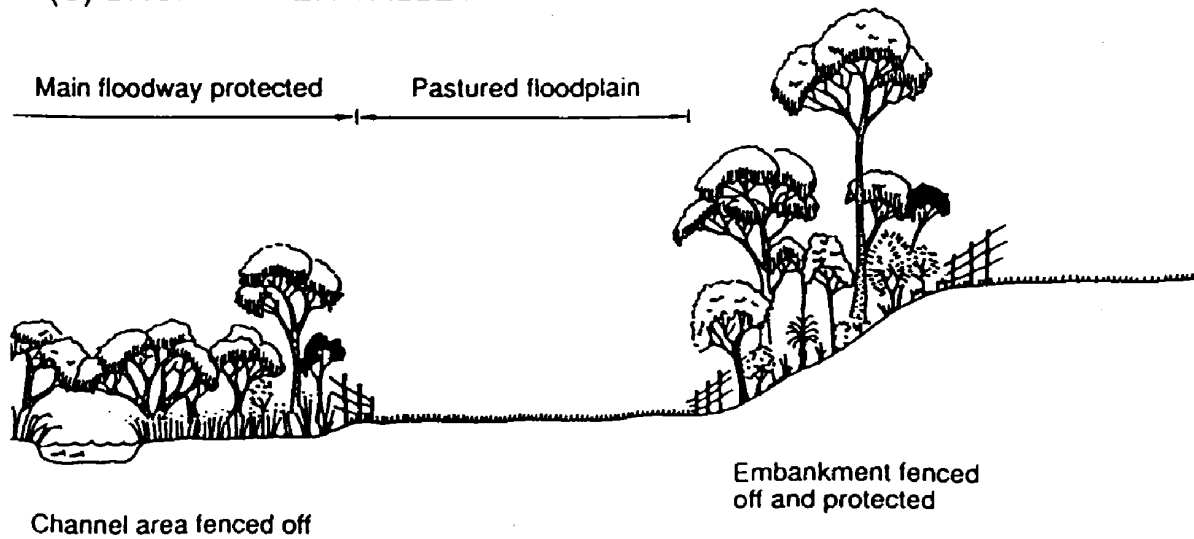


Figure 6: The correct and incorrect placement of fences in relation to the river valley - the deep river valley, the shallow river valley and the broad river valley and flood plain (Pen, 1995).

It is recommended that landholders consider the following:

1. Make the commitment to retain and protect the river, tributaries and drains, and exclude stock permanently.
2. Fence the river to exclude stock permanently, or to achieve management that allows for bank stabilisation and vegetation establishment, for biodiversity or a commercial enterprise.
3. Aim to eliminate the need for any cattle stops along the entire length of the river.
4. Create a corridor which promotes the movement of wildlife and recreates their habitats.
5. Eradicate the weeds dominating the riparian zone by chemical and non-chemical means instead of grazing, and reduce the fire hazard.
6. Approach your neighbour and ask that he keep his stock on his part of the river as you no longer want them on yours.
7. Utilise current sources of funding to entirely fence the river and its tributaries, add stock crossings and bridges, and control pests such as grasshoppers and rabbits which make revegetation difficult.
8. Consider widening the riparian zone in various ways to a minimum of thirty metres from the top of each bank where possible; options aside from indigenous vegetation could include commercial trees, fodder trees, commercial plantings of native shrubs for seed, flower production, dried foliage etc.
9. Gain consensus on property and Drain Reserve boundaries to allow participation in revegetation projects by those interested.
10. Take boundary disputes to AGWEST's Agricultural Practices Board (Oates, pers comm, 1999).



Keeping stock out of the river channel is the most important action to take in river restoration.

6.8 Riparian buffer width

The width of riparian vegetation along the river determines its effectiveness as a buffer zone. It is also a major factor in sustaining aquatic ecosystems, protecting aquatic invertebrate communities, riverine processes and the riparian buffer itself. The zone can vary with adjoining land use, soil type, slope, surface roughness, rainfall and vegetation type (Riding and Carter 1992).

There is now general acceptance that 20 to 30 m either side is a minimum requirement for adequate protection of the waterway, but with steep slopes up to 60% and highly erosive soils, 90 metres may be desirable.

Wildlife corridors have a minimum requirement of 80 to 100 metres for the long-term retention of most birds and mammals. An alternative to this would be 20 metre buffer strips with 'islands' of vegetation 50 to 60 metres wide nearby linked by short corridors 20 metres wide (Kelly & Barry, 1986).

6.9 Preventing erosion

The density and type of riparian vegetation helps resist the erosive forces of water. Revegetating unstable banks provides a relatively cheap long term solution for achieving stability and also provides many other benefits to the landholder and to the environment.

It is important to understand the reason for the erosion. For example, in the middle catchment of the Vasse where did the sediment originate, what caused it to be removed, why does a particular area continually build up sediment, what are the factors involved in creating the problem and how can they be resolved? Look further upstream for the answers and then select strategies that are appropriate and will have a good chance of remedying the problem and meeting with success.

In some instances revegetation may be inadequate to address the problem and a complementary engineering solution may have to be used such as judicious pruning of instream vegetation, moving sediment from the centre channel to the outer embankments or repairing eroded gullies by grading.

It is recommended that landholders consider the following:

1. Ask the relevant authorities for assistance with problems you are experiencing with the water channel - WRC, WC, GeoCatch etc.
2. Notify them immediately of damage or blockages that are their responsibility to resolve.
3. Ask for agency advice and expertise in resolving your problems.
4. Request a review of the management of the penstock at the Diversion Drain and its coordination with the floodgates and the check boards further downstream.
5. Attend GeoCatch seminars for information on future management of all the waterway structures (the penstock at the Diversion Drain, the check boards at the Butter Factory, the floodgates at the estuary) impacting on the natural flow of the Vasse River.

6.10 Planting the riparian zone

The land management practices on-site, the present site condition, the revegetation strategy selected and the maintenance of that revegetation, all influence overall success when planting new vegetation. Consider the management issues of the site and then select the most appropriate technique - natural regeneration by fencing and stock exclusion, direct seeding or hand planting seedlings.

Fencing is required for every strategy. Natural regeneration is the easiest and most cost-effective option where both trees and understorey still exist. It is vital to control invasive weeds such as bridal creeper and blackberry. Burning small patches can also promote natural regeneration by smoke or heat. Weed seedbed reduction can also be achieved by raking small areas into heaps in autumn or winter, and carrying out isolated 'hot burns' which bare the ground and provide ash beds for scattering seeds or for laying down seed bearing branches of certain plants. The seedlings will usually establish in the weed free conditions.

Heavily grazed and cleared sections generally contain more weeds and have a diminished seed bank. Direct seeding and hand planting seedlings are good options to choose for these areas. Weed and pest control is essential to reduce competition for young seedlings and germinating seeds. Grassy weeds can be replaced by broad-leaved weeds that are more difficult to control, so they need management until the new plants establish and their shade eliminates the grasses. Seeding small areas at first to establish a successful technique is recommended.

Hand planting is often the only option and the position of plants is important, along with good weed and pest control and plant maintenance for the first year.

Plant towards the edge of the channel as the banks become more stable to avoid the work being washed away. Sedges and rushes are best

planted along the edge of the channel as they can adapt to inundation and flooding and afford the embankment good protection and stabilisation.

Seedlings are best established without weed competition and need an area of about a metre clear around each plant. Cardboard boxes weighted with a stone have been successful in reducing weeds, protecting the plant from pests and providing a micro-climate. The seedling is planted in the centre of the box and over time the box flattens and mulches the ground.

For specific information on means of control or eradication refer to officers at AGWEST, 'WeedFax' and 'FarmNotes'.

6.11 Plant species for rehabilitation

Below is a list of local native plants that grow in and near the waterways of the Geographe Bay Catchment. These species can be funded under current programs and should be used as the basis for all indigenous revegetation in the region. As species can vary substantially from one locality to another, it is advisable to study the plants already naturally established near the area to be revegetated, and if possible collect seed from them to maintain the local provenances of that area. This strategy ensures genetic continuity.

A licence to collect seed is not required for private land where there is no commercial gain and the seed is for a rehabilitation project. CALM strongly supports and applauds groups and individuals engaged in this work. Where seed is to be collected from Crown Land, including road reserves, the land manager eg .Sh Bsn, WC, WRC etc must first give approval and then an application must be made to CALM for a licence. Application forms are available at CALM offices.

The following plants are particularly suitable for creekline revegetation in the southern part of the Swan Coastal Plain (Hussey et al., 1997). Further details can be found in the Geographe Bay Catchment Natural Resource Atlas.

Botanical Name	Common Name	Form
Trees		
<i>Acacia saligna</i>	Golden wreath wattle	tree/shrub
<i>Agonis flexuosa</i>	Peppermint	tree 10 m
<i>Allocasuarina fraseriana</i>	Sheoak	tree
<i>Banksia attenuata</i>	Slender banksia	tree
<i>Banksia grandis</i>	Bull banksia	tree 8 m
<i>Banksia ilicifolia</i>	Holly-leaved banksia	tree
<i>Banksia littoralis</i>	Swamp banksia	tree 10 m
<i>Casuarina obesa</i>	Swamp sheoak	tree 10 m
<i>Corymbia calophylla</i>	Marri	tree 30 m
<i>Eucalyptus gomphocephala</i>	Tuart	tree 30 m
<i>Eucalyptus marginata</i>	Jarrah	tree
<i>Eucalyptus. patens</i>	Blackbutt	tree
<i>Eucalyptus rudis</i>	Flooded gum	tree 25 m
<i>Hakea prostrata</i>	Harsh hakea	small tree / shrub 3m
<i>Melaleuca incana</i>	Grey honey myrtle	small tree / shrub 4m
<i>Melaleuca cuticularis</i>	Saltwater paperbark	tree 10 m
<i>Melaleuca preissiana</i>	Modong	tree 15 m
<i>Melaleuca raphiophylla</i>	Freshwater paperbark	tree 10 m
<i>Nuytsia floribunda</i>	Christmas tree	tree
<i>Persoonia longifolia</i>	Snottygobble	small tree
<i>Xylomelum occidentale</i>	Woody pear	small tree
Shrubs		
<i>Acacia dentifera</i>	-	shrub 3 m
<i>Acacia pulchella</i>	Prickly Moses or Blackwood curse	shrub 1.5 m
<i>Acacia saligna</i>	Golden wreath wattle	shrub / tree
<i>Agonis lineariflora</i>	Swamp peppermint	shrub 3 m
<i>Astartea fascicularis</i>	Tea tree	shrub 2 m
<i>Boronia heterophylla</i>	Pink boronia	shrub 2 m
<i>Calostachys lanceolatum</i>	Greenbush	shrub 4 m
<i>Calothamnus latoralis</i>	Swamp one-sided bottlebrush	shrub 1.5 m
<i>Calothamnus quadrifidus</i>	One-sided bottlebrush	shrub 2 m
<i>Dasyogon hookerii</i>	Pineapple bush	shrub
<i>Dryandra sessilis</i>	Parrot bush	shrub 3 m
<i>Eriostemon spicatus</i>	Pepper and salt	shrub 1.5 m
<i>Grevillia diversifolia</i>	Valley grevillea	shrub 10 m
<i>Grevillia vestita</i>	-	shrub 2 m
<i>Hakea prostrata</i>	Harsh hakea	shrub 3 m
<i>Hypocalymma angustifolium</i>	White myrtle	shrub 1 m
<i>Kunzea ericifolia</i>	Spearwood	shrub
<i>Kunzea recurva</i>	-	shrub 1.5 m
<i>Labichea lanceolata</i>	Tall labichea	shrub 3 m
<i>Melaleuca incana</i>	Grey honey myrtle	shrub / small tree 4 m
<i>Melaleuca latteriflora</i>	Gorada	shrub 3 m
<i>Melaleuca laterita</i>	Robin redbreast bush	shrub 1.5 m
<i>Melaleuca terifolia</i>	Banbar	shrub 3 m

<i>Melaleuca uncinata</i>	Broombush	shrub 4 m
<i>Melaleuca viminea</i>	Mohan	shrub 3 m
<i>Myoporum cararioides</i>	Slender myoporum	shrub 2 m
<i>Oxylobium lineare</i>	River pea	shrub 3 m
<i>Regilia inops</i>	Mouse bush	shrub 1.5 m
<i>Viminaria juncea</i>	Swishbush	shrub 2 m

Ground Layer Plants

<i>Anigozanthos viridis</i>	Green kangaroo paw	low plant
<i>Arthropodium capillipes</i>	Chocolate lily	low plant
<i>Billardiera candida</i>	Wedding creeper	runner / climber
<i>Billardiera coeruleopunctata</i>	-	runner / climber
<i>Hardenbergia comptoniana</i>	Native wisteria	runner / climber
<i>Kennedia prostrata</i>	Red runner	runner
<i>Petrophile linearis</i>	Pixie mops	low plant 0.5 m

Reed-like tussocks

<i>Agrostocrinum scabrum</i>	Blue-eyed reed	tussock
<i>Baumea articulata</i>	Jointed rush	tussock
<i>Dianella revoluta</i>	-	tussock
<i>Juncus kraussii</i>	Sea rush	tussock
<i>Lepidosperma gladiatum</i>	Coastal sword sedge	tussock
<i>Lepidosperma effusum</i>	Inland sword sedge	tussock
<i>Leptocarpus coangustatus</i>	Twine rush	tussock
<i>Orthrosanthos laxus</i>	Morning iris	tussock
<i>Patersonia occidentalis</i>	Western iris	tussock

It is recommended that the Vasse-Wonnerup LCDC considers the following:

1. Create a revegetation strategy for the length of the river and for the whole catchment, including the protection and rehabilitation of wetlands, once the catchment's compensating basins.
2. Investigate faster and more efficient ways of establishing understorey species by using direct seeding techniques and encouraging natural regeneration with smoked water.
3. Publish and distribute the list of plants suitable for revegetation projects along the Vasse River and throughout the catchment.
4. Approach local nurseries to grow and popularise the plants needed for revegetation along the Vasse.
5. Conduct seed collecting workshops and expeditions to retain and build local provenances of all species with support and advice from CALM.
6. Visit agroforestry and rehabilitation sites in other catchments.
7. Extend the focus to include the rehabilitation of the smaller drains and tributaries to achieve the greatest impact on stripping sediments and nutrients before they reach the main river channel.

6.12 Weed management

Management of declared plants in the agricultural area is controlled by the Agriculture and Related Resources Protection Act 1976. The Act may prohibit their introduction to certain areas and stipulate what action (eradication, control or containment) landholders must take for those plants found within the specified area. It is the legal responsibility of all landholders to comply with the management requirements of Declared Plants.

The recently revised list of Declared Plants includes apple of Sodom, arum lily, blackberry, cape tulip, double Gee, Paterson's curse, thornapple and variegated thistle which are all found in the Busselton area in particular. Other Declared Plants are common across the state, A full list can be obtained from the local Protection Officer at Agriculture WA.

6.12.1 Weeds (Dewing, 1999)

Priority weeds need to be identified and a weed control strategy planned as part of site preparation and ongoing maintenance. It is good practice to commence treatment of perennial weeds such as bridal creeper and watsonia in the

season prior to revegetation as the treatments are often non-selective and usually require follow-up control.

Some general principles for weed control are:

- The less important weeds should be controlled if revegetation is being carried out, to improve seedling establishment.
- Broad-scale weed control without replanting can lead to the replacement of one weed by another - maybe something worse such as a broadleaf weed that cannot be controlled selectively.
- Aggressive, perennial weeds that spread readily along riparian corridors are the most important to concentrate on eradicating - arum lily, blackberry, bridal creeper, watsonia, pampas grass.
- Weed Action Plans should be strategic - the more stakeholders involved the more effective the effort will be. Weed mapping is helpful.
- Weed Action Plans are ongoing. Once started, the plans must continue maintaining and monitoring the work.

Dewing, J., unpublished, Bridgetown.

It is recommended that landholders consider the following:

1. Identify all weed infestations on your property.
2. Prioritise weed species and tackle the worst first.
3. Ascertain the optimum times for control and eradication techniques, and the most appropriate methods and substances to use for greatest effect.
4. Plan follow-up treatments, and check annually to locate and deal with new infestations.
5. Plan an activity for National Weedbusters Week in October each year. Encourage upstream neighbours to join in weed busting with you.
6. Eradicate rabbits using a systematic strategy along the whole river.
7. Fence wider to allow for strategic grazing and fire management of weeds by reducing fuel loads.
8. Establish native vegetation that smothers weed infestations and reduces flash fuel loads.

6.12.2 Weed control as part of site preparation in revegetation (Dewing, 1999)

Determining the best time to commence site preparation for hand planting or direct sowing in the riparian zone is difficult.

Creek situations are predictable - winter flow levels are easy to determine from the vegetation distribution patterns and water level marks along the banks. Occasional flash floods burst the banks, spilling onto the flood plain, but these events are usually short-lived and sometimes last only hours.

River situations with winter water levels are less predictable and the variation in river height from year to year can be many metres. It is impossible to predict the winter level and heavy rain in the upper catchment can quickly cause a dramatic

increase in lower catchment levels without much local rain.

Spraying weeds too early can expose areas of bare ground to the erosive forces of water. Flooding events or prolonged high winter levels usually create a weed free seedbed naturally on the lower bank, thus eliminating the need for chemical control.

Revegetation work on the lower bank is always a gamble. Every five to ten years the conditions are perfect for mass planting and direct sowing - a lower bank and flood plain with natural weed control and soil that stays moist well into late spring. It is only possible to make the best of the seasonal conditions on offer. Monitor weather and river conditions closely so that seedlings are planted as the winter water levels recede.

It is recommended that the Vasse-Wonnerup LCDC and landholders consider the following:

1. Hold an annual Chemical Users Accreditation Course for all landholders and their families to become well qualified and well informed about the safe and appropriate use of chemicals around the farm, the livestock, the garden, the waterways and the house.
2. Access courses advertised locally by chemical suppliers.
3. Utilise InfoNotes and FarmNotes free from the AGWEST Office or AgFax Service to access information on controlling weeds, using protective clothing, withholding periods before grazing stock, and 'safe' chemicals to use near waterways and wetlands.

6.12.3 Weeds at the water's edge (Dewing, 1999)

Along the water's edge, weed control needs to be conducted in spring and early summer, as the weeds recover from their winter dormancy. Many riparian weeds grow vigorously in the warmer months. Perennial weeds such as kikuyu and dock withstand flooding by being dormant through the winter. They begin to grow again as the banks start to dry out.

Annual weeds such as hastate orache (*Atriplex prostrata*), wild radish (*Raphanus raphanistrum*) and prickly lettuce (*Lactuca serrida*) germinate readily in late spring and through early summer as each rain event occurs.

In this situation, weed control needs to be maintained and target weeds may need repeat treatments. The goal is to prevent weeds from setting and dispersing seed each season.

The river environment is very sensitive to chemical applications and extreme care must be taken. Manual weed control is the preferred option. Weeds such as dock can be hand pulled in late spring while the soil is still moist. Seed heads can be cut off and bagged. Wild radish and prickly lettuce can be hand pulled and bagged before seed set.

Weeds such as blackberry and kikuyu grass may need chemical treatment but may also be controlled by slashing and then mulching with old carpet. Areas prepared for hand planting should be large enough to allow the establishment of seedlings without weed competition, a one metre square or circle per plant.

Bare ground is likely to be colonised by other weeds, or perhaps a new weed that is harder to control. Grassy weeds such as kikuyu, phalaris and veldt grass are usually replaced by broad-leaved weeds such as wild radish, dock and sorrel. These weeds readily become established and are more difficult to control.

Grassy weeds can be selectively treated with chemicals that will not damage the new native vegetation and their presence can become part of the management, keeping out broad-leaved weeds while the new vegetation establishes and eventually shades out the grasses.

The composition of the vegetation cover of the river environment is dynamic, resulting from the interaction between natural events such as flooding and the management practices of weed control, burning and grazing.

6.12.4 Revegetation Trials (Dewing, 1999)

It is sensible to trial revegetation techniques in small patches. A half tennis court area is recommended before extending the techniques to larger areas. Trial patches should be carefully monitored to establish the success of the treatment.

Another weed control technique that can be trialled to create a weed free seed bed is the 'small heap burn'. Little piles of woody debris can be collected on site. A firebreak is raked around the heaps and a hot burn is carried out in autumn or early winter when conditions are safe for burning. This technique allows a hot burn to also be achieved in winter. The resulting patches of bare ground are weed free, and provide ideal seed beds for seed to be scattered, or for seed bearing brush to be laid over the cool ash bed. The weed free conditions will usually last through the establishment phase of the seedlings.

6.13 Water quality monitoring

In the course of investigating any water body, the following parameters all provide indications of the health or degradation of a stream. While some require specific expertise and equipment to measure them accurately (Nitrogens and Phosphorus), most can be well-documented by community groups with some training.

Temperature	Nitrite
Dissolved Oxygen	Nitrate
pH	Total Phosphorus
Turbidity	Colour
Salinity / Conductivity	Odour
Ammonia	Flow measurements
Ammonium	Macro-invertebrates
Total Nitrogen	Phytoplankton
Total Inorganic Nitrogen	

Once the general principles of collecting samples and testing are understood, consistency in technique and attention to every detail of testing procedures will give sound results that indicate trends. Careful sample collection and storage for laboratory analysis will also give useful results. The information the community is able to gather can complement and extend agency data, creating very useful and worthwhile partnerships for mutual benefit.

To gain an improved understanding of catchment water quality over time an annual 'snapshot' of water quality would assist. The following sites are suggested for the main channel of the Vasse:

- Site 1: Hopkins Road
- Site 2: Price Road
- Site 3: private road bridge on the Avery property (with owner's permission)
- Site 4: Don Road (caution needed for traffic)
- Site 5: private road bridge on the Vasse Research Station (with manager's permission)
- Site 6: Chapman Hill Road (caution needed for traffic)
- Site 7: above the confluence with Boxer Gully (with owner's permission)
- Site 8: above the confluence with Green Gully (with owner's permission)

It is recommended that the Vasse-Wonnerup LCDC and landholders consider the following:

1. Conduct an annual 'snapshot' of water quality, parameters that can be monitored are nutrients (TP, TN), turbidity, sediments, pH, salinity, DO and macroinvertebrates
2. Utilise the flow data from the WRC gauging stations within the catchment to assess loads of nutrients and salt.
3. Record information on a database that will produce graphs of data for displaying on field days and workshops, and for including with future funding applications for projects along the river.
4. Share data freely with WRC, GeoCatch, landholders and other interested groups.



Typical C-grade foreshore.

7. Other catchment strategies

Some additional strategies were seen as important by landholders attending a workshop to present the outcomes of the Vasse River Assessment Survey. The issues listed here are additional to the river assessment, and largely correspond with concerns expressed by landholders during the course of the original survey. A coordinator is seen by landholders to be the key to ensuring that these proposals are acted on in the future. It is highly desirable that whole of catchment participation is achieved.

7.1 Communication - LCDC and Landholders

- Request GeoCatch to attract funding to employ a local, part-time coordinator for information communication and to help design, write and implement new strategies on weed management, communication, water quality monitoring, streamlining, revegetation, and fencing.
- Forge closer links with the Vasse-Wonnerup Land Conservation District Committee, GeoCatch and each of the government agencies and their officers.
- Build a file of useful information pertaining to river and land management.
- Hold an 'Open Day' and tour the full length of the Vasse River visiting as many different properties as possible to see, understand and appreciate the full scope of the river.
- Subscribe to 'RipRap' and other FREE Land and Water Resource, Research and Development Corporation (LWRRDC) publications
- Locate a twin catchment with which to correspond and exchange information and visits - eg Inverbrackie Landcare group, Mt Lofty Ranges, South Australia.
- Approach the local high school to establish a website with which to seek and exchange information world wide - approach the students to help create and maintain the site for a small fee.

- Join the Kondinin Group's new LANDCARELINK to communicate with other Landcare groups Australia wide.
- Ask AGWEST for FarmNotes, WeedNotes and AgFax information, and CALM for TreeNotes on issues relevant to you, like erosion repair, weed eradication, tree establishment, etc.
- Communicate details of current funding available for projects.

7.2 Hydrology and dryland salinity - LCDC

- Seek Natural Heritage Trust Funding for a study of the hydrogeology of the Vasse Catchment to assist with designing agroforestry and other high water use projects across the catchment to alleviate increasing surface water flows, inundation and flooding.
- Investigate the recharge system of the Donnybrook Sunklunds to ascertain its impact, if any, upon the Vasse River Catchment.
- Check with Sh Bsn and GeoCatch to find what regional studies are being planned that would be of use to the Vasse River Catchment.
- Access and distribute information from the WRC Busselton Regional Flood Study Review – 1998 to explain how the catchment affects the town, and how compensating basins may be used to improve farm productivity.
- Include mainstream farming activities in the study which may reduce water run-off and increase water use.
- Encourage landholders to use the LCDC Salinity Package to map soil salinity on your property and through the catchment.
- Identify what techniques and farming systems are available to improve water quality before the run-off reaches the waterways.

7.3 Land monitoring and management - LCDC and landholders

- Approach the Land Management Society for a workshop on using the Land Management Monitoring Kit and associated handbook.
- Develop comprehensive weed management actions amongst adjoining landholders.
- Develop farm plans that will improve farm production, and protect and enhance environmental values.
- Keep simple but accurate and comprehensive records.
- Establish photographic sites to record site progress annually.

7.4 Demonstration site proposal

The Vasse Diversion Drain and that part of the river leading to it present one of the worst visual and environmentally degraded areas of the river, in full public view along the Busselton Golf Course.

During the 1980s the river was excavated to contain the backwaters from the Diversion Drain and is now overgrown with kikuyu. Some trees remain along the banks and some original understorey plants remain near the upstream boundary of the golf course,.

The banks are sandy and need stabilising with deep-rooted vegetation. A tree which fell across the river has caused sedimentation at that site, and the water flowing over and around it eroded the bank and de-stabilised it sufficiently to cause a major slump of land into the drain - a situation that could easily continue or be repeated elsewhere without intervention.

A detailed and well-presented proposal from a number of community and agency groups prepared to make their own contributions to the project could be met favourably by a sponsor such as Iluka Resources. Their mineral sands mining lease of the land opposite the Golf Club expires in two years. The company has previously been involved in many worthy projects and may well consider assisting to create another legacy for the people of Busselton and their many visitors.

The site presents many challenges but would serve as an excellent demonstration site to all potential rehabilitators of rivers, streams and drains throughout the region. Iluka Resources has the environmental expertise to make the project a great success with input from as many groups and individuals from the Busselton community as possible.



Proposed restoration site adjoining Busselton Golf Course.

8. Contacts, references and recommended reading

8.1 Contacts for catchment management

Vasse-Wonnerup Land Conservation District Committee	David Kemp:	(08) 9753 3210
Geographe Catchment Council - GeoCatch	Anthony Sutton:	(08) 9754 4331
Remnant Vegetation Protection Scheme – AGWEST	Will Oldfield:	(08) 9752 1688
Natural Heritage Trust Funding - AGWEST	John Holley:	1800 198 231
Bushcare - National Vegetation Initiative - CALM and Greening WA	Gary McMahon:	(08) 9725 4300
	Nathan McQuoid:	(08) 9335 8933
Rivercare - National Rivercare Program - Water and Rivers Commission		(08) 9278 0300
National Landcare Program - AGWEST, CALM and Greening WA		(08) 9752 1688
Coastcare	Nicci Tsernjavski:	(08) 9791 4699
State Landcare Program - Soil and Land Conservation Council		(08) 9222 0000
Roadside Conservation Committee - CALM	David Lamont:	(08) 9334 0423
Ribbons of Green - Greening WA		(08) 9335 8933
Trees and Seeds for Diversity - Greening WA		(08) 9335 8933
Gordon Reid Foundation for Conservation		(08) 9322 1850
WA Salinity Action Plan - AGWEST		(08) 9752 1688
Australian Trust for Conservation Volunteers (ATCV)		(08) 9368 2160
Land for Wildlife - CALM	Cherie Kemp:	(08) 9752 1677
Geographe Bay Catchment Streamlining Fund Field Officer –	Kay Lehman:	(08) 9757 3727
Busselton Naturalists Club	Bernie Masters:	(08) 9752 1949
Local Member of Parliament - Mr Bernie Masters MLA		(08) 9752 1949
Environmental Weeds Action Network	Sandy Lloyd:	(08) 9368 3215
Water and Rivers Commission	Bunbury Office:	(08) 9721 0666
Water Corporation	Bunbury Office:	(08) 9791 0400

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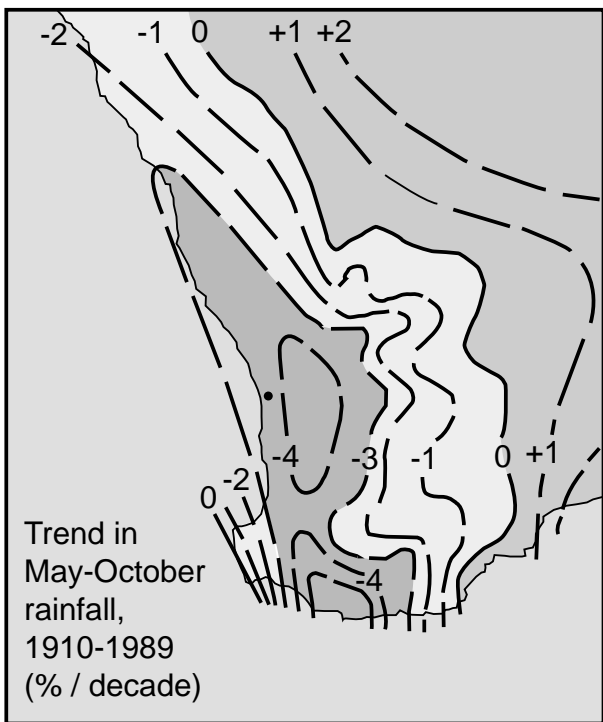
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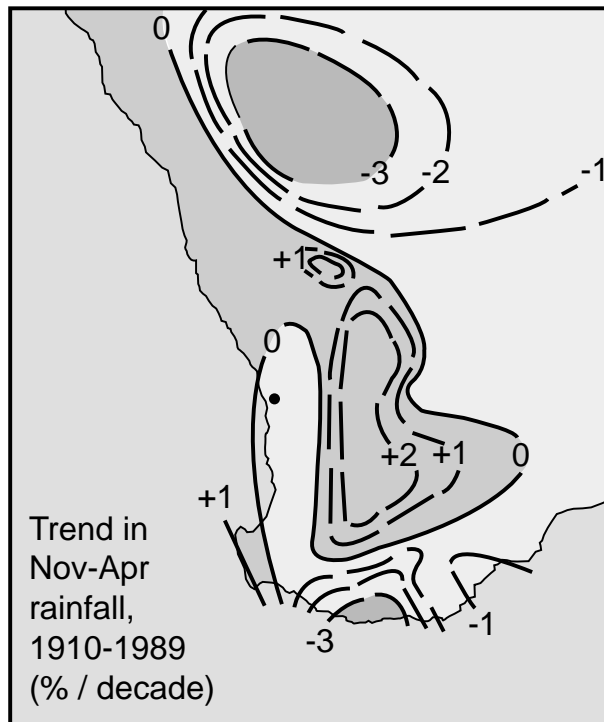
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Appendices

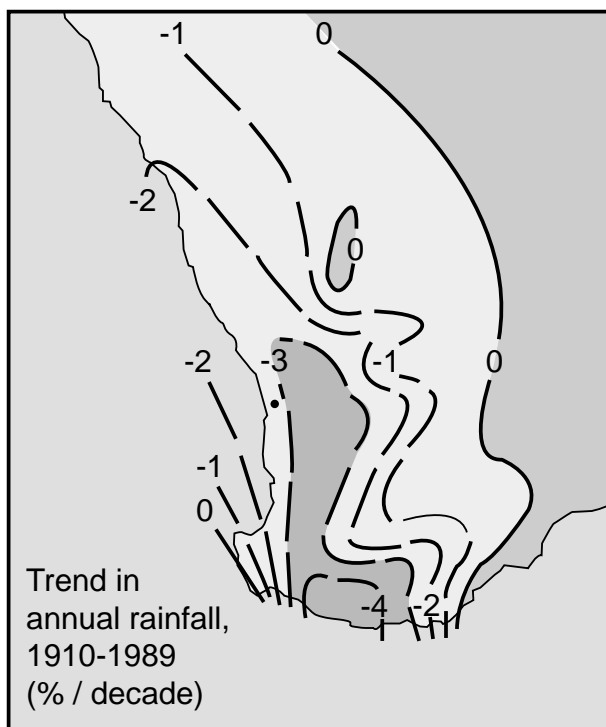
Appendix 1: South West Rainfall Trends 1910-1989



Trend in annual winter rainfall (May to October) depicting a 2% decline per decade for Busselton 1910 to 1989.

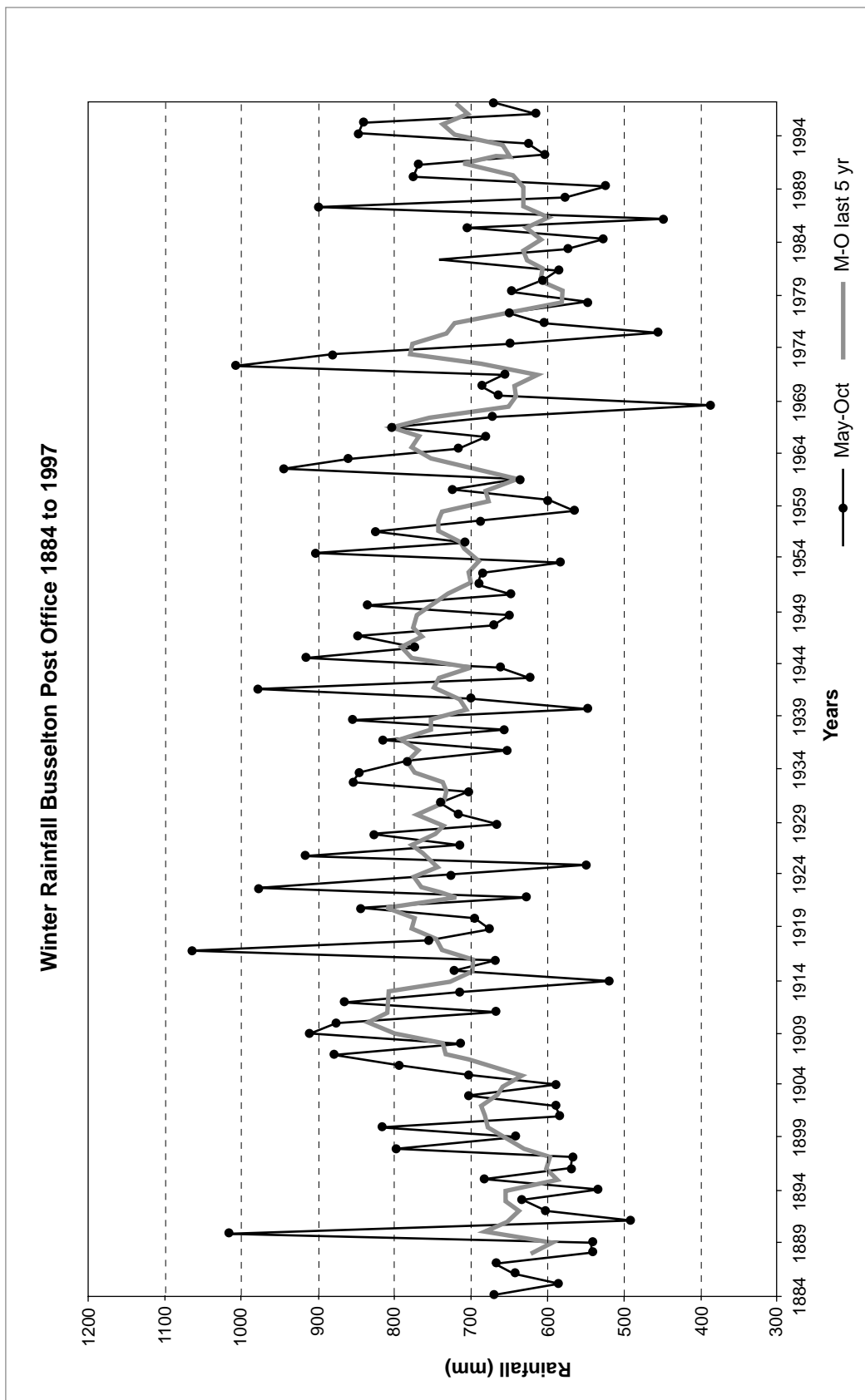


Trend in annual summer rainfall (November to April) depicting no change for Busselton 1910 to 1989.

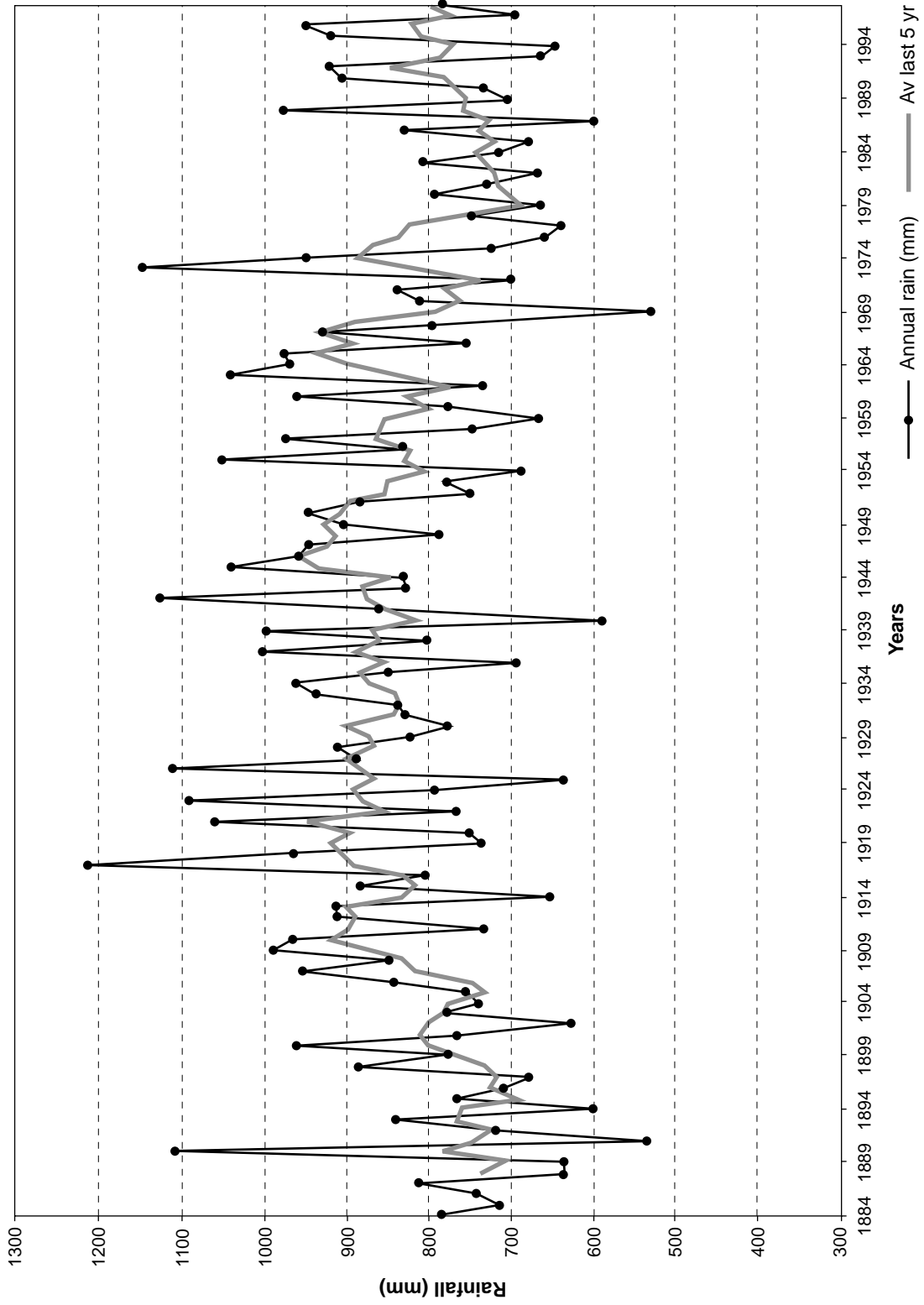


Trend in annual rainfall depicting a 2% decline per decade for Busselton 1910 to 1989.

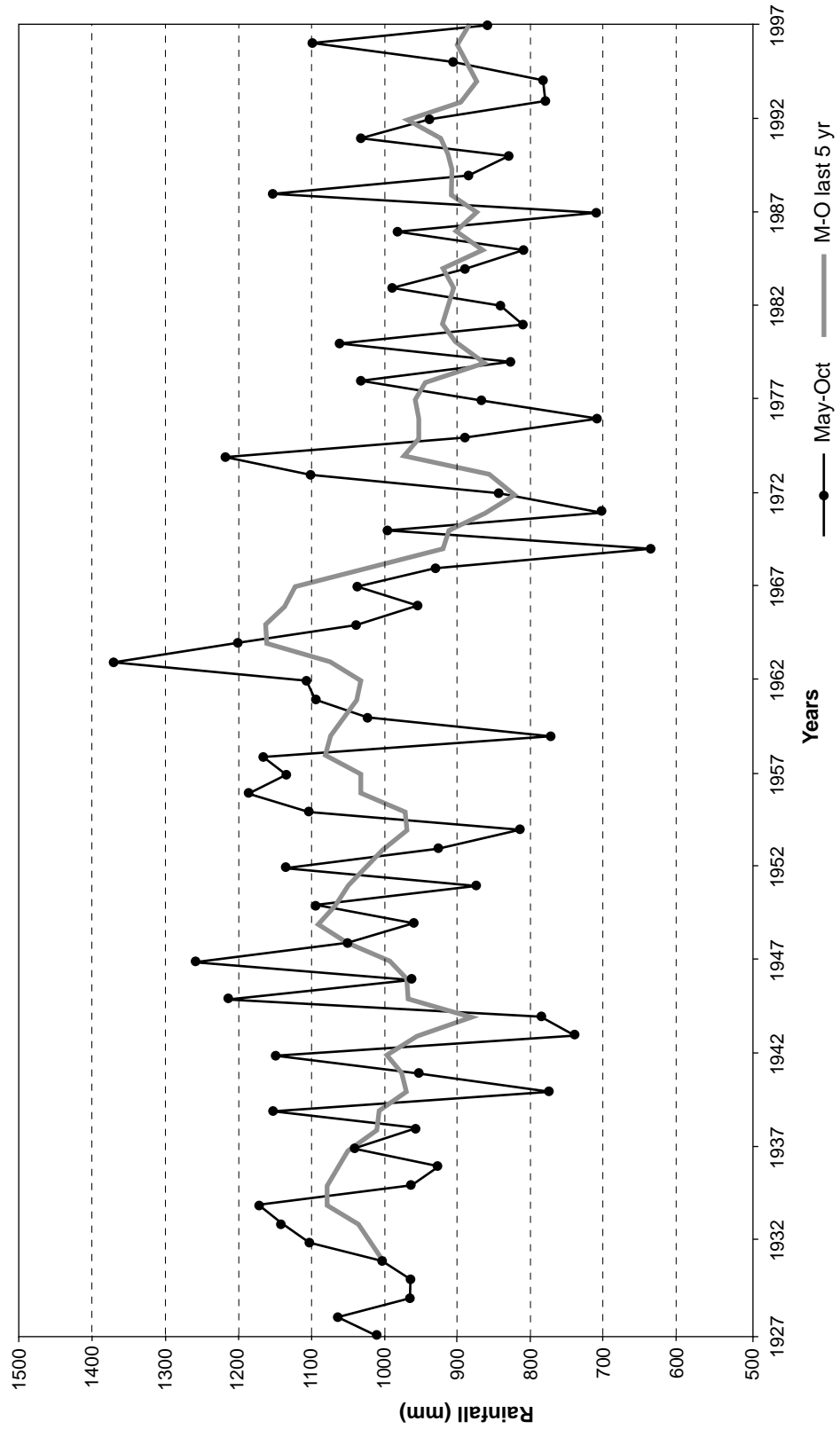
Appendix 2: Rainfall Charts - Busselton and Cowaramup – 1884 to 1997



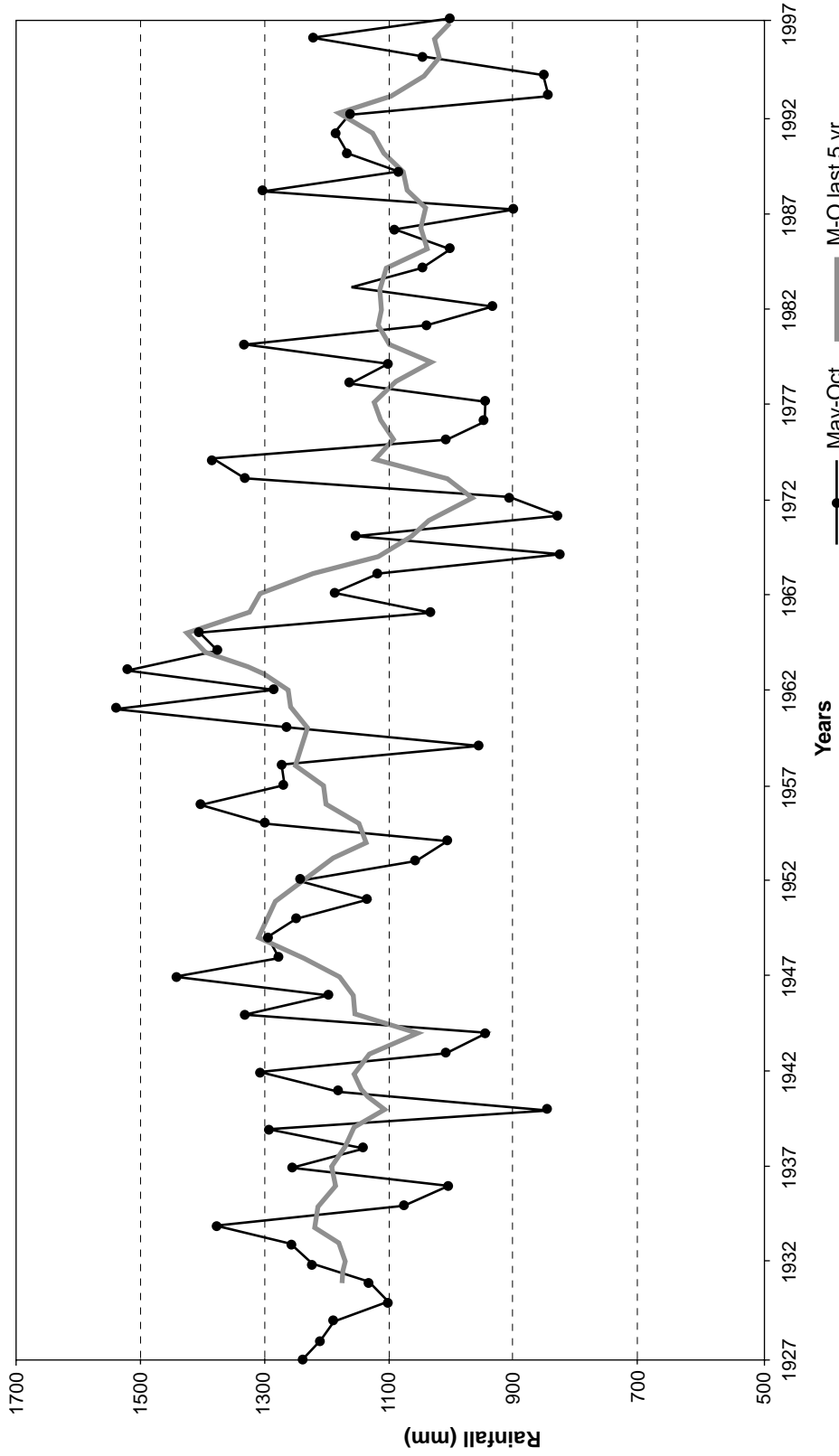
Annual Rainfall Busseilton Post Office 1884 to 1997



Winter Rainfall at Cowaramup 1927 to 1997



Annual Rainfall at Cowaramup 1927 to 1997



Appendix 3: Responsibilities of State Government Agencies

Information from the Water Corporation (WC), the Water and Rivers Commission (WRC), Agriculture WA (AGWEST) and the Department Conservation and Land Management (CALM) follows which helps define their responsibilities to waterways and landholders and the services they are able to provide. Further information is available from the respective departments.

Water Corporation

WC provides water, wastewater, drainage, irrigation and other water-related services throughout Western Australia. WC carries out maintenance of the Rural Drainage system under licence to the Office of Water Regulation on behalf of the State Government. In essence this means the Water Corporation is like a contractor being funded by Government to carry out the work under the supervision of the Office of Water Regulation.

The Corporation is charged with ensuring that the drains are cleaned to a degree that they clear water from rural properties within 3 days of a storm event where this is physically possible and the property is served by a Corporation drain.

Under direction from the Government, cattle stops and structures which allow access for property run-off into the Corporation drains are the responsibility of the land owner regardless of who constructed them. The owners of land are required to leave access to the drains for maintenance purposes. If they do not they are required to do their own maintenance and also carry the responsibility for any liability that arises from poor performance. Land owners are not permitted to obstruct the drain in any way and can be held liable for the cost of removing obstructions and any repairs required. This includes the placement of pipes or any other structure in the drain without approval.

If you see any problems please telephone:

DRAINS: John Moon 0417 928 714

STRUCTURES: Clive Piggot 0417 911 839

BUSSELTON OFFICE: 9752 1308

Water and Rivers Commission

WRC ensures that the State's water resources are managed to support sustainable development and conservation of the environment for the long-term benefit of the community. Water resources are all inland surface water, which includes rivers, lakes, wetlands, estuaries and inlets, and all underground water including that below near-coastal marine waters.

The Commission provides services to the community, which are delivered across three broad sub-program areas:

- Water resource investigations - the investigations of the quality, quantity and location of ground and surface water resources.
- Water resource allocation and management - the allocation and management of efficient use of water resources.
- Water quality and conservation - the conservation, protection and enhancement of water quality for public, private and environmental uses of water.

**BUSSELTON DISTRICT
OFFICE (GEOCATCH): (08) 9754 4331**

**REGIONAL OFFICE
BUNBURY: (08) 9721 0666**

Agriculture Western Australia

Agriculture Western Australia provides leadership and innovation to ensure the development and success of the State's agriculture, food and fibre industries.

AGWEST has programmes to minimise the impact of pests and diseases, utilise and develop new technologies, undertake strategic and applied research and provide timely, relevant information. Regional and local centres deliver services directly to farmers and rural businesses.

**BUSSELTON DISTRICT
OFFICE: (08) 9752 1688**

VASSE RESEARCH STATION: (08) 9753 1076

Department of Conservation and Land Management (CALM)

CALM is an agency with several integrated responsibilities. They manage State lands and waters for their renewable resources, for the recreation and tourism they can support, and for the conservation of the native wildlife, both plant and animal, which they sustain.

By building conservation partnerships with the community, landholders, industry and other agencies, CALM controls processes which threaten natural values of reserves, including feral animals, weeds, dieback and inappropriate fire regimes.

BUSSELTON DISTRICT

OFFICE: (08) 9752 1677

FARM FORESTRY: (08) 9752 1677

FORESHORE CONDITION

A Pristine to slightly disturbed

- A1 Pristine: no weeds
- A2 Near pristine: some weeds
- A3 Slightly disturbed

B Degraded - weed infested but tree cover still largely present





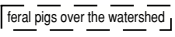





- B1 Understorey: mainly natives
- B2 Understorey: 50 per cent weeds
- B3 Understorey: mainly weeds

C Erosion prone to eroded

- C1 Erosion prone
- C2 Soil exposed
- C3 Eroded

D Ditch or drain

- D1 Ditch - eroding
- D2 Ditch - freely eroding
- D3 Drain - weed dominated

	river channel width
	weeds
	fauna
	special features and notes
	hazard area
	fencing and grazing status of the riparian zone
	foreshore assessment grading and river reach
	stock crossing
	road crossing or bridge
	remnant bush area to be fenced

Topographic and cadastral data supplied by the Department of Land Administration

Map Legend



CUSTOMER
FOCUS
WESTERN AUSTRALIA
