Capel River
Action Plan

1999

Soil and Land Conservation Council Western Australia

Water and Rivers Commission

GeoCatch

Natural Heritage Trust

Capel River
Action Plan

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Prepared for Geographe Catchment Council - GeoCatch
and the Capel Land Conservation District Committee

by
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How to use this river action plan

Read the text at the front of the report. This will provide background information regarding river processes, water quality and heritage issues which relate specifically to the Capel River.

The Capel River was broken into seven sections according to the primary management issues (or problems). Use the location map (page 3) to find the section of the Capel River that your property lies within.

Turn to the description of the relevant river section. This will provide a summary of the state of the Capel River throughout that section.

Find the map containing your property by searching for your location number or lot number by using local landmarks.

Use the foldout legend (at the back of all of the maps) to understand the detail contained on the map referring to your property.

Each map has a table facing it which gives general rehabilitation and management advice. The tables will refer you to more specific advice relating to erosion management, weed management and rehabilitation advice, including appropriate species to replant on your property. The table will identify a specific management advice point (a number). Refer to Chapter eight of the report for the details.

Use a combination of the section descriptions, the table, and the specific management advice points, to determine what recommendations have been made for your property.

Acknowledgments

This river action plan was developed in consultation with the Capel Land Conservation District Committee (LCDC). The authors wish to thank the members of the LCDC for their extensive time and effort in assisting with the development of this plan. The Capel LCDC has been closely involved in monitoring water quality within the Capel River, and actively encouraging private landowners to fence and rehabilitate the river for some time. It is hoped that this plan will assist them with future efforts in this area.

We also wish to thank members of the Capel community who participated with the assessment of the river foreshore and provided anecdotal information about changes that have occurred along the Capel River over the past few decades:

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Summary of content, issues and recommendations

This report presents a summary of the environmental status of the Capel River foreshore, the issues associated with its use and management, and recommendations relating to the future management of the foreshore reserve. The report and associated maps are collectively referred to as a 'river action plan'. This action plan aims to provide landholders and the wider community of Capel with a tool to guide the use of limited resources available for weed control, erosion control and replanting of native vegetation along the foreshore reserve.

A primary focus of the study was to ensure that the local community had an opportunity to contribute information to the action plan and to raise issues of concern that related to the Capel River and its management. Many landholders adjacent to the Capel River participated in assessing the foreshore, as well as providing historical anecdotal information and identifying individual concerns associated with the Capel River.

An assessment of the river foreshore was undertaken between the mouth of the Capel River and the Capel Shire boundary. The foreshore assessment involved rating the condition of the foreshore with respect to the level of erosion and weed invasion (using the Pen-Scott evaluation technique); recording the vegetation species (both native and exotic) along the foreshore reserve; and recording the type of vegetative cover present along each section surveyed. The results of the survey have been mapped along with other important features of the Capel River. These maps are intended to assist landowners, the Capel LCDC and the Capel community to prioritise resources for restorative action along the Capel River.

A summary of the foreshore condition ratings along the Capel River is presented in Table i below. Table ii presents the length of river that was fenced and unfenced and the length of fencing recommended for each bank.

Table i: Summary of foreshore condition rating of the Capel River

Condition Rating	North Bank		South Bank	
	Total Length	Total %	Total Length	Total %
A	0.9 km	3%	0.0 km	0%
B	6.3 km	21%	6.8 km	23%
C	23.2 km	75%	23.2 km	75%
D	0.4 km	1%	0.9 km	2%

Table ii: Length of fenced and unfenced areas on the Capel River with length of fencing required

	Length Fenced	% of Length	Length Unfenced	% of Length	Fencing Required	% of Length
North Bank	14.3 km	46%	16.7 km	54%	8.4 km	27%
South Bank	12.6 km	41%	18.4 km	59%	9.9 km	32%

The most prominent issues of concern along the Capel River were:

- Weed invasion - isolated areas of the foreshore were suffering from serious invasion by a variety of exotic species. Bridal creeper, fruit trees, blackberry, arum lily and blue periwinkle were particularly problematic in some sections.
- Scouring of the riverbanks - in some cases this was resulting in bank incision and subsidence, which add to water quality problems and lead to alterations in the river course.
- Loss of native vegetation - while some good quality reserves exist, in general the understorey along the margins of the Capel River was highly degraded.

In response to these issues, general recommendations to improve the condition of the Capel River are as follows:

- Protect existing native fringing vegetation along the length of the Capel River.
- Increase the amount and diversity of fringing vegetation along the Capel River by revegetating the river valley.
- Fence some remaining sections of the Capel River where stock need to be excluded from the river valley.
- Control a variety of weeds which are currently flourishing along much of the Capel River.
- Assist with the stabilisation of the riverbanks where severe bank subsidence and undercutting is occurring.
- A similar foreshore survey and action plan should be prepared for the upper portion of the Capel River (flowing through the Donnybrook Shire). Flow pattern and the spread of invasive weeds in this section of the river are likely to impact upon management of the river within the Capel Shire.

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1. Introduction

1.1 Background

The Capel LCDC was gazetted in 1993, largely in response to the concerns of Capel residents regarding the health of the Capel River and its catchment. The philosophy of integrated catchment management is supported by the Capel LCDC as a means to promote the good health of the Capel River.

Initial sampling of salinity, temperature and dissolved oxygen initiated by the Capel LCDC indicated that the river was healthy upstream of the Capel townsite, but downstream there were some problems. Erosion of the riverbanks was a notable problem, and some sections of the river have changed course over the past thirty years. Because of these issues, a plan to report on the state of the river, and provide a prioritised plan of action to address degradation of the Capel River was instigated by the Geographe Catchment Council. The project was funded through the National Rivercare component of the Natural Heritage Trust (NHT) and by the Water and Rivers Commission.

1.2 Study Aims

The primary aims of the Capel River Action Plan are as follows:

- To provide a benchmark against which the local community's future work to protect and rehabilitate the river can be gauged.
- To provide a tool to better guide the limited resources available for weed control, erosion control, tree planting and rehabilitation.
- To provide a sound technical basis for future funding or project submissions.
- To produce a description of the state of the Capel River and a river action plan which provides a prioritised plan of action through which riverine degradation can be addressed.

1.3 Plan Development

The river action plan was developed in close consultation with the Capel LCDC, landowners adjacent to the Capel River, and other community members. The length of the Capel River foreshore between the mouth of the river and the Capel Shire boundary was walked to systematically assess and map foreshore condition (using the Pen-Scott method); erosion and weed infestation; requirement and existence of fencing; and the type and cover of vegetation present. Individual landowners were approached to take part in the assessment of their property, and many also contributed valuable anecdotal information to the study.

A series of public meetings were held to inform the local community about the action plan; to report results of field assessments; and to obtain local contribution to the prioritisation of the recommendations presented within the plan.

The resultant river action plan includes recommendations on priorities and approaches to restorative work accompanied by detailed maps of the river foreshore which identify the locations of sites which require restorative work such as weed control, fencing or erosion control. These maps were designed for use by individual landowners, or members of the Capel LCDC and the wider Capel community wishing to undertake restorative action at particular locations.

2. Study area

This river action plan includes the foreshore of the Capel River from the river mouth to the boundary of the Capel Shire. The location of the study area is presented in Figure 2.1 overleaf. Background information in relation to the Capel River is discussed below.

2.1 Capel River and its catchment

The Capel River is the largest river in the Geographe Bay catchment, and has a catchment area of approximately 653 km^2 (Campagna, 1997; Water Resources Branch, 1984). The Capel River rises on the edge of the Darling Scarp, and flows across the northern part of the Blackwood Plateau and the Swan Coastal Plain before discharging into the Indian Ocean (Olsen & Skitmore, 1991). The river flows through both the Donnybrook and the Capel Shires.

The Stirling wetlands are located at the mouth of the Capel River, approximately 5 km NW of Capel. These saline wetlands lie between tuart (*Eucalyptus gomphocephala*) dominated Tamala Limestone ridges to the east and peppermint (*Agonis flexuosa*) covered primary and secondary dune fields to the west. The low lying areas are dominated by estuarine silts and calcareous sand sheets.

The mouth of the Capel River was once connected to the Stirling wetland system and water flowing down the Capel River eventually passed into the Vasse-Wonnerup estuary through the chain of connected wetlands. In 1880 an artificial river mouth was cut through the coastal sand dunes allowing the river water to flow into Geographe Bay (Campbell, pers. comm., 1998). A number of difficulties were experienced following the formation of the cut, primarily related to sea water entering the wetlands at high tide, and the high maintenance that was required to keep the sand bar open. Near the turn of the century, the Capel River was isolated from the Stirling wetlands when high banks were built on either side of the river to prevent sea water from entering the Stirling wetland system (Campbell, pers. Comm., 1999). Today a sand bar forms across the mouth of the river during the summer months when flow from the river is low, and this is broken seasonally under high flow conditions.

2.2 Climate

The Capel region experiences a Mediterranean climate, which is characterised by a hot dry summer period (November to April) and mild wet winters (June to September). The average annual rainfall is 881 mm, normally received between April and November. Rainfall varies from the coast (Capel 840 mm) to the headwaters (Kirup 990 mm), with approximately 90% falling between April and October.

The prevailing winds are related to the position of high and low-pressure systems travelling east. Winter periods are associated with intermittent storms with winds from the northwest, west and southwest. During summer, winds are controlled by the sea breeze / land breeze system. Summer afternoons are typified by southwest winds.

2.3 Aboriginal heritage

Information compiled from the oral history of the southwest Aboriginal communities (collectively known as the Nyungar people) indicates that rivers, estuaries and wetlands generally were very important to these communities, in both a practical and a spiritual sense (O'Conner, Quartermaine & Yates, 1995). Early European settlers recorded many observations of Aboriginal communities using the southwest waterways during summer for fish, while they appeared to move further inland during the winter to hunt kangaroo and other marsupials (O'Conner *et al*., 1995). The group of Nyungar people that occupied the coastal area of the Geographe Bay catchment were known as the Wardandi people 'the people that lived by the ocean and followed the forest paths' ('Wardan' meaning 'ocean') (Collard, 1994).

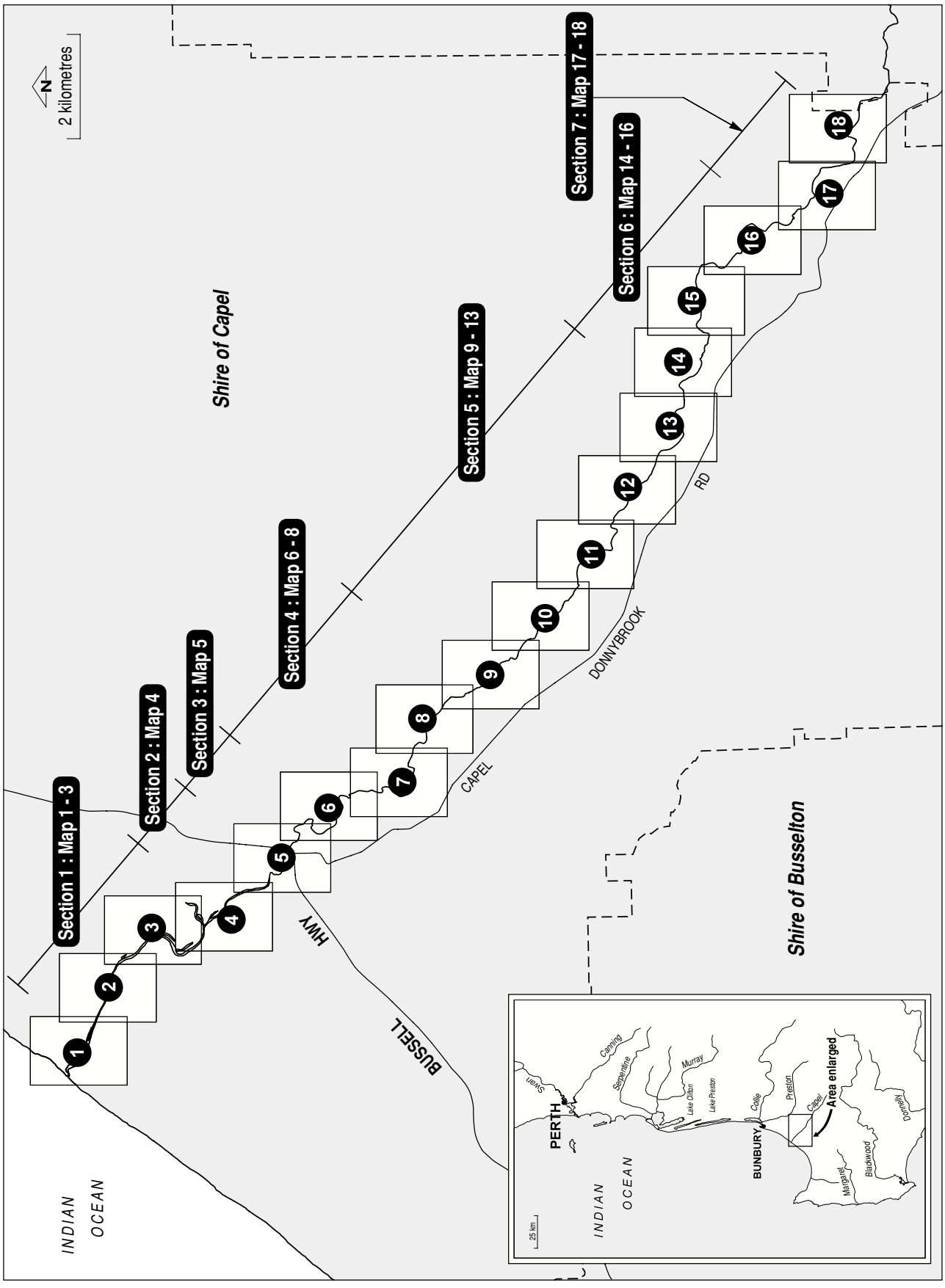


Figure 2.1: Location of the Capel River and sections of the Capel River Action Plan.

From the records of artifacts lodged with the Aboriginal Affairs Department, it appears that the Capel River was frequently used by local Nyungar communities. Stone artifacts found scattered in the area suggest that camping grounds were located near the river (Reynolds, pers. comm., 1998). Anecdotal evidence from descendants of Nyungars in the Busselton area suggests that the Capel Aboriginal community comprised about thirty to forty members, and that the river was a traditional tribal boundary between local clan groups.

The shores of the lower Capel River have particular Aboriginal historical significance (Hill, pers. comm., 1998). They were once used as a burial ground for the local groups, but this practice ceased following a massacre that occurred there in 1841. A Wonnerup settler named George Layman was drawn into an argument over flour between some local settlers and a group of Aborigines. During the argument Layman shook the beard of the group's leader, Gayware; the enraged Gayware who took offence at the action responded by spearing Layman who subsequently died from the injuries (Shann, cited in Chase & Krantz, 1995). Help was sought from the Bussells' residence Cattle Chosen, and John Bussell (Justice of the Peace at Vasse) and the Vasse Magistrate, Molloy, led a group in pursuit. This party opened fire near the ford over the Capel River, killing at least five innocent people. Gayware escaped but was later captured and killed (Chase & Krantz, 1995). Apparently the skeletons of those killed at the massacre were left on the dunes and the place was avoided by local Aborigines thereafter (Chase & Krantz, 1995). The massacre site is on the north side of the Capel River (Hill, pers. comm, 1998)

Scattered skeletal bones have been discovered on the dunes over the years since European settlement, and some are now covered by residential housing developments. In January 1997 the full skeletal remains of a fifteen year old Aboriginal girl were found in a shallow grave on M'Courts Farm, Peppermint Beach. The remains have not been carbon dated, yet it is widely believed the young girl may have died during the early or pre-European settlement years. The remains were re-buried traditionally in October 1997 in a ceremony held by local Wardandi elders. The plaque that marks the site of reburial bears the following epitaph:

> *The sun will shine ever so peaceful and 'Walgur' the eagle will soar silently overhead watching the grave of our little 'Wardandi' girl where she will find rest in peace forever by the Lakes and waters of 'Dunan' Capel. (by Vilma Webb).*

Traditional names of places along the Capel River also give some indication as to the importance of the area to these people. For example, Mallokup, the area where the river once emptied into the Stirling wetlands means 'place of swans', also the estuary was known as Kooroobunup, meaning 'place of many good things' (Campbell, pers. com., 1998). The Capel River is just one of many waterways in the southwest that hold great historical and cultural significance for Aboriginal people.

2.4 European heritage

The first Europeans to arrive in the Capel area were the French explorers on board the *Geographe* for the Baudin expedition. The French arrived at Minninup in 1801 (Horwitz & Wardell-Johnson, 1996). They failed to identify the Capel River behind the sand dunes and decided to travel farther, thus missing the discovery of a plentiful supply of fresh water (Chase & Krantz, 1995). Later, in 1827, Governor Stirling explored the coast of Geographe Bay in the *Success*, noting areas of good quality soils and freshwater.

The Capel River was officially recorded by H.W. Bunbury, who was exploring the country between Pinjarrup and the Vasse in 1837. Although the river was recorded by Bunbury, it was named by John Bussell who called it the Capel after his English cousin Capel Carter. It is thought that this indicates that Bussell had prior knowledge of the river, and Bunbury acknowledged this by allowing Bussell to name it (Chase & Krantz, 1995).

It was not until 1843 that the first European settlers arrived in the Capel area, accompanied by military protection (Horwitz & Wardell -

Johnson, 1996). James Child, Samuel Rose and W.J. Roberts settled Minninup, Dougup and North Capel Farm respectively in 1843. The area was attractive for settlers due to the permanent supply of water. In 1851 George Payne built Payne's water driven flourmill, which became a focal point for a small village. A bridge was built near the mill to allow the transport of grain for milling (Horwitz & Wardell - Johnson, 1996).

2.5 Land use, tenure and vesting

Historically the river valley was used for grazing horses and cattle. Crops grew well, with the abundance of good water and fertile river soils (Chase & Krantz, 1995). Land use in the Capel River catchment today is predominantly horticultural and agricultural, including dairy and beef farming, fruit orchards and viticulture.

The majority of the Capel River foreshore is vested with the Water Corporation; while many private property boundaries once extended into the river, many of these have since been reclaimed into public land. A small number of lots still have the traditional 'old title' which extends into the river. These lots are mainly located upstream of the town of Capel and include lots 28, 19, 166, 30, 5, 91, 619, 164, 84, and 83.

2.5.1 Reserves: tenure and vesting

Several foreshore reserves are situated on the Capel River, and of these the Ironstone Gully Falls and some Capel River foreshore reserves (particularly 3802) were found to have significant conservation value (Masters, 1995). Management plans have been prepared for some of the foreshore reserves. These examine various management issues including foreshore protection, weed control and management of flora and fauna. Vesting of reserves is summarised in Table 2.1.

With respect to the river action plan a few of the reserves on the Capel River provide some clues as to the type and structure of original riparian vegetation. In particular reserve 3802 (Plate 1, page 5) could provide a valuable source of provenance seed for revegetation projects, as this reserve contains an excellent representation of the vegetation of the riparian zone. Comments on the values of reserves on the Capel River are presented in Appendix A.

Plate 1: Riparian vegetation of reserve 3802.

Table 2.1: Vesting and purpose of Capel River foreshore reserves

Reserve	Map Number	Vesting	Purpose
2850	9	Unvested 'C' class	Grazing lease
3802	12	Unvested	Public utility
8934	5	Unvested	Excepted from sale occupation
11797	17/18	Shire of Capel 'A' classreserve	
15550	1	Water Corporation	Drainage
24563	1	Shire of Capel	Recreation/camping
25516	5	Shire of Capel	Recreation

3. Capel River water quality

3.1 Impetus for monitoring

The Capel LCDC instigated water quality monitoring in 1993 in response to growing concern over water quality problems, particularly in the lower Capel River. A major impetus for the monitoring program was a variety of point sources of effluent along the Capel River. Accordingly, two monitoring stations were installed, one at Yate's farms and one at the railway bridge.

In 1994 and 1995, the LCDC monitoring program revealed an organic growth referred to as 'sewerage fungus' downstream from local industry (Chemistry Centre WA, 1994). Improvements in local industry effluent management since that time have been aimed at reducing odour problems and removing nitrogen and phosphorus from the wastewater.

Algal blooms have been recorded at several sites along the Capel River. In April 1994 the Capel River was reported to have turned black at several of the Capel LCDC's monitoring sites. It was surmised that the cooler night time conditions which followed an extended warm summer period resulted in a temperature-induced inversion. Seasonal conditions that result in temperature differences between the surface and bottom water can cause the water in river pools to invert. As surface water cools, it becomes denser than the warmer water on the bottom, resulting in the cooler water sinking to the bottom and the warmer water rising to the surface. As the warm water rises to the surface it can bring fine particles of sediment and organic ooze to the surface, which often causes the river to turn temporarily black. An inversion is often accompanied by a release of gases from the sediments, often hydrogen sulfide, which is toxic to fish. Temperature inversions are not uncommon in rivers with little or no flow in late summer/autumn.

3.2 Water quality data

Water quality data from the Water & Rivers Commission was analysed and compared to criteria established by the Swan River Trust for waterways on the Swan Coastal Plain. Interpretations and results of the data analysis are presented below.

3.2.1 Flow

Daily discharge, or flow, from the Capel River was measured at the railway bridge using an 'automatic logger'. A graph of the flow data shows the variations in flow that occurred between 1994 and 1998 (Appendix B, Figure 1A). 1995 was a 'wet' year, with discharge of up to 300,000 m^3/day recorded during the peak winter period, while 1994 was a reasonably 'dry' year with a maximum discharge of about 110,000 m^3/day recorded. The minimum discharge recorded over the sampling period was 3230 m^3/day.

The seasonal pattern of discharge for all of the years recorded is presented in Appendix B, Figure 1B. This figure shows all of the data points plotted on a single graph of discharge vs. day of the year (i.e. 1 to 365). Very low flow was recorded from January to May for all of the years sampled. This was followed by a rapid increase in flow, reaching peaks in July before decreasing slowly over the next 3 months.

This pattern of flow reflects the seasonal Mediterranean rainfall experienced in the southwest region. The seasonal variability is related to this annual pattern and seems relatively predictable, while variability between years is related to rainfall cycles. The high and low flow years depicted by the graphs reflect 'short term' rainfall cycles.

3.2.2 Conductivity

Daily measurements of conductivity for the Capel River were taken at the railway bridge between 1995 and 1998. Conductivity is a measure of a range of dissolved salts, the most common being sodium chloride. It is the level of sodium chloride that is referred to as 'salinity'. Figures 2A and 2B in Appendix B depict the time series and seasonal graphs of daily conductivity respectively. The criteria for 'fresh', 'moderately brackish' and 'highly brackish' water are marked on the graph. For much of each year sampled, the Capel River water at the railway bridge was

moderately brackish, although at the end of each winter when dilution from seasonal rainfall tends to be at its peak, the water was fresh.

The seasonal plot clearly shows the changes in conductivity that occurred in the Capel River throughout each year sampled. The pattern observed is common to many southwest waterways. At the start of the year the water is moderately brackish; this becomes increasingly brackish with the onset of the first winter rains which 'flush' accumulated salt from the soil profile. Conductivity then decreases over the course of the winter as salts are diluted by fresh rainwater. From spring to the end of the year conductivity steadily increases in response to evaporation which concentrates existing salts in the water column.

The Swan River Trust recommends careful monitoring of waterways with moderately brackish water. Many waterways flowing from the Darling Scarp fall within this criterion. For fresh waterways no action is required, these are typically rivers flowing through forested catchments. Should the salinity of the Capel River approach the highly brackish criteria, it recommended that a search for the sources of the problem be undertaken and management possibilities discussed with the local community. While the data set analysed for this project did not indicate a severe salinity problem at the sites monitored, previous investigations have identified potential salinity problems in the lower Capel River area. The background to these problems is discussed in more detail below.

3.2.3 pH

The pH of a waterbody is a measurement of its relative acidity or alkalinity. The pH scales ranges from 0 (acidic) to 14 (alkaline) with the value of 7 indicating neutral conditions such as those of distilled water. The natural pH of a waterbody is dependent on the predominant landforms and soil types present. For example for waterways flowing through a predominantly limestone catchment, a neutral to alkaline pH would be expected. For those flowing through a catchment without limestone and with humus soils, a slightly acidic pH would be expected.

For all waterways, a pH of less than 4 or greater than 9 would indicate potential pollution problems. Normally such extreme values are only recorded in very urbanised catchments where pollution from road surfaces is contributing to surface runoff.

The pH measurements recorded for the Capel River at Yate's farm and the railway bridge between 1996 and 1998 are presented in Figures 3A and 3B of Appendix B respectively. Results for both sites are within acceptable criteria, although Yate's farm recorded slightly lower pH in early 1998. The levels recorded were not low enough to be of concern, and may be related to differences in soil type present in the upper Capel River catchment.

3.2.4 Turbidity

Turbidity is a measurement of the level of suspended solids such as inorganic and organic matter. The measurement is made by passing light through a tube of the water sample and the associated measurement units are referred to as NTUs, (Nephelometric Turbidity Units). The turbidity of a waterbody changes seasonally in response to flow pattern. During summer, when flow is minimal, particles tend to settle to the river floor, creating reasonably clear conditions. Turbidity usually increases after a storm or when water flow is very high, causing turbulent conditions in the water which re-suspend material as well as adding more material to the flow.

Turbidity measurements recorded for the Capel River between 1997 and 1998 are presented in Figures 4A and 4B of Appendix B. For much of period sampled, the turbidity was low to moderate, reflecting relatively stable conditions in the water. The only winter period monitored was in 1997. The peak in the graphs at July 1997 clearly shows the extreme turbidity measurements recorded at that time (values of over 160 NTU were recorded in the Capel River at both monitoring stations, indicating a serious erosion problem). The Swan River Trust recommends that for waterways with turbidity measurements exceeding 45 NTU, urgent action should be taken to reduce erosion.

3.2.5 Nutrients

Total phosphorus and total nitrogen measurements were recorded at both monitoring stations on the Capel River between 1996 and 1998. Elevated levels of phosphorus and nitrogen have been found to contribute to the proliferation of nuisance algal blooms in many southwest waterways, and for this reason these nutrients are routinely included in most water quality monitoring programs.

For the majority of the sampling period, total phosphorus levels in the Capel River were within acceptable criteria (Appendix B, Figures 6A and 6B). On a number of occasions values exceeding the acceptable criteria were recorded at both monitoring stations. Given the isolated occurrences and intermittent timing of these events, it is not possible to ascertain the causes of the elevated levels.

There are no established criteria for nitrogen levels in southwest waterways since natural levels are often highly varied. The levels of total nitrogen measured in the Capel River during the sampling period appear to be strongly related to the flow (discharge) pattern (Appendix B, Figures 1A and 1B). As for conductivity, there is a strong seasonality in the data, with nitrogen levels increasing rapidly during the early winter rainfall period ('first flush'), then decreasing as winter flow continues to dilute the concentration.

4. Environmental processes influencing the Capel River

4.1 Catchment processes

The characteristic dry summers and wet winters in the Capel region are particularly significant for the way in which water moves across the landscape. These processes in turn can influence the susceptibility of the Capel River to degradation such as scouring and nutrient pollution.

Prior to European development in southwest catchments, the hydrological balance was maintained via a number of buffering mechanisms. Natural vegetation aided infiltration by redistributing water within the canopy and on the soil surface, while chains of wetlands served as intermediate drainage basins thus slowing the transfer of water from the land to river systems (McFarlane *et al*., 1993). Removal of vegetation and alteration of these wetlands has resulted in a reduced ability of the landscape to absorb rainfall, causing water to flow more uniformly over the land. This process greatly increases both the velocity and volume of overland flow, leading to higher levels of nutrient leaching from the soil profile, and greater velocities of water flow in drainage lines (Ralph, 1993).

In areas of cleared land, the absence of an organic crust has also left the soil surface unprotected thus increasing the risk of erosion and transporting phosphate bound sediment particles to streamflow (McFarlane *et al*., 1993). As a result of these processes, the relationship between catchment clearing and phosphorus removal is nearly exponential, that is, it escalates rapidly following 70% removal of native vegetation for agricultural development (Bott, 1993).

4.2 River form, functions and processes

The form, functions and processes which impact on rivers in the southwest of Western Australia and the values of riparian vegetation have been described in detail by Dr Luke Pen (APACE Green Skills and Pen, 1995). A brief summary of these factors as they relate to the Capel River is included below. They are also illustrated in Figure 4.2.

The Capel River is an excellent example of the typical river form in the southwest of Western Australia. In this area a river typically consists of a floodway which lies within a river valley. Within the floodway is a central channel which contains the main, flowing body of water (Figure 4.2). The central channel meanders along the floodway, and, in the case of the Capel River, does not reflect the cadastral (land title) boundaries.

The floodplain

The floodplain tends to support a diverse riparian vegetation, which may extend up the valley banks. The frictional effects of water movement in the channel tend to restrict vegetation growing in this area.

Floodway

As the floodway meanders along the floodplain, three distinct zones occur: long narrow meandering channels, broad shallow riffle zones and deep pools.

Channels, riffles and pools

Channels meander along the floodplain, and are often fairly narrow compared to the width of the floodplain. Riffle zones are broad, shallow areas where water passes over stones, rocks or through dense sedges or trees. Deep pools are scattered along the river length, and usually retain water throughout the year. Pools are an important refuge for aquatic animals in times of drought.

In cleared catchments, such as the Capel River catchment, the river channels are often susceptible to widening caused by scouring from the increased volume and velocity of water entering the system. The widening of these channels is a symptom of the altered hydrological regime caused by the clearing of native vegetation within the catchment, and this in turn also affects the natural processes which occur within the floodplain.

River flow

Ultimately the flow of water within a river channel is derived from rain. At any point in time, however, the river flow is derived from a combination of surface water, soil water and groundwater input. Various factors determine how rainfall reaches the river channel, including climate, geology, topography, soil type and vegetation (Poff *et al*., 1997).

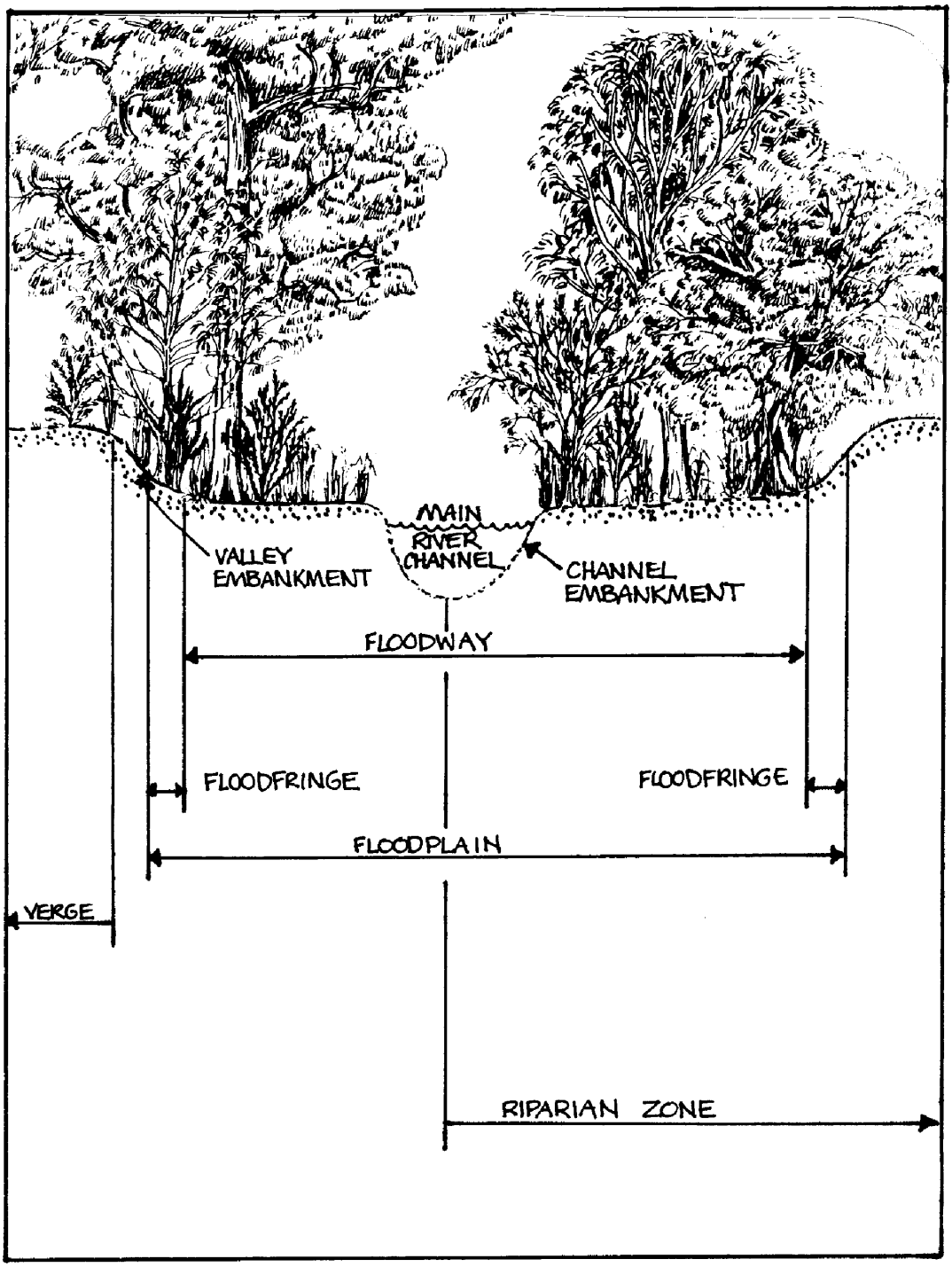


Figure 4.2: Terms used to describe the river valley form.

4.3 Value of riparian vegetation in catchment management

The rich soils of a river valley generally support a diverse flora including trees, shrubs, sedges, rushes and herbs. This vegetation, known as riparian vegetation, acts to support the soil of the stream bank, helping to prevent erosion and subsidence. In addition riparian vegetation provides important habitat for native fauna, and can decrease the amount of soil and nutrients moving from the catchment into the river system. The values of riparian vegetation are discussed in more detail below.

Preventing erosion

Large roots of trees and shrubs anchor the river embankments in place (Plate 2, page 11). The finer roots of shrubs, sedges and rushes effectively stabilise the riverbanks by reinforcing the river embankments. Well vegetated stream banks are less likely to suffer from undercutting and slumping.

Dissipating flow

Riparian vegetation increases the roughness of the riverbanks, which serves to dissipate the energy of running water thereby reducing the erosive capacity of the flow. The type of vegetation present determines the extent to which water velocity is decreased. Widely spaced trees are not as effective in reducing velocity as grasses.

Stabilising sediments

Riparian vegetation acts in several ways to hold sediments (soil particles) and reduce nutrient runoff into river systems. Vegetation slows overland movement of water resulting in sediments and nutrients being deposited on land prior to reaching the river channel. Nutrient uptake by vegetation also results in absorption of some nutrients before reaching the river channel. This effect is known as buffering.

Preventing bank collapse

Most riverbanks will collapse when saturated with water. By using and dissipating most of the available water in the soil, riparian vegetation effectively improves drainage. This stabilises the riverbank and reduces the risk of sudden bank collapse (Thorne, 1990; Riding & Carter, 1992).

Improving water quality

Riparian vegetation influences water quality in several ways. Shade provided by overhanging trees and shrubs assists in maintaining low water temperatures. Many native plants and animals can only survive in cooler conditions. The shading effect also decreases the amount of light available for nuisance plant and algal growths.

Enhancing ecological values

Riparian vegetation provides an excellent range of habitats for many species of flora and fauna.

Plate 2: Roots of vegetation provide some anchorage even when scoured.

In particular biota which is restricted to the moist cooler zones on river foreshores is dependent on riparian zone vegetation. For example, during the Capel River study many species of waterbirds were observed on the stream banks.

Aquatic plants and animals are reliant on the leaf litter, insects and organic debris provided by riparian vegetation. Many of these are food sources, for example some native fish feed exclusively on insects which fall into rivers from native vegetation. Limbs or branches of trees which fall into rivers can provide microhabitats within the river channel. These often act to slow the water flow, thereby creating pools which are suited to particular aquatic species' habitats.

Habitat network

Riparian vegetation is also important on a large scale within the catchment, as it often forms corridors which link bushland remnants. Corridors allow plant and animal species to move between remnants or along the riverbank. The ultimate effect of this can be to create sustainable regional networks of corridors, which allows movement of species throughout a larger area (Arthrington *et al*., 1993; Saunders *et al*., 1987). Through linkages with other remnants, riparian vegetation can provide a critical habitat refuge which maintains species during crisis situations, such as drought or fire.

4.4 River valley degradation: from river to drain

Pen (1995) recognised a pattern of degradation that can be used to describe the state of river systems in the southwest of Western Australia. This pattern is applicable to the Capel River, and the Pen-Scott Foreshore Assessment was used to detail the condition of the Capel River foreshore.

A healthy river valley

Native vegetation dominates a healthy river valley, and acts in several ways to provide stability to the river valley substrate as discussed above. The root system, or matrix, may form a mesh up to 3 m deep. This mesh stabilises the banks and holds soil particles in place.

A degrading river valley

Normally the first sign of a degrading river valley is invasion of weeds. Points of disturbance from feral animals, vehicles or stock trampling allow weed species to dominate. Altering the natural fire regime also allows some weed species to out-compete native vegetation.

The degradation of a river valley continues when stock access becomes more regular. Understorey species are trampled or eaten, exotic weeds are spread more prolifically. Localised soil exposure may also lead to the risk of erosion. An example of uncontrolled stock access on the Capel River foreshore is illustrated in Plate 3 (page 12).

Plate 3: Uncontrolled access leads to a degraded river foreshore.

An eroding river valley

When stock access to the river foreshore occurs regularly, the river valley may become prone to severe erosion. The continued trampling of native vegetation and the gradual replacement of the understorey with exotic perennial species leaves the banks of the river without the strong protective root structures of native shrubs, sedges and grasses.

The soil between roots of trees and shrubs may be washed away and surface flow can scour the banks, effectively widening the river channel and isolating water flow from the natural floodplain.

Where trees and shrubs are absent from the banks, sodden soil may become too heavy to be supported by the bare bank and subside into the river (Plate 4, page 13).

The lack of native vegetation to dissipate flow energy may allow more sediment to be removed from the riverbanks and carried downstream. Here it may accumulate into point bars which deflect flow onto the opposite bank creating a new erosion point, or cause upstream flooding by retarding flow under shallow conditions (Plate 5, page 13).

Plate 5: A vegetated meander showing point bar formation.

Plate 4: Subsidence or slumping of the river bank.

5. Foreshore assessment methods

5.1 Vegetation assessment

The vegetation communities of the Capel River were assessed during the field survey work. Although detailed floristic surveys were not completed for this project, descriptions of species present on each site were recorded, and from these it was apparent that a number of vegetation communities were likely to be found on the Capel River foreshore.

A list of native and weed species found on each section of the foreshore was compiled during the survey work. A brief description of the vegetation community type was also completed for each section. Native and exotic plant species were identified and are listed in Appendix C. This list is not exhaustive, and it is highly likely that it will be added to in the future.

5.2 River foreshore condition assessment

The Pen-Scott method of riparian zone assessment was used (Pen & Scott, 1995). This system provides a graded description of the river foreshore that runs from pristine (A grade) through to completely degraded (D grade).

A summary of the grades of the Pen-Scott system follows. These are also illustrated in Figure 5.2.

• A grade foreshore

A1: Pristine

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

A2: Near pristine

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

A3: Slightly disturbed

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

• B grade foreshore

B1: Degraded - weed infested

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

B2: Degraded - heavily weed infested

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

B3: Degraded - weed dominated

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

• C grade foreshore

C1: Erosion prone

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

C2: Soil exposed

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

C3: Eroded

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

• D grade foreshore

D1: Ditch - eroding

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

D2: Ditch - freely eroding

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

D3: Drain - weed dominated

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

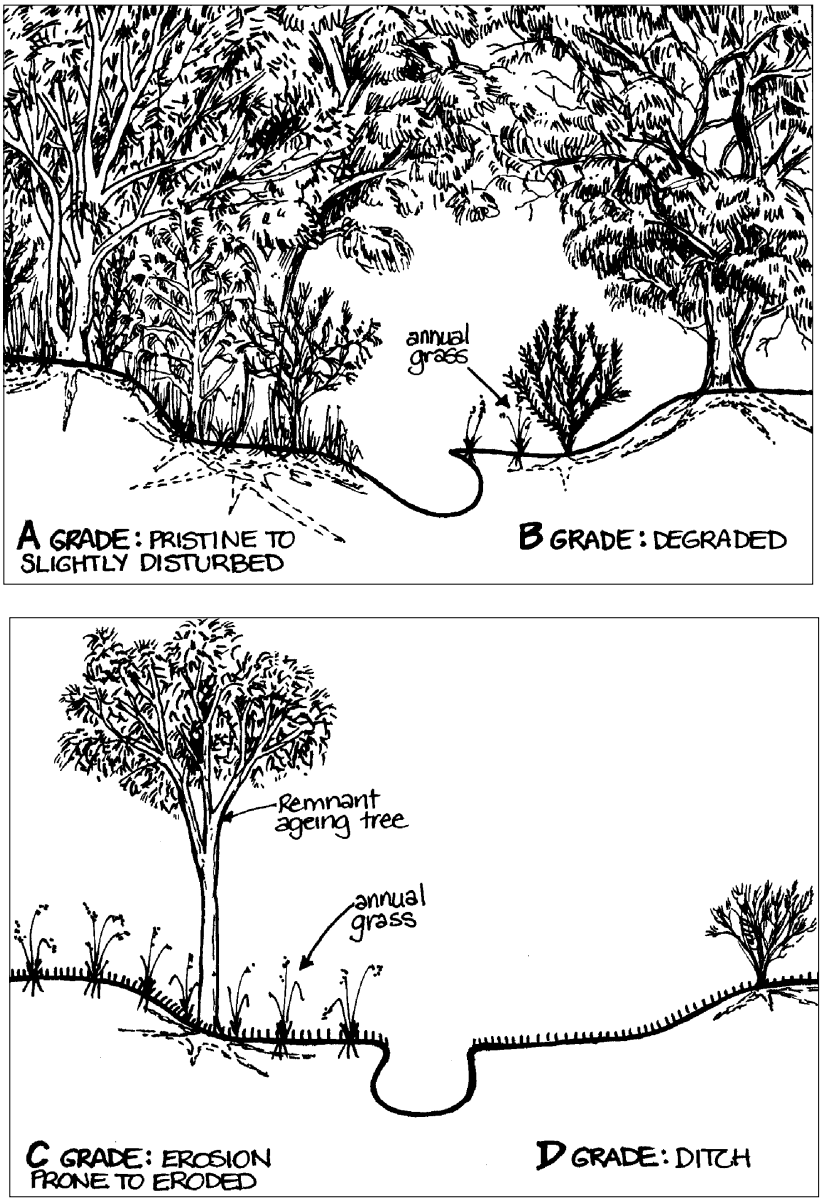


Figure 5.2: Four stages of river foreshore condition following the generalised processes of river degradation (from A — pristine to D — ditch).

6. Vegetation communities

The native vegetation of the Capel River riparian zone was generally limited to medium and large shrubs, and larger trees. Native herbs and small shrubs were restricted to areas of little or no disturbance. The nature of disturbance to the Capel River foreshore has resulted in the modification of the original riparian vegetation along much of the area surveyed. In many areas the low diversity of native species, in particular low shrubs and herbs, appeared to be the direct result of grazing pressures and weed invasion. There were, however, some areas (mentioned in section descriptions) which were relatively undisturbed, and these were used as indicators of the types of vegetation likely to have originally occurred on the Capel River[1]. A schematic representation of native vegetation as it may have once looked in the Capel River valley is contained in Figure 6.1.

Although detailed surveys were not completed for this project, descriptions of species present on each site were recorded. From these descriptions and those compiled by Smith (1974), at least four distinct vegetation communities[2] are likely to be found on the Capel River foreshore reserve. A matrix of the native plant species for each section of the river is presented in Appendix C and brief descriptions of these are included below. This information can be used as a guide for revegetation of particular sections. A list of all plant species is presented in Appendix D.

COMMUNITY TYPE 1

Flooded gum *Eucalyptus rudis* woodland over *Astartea fascicularis*, swamp peppermint *Agonis linearifolia* scrub.

This community type was restricted to the riparian fringe, and low lying areas. It was reasonably continuous on the riparian fringe in Sections 6 and 7, with a more patchy distribution in Section 5. A few examples of this community type were observed in Sections 3 and 4. In Sections 6 and 7 the understorey of this type was generally dominated by *Astartea fascicularis* and swamp peppermint *Agonis linearifolia*, with only a few areas containing a larger representation of understorey species (e.g. Ironstone Gully Reserve) (Plate 6, page 17). In Sections 4 and 5 there were several isolated stands of this community type with a much higher diversity of understorey species observed.

The dominant species were flooded gum *Eucalyptus rudis*, *Astartea fascicularis* and swamp peppermint *Agonis linearifolia*. Blackbutt *Eucalyptus patens*, *Banksia seminuda*, prickly Moses *Acacia pulchella* and *Bossiaea rufa* were found less frequently in this community type. The common maidenhair fern *Adiantum aethiopicum* was prolific in some areas. Sedges and rushes associated with this community type included species such as pale rush *Juncus pallidus*, marsh club-rush *Bolboschoenus caldwellii*, angle sword-sedge *Lepidosperma tetraquetum* and spreading sword-sedge *Lepidosperma effusum*.

COMMUNITY TYPE 2

Marri *Corymbia calophylla* (previously *Eucalyptus calophylla*) forest over soapbush *Trymalium floribundum*, heart-leaf poison *Gastrolobium bilobum* scrub, and sword-sedges *Lepidosperma* spp.

This community type was found a marginal distance from the riparian fringe in Sections 4, 5, 6 and 7, often bordering or contiguous with community type 1. Other species associated with this community type were flooded gum *Eucalyptus rudis*, blackbutt *Eucalyptus patens*, jarrah *Eucalyptus marginata*, Cape Leeuwin wattle *Paraserianthes lophantha*, *Callistachys lanceolata*, prickly Moses *Acacia pulchella*, and *Clematis pubescens*, and native wisteria *Hardenbergia comptoniana*. Angle sword-sedge *Lepidosperma tetraquetum*, spreading sword-sedge *L. effusum* and pale rush *Juncus pallidus* were commonly occurring sedges and rushes in this community. In relatively undisturbed areas tail-leaved acacia *Acacia urophylla*, river pea *Oxylobium lineare*, holly-leaved flame pea *Chorizema ilicifolium*, *Sollya heterophylla* and swamp kangaroo paw *Anigozanthos viridis* were

1 It is recommended that detailed floristic surveys of one or all of these sites are completed. This will enable the list of species suitable for revegetation of the Capel River foreshore to be increased.

2 A plant community (or vegetation association) is an assembly of plants which grow together in response to soil, water, light and temperature. A community describes the structure of the plant life forms, the area plant forms cover and the floristics or species present in the community. Vegetation communities appear as a natural pattern of plants in the landscape; when factors which influence them change, so do the communities (Keighery, 1994).

found. Tail — leaved acacia *Acacia urophylla*, wonnich *Callistachys lanceolata* and river pea *Oxylobium lineare* were uncommon species in this community type. It is likely that detailed botanical surveys of this vegetation type would result in it being split into two distinct community types, with the Cape Leeuwin wattle *Paraserianthes lophantha*, soap bush *Trymalium floribundum* understorey distinct from the *Acacia* spp. scrub.

COMMUNITY TYPE 3

Peppermint *Agonis flexuosa*, marri *Corymbia calophylla* woodland.

This community type was found in the lower middle and lower reaches of the Capel River, predominantly in Sections 3 and 4. The dominance of the peppermint *Agonis flexuosa* characterised this community type. Marri *Corymbia calophylla* was a co-dominant tree, and scattered flooded gum *E. rudis* were observed. Very few areas were undisturbed by stock or weeds, resulting in a highly degraded understorey. Understorey species which were regularly observed include prickly Moses *Acacia pulchella*, swamp peppermint *Agonis linearifolia* and spreading sword-sedge *Lepidosperma effusum*. In undisturbed areas swamp kangaroo paw *Anigozanthos viridis*, holly-leaved flame pea *Chorizema ilicifolium*, and *Leucopogon propinquus* were found, but few other species were noted.

COMMUNITY TYPE 4

Freshwater paperbark *Melaleuca rhaphiophylla*, flooded gum *Eucalyptus rudis* open woodland.

This vegetation community was highly disturbed along most of the lower reaches of the Capel River (Sections 1 and 2). The trees are the dominant species in this community type. In several areas *Astartea fascicularis* and modong *Melaleuca preissiana* were observed. Pale rush *Juncus pallidus*, jointed twig-rush *Baumea articulata*, common sword-sedge *Lepidosperma longitudinale*, marsh club-rush *Bolboschoenus caldwellii* were observed in this community type. In a few areas the backwaters supported a reasonably diverse flora, however even these were infested with weeds, in particular Typha and arum lily (Plate 7, page 18). Detailed surveys of these areas were not completed.

Flora of reserve 24653

This reserve has been subjected to a high level of understorey disturbance, and was relatively poor in species diversity. However, a detailed community description for this area was prepared by Smith (1974), and this could be consulted for possible revegetation species. The location of this reserve with respect to the Capel River mouth is illustrated in (Plate 8, page 18).

Plate 6: Swamp peppermint in the river channel.

*Plate 7: A paperbark (*Melaleuca *sp.) swamp backwater.*

Plate 8: The Capel River mouth and reserve 24653.

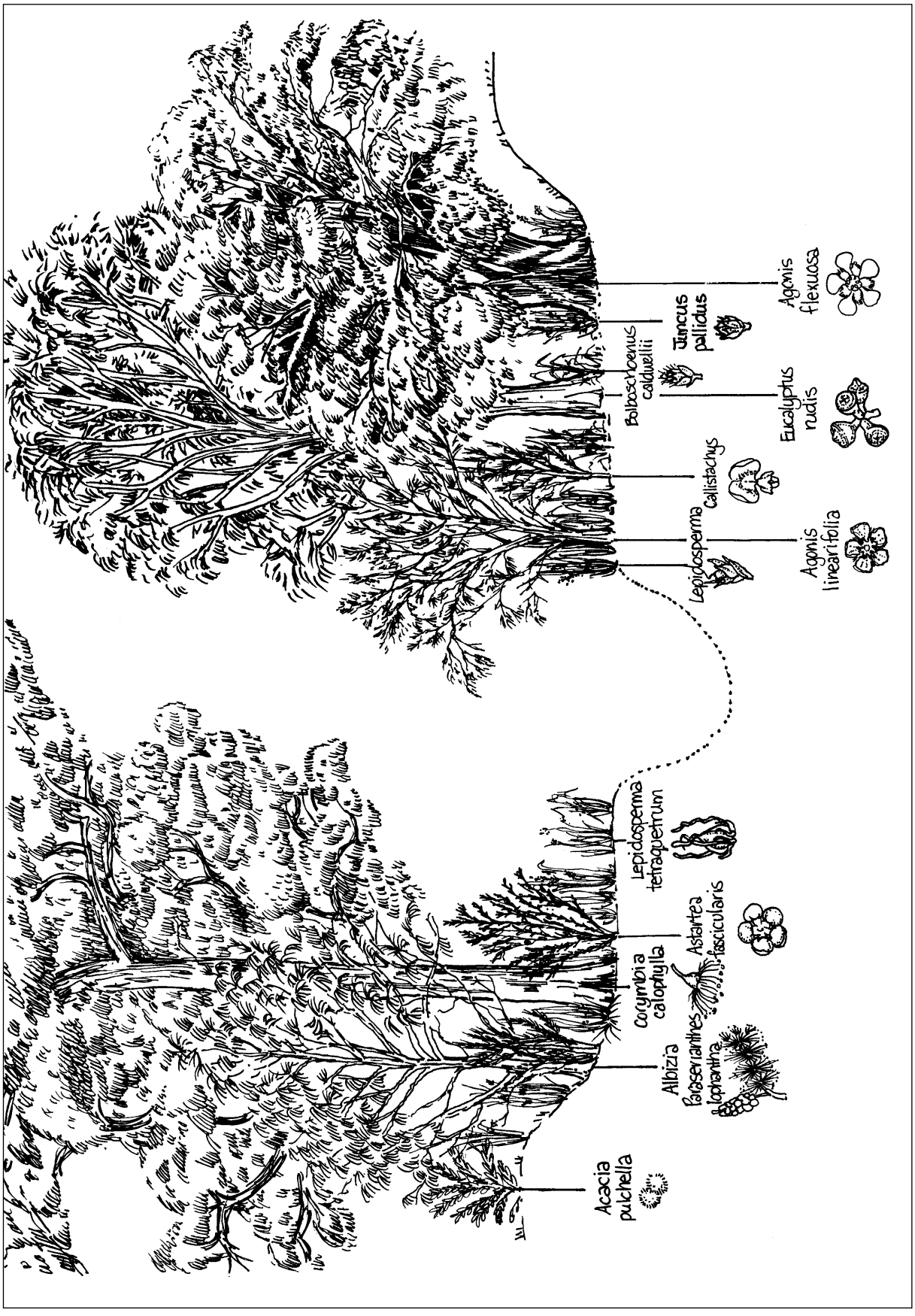


Figure 6.1: Vegetation of the Capel River

7. Management issues along the Capel River foreshore

7.1 Loss of native riparian vegetation

Three major threats to the Capel River were identified by the foreshore assessment. These included the loss of native riparian vegetation, erosion and siltation of the river channel, and invasion of exotic weed species. These three threats are common to most southwest rivers. As discussed in Chapter four, these threats are intrinsically linked, and form a cycle of riverine degradation when they are not appropriately managed.

The riparian vegetation along the section of the Capel River surveyed was, in most areas, represented by a healthy layer of canopy trees. In many areas the native understorey was degraded to highly degraded, with grazing and competition from weeds the most obvious causes.

The role of native understorey in the management of river systems cannot be understated. Where native shrubs, sedges and rushes provide a dense soil-root matrix a riverbank is afforded some protection from the scouring and erosive forces of water movement. In areas where annual grasses and weed species dominate the understorey the soil-root matrix affords little protection against the erosive forces of water movement.

The loss of native riparian vegetation is also important with respect to the value of riparian habitat for native fauna. Introduced species do not provide a full range of habitat requirements for native species. On the other hand problematic species such as the rabbit are favoured by the disturbed conditions where native vegetation has been cleared. Between Section 4 and Section 7, there was evidence of inhabitation by native mammals, such as the ring-tailed possum and bandicoot, and birds such as the golden whistler, fantail, western thornbill and splendid wren. Habitat for these species could be improved within this section with management and regeneration of the native vegetation within the foreshore reserve.

Riparian vegetation also has an important role to play in the dynamics of the food webs within rivers. The leaf litter (leaves, branches and bark) from native vegetation is an important energy source for specialised aquatic fauna, termed shredders, within the river system. Maintaining a balanced quota of functional feeding groups is crucial to the healthy functioning of river ecosystems (Lake, 1994; Davies & Christidis, 1997).

7.2 Erosion and siltation

Erosion of the river channel was a notable problem along much of the surveyed area of the Capel River. A combination of physical disturbance from historical stock access and changes to the hydrological balance from clearing of the native vegetation within the catchment has led to the erosion problem. While some level of erosion and deposition is natural within any riverine system, the acceleration of these processes can cause management problems. Of particular concern is the cycle of erosion and deposition which can occur when eroded sediment accumulates downstream to form point bars which deflect flow onto the opposite bank thus creating a new point of erosion (Plate 5, page 13). Environmental issues associated with erosion problems include:

- A reduction in aquatic habitat diversity as deep pools used by a number of macroinvertebrates and larger aquatic fauna, including marron and fish, are slowly filled with sediment.
- Poor water quality resulting from increased turbidity and nutrients.
- Potential downstream impacts on estuarine or marine environments resulting from poor quality flow.
- Further loss of native riparian vegetation as severe erosion problems cause subsidence.
- Alterations to the natural hydrological regime as the river channel widens, thus isolating winter flow from the floodplain. This can cause a reduction in vegetation diversity with resultant adverse impacts on native fauna.

In addition to these, social issues of concern include the loss of fences as the river course deviates (Plates 9 and 10, page 21); the loss of valuable soil; reduced visual amenity associated with the river; and a potential for the limitation of beneficial uses, such as fishing, marroning and water supply, as water quality deteriorates.

Plate 9: Loss of fence-lines due to subsidence.

7.3 Weed invasion

Numerous species of weeds were encountered during the field survey of the Capel River. Due to the large number of weed species only those considered to be of a high priority for control are identified on the maps. There is, however, a need to acknowledge the invasive nature of all weed species.

7.4 Access

7.4.1 Stock access

The majority of properties with stock along the Capel River have been fenced; however, uncontrolled stock access in some sections is contributing to the loss of native riparian vegetation through trampling or consumption of understorey species; spreading of weeds; and erosion of the foreshore from physical disturbance (Plate 3, page 12). Continuation of this practice has the potential to frustrate management efforts in other sections of the river, primarily through the cycle of erosion and deposition described above.

7.4.2 Community access

Public access to the Capel River was a notable community issue raised throughout the course of the field assessments and public consultation process. Access to the river is very difficult without going through private property. A few reserves on the Capel River are also surrounded by private property. During the summer months, the Capel River is a popular site for picnicking and marroning. This sometimes causes conflict between visitors to the river and landholders whose properties abut the river foreshore. While the resolution of this problem is outside the scope of this study, it should be recognised as an issue that requires attention.

7.5 Water quality

Water quality problems have been a prominent issue in the Capel area for some time. Recent improvements to dairy effluent management practices have led to a reduction in severe water quality problems within the river. Recent monitoring data has, however, indicated potential nutrient management problems. The continuation of water quality monitoring and river foreshore restoration action should ensure that this potential problem does not become unmanageable.

Plate 10: Close up of fence-line and subsidence.

8. Capel River restoration principles

8.1 Weed management

8.1.1 General information on management of weeds

There has been much debate over the definition of a weed in Australia. A weed is generally classified as a plant which is growing where it is not wanted. This assumes that a human being has made a decision about whether the plant is wanted, or not, and hence may be accepted at one location but may be considered a weed elsewhere (Hussey, *et al*., 1997).

In foreshore areas removal or control of weeds must be completed with great care. In the riparian zone the erosive power of water requires consideration when planning a weed strategy. Clearing weeds in an unplanned manner could result in an increase in the erosive capability of water in the river channel. Bradley (1988) supports three principles which have been found to be successful in the management of weed species:

I Work outwards from good patches of bush towards areas with weed infestations

II Minimise disturbance to the soil and surrounding environment

III Let the rate of native plant regeneration dictate the rate of weed removal

The impact of weeds on the foreshore reserve is not limited to their invasive nature and competitive advantages which they may have over native vegetation. Weeds increase the flammability of existing remnant vegetation on the foreshore reserve (Dodd *et al*., 1993), increasing the risk of loss of riparian habitat. The greater the disturbance in an area - the greater the degree of weed invasion. Disturbance may be the result of fire, changing water regime, grazing, changes in nutrient availability, or baring of soil (Buchanan, 1989). Conversely, if the natural community maintains a high level of diversity, weeds find it more difficult to invade.

Generally weed strategies which have well defined objectives are more likely to succeed. In the case of the Capel River foreshore reserve strategies for weed control could include:

- preventing invasion where possible by preventing disturbances which create sites for weed invasion. This includes controlling vermin and restricting stock access;
- controlling weed species in reserves and working out from good areas (low infestation) to bad (high infestation);
- investigating the possible use of chemical firebreaks on properties, which can assist in preventing weed establishment on fence lines (Dodd *et al*., 1993).

Further information on methods and techniques of weed control can be found in some of the publications listed in Appendix E.

Chemical control of weeds on waterways requires careful consideration. Issues which must be considered prior to any type of chemical control include the effects of the herbicides on native flora and fauna and the impact on water quality. It is beyond the scope of this report to advise on specific control methods for the problematic species identified. However, a summary of the principal pest species, their characteristics, and non-chemical methods of control is included below.

8.1.2 Specific weed management advice[3]

The weeds listed here have been identified as priority species for control on the Capel River. They are either listed as Declared Plants or Pest Plants, or were observed to be invasive or problematic during the survey work[4].

3 These notes were compiled using information from Dixon & Keighery, 1995; Hussey *et al*., 1997; Piggot *et al*., 1993; Pierce, 1998; Scott & Wykes, 1997; Harley & Forno, 1992; Dodd *et al*., 1993; Department of Environmental Protection & Swan River Trust, 1995 and Buchanan, 1989. More specific information on weed control can be obtained by contacting AgWA, Streamlining Officers or landcare technicians working in the Capel area.

4 Agriculture Western Australian administers the *Agriculture and Related Resources Protection Act* 1976 [the Act] under which plants may be declared by the Agriculture Protection Board. If a plant is declared (DP), landowners are obliged to control that plant on their properties (Pierce, 1998). Local government authorities administer the pest plant (PP) provisions of the Act, and Shire Councils are authorised to enforce control of a particular plant within their boundaries.

The management of the serious environmental weeds found on the Capel River foreshore should be tackled on a catchment scale. In particular, the control of blackberry, figs and other fruit trees needs to be addressed from upstream down, and within the Donnybrook Shire.

1. Apple of Sodom DP, PP
Solanum linnaeanum

A shrub which grows to 2 m or more in height and width, apple of Sodom is a native of South Africa. Its yellow berry is toxic to stock and humans. The leaves are distinctive, with deep lobes and shrub prickle on both surfaces. The flowers are purple and have a prominent yellow stamen. Small plants can be grubbed out by hand, taking care not to leave any root behind to regrow. Larger plants can be cut, and the stump painted with an appropriate herbicide. Seeds need to be disposed of with care.

2. Arum lily DP
Zantedeschia aethiopica

Arum lily is a widespread tuberous perennial herb which is native to South Africa. The leaves are toxic to stock. Flowering is mainly in spring to early summer, although occasionally blooms can be found throughout the year. Arum lily is spread by birds, water and vegetative reproduction. The threat to waterways is high, as arum lily can impede water flow. Continuous cutting and removal of all leaf matter will eventually kill arum lilies. Spraying with appropriate herbicide may be undertaken between June and October, prior to flowering.

3. Blackberry DP
Rubus sp.

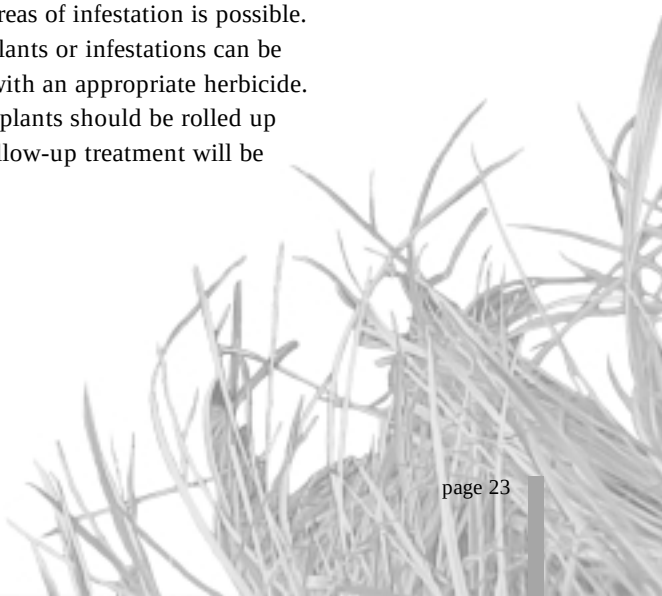
Blackberry was originally introduced from Europe as a fruit crop. This perennial plant is spread by birds, other animals and vegetatively. It is a serious threat to the Capel River due to its invasiveness, ease of spread and its potential to clog up the river bed. It is possible, with protective clothing such as gloves, to hand pull small infestations. Larger infestations require treatment with chemicals or, in suitable situations, removal by mechanical means. Brush cut/burn. Treat regrowth with the appropriate chemical from December to April. Follow-up treatment of blackberry is usually necessary.

4. Blue periwinkle
Vinca major

This climbing perennial is a native of the Mediterranean area. A garden escapee, it favours shady spots and smothers vegetation along much of the Capel River. The large blue/purple flowers seed in winter and spring. The stems of this plant take root where they come into contact with the ground. This weed does not appear to be palatable to stock, as it was untouched in many areas which were heavily grazed. Periwinkle is difficult to dig out, but stolons can be removed by hand. Spraying with an appropriate herbicide should occur when the plant is actively growing, at four week intervals. Periwinkle is difficult to kill, and follow-up treatment will be required.

5. Bridal creeper
Asparagus asparagoides

The perennial bridal creeper was introduced from South Africa as a garden plant, and has become one of the most serious environmental weeds in WA. It is an extremely invasive weed, which can smother native vegetation in a short period of time. Bridal creeper also has the potential to create a fire hazard as it dies back during the summer and increases the fuel load within severely invaded areas. Birds are fond of the fleshy fruits, and spread the seed considerable distances in their droppings. Bridal creeper also spreads vegetatively. Control is difficult. Hand weeding in small areas of infestation is possible. More established plants or infestations can be wiped or sprayed with an appropriate herbicide. Mats of controlled plants should be rolled up and destroyed. Follow-up treatment will be necessary.



6. Californian poppies
Eschscholzia californica

This garden escapee was only found in a small area of the Capel River. An annual, the Californian poppy flowers in spring and subsequently produces large amounts of seed in a narrow, cylindrical seed capsule. If unchecked this species can spread rapidly into adjacent bush. This aspect of their growth is of particular significance as the Ironstone Gully Reserve is near the worst area of infestation. Removal of the plants prior to flowering is effective, they are easy to pull by hand. Follow-up may be necessary as the seed can remain dormant for several years.

7. Castor oil plant
Ricinus communis

This tall, perennial shrub grows up to 4 m and originated in tropical Africa and Asia. Its fruits resemble burrs, and the branches are tinged green-red. The male flowers are yellow, the female red. The seeds are highly poisonous.

It is easily spread by flowing water and animals. The seeds remain dormant until the parent plant is removed, so follow-up treatment is recommended. Small plants can easily be removed by hand. Larger plants can be cut down and the stumps painted with an appropriate herbicide, or alternatively the stems may be injected with a herbicide.

8. Cotton bush DP
Gomphocarpus fruticosus

This South African native forms a shrub up to 2 m high which favours moist sites. A garden escapee, it has formed dense thickets in at least one area on the Capel River. Other plants observed were single specimens. Cotton bush can be pulled from damp soils (up to late October/November). Alternatively it can be cut at or just below ground level. The plant seldom regrows following removal. Seed heads must be removed for this method to be effective. This weed contains cardiac glycosides[5] and gloves must be worn and contact with sap avoided when undertaking control. Infestations should be sprayed between September and December with an appropriate herbicide.

9. Double gee DP
Emex australis

This annual weed is native to South Africa and was introduced as a salad vegetable. The woody fruit has three spines, and the green flowers are borne in winter. Small populations can be removed by hand, and great care should be taken to destroy the plants with seeds. Spraying with an appropriate herbicide should be carried out in winter and spring.

10. Fig
Ficus carica

The fig is believed to be a native of the Mediterranean and Middle East, and displaces native species on the Capel River banks. The distinctive leaves are large and lobed, and the green or purple fleshy pear shaped fruits appear in early summer. Evidence of spread of fig from cuttings and branches washed downstream in the river flow was found along the middle reaches of the Capel River. Some control had been undertaken in places, but regeneration was common as backup control had not occurred. The cut-stump method, using an appropriate herbicide, can be used to control figs. Follow-up treatment will be necessary.

11. Oyster plant
Tragopogon porrifolius

A short lived perenial or annual which grows up to 1.5 m. A tall hollow stalk carries lilac coloured flower heads which are ejected from the parent plant. This garden escapee is native to northern Africa and Europe. On the Capel River it was confined to a small patch in Section 4. Prompt control will prevent further spread.

5 Cardiac glycosides are plant glycosides (chemical compounds) that have stimulatory effects on vertebrate (especially human) hearts and are therefore highly toxic.

12. Fruit trees
Prunus spp

These orchard escapees were found mainly on the upper sections of the Capel River study area. Some control had been undertaken in places, but regeneration was common as backup control had not occurred. The cut-stump method, using an appropriate herbicide, can be used to control fruit trees. Follow-up treatment will be necessary.

13. Snail creeper
Phaseolus curricula

Snail creeper is a climbing plant with clusters of pink, snail like flowers in summer. This garden escapee has established several vigorous populations on the Capel River foreshore. It climbs and eventually smothers native vegetation, and forms dense mats on the ground in cleared areas.

14. Snowflake
Leucojum aestivum

Snowflakes are garden escapees which grow from bulbs. Flowering is in spring, and the plants die back during summer. They are particularly well adapted to the fertile moist soil of the river valley. Small populations can be removed by careful digging, ensuring that all bulbs are removed. Larger infestations should be treated with the appropriate herbicide prior to flowering.

15. Sweet Pittosporum
Pittosporum undulatum

A tree which grows to about 9 m, Pittosporum is native to the eastern states. In areas invaded by sweet Pittosporum the understorey consisted of abundant low shrubs, grasses and herbs with few sedges. The seed is dispersed by birds, and seeds will germinate best between 18 and 21˚ C. One of the concerns with Pittosporum in the riparian fringe is the litter fall. Compared with the litter fall of eucalypts (around 0.9 tonnes per hectare per year) the litter fall of Pittosporum is heavy (around 2.6 tonnes per hectare per year). The nutrient content of the Pittosporum litter is much higher in calcium and magnesium than eucalypt litter.

16. Thistle
Cardus sp.

Thistles are native to Europe, Asia and North Africa, but several have naturalised in WA. Insufficient material was available to identify this specimen to species level. Flowers were purple, and appeared early in summer. The seeds are wind borne, carried on a parachute of hairs. Small populations can be weeded by hand prior to seed set. If herbicides are to be used they should be applied before flowering, when the plant is actively growing.

17. Bulrush
Typha orientalis

This is a perennial emergent aquatic plant which is native to the eastern states. It is considered to be a major threat to waterways of Western Australia, as it outcompetes many local sedges and rushes and can clog waterways. It is important to correctly identify the *Typha* species. The native *Typha, T. domingensis* or cumbingi , is readily confused with *T. orientalis*. Seed is spread by animals, water and wind. Bulrush can be controlled by cutting the stems below the summer water level, which results in the plants rotting. It is important to ensure that flower heads are removed from the area.

18. Watsonia PP
Watsonia spp.

Watsonia is a herb, native to South Africa, growing from a corm[6] and with the above ground parts of the plant renewed annually. All species are garden escapees. Watsonia is a higly invasive weed, and a serious threat where any disturbance exists. Corms are difficult to remove by hand, but can be sieved out of soil where small infestations are found. For larger infestations treatment with an appropriate herbicide just prior to flowering can be effective.

6 A corm is an underground stem, like a bulb yet more solid.

19. Rose
Rosa sp.

Roses were cultivated in China, Europe and the Middle East for at least 5000 years. Of the cultivars brought into Western Australia, only those nearest in character to the original wild species appear to have spread out of cultivation. The habit is dense, with thorny thickets formed at various sites along the Capel River. Small seedlings can be pulled by hand, gloves are recommended. Mature plants can be cut down or spot sprayed with an appropriate herbicide. Regrowth will need to be controlled.

20. Giant reed (bamboo)
Arundo donax

A small localised section of bamboo was located in the upper Capel River (Section 7). Anecdotal evidence suggests that this species has not spread in recent years, however it has the potential to become a serious weed in wetland areas. Burn down or cut clumps. Spray regrowth between 0.5 and 1 metre high with an appropriate herbicide. Follow-up treatment may be necessary.

8.2 Revegetation

Throughout Australia there is an ever increasing effort being devoted to methodologies behind the revegetation, or restoration of native plant communities in river valleys. The information summarised here is obtained from several publications, including Raine & Gardiner, 1995; Hussey & Wallace, 1993; Bradley, 1988; Buchanan, 1989; and Fielder, 1996.

Strategies

For revegetation efforts to succeed it is important to spend time planning. Factors which are often crucial to the success of a project include the amount of labour available, the amount of funding available (which will dictate the area which can be covered), and the long term goals of the community with an interest in the project. With a working revegetation plan in place, specific modifications can be made to adapt techniques to the Capel River foreshore. For example, some revegetation efforts may need to be modified to suit stream flow; successful techniques in a particular area can be used elsewhere; and unsuccessful techniques can be modified and retried.

The value of planting a diverse suite of species (including trees, shrubs, sedges, rushes, herbs and native grasses) has been discussed previously.

Revegetation principles and methods

Bradley's three principles of weed control outlined at the beginning of this chapter, apply to all revegetation efforts. Areas where this is possible should be considered as priority areas, as natural regeneration from the 'undisturbed' bush will complement other efforts.

The potential for native species to be washed away, damaged, or covered by sediments before they have successfully established is high. Techniques and species used for revegetation of the river foreshore vary, depending on the section being planted. The toe of the bank, or channel embankment, is subject to seasonal flooding. This area should be planted with species which can withstand high velocity flow, including sedges and rushes.

The floodfringe should be planted in a wide band with a mixture of deep rooted trees and shrubs. A diverse suite of species should be planted. This not only improves the habitat value of the foreshore reserve, but also provides a suite of different root structures which will assist in erosion control. Species suitable for revegetation of specific areas of the Capel River foreshore are listed, by community type, in Table 8.1.

Methods of planting include direct seeding, brushing with woody natives containing seed, planting of tube stock. Direct seeding has a few distinct advantages over other methods:

- it is less time consuming and requires less labour than planting tube stock;

- a mixture of trees, shrubs, sedges and ground covers can be planted at the same time, resulting in a plant community with a natural look;
- it is less expensive than providing tube stock, and on the Capel River several areas have been identified as having good potential for the collection of local provenance[7] seed; and
- the natural root development of seedlings grown from seed usually results in plants developing deep taproots, requiring less follow-up care.

However, direct seeding can be less reliable than direct planting, due to predation, specific germination requirements not being met, and poor conditions for direct seeding.

Direct seeding may not be possible when high winds or strong water flow is present. In these cases nursery tube stock is ideally supplied from local provenance seed. Plants should be transplanted when they are actively growing; the surrounding soil is moist and follow-up rain is likely (usually between May and July). Care should be taken to ensure that specimens are not root bound, and that minimal damage to the roots occurs when removing from pots.

Alternately brush matting, with cut stems from woody plants, is a technique which can be used to spread seed and assist with erosion control simultaneously. Species suitable for this technique are those which retain seed on the plant, but shed it when the plant dries out. On the Capel River this includes *Melaleuca* spp. and *Eucalyptus* spp.

Bradley (1998) suggests that spot regeneration should occur from the top flood level to the creek bed. A very small wedge shaped opening is made in the upper part of the bank, with the apex facing towards the river. Weed control, followed by spot regeneration, is carried out from the top flood level toward the creek bed. This process will be slow, but as the native vegetation spreads towards the riverbank the visible effects of roots holding the banks and displacing weeds will become apparent.

Site preparation and timing

Good site preparation is often crucial to the successful revegetation. Areas which need to be considered are weed removal, soil amelioration and preparation of the soil surface for direct seeding or planting. Pest control and ongoing control of weeds also need to be factored into the project. Planting and sowing at the right time of year, and at the appropriate depth will also influence the success of the revegetation effort.

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

Table 8.1: Species which can be used for revegetation of the Capel River, community in which they were found, and revegetation advice (Water & Rivers Commission, 1997; APACE, 1995; Chambers et al.*, 1995; Powell, 1990). Notes: Some of these notes involve technical procedures such as tissue propagation. This is included for information purposes only.*

COMMUNITY TYPE 1: Flooded gum *Eucalyptus rudis* woodland over *Astartea fascicularis*, swamp peppermint *Agonis linearifolia* scrub.

HABIT	SPECIES	PROPAGATION	FLOWERING TIME	NOTES
Tall shrub	*Acacia pulchella*	Seed	Winter to spring	Scarify or soak seed before sowing
Fern	*Adiantum aethiopicum*	Division		
Tall shrub	*Agonis linearifolia*	Seed or cuttings, or suitable for direct seeding.	Throughout the year	Collect seed capsules between March and May
Shrub	*Astartea fascicularis*	Direct seed or cuttings taken in autumn	Spring and summer	Collect seed from mature capsules in winter and early spring
Tree	*Banksia seminuda*	From seed	Late summer to winter	Favours slightly acidic or neutral soils
Rush	*Bolboschoenus caldwellii*	Seed germination	Spring	Germinate seed immediately after collection
Shrub	*Bossiaea rufa*		Summer	
Tree	*Eucalyptus patens*	Seed or direct seeding	Spring to summer	
Tree	*Eucalyptus rudis*	Seed planted in spring, direct seed or seedling	Autumn to spring	Seed can be collected throughout the year, plant in early spring
Rush	*Juncus pallidus*	Seed	Spring	Seed will germinate any time of year, but do not cover as they require light for germination. Does not transplant well
Sedge	*Lepidosperma effusum*	Tissue culture from seed	Spring	There has only been some success with the method mentioned
Sedge	*Lepidosperma tetraquetum*	Tissue culture	Mid-winter to summer	Seeds mature in spring and early summer

COMMUNITY TYPE 2: Marri *Corymbia calophylla* forest over soapbush *Trymalium floribundum*, *Gastrolobium bilobum* scrub, and *Lepidosperma* spp. sedges.

HABIT	SPECIES	PROPAGATION	FLOWERING TIME	NOTES
Tall shrub	*Acacia pulchella*	Seed	Winter to spring	Scarify or soak seed before sowing
Tall shrub	*Acacia urophylla*	Seed	Autumn to spring	Scarify or soak seed before sowing
Tree	*Agonis flexuosa*	Seed sown in autumn or spring. Direct seed, plant as seedling or grow from cuttings.	Spring and early summer.	Striking hormone will assist propagation of cuttings
Shrub	*Anigozanthos viridis*	Seed/division	Summer	
Rush	*Baumea articulata*	Seed or division	Spring to early summer	Readily established through rhizome transplantation. Best results in winter
Tall shrub	*Callistachys lanceolata*	Seed	Spring and early summer	Scarify seeds or immerse in hot water
Shrub	*Chorizema ilicifolium*	Seed		
Creeper	*Clematis pubescens*	Seed/cuttings	Winter to late spring	Fresh seed required for successful germination
Tree	*Corymbia calophylla*	Seed or direct seeding	Summer to spring	Collect seed from February to March.
Tree	*Eucalyptus marginata*	Seed or direct seeding	Spring	Collect seed all year round
Tree	*Eucalyptus patens*	Seed or direct seeding	Spring to summer	Collect seed all year round
Tree	*Eucalyptus rudis*	Seed direct seed or seedling	Autumn to spring	Plant seed in spring
Creeper	*Hardenbergia comptoniana*	Seed	Winter to spring	
Rush	*Isolepis nodosa*	Direct seeding	Spring to late summer	Seed matures in late summer to early autumn
Rush	*Juncus pallidus*	Seed	Spring	Seed will germinate any time of year, but do not cover as they require light for germination. Does not transplant well.
Creeper	*Kennedia coccinea*	Seed	Spring to early summer	

HABIT	SPECIES	PROPAGATION	FLOWERING TIME	NOTES
Sedge	*Lepidosperma effusum*	Tissue culture from seed	Spring	There has only been some success with the method mentioned
Sedge	*Lepidosperma longitudinale*	Rhizome transplantation	Winter	10 mm sections of rhizome with intact root mass and healthy leaves are recommended. Spacing at 0.5 m and to a depth of 30 cm in winter and spring is also advised
Shrub	*Leucopogon propinquis*	Possibly from seed	Late summer to winter	Can be difficult to propagate
Tall shrub	O*xylobium lineare*	Seed	Spring to mid-summer	Scarify seed or immerse in hot water
Tree	*Paraserianthes lophantha*	Grow from seed	Winter and early spring	Collect seed pods early to mid-summer. Scarify seed or immerse in hot water
Herb	*Patersonia occidentalis*	Seed	Spring to early summer	
Tall shrub	*Persoonia longifolia*	Seed	Late spring to summer	Difficult to propagate, collect drupes June to July
Shrub	*Phyllanthus calycinus*	Seed		
Shrub	*Sollya heterophylla*	Seed or seedling	Spring to summer	
Tall shrub	*Trymalium floribundum*		Spring	No information on propagation found
Shrub	*Xanthorrhoea preissii*	Seed, transplant	Summer to winter	Extract seeds from capsules with tweezers

COMMUNITY TYPE 3: *Agonis flexuosa*, *Corymbia calophylla*, woodland.

HABIT	SPECIES	PROPAGATION	FLOWERING TIME	NOTES
Tall shrub	*Acacia pulchella*	Seed	Winter to spring	Scarify or soak seed before sowing
Tree	*Agonis flexuosa*	Seed sown in autumn or spring Direct seed, plant as seedling or grow from cuttings	Spring and early summer	Striking hormone will assist propagation of cuttings
Shrub	*Anigozanthos viridis*	Seed/division	Summer	
Rush	*Bolboschoenus caldwellii*	Seed germination	Spring	Germinate seed immediately after collection
Shrub	*Chorizema ilicifolium*	Seed	Spring to early summer	
Creeper	*Clematis pubescens*	Seed/cuttings	Winter to late spring	Fresh seed required for successful germination
Tree	*Corymbia calophylla*	Seed or direct seeding	Summer to spring	
Tree	*Eucalyptus rudis*	Seed, direct seed or seedling	Autumn to spring	Plant seed in spring
Creeper	*Hardenbergia comptoniana*	Seed	Winter to spring	
Rush	*Isolepis nodosa*	Direct seeding	Spring to late summer	Seed matures in late summer to early autumn
Rush	*Juncus pallidus*	Seed	Spring	Germinate seed throughout the year, but do not cover as light is required for germination. Does not transplant well
Sedge	*Lepidosperma effusum*	Tissue culture from seed	Spring	There has only been some success with the method mentioned
Sedge	*Lepidosperma tetraquetum*	Tissue culture	Mid-winter to summer	Seeds mature in spring and early summer
Shrub	*Leucopogon propinquis*	Possibly from seed	Late summer to winter	Can be difficult to propagate

COMMUNITY TYPE 4: *Melaleuca rhaphiophylla,* Flooded gum *Eucalyptus rudis* open woodland.

HABIT	SPECIES	PROPAGATION	FLOWERING TIME	NOTES
Tall shrub	*Agonis linearifolia*	Seed or cuttings, or suitable for direct seeding	Throughout the year	Collect seed capsules between March and May
Shrub	*Astartea fascicularis*	Direct seed or cuttings taken in autumn	Spring and summer	Collect seed from mature capsules in winter and early spring
Rush	*Baumea articulata*	Seed or division	Spring to early summer	Readily established through rhizome transplantation. Best results in winter
Rush	*Bolboschoenus caldwellii*	Seed germination	Spring	Germinate seed immediately after collection
Tree	*Eucalyptus rudis*	Seed planted in spring, direct seed or seedling	Autumn to spring	Collect seed all year round, plant in spring
Creeper	*Hardenbergia comptoniana*	Seed	Winter to spring	
Rush	*Isolepis nodosa*	Direct seeding	Spring to late summer	Seed matures in late summer to early autumn
Rush	*Juncus pallidus*	Seed	Spring	Seed will germinate any time of year, but do not cover as they require light for germination. Does not transplant well
Sedge	*Lepidosperma longitudinale*	Rhizome transplantation	Winter	10 mm sections of rhizome with intact root mass and healthy leaves are recommended. Spacing at 0.5 m and to a depth of 30 cm in winter and spring is also advised
Tree	*Melaleuca preissiana*	Seed	Summer	Collect seed all year round
Tree	*Melaleuca rhaphiophylla*	Seed planted in autumn and spring Direct seed, seedlings or cuttings	Spring to summer	It has been suggested that if the seed is thrown onto the water then they will be placed at the right height on the bank for successful germination

8.3 Erosion control

Control of erosion is a primary management requirement within the Capel River foreshore, with many areas showing signs of severe undercutting and bank slumpage. As for many other rivers in Australia, the cause of the erosion is related to an imbalance in the natural hydrological cycle, which has resulted from catchment and channel clearing. Once a river is out of equilibrium, there is little point in revegetating the banks without first attending to the characteristics of the channel flow. The hard work that is put into site preparation and planting may be lost with the next winter flow if this basic principle is ignored.

It is possible that the Capel River could be brought back to a more natural state with the use of a number of restoration principles such as the use of small rock structures to restore a pool and riffle sequence in the river. A number of these approaches are discussed below. It should be noted however that a detailed river geometry survey and a variety of calculations are usually required for the correct design of restorative works. It is also important to remember that rivers are part of a dynamic system, that is, they are in a constant state of change. Care should therefore be taken when attempting to predict the outcome of alterations to flow regimes in such circumstances. Site specific technical support should be obtained prior to commencing any form of physical modification to the river channel.

1. Point bars

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

This cycle of erosion and deposition often continues downstream, and is the classic symptom of a river in which the hydrological balance has been disturbed (Figure 8.3.1).

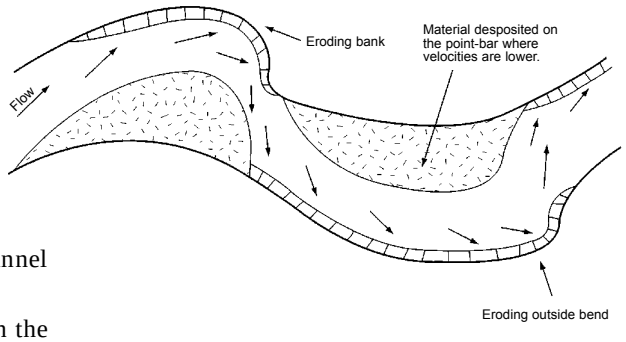


Figure 8.3.1: Outside bend bank erosion - Arrows mark the direction of flow showing that outside bends have the greatest erosion potential, so the meanders migrate downstream (Raine & Gardiner, 1995).

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

2. Undercutting

Undercutting often occurs in conjunction with the formation of point bars (above). Material is scoured from the toe of the bank, resulting in loss of bank support; this often results in subsidence as illustrated in Figure 8.3.2 (Raine & Gardiner, 1995). Previous experience has shown that undercutting can be prevented by supporting and protecting the toe of the bank. Generally undercutting will occur where there is a meander. If this is the case only the outside bends need to be supported as the flow velocity on the inside bend is much lower. Once an outside bend is stabilised, the corresponding inside bend will usually adjust its width to cater for the change in flow.

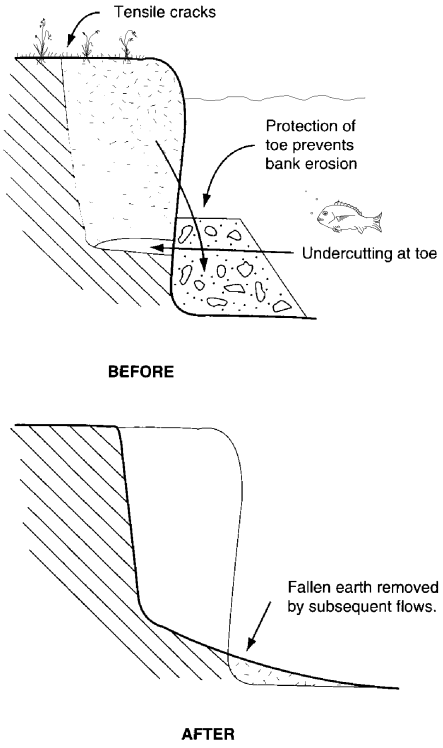


Figure 8.3.2: The use of structural works, such as a rock toe, will prevent the process of undercutting (adapted from Raine & Gardiner, 1995).

3. Bank slumping

Bank slumping can occur when poorly drained material within the bank becomes heavy with saturation and collapses into the river channel (Figure 8.3.3). This can occur without prior undercutting. It will often occur in response to the loss of native deep rooted vegetation to improve bank support. The best way to manage this problem is to exclude stock with fencing set well back from the river channel, and revegetate the foreshore with suitable species. Raine & Gardiner (1995) provide the following advice on this process:

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

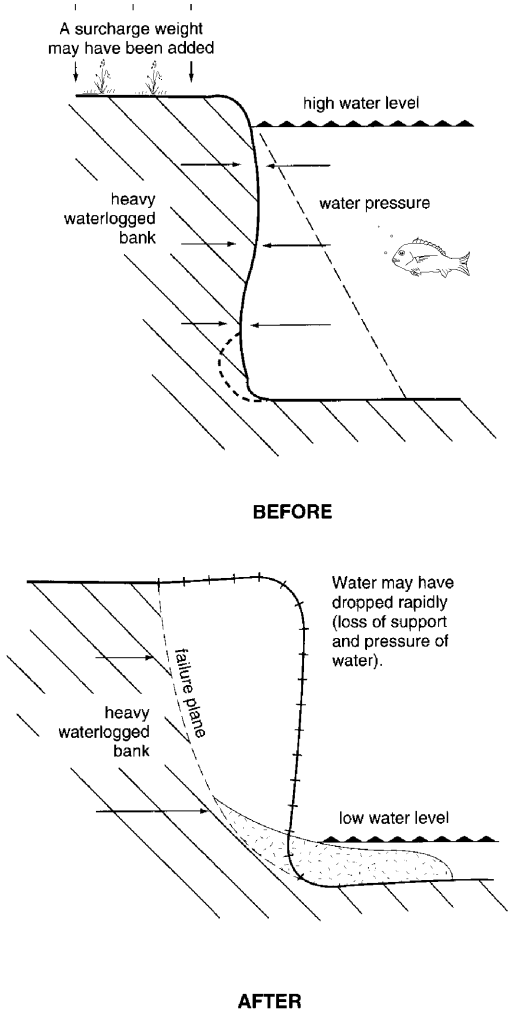


Figure 8.3.3: The process of bank slumping caused by excessive weight and lack of support (adapted from Raine & Gardiner, 1995).

4. Large woody debris

Snags, or large woody debris, are a natural component of the river system. They play an important role in the river ecology, by providing a range of flow conditions within the channel and by providing habitat for aquatic life forms.

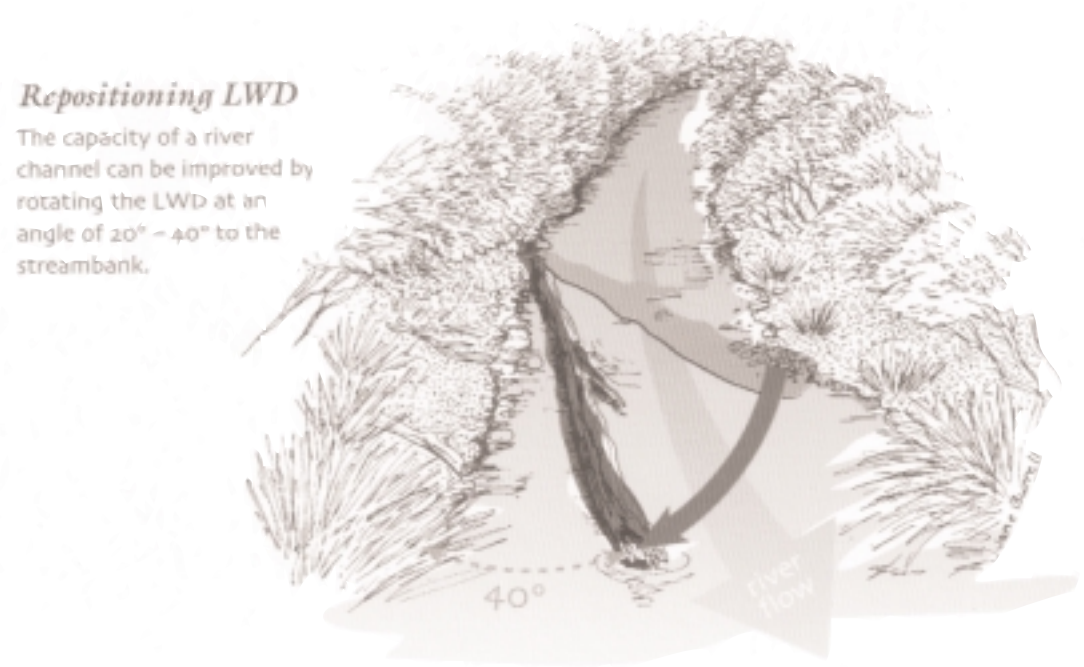


Figure 8.3.4: Repositioning large woody debris (Gippel et al, 1998).

Occasionally snags can divert the flow onto the bank and subsequently cause erosion in areas which lack support from native vegetation. While de-snagging rivers has been a common practice in the past, the current management emphasis is to leave as much woody debris as possible in order to provide habitat for aquatic plants and animals. Rather than removing large woody debris from the channel, the offending object should be repositioned at an angle 20˚ - 40˚ to the stream bank (Figure 8.3.4). This action will minimise the effect of the snag on the flow levels and direction, while maintaining the habitat available for plants and animals that benefit from low flow conditions.

8.4 Fencing

APACE Green Skills & Pen (1995) provide some good advice with regard to the placement of fences alongside waterways. This advice is detailed below.

'Ideally, fences should be placed above the river valley (Figure 8.4). Depending on the steepness of the embankment, the fence should be placed 5 m to 20 m back from the edge of the river valley (Figure 8.4 A). Five metres is sufficient for a shallow valley a couple of metres deep but a broader zone, greater than ten metres, is required for valleys deeper than five metres. The purpose of fencing off the shoulders of the river is to enable trees on the upper part of the embankment and those above the river valley to anchor the adjacent land, and thereby prevent subsidence.

In the case of shallow river valleys, there is little chance that embankments will subside. Nevertheless, fence-lines should be located above the river valley (Figure 8.4 B). This is because fences and firebreaks located within the river valley will be damaged and eroded by floodwaters. When they occur, firebreak washouts can be severe and contribute large quantities of sediment to the river system.

If the river valley is particularly broad and floodplains have been cleared for grazing, fencing them off may mean sacrificing good farmland. In this case it is necessary that only those areas that are prone to water erosion or stock damage, such as embankments and secondary river channels which only flow strongly at times of flood, need to be fenced off (Figure 8.4 C). Some of these fence-lines will be prone to flood damage, but this can be minimised if fences run, as much as possible, parallel to the direction of floodwaters.

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

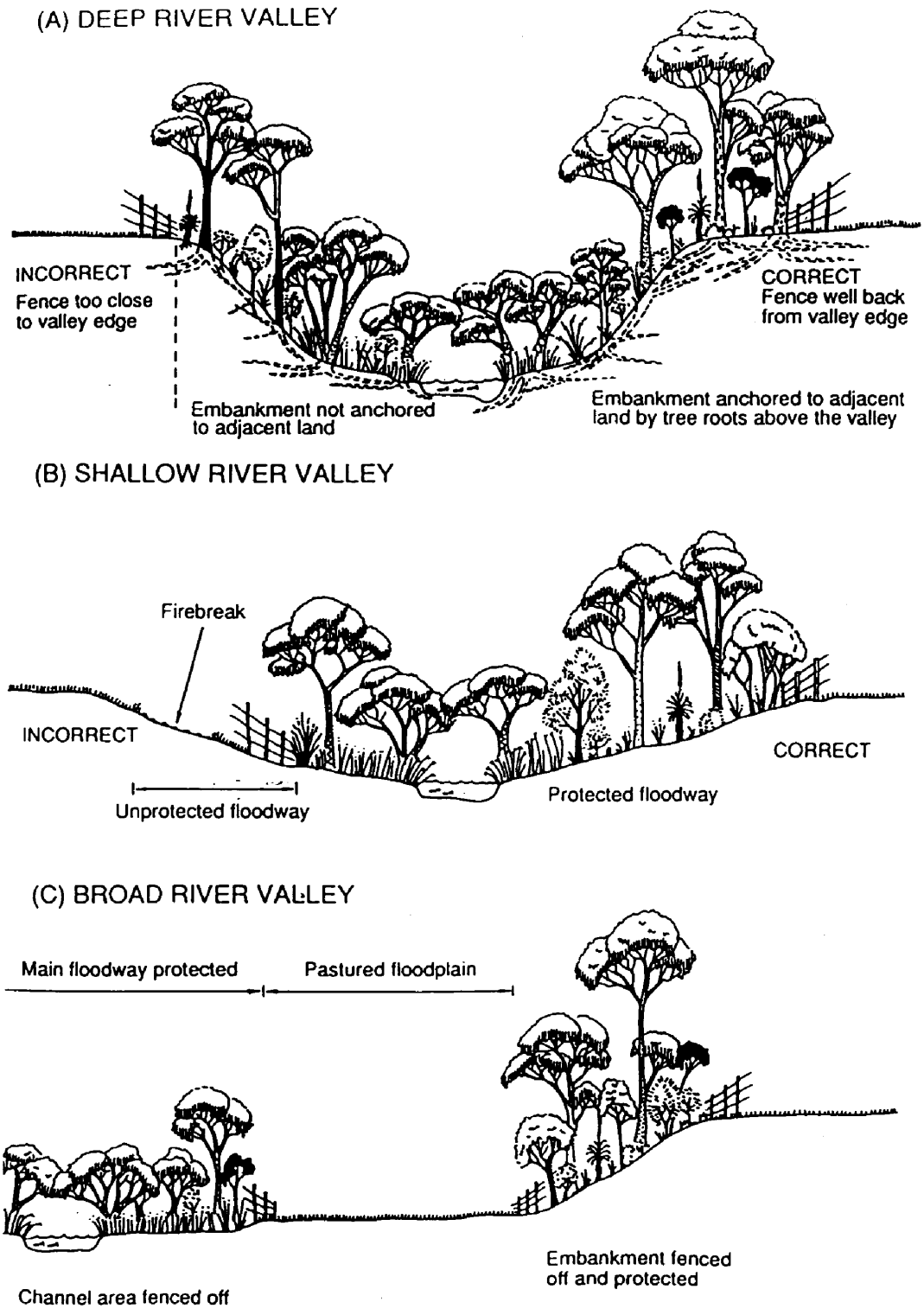


Figure 8.4: The correct placement of fences in relation to the river valley: (A) the deep river valley, (B) the shallow river valley and (C) the broad river valley with broad flood-plain (APACE Green Skills & Pen, 1995).

Detailed description of the condition and rehabilitation needs of Capel River

9. Capel River foreshore condition and recommendations for management

This chapter presents the results of the foreshore assessment in a series of eighteen maps, each accompanied by a table of environmental issues and management advice. The Capel River has been divided into seven sections, based on management issues and vegetation communities. Each section starts with a summary of the common issues.

Disclaimer: The maps presented in this report have been produced at a scale equal to that of available digital mapping information. Some discrepancies may occur in the locations of features marked on the maps and their actual locations. Comments from the readers, which would refine or improve these maps for future publications, are welcomed by the authors. In relation to fencing, the authors have not recommended that foreshore areas should be fenced at sites where there are currently no stock to exclude (such as foreshore adjacent to orchards). If land use in these areas should change in the future, these recommendations may need to be reviewed. For unfenced and unstocked areas adjacent to the river foreshore, it is recommended that some form of marker be erected to ensure that the foreshore boundary is well demarcated for the purposes of revegetation and remnant bushland management.

Specific management priorities for each section are identified in Table 9.2 below. A community workshop held in January 1999 also identified that a number of local residents were keen to see the coastal reserve at the river mouth (in Section 1) rehabilitated and protected from stock damage. A further priority was that a similar foreshore survey should be undertaken for the upper reaches of the Capel River that flows through the Donnybrook Shire; and that an Integrated Catchment Management Plan should be prepared for the Capel River catchment.

Table 9.1: Sections of the Capel River Action Plan.

Section1	Capel River mouth to Gynudup Brook
Section 2	Capel River at Gynudup Brook to Capel town road bridge
Section 3	Capel town bridge to Jamieson footbridge
Section 4	Jamieson footbridge to the upper boundary of the marron farm
Section 5	The marron farm to the lower end of Lot 934 (upper catchment)
Section 6	From lower lot 934 to lower lot 828 (upper catchment)
Section 7	From lower lot 828 to the Capel Shire boundary (upper catchment)

Table 9.2: Management priorities for the Capel River foreshore.

SECTION	PRIORITIES			
	Fencing	Rehabilitation	Weed Control	Erosion Control
1	✓	✓	✓	
2	✓	✓	✓	
3	✓	✓	✓	✓
4	✓	✓	✓	✓
5		✓	✓	✓
6		✓	✓	
7		✓	✓	

Section 1 - Description

Capel River mouth to Gynudup Brook.

Condition Rating

Map	North Bank	South Bank
1	B2 C1	B2-B3 C1
2	C1	B3 C1
3	C1	B2 C1

Section 1 extends from the mouth of the Capel River to the Gynudup Brook convergence. This area was characterised by coastal low lands and a predominantly cleared foreshore with occasional remnant trees and patches of native sedges. In most areas large expanses of Kikuyu, currently grazed, stretched down to the river edge (Plate 11, page 40).

This section is associated with a high use by waterbirds, particularly during the summer months. The coastal section acts as a floodplain during winter and this precludes rehabilitation of the foreshore area. The coastal dune areas are interesting as the river was once connected to the Stirling wetlands. Rehabilitation of these dunes is in process, and fencing of the waterway would complement this project.

A significant amount of the introduced bulrush *Typha orientalis* (Plate 11, page 40) was recorded in the middle and upper reaches of this section. This particular weed is regarded as a pest species in waterways and should be controlled as it also tends to out-compete native species, which unbalances the system ecology.

Large patches of arum lily were also recorded along this stretch of the river. This is a notorious weed within the Geographe Bay catchment, although it appeared to have been well controlled in most other sections of the Capel River. A variety of other weed species were also recorded including apple of Sodom and wild rose. While not yet out of control, all of these weed species can create seemingly 'unmanageable' problems if left unchecked.

The majority of this section was unfenced and, although there was no obvious erosion recorded, there were many sites where stock had direct access to the river foreshore. While erosion was not an immediate management issue in this section, exclusion of stock from the foreshore by fencing is recommended prior to replanting. Revegetation of the river foreshore would add significantly to the existing visual amenity of this area, as well as enhancing habitat for waterbirds. This section was also easily accessible by boat, offering potential for recreational uses which would benefit from an enhancement of the visual amenity.

Vegetation community type 4 (freshwater paperbark *Melaleuca rhaphiophylla*, flooded gum *Eucalyptus rudis* open woodland) was most likely once wide spread in this section. Although most of the vegetation had been cleared, several areas with high species diversity were located upstream of the Malokup Bridge. The Gynudup Brook also had some good stands of this vegetation type. Invasive weeds threaten the ecological integrity of these sites.

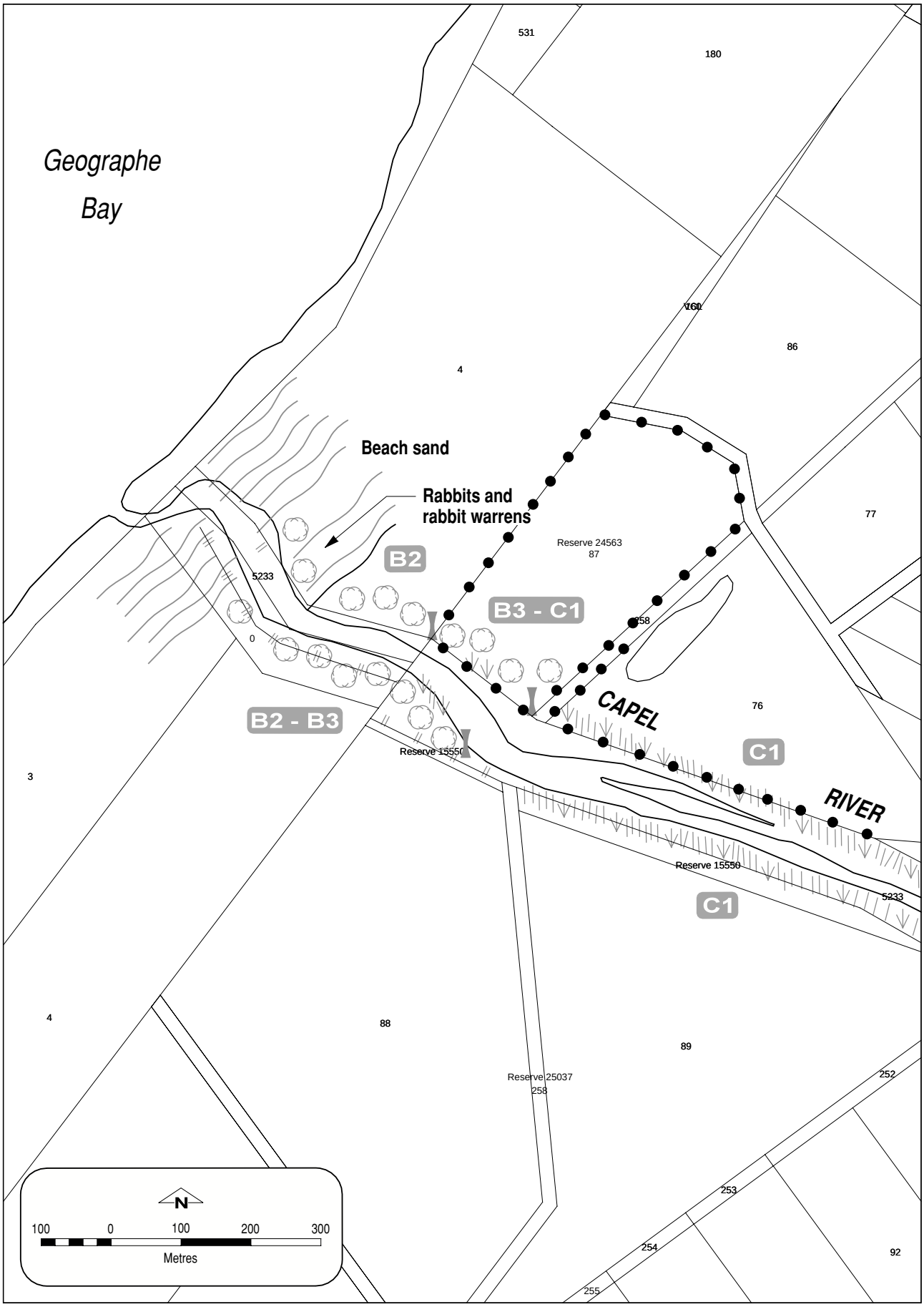
Plate 11: The lower Capel foreshore with Typha and Kikuyu.

Map 1

North	South
Reserve 5233, reserve 24563, and lot 76	Reserve 15550, and lots 3, 4, 88 and 89 (setback)

Management and rehabilitation advice to landowners

Issues	Comments	Management Advice
General foreshore condition	River mouth and coastal dunes are well vegetated though degraded (channel to river mouth is artificial with a raised embankment). The reserve is grazed on both sides.	N/A
Fencing	The lower section has been fenced although the fencing is now in poor condition, and is set well back from the river bank. It is possible that stock may still have access to these areas. The upper section is not fenced.	Fencing is required to exclude horses and cattle on the north bank. Length of fencing recommended: ~ 900 m.
Erosion	N/A	
Revegetation requirement	The Capel River acts as a flood channel in this section, thus precluding the area from revegetation.	N/A
Weed invasion	Reserve 24563: thistles and Pelargonium observed (not on foreshore).	Refer to Specific weed management advice Chapter 8.1.2 point 16 (page 25).
Other comments	The foreshore area is dominated by Kikuyu, yet this is stabilising the banks.	N/A



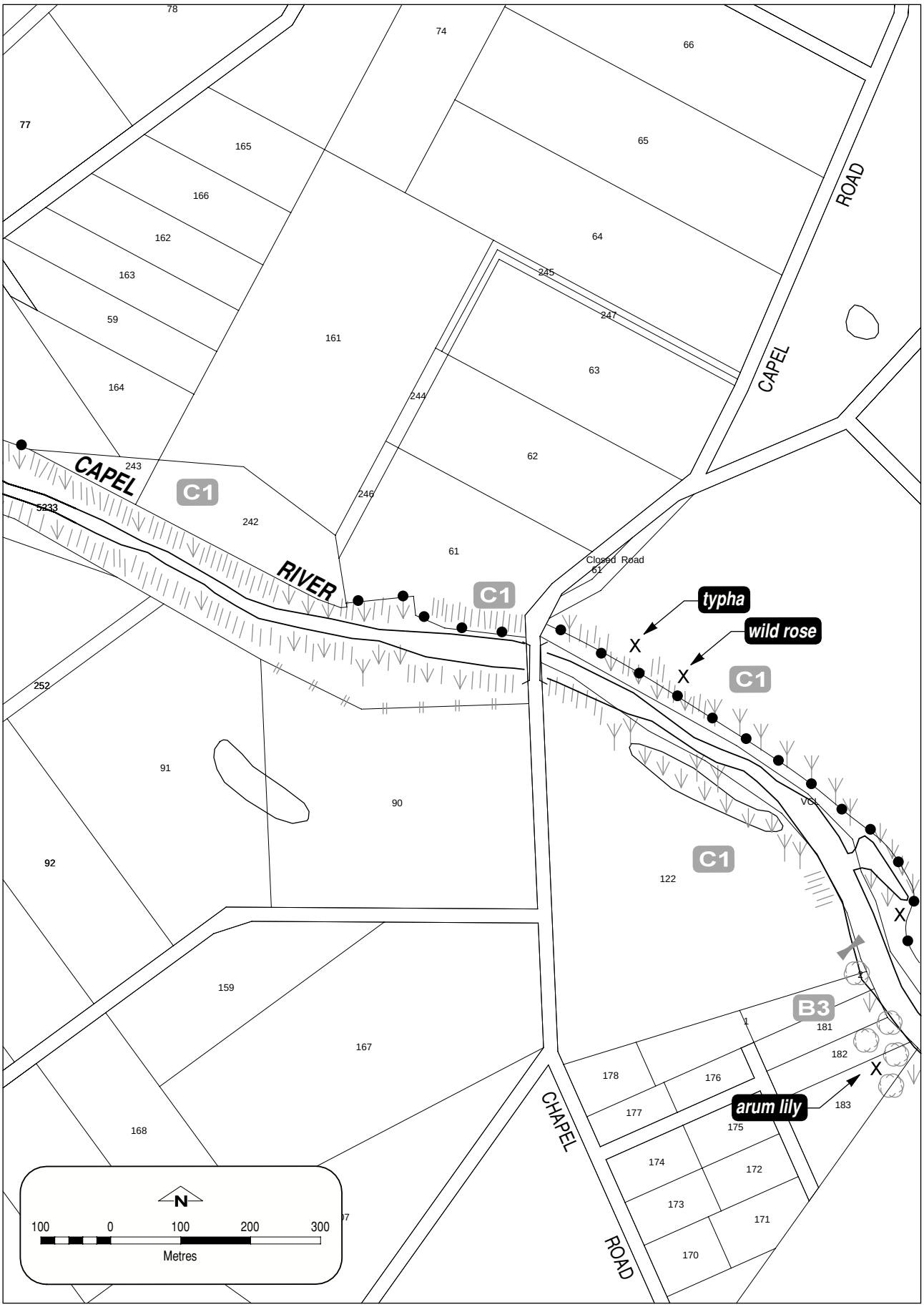
Capel River Map 1

Map 2

North	South
Lots 243, 242, 61 & 148	Reserve 15550, lots 89, 91, 90, 122, 181, 182 and 183

Management and rehabilitation advice to landowners

Issues	Comments	Management Advice
General foreshore condition	This section of the foreshore was very homogenous, resembling parkland (with virtually no understorey). A small section of good quality riparian vegetation was recorded at the upper south margin; this site had also been rehabilitated in the past.	N/A
Fencing	Some isolated areas have been fenced, yet fencing is set well back from the foreshore and it is possible that stock have access to these areas. The upper section is obviously grazed to the edge of the foreshore.	Fencing is recommended on both sides of the river in the section. Length of fencing recommended: north bank ~ 1300 m; south bank ~ 900 m.
Erosion	N/A	
Revegetation requirement	Understorey is particularly sparse in this area a narrow band of flooded gums lined the foreshore and isolated areas of dense rushes and sedges also occurred. Kikuyu dominated much of the foreshore.	Revegetation with understorey and sedge species, and widening the band of trees would improve the quality of the foreshore. Select species from community type 4, Table 8.1 (page 32).
Weed invasion	*Typha orientalis* was common in this area, particularly in the upper section. Arum lily and wild rose were also recorded in this area.	Refer to Specific weed management advice Chapter 8.1.2 points 2, 17 and 19 (page 23 - 26).
Other comments	The club-rush *Bolboschoenus caldwellii* was recorded in this section. *B. caldwellii* can congest waterways, and is invasive in disturbed areas.	Monitor spread of this rush.



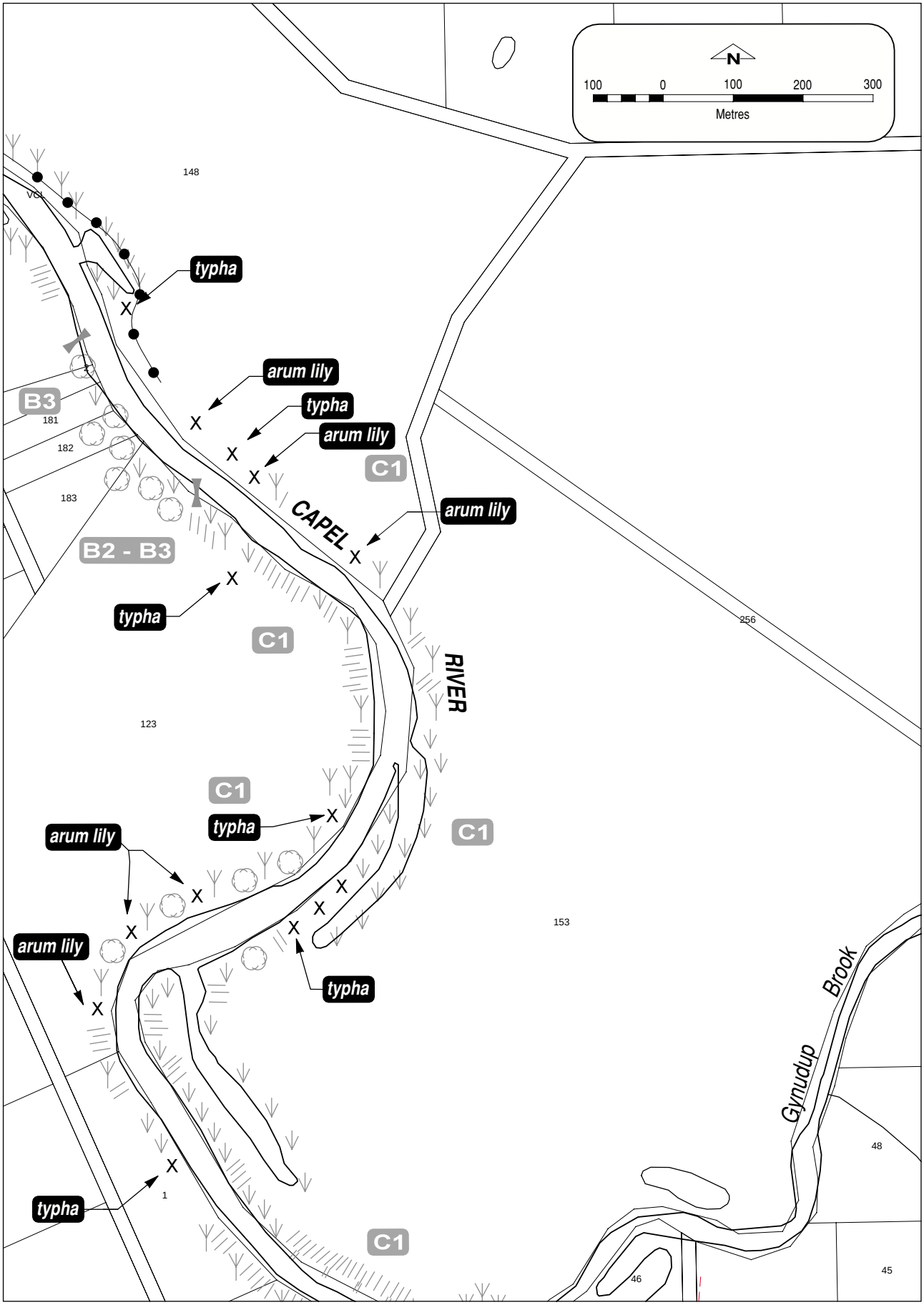
Capel River Map 2

Map 3

North	South
Lots 148 & 153	Lots 122, 181, 182, 183, 123, & 1

Management and rehabilitation advice to landowners

Issues	Comments	Management Advice
General foreshore condition	The higher ground resembled cleared parkland (with virtually no understorey). A small section of good quality riparian vegetation was recorded at the lower south margin; this site had previously been rehabilitated.	N/A
Fencing	The area was not fenced close to the foreshore, although it appeared that stock had been excluded from the area. The smaller lots in the lower section were not stocked.	N/A
Erosion	N/A	
Revegetation requirement	Understorey was particularly sparse in this area. A narrow band of flooded gums lined the foreshore and isolated areas of dense rushes and sedges also occurred. Kikuyu dominated much of the foreshore.	Revegetation with understorey and sedge species, and widening the band of vegetation would improve the quality of the foreshore. Select species from community type 3 & 4, Table 8.1 (pages 31 & 32).
Weed invasion	Typha and arum lily were common in this section.	Refer to Specific weed management advice Chapter 8.1.2 points 2 & 17 (pages 23 & 25).
Other management comments	The club-rush *Bolboschoenus caldwellii* was recorded in this section. *B. caldwellii* can congest waterways, and is invasive in disturbed areas.	Monitor spread of this rush.



Capel River Map 3

Section 2 - Description

Gynudup Brook to Capel town road bridge

Condition Rating

Map	North Bank	South Bank
4	C1	C1

This section comprised a series of small lots that were predominantly unfenced. The land use included a mixture of hobby farms, agriculture and semi-rural residential developments. The river foreshore was particularly narrow in many sections, and some landowners had developed below the high water mark.

The river channel was very straight in this section, and uniform in width. The surrounding land was just starting to rise out of the floodplain flats, with gentle undulations on the north bank. Public access to the river foreshore is difficult owing to the absence of reserves and the resulting need to pass through private property to reach the river. Boat access to this section is possible in the lower reaches, yet this is limited in the upper reaches by a large amount of woody debris. Although these snags restrict recreational use of the upper portion, it is recommended that they are left in the river channel as they provide important habitat for aquatic plants and animals.

While many of the properties were not stocked during the period of the foreshore survey, the presence of grazed pasture indicated that this section was stocked at some time. It is therefore recommended that these sections are fenced to prevent stock access to the river foreshore. Exclusion of stock and widening the foreshore reserve would allow natural regeneration to occur with some management assistance such as weed control.

Some Typha and arum lilies were recorded in the lower section. Arum lily and Typha can potentially become 'unmanageable' if left unchecked. Both of these weed species should, therefore, be controlled. A number of willows were also recorded throughout this section. Unlike peppermint trees, willows are not native to Western Australia, and their deciduous nature means that dropping of leaf litter during winter has potential to contribute nutrients to the system. It is therefore suggested that consideration be given to removing these willows, and rehabilitating the foreshore with native species.

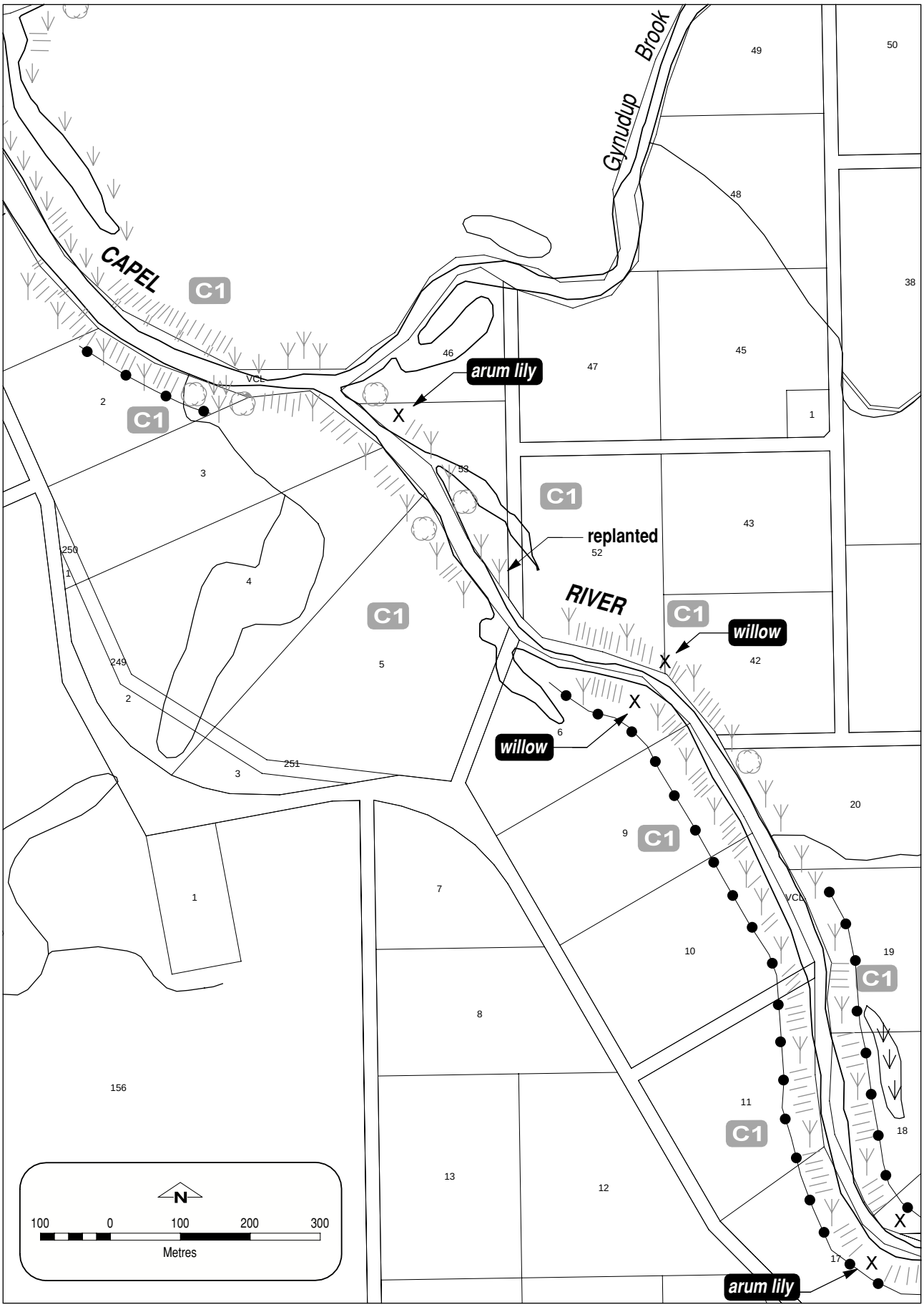
The condition of remnant vegetation in this section was generally poor, with little of the original structure remaining. From the structural composition of the remnants it is probable that vegetation types 1 (flooded gum *Eucalyptus rudis* woodland) and 4 (*Melaleuca rhaphiophylla*, flooded gum *Eucalyptus rudis* open woodland) were found in this area. As for Section 1, native understorey was virtually absent from this section, and the foreshore vegetation consisted of a narrow band of flooded gums. Revegetation of this section is required to restore the understorey and ensure sufficient bank stabilisation is provided.

Map 4

North	South
Lots 153, 46, 53, 52, 42, 20, 19 & 18	Lots 2, 3, 4, 5, 6, 9, 10, 11 & 17

Management and rehabilitation advice to landowners

Issues	Comments	Management Advice
General foreshore condition	Narrow foreshore, isolated trees, little or no understorey.	
Fencing	Some sections were fenced close to the foreshore, in other areas fencing was absent or set well back from the foreshore. The smaller lots in the upper section were not stocked at the time of survey.	Fencing is recommended along sections of the north and south bank. Length of fencing recommended: south bank ~1000 m, north bank ~ 600 m.
Erosion	N/A	
Revegetation requirement	Understorey is particularly sparse in this area, a narrow band of flooded gum lined the foreshore, with isolated clumps of rushes and sedges.	Revegetation with understorey and sedge species is recommended. This should include widening the riparian buffer zone to allow natural regeneration to occur. Select species for replanting from community types 1 & 4, Table 8.1 (pages 28 & 32).
Weed invasion	Typha was common in the lower section. Large willows were recorded in the middle reaches of this section. Occasional arum lilies were also recorded	Treat arum lily and Typha; consider removing willows and replacing with native trees such as flooded gum, or peppermint. Refer to Specific weed management advice Chapter 8.1.2 points 2 and 17 (page 23 & 25).



Capel River Map 4

Section 3 - Description

Capel town bridge to Jamieson footbridge

Condition Rating

Map	North Bank	South Bank
5	B3 D1	C3 D1

Section 3 passes through a central section of the Capel town site and is the most publicly visible section of the Capel River. A footbridge crosses the river here and leads directly to the Capel Primary School. These aspects offer an excellent opportunity for river restoration to be demonstrated. The visual amenity of this area could be substantially improved with intensive weed control and rehabilitation of the native vegetation communities.

The river meanders considerably within this section, and the surrounding landforms change from gentle undulations on the north bank to sharp rises. The south bank remains relatively flat.

The remnant vegetation in this section was generally degraded by weeds. Vegetation types 1 (flooded gum *Eucalyptus rudis* woodland), 3 (peppermint *Agonis flexuosa*, flooded gum *Eucalyptus rudis* woodland) and 4 (freshwater paperbark *Melaleuca rhaphiophylla*, flooded gum *Eucalyptus rudis* open woodland) were found in this area.

This section contains a number of reserves that are severely degraded with highly invasive weeds, yet these have the potential to be of value for conservation if rehabilitated. Many of the weeds found in this section are garden escapees, such as leek and Watsonia. These appear to have been spread by the dumping of garden waste, which, judging from recent refuse observed at the site, may be an ongoing event. Raising local awareness of the spread of weeds which results from this practice could help to encourage individuals to dispose of waste in a responsible manner.

The dairy site offers some potential for recreation opportunities, with the landholder actively encouraging public use of the foreshore. Horses have been allowed to graze to the river's edge throughout this section, with the owners intent on ensuring public access to the river by keeping the grass down. Exclusion of stock from this area, and the use of an alternative means to maintain the lawn (such as mowing) would enable the parkland style use of this area without further damage to the river foreshore.

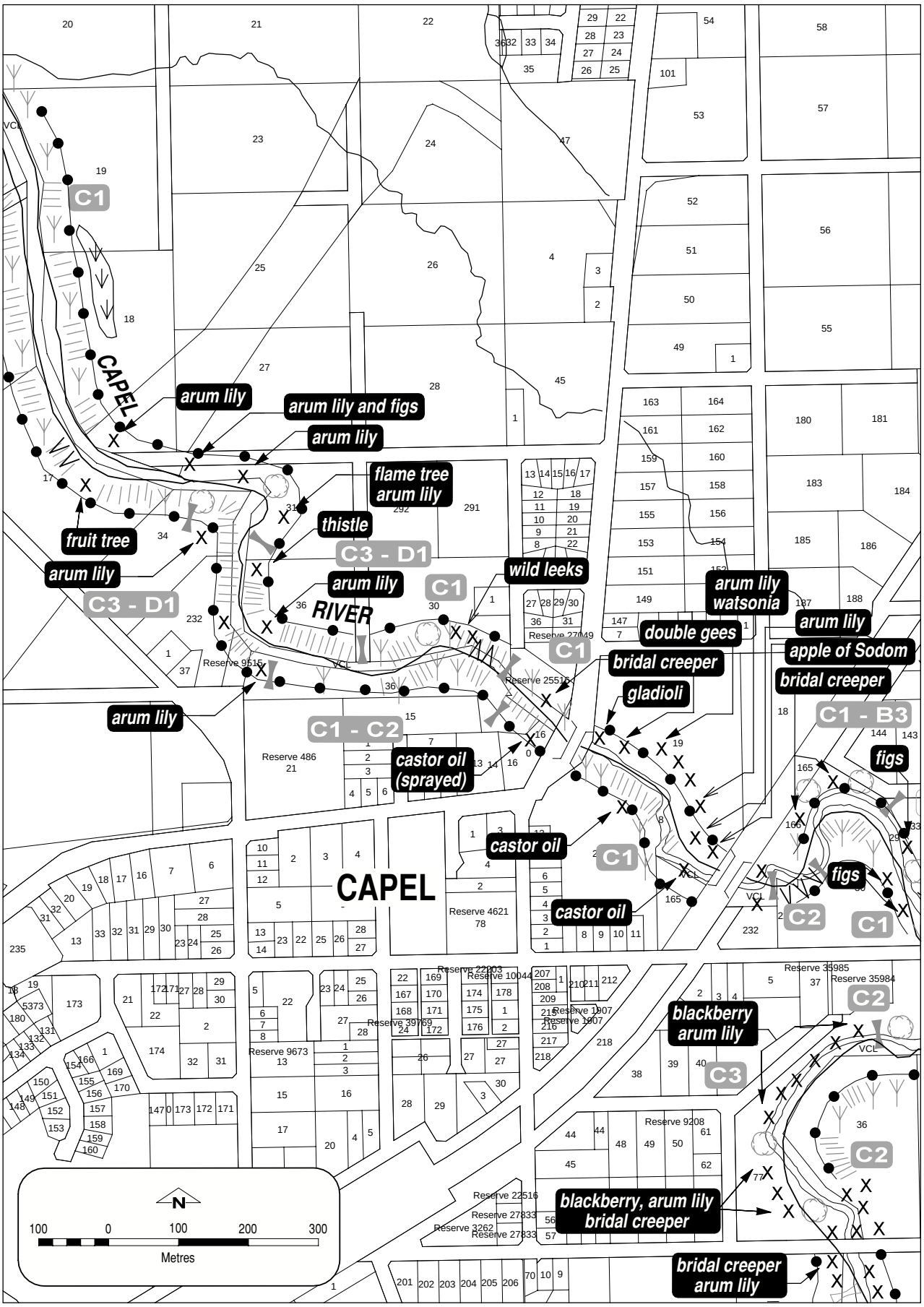
Following rehabilitation of the foreshore reserve 8934, a formal path system could be incorporated into the foreshore to optimise public appreciation of the native reserves.

Map 5

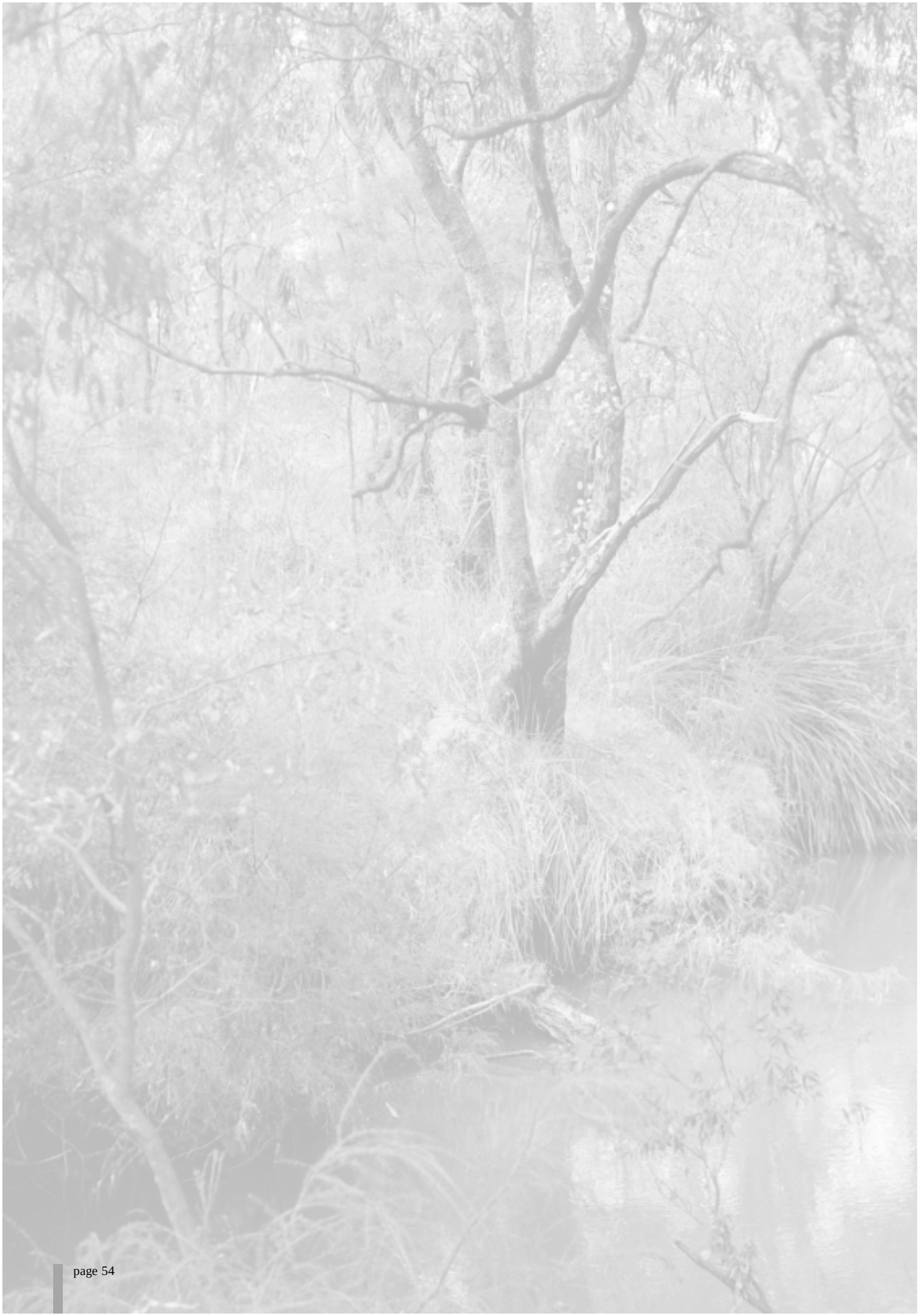
North	South
Lots 20, 19, 18, 31, 36, 30, Lots 19, 166 (Reserve 8934), 133, 36	Lots 17, 34, 232, Lots 36, 16, 28, 165, VCL, 30, 77.

Management and rehabilitation advice to landowners

Issues	Comments	Management Advice
General foreshore condition	The foreshore in this section was generally degraded, with little or no understorey, many sites of erosion and scouring, and severe weed invasion.	
Fencing	There was no fencing of the foreshore in this section. However, exclusion of stock from the foreshore reserve would limit the need for fencing in much of this section.	Fencing recommended along both sides of the foreshore in this section. Length of fencing recommended: North bank ~ 2300 m; south bank ~ 2000 m.
Erosion	Several sites of severe scouring were noted in this section.	Refer to Erosion control Chapter 8.3 — points 1 & 2 (page 33).
Revegetation requirement	Understorey is particularly sparse in this area, a narrow band of flooded gum lined the foreshore, with isolated clumps of rushes and sedges.	Revegetation with understorey nd sedge species is recommended. This should include widening the riparian buffer zone to allow natural regeneration to occur. Select species from community type 1 & 3, Table 8.1 (pages 28 & 31).
Weed invasion	Arum lily, wild rose, bridal creeper, blue periwinkle, figs, apple of Sodom, double gees all recorded in this section. In addition, wild grapes, wild garlic and easter lilies are problematic in this area.	Refer to Specific weed management advice Chapter 8.1.2 points 2, 19, 5, 4, 10, 1, and 9 (pages 23 -26). Also treat wild grapes, wild garlic and easter lilies.
Other management comments	Due to its proximity and high visibility to the town of Capel this section could be used as a priority site for restoration action. *Bolboschoenus caldwellii* recorded in this section. *B. caldwelli* readily invades disturbed areas and can clog waterways.	PRIORITY ACTION SITE Monitor spread of this rush.



Capel River Map 5



Section 4 - Description:

Jamieson footbridge to the marron farm.

Condition Rating

Map	North Bank	South Bank
6	B3 D1	B3 D1
7	B3 C3	C1 C3
8	A3 C3	B3 C1

This section of the river is highly degraded with erosion of the river channel the most notable problem. The majority of this section has not been fenced and stock have had access to both sides of the river in some areas.

Vegetation types 2 (*Corymbia calophylla, E. rudis* forest) and 3 (Agonis flexuosa, marri *Corymbia callophylla* woodland) were found in this area, with the latter the dominant vegetation type. In many areas the understorey was grazed and the native understorey diversity was very low.

Weeds are also a notable problem, particularly bridal creeper, fig, arum lily and blue periwinkle. In particular blue periwinkle is well established on the southern bank, and forms dense mats that exclude native species and restrict regeneration. No evidence of stock grazing of this plant was found in this section. There were several small populations of apple of Sodom in this section.

In a few areas in the lower reaches of this section the native sedge *Bolboschoenus caldwellii* is establishing large thickets within the river bed. These need to be monitored, as this sedge can clog the waterways if left unchecked.

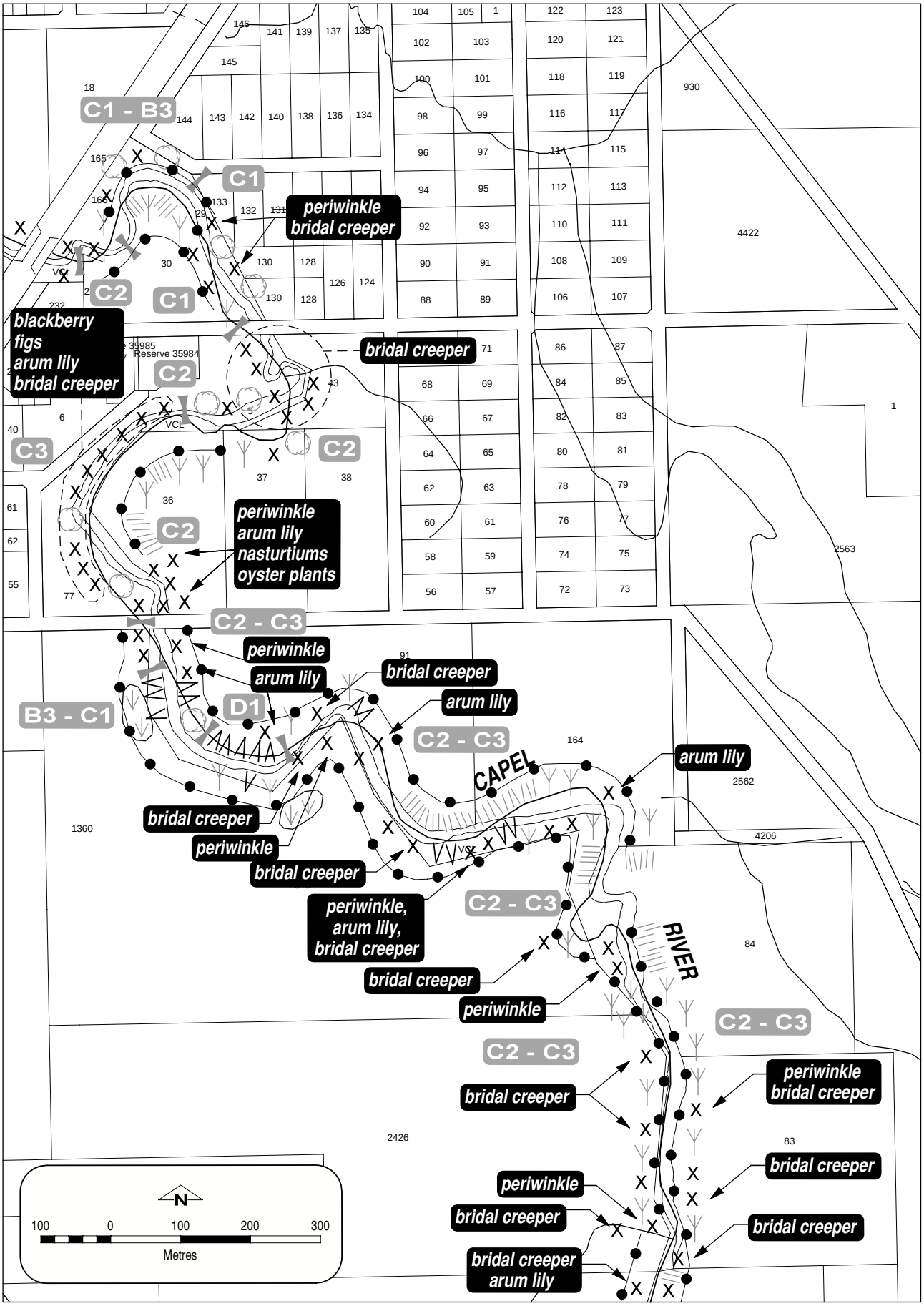
The area appears to be a sediment deposit area and numerous point bars seem to be exacerbating the erosion problem by redirecting flow directly onto banks that are already unstable. Control of stock would assist in reducing bank erosion in this section, yet it is likely that physical restoration may be required to reduce the impact of the point bars. The action should be undertaken in conjunction with management of large woody debris.

Map 6

North	South
Reserve 166, Lots 133, 130, 43, VCL, 36, 91, 164, 84, 83	Lots 30, 5, 77, 1360, 2426

Management and rehabilitation advice to landowners

Issues	Comments	Management Advice
General foreshore condition	The foreshore in this section was generally degraded, with little or no understorey, many sites of erosion and scouring, and severe weed invasion.	
Fencing	Fencing of the foreshore was absent or set well back from the foreshore, and not excluding stock.	Fencing recommended along both sides of the foreshore in this section. Length of fencing recommended: north bank ~ 1650 m; south bank ~ 1550 m.
Erosion	Severe scouring was recorded at many sites in this section.	Refer to Erosion control Chapter 8.3, points 1, 2 and 4 (pages 33 & 34).
Revegetation requirement	Understorey is particularly sparse in this area, a narrow band of flooded gum lined the foreshore, with isolated clumps of rushes and sedges.	Revegetation with understorey and sedge species is recommended. This should include widening the riparian buffer zone to allow natural regeneration to occur. Select species primarily from community type 3, and some type 2, Table 8.1 (pages 29 - 31).
Weed invasion	Arum lily, wild rose, bridal creeper, blue periwinkle, figs, all recorded in this section.	Refer to Specific weed management advice points 2, 19, 5, 4, and 10 (pages 23 - 26).
Other management comments	Due to its proximity and high visibility to the town of Capel this section could be be used as a priority site for restoration action. *Bolboschoenus caldwellii* recorded in this section.	*B. caldwellii* can congest waterways Monitor spread of this rush.



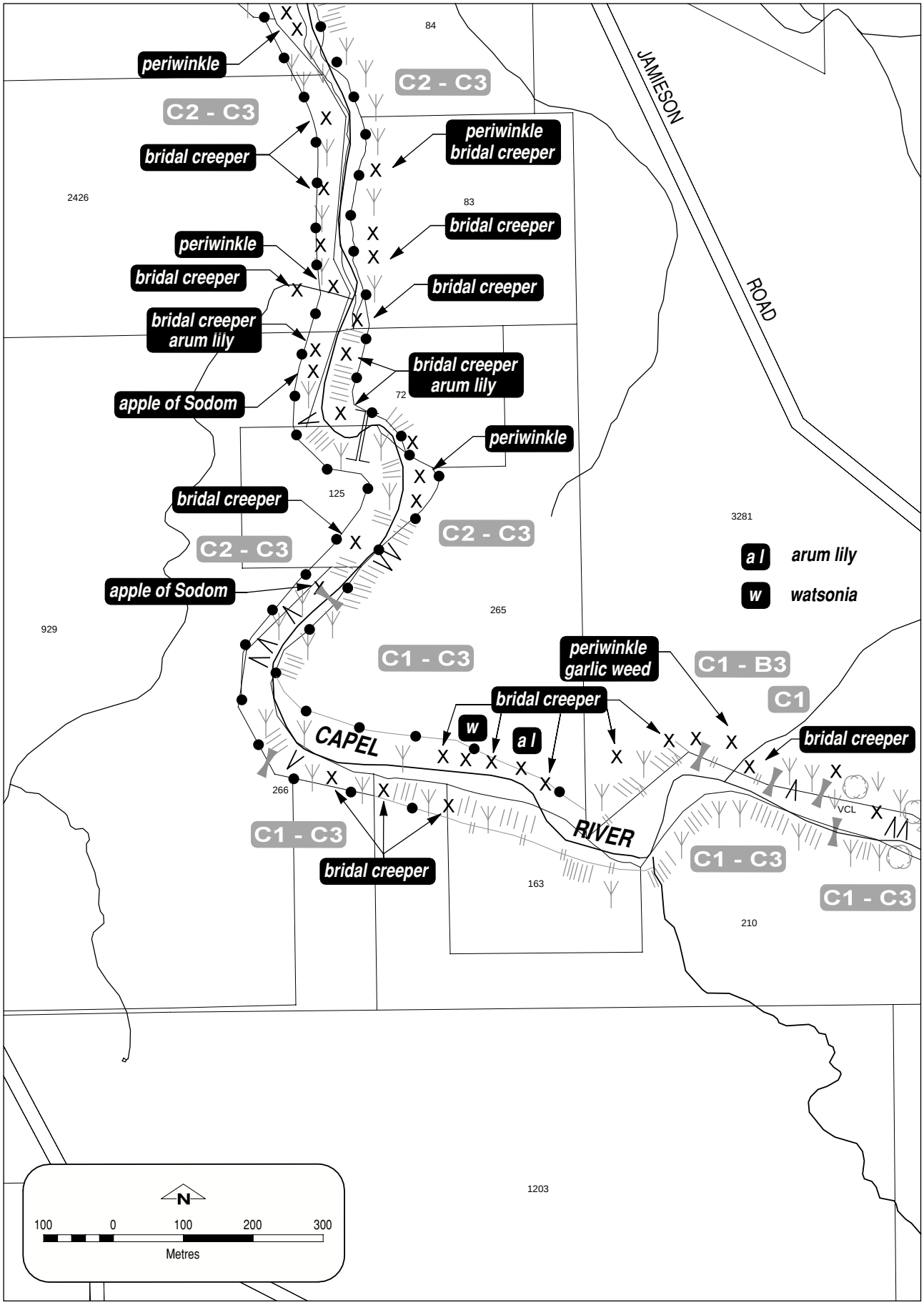
Capel River Map 6

Map 7

North	South
Lots 84, 83, 72, 265, 3281	Lots 2426, 929, 125, 266, 163, 210

Management and rehabilitation advice to landowners

Issues	Comments	Management Advice
General foreshore condition	The foreshore in this section was generally degraded, with little or no understorey, many sites of erosion and scouring, and severe weed invasion.	
Fencing	Fencing of the foreshore was absent or set well back from the foreshore, and not excluding stock.	Length of fencing recommended: south bank ~ 1100 m north bank ~ 1265 m.
Erosion	Severe scouring was recorded at many sites in this section.	Refer to Erosion control Chapter 8.3, points 1, and 2 (page 33).
Revegetation requirement	Understorey is particularly sparse in this area, a narrow band of flooded gum lined the foreshore, with isolated clumps of rushes and sedges.	Revegetation with understorey and sedge species is recommended. This should include widening the riparian buffer zone to allow natural regeneration to occur. Select species from community type 2 and 3, Table 8.1 (pages 29 - 31).
Weed invasion	A variety of invasive weeds were recorded in this section, including blue periwinkle, bridal creeper, arum lily, apple of Sodom, and garlic weed.	Refer to Specific weed management advice Chapter 8.1.2 points 1, 2, 4, and 5 (page 23).
Other management comments		



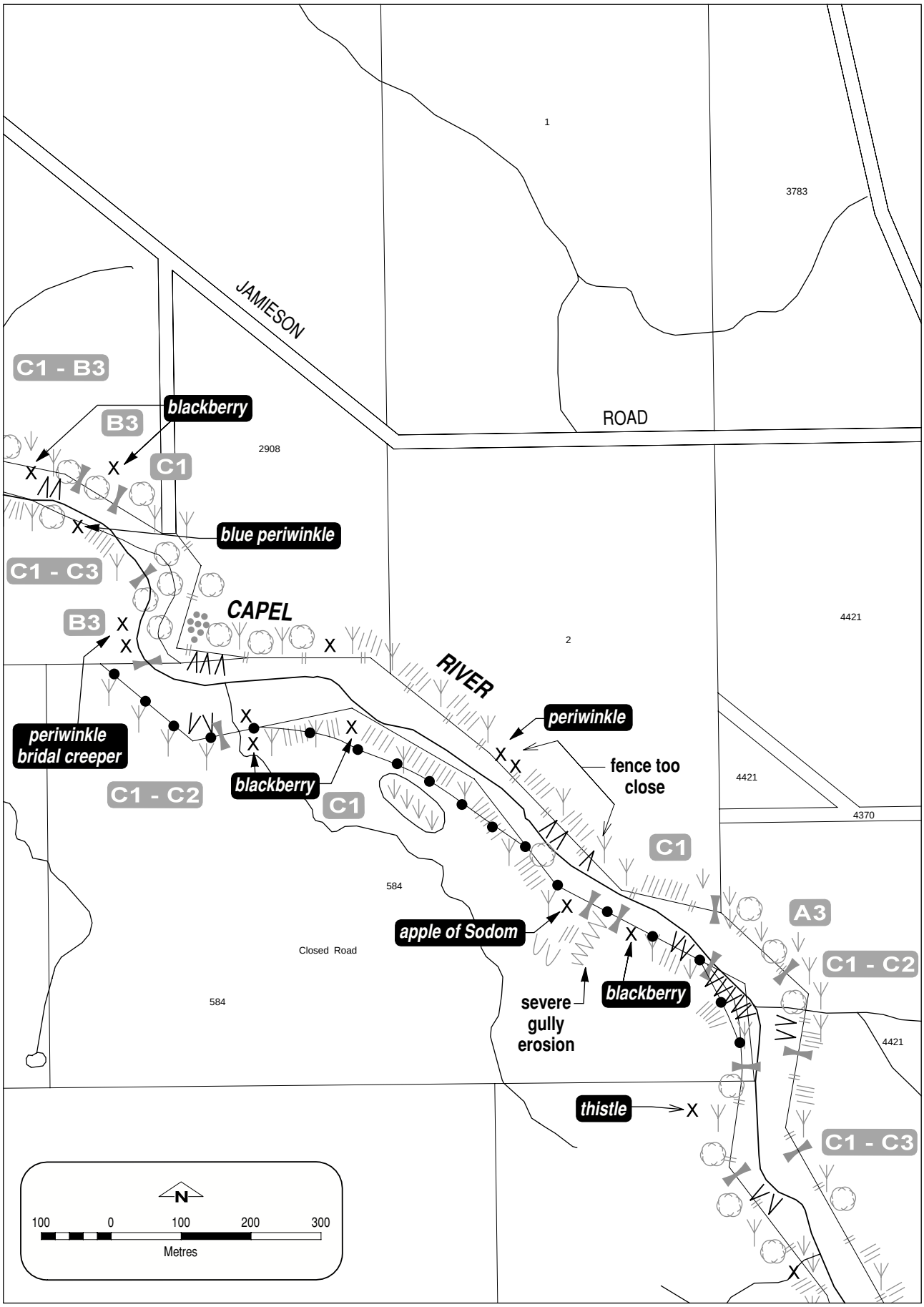
Capel River Map 7

Map 8

North	South
Lots 3281, 2908, 2, 4421	Lots 210, 584, 3366

Management and rehabilitation advice to landowners

Issues	Comments	Management Advice
General foreshore condition		
Fencing	Fencing recommended along much of the southern foreshore of this section. Fence too close to the riverbank on some sections of the northern foreshore.	Length of fencing recommended: south bank ~ 1300 m
Erosion	Frequent sites of scouring along this section. Also, two small areas of sheet erosion noted on the southern bank. Some severe gully erosion and sheet erosion on the southern foreshore of this section.	Refer to Erosion control Chapter 8.3, points 1 and 2 (page 33).
Revegetation requirement	Revegetation of understorey species recommended along much of this section.	Select species from community type 2 & 3, Table 8.1 (pages 29 - 31).
Weed invasion	Bridal creeper, blackberry, apple of Sodom, periwinkle, figs and thistles.	Refer Specific weed management advice Chapter 8.1.2 points 1, 5, 3, 4, 10, and 16 (pages 23 - 25).
Other management comments	Small area of excellent vegetation on northern foreshore could be used as potential seed source for revegetation.	Complete detailed vegetation survey of this area.



Capel River Map 8

Section 5 - Description:

Marron farm to lot 934

Condition Rating

Map	North Bank	South Bank
9	A3 C3	B2 C2
10	B3 C3	C2 D1
11	B2 C3	C1 D1
12	A2 C2	A2 C2
13	B2 C1	B3 C2

The majority of this section of the river has been fenced for some time, yet scouring of the river channel remains a notable problem. It is probable that the topography is such that flow velocity increases over this section, making it more susceptible to scouring. The main river channel consists predominantly of open water, which also suggests that flow velocity is likely to be high (since there has been little colonisation within the channel).

In several areas of this section the existing fencelines have been placed too close to the river channel. At several of these sites the existing fenceline actually passes over areas which have been severely scoured (Plate 9 and 10, page 21). Fences should be placed well back from floodway, preferably outside the floodplain to ensure that sufficient space is provided for regeneration of a wide band of native vegetation. This vegetation should assist in preventing severe channel scouring and thus reduce the cost involved in re-locating fencelines when they are lost to a river meander.

One site of very severe gully erosion was also recorded in the lower stretch of this section (Plate 12 page 64). This gully erosion is believed to have been caused by inappropriate pipe drainage design. Remediation for this erosion is considered urgent. Initial steps have been taken to address this problem.

Vegetation type 1 (flooded gum *Eucalytpus rudis* woodland) was prominent on the riparian fringe in this section, while type 2 (marri *Corymbia calophylla*, flooded gum *E. rudis* forest) dominated the valley flat. There were some good pockets of remnant vegetation in this section, and with much of the river foreshore fenced, good regeneration has occurred in many areas.

However, in some areas of the foreshore reserve bracken dominates the understorey, in particular where stock have had no access for long periods of time. Bracken fern has the potential to restrict regeneration of other native vegetation and may need to be controlled in some cases.

Reserve 3802 (Map 12), which spans the north and south banks, has good stands of remnant vegetation. A detailed floristic survey of this reserve is recommended. This reserve has good potential both as a source of seed for revegetation projects, and as a potential starting point for rehabilitation and weed control.

Plate 12: Severe gully erosion on the Capel River.

Invasive weeds have been controlled in the lower part of this section, with isolated occurrences of a few problem species needing control. These include arum lily, bridal creeper, snowflake, snail creeper and double gees. The upper section has some weed problems, notably fig, periwinkle and bridal creeper.

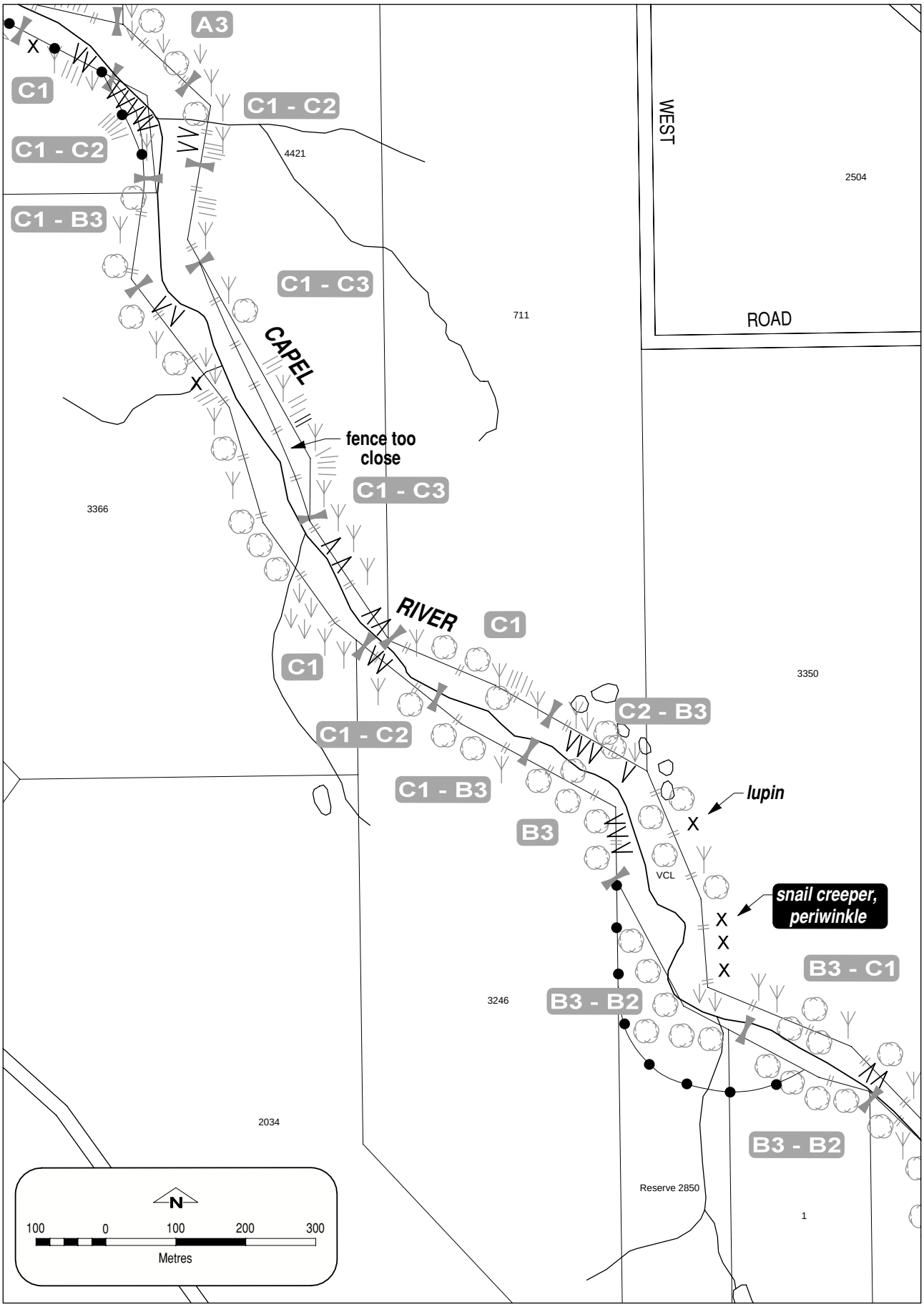
Fruit trees are establishing thickets in the upper reaches of this section. Prompt control is recommended to restrict further spread downstream. In the upper reaches of this section there were some untended orchards. Regular firebreak maintenance and control of weeds within these sites will assist in controlling the spread of weed species in the foreshore reserve.

Map 9

North	South
Lots 4421, 711, 3350	Lots 3366, 3246, Reserve 2850, lot 2432-1

Management and rehabilitation advice to landowners

Issues	Comments	Management Advice
General foreshore condition	Most of the eastern part of this section is in reasonable condition, weeds and scouring more significant on the western foreshore of this section.	
Fencing	Two small sections of fencing recommended on the southern foreshore. Fence too close to river in some areas on northern foreshore. Otherwise all fences in good condition.	Length of fencing recommended: south bank ~ 750 m.
Erosion	Frequent sites of scouring along this section. Also, two small areas of sheet erosion noted on the southern bank. One site of severe gully erosion was recorded.	Refer to Erosion control Chapter 8.3, points 1, 2 and 3 (pages 33 & 34). Seek specialist engineering advice for remediation of gully erosion problem.
Revegetation requirement	Revegetate with understorey species, especially on north banks. In some areas bracken fern has dominated the understorey, to the detriment of regeneration of other native species.	Select species from community type 1 on the riparian fringe & 2 of the floodplain, Table 8.1 (pages 28 & 29). Control bracken fern in areas where regeneration of understorey is restricted.
Weed invasion	Periwinkle, snowdrops and snail creeper.	Refer to Specific weed management advice Chapter 8.1.2 points 4, 14 and 13 (pages 23 & 25).
Other management comments	Good source of seed for revegetation around soaks on reserve 2850.	Complete detailed vegetation survey of vegetation surrounding the soak on reserve 2850.



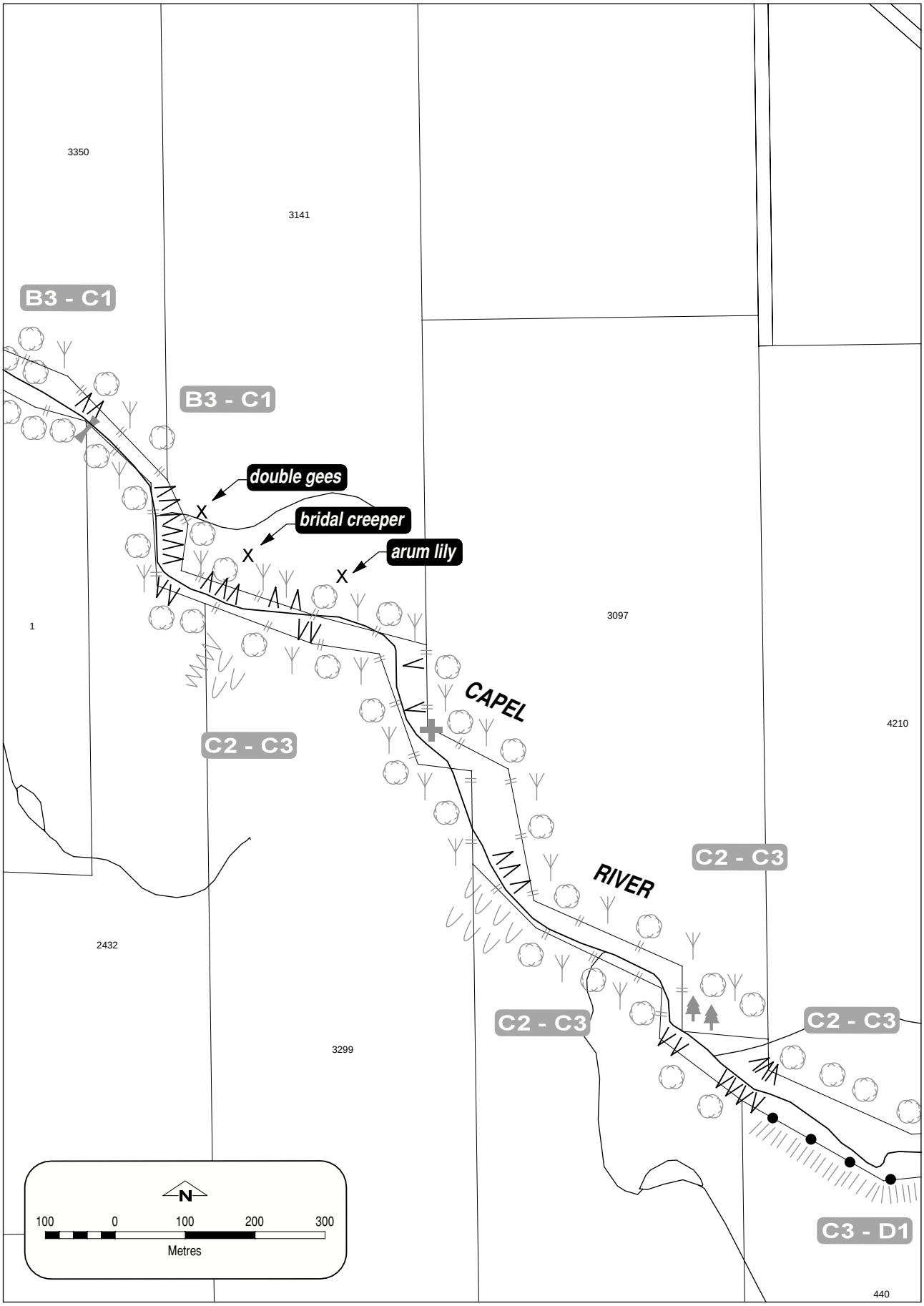
Capel River Map 9

Map 10

North	South
Lots 3350, 3141, 3097, 4210	Lots 2432-1, 2432, 3299, 3096, 440

Management and rehabilitation advice to landowners

Issues	Comments	Management Advice
General foreshore condition	Much of this foreshore was reasonably homogeneous, with the exception of the extremely degraded area on the southeastern foreshore.	
Fencing	A small section of fencing recommended on the southeastern foreshore. Otherwise all fences in good condition.	Length of fencing recommended: south bank ~ 300 m
Erosion	Frequent sites of scouring along this section. Also, two small areas of sheet erosion noted on the southern bank.	Refer to Erosion control Chapter 8.3, points 1 and 2 (page 33).
Revegetation requirement	Encourage revegetation with local species. Bracken dominates understorey in areas where stock have been restricted for some time.	Select species from community type 1 on the riparian fringe & the floodplain, Table 8.1 (page 28). Control bracken fern in areas where regeneration of understorey is restricted.
Weed invasion	Weeds along much of this section well controlled. Bridal creeper, arum lily and double gees in sections on northern banks.	Refer to Specific weed management advice Chapter 8.1.2 points 5, 2 and 9 (pages 23 & 24).
Other management comments	Some restoration/bunding attempted.	



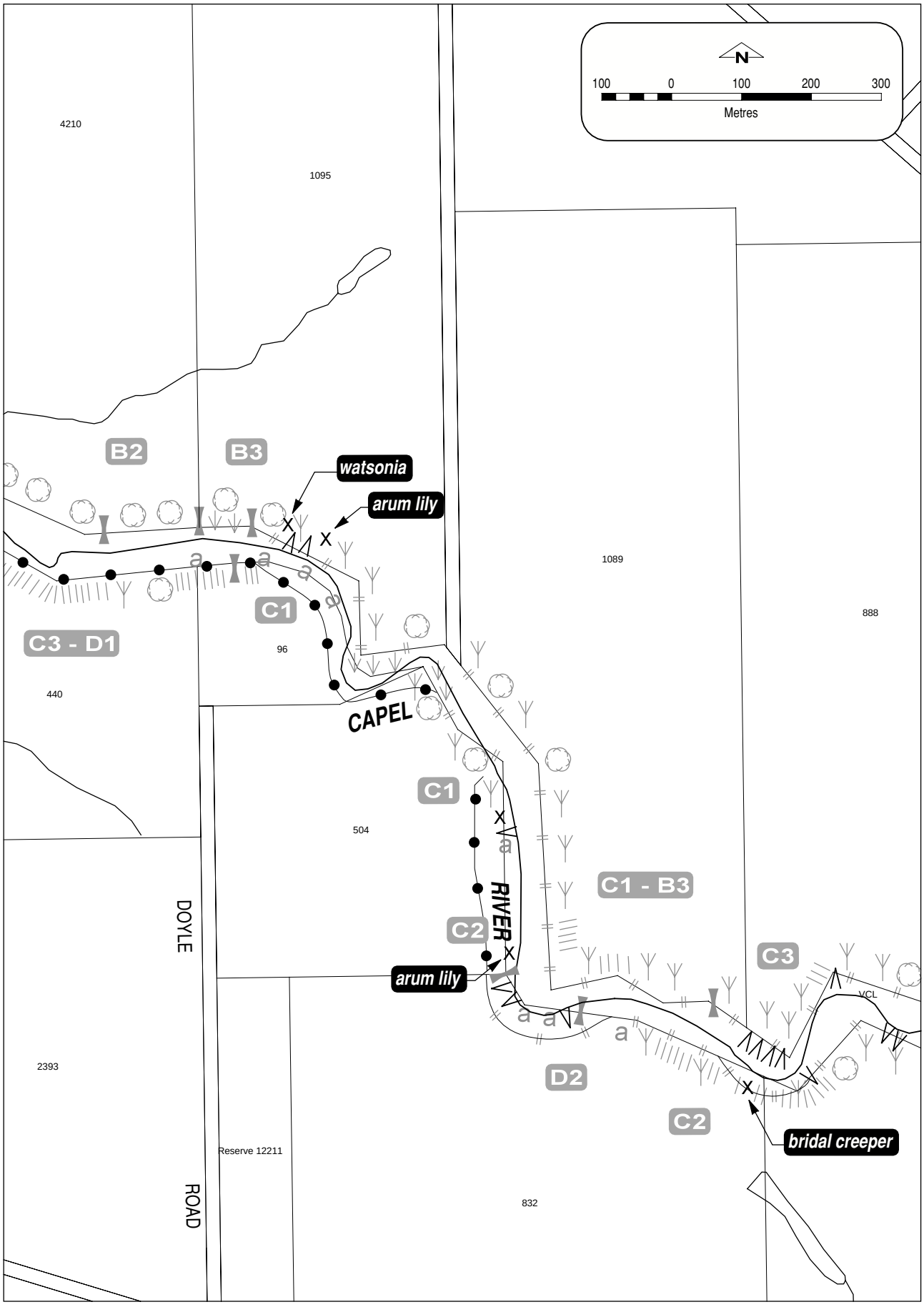
Capel River Map 10

Map 11

North	South
Lots 4210, 1095, 1089, 888	Lots 440, 96, 504, 832, 833

Management and rehabilitation advice to landowners

Issues	Comments	Management Advice
General foreshore condition	Areas in this section are severely degraded.	Action to control stock access is a priority.
Fencing	Fencing to restrict access of livestock recommended on the southwestern foreshore of this section.	Approximately 850 m of fencing is recommended on the south bank of this section.
Erosion	Frequent severe scouring was noted on this section. In some cases this was exacerbated by unrestricted livestock access.	Refer to Erosion control Chapter 8.3, 1 and 2 (page 33), and implement recommendations related to stock access points and fencing.
Revegetation requirement	Some areas in this section require extensive revegetation, others require revegetation of understorey species to increase diversity.	Select species from community type 1 on the riparian fringe & 2 on the floodplain, Table 8.1 (pages 28 - 31).
Weed invasion	Occasional outbreaks of bridal creeper and arum lily in this section.	Refer to Specific weed management advice Chapter 8.1.2 points 2 and 5 (page 23).
Other management comments	Areas rated D1 require priority action.	All management advice with respect to fencing, restoration and revegetation is appropriate. for this section.



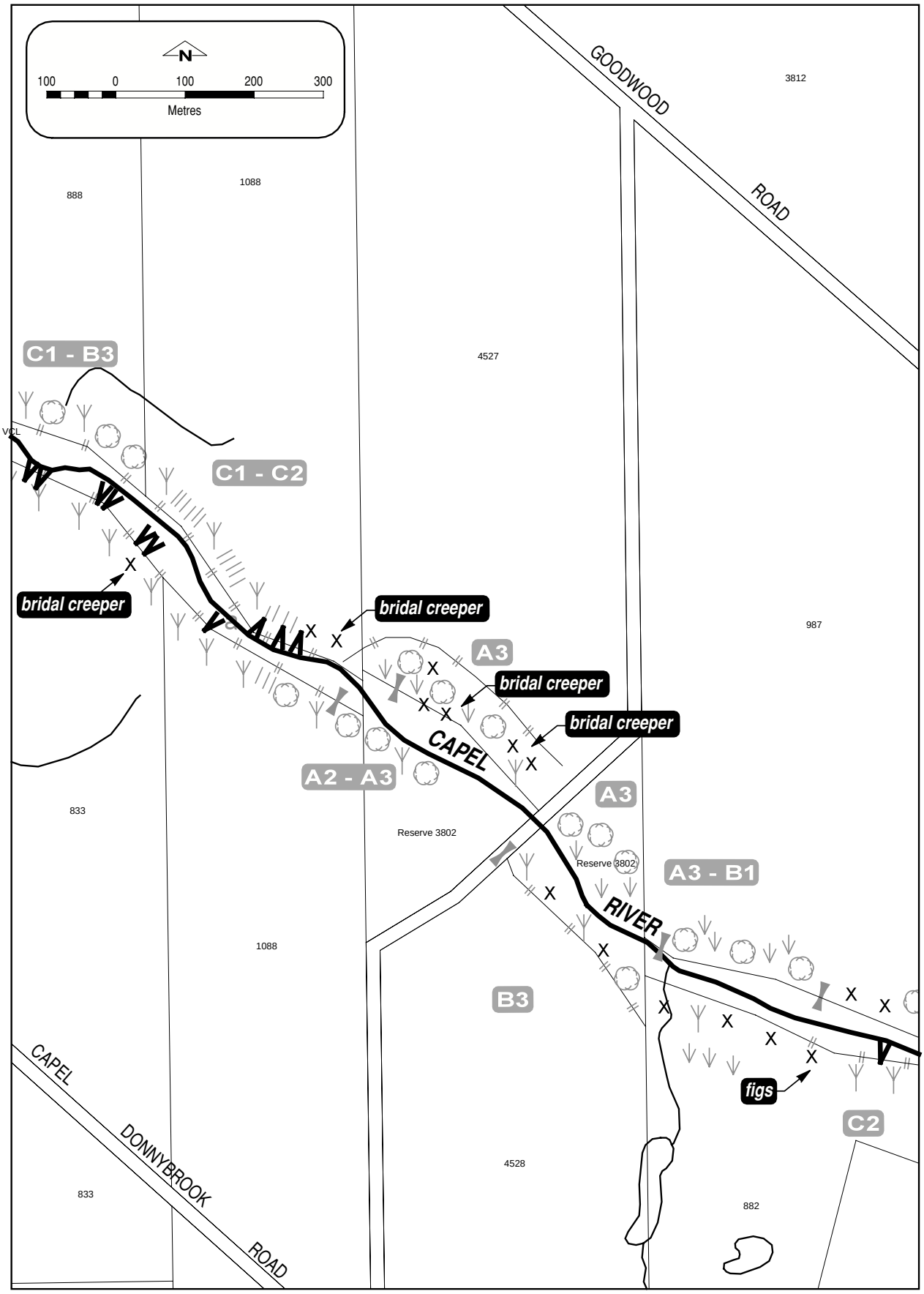
Capel River Map 11

Map 12

North	South
Lots 888, 1088, 4527, Reserve 3802, lot 987	Lots 833, 1088, Reserve 3802, lots 4528, 882

Management and rehabilitation advice to landowners

Issues	Comments	Management Advice
General foreshore condition	Some of the foreshore in this section was in excellent condition (A2-A3).	A comprehensive floristic survey of the vegetation of reserve 3802 is recommended.
Fencing	Some fencing recommended on the southern bank of this section.	Length of fencing recommended: south bank ~ 400 m.
Erosion	Some sites of severe scouring observed at the western end of this section, on both sides of the river.	Refer to Erosion control Chapter 8.3, 1 and 2 (page 33).
Revegetation requirement	Good remnant vegetation remains in areas of this section. Reserve 3802 on the north bank provides an excellent opportunity to act as a starting point for revegetation on both the north and south banks, and also provides a good source of provenance seed for revegetation in other areas.	Select species from community type 1 on the riparian fringe & 2 on the floodplain, Table 8.1. (pages 28 & 29).
Weed invasion	Some arum lily and bridal creeper, occasional Pittosporum and patches of figs found in this section.	Refer to Specific weed management advice Chapter 8.1.2 points 2, 5, 10 and 15 (pages 23 - 25).
Other management comments	Stock access point needs maintenance to limit area of access on foreshore. Reserve 3802 contains good quality remnant vegetation.	Complete a detailed vegetation survey of reserve 3802.



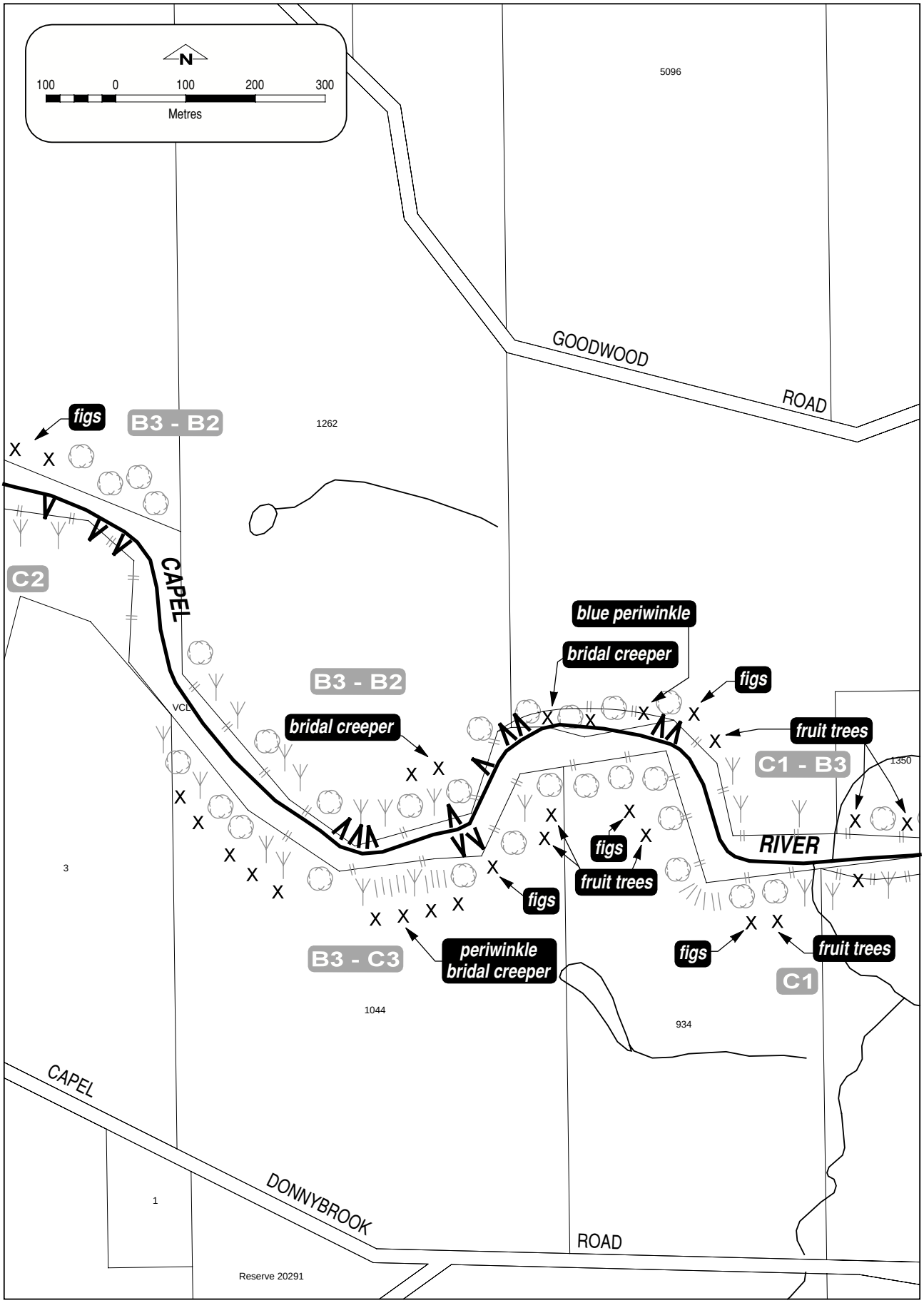
Capel River Map 12

Map 13

North	South
Lots 987, 1262, 933, 1350	Lots 882, 1044, 934, 3239

Management and rehabilitation advice to landowners

Issues	Comments	Management Advice
General foreshore condition	While all of this section has been fenced and the lower section has reasonable vegetation cover, channel erosion remains a notable problem in the upper section and a variety of weed species were also prolific.	
Fencing	N/A	
Erosion	Frequent sites of scouring occurred along this section.	Refer to Erosion control Chapter 8.3, 1 and 2 (page 33).
Revegetation requirement	Some areas in this section require extensive revegetation, others require revegetation of understorey species to increase diversity.	Select species from community type 1 on the riparian fringe & 2 on the floodplain, Table 8.1 (pages 28 & 29).
Weed invasion	Bridal creeper, figs, fruit trees, Pittosporum, periwinkle and snail creeper all found on this section.	Control weeds where possible. Refer to Specific weed management advice Chapter 8.1.2 points 5, 10, 12, 15, 4 and 13 (pages 23 - 25).
Other management comments		



Capel River Map 13

Section 6 - Description:

Lower lot 934 to lower lot 828.

Condition Rating

Map	North Bank	South Bank
14	B3 C1	B2 C1
15	B3 C1	B2 C1
16	B3 C1	B3 C1

This section was characterised by a predominantly closed water channel, i.e. the main river channel was well vegetated with *Agonis linearifolia*. (Plate 6 & page 17). The majority of this section has been well fenced. In most cases where fencing is lacking, the land is used for orchards, hence there are no stock to exclude.

Erosion was not noted as a management concern in this area. This may be related to the land use of the area (i.e. there does not seem to be a history of stock access). The banks of the river were not as steep as some erosion prone areas downstream.

Weeds are the main issue of concern in this section with blackberry and fruit trees the major problem. The weed infestations are particularly bad in the upper stretches of this section.

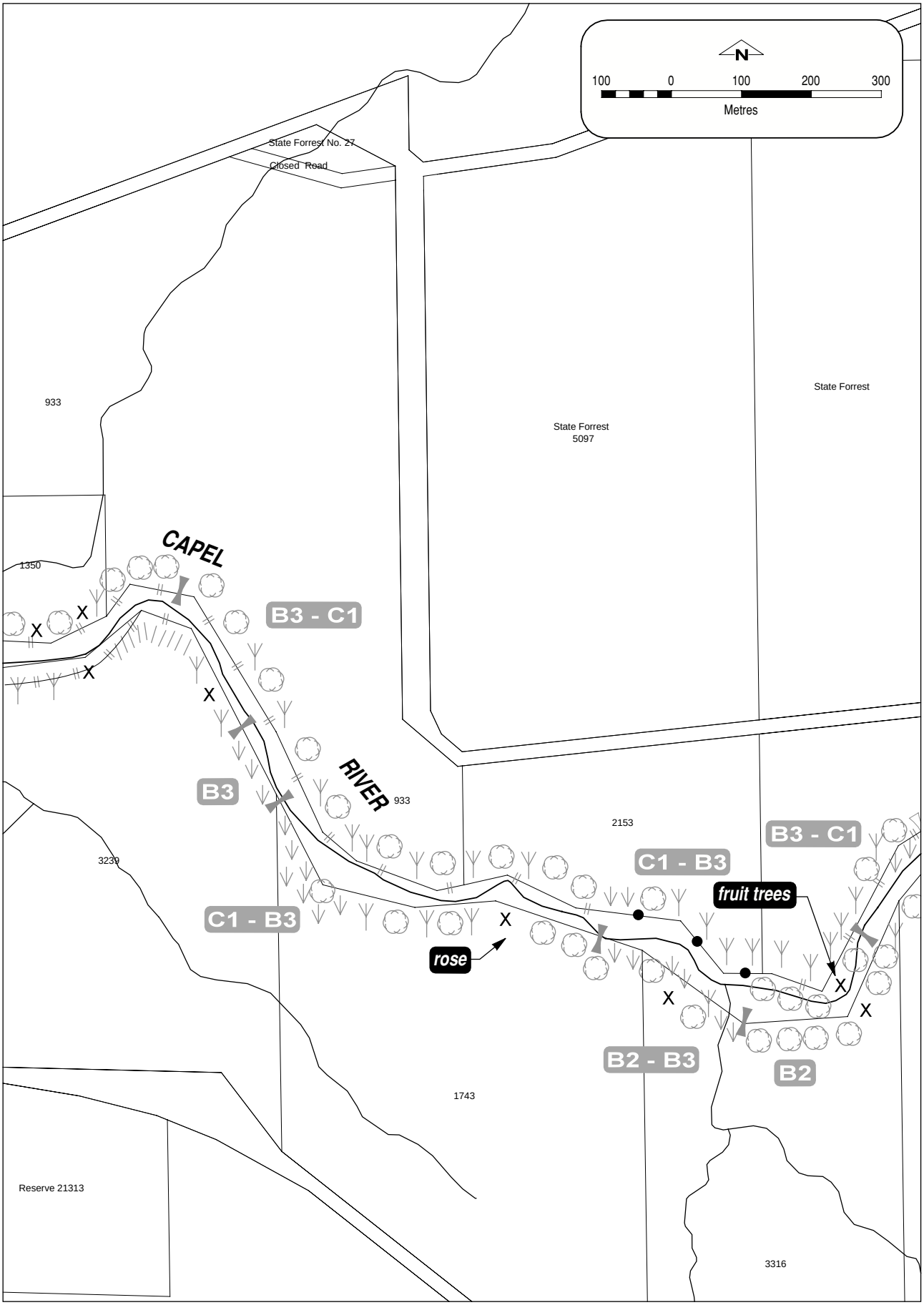
Vegetation type 1 (flooded gum *Eucalytpus rudis* woodland) was prominent on the riparian fringe in this section, while type 2 (marri *Corymbia calophylla,* flooded gum E. rudis forest) was observed in isolated pockets on the valley floor. There were some good pockets of remnant vegetation in this section.

Map 14

North	South
Lots 1350, 933, 2153, 2077	Lots 3239, 1743, 3316

Management and rehabilitation advice to landowners

Issues	Comments	Management Advice
General foreshore condition	Some good areas of remnant vegetation remain on the southeastern foreshore in this section.	N/A
Fencing	Much of this section either fenced or does not require fences due to nature of land use.	Length of fencing recommended 200 m on north bank.
Erosion	N/A	
Revegetation requirement	Revegetation with understorey species would increase diversity and improve vegetation structure in areas on this map. On the south-west section of this map some canopy species could be planted.	Select species from community type 1 on the riparian fringe & 2 on the floodplain, Table 8.1 (pages 28 - 30).
Weed invasion	Fruit trees, wild rose, arum lily, bridal creeper, and cotton bush found on this section.	Control weeds where possible. Refer to Specific weed management advice Chapter 8.1.2 points 12, 19, 2, 5 and 8 (pages 23 - 26).
Other management comments		



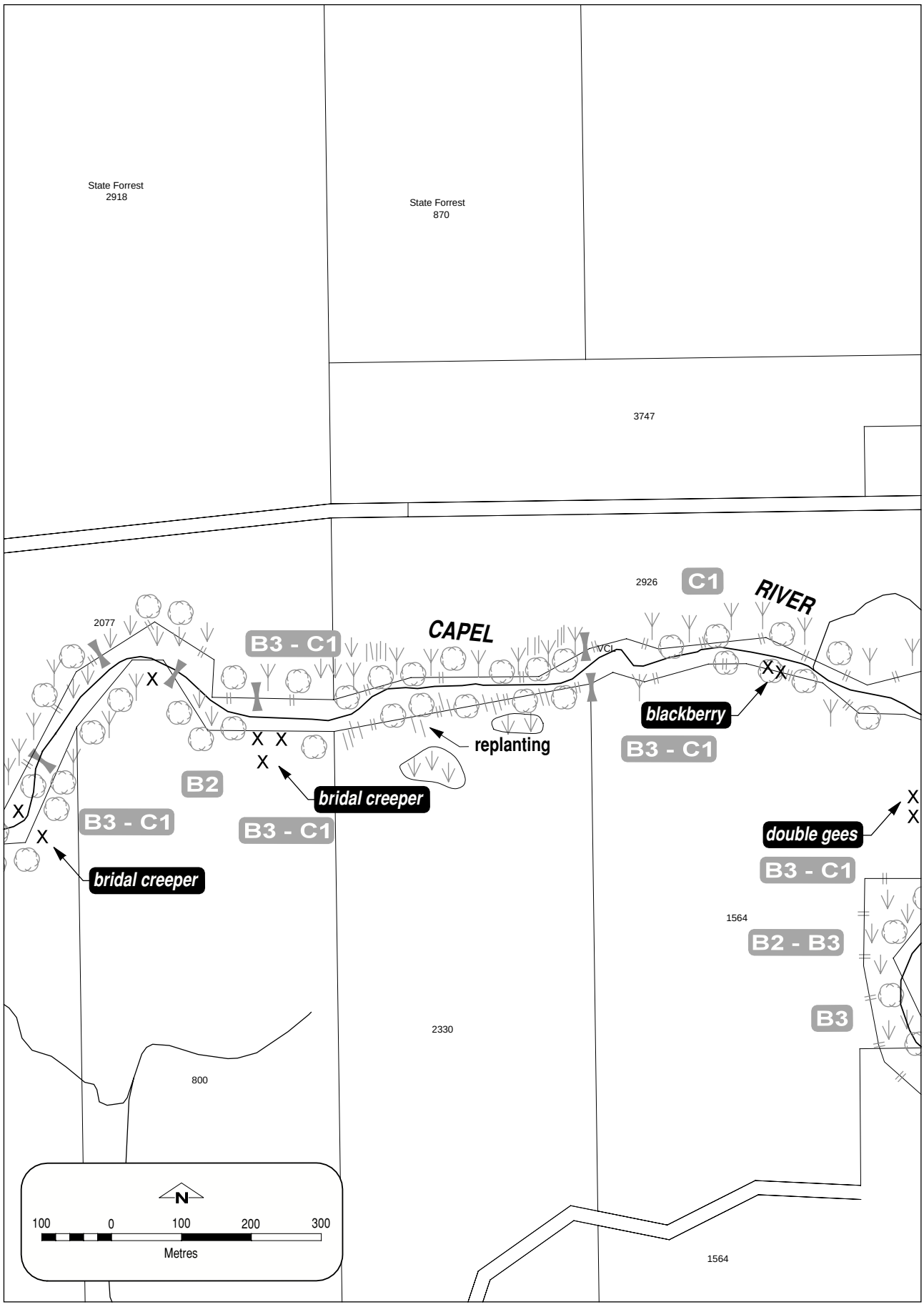
Capel River Map 14

Map 15

North	South
Lots 2077 & 2926	Lots 800, 2330, 1564

Management and rehabilitation advice to landowners

Issues	Comments	Management Advice
General foreshore condition	Some good areas of remnant vegetation remain on the northwestern foreshore in this section.	N/A
Fencing	Only a short section of fencing recommended on the southeastern bank of this section.	Length of fencing recommended ~ 200 m on southern bank.
Erosion	N/A	
Revegetation requirement	Understorey species lack diversity along much of this map.	Revegetate with understorey species, and sedges and rushes. Select species from community type 1 on the riparian fringe & 2 on the floodplain, Table 8.1. (pages 28 & 29)
Weed invasion	Bridal creeper, blackberry and double gees found on this section.	Control weeds where possible. Refer to Specific weed management advice Chapter 8.1.2 points 5, 3, and 9 (pages 23 & 24).
Other management	Previous control of blackberry requires follow-up as regeneration was observed. comments	



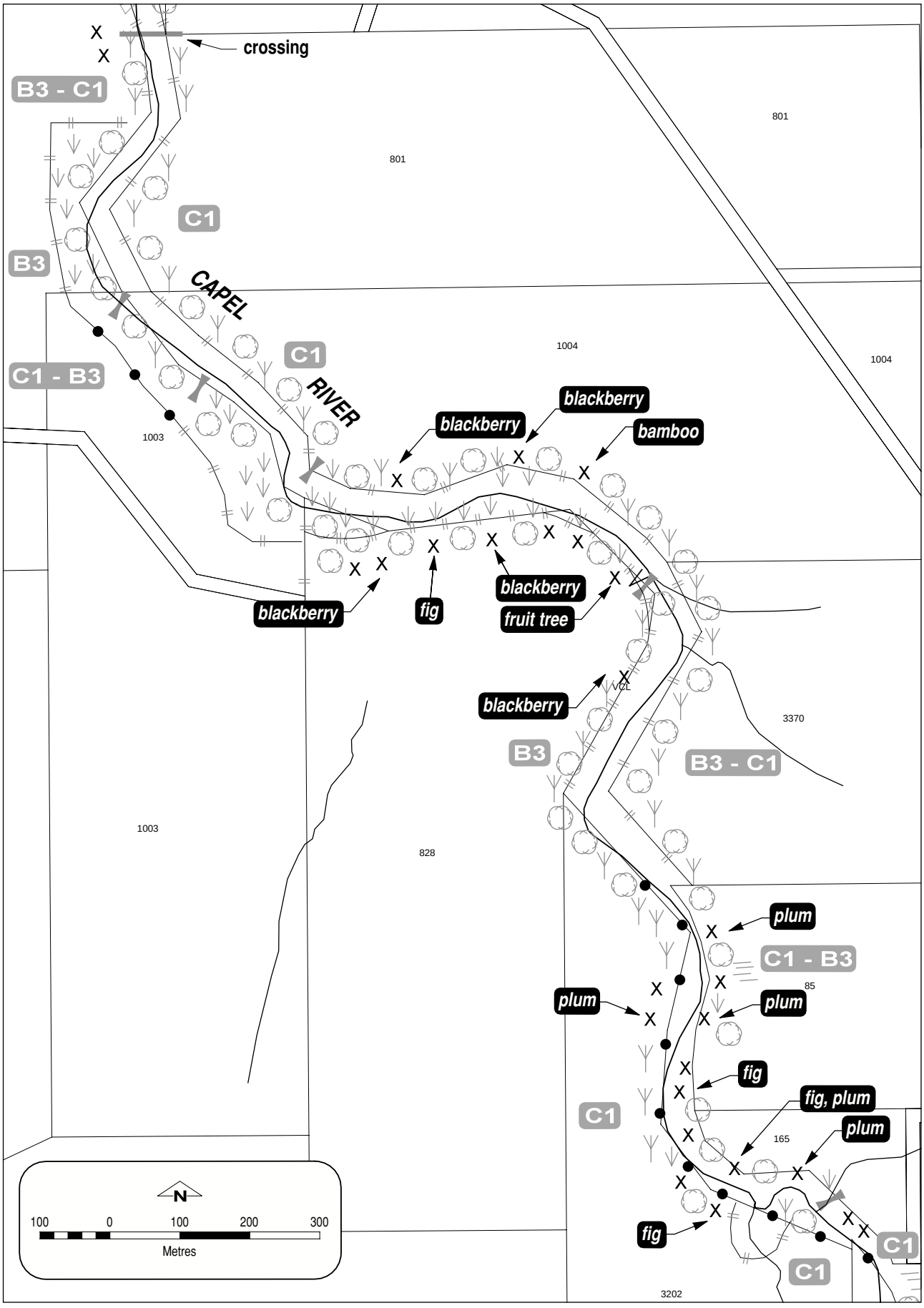
Capel River Map 15

Map 16

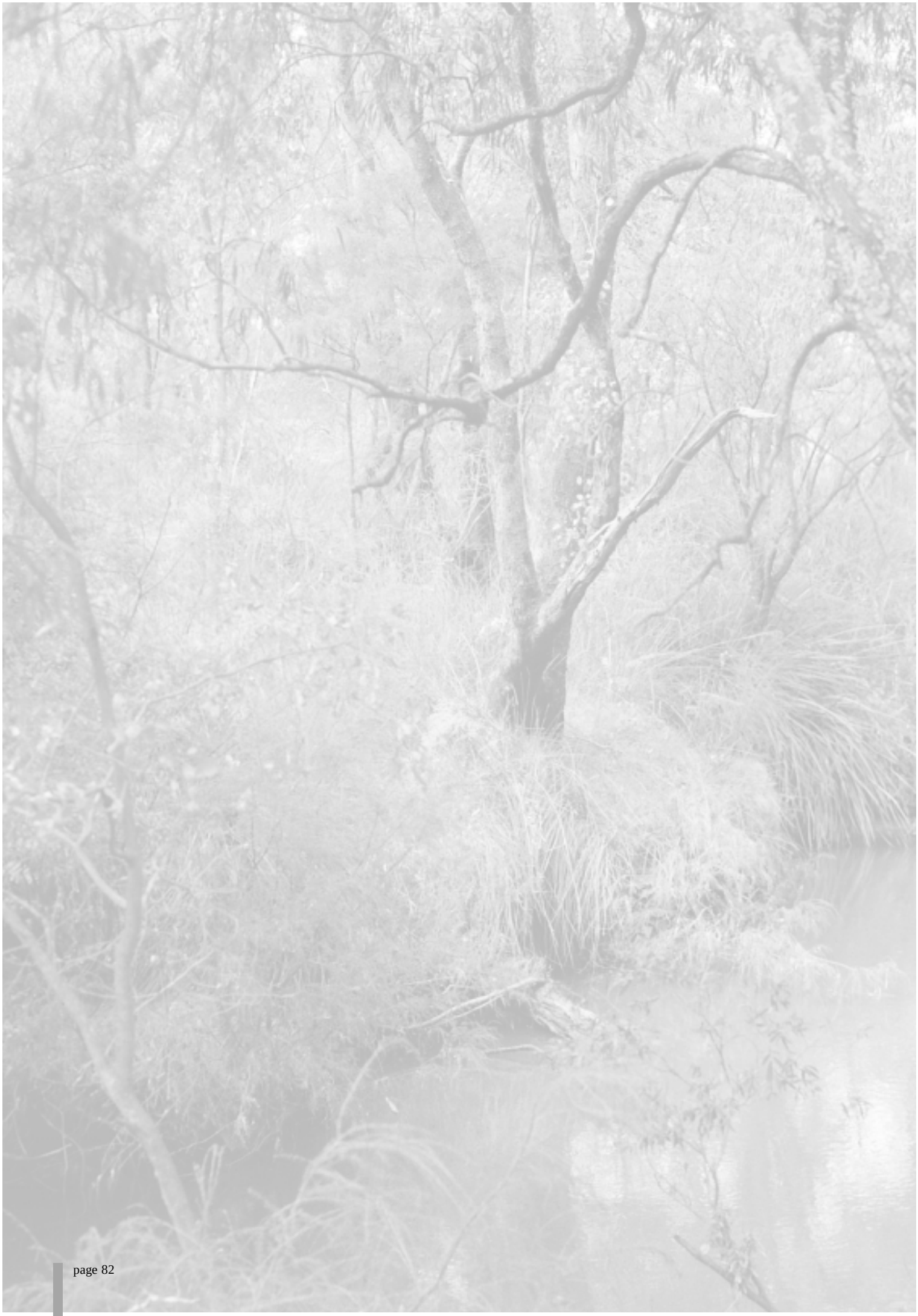
North	South
Lots 801, 1004, 3370, 85, 165	Lots 1003, 828, 3202

Management and rehabilitation advice to landowners

Issues	Comments	Management Advice
General foreshore condition	Riparian vegetation was relatively narrow in this section, though some sections of good understorey were recorded. Weed invasion from fruit trees and blackberry was the primary management concern.	
Fencing	Some fencing required on the southern bank in this section.	Length of fencing recommended: south bank ~ 1150 m.
Erosion	One site of severe scouring was recorded in the middle part of this section.	Refer to Erosion control Chapter 8.3, point 2 (page 33).
Revegetation requirement	Understorey requires revegetation on southern end of this section, in other areas regeneration should occur following weed control	Revegetate with understorey species, and sedges and rushes. Select species from community type 1 on the riparian fringe & 2 on the floodplain, Table 8.1. (pages 28 - 30)
Weed invasion	Blackberry, fig, bamboo and plums all found on this section.	Control weeds where possible. Refer to Specific weed management advice Chapter 8.1.2 points 3, 10, 12, and 20 (pages 23 - 26).
Other management comments	Previous control of blackberry requires follow-up.	



Capel River Map 16



Section 7 - Description:

From lower lot 828 to the Capel Shire boundary.

Condition Rating

Map	North Bank	South Bank
17	C1	C1
18	C1	B3 D1

This section is largely fenced with some reasonable areas of remnant vegetation. Vegetation type 1 (Flooded gum *Eucalyptus rudis* woodland) was prominent on the riparian fringe in this section and type 2 (*Corymbia calophylla*, *E. rudis* forest). However, in many areas the level of disturbance has severely impinged on native vegetation, and diversity is low along much of the foreshore, *Agonis linearifolia* dominating the channel. Fruit trees and blackberry are the main management issues, with a variety of self-seeded fruit trees growing within the river channel and on the foreshore. Control of the fruit trees was attempted recently yet the lack of follow-up treatment has allowed most of the trees to re-sprout. Similarly, blackberry infestation is severe in a few areas, and lack of follow-up treatment has resulted in re-sprouting.

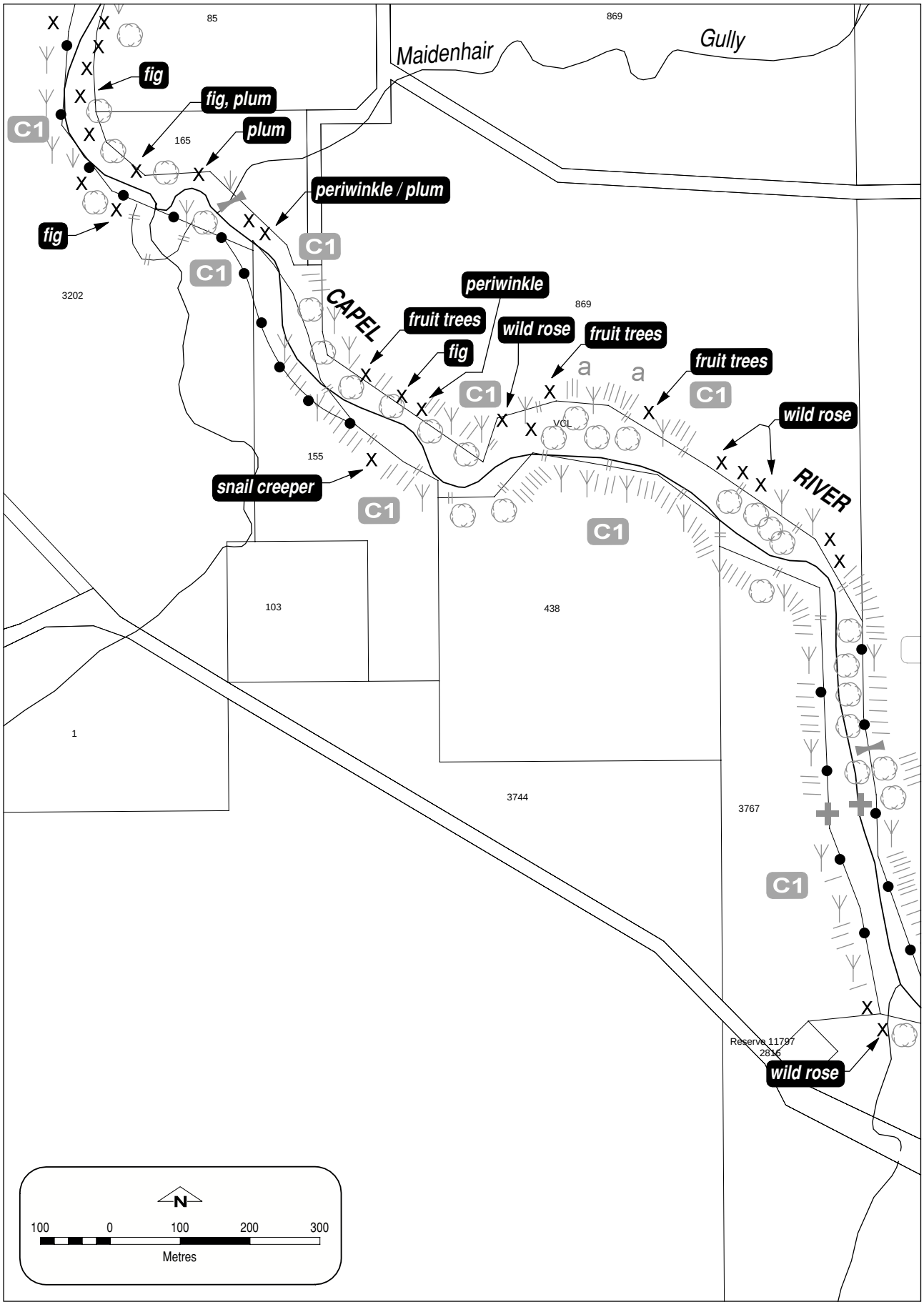
Ironstone Gully Reserve is within this section. Although a large amount of the riparian fringe of this reserve is badly infested with weeds, there is considerable scope for revegetation efforts to be directed at removing these. The reserve is popular, and is one of the few in the area surveyed to have good access from Goodwood Road.

Map 17

North	South
Lots 85,165,869	Lots 3202,155,438,3767,11797

Management and rehabilitation advice to landowners

Issues	Comments	Management Advice
General foreshore condition	Much of the southern bank limited to trees with grassy weeds in the understorey.	
Fencing	The majority of this section was fenced, although stock have access to the river shore at a few properties.	Length of fencing recommended, north bank ~ 1350 m, south bank ~ 450 m.
Erosion	N/A	
Revegetation requirement	Understorey species absent or lacking diversity along much of this section.	Revegetate with understorey species, and sedges and rushes. Select species from community type 1, Table 8.1 (page 28).
Weed invasion	Plum, fig, periwinkle and wild rose.	Refer to Specific weed management advice Chapter 8.1.2 points 12, 10, 4 and 19 (pages 23 - 26).
Other management comments	Fencing only recommended where stock access obviously a problem - much of this section was orchard. Issues which might be relevant to the river include use of chemical sprays. Old stock crossing on lot 3767 has been stabilised	



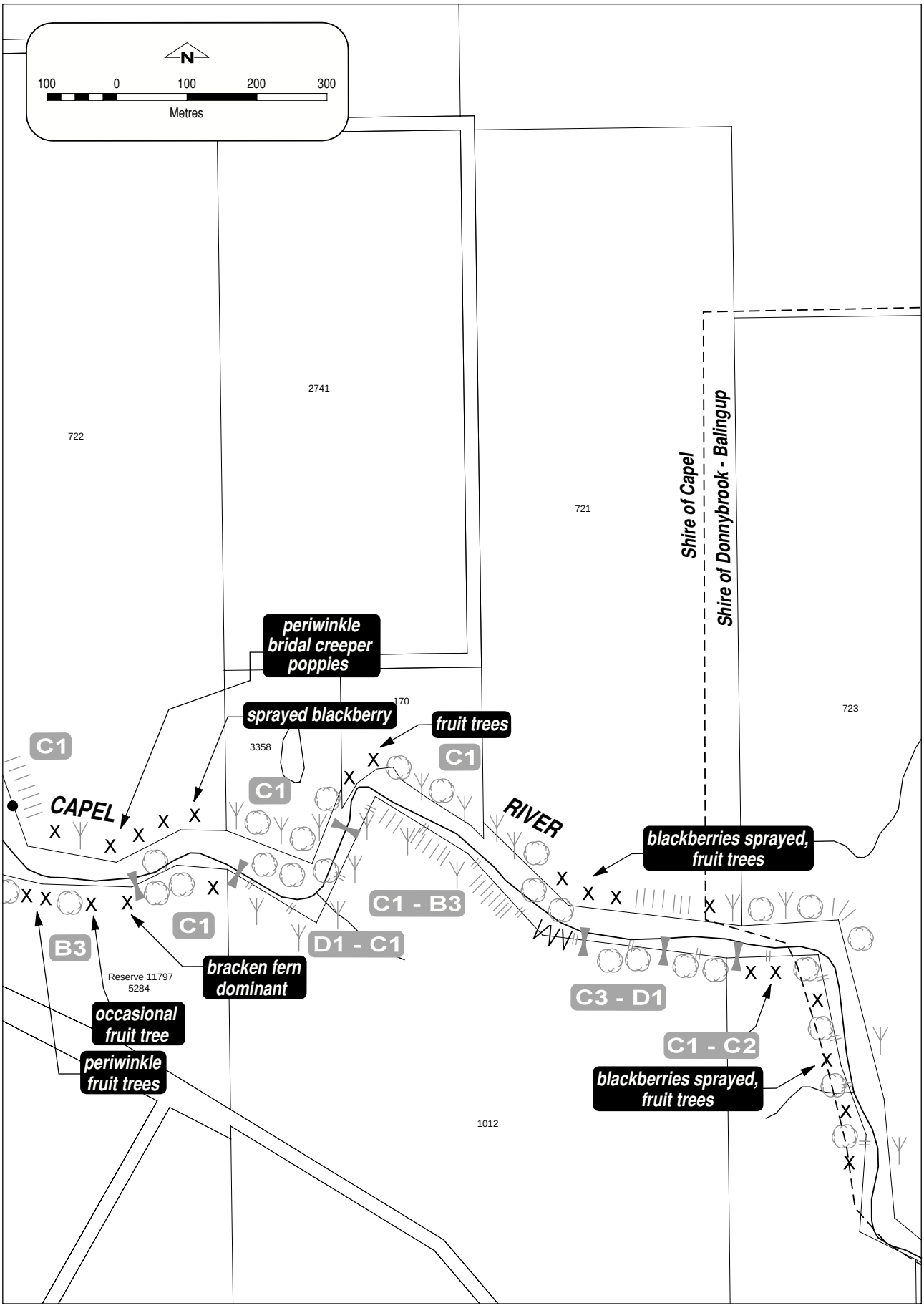
Capel River Map 17

Map 18

North	South
Lots 722, 3358, 170, 721	Reserve 11797, lots 1012 & 829

Management and rehabilitation advice to landowners

Issues	Comments	Management Advice
General foreshore condition	Varying foreshore condition. Weeds and lack of understorey is biggest problem on this stretch.	N/A
Fencing	Most unfenced areas were orchards and stock access minimal.	Fencing of stock access point required to restrict the area of access; ~ 300 m on southern bank.
Erosion	One site of severe scouring was recorded in this section.	Refer to Erosion control Chapter 8.3, point 2 (page 33).
Revegetation requirement	In some areas understorey requires replanting, also transplanting of sedges and rushes. Grassed areas require planting with canopy species.	Reserve 11797 could act as potential seed source for revegetation of this area. Revegetate with understorey species, and sedges and rushes. Select species for from community type 1, Table 8.1 (page 28).
Weed invasion	Fruit trees, blackberry, California poppies and periwinkle all require control in this section.	Refer to Specific weed management advice Chapter 8.1.2 points 12, 3, 6 and 4 (pages 23 - 25).
Other management comments	Some control of blackberry and fruit trees during summer of 1997-98. This requires follow-up for effectiveness.	Bracken will also require control in some areas to allow diverse range of native understorey species to regenerate.



Capel River Map 18

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Appendix A: Reserves on the Capel River

This information is based on the reports of Masters (1995) and Chambers *et al*. (undated) and observations that were made during the field assessment of the foreshore reserves.

Reserve	Comments (Masters & Chambers *et al*.)	Updated comments
3802	Spans both banks of the Capel River, about 12 km south of Capel. Dense cover of marri/flooded gum/peppermint with moderately diverse understorey.	Good example of undisturbed remnant vegetation, amongst the best remnants observed whilst surveying the Capel River foreshore.
8934	South of Austin Rd, Capel, on northern bank of Capel River. Good tree cover with some dense understorey, especially along edge of river. Excellent views of river (Masters, 1995). Level of weed infestation in understorey is high. Valuable resource for recreational use (Chambers *et al*., undated).	Bad weed infestations, including bridal creeper, figs and other invasive species. Could be a significant reserve for restoration due to its proximity to the town centre.
11797	Ironstone Gully Falls, Goodwood Road, Paynedale. High quality bushland with high scenic and recreational value.	Good representation of ironstone riparian community types, although weed infestations on the foreshore are impinging on the remnant native vegetation. Species of note which require control include fruit trees, figs and blackberry.
25516	Recreation reserve off Capel Drive on east bank of Capel River downstream from Capel Bridge. Many large flooded gums to 20 m, but little understorey. Main value is aesthetic value of trees in an urban area.	Understorey badly infested by weeds. This reserve offers a good opportunity for demonstration of rehabilitation techniques due to its location adjacent to the Capel Bridge.
25037	Main Stirling Flats drain running west from the Capel River. Has some dense areas of fringing wetland vegetation. High usage by waterbirds.	Weed infestation is significant, also livestock access an issue. While the drain channel needs to be kept clear we could suggest revegetation of the levy banks to provide habitat/corridor value.
24563	Recreation and camping reserve next to Capel River near the cut. Peppermint woodland with Typha swamp on inland edge. Could form part of a walking trail along the Capel River.	This reserve offers an excellent opportunity to demonstrate rehabilitation techniques on a secondary dune system. In addition it could be a valuable recreational reserve for Capel residents.

Discharge volume

Figures 1 and 2 represent monitoring at the Capel Railway Bridge.

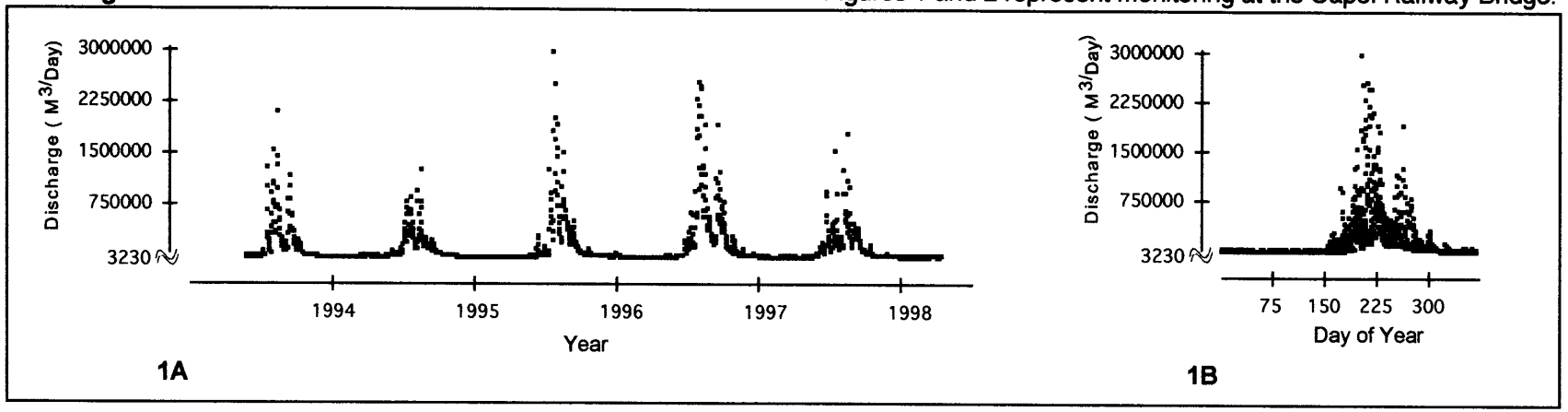

Figure 1A: Capel River discharge (m^3) at the railway bridge between 1994 and 1998.

Figure 1B: Capel River seasonal discharge (m^3).

Conductivity (salinity)

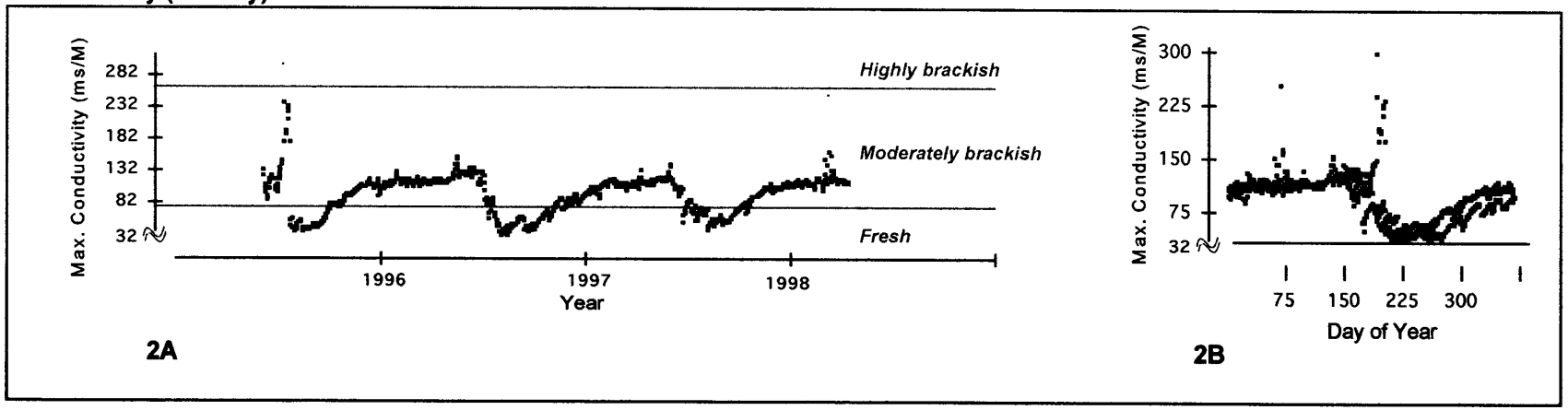

Figure 2B: Capel River maximum conductivity (ms/m) at the railway bridge between 1996 and 1998.

Figure 2B: Capel River seasonal maximum conductivity (ms/m).

pH (acidity or alkalinity)

Figures 3-8 represent monitoring at 2 sites, the Capel Railway Bridge and Yate's Farm.

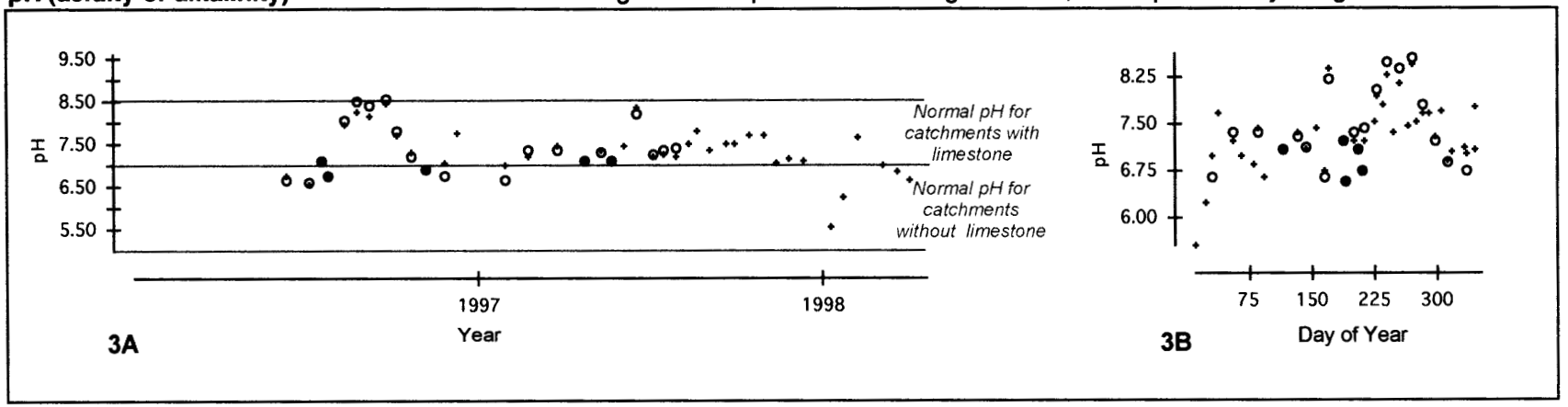

Figure 3A: Capel River pH between 1997 and 1998.
Figure 3B: Capel River seasonal pH.

KEY:
- o **Site 610219 Capel River at Yate's farm**
- \+ **Site 610010 Capel River at the railway bridge**

Turbidity (suspended sediment)

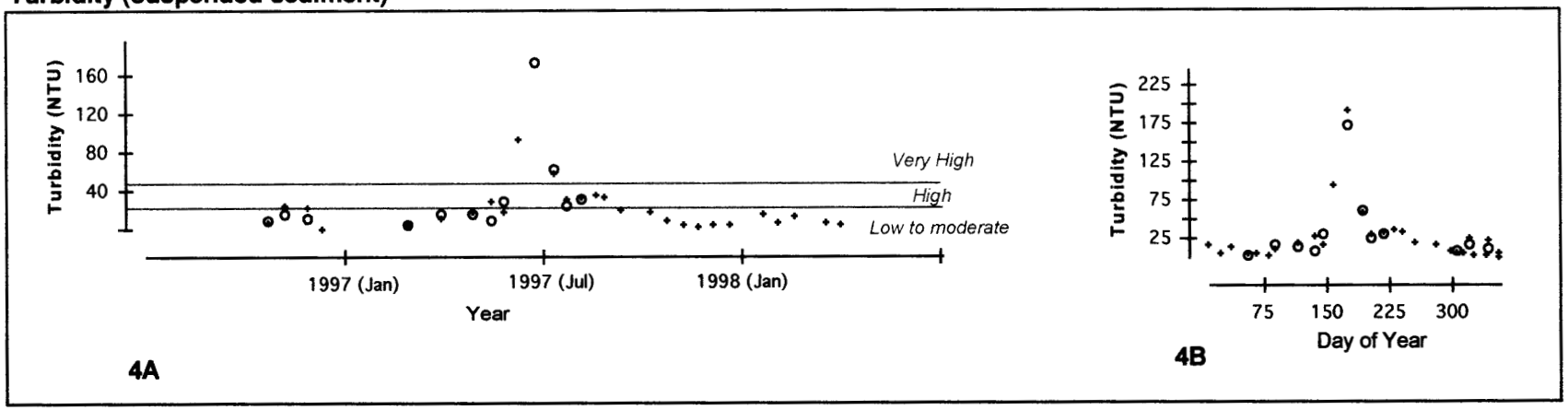

Figure 4A: Capel River turbidity (NTU) between 1997 and 1998.
Figure 4B: Capel River seasonal turbidity (NTU).

KEY:
- o **Site 610219 Capel River at Yate's farm**
- \+ **Site 610010 Capel River at the railway bridge**

Water temperature

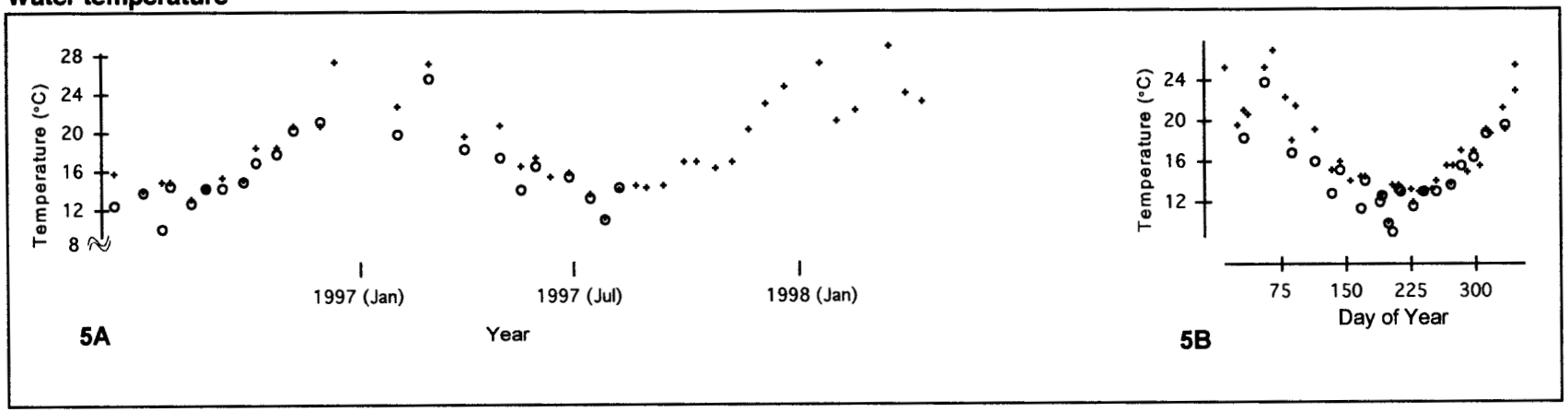

Figure 5A: Capel River temperature (°C)between 1997 and 1998.
Figure 5B: Capel River seasonal temperature (°C).

KEY:
- o **Site 610219 Capel River at Yate's farm**
- \+ **Site 610010 Capel River at the railway bridge**

Total phosphorus

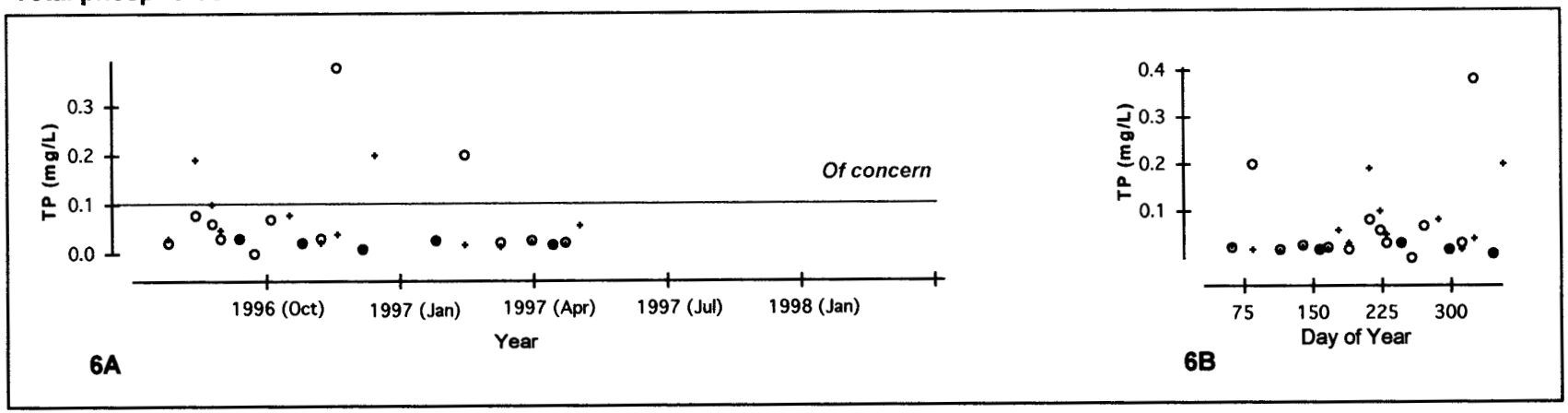

Figure 6A: Capel River total phosphorus (mg/L) between 1997 and 1998.
Figure 6B: Capel River seasonal total phosphorus (mg/L)

KEY:
- o **Site 610219 Capel River at Yate's farm**
- \+ **Site 610010 Capel River at the railway bridge**

Ammonia

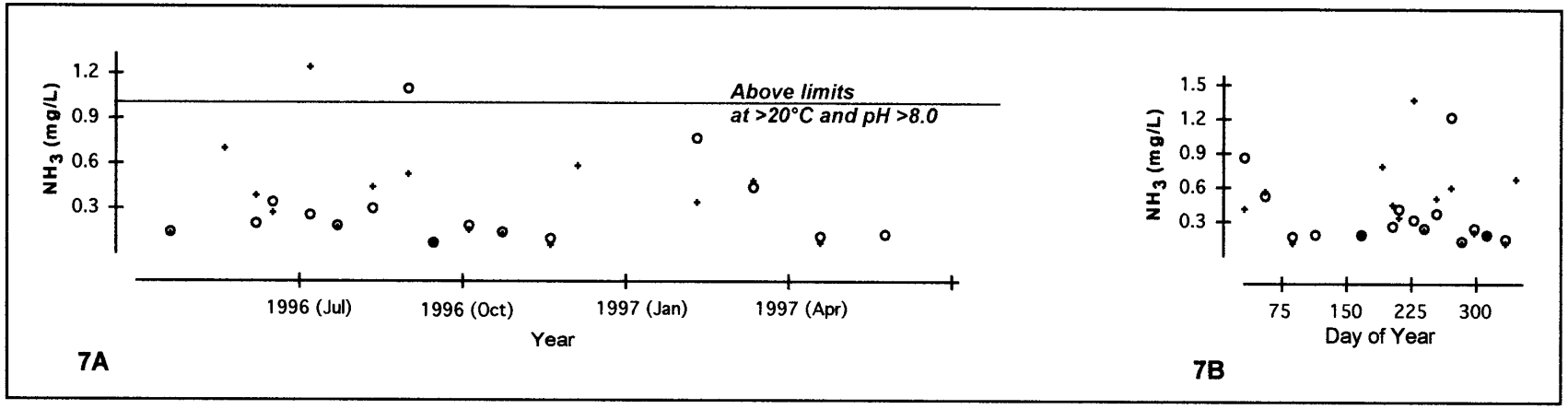

Figure 7A: Capel River ammonia (mg/L) between 1996 and 1997.
Figure 7B: Capel River seasonal ammonia (mg/L)

KEY:
- o **Site 610219 Capel River at Yate's farm**
- \+ **Site 610010 Capel River at the railway bridge**

Total nitrogen

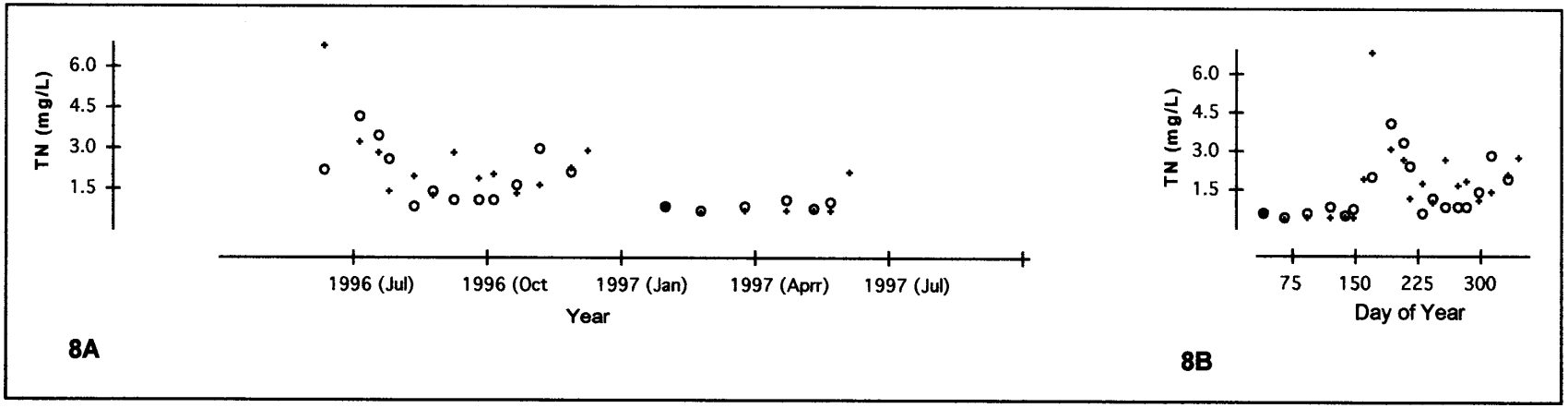

Figure 8A: Capel River total nitrogen (mg/L) between 1996 and 1997.
Figure 8B: Capel River seasonal total nitrogen (mg/L)

KEY:
- o **Site 610219 Capel River at Yate's farm**
- \+ **Site 610010 Capel River at the railway bridge**

Appendix C : Matrix of Vegetation Species, Section and Community Type.

	Section							Community Type			
Species	1	2	3	4	5	6	7	1	2	3	4
Acacia pulchella			*	*	*	*	*	✓	✓	✓	
Acacia urophylla				*	*	*	*		✓		
Adiantum aethiopicum		*	*		*	*	*	✓			
Agonis flexuosa	*	*	*	*	*	*	*		✓	✓	
Agonis linearifolia	*	*	*	*	*	*	*	✓		✓	✓
Anigozanthos viridis	*	*	*	*	*	*	*		✓	✓	
Astartea fascicularis	*	*	*		*	*	*	✓			✓
Banksia seminuda		*	*		*	*	*	✓			
Baumea articulata	*	*	*	*	*	*	*		✓		✓
Bolboschoenus caldwellii	*	*	*	*	*	*	*	✓		✓	✓
Bossiaea rufa		*	*		*	*	*	✓			
Burchardia umbellata	*	*	*	*	*	*	*		✓	✓	
Callistachys lanceolata				*	*	*	*		✓		
Carex appressa		*	*		*	*	*	✓			
Chorizema ilicifolium	*	*	*	*	*	*	*		✓	✓	
Clematis pubescens	*	*	*	*	*	*	*		✓	✓	
Corymbia calophylla	*	*	*	*	*	*	*		✓	✓	
Eucalyptus marginata				*	*	*	*		✓		
Eucalyptus patens		*	*	*	*	*	*	✓	✓		
Eucalyptus rudis	*	*	*	*	*	*	*	✓	✓	✓	✓
Gastrolobium bilobum				*	*	*	*		✓		
Grevillea diversifolia				*	*	*	*		✓		
Hakea lissocarpha				*	*	*	*		✓		
Hardenbergia comptoniana	*	*	*	*	*	*	*		✓	✓	
Isolepis nodosa	*	*	*	*	*	*	*		✓	✓	✓
Juncus pallidus	*	*	*	*	*	*	*		✓	✓	✓
Kennedia coccinea				*	*	*	*		✓		
Lepidosperma effusum	*	*	*	*	*	*	*	✓	✓	✓	
Lepidosperma longitudinale	*	*	*	*	*	*	*		✓		✓
Lepidosperma tetraquetum	*	*	*		*	*	*	✓		✓	
Leucopogon propinquus	*	*	*	*	*	*	*		✓	✓	
Melaleuca preissiana	*	*	*								✓
Melaleuca rhaphiophylla	*	*	*								✓
Mesomelaena stygia				*	*	*	*		✓		
Mirbelia dilatata	*	*	*	*	*	*	*		✓	✓	
Oxylobium lineare				*	*	*	*		✓		
Paraserianthes lophantha				*	*	*	*		✓		
Patersonia occidentalis	*	*	*	*	*	*	*		✓	✓	
Persoonia longifolia				*	*	*	*		✓		
Phyllanthus calycinus				*	*	*	*		✓		
Sollya heterophylla	*	*	*	*	*	*	*		✓	✓	
Tetraria octandra				*	*	*	*		✓		
Trymalium floribundum				*	*	*	*		✓		
Xanthorrhoea preissii				*	*	*	*		✓		

Appendix D: Plant species of the Capel River

✕ - Indicates exotic/weed
DP - Indicates declared plant
PP - Indicates pest plant

Botanical Names	Common Names
Ferns	
ADIANTACEAE	
Adiantum aethiopicum	Common maidenhair fern
DENNSTAEDTIACEAE	
Pteridium aquilinum[1]	Bracken
CYCADS	
Macrozamia reidlei	Zamia palm
Monocotyledons	
ALLIACEAE	
✕ *Allium triquetrum*	Three-cornered garlic
✕ *Allium* sp.	Wild leek
AMARYLLIDACEAE	
✕ *Leucojum aestivum*	Snowflake
ANTHERICACEAE	
Sowerbaea laxiflora	Tassel flower
Thysanotus manglesianus	Twining fringe lily
Chamaescilla corymbosa	
ARACEAE	
✕ *Zantedeschia aethiopica* DP	Arum lily
ASCLEPIADACEAE	
✕ *Gomphocarpus fruticosus* DP	Narrowleaf cotton bush
ASPARAGACEAE	
✕ *Asparagus asparagoides*	Bridal creeper, florists' smilax
ASPHODELACEAE	
✕ *Trachyandra divaricata*	Strapweed, dune onion weed
ASTERACEAE	
✕ *Arctotheca calendula*	Capeweed
✕ *Carthamus* sp. DP	Thistle
COLCHICACEAE	
Burchardia umbellata	Milkmaids
CYPERACEAE	
Baumea articulata	Jointed twig-rush
Baumea juncea	Bare twig-rush
Bolboschoenus caldwellii	Marsh club-rush
Isolepis nodosa	Knotted club-rush
Lepidosperma longitudinale	Common sword-sedge
Lepidosperma tetraquetum	Angle sword-sedge

1 Although bracken is a West Australian native it can be a serious weed, especially in areas where disturbance has allowed it to dominate understorey areas. This is particularly relevant along some of the Capel River foreshore reserve, especially where livestock have had access but are now restricted by fencing.

Lepidosperma effusum	Spreading sword-sedge
Mesomelaena stygia	Semaphore sedge
Tetraria octandra	
HAEMODORACEAE	
Anigozanthos viridis	Swamp kangaroo paw
HYDROCHARITACEAE	
✕ *Vallisneria americana*	Ribbon weed
IRIDACEAE	
✕ *Babiana stricta*	Baboon flower
✕ *Chasmanthe floribunda*	African cornflag
✕ *Freesia* sp.	Freesia
Patersonia occidentalis	Purple flag
✕ *Romulea rosea*	Guilford grass, onion grass
✕ *Watsonia bulbillifera*	Bulbil watsonia
JUNCACEAE	
Juncus pallidus	Pale rush
POACEAE	
✕ *Avena barbata*	Bearded oat
✕ *Briza maxima*	Blowfly grass
✕ *Briza minor*	Shivery grass
✕ *Bromus diandrus*	Brome grass
✕ *Cynodon dactylon*	Couch
✕ *Ehrharta calycina*	Perennial veldt grass
✕ *Ehrharta longiflora*	Annual veldt grass
✕ *Hordeum* spp	Barley grasses
✕ *Lolium* spp	Rye grasses
✕ *Paspalum dilatatum*	Paspalum
✕ *Paspalum distichum (=P. paspaloides)*	Water couch
✕ *Pennisetum clandestinum*	Kikuyu
✕ *Phalaris* sp.	Canary grass
✕ *Poa annua*	Winter grass
✕ *Secale cereale*	Rye
✕ *Stenotaphrum secundatum*	Buffalo grass
✕ *Vulpia myuros*	Silver grass, rat's tail fescue
TYPHACEAE	
✕ *Typha orientalis*	Bulrush, cumbungi
XANTHORRHOEACEAE	
Xanthorrhoea preissii	Balga, blackboy

Dicotyledons

APOCYNACEAE	
✕ *Vinca major*	Blue periwinkle
ASCLEPIADACEAE	
✕ *Gomphocarpus fruticosus* DP	Narrowleaf cotton bush, swan plant
ASTERACEAE	
✕ *Arctotheca calendula*	Capeweed
✕ *Aster* sp.	Starwort
✕ *Carduus* sp.	Thistle
✕ *Crepis* sp.	Hawksbeard
✕ *Hypochaeris radicata*	Flatweed

✕ *Senecio* sp.	Ragwort
BRASSICACEAE	
✕ R*aphanus raphanistrum*	Wild radish
DROSERACEAE	
Drosera sp.	Sundew
EPACRIDACEAE	
Leucopogon propinquis	
EUPHORBIACEAE	
Phyllanthus calycinus	False Boronia
✕ *Ricinus communis*	Castor oil plant
FUMARIACEAE	
✕ *Fumaria capreolata*	White fumitory
GERANIACEAE	
✕ *Pelargonium capitatum*	Rose pelargonium
MALVACEAE	
Malva parviflora	Small flowered mallow
MIMOSACEAE	
Acacia pulchella	Prickly Moses
Acacia urophylla	Tail-leaved Acacia
Paraserianthes lophantha	Cape Leeuwin Wattle
MORACACEAE	
Ficus carica	
Edible fig	
MYRTACEAE	
Agonis flexuosa	Peppermint, Willow myrtle
Agonis linearifolia	Swamp peppermint
Astartea fascicularis	
Eucalyptus (Corymbia) calophylla	Marri
Eucalyptus marginata	Jarrah
Eucalyptus patens	Yarri, blackbutt
Eucalyptus rudis	Moitch, flooded gum
Melaleuca preissiana	Modong, stout paperbark
Melaleuca rhaphiophylla	Freshwater paperbark
OROBANCHE	
✕ *Orobanche minor*	Lesser broomrape
OXALIDACEAE	
✕ *Oxalis pes-caprae* DP	Soursob
PAPAVERACEAE	
✕ *Eschscholzia californica*	Californian poppy
PAPILIONACEAE	
Bossiaea rufa	
Callistachys lanceolata	Wonnich, Native Willow
Chorizema ilicifolium	
Gastrolobium bilobum	Heart-leaf poison
Hardenbergia comptoniana	
Kennedia coccinea	
Mirbelia dilatata	Prickly mirbelia
Oxylobium lineare	River pea
✕ *Phaseolus curricula*	Snail creeper

✕ *Trifolium* spp.	Clovers
✕ *Vicia sativa*	Common vetch
PITTOPSPORACEAE	
Sollya heterophylla	
✕ *Pittosporum undulatum*	Sweet Pittosporum
PLANTAGINACEAE	
✕ *Plantago lanceolata*	Ribwort plantain
POLYGONACEAE	
✕ *Emex australis* DP, PP	Double gee, spiny emex
✕ *Rumex acetosella* PP	Sorrel, sheep's sorrel
✕ *Rumex crispus*	Curled dock
PRIMULACEAE	
✕ *Anagallis arvensis var. caerulea*	Pimpernel
PROTEACEAE	
Banksia seminuda	River banksia
Grevillea diversifolia	Valley Grevillea
Hakea lissocarpha	Honey bush
Persoonia longifolia	Upright snottygobble
RANUNCULACEAE	
Clematis pubescens	
RHAMNACEAE	
Trymalium floribundum	Soap bush
ROSACEAE	
✕ *Eriobotrya japonica*	Loquat
✕ *Prunus* sp.	Plum
✕ *Rosa ?canina*	Dog rose
✕ *Rubus* sp.DP, PP	Blackberry, bramble
SALICACEAE	
✕ *Salix babylonica*	Weeping willow
SOLANEACEAE	
✕ *Solanum nigrum*	Blackberry nightshade
✕ *Solanum linnaeanum* DP, PP	Apple of Sodom

Appendix E: Useful references for vegetation indentification, revegetation and weed control

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LEGEND : CAPEL RIVER MAPS

Symbol	Description
D1 - C1	survey class
	sheet erosion
	gully erosion
	bared streambank
a	access point
	invasive weed infestation
	bank collapse
	site restoration
	existing fencing
	fencing required
	herbaceous and lawn
	dense rush growth
	dense grass only (no understorey) with mature trees
	plantation or non-native trees
	remnant trees - understorey
	section break for survey class

Survey class		Description
A grade foreshore	A1	pristine
	A2	near pristine
	A3	slightly disturbed
B grade foreshore	B1	degraded / weed infested / localised erosion
	B2	degraded / heavily weed infested / some erosion
	B3	degraded / weed dominated / some erosion
C grade foreshore	C1	erosion prone / little foreshore vegetation / weeds
	C2	soil exposed / eroded / weeds
	C3	eroded and subsiding / weeds
D grade foreshore	D1	ditch eroding
	D2	ditch / freely eroding
	D3	drain / weed dominated

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