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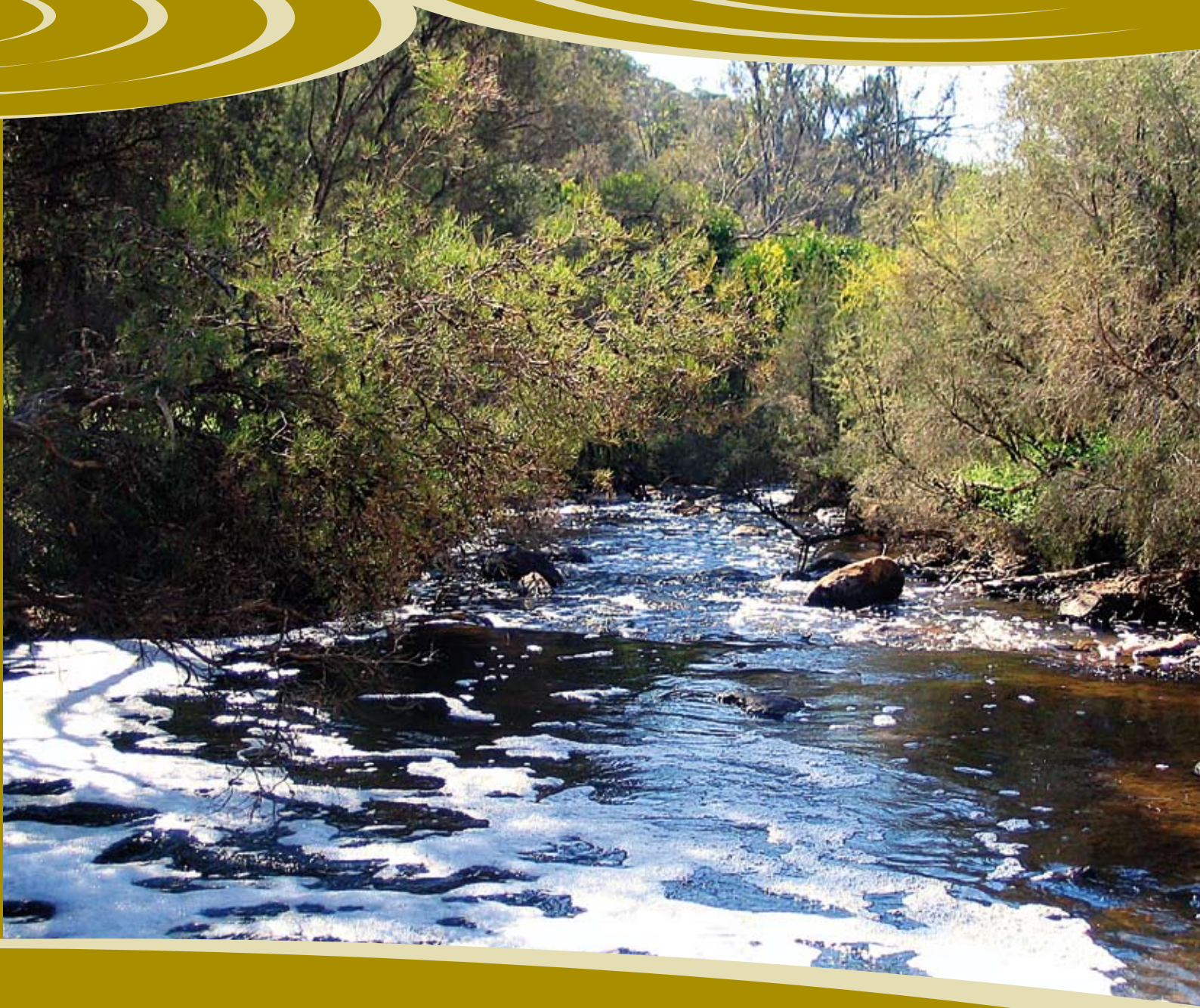

Foreshore and channel assessment of Jimperding Brook

Water resource management series

Report No. WRM 48
February 2008

Department of Water
Government of Western Australia

Foreshore and channel assessment of Jimperding Brook

Prepared by Viv Read & Associates for Department of Water and the Avon Waterways Committee

AVON CATCHMENT COUNCIL

Australian Government

Government of Western Australia

This is an Avon Catchment Council project delivered by the Department of Water and funded with investment from the Australian and Western Australian Governments through the Natural Heritage Trust and the National Action Plan for Salinity and Water Quality

AVON RIVERCARE PROJECT

Department of Water

Water Resource Management Series

Report No. WRM 48

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People who contributed significantly to arranging and participating in the survey were:

- Terry Brooks, Kate Gole and Bernard Kelly (Department of Water, Northam Office)
- Chrystal King (Department of Water, Perth)
- Wayne Clarke (Toodyay Friends of the River)
- Bethan Lloyd (Toodyay Landcare Centre)
- members of the Deepdale Catchment Group.

The project was undertaken by Viv Read & Associates. All photographs were taken by Viv Read unless otherwise stated.

Disclaimer

Cover photograph: Jimperding Brook, courtesy of Chrystal King, Department of Water

Foreword

Jimperding Brook is a significant tributary to the Avon River in the Shire of Toodyay. The purpose of the Foreshore and Channel Assessment was to document the current condition of the waterway through field surveys in consultation with adjacent landholders and the local community.

This survey was undertaken as a part of the Avon Rivercare Project. Previously, surveys and management plans have been prepared as part of this project for the main channel of the Avon River and some of its tributaries. The current focus is to undertake foreshore surveys of major tributaries that flow into the Avon River.

This report documents the methods and results of the foreshore survey for Jimperding Brook undertaken during September, 2006. It provides baseline information to land and waterway managers in the catchment. The report also identifies priorities for management of Jimperding Brook. It is intended that this information will guide, encourage and assist in the planning and management of the river environment.

The survey has shown that Jimperding Brook is in relatively poor condition and in need of management. The Department of Water is able to assist with developing:

- appropriate principles for waterway management relevant to the brook
- a set of management actions that will enable the waterway to recover to a condition that provides environmental, social and economic benefits to those living alongside, to the local community and to others downstream.

This is an Avon Catchment Council project delivered by the Department of Water and funded with investment from the State and Australian Governments through the Natural Heritage Trust and the National Action Plan for Salinity and Water Quality.

This project is part of the Avon Rivercare Project, delivered through the Avon Natural Diversity Alliance (ANDA), incorporating the Department of Water, the Department of Environment and Conservation, Greening Australia WA and World Wildlife Fund Australia.

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Summary

Jimperding Brook is a tributary of the Avon River and is located primarily in the Shire of Toodyay although the top end flows from the Shire of Northam. A foreshore and channel condition assessment was undertaken to provide baseline information for waterway management. The walking survey was undertaken during September, 2006. Survey information was based on 26 sections where each section was identified on the basis of being a unit of consistent management (i.e. a paddock or a small-scale farm).

The length of Jimperding Brook was measured as 19.75 km although the actual length of stream channel, considering meanders, was estimated to be 25.7 km.

The brook was found to have distinctive characteristics:

- The channel descended 150 metres over its length at an average gradient of 0.78 per cent.
- There were 62 tributaries, including 10 major tributaries. These were 'second-order' streams with a gradient range of between 1.2 per cent and 6.5 per cent.
- The waterway was primarily a single channel, with small sections where it is braided.
- There were identified anabranches; however, there was no consistent floodway formation within the floodplain.
- The channel width was generally less than 10 metres upstream of and greater than 10 metres downstream from Salt Valley Road. The channel depth with base flow was generally less than one metre and commonly less than 0.30 metres.
- Some sections had a highly sinuous meander pattern.
- Four deep pools were identified, although they were relatively small.
- Natural cobblestone riffles were common, particularly downstream from Toodyay Road.
- Naturally occurring fringing and floodplain vegetation was dominated by flooded gum *(Eucalyptus rudis).* Wandoo (*Eucalyptus wandoo)* commonly occurred while swamp paperbark *(Melaleuca rhaphiophylla)* occurred commonly downstream from Salt Valley Road but not upstream of it.
- Middlestorey and understorey species were mostly absent from the riparian vegetation community structure.
- Only one section was considered to be in a near-natural condition while all other sections have been substantially altered.

The condition of Jimperding Brook was generally assessed as being poor, due to:

- A high level of active bank erosion, especially where there were meanders without fringing vegetation, where stock have had access to the waterway or where there was the compounding impact of salinity.
- Very significant gully erosion in one section with the potential for this to progress upstream. Gully erosion was also occurring at the confluence of some major tributaries.
- A significant discrepancy between the high level of channel erosion and low levels of sediment deposition, which indicated that most eroded sediments were transported to the Avon River suspended in stream flow.
- A relatively high level of phosphorus in stream flow.
- Regeneration of natural vegetation being restricted by stock grazing.
- No fringing or floodplain vegetation in two sections.
- Jarrah Leaf Miner affecting (at the time of the survey) the foliage of flooded gum (*Eucalyptus rudis)* near and downstream from Toodyay Road. While it was expected that these trees would recover from this attack, it was regarded as a compounding environmental threat.
- A high level of agricultural and environmental weeds in the riparian zone.
- Spiny rush (*Juncus acutus*) and bulrush (*Typha* spp.) occurring in many sections, often in small numbers. These are significant environmental weeds regarded as having the potential to increase significantly without pre-emptive management.
- Only 10.8 per cent of the brook having good stock-proof fencing on both sides. An additional 26.5 km of fencing was regarded as being needed for the brook to have at least moderate fencing condition on both sides.
- Eight of the 10 major tributaries not being fenced near their confluence with Jimperding Brook.

An overall stream environmental rating for Jimperding Brook showed a range from ‘very poor’ to ‘excellent’. Most sections were poor or moderate at best.

Despite the relatively poor channel condition and environmental health of Jimperding Brook, it was expected that the riparian zone would recover with management, particularly fencing and weed control. There were sections that demonstrated this capacity. There was a further priority to control gully erosion where it occurred and to reduce the impact of salinity on the riparian zone.

Future management for waterway recovery was required to improve environmental and social values of Jimperding Brook and to control erosion processes that were contributing to downstream sedimentation of the Avon and Swan rivers.

Introduction

The Avon River and its many tributaries have changed significantly since the time of early European settlement in Western Australia. Clearing natural vegetation from the landscape for agriculture has caused increased surface water run-off, soil loss and salinity. In addition, the channel of the Avon River was substantially altered from the late 1950s to the early 1970s to reduce the impact of flooding in towns and on farms. Known as the River Training Scheme, this contributed to massive sedimentation problems. These and other pressures have continued to affect the waterways of the Avon in many ways.

Coordinated management of the Avon River system commenced as a result of concern by local communities and local government about the declining health of the river system during the 1980s. The pools were filling with sediment, water quality was declining, riparian vegetation was diminishing and native fauna habitat was being lost from the river environment. Those who lived along the river and its tributaries lamented the loss of social values as pools became unsuitable for summer swimming. There were also economic costs with river water being no longer suitable for stock, and in some cases, irrigated orchards. It was clear to all involved that the river was changing for the worse, but little was known about it.

Support for river management was provided by government through a range of organisational structures. Processes were arranged to address community concerns and to adopt a catchment-based approach to managing the river system. These processes were based substantially on developing an understanding of hydrology and ecological components of the river and its tributaries.

In 1996, a systematic survey (Ecoscape and Jim Davies & Associates, 1996) was undertaken of the main channel of the Avon River extending from the Avon Valley National Park in the Shire of Toodyay 190 km upstream to the Yenyening Lakes in the Shires of Beverley and Brookton. This provided a substantial set of information about the condition of the river and the needs for management. In response, River Recovery Plans were prepared by the Department of Water (DoW) in consultation with local communities for the various river sections of the main channel of the Avon River during the period 1995–2007. Funds were allocated to priority river works according to these plans. For example, most of the river has been fenced both sides with costs shared between landholders adjacent to the river and government.

There has been a new focus on arranging management for tributaries of the Avon River in a similar way. Foreshore and channel assessment surveys have been completed for three branches of the Mortlock River, the Dale River, Talbot Brook, the Upper Avon, the Mackie River, Spencers Brook and Toodyay Brook – all significant tributaries of the main river system.

The foreshore and channel assessment for Jimperding Brook continued the process of systematic survey for coordinated management. This report provides information about the waterway as recorded from the survey.

Objectives of the survey

The foreshore and channel assessment provides information about the condition of the waterway and associated landscapes, particularly in relation to management needs. It is baseline information collected in a way that will enable future assessment of change in the condition of the waterway, either in response to management action or through on-going environmental decline.

Objectives of the assessment:

1 Identify the current environmental condition of Jimperding Brook.

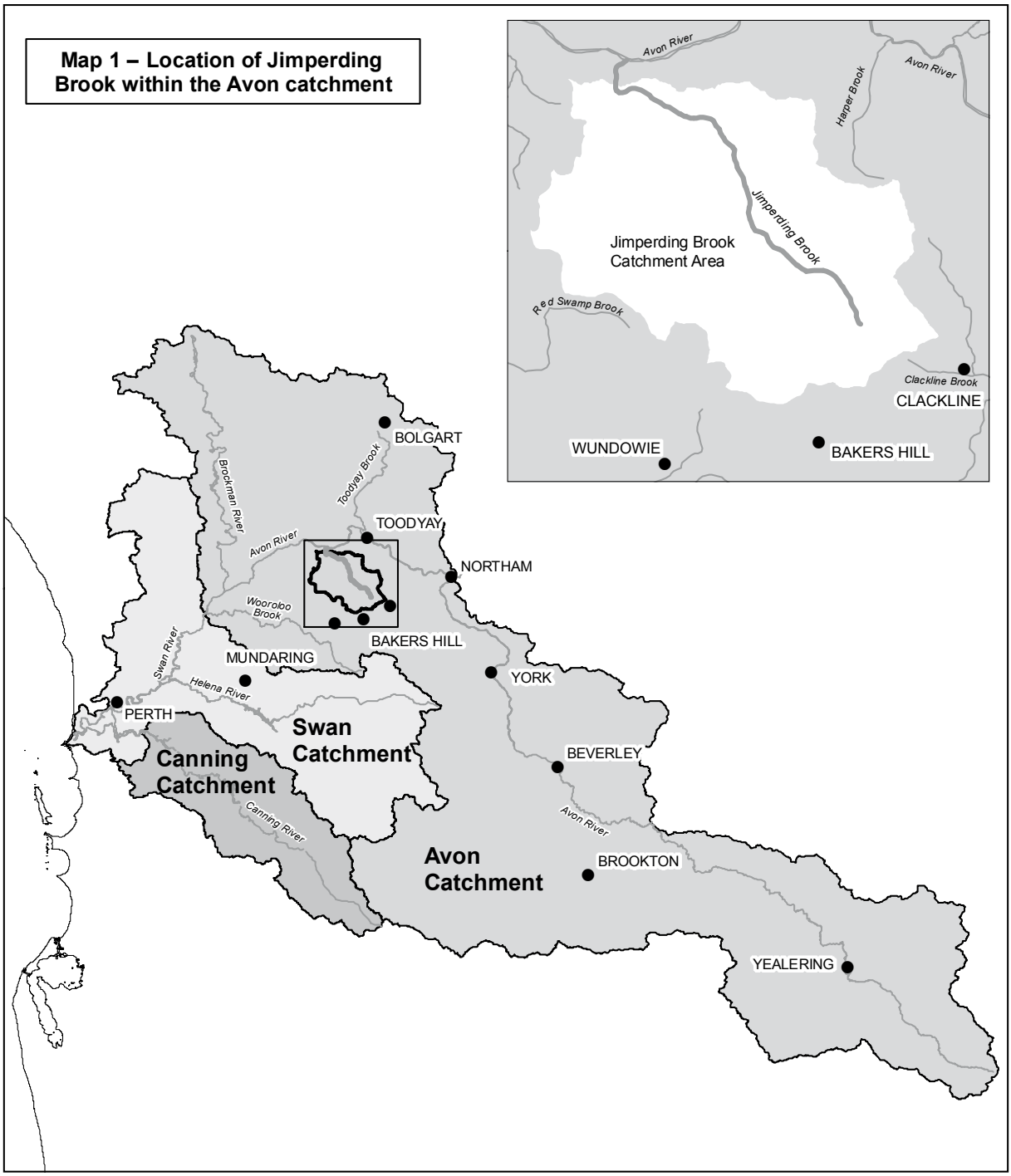
2 Provide an information database that enables:
   a. comparison of the condition of Jimperding Brook with other waterways
   b. measures of change in the condition of Jimperding Brook over time.

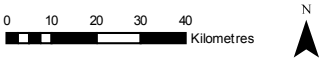
3 Identify the effect of the changing condition of Jimperding Brook on the Avon River.

4 Provide information required for waterways management and river recovery planning.

5 Engage landholder/manager interest in making informed decisions for waterways management.

The foreshore and channel assessment was undertaken in September 2006.





SOURCES

DoW acknowledges the following datasets and their Custodians in the production of this map:

Jimperding Brook Catchment - DOE - 11/05
Towns - DLI - 08/04
Hydrography, Linear (heirarchy) - DOE - 04/05
Hydrography Catchment - DOE - 03/05

Legend

- Towns
- Watercourses
- Jimperding Brook
- Canning Catchment
- Avon Catchment
- Swan Catchment
- Jimperding Brook Catchment Boundary

Datum and Projection Information

Vertical Datum: AHD
Horizontal Datum: GDA 94
Projection: MGA Zone 50

Project Information

Requestee: Terry Brooks
Map Author: Fang Yan
Task ID:6648
Filename J:\RS\SN\96209\0004
Date: 18th June 2007

Department of Water
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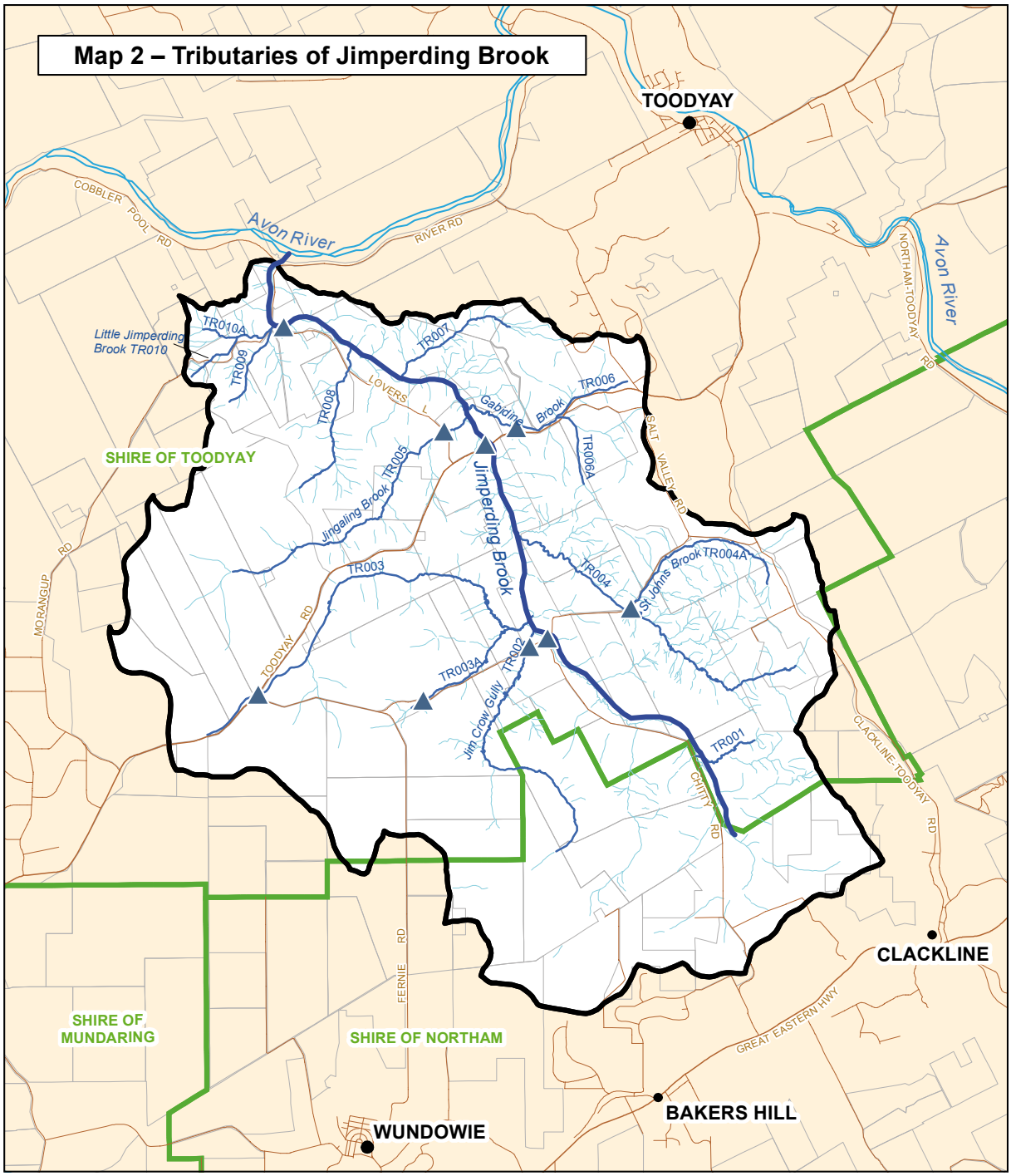

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Hydrography, Linear (heirarchy) - DOE - 04/05
Local Goverment Authorities - DLA - 12/06
Roads - DLI - 06/04
Cadastre - DLI - 12/06
Jimperding Brook Monitoring Project Site - Bloom, L., Clarke, W. and Judd, S. - 2002

Legend

- Towns
- Local Roads
- Avon River
- Minor Tributaries
- Main Tributaries
- Jimperding Brook
- Cadastre
- Local Government Authorities
- Jimperding Brook catchment boundary
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Description of Jimperding Brook

Location, land use and tenure

Jimperding Brook is located approximately 10 km south-west of the town of Toodyay and 80 km north-east of Perth. The waterway flows from minor tributaries near Bakers Hill (in the Shire of Northam) in a north-westerly orientation to the Avon River. Other towns close to Jimperding Brook include Toodyay, Clackline and Wundowie, while the main business centre of Northam is 20 km to the east (See Map 1).

Most land adjacent to Jimperding Brook is privately owned. There is one relatively small area of public land associated with the rail transport corridor near the confluence with the Avon River. The current owners of land and their respective Location Numbers are listed in Appendix 1.

The larger land holdings were used for agriculture at the time of survey. Some of the smaller holdings were rural lifestyle blocks.

Commercial sand and clay extraction occurred on one private property and there was a sandstone quarry on another.

There were five major road or rail crossings over the main channel of Jimperding Brook. The inter-state rail bridge crossed the brook near its confluence with the Avon River with the crossing for Cobbler Pool Road very close to the rail bridge. Lovers Lane forded the Brook 1.5 km from the confluence and Toodyay Road crossed a further 6.5 km upstream. The Salt Valley Road crossing was a further 4.5 km upstream.

The Morangup Nature Reserve and the Clackline Nature Reserve have been designated for the purpose of conservation of flora and fauna within the Jimperding Brook catchment although they are not directly connected to the main waterway.

Catchment description

The Jimperding Brook catchment (Map 1) is an area of approximately 18 000 ha.

Natural vegetation

Most land has been cleared for agriculture although there were significant areas of natural vegetation on private and public land. Locations 6 and 11 both had significant areas of privately owned remnant vegetation adjacent to the brook. Otherwise, the waterway had generally sparse riparian vegetation.

The natural vegetation communities have been described broadly in the *Native Vegetation Handbook for the Shire of Toodyay* (Agriculture WA, 1999).

Climate

The climate for Bakers Hill was considered to be representative of the catchment. The Bureau of Meteorology records (Bureau of Meteorology 2006, Western Australian Climate Averages (online), available <www.bom.gov.au> accessed September 2006) show the average annual rainfall to be 595 mm with an average of 96 rain days each year. Of this, 454 mm (76.2%) occurs during the May-September period. Highest rainfall is during June and July. On average, there are three days each year when temperatures are lower that 2˚C and 26 days when temperatures are greater than 36˚C. Average daily evaporation is 5.6 mm.

Landform and soils

Jimperding Brook drains through a well-dissected landscape described as the Darling Range Zone (Lantzke and Fulton, 1992). High in the catchment, the landscape was of undulating lateritic plateau with narrow swampy valley floors (the *Yalanbee* landscape unit). This was extensive south and west of the main channel of the waterway. The dissected plateau graded down slope to steep irregular hills with red and brownish soils associated with bedrock outcrop (the *Michibin* landscape unit) and relatively steep gravely slopes with duplex profile soils (the *Leaver* landscape unit).

The landscape differed north and east of the main channel where there were extensive areas of bare rock and steep slopes (the *Steep Rocky Hills* landscape unit). These areas had high surface water run-off.

The main valley floor was about 100 m wide with mixed alluvial soils (the *Williams* landscape unit). The tributaries were steeper and generally waterlogged (the *Hamersley* landscape unit) while further upstream, they were swampy, often saline and of low gradient (the *Pindalup* landscape unit).

The elevation of the catchment was approximately 310–330 m Australian Height Datum (AHD) for the areas of dissected plateau and extended up to 400 m AHD east in the catchment down to 110 m AHD at the confluence of the brook with the Avon River.

Tributaries

There are 10 significant tributaries to Jimperding Brook. They are shown in Map 2 numbered downstream from the top of the brook. Parameters for each tributary are shown in Table 1.

All tributaries were second-order streams (based on the stream order classification of Strahler, 1957). Jimperding Brook was a third-order stream.

Table 1 Description of tributaries of Jimperding Brook.

Tributary No.	Location[1]	Length (km)	Elevation range (m AHD)	Relief (m)	Gradient (%)	Name
TR001	E	2.4	240–340	100	4.2	
TR002	SW	6.4	200–285	85	1.3	Jim Crow Gully
TR003	W	9.8	200–320	120	1.2	
TR004	SE	8.0	185–330	145	1.8	
TR005	SW	7.9	165–290	125	1.6	Jingaling Brook
TR006	E	4.3	165–300	135	3.1	Gabidine Brook
TR007	NE	4.1	155–360	205	5.0	
TR008	SW	3.2	135–265	130	4.1	
TR009	SW	2.2	120–225	115	5.2	
TR010	SW	2.0	120–250	130	6.5	Little Jimperding Brook

Note 1: E = east of Jimperding Brook. W = west of Jimperding Brook etc

Tributaries that drained from the *Steep Rocky Hills* landscape unit (TR001, TR006, TR007, TR008, TR009 and TR010) had very steep average channel gradients (i.e. 3% to 6.5%). TR004 was also quite steep (1.8%) and in addition had many very steep minor tributaries from steep rocky outcrop areas. TR002, TR003 AND TR005 were of a lower gradient and located south-west in the catchment.

Water quality

The water quality of stream flow for Jimperding Brook and six of its tributaries was monitored for a three-year period (July 1997 to June 2000) as reported by Bloom et al. (2002). Monitoring occurred at monthly intervals at nine sites (locations shown on Map 2). The water quality parameters measured were the concentration of phosphorus (P), acid-alkaline trend (pH), electrical conductivity (EC: an index of salt concentration) and temperature.

The site relevance to Jimperding Brook and its tributaries is shown below:

Monitoring Site	Tributary	Location
1	tributary of TR003	Fernie Road.
2	TR003A	Salt Valley Road.
3	TR002 Jim Crow Gully	Salt Valley Road.
4	Jimperding Brook	Salt Valley Road intersection with Chitty Road.
5	TR004A St Johns Brook	Salt Valley Road.
6	TR006 Gabidine Brook	Toodyay Road.
7	Jimperding Brook	Toodyay Road.
8	TR005 Jingaling Brook	Lovers Lane.
9	Jimperding Brook	Lovers Lane.

Analysis of results showed there to be little difference in P between the nine sites. The concentration increased after high rainfall events as may be expected. The average concentration for all sites was less than 0.20 ppm (parts per million) which is classified as 'moderate' according to standard water quality guidelines (ANZECC, 2000). There were many sampling months when the P concentration was either 'high' (> 0.2, < 0.3 ppm), 'very high' (> 0.3, < 0.5 ppm) or 'extreme' (> 0.5 ppm). Table 2 shows the number of months with stream flow at each site for which the P concentration exceeded the 'low' category (< 0.2 ppm). For most sites, more than 50 per cent of the months had measurements which exceeded the 'low' category. All sites had months with 'very high' concentrations and almost all had at least one 'extreme' level of P concentration.

Table 2 Number of months with flow for P concentration categories at water quality monitoring sites in the Jimperding Brook catchment (July 1997 to June 2000 sampling period).

Site Number	No. months with flow	No. flow months with P > 0.10 ppm	No. flow months with P > 0.20 ppm	No. flow months with P > 0.30 ppm	No. flow months with P > 0.50 ppm
1	32	22	10	5	1
2	34	18	9	2	0
3	34	21	5	3	2
4	34	23	6	2	1
5	17	7	1	1	1
6	31	17	3	1	1
7	33	14	9	2	2
8	31	21	6	2	1
9	34	19	7	2	2

Information source: Bloom et al. *(2002)*

Note: parts per million (ppm) = Milligrams per Litre (mg/L)

Analysis provided by Bloom et al. (2002) indicated an increased trend of P concentration with time. Almost all of the measures of concentration levels that were 'very high' or 'extreme' occurred after March 1999. All 'extreme' levels of P occurred during the period March–June 1999. Site 1 had the highest number of months with P concentration being 'very high' or more. The soils of this site were generally sandy textured with low phosphorus retention capacity.

The increasing trend in P concentration could be related to a decreased stream flow volume (as has occurred in other comparable areas) although this has not been measured.

The measures of pH showed very little differences between the nine sites with all being at a low alkaline level. There was no apparent change in pH over time.

Salinity was generally quite low for all sites at all times compared with flow in the Avon River (5000–8000 mg/L during winter and 20 000–30 000 mg/L during summer). Only one site (Site 9) exceeded 10 000 mg/L on one occasion (March, 1998). Sites 1, 6 and 8 had quite low salinity levels. The highest levels of salinity measured were at sites 3 and 4. Table 3 showed the number of months with salinity > 5500 mg/L (= 1000 mS/m).

Table 3 Number of months with flow for which salinity was greater than 5500 mg/L TSS at water quality monitoring sites in the Jimperding Brook catchment (July 1997 to June 2000 sampling period).

Site Number	No. months with flow	No. flow months with salinity > 5500 mg/L
1	32	0
2	34	6
3	34	15
4	34	19
5	17	1
6	31	0
7	33	10
8	31	0
9	34	8

Information source: Bloom et al. *(2002)*

The water temperature range was from 5.4°C (July, 1997 at Site 1) to 28.5°C (December, 1999 at Site 3).

Description of methods

Contact with landholders

Prior to the survey, letters were sent by the Northam office of the Department of Water to all landholders with properties adjacent to Jimperding Brook. This correspondence informed landholders of the purpose of the survey and requested permission for access to their properties during the survey. Landholders were also invited to participate in the survey.

All landholders were contacted by phone in the week prior to the survey to ensure permission for entry was granted and to obtain practical information for ease of access. All landholders permitted entry to their properties. Some landholders provided useful survey information during phone conversations and by contact during the survey period.

Results of the survey were presented to landholders who accepted an invitation to attend a final briefing to the Deepdale Catchment Group. All landholders received a summary of results by post.

Community engagement

During the 1990s, the Jimperding Brook Catchment Group was actively involved with landcare initiatives that were aimed primarily at tackling salinity in the catchment. More recently, the Deepdale Catchment Group has taken the initiative for catchment and waterway management in the lower Jimperding Brook and sections of the Avon River. This has included fencing and rehabilitation of Jimperding Brook between Lovers Lane and Cobblers Pool Road, and the establishment of a public access area near the confluence of the brook with the Avon River.

A briefing on the survey was provided to the Deepdale Catchment Group before and after the survey.

Field survey

The foreshore and channel assessment was undertaken by a survey conducted on foot during September, 2006. The survey commenced on Location No 5 on Chitty Road where the main channel of Jimperding Brook becomes well defined. The survey was of the main channel downstream to the confluence of Jimperding Brook with the Avon River, a distance of 19.75 km.

Further assessment was made of the ten major tributaries. These assessments were of the foreshore and channel for a distance of 200–500 metres upstream from the confluence for each tributary.

The field survey was planned using 1:5000 scale colour aerial ortho photo-mosaics (December 2003 photography) showing property boundaries, roads, farm dams, tributaries and the approximate location of the main channel. Additional mapping of cadastre (scale 1:20 000) was used for liaison with landholders.

Survey section lengths were measured using a *Scalex* map wheel along the survey traverse identified on the 1:5000 scale aerial photos. The length of waterway is estimated to be 30 per cent greater than the survey distance.

The method of survey was to walk both sides of the waterway making observations of foreshore and channel condition for each of the 26 survey sections. The length of the section was determined by identified management units (most commonly farmers' paddocks, but in some cases it was all of a small property). At the end of each section, records were made of observations for:

- waterway features
- river landform
- stream bank stability
- water quality
- riparian vegetation species and health
- habitat quality and diversity
- birds and other native animals
- weeds and feral animals
- riparian zone fencing and management
- opportunities and needs for further river management
- Foreshore Condition Grade (based on criteria developed by Pen and Scott, 1995)
- Stream Environmental Rating.

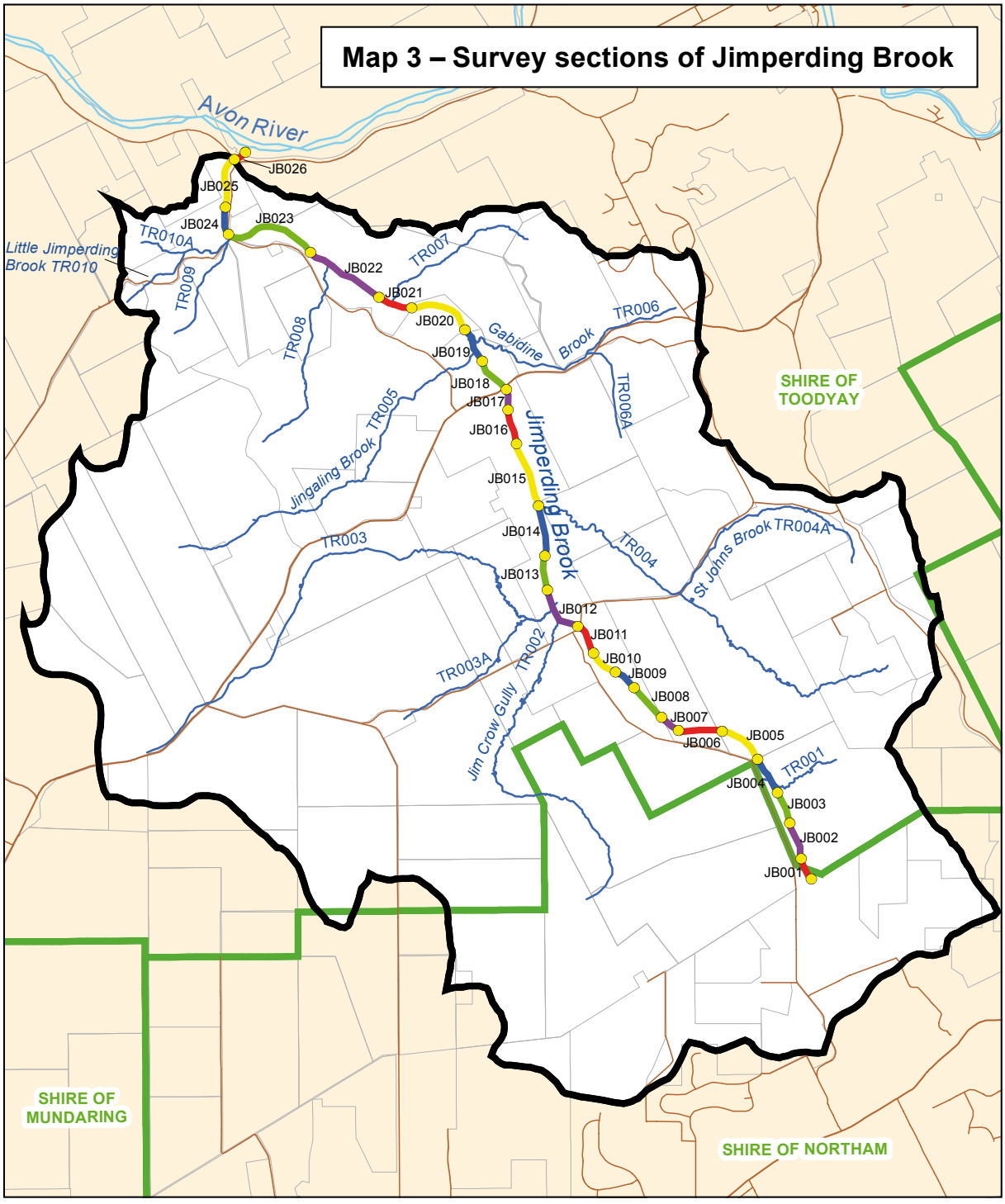
The location for the start and finish of each section was recorded using a global positioning system (Magellan GPS 315). The coordinates for each section are provided in Appendix 2 and the location of each survey section is shown in Map 3. Additional locations for sites of specific interest were also recorded for each section.

The length of each section is shown in the description notes for each section (Appendix 6).

A standardised *Foreshore and Channel Assessment Form* (adapted from Pen & Scott 1995) was used to record survey information (Appendix 3).

Stream salinity was measured at each section end and tributary confluence using a *Hanna HI 8733* conductivity meter. All sections and tributaries except TR001 had stream flow during the period of the survey.

Plants and weeds were identified in the field and confirmed with relevant flora reference manuals.



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Local Goverment Authorities - DLI - 12/06
Roads - DLI - 06/04
Cadastre - DLI - 12/06

Legend

- Local Roads
- Main Tributaries
- Avon River
- Survey sections
- Cadastre
- Local Government Authorities
- Jimperding Brook catchment boundary

Datum and Projection Information

Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA Zone 50

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Birds and other animals were recorded for each section by sightings and call identification.

All information was recorded in the standard format of LHS and RHS being as if facing upstream. Recordings of observations and water quality data were made at the downstream end of each section.

Information analysis

All quantified information has been recorded in a formatted *Microsoft Access* database. This provided for analysis of sites and the complete set of stream sections. These are discussed in the following sections.

The Foreshore Condition Grade is based on an on-site assessment of the foreshore considering a range of factors, but particularly the impacts of weed invasion and erosion. A description of the foreshore condition grades is included as Appendix 4.

The Stream Environmental Rating was also assessed on site. It integrated a set of criteria to provide a holistic index of environmental health. The criteria included:

- floodway and bank vegetation
- verge vegetation
- stream cover
- bank stability and sedimentation
- habitat diversity
- surrounding land use.

Assessment of values for each of these criteria is relatively subjective; however, the summation of all values does provide a comparative basis for identifying areas of high values and other areas in need of management effort. A description of the Stream Health Rating is included in Appendix 9.

Survey results

The survey of Jimperding Brook was based on 26 survey sections that vary in length from 270 metres (JB026) to 1780 metres (JB023). The average survey length was 760 metres. The survey length for each section is shown in Appendix 6. The total survey distance was 19.75 km. Assuming the stream length is 30 per cent greater than the survey distance, the length of Jimperding Brook was approximately 25.70 km.

The elevation of Jimperding Brook descended from 260 metres to 110 metres AHD over the survey distance. The 150 metres fall was a gradient of 0.78 per cent over the length of the brook. This compared with a gradient of 0.25 per cent for the Avon River channel at the confluence with the brook. All tributaries to Jimperding Brook had a high channel gradient (range of 1.2–6.5%).

Waterway features

The waterways features that characterise the foreshore and channel were recorded as presence/absence information for each survey section. This information is shown in Appendix 5 (Table 5.1) and summarised below in Table 4. A description is provided below.

Table 4 Existence of waterway features for Jimperding Brook survey sections and tributaries

Waterway Feature	Jimperding Brook Sections (n = 26)	Tributaries (n = 10)
Single Channel	25	9
Braided Channel	4	1
Anabranch	5	5
Deep pool	4	0
Natural Riffles	9	0
Sediment Slugs	12	0
Vegetated Island	6	0
Large Woody Debris	20	6
Wetlands	1	0
Tributary	9	0
Dam	4	0
Bridge	2	0

Channel and floodplain morphology

Jimperding Brook was a single channel in all sections with the exception of JB003 where the channel is predominantly braided due to well-established couch grass (Photo 1). There were three other sections (JB002, JB005 and JB006) where some parts of the section were braided.

The major tributaries had a single channel with the exception of TR005 (Jingaling Brook) which is braided near the confluence.

The channel dimensions for each section are provided in Appendix 5 (Table 5.2). Median values were used for analysis.

The width of the channel increased downstream. Figure 1 shows the median channel width for Jimperding Brook. Upstream from Salt Valley Road, the width was less than 10 metres with many sections less than five metres. Downstream from Salt Valley Road most stream channel widths were greater than 10 metres. There was a general increase in channel width as the brook flowed to its confluence with the Avon River.

Photo 1 *Braided stream channel stabilised by couch grass in section JB003*

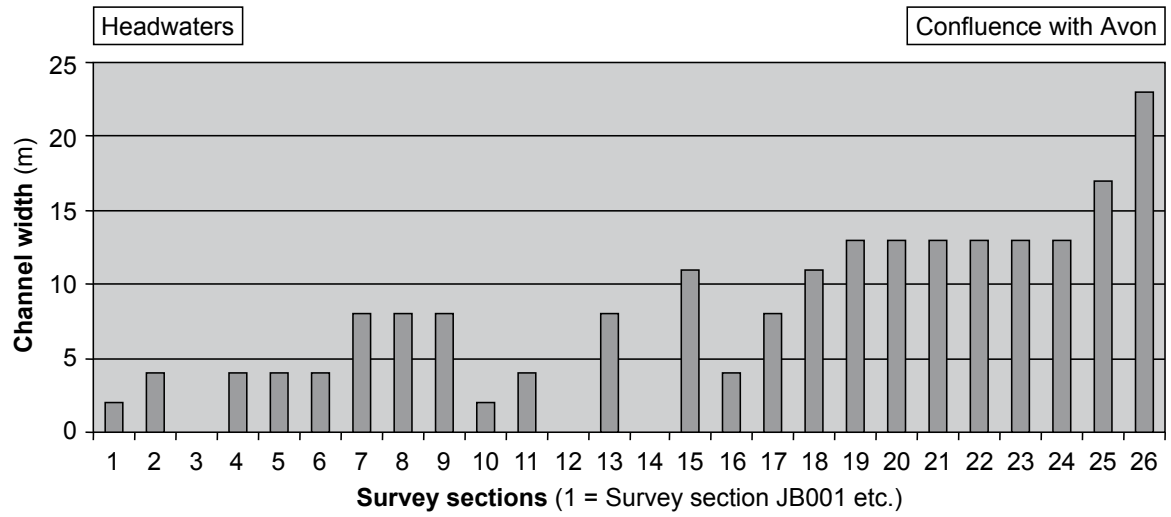


***Figure 1** Median channel width for Jimperding Brook survey sections*

Note: Section 3 is a broad wetland. No data was recorded for Sections 12 and 14.

Channel depth varied significantly within each section but not significantly between sections (Figure 2). The depth was recorded at the end of each section. Within sections, there were pools estimated to be 1.5 metres deep and many riffles less than 20 cm deep. There was no clear trend in channel depth downstream.

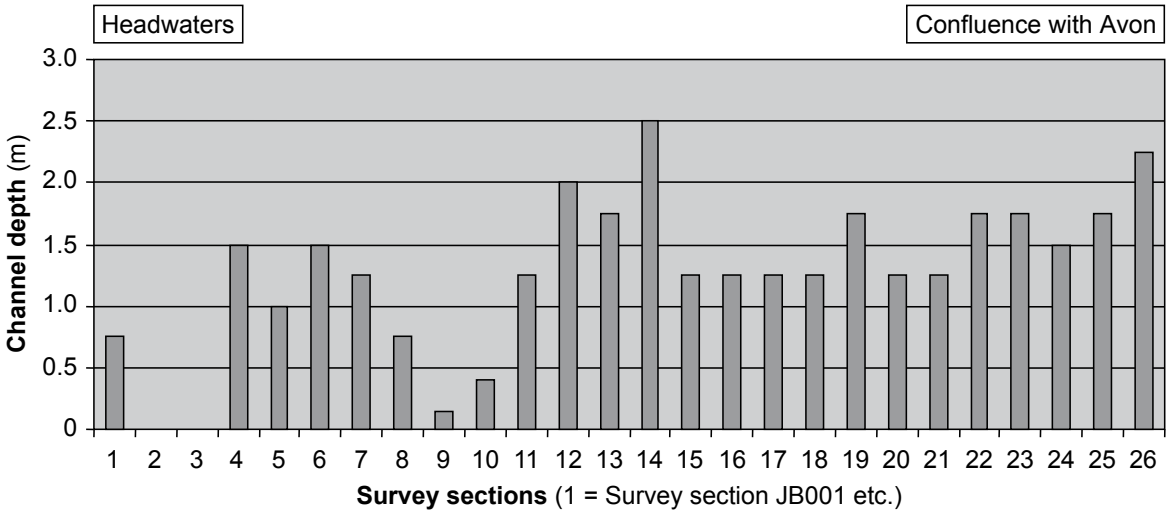


***Figure 2** Median channel depth for Jimperding Brook survey sections*

Note: Sections 2 and 3 were comprised of a shallow wetland.

Floodplain width varied considerably between sections. It was greater than 100 metres both sides for three sections (JB012, JB018 and JB022). In most sections, the floodplain was less than 40 metres or otherwise poorly defined.

The floodplain for major tributaries was not well defined.

Photo 2 *Stream meander with active bank erosion*

Anabranches and meanders

An anabranch occurred where the channel had a distinctly different flow path for higher stream flow. There were five sections of Jimperding Brook with anabranches (JB005, JB006, JB010, JB014 and JB022). Jimperding Brook did not have clearly defined floodways.

Five of the major tributaries had anabranches. These were more likely to occur in the lower gradient sections of tributaries.

The meander pattern of Jimperding Brook varied considerably. A subjective assessment from 1:5000 scale aerial photographs (Table 5) showed some sections to have high or very high sinuosity (JB004, JB005, JB008, JB009, JB012, JB013, JB014, JB019 and JB022). The sinuosity of meanders varied for a range of causes, including gradient, soil type and shallow bedrock intrusions. The highly sinuous meander pattern at JB008 and JB009 was likely to be caused by intrusive bedrock. Other areas may also have had geological controls.

Sections with high meander sinuosity were generally at higher risk for bank erosion (Photo 2).

Table 5 Meander sinuosity and tributaries for Jimperding Brook survey sections

Section Number	Meander sinuosity	Tributaries	Comments
JB001	Low	0	Channelised by excavated drainage
JB002	Medium	2	One major meander
JB003	Medium	0	
JB004	High	3	
JB005	High	1	One major meander
JB006	Medium	1	One major meander
JB007	Medium	0	
JB008	Very High	2	
JB009	High	0	
JB010	Medium	1	
JB011	Medium	1	
JB012	High	3	Two major meander
JB013	High	0	Two major meanders
JB014	Very High	3	
JB015	Medium	6	
JB016	Medium	4	
JB017	Low	1	
JB018	Low	1	
JB019	High	3	One major meander
JB020	Medium	10	
JB021	Medium	2	One major meander
JB022	High	5	One major meander
JB023	Medium	5	Two major meanders
JB024	Low	2	
JB025	Low	1	
JB026	Low	4	One major meander

Major meanders occurred in some sections of Jimperding Brook (Table 5). These occurred most commonly where the water course changed orientation. These had a high probability of being geologically controlled.

Pools and riffles

Relatively deep pools were recorded in only four of the survey sections (JB002, JB020, JB021 and JB023). These pools were small and not comparable in ecological or social values to major river pools of the Avon River although some may have had local historical significance (none were noted as significant in landholder discussions).

Naturally occurring riffles were recorded at nine survey sections. A pool-riffle sequence for Jimperding Brook was not well developed upstream of Salt Valley Road. The riffles that did occur are most commonly medium cobblestones. Riffles commonly occur in Sections JB023 to JB025 and some were short (15–20 metres) and closely spaced (50–100 metres).

Vegetated islands

Vegetated islands occurred in six survey sections. These were formed by changes in surface flow direction. None were formed by sediment accretion.

Wetlands

Only one survey section (JB003) had a significant wetland (Photo 3). This was a small area where surface water ponded on the LHS.

Photo 3 *Perched wetland adjacent to Jimperding Brook in section JB003*

Tributaries

There were 61 tributaries to Jimperding Brook (Table 5). This included the 10 major tributaries for which assessment was made of each at the confluence with Jimperding Brook. The very high number of tributaries was a distinctive characteristic of this waterway. Most were relatively short and had no flow at the time of survey (September, 2006).

Management features

There were four sections with dams in or adjacent to Jimperding Brook (JB001, JB05, JB09 and JB010).

Road bridges occur as follows:

JB003	farm bridge (culverts)
JB011/012	Salt Valley Road
JB017/018	Toodyay Road
JB021/022	farm bridge (culverts)
JB024/025	Lovers Lane (floodway and culverts)
JB026	Cobblers Pool Road and rail bridge.

The culverts at Salt Valley Road appeared inadequate for high flows and may be a cause of localised flooding. The culverts in JB021/022 were ponding water upstream.

Stream bank stability and sediments

Bank stability was highly variable between survey sections. It was recorded as different forms of erosion. It is generally observed that erosion increased with high stream sinuosity and where fringing vegetation was poor or absent. Stock access caused undercut banks to subside where the section was inadequately fenced. Where the stream channel was stabilised by saltwater couch (*Paspalum vaginatum*), erosion was minimal.

Channel erosion

This was recorded as ‘subsidence’, ‘undercutting’ and ‘slumping’ although it was difficult to differentiate clearly between these processes. Figure 3 shows a relative index that is cumulative for the scores recorded for each type of channel erosion. From this, it is clear that erosion was significant at all but three sites (JB003, JB015 and JB024). Erosion was particularly significant at JB004, JB006 and JB020.

Established saltwater couch (*Paspalum vaginatum*) had stabilised the banks and bed sediments in the lower part of JB003 (a section that was also well fenced) except where the channel was excavated (JB001 and JB002). However, the extent of saltwater couch (*Paspalum vaginatum*) stopped at the end of JB003 and the next section had a high level of channel erosion.

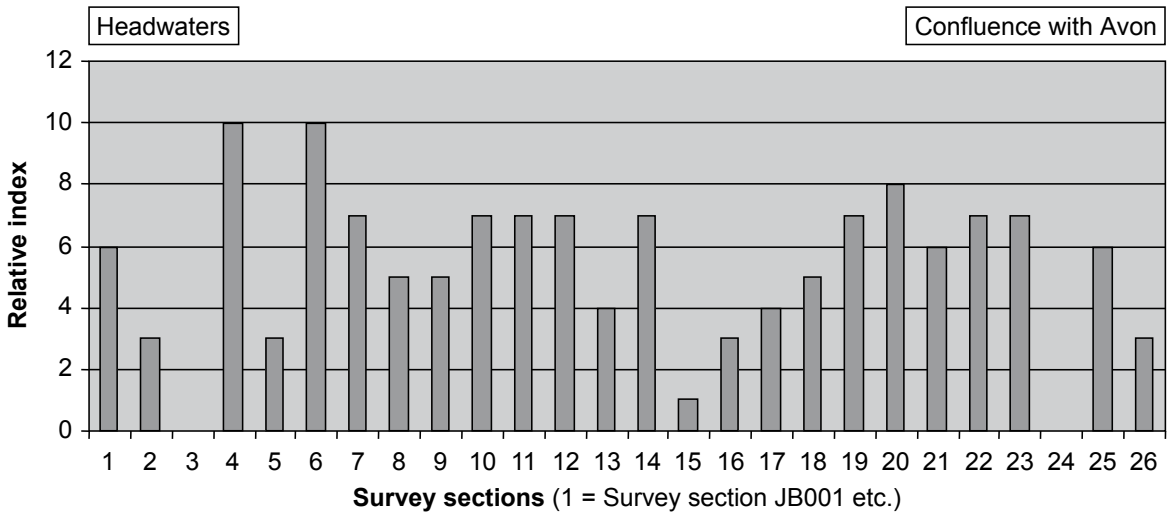


Figure 3 *Relative index for channel erosion of Jimperding Brook survey sections*

Note: Section 3 is comprised of a shallow wetland.

Undercutting was extensive where there was limited fringing vegetation. This was the major cause of erosion in section JB010 (photo 4). Where fringing vegetation was in near natural condition, there was little or no channel erosion (e.g. section JB024).

Photo 4 *Bank erosion where there is no fringing vegetation*

Photo 5 *Active bank erosion at the confluence of a major tributary (TR006)*

As the stream meander pattern became more sinuous, the level of erosion increased. This was quite extensive for section JB012 (photo 2). There was one acute meander with active bank erosion estimated to be three metres deep in section JB019 (photo 5). This was immediately downstream from the confluence of a major tributary (TR006) so bank erosion would have occurred during high flow events when the combined stream flow was turbulent.

There were sections where cobblestones have been deposited in alluvial soils of the floodplain. These were occasionally exposed in the eroding channel bank (e.g. section JB015) and appear to have stabilised the bank.

Gully erosion

The processes of gully erosion were very significant for Jimperding Brook and its tributaries. Figure 4 shows that gully erosion occurred in 11 sections; however, the low frequency of occurrence understated the importance of the process.

The erosion processes were best observed at section JB006 where gully head erosion was very active in the channel (photo 6). This section also had extensive salinity due to intrusive bedrock. This was further cause for reduced bank stability. The gully was one to two metres deep (photo 7) and had the potential to continue eroding upstream. It is noted that extensive sheet erosion also occurred in this section due to soil salinity (photo 8).

Photo 6 *Active gully erosion in section JB006*

Photo 7 *Deep gully erosion in section JB006*

Photo 8 *Sheet erosion adjacent to Jimperding Brook in section JB006*

Photo 9 *Log jam controlling gully erosion in section JB013*

The culvert crossing at the downstream end of section JB003 had an estimated 1.5 metres gradient drop from one side to the other. This further indicated the potential for very active gully erosion (i.e. erosion would occur if this structure were removed). Similarly, it was noted that a log jam in section JB013 (photo 9) was containing a significant gully. If this were to be removed (e.g. by fire), the gully had potential to advance upstream.

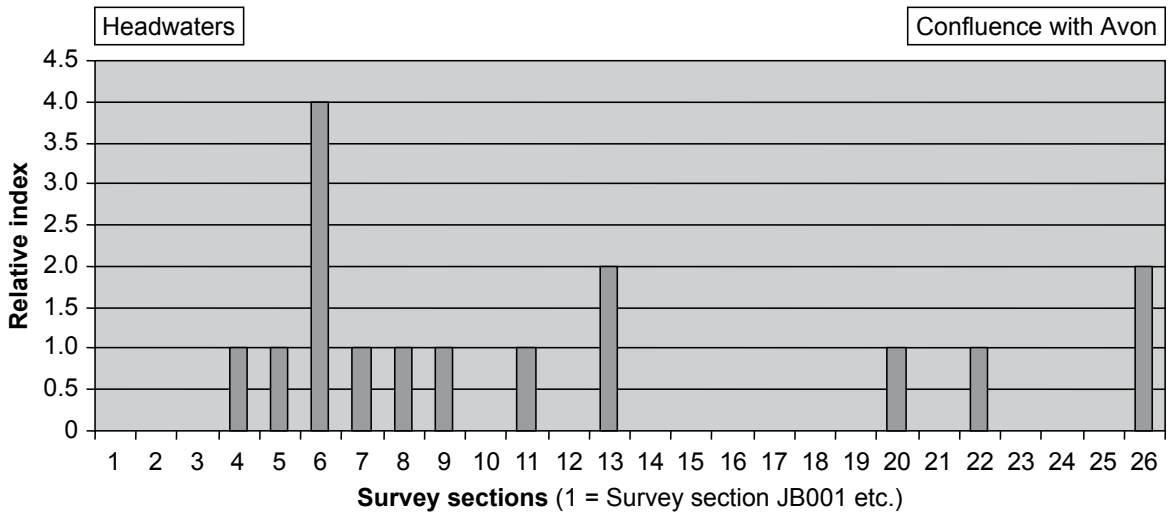


***Figure 4** Relative index for gully erosion of Jimperding Brook survey sections*

There were many old crossings that have washed out and were no longer in use. This indicated that the stream channel has increased in width and depth through the processes of erosion. These processes continued to be active and were a significant source of sediment.

Sedimentation

The occurrence of sediments was recorded for each section during the survey. Figure 5 shows that most sections had a medium level of sediment and there was a higher level for three sections (JB012, JB013 and JB026). However, observations of sediment did not provide estimates of volume. In most sections, there were only minimal amounts of sediment and pools, although small, were not filled with sediment.

The processes of sediment transport were important. Coarse sediments were recorded only in sections JB021 (photo 10), JB025 and at the confluence with the Avon River (JB026). Most sediment was of a medium-to-fine texture. It was likely that most sediment was easily transported downstream and that the sediments observed were mostly temporary depositions. The highly mobile character of sediments provided explanation for there being so little sediment deposition compared with the high level of channel erosion that has occurred.

It is likely that Jimperding Brook was a significant contributor of medium-to-fine sediments to the Avon River system.

None of the major tributaries had significant sediment load near their confluence with Jimperding Brook.

Photo 10 *Coarse sand sediment deposit in section JB021*

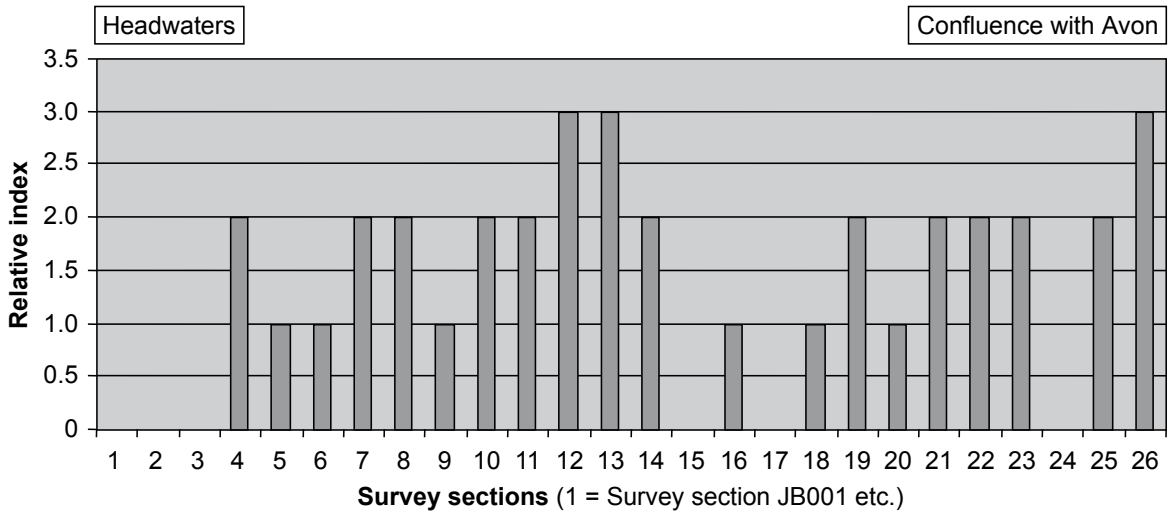


Figure 5 *Relative index for sedimentation of Jimperding Brook survey sections*

Water quality

Stream flow salinity was measured at the downstream end of each section (Appendix 6, Table 5.4). The results shown in Figure 6 indicated a generally declining trend with the distinct exception for sections JB004-6. These were high due to saline groundwater discharge. In section JB006, salinity was exacerbated by intrusive bedrock.

There were three significant reductions in stream salinity (sections JB007, JB012 and JB019). It was not clear why the first two sections were lower, but for section JB019, there were two major tributaries that had flow with low salinity.

No stream flow salinity measures exceeded 10 000 mg/L at the time of sampling (26–27 September 2006). From section JB019 downstream, stream flow salinity was consistent (approximately 4000 mg/L).

At the confluence of Jimperding Brook with the Avon River, the stream flow salinity of the river was 7700 mg/L.

The stream flow salinity for the 10 major tributaries ranged from 660 mg/L (TR004) up to 5280 mg/L (TR002).

The acid-alkaline trend for steam flow in Jimperding Brook and the 10 major tributaries ranged from pH 7.6 to 8.5. This was consistent with the low alkaline range recorded by Bloom et al. (2002).

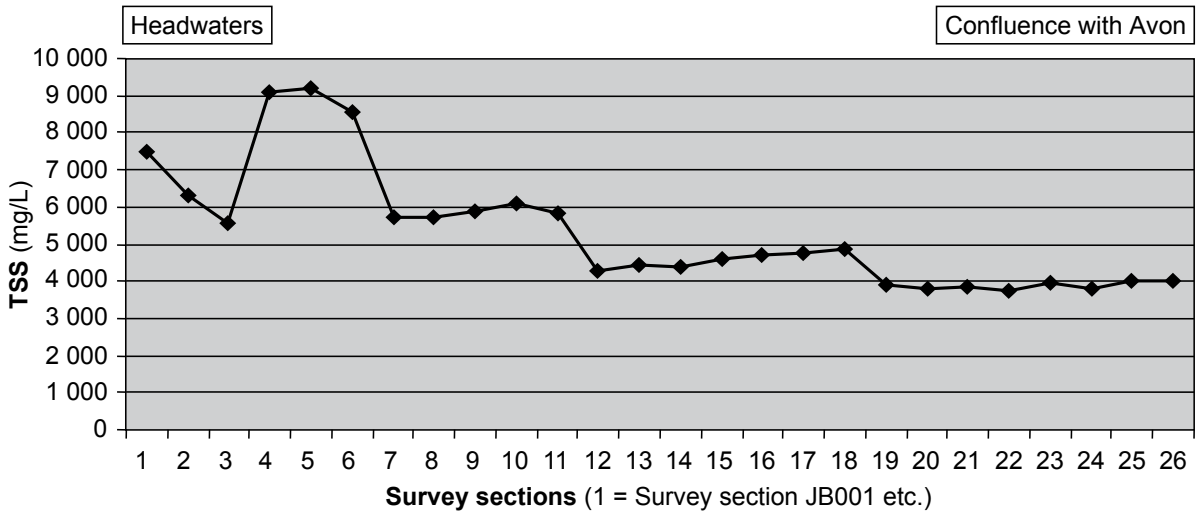


Figure 6 *Stream flow salinity of Jimperding Brook survey sections*

Riparian vegetation species and health

Riparian zone vegetation was relatively consistent in composition and structure but varied considerably in extent, health and regenerative capacity between survey sections.

Table 6 shows the occurrence for the 10 most common native riparian zone vegetation species with dominant growth form. The dominant species were the flooded gum (*Eucalyptus rudis*), wandoo (*E. wandoo*), golden wreath wattle (*Acacia saligna*), swamp paperbark (*Melaleuca raphiophylla*), prickly moses (*A. pulchella*), jam (*A. acuminata*), grasstree, (*Xanthorrea preissii*), swamp sheoak (*Casuarina obesa*), York gum (*Eucalyptus loxophleba*) and marri (*Corymbia calophylla*). A full list of riparian zone plants recorded is provided in Appendix 7.

There was a general trend of increased species richness (i.e. number of species) for dominant species downstream. Higher richness also occurred where differing landforms intrude into the riparian zone. Sections JB019-JB024 had quite high species richness including many species not included as dominant species. This was due to the adjacent rocky outcrop with native vegetation north of the brook.

Riparian zone vegetation cover for each stratum is shown in Appendix 5 (Table 5.5). This indicated the upper storey to be relatively consistent (i.e. 20–80%) with only JB023 and JB024 having higher cover. There were only three sections with any middlestorey upstream from JB015 and these have only sparse cover (<20%). Only two sections (JB002 and JB024) had any native understorey and these were both of sparse cover.

Two sections had no riparian vegetation at all. They were JB001 and JB010.

A subjective assessment was made of vegetation health. This was shown in Figure 7. In general, the dominant species were quite healthy. Salinity was affecting riparian vegetation in section JB001 (all trees in the riparian zone were dead), JB002 and JB006. Jarrah Leaf Miner (*Perthida glyphopa*), an insect that causes significant foliage damage to flooded gums (*Eucalyptus rudis*), has inflicted such damage downstream from section JB016.

Ground cover was recorded and is shown in Appendix 5 (Table 5.6).

Regeneration was recorded for dominant riparian zone vegetation species. There was no record of regeneration for sections JB001, JB003, JB004, JB010 and JB015. There was also no regeneration recorded for two major tributaries (TR004 and TR008).

Regeneration was limited where stock had access to the riparian zone. Grazing of native species was noted for many species but particularly for golden wreath wattle (*Acacia saligna*).

Table 6 Occurrence of dominant riparian zone plant species within Jimperding Brook survey sections

Section	Riparian Zone Plant Species										
	Flooded gum (*Eucalyptus rudis*)	Swamp paperbark (*Melaleuca rhaphiophylla*)	Golden wreath wattle (*Acacia saligna*)	Wandoo (*Eucalyptus wandoo*)	York gum (*Eucalyptus loxophleba*)	Swamp sheoak (*Casuarina obesa*)	Prickly moses (*Acacia pulchella*)	Jam (*Acacia acuminata*)	Grasstree (*Xanthorrhoea preissii*)	Marri (*Corymbia calophylla*)	**Richness (number of species)**
JB001				✓							1
JB002	✓		✓	✓	✓						4
JB003	✓		✓			✓					3
JB004		✓	✓	✓							3
JB005	✓		✓	✓			✓				4
JB006	✓			✓				✓			3
JB007				✓			✓				2
JB008				✓							1
JB009	✓		✓	✓				✓			4
JB010	✓										1
JB011	✓			✓	✓						3
JB012	✓	✓	✓	✓	✓			✓			6
JB013	✓	✓	✓	✓							4
JB014	✓	✓	✓	✓			✓	✓			6
JB015	✓	✓	✓	✓			✓	✓			6
JB016	✓	✓	✓	✓			✓	✓			6
JB017	✓			✓			✓			✓	4
JB018	✓	✓		✓			✓				4
JB019	✓	✓	✓	✓	✓		✓	✓	✓		8
JB020	✓	✓	✓				✓	✓	✓	✓	7
JB021	✓	✓	✓	✓				✓	✓		6
JB022	✓	✓	✓	✓			✓	✓	✓	✓	8
JB023	✓	✓	✓	✓			✓	✓		✓	7
JB024	✓	✓	✓				✓	✓		✓	6
JB025	✓	✓	✓				✓				4
JB026	✓	✓	✓			✓		✓			5
Total	**22**	**15**	**18**	**20**	**4**	**2**	**13**	**13**	**4**	**5**	

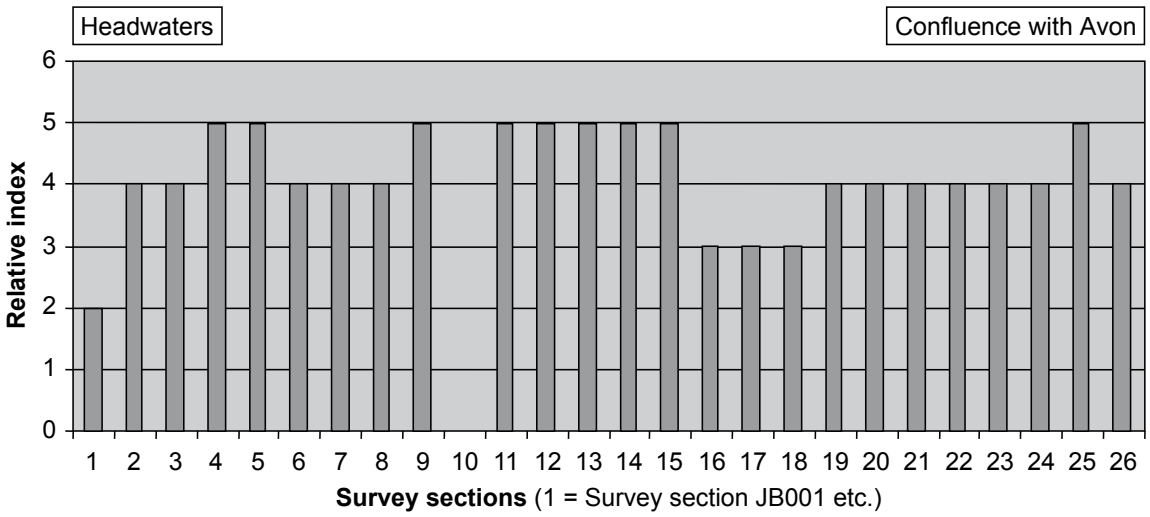


Figure 7 *Riparian zone vegetation health of Jimperding Brook survey sections*

Note: 5 = 'looks healthy'; 4 = 'some sick trees'; 3 = 'many sick trees'; 2 = 'some dead trees'; 1 = 'many dead trees'; 0 = no vegetation.

Weeds and feral animals

The understorey of the riparian zone was substantially dominated by introduced weeds. Most are annual species. The most commonly occurring of these were barley grass (*hordeum* spp.), ryegrass (*Lolium* spp.), cape weed (*Arctotheca calendula*), brome (*Bromus* spp.) and wild oats (*Avena* spp.).

Weeds of greater concern in the riparian zone include cape tulip (*Homeria* spp.), soursob (*Oxalis pes-caprae*), Paterson's curse (*Echium plantagineum*) and spiny rush (*Juncus acutus*). These weeds were established in the riverine environment and generally suppress regeneration of native species. Other weeds occurred that were unlikely to further devalue the riparian zone.

Table 7 showed the frequency of occurrence for major weeds that occur in the riparian zone. There was a significant threat to the riparian environment by the rapid spread of spiny rush (J*uncus acutus)*. This occurred in 20 sections of the brook. Many sections had only small numbers of plants established and could be controlled. This introduced rush has potential to block tributaries and is a contaminant to wool. Healthy riparian vegetation will reduce available light which inhibits its growth.

Cape tulip (*Homeria* spp.) occurred in 18 sections and soursob (*oxalis pes-caprae*) in 16 sections. Wild radish (*Raphanus raphanistrum*) was significant where it occurred and could increase substantially.

It is significant to note that bridal creeper (*Asparagus asparagoides*) was not established in Jimperding Brook.

The sections with most weed species were JB004 and JB017.

Table 7 Occurrence of dominant riparian weeds within Jimperding Brook survey sections

Section	Dominant Riparian Weeds									Number of species
	spiny rush (*Juncus acutus*)	cape tulip (*Homenia* spp.)	soursob (*Oxalis pes-caprae*)	veldt grass (*Ehrharta calycina*)	wild oats (*Avena* spp.)	Paterson's curse (*Echium plantagineum*)	Bulrush (*Typha* spp.)	blackberry nightshade (*Solanum nigrum*)	wild radish (*Raphanus raphanustrum*)	
JB001	✓									1
JB002	✓	✓	✓							3
JB003	✓			✓	✓					3
JB004	✓	✓	✓	✓	✓	✓				6
JB005	✓		✓							2
JB006	✓						✓			2
JB007	✓						✓			2
JB008		✓								1
JB009	✓	✓					✓			3
JB010		✓								1
JB011		✓	✓			✓				3
JB012	✓		✓							2
JB013	✓	✓	✓			✓				4
JB014	✓	✓	✓			✓				4
JB015	✓	✓				✓				3
JB016	✓	✓	✓				✓			4
JB017	✓	✓	✓			✓		✓	✓	6
JB018	✓	✓	✓			✓				4
JB019	✓	✓								2
JB020		✓	✓							2
JB021	✓	✓	✓							3
JB022	✓	✓	✓				✓			4
JB023	✓	✓	✓						✓	4
JB024		✓	✓							2
JB025	✓									1
JB026			✓							1
Total	**20**	**18**	**16**	**2**	**2**	**7**	**5**	**1**	**2**	

There were occasional records of rabbits and foxes. Neither was significant to the condition of the riparian zone at their current low population levels. There were no signs of feral pigs, goats or deer in Jimperding Brook.

Habitat quality

Habitat quality was best estimated from the species richness and structural diversity of natural vegetation. This was derived from Table 6 and from Appendix 5 (Table 5.5). The quality of habitat also increased where riparian vegetation was adjacent to extensive areas of remnant native vegetation. This occurred downstream from JB019. Habitat quality upstream of Salt Valley Road was generally poor due to absence of middle and lower vegetation strata.

The aquatic environment provided moderately good habitat opportunity as water quality was not excessively saline or acidic and there was frequent occurrence of in-stream debris. Only the introduced Mosquito Fish (*Gambusia holbrooki*) was observed in stream flow.

Birds and other native animals

Thirty-three bird species were recorded at survey sections during the survey period. Appendix 8 shows the number of species recorded for each section. This is primarily of general interest and does not provide any significant indication of habitat quality or environmental health for each section. The records were from one sampling period only, rather than from repeat survey methods. There are many variables that influence bird surveys, including time of day and wind conditions, so the lists provided should not be used for assessment of river condition.

Based on the recorded information, no bird species were of disproportionately high population size and the Black Cockatoo (*Calyptorhynchus* spp.) (either Carnabys Cockatoo or Forest Red-tailed Cockatoo) is considered rare or likely to become rare (Department of Environment and Conservation, 2006).

This highlights the importance of the existing remnant vegetation within the Jimperding Brook catchment.

Very few other native animals were recorded. A frog call was recorded in section JB001. There were indications that kangaroos inhabited the river environment downstream from section JB018. Reptiles were not observed during the survey.

Riparian zone fencing and management

The condition of fencing adjacent to Jimperding Brook was assessed. There were five sections fenced on both sides, 11 sections fenced on one side and 10 sections with no fencing. There was a very high level of stock access to the riparian zone of Jimperding Brook.

The condition of existing fencing varies considerably. Fencing condition was recorded as:

Good. Relatively new and expected to remain stock-proof with minor maintenance for > 30 years.

Moderate. Stock-proof, but will need maintenance or replacement within 10–20 years.

Poor. Barely stock-proof and will need to be replaced within five years.

A section where old fencing exists but was clearly not stock-proof was recorded as being not fenced.

The condition of fencing for each section was identified in Table 8. This showed that only 2.12 km of Jimperding Brook (10.8%) had good fencing along both sides. A further 2.06 km (10.5%) had moderate fencing on both sides. In total, 21.2 per cent of Jimperding Brook was at least moderately fenced on both sides.

One section (JB018) had good fencing at a distance of approximately 200 metres from the riparian zone. This included a significant area of pasture which was used as a paddock for grazing. For this section, the brook was identified as being not fenced.

The amount of fencing required for the brook to be fully fenced with at least moderate condition was estimated as follows:

Length with none or poor fencing – 11.62 km (23.24 km considering both sides).

Good or moderate fencing one side – 3.93 km.

Sections for which fencing is not required (JB024 and JB026) – 0.56 km.

Total fencing required – 26.5 km.

Eight of the major tributaries had no fencing at their confluence with Jimperding Brook. Two were fenced both sides (TR002 and TR010) with materials that were in moderate condition.

Table 8 River fence distance (m) for Jimperding Brook survey sections

Section	Fence Condition						
	Good 2-sides	**Good 1-side**	**Moderate 2-sides**	**Moderate 1-side**	**Poor 2-sides**	**Poor 1-side**	**None**
JB001							200
JB002	745						
JB003	560						
JB004							720
JB005							760
JB006							1080
JB007				285			
JB008				910			
JB009		400					
JB010							630
JB011				540			
JB012			975				
JB013							645
JB014				890			
JB015			1090				
JB016						700	
JB017				340			
JB018							690
JB019							760
JB020							1330
JB021						650	
JB022							1675
JB023							1780
JB024				295			
JB025	810						
JB026				270			
Total (m)	**2115**	**400**	**2065**	**3530**	**0**	**1350**	**10270**

Foreshore condition grade

The condition of the foreshore was assessed for each survey section. The grades for assessment are shown below:

A Grade Foreshore	B Grade Foreshore	C Grade Foreshore	D Grade Foreshore
A1 Pristine	B1 Degraded – weed infested	C1 Erosion prone	D1 Ditch – eroding
A2 Near pristine	B2 Degraded – heavily weed infested	C2 Soil exposed	D2 Ditch – freely eroding
A3 Slightly disturbed	B3 Degraded – weed dominant	C3 Eroded	D3 Drain – weed dominant

A field guide to foreshore condition grades is provided in Appendix 4.

Map 4 provides the condition grade of the foreshore for each section. This showed that no sections in Jimperding were in pristine or near pristine condition (A1 or A2 grade). Only one section (JB024) was graded as 'slightly disturbed' (A3).

Nine sections were assessed as B-grade and were described as 'degraded' with weeds being the dominant factor. Most sections (14) were assessed as C-grade based on existing or potential for erosion.

Two sections had a D-grade and were described as an eroding ditch (JB001 and JB010).

The major tributaries were assessed as degraded or eroded. The grades were:

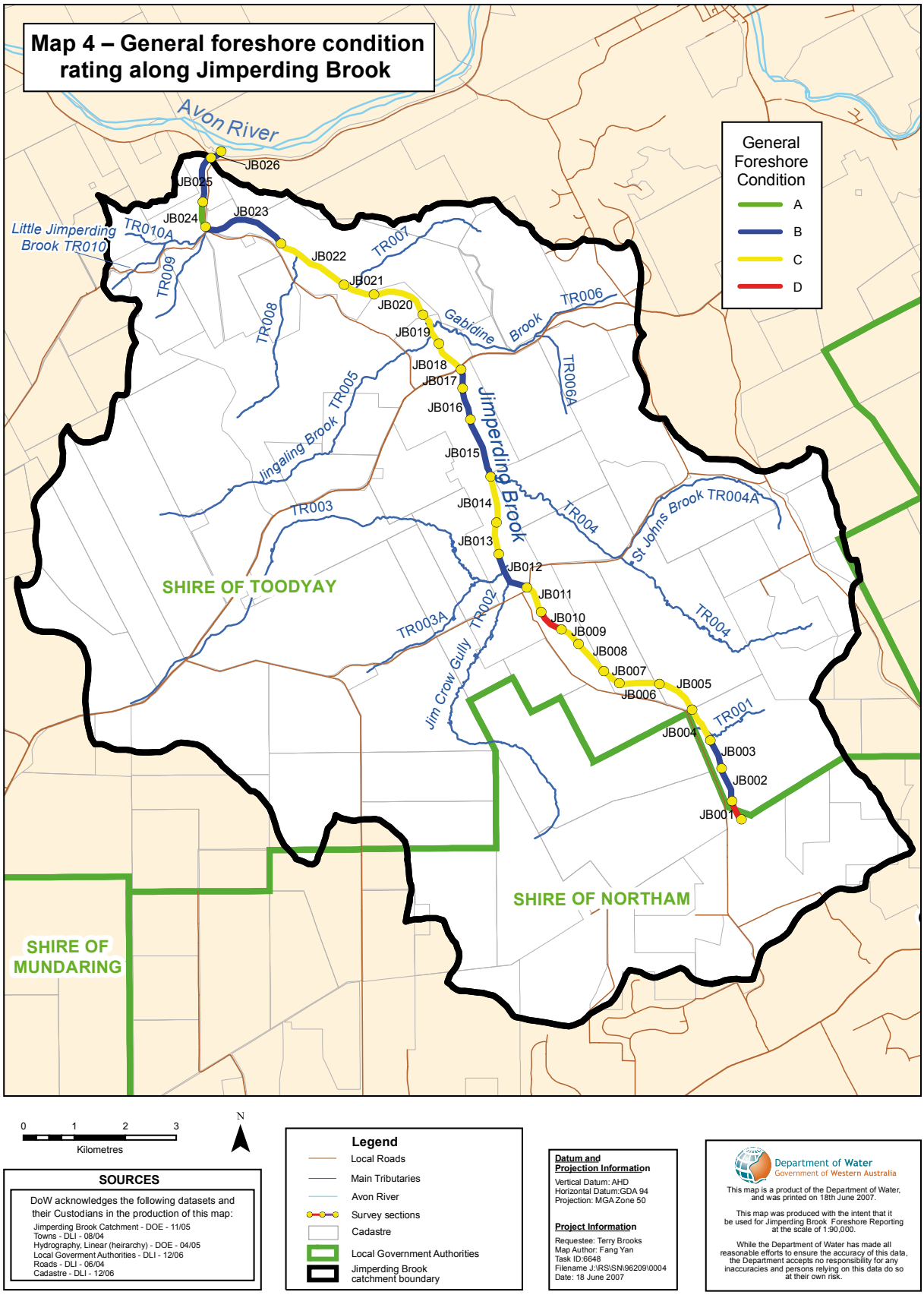
B2: TR007
B3: TR001, TR006, TR008, TR009, TR010
C1: TR002, TR003, TR004
C3: TR005.

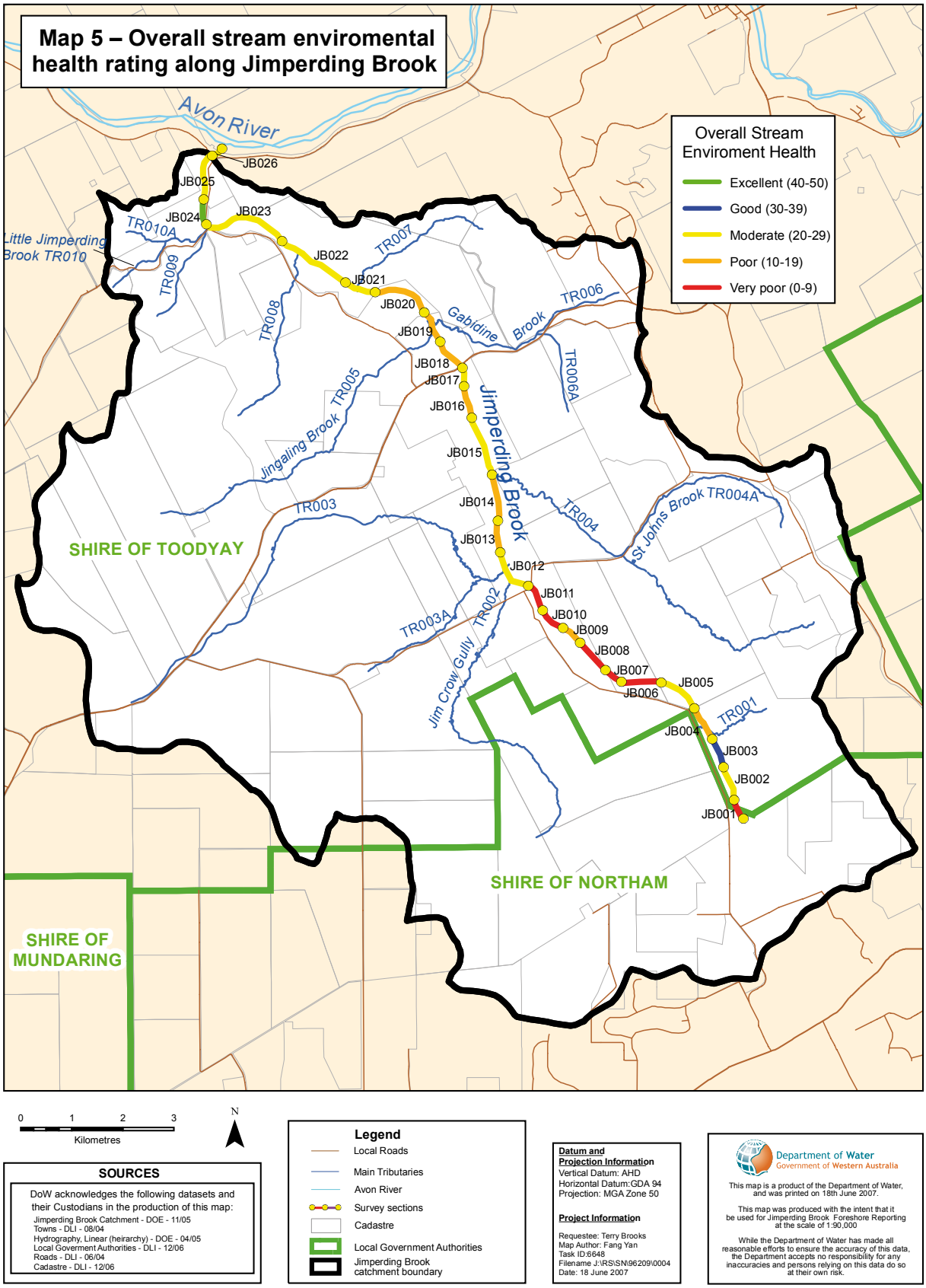
Stream environmental rating

The stream environmental rating provides an integrated assessment considering a range of factors resulting in an overall score for each survey section. This provides a relative index for environmental health for sections of Jimperding Brook. Explanatory information for the environmental rating is provided in Appendix 9.

Map 5 shows the rating for each of the sections. There was no clear trend in environmental health for the whole river system. It showed the first section to be poor compared with the two immediate downstream sections. The set of sections from JB006 to JB011 were consistently of poor environmental health with JB010 having an exceptionally low score (2).

While section JB018 was of poor environmental health, there was a steadily increasing health trend downstream to section JB024 which was rated as 'excellent' with a score of 42 (the maximum possible score is 55). The relatively low score for section JB025 reflected its previous degraded condition. This section was recovering as a result of good river management (fencing and revegetation) activities.


Map 4 – General foreshore condition rating along Jimperding Brook
Avon River
General Foreshore Condition
A
B
C
D
JB026
JB025
JB024
JB023
JB022
JB021
JB020
JB019
JB018
JB017
JB016
JB015
JB014
JB013
JB012
JB011
JB010
JB009
JB008
JB007
JB006
JB005
JB004
JB003
JB002
JB001
Little Jimperding Brook TR010
TR010A
TR009
TR008
TR007
TR006
TR006A
Gabidine Brook
Jimperding Brook
TR005
Jingaling Brook
TR003
TR004
St Johns Brook TR004A
TR003A
TR002
Jim Crow Gully
TR001
SHIRE OF TOODYAY
SHIRE OF NORTHAM
SHIRE OF MUNDARING
0 1 2 3
Kilometres
N
Legend
Local Roads
Main Tributaries
Avon River
Survey sections
Cadastre
Local Government Authorities
Jimperding Brook catchment boundary
SOURCES
DoW acknowledges the following datasets and their Custodians in the production of this map:
Jimperding Brook Catchment - DOE - 11/05
Towns - DLI - 08/04
Hydrography, Linear (heirarchy) - DOE - 04/05
Local Goverment Authorities - DLI - 12/06
Roads - DLI - 06/04
Cadastre - DLI - 12/06
Datum and Projection Information
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA Zone 50
Project Information
Requestee: Terry Brooks
Map Author: Fang Yan
Task ID:6648
Filename J:\RS\SN\96209\0004
Date: 18 June 2007
Department of Water
Government of Western Australia
This map is a product of the Department of Water, and was printed on 18th June 2007.
This map was produced with the intent that it be used for Jimperding Brook Foreshore Reporting at the scale of 1:90,000.
While the Department of Water has made all reasonable efforts to ensure the accuracy of this data, the Department accepts no responsibility for any inaccuracies and persons relying on this data do so at their own risk.


Map 5 – Overall stream enviromental health rating along Jimperding Brook
Avon River
Overall Stream Enviroment Health
Excellent (40-50)
Good (30-39)
Moderate (20-29)
Poor (10-19)
Very poor (0-9)
JB026
JB025
JB024
JB023
JB022
JB021
JB020
JB019
JB018
JB017
JB016
JB015
JB014
JB013
JB012
JB011
JB010
JB009
JB008
JB007
JB006
JB005
JB004
JB003
JB002
JB001
TR010A
Little Jimperding Brook TR010
TR009
TR008
TR007
TR006
TR006A
TR005
TR004
TR004A
TR003
TR003A
TR002
TR001
Gabidine Brook
Jingaling Brook
Jimperding Brook
St Johns Brook
Jim Crow Gully
SHIRE OF TOODYAY
SHIRE OF NORTHAM
SHIRE OF MUNDARING
0 1 2 3
Kilometres
N
SOURCES
DoW acknowledges the following datasets and their Custodians in the production of this map:
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Discussion with implications for management

Jimperding Brook is a significant tributary to the Avon River. It is located primarily in the Shire of Toodyay; however, a small section of the top end of the watercourse is located in the Shire of Northam. The survey was undertaken to assess the condition of the brook with consideration given to the impact that Jimperding Brook may have on the Avon River.

Distinct characteristics of Jimperding Brook

The survey was over a distance of 19.75 km. This was identified as the length of Jimperding Brook; however, the actual distance of the waterway, considering the meander pattern, was estimated to be 27.5 km.

A significant characteristic of the catchment was the high number of tributaries. There were 61 in total, of which 10 were considered to be major and were included as a part of the survey. In the upstream sections, the tributaries were of equivalent importance as the brook itself.

Jimperding Brook had the characteristics of a naturally functioning waterway through both its meander pattern and remnant riparian vegetation. However, the processes of degradation through erosion, salinity, livestock grazing and weed invasion were substantial.

Land tenure and riparian rights

The land tenure of Jimperding Brook, with the exception of road and rail reserves, is held in private tenure as freehold land. Any activities or works within road or rail reserves requires authorisation from the management body.

The law relating to rights to surface water is contained in the Rights in Water and Irrigation Act 1914 (RIWI Act). The Department of Water manages licensing of water and issues permits (for interference to the bed and/or banks) for wetlands and watercourses in proclaimed surface water areas. The Jimperding Brook catchment is located within an area that is proclaimed under the Act.

Landowners who have access to Jimperding Brook have riparian rights that allow the extraction of water from watercourses for stock and domestic purposes; however, taking water in excess of riparian rights (i.e. for commercial purposes) requires a licence.

The Department of Water encourages owners of properties adjacent to waterways to adopt a stewardship role to protect these precious water resources and recognise the rights of downstream users.

Channel erosion

The stream channel has altered significantly since natural vegetation has been cleared from the catchment, primarily for agricultural land use. Higher stream flow has caused the channel to erode. The brook has altered from what was previously considered to be a relatively shallow, stable and possibly braided channel to a deep, single channel. Loss of riparian vegetation and increasing soil salinity have further de-stabilised the channel.

The processes of erosion were very active in the channel of Jimperding Brook, particularly for the sections upstream from Toodyay Road. Undercutting and slumping of stream banks was occurring in all but three survey sections and is almost continuous in some sections. Bank erosion was active in sections where there was high sinuosity of the meander pattern (e.g. sections JB008 & JB009), where there was stock access to the brook and where fringing vegetation was sparse.

There is evidence that the bed of Jimperding Brook has eroded to a lower depth by up to 1.5 metres with some locations eroding to a depth of two to three metres. The active gully erosion in section JB006 was a prime example of the progression of these processes that were exacerbated by salinity and stock access.

The width of the channel upstream of Salt Valley Road was less than 10 metres while downstream it was generally wider.

Established saltwater couch (*Paspalum vaginatum)* combined with good fencing to control stock access in section JB003 demonstrated the potential for channel erosion to be stabilised. There were occasional occurrences of saltwater couch (*Paspalum vaginatum*) in other sections (e.g. JB010); however, these occurrences have not stabilised the banks or sediment downstream of section JB003.

Planting native vegetation increases bank stability and additionally provides habitat and improves water quality by filtering sediment and nutrients. Severely eroded banks may need stabilising prior to replanting to prevent plants from being washed away.

Where channel incision is the main cause of bank instability, the re-creation of pool-riffle sequences can be effective. This technique involves placing rocks or logs in straight sections or at meander crossovers to raise the channel bed and reduce the channel gradient, which effectively reduces flow velocity and encourages coarse sediment to drop out. Riffles have the added benefits of providing stable stock and vehicle crossings (Pen, 1999; Water and Rivers Commission, 1999b).

Sedimentation

A large volume of sediment has originated from channel erosion processes in Jimperding Brook and these processes continue to be active. However, it was significant to note that the volume of sediment deposition was only minimal. Most

sediment observed was medium to fine-grained. Coarse sediments were noted in very few locations.

Considering the significant discrepancy between the volume of sediments that have been eroded and the volume deposited, it may be assumed that a large volume of sediment has been transported from Jimperding Brook to the Avon River. The average channel gradient of 0.78 per cent for Jimperding Brook has indicated the high sediment transport capacity of stream flow in the brook. Sediments that were recorded may be temporary depositions.

The major tributaries had relatively high channel gradients. While no significant deposition of sediment was recorded at the confluence of these tributaries, they may be a further source of mobile sediments if also actively eroding upstream (this survey considered only the lower 200–500 metres of major tributaries).

Most riffles were formed by cobblestones. The stones were generally stable although they may be transported in major flood events. The accumulation of cobblestones in the Avon River near the confluence with the brook suggests these have been transported in the past.

The strategy for sediment management really depends on how much sediment is present and whether it is causing a problem; for example, where stabilised sediment is deflecting flow into banks and causing further erosion. If sediment slugs do not pose a risk to bank stability then suitable native species, such as Native marine couch (*Sporobolus virginicus*) or shore rush (*Juncus krausii*), can be planted to stabilise the plume. Some of the sediment slugs in Jimperding Brook have colonised naturally by sedges or rushes but most commonly by Salt water couch (*Paspalum vaginatum*). Where plumes are causing problems, sediment may need to be mechanically removed or encouraged to move further downstream, either by managed grazing to de-stabilise the plume or deflecting flow into the plume (Pen, 1999).

In conjunction with the stabilisation of existing sediment slugs, the sediment source also needs to be managed by stabilising banks to prevent further erosion. Where the sediment source is bank erosion, river banks need to be stabilised using techniques such as revegetation, rebuilding pool-riffle sequences and replacing large woody debris. Where soil erosion in nearby paddocks is a significant sediment source, surface water management is necessary to minimise erosion.

Water quality

Stream flow salinity was not particularly high for Jimperding Brook and was significantly lower than that of the Avon River during the survey period. Previous water quality monitoring (Bloom, et al. 2002) showed salinity levels were higher in some locations. Sampling near Salt Valley Road showed the highest stream salinity.

The previous water quality monitoring (Bloom, et al. 2002) indicated a high level of phosphorus (P) in stream flow. This originated from dissolved farm fertiliser transported by surface and sub-surface flow from the catchments. This form of nutrient transport is greatest from areas with deep sandy soils and least from clay soils. The sampling identified stream flow from the major tributary TR003 to have the highest level of P.

In addition to nutrients measured in stream flow, are the nutrients transported in sediments during high flow events. This could be quite substantial for Jimperding Brook. The sediments were relatively fine-grained and may have a high P content. Further nutrients were from stock manure washed into the brook where there was inadequate filtering capacity in the remaining riparian vegetation.

Stream flow had a low alkaline trend and this was not considered to be significant for management.

The most effective way to manage water quality is through integrated catchment management, where the catchment is managed as a whole across the diverse range of social, economic and ecological activities that occur. These recommendations are beyond the scope of this report; however, there are a number of management activities that can be implemented along Jimperding Brook and its tributaries to improve water quality.

Restoring the fringing vegetation along the main channel of Jimperding Brook and its tributaries is an important step in improving water quality. This could be achieved through fencing to exclude stock (except for crash grazing to control weeds), installing fenced or off-stream watering points, weed control and revegetation. Restoring fringing vegetation would improve water quality by improving bank stability to minimise erosion and sedimentation and filtering nutrients and sediments from streamflow and run-off. As well as allowing natural regeneration of native species, stock exclusion has the added benefit of reducing the direct contribution of manure to the nutrient load in the river.

From a nutrient management point of view, it is also important to manage point sources of pollution; for example, stock yards close to the river that may contribute high concentrations of nutrients into the river. Stock yards should be located well away from riparian areas and other water sources such as dams, drains or waterways. If, due to land constraints, this is not possible it is vital to manage surface water flow so that run-off does not transport manure into nearby water sources.

Riparian vegetation

The original condition of riparian vegetation for Jimperding Brook is indicated by that which remains in section JB024 and parts of JB023. This referral to near-natural vegetation shows that the condition of riparian vegetation for the brook has declined significantly.

The flooded gum (*Eucalyptus rudis*) and wandoo (*Eucalyptus wandoo*) were the most commonly occurring dominant over-storey species. It was interesting to note that swamp paperbark (*Melaleuca raphiophylla*) did not occur consistently until downstream from Salt Valley Road. Flooded gum (*Eucalyptus rudis*), swamp paperbark (*Melaleuca raphiophylla*) and the golden wreath wattle (*Acacia saligna*) all have high capacity to regenerate but were restricted by stock grazing.

The foliage of flooded gum (*Eucalyptus rudis*) was significantly affected by Jarrah Leaf Miner (*Perthida glyphopa*) downstream from section JB016.

The most significant factor for management of the remaining riparian vegetation was the almost continuous absence of middlestorey shrubs, understorey plants and native groundcover. The very high level of weeds and livestock grazing restricted these from regenerating.

Revegetating the riparian zone has a number of benefits, including:

- improved water quality
- increased bank stability
- increased aesthetic and recreational value
- filtering of sediment and nutrients from streamflow and overland flow
- provision of essential habitat for terrestrial and in-stream fauna and corridors for native wildlife
- localised salinity control (Water and Rivers Commission, 2001; Pen, 1999).

Revegetation of the riparian zone needs to be based on realistic outcomes that are practical and realistic to achieve and maintain. Undertaking riparian revegetation presents unique challenges due to the changes in the landscape brought about by widespread land clearing. Increased waterlogging, increased salinity and changes in flow regime in the Jimperding Brook catchment mean that many of the original species may not be able to survive; therefore, plant species tolerant to waterlogging and salinity may need to be chosen. Badly eroded banks may need to be stabilised before planting can take place to prevent newly established vegetation from being washed away and weeds may need to be controlled so that they do not compete with native seedlings for light, water and nutrients (Water and Rivers Commission, 2001).

Prioritiies need to be established for management works to gain the greatest benefit from the available resources. As a general rule, the greatest benefit to both landholders and the environment comes from protecting and enhancing areas of riparian vegetation in good condition, that is those that are relatively intact and weed-free, and then working towards more degraded areas (Water and Rivers Commission, 2001; Price and Lovett, 1999).

The choice of species for revegetation depends very much on the reasons for revegetating and the environmental characteristics of your site, including the position of the site in the landscape, soil type and salinity and waterlogging characteristics. For example, if you were revegetating to control erosion you would choose different

species to those you would plant to increase biodiversity or improve water quality. Similarly, you would choose different species if you were revegetating within the floodway as opposed to the verge or if your site was heavily salt-affected or waterlogged. Having said that, planting for any of the purposes outlined above will have multiple benefits so that revegetating to improve water quality may also have benefits for erosion control and biodiversity (Water and Rivers Commission, 2001; Water and Rivers Commission, 1999b).

Native species suitable to use for revegetation along Jimperding Brook include shore rush (*Juncus krausii*), native marine couch (*Sporobolus virginicus*), jam wattle (*Acacia acuminata*), swamp paperbark (*Melaleuca rhaphiophylla*), flooded gum (*Eucalyptus rudis*) and swamp sheoak (*Casuarina obesa*).

For more detailed information on revegetating riparian areas, refer to Riparian plants of the Avon catchment: A field guide by Brendan Oversby (2004), available from the Avon Catchment Council. The Council can be contacted by email <avonnrm@agric.wa.gov.au> or by telephoning 9690 2250. The Avon Catchment Council's website is <www.avonnrm.org.au>.

Weeds

Annual weeds occurred very commonly in all sections of Jimperding Brook with the exception of section JB024.

Weeds that were significant to management include spiny rush (*Juncus acutus*), cape tulip (*Homeria* spp.), soursob (*Oxalis pes-caprae*), Paterson's curse (*Echium plantagineum*) and bulrush (*Typha* spp.). Both spiny rush (*Juncus acutus*) and bulrush (*Typha* spp.) occurred in small numbers in most sections where they were recorded, so they are at a level that could be controlled. Both of these weeds have significant potential to expand and affect the river environment. These were difficult to control when established at a high level.

It is significant to note that bridal creeper (*Asparagus asparagoides*) was not evident in Jimperding Brook.

In some circumstances, weeds perform a useful role in rehabilitation and streambank stabilisation. Salt water couch (*Paspalum vaginatum*) for example, colonises bare areas on streambanks and verges and is useful in stabilising areas that would otherwise be vulnerable to erosion. This should only be considered a short-term solution and native species, including native marine couch (*Sporobolus virginicus*), bare twigrush (*Baumea juncea*) and shore rush (*Juncus kraussii*), should be encouraged to grow in their place. Weeds can also consolidate sediment slugs, preventing sediment from moving further downstream. In some circumstances however, dense weed growth in the channel can retard stream flow and cause sedimentation and raising of the channel bed, subsequently leading to flooding (Pen, 1999).

Issues to consider about when deciding on how to manage a weed problem include:

- The area(s) that should be targeted first. Generally it is good practice to target smaller infestations in good quality native vegetation first and then work towards more degraded areas.
- The order in which weeds should be removed – determined by which species are the most invasive and the size of the infestation(s).
- The control method (or combination of methods) which will be the most effective given the weed species, the size of the infestation and the cost.
- The time of year you need to implement the control strategy for it to be most effective.

Weeds growing along road verges close to Jimperding Brook and its tributaries also need to be controlled to reduce the risk of them spreading into the riparian zone.

Broad management strategies for managing weeds include controlled stock grazing, herbicides, manual removal and natural suppression. Using herbicides in riparian areas involves some extra care to avoid spray drift and the use of chemicals that move easily through soils and could leach into waterways. There are a number of selective and non-selective herbicides suitable for use near waterways on the market (Scheltema and Harris, 1995; Brown and Brooks, undated).

Fencing

The riparian zone of Jimperding Brook was not well fenced. Only 10.8 per cent of the length of the brook had fencing in good condition along both sides. A further 10.5 per cent had fencing both sides in moderate condition. The total length of fencing required for at least moderate condition fencing for the entire brook was 26.5 km; however, it was recognised that for some sections, adjacent land may not be stocked so fencing would not be required.

Fencing the lower sections of major tributaries to facilitate regeneration of riparian vegetation would assist in controlling the spread of weeds, particularly spiny rush (*Juncus acutus*).

There are many advantages of fencing waterways, both to farmers and the environment, including:

- reduced stock losses from flooding
- more freedom to leave the property as stock do not have be checked as often
- time saved rounding up stock
- a reduction in the amount of productive land lost to erosion
- the provision of shelter for stock from riparian vegetation acting as a windbreak
- improved water quality
- fewer cross-creek fences
- improved bank stability
- improved property appearance and resale value (Rutherfurd et al, 2000; Bell and Priestley, 1998).

The easiest way to exclude stock from riparian areas is by fencing and constructing stock crossings and watering points. In some circumstances, it is not practical to completely exclude stock. If riparian land is to be grazed, for example for weed control, there are several guidelines that can be followed:

- Only graze riparian areas when soil is relatively dry and the bulk of the vegetation is dormant.
- Avoid grazing during the growing, flowering and germination seasons of native vegetation, which typically means spring and summer.
- Adjust stocking rates and frequency of grazing to suit the sensitive nature of the land (Price and Lovett, 1999).

A frequently asked question in relation to fencing waterways is: How far away from a waterway should the fence be placed? The ideal width of the fenced area depends on a number of factors including the form of the river valley, the presence of riparian vegetation that needs to be protected, and frequent flood levels. The fenced off area must be able to function as a waterway and wherever possible the floodway should be included to contribute to waterway functioning, reduce stock and property losses and reduce fence repair and maintenance. As a general guide, a river fence along a major waterway, such as Jimperding Brook, should ideally be located a minimum of 30 m from the edge of the channel (Water and Rivers Commission 2000e).

To assist landholders in the Avon River catchment, the Department of Water and the Avon Catchment Council developed the Avon River Basin Fencing Project, which supplies materials for the fencing of foreshore areas. Landholders whose property lies adjacent to the Avon River or its tributaries (including Jimperding Brook) may be eligible for materials to construct a new fence or to replace existing fencing in poor condition. Landholders who receive fencing enter into a voluntary agreement to erect and maintain the fence and to allow only limited stock grazing to control weeds. For more information contact the Department of Water ‘s Northam office on 9690 2600.

There are several fences along Jimperding Brook that cross the main channel; this is a necessity in many instances to prevent livestock from wandering onto neighbouring properties. Where possible, fences should be located on a straight section of the river or at the crossover point on a meander bend and not on meander bends where fences may exacerbate scouring (Water and Rivers Commission, 2000f).

Fences can be constructed to resist flood damage by constructing them at the lowest height to give adequate stock control, locating posts as close together as possible and in as firm soil as possible – that is in clay as opposed to sandy soils. Fences crossing waterways also need regular maintenance to prevent damage from accumulating flood debris.

Stock crossings protect livestock and the river from problems associated with unrestricted access, plus they have the added benefit of acting as ‘riffles’ which aerate the water, trap sediment and provide habitat for aquatic fauna. Stock crossings should not adversely affect the flood conveyance or stability of the channel.

Site selection for crossings is the most important consideration as incorrect siting can exacerbate erosion and cause the crossing to be washed out. Crossings should always be sited along straight sections of the waterway or on the crossover point of a meander bend. The crossing should be as low as is practicable, be constructed by bed hardening, for example using rock, and should not change the profile of the channel. It is also good practice to extend the rock cover up the banks to the high water mark to provide better footing for stock and prevent damage to banks caused by livestock and scouring from high flows (Water and Rivers Commission, 2000a).

On-stream watering points are relatively simple to construct and maintain, provided they are located properly. The width of the construction can vary from between two and 20 m depending on stock numbers and how many access points are available. It is good practice to locate access points on the inside of a bend where water movement is slowest and there is less chance of scouring. The outer bend of meanders is where banks actively erode and is therefore more sensitive to trampling.

Other things to keep in mind are to site access points where:

- streambank gradients are relatively low (1:6 or under) to prevent erosion and enable stock to easily access water
- access ramps can be angled away from direction of flow (Water and Rivers Commission, 2000a; Lovett and Price, 1999).

While on-stream access points minimise trampling of the banks, they do not prevent nutrients entering the water and, unless they are sited properly and regularly maintained, they can cause serious erosion problems. Pumping water from waterways directly into a trough or tank is a good alternative to the construction of on-stream watering points. There are a number of options available including electrical mains, solar, wind, petrol and diesel-powered systems (Water and Rivers Commission, 2000b).

More information on fencing waterways and installing stock crossings and watering points is available from Department of Water in Northam on 9690 2600 or on its website <http://www.water.wa.gov.au>.

Foreshore condition and river health

Jimperding Brook is in poor condition with a high level of erosion and weeds. There are very few sections with a low level of weeds and where erosion is minimal. The broader stream health rating shows that only 12 of the survey sections are rated as at least ‘moderate’ (score of 20 or more).

Despite the current poor condition and relatively low stream environment health, Jimperding Brook has the capacity to recover in response to management. Most sections have indications of riparian vegetation regeneration, but this is limited where there is stock access. The sections that are fenced to control stock access

demonstrate the potential for the recovery of the riparian zone and for stabilisation of stream channel processes.

Significant environmental weeds, including sharp rush (*Juncus acutus*) and bulrush (*Typha* spp.), can be controlled while at relatively low levels in most sections. These are expected to increase significantly without management control.

Large woody debris

Large woody debris (or snags) refers to branches, large limbs or whole trees lying in the channel. It is an essential component of the river ecosystem, providing habitat to a myriad of aquatic fauna and physically protecting banks from erosion. It is a common belief that the presence of large woody debris causes flooding and that its removal will increase flood conveyance. This is the reason that large woody debris was removed from the Avon River through the Avon River Training Scheme between 1958 and 1970.

Removal of snags does increase flow velocity, but doesn't necessarily reduce flood risk, and it comes at the cost of significantly reducing bank stability and river habitat. One of the effects of the training scheme on the Avon River has been the in-filling of river pools with mobilised sediment, resulting in a loss of habitat and recreation areas (Pen, 1999; Harris, 1996).

When restoring snags, the natural load of the waterway can be estimated from looking at the amount of wood present in undisturbed reaches of the waterway (or in nearby waterways under the same conditions). Snags are best placed on the outside and downstream of bends to help minimise erosion. In some cases, natural large woody debris may be deflecting flows into banks and causing erosion. In these situations snags can be re-angled so as to protect the eroding bank (Price and Lovett, 1999).

Fire management

The dominance of grassy, annual weeds in the understorey and the fact that the vegetation along Jimperding Brook exists as a corridor, may pose a fire risk. A severe and uncontrolled fire in the riparian zone could potentially cause damage to farm assets, such as fences, stock and native vegetation, as well as reducing habitat available for native fauna and leaving the riparian zone vulnerable to weed invasion and erosion. Under controlled circumstances, where risks are minimised, fire can be beneficial to native vegetation by stimulating some plant species to germinate; however, in most cases preventing fire is the management aim (Price and Lovett, 1999).

Firebreaks along foreshore verges are important to protect fragile riparian vegetation and fences from unintentional fires that may result from stubble burning in adjacent paddocks. Firebreaks and fences along riparian verges should be maintained and

upgraded if necessary. When fencing for riparian zone protection, firebreaks should be on the river side of the fence, allowing easy access to the area and preventing stock from pushing through fences to graze on the other side of the fence. It is also important that there is vehicle access to the riparian zone so that fires that break out in this area can quickly be controlled.

The Avon Waterways Committee has developed a fire policy setting out objectives for bushland management in and around the Avon River and its major tributaries (refer to Appendix 11). The main aims of the policy are to protect river ecosystems from uncontrolled fires, while managing the fire hazard in riparian areas to minimise the threat to the river environment and adjacent land holders.

Impact on the Avon River and Swan estuary

The survey of Jimperding Brook has recorded the high level of erosion and the low level of sediment deposition in the channel of the brook. The survey did not directly measure the rate of sedimentation from Jimperding Brook. From this it was inferred that the relatively fine sediments have been transported from the brook to the Avon River and probably further downstream to the Swan–Canning estuary. The volume of sediment transported from Jimperding Brook as a result of channel erosion since the Avon River catchment was cleared for agriculture was estimated by the consultant to be approximately 100 000 m^3.

Jimperding Brook was continuing to erode and contribute sediment to waterways downstream.

Glossary

Algal bloom	The rapid excessive growth of algae, generally caused by high nutrient levels and favourable conditions.
Anabranch	A secondary channel of a river which splits from the main channel and then later rejoins the main channel.
Bank	The steeper part of a waterway channel cross section, which is usually considered to lie above the usual water level.
Bed stability	When the average elevation of the streambed does not change much through time.
Carrying capacity	The maximum population of organisms or the maximum pressure that an environment can support on a sustainable basis over a given period of time.
Catchment	The area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater.
Channelisation	The straightening of the river channel by erosional or mechanical processes.
Contour farming	Ploughing and planting along the contour of the land, rather than in straight lines, to help retain water and reduce soil erosion.
Culverted floodway	Crossing or causeway across a watercourse that incorporates culverts for the conveyance of flood waters
Culverts	Pipes incorporated into roads or tracks to cater for surface water drainage
Debris	Loose and unconsolidated material resulting from the disintegration of rocks, soil, vegetation or other material transported and deposited during erosion.
Degradation	Specifically for waterways, the general excavation of a streambed by erosional processes over a number of years. Has a broader meaning of reduction in quality.
Discharge	Volumetric outflow of water, typically measured in cubic metres per second.
Ecosystem	A term used to describe a specific environment, e.g. lake, to include all the biological, chemical and physical resources and the inter-relationships and dependencies that occur between those resources.
Electrical conductivity (EC)	A measure of salinity. The higher the electrical conductivity of a stream, the greater the salinity.

Electric fence	Any fence design which is electrified, irrespective of whether it consists of electric tape, a single smooth electric wire or four plain wires of which two are electric.
Environment	All the biological and non-biological factors that affect an organism's life.
Environmental degradation	Depletion or destruction of a potentially renewable resource such as soil, grassland, forest or wildlife by using it at a faster rate than it is naturally replenished.
Erosion	The subsequent removal of soil or rock particles from one location and their deposition in another location.
Eutrophication	An excessive increase in the nutrient status of a waterbody.
Evaporation	A physical change in which liquid changes into a vapour or gas.
Exotic vegetation	Introduced species of vegetation from other countries or from other regions of Australia (i.e. not endemic to the region).
Fabricated fence	Includes rabbit netting, sheet metal and hinge joint fences.
Flood fringe	The area of the floodplain, outside the floodway, which is affected by flooding. This area is generally covered by still or very slow-moving waters during high flood events.
Floodplain	A flat area adjacent to a waterway that is covered by floods every year or two.
Floodway	The river channel and portion of the floodplain which forms the main flow path of flood waters once the main channel has overflowed.
Floodway and bank vegetation	Vegetation which covers the floodway and bank part of the riparian zone. The vegetation which actually grows in the floodway or on the banks above the stream.
Foreshore	Area of land next to a waterway.
Groundwater	Water which occupies the pores and crevices of rock or soil.
Gully erosion	Creation of a gully from erosion occurring in areas of concentrated run-off. Unstabilised gullies advance up gradient.
Habitat	The specific region in which an organism or population of organisms live.
Hydrology	The study of water, its properties, distribution and utilisation above, on and below the earth's surface.
Large woody debris	A branch, tree or root system that has fallen into or is immersed (totally or partially) in a waterway.

Leaf litter	The uppermost layer of organic material in a soil, consisting of freshly fallen or slightly decomposed organic materials which have accumulated at the ground surface.
Levee	An artificial embankment or wall built to exclude floodwaters, or a natural formation next to a waterway built by the deposition of silt from floodwaters.
Monitoring	The regular gathering and analysing of information to observe and document changes through time and space.
Native species	Species that normally live and thrive in a particular ecosystem.
Organism	Any form of life.
Overgrazing	Destruction of vegetation when too many animals feed too long and exceed the carrying capacity of an area.
Pest plant	Weed species that are seen as being a nuisance to the existing land use. Local government authorities can enforce the control of such a species.
pH	Technically, this is the hydrogen ion (H+) concentration in the water. It is the simplest measure of acidity/alkalinity.
Pollution	Any physical, chemical or biological alteration of air, water or land that is harmful to living organisms.
Regeneration	Vegetation that has grown from natural sources of seed, from vegetative growth, or has been artificially planted.
Riffle	The high point in the bed of the stream (accumulation of coarse bed materials) where upstream of accumulations a shallow pool is formed. Downstream from the crest of the accumulation the water is often shallow and fast flowing.
Riparian zone	Refers to the zone directly adjoining a waterway. Any land that adjoins, directly influences, or is influenced by a body of water.
Salinisation	The accumulation of salts in soil and water which causes degradation of vegetation and land.
Sediment	Soil particles, sand and other mineral matter eroded from land and carried in surface waters.
Sedimentation	The accumulation of soil particles within the channel of a waterway.
Slumping	The mass failure of part of a stream bank.
Snags	Large woody debris such as logs and branches that fall into waterways.
Subsidence	Sinking or settling of the ground surface due to natural or anthropogenic causes.

Terrestrial	Relating to land.
Threatened Ecological Community	A Threatened Ecological Community (TEC) is one that is either presumed totally destroyed, critically endangered, endangered or vulnerable.
Turbidity	A measure of the suspended solids in the water.
Undercutting	The undermining or erosion of soil by water from underneath an existing landform (i.e. riverbank), structure (i.e fence post) or vegetation (i.e. tree).
Verge	The area extending from the top of the bank to the next major vegetation or land use change.
Verge vegetation	The strip of land up to 20 m from the immediate river or creek valley.
Waterlogging	Saturation of soil with irrigation water or excessive rainfall, so that the water table rises close to the surface.
Water quality	The physical, chemical and biological measures of water.
Weed	A plant considered undesirable, unattractive, or troublesome, especially growing where it is not wanted.

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Appendices

Appendix 1 Landholders adjacent to Jimperding Brook

Landholder	Location Numbers
Bloom, WR & LM	11
Chitty, WF	M1944
Chitty, WG	M1397, M1919
Christian, LP	3
Farrell, SJ	11
Farrell, SJ & AW	1, 3, 12, M1455
Farrell, SJ & Jovita Holdings Pty Ltd	10, 1283, 4113, 4114, M1455
Fulker, AJ	173
Hill, RN	3
House, SJ	11
Jovita Holdings Pty Ltd & Cherek Pty Ltd	6
Karratta Pty Ltd	M2039
Maslen, MM	4
Munckton, DL	4
Murray, IG	2, 4, 195, 864, 3204
No name given – Railway	0
Pearce, RV	257, 325, 954, M1105
Public Transport Authority	202
Ronan, KJ	5
Valli, P & E	15417
Walker, R & MJ	101
Yarralee Pty Ltd	1

Appendix 2
GPS coordinates (GDA 94) for Jimperding Brook survey sections

Section number	Easting	Northing
1	450119	6492972
2	449926	6493366
3	449710	6494007
4	449488	6494504
5	449169	6495158
6	448532	6495601
7	447708	6495565
8	447368	6495788
9	446927	6496416
10	446590	6496649
11	446122	6497003
12	445909	6497471
13	445380	6498217
14	445302	6498860
15	445235	6499742
16	444772	6500841
17	444648	6501469
18	444605	6501804
19	444240	6502351
20	443855	6502833
21	442949	6503252
22	442345	6503447
23	441064	6504237
24	439641	6504615
25	439628	6505113
26	439775	6505930
End	439944	6506126

Appendix 3
Foreshore and Channel Assessment Field Survey Form

For property and paddock scale surveys

General details

Recorder's name: Viv Read and Chrystal King — Survey date: ……

Tributary name: Jimperding Brook — Section number: …….

Catchment name: Avon River — Length of section: ……...

Sub-catchment name: …….. — Shire: Toodyay

GPS (start of survey section) E: ……..…… N:…..……

GPS (end of survey section) E: …….. N: …….

Landholder contacted: Yes ❒ No ❒ — Bank(s) surveyed (facing upstream)

Landholder consent obtained: Yes ❒ No ❒ — Left ❒ Right ❒ Both ❒

Landholder present during survey: Yes ❒ No ❒

Landholder: …….. Contact Number: .....

Property address: ……

Bank Stability

Proportion of bank affected (% of survey area)	Undercutting	Firebreak/track washouts	Subsidence (sinking of soil)	Erosion	Gully erosion	Sedimentation	Slumping (mass movement)
0-5% Minimal							
5-20% Localised							
20-50% Significant							
>50% Severe							

Are the banks subject to any artificial stabilisation?: ❒ Yes ❒ No

Give details:

……

……

……

Waterways Features

❒ Single channel
❒ Braided channel
❒ Deep pool
❒ Wetlands
❒ Groundwater seep
❒ Natural riffle
❒ Anabranch
❒ Tributary
❒ Large woody debris
❒ Vegetated island
❒ Constructed riffles
❒ Sediment slug
❒ Crossing
❒ Dam
❒ Bridge
❒ Other
……
……

Vegetation Health

❒ Looks healthy ❒ Some sick trees (some foliage loss) ❒ Many sick or dying trees ❒ Some dead trees ❒ Many dead trees

Are there any tree seedlings or saplings present?: ❒ Yes ❒ No Species: ……

Leaf litter: ❒ Absent ❒ Minimal cover ❒ Good cover ❒ Deep cover

Bare Ground: % cover: …….

Native vegetation: ❒ Abundant ❒ Frequent ❒ Occasional ❒ Rare ❒ Absent

Exotic vegetation: ❒ Abundant ❒ Frequent ❒ Occasional ❒ Rare ❒ Absent

Instream cover: ❒ Leaf litter/detritus ❒ Rocks ❒ Branches ❒ Vegetation

Vegetation cover (Native and weeds)

Proportion cover	Overstorey	Middlestorey	Understorey
> 80% Continuous			
20-80% Patchy			
< 20% Sparse			
0% Absent			

Proportion of Native Species

	Proportion (%) of native species
Overstorey	
Middlestorey	
Understorey	

Habitats

Aquatic organisms

Invertebrates, reptiles and fish
- Cascades, rapids, riffles
- Meanders, pools
- Instream cobbles, rocks
- Instream logs
- Variety of instream and bank vegetation types

Terrestrial animals

Invertebrates
- Variety of vegetation types
- Protected basking sites (tree bark, leaf litter)

Birds (roosting/nesting sites)
- Trees
- Shrubs
- Rushes

Frogs
- Dense fringing vegetation
- Emergent plants/soft substrate for eggs

Reptiles
- Variety of vegetation types
- Protected basking/nesting sites (leaf litter, logs)

Mammals
- ❒ Dense protective vegetation

Habitat Diversity

Any data or observations on variation in water depth? Evidence – debris, water marks, salt deposits etc

Any data or observations on water quality? (i.e. discoloured water, debris, algal blooms)

Landform Types

Description/Diagram (ie. major v-shaped river valley with granite outcrops, shallow valley with low relief).

Fencing status

Fence section 1

Start……E Start……..N End……..……E End…….……..N

Left bank □ Right bank □ Fence condition: □Good □ Moderate □ Poor □ No fence

Fence style: □ Barbed wire □ Electric □ Fabricated □Ringlock □ Plain wire

Approximate distance [m] from main channel: □>10m □ 10-20m □ 20-30m □ >30m

Fence section 2

Start……E Start……..N End……..……E End…….……..N

Left bank □ Right bank □ Fence condition: □Good □ Moderate □ Poor □ No fence

Fence style: □ Barbed wire □ Electric □ Fabricated □Ringlock □ Plain wire

Approximate distance [m] from main channel: □>10m □ 10-20m □ 20-30m □ >30m

Fence section 3

Start……E Start……..N End……..……E End…….……..N

Left bank □ Right bank □ Fence condition: □Good □ Moderate □ Poor □ No fence

Fence style: □ Barbed wire □ Electric □ Fabricated □Ringlock □ Plain wire

Approximate distance [m] from main channel: □>10m □ 10-20m □ 20-30m □ >30m

Fence section 4

Start……E Start……..N End……..……E End…….……..N

Left bank □ Right bank □ Fence condition: □Good □ Moderate □ Poor □ No fence

Fence style: □ Barbed wire □ Electric □ Fabricated □Ringlock □ Plain wire

Approximate distance [m] from main channel: □>10m □ 10-20m □ 20-30m □ >30m

Fence section 5

Start……E Start……..N End……..……E End…….……..N

Left bank □ Right bank □ Fence condition: □Good □ Moderate □ Poor □ No fence

Fence style: □ Barbed wire □ Electric □ Fabricated □Ringlock □ Plain wire

Approximate distance [m] from main channel: □>10m □ 10-20m □ 20-30m □ >30m

Stock access to foreshore: □Yes □ No Vehicle access to foreshore: □Yes □ No
Crossing Point: ❒ Yes ❒ No

Foreshore Condition Assessment

A Grade Foreshore	B Grade Foreshore	C Grade Foreshore	D Grade Foreshore
A1 Pristine	B1 Degraded – weed infested	C1 Erosion prone	D1 Ditch – eroding
A2 Near pristine	B2 Degraded – heavily weed infested	C2 Soil exposed	D2 Ditch – freely eroding
A3 Slightly disturbed	B3 Degraded – weed dominant	C3 Eroded	D3 Drain – weed dominant

(Choose one of the above. Use Grades A, B, C or D for General condition and use sub-grades for best and poorest ratings ie A1 through to D3)

General: Best: Poorest:

Overall Stream Environmental Rating

Rating	Floodway & bank vegetation	Verge vegetation	Stream Cover	Bank stability & sediment	Habitat diversity
Excellent	15	8	8	8	6
Good	12	6	6	6	4
Moderate	6	4	4	4	2
Poor	3	2	2	2	1
Very poor	0	0	0	0	0

Surrounding landuse:

Conservation reserve (8) Urban (2) Agricultural (2)

Rural residential (4) Remnant bush (6) Commercial/industrial (1)

Total score = ☐

Score	40-55	30-39	20-29	10-19	0-9
Rating	Excellent	Good	Moderate	Poor	Very poor

Evidence of Management

Tick the appropriate boxes:

❒ Prescribed burning ❒ Weed control ❒ Sediment management
❒ Firebreak control ❒ Revegetation ❒ Other:……..
❒ Fencing ❒ Erosion control

Management Issues

Tick the appropriate priority box for each management issue. If the issue does not exist along this section of the waterway it can be crossed out.

Issue	Priority		
	High	Medium	Low
Fire			
Disease			
Weeds			
Erosion			
Salinity			
Sediment			
Stock Access			
Vehicle Access			
Rubbish			
Pollution			

Issue	Priority		
	High	Medium	Low
Recreation			
Service Corridors (roads)			
Crossing point			
Feral Animals			
Point source discharge			
Pumps or off-take pipes			
Dam/weir			
Cultural Features			
Other			

Ideas for Management

Tick the appropriate boxes:

❒ Firebreak control ❒ Stock/vehicle crossing ❒ Riffles
❒ Fencing ❒ Revegetation ❒ Sediment management
❒ Erosion control ❒ Weed control
❒ Other: ……

Native plant list

Introduced plant list

Native fauna list

Introduced fauna list

Water Quality Data

Sample Number	pH	Conductivity mS/cm	Temperature ºC	Location

GPS Coordinates

Coordinate	Description

Photos

Photo number	Description

Appendix 4 Foreshore condition grade descriptions

River foreshore condition grades

A Grade

Foreshore has healthy native bush (ie. similar to that found in nature reserves, state forests and national parks).

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

A2. Near Pristine – Native vegetation dominates. Some introduced weeds may be present in the understorey but not as the dominant species. Otherwise, there is no evidence of human impact.

A3. Slightly Degraded – Native vegetation dominates. Some areas of human disturbance where soil may be exposed and weeds are relatively dense (ie. along tracks). Native vegetation would quickly recolonise if human disturbance declined.

B Grade

The foreshore vegetation had been invaded by weeds, mainly grasses and looks similar to typical roadside vegetation.

B1. Degraded – weed infested - Weeds have become a significant component of the understorey vegetation. Native species are still dominant but a few have been replace by weeds.

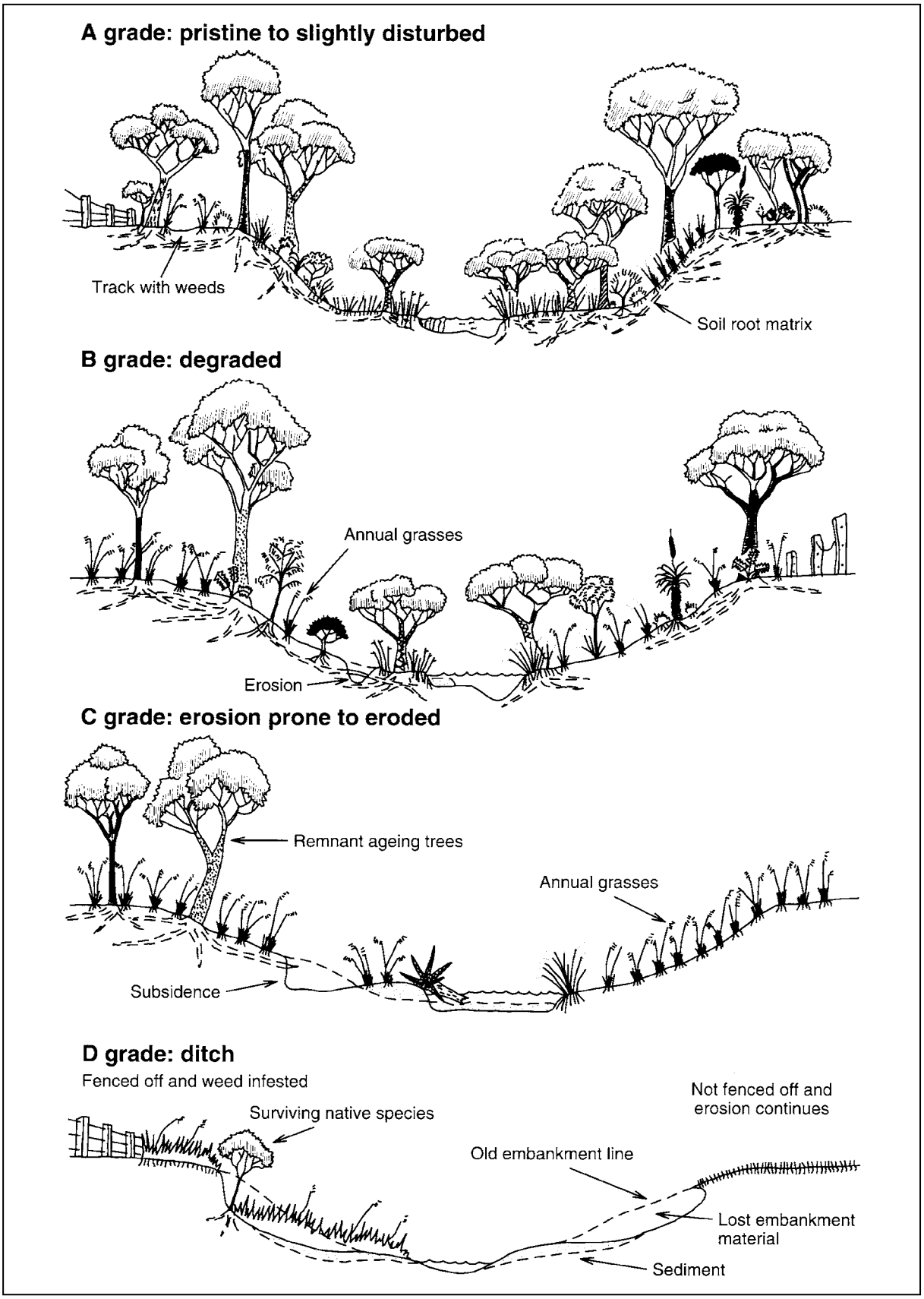
B2. Degraded – heavily weed infested - Understorey weeds are nearly as abundant as native species. The regeneration of trees and large shrubs may have declined.

B3. Degraded – weed dominant – Weeds dominate the understorey, but many native species remain. Some trees and large shrubs may have disappeared.

C Grade

The foreshore supports only trees over weeds or pasture. Bank erosion and subsidence may occur in localised areas.

C1. Erosion prone – Trees remain with some large shrubs or tree grasses and the understorey consists entirely of weeds (ie. annual grasses). There is little or no evidence of regeneration of tree species. River embankment and floodway are vulnerable to erosion due to the shallow-rooted weedy understorey providing minimal soil stabilisation and support.



Source: Water and Rivers Commission, 1999

C2. Soil exposed – Older trees remain but the ground is virtually bare. Annual grasses and other weeds have been removed by livestock grazing and trampling or through humans use and activity. Low level soil erosion has begun.

C3. Eroded – Soil is washed away from between tree roots. Trees are being undermined and unsupported embankments are subsiding into the river valley.

D Grade

The stream is little more than an eroding ditch or a weed infested drain.

D1. Ditch – eroding – There is not enough fringing vegetation to control erosion. Remaining trees and shrubs act to impede erosion in some areas, but are doomed to be undermined eventually.

D2. Ditch – freely eroding – No significant fringing vegetation remains and erosion is out of control. Undermined and subsided embankments are common. Large sediment plumes are visible along the river channel.

D3. Drain – weed dominant – The highly eroded river valley has been fenced off, preventing control of weeds by stock. Perennial weeds have become established and the river has become a simple drain.

Appendix 5 Foreshore information for each section and tributary

Table 5.1 Waterway Features (1 = feature present: 0 = feature not present)

Section number	Single channel	Braided channel	Deep pool	Large woody debris	Wetlands	Vegetation island	Tributary	Anabranch	Sand slugs	Dam	Natural riffle	Bridge
JB001	1	0	0	0	0	0	0	0	0	1	0	0
JB002	1	1	1	1	0	0	1	0	0	0	0	0
JB003	0	1	0	1	1	1	0	0	0	0	0	1
JB004	1	0	0	1	0	0	1	0	1	0	0	0
JB005	1	1	0	1	0	0	1	1	0	1	0	0
JB006	1	1	0	1	0	0	1	1	0	0	1	0
JB007	1	0	0	1	0	0	0	0	1	0	0	0
JB008	1	0	0	1	0	0	1	0	1	0	0	0
JB009	1	0	0	1	0	0	0	0	0	1	1	0
JB010	1	0	0	0	0	0	1	1	0	1	1	0
JB011	1	0	0	1	0	0	1	0	0	0	0	1
JB012	1	0	0	1	0	0	1	0	1	0	0	0
JB013	1	0	0	1	0	0	0	0	1	0	0	0
JB014	1	0	0	1	0	0	1	1	1	0	1	0
JB015	1	0	0	1	0	1	1	0	0	0	1	0
JB016	1	0	0	1	0	0	1	0	1	0	0	0
JB017	1	0	0	1	0	0	1	0	0	0	0	1
JB018	1	0	0	1	0	0	1	0	0	0	1	0
JB019	1	0	0	1	0	0	1	0	1	0	0	0
JB020	1	0	1	0	0	1	1	0	0	0	0	0
JB021	1	0	1	0	0	0	1	0	0	0	0	0
JB022	1	0	0	0	0	1	1	1	1	0	0	0
JB023	1	0	1	1	0	1	1	0	1	0	1	0
JB024	1	0	0	0	0	0	1	0	0	0	1	1
JB025	1	0	0	1	0	1	1	0	1	0	1	0
JB026	1	0	0	1	0	0	1	0	1	0	0	1
TOTAL	**25**	**4**	**4**	**20**	**1**	**6**	**21**	**5**	**12**	**4**	**9**	**5**

Section number	Single channel	Braided channel	Deep pool	Large woody debris	Wetlands	Vegetation island	Tributary	Anabranch	Sand slugs	Dam	Natural riffle	Bridge
TR001	1	0	0	1	0	0	0	0	0	0	0	0
TR002A	1	0	0	1	0	0	0	0	0	0	0	0
TR003A	1	0	0	1	0	0	0	1	0	0	0	0
TR004	1	0	0	0	0	0	0	0	0	0	0	0
TR005	0	1	0	0	0	0	0	1	0	0	0	0
TR006	1	0	0	0	0	0	0	1	0	0	0	0
TR007	1	0	0	0	0	0	0	0	0	0	0	0
TR008	1	0	0	1	0	0	0	1	0	0	0	0
TR009	1	0	0	1	0	0	0	0	0	0	0	0
TR010	1	0	0	1	0	0	0	1	0	0	0	0
TOTAL	**9**	**1**	**0**	**6**	**0**	**0**	**0**	**5**	**0**	**0**	**0**	**0**

Table 5.2 Channel and floodplain morphology

Section	Channel width (m)	Channel depth (m)	Floodplain LHS (m)	Floodplain RHS (m)	Section or tributary	Channel width (m)	Channel depth (m)	Floodplain LHS (m)	Floodplain RHS (m)
JB001	2	0.5–1			JB019	10–15	1.5–2	50–100	50–100
JB002	3–5	1	15–20	20–50	JB020	10–15	1–1.5	20–30	20–30
JB003	3–5	0.5–1	5–10	50–100	JB021	10–15	1–1.5		
JB004	3–5	1.5	50	50	JB022	10–15	1.5–2	100–200	100–200
JB005	3–5	1			JB023	10–15	1.5–2		
JB006	3–5	1–2	10–20	10–20	JB024	10–15	1.5		
JB007	5–10	1–1.5			JB025	15–20	1.5–2		
JB008	5–10	0.5–1			JB026	20–25	1.5–3		
JB009	5–10	0.1–0.2			TR001	1–3	0.5		
JB010	1–3	0.3–0.5	20–50	20–50	TR002	3–5	1		
JB011	3–5	1–1.5	Broad		TR003	3–5	1.5		
JB012	3–5	2	100–200	100–200	TR004	1–3	0.5–0.8		
JB013	5–10	1.5–2	30–50	30–50	TR005	3–5	1		
JB014	5–10	2–3	10–20	10–20	TR006	1–3	1.0–1.5		
JB015	10–12	1–1.5		30–50	TR007	1–3	1.0–1.5		
JB016	3–5	1–1.5	30	30–50	TR008	1–3	1		
JB017	5–10	1–1.5			TR009	NA	NA		
JB018	10–12	1–1.5	100–150	20–30	TR010	3–5	2		

Table 5.3 Channel erosion and sedimentation

Section	Under-cutting	Subsidence	Gully erosion	Sediments	Slumping	Section or tributary	Under-cutting	Subsidence	Gully erosion	Sediments	Slumping
JB001	20-50				20-50	JB019	5-20	5-20		5-20	20-50
JB002	< 5	< 5			< 5	JB020	5-20	20-50	< 5	< 5	20-50
JB003						JB021	5-20	< 5		5-20	20-50
JB004	>50	20-50	< 5	5-20	20-50	JB022	20-50	5-20	< 5	5-20	5-20
JB005	< 5	< 5	< 5	< 5	< 5	JB023	20-50	5 - 20		5-20	5-20
JB006	>50	20-50	>50	< 5	20-50	JB024					
JB007	5-20	5-20	< 5	5-20	20-50	JB025	5-20	5-20		5-20	5-20
JB008	< 5	5-20	< 5	5-20	5-20	JB026	< 5		5-20	20-50	5-20
JB009	5- 0	< 5	< 5	< 5	5-20	TR001					
JB010	20-50	5-20		5-20	5-20	TR002	< 5				
JB011	5-20	5-20	< 5	5-20	20-50	TR003	5-20		5-20	5-20	5-20
JB012	20-50	5-20		20-50	5-20	TR004	5-20			< 5	5-20
JB013	5-20	< 5	5-20	20-50	< 5	TR005	< 5		< 5	< 5	< 5
JB014	20-50	5-20		5-20	5-20	TR006	< 5		< 5	< 5	< 5
JB015	< 5					TR007		< 5		< 5	< 5
JB016	< 5	< 5		< 5	< 5	TR008		< 5		< 5	< 5
JB017	5-20	< 5			< 5	TR009					
JB018	< 5	< 5		< 5	20-50	TR010					

Note: all measures are in metres and where there is no measure given, there is no current issue.

Table 5.4 Water quality

Section	TDS* mg/L	pH	Section or tributary	TDS* mg/L	pH
JB001	7480	7.8	JB019	3905	7.8
JB002	6303	NA	JB020	3795	8.0
JB003	5555	NA	JB021	3850	8.1
JB004	9075	NA	JB022	3740	8.1
JB005	9185	NA	JB023	3960	8.2
JB006	8580	7.1	JB024	3795	8.3
JB007	5720	7.6	JB025	4015	8.3
JB008	5720	7.7	JB026	4015	8.0
JB009	5885	7.7	TR001	NA	NA
JB010	6105	7.9	TR002	5280	8.1
JB011	5830	8.1	TR003	3190	8.3
JB012	4290	NA	TR004	6600	7.8
JB013	4455	8.1	TR005	1815	8.1
JB014	4400	8.0	TR006	2695	7.6
JB015	4620	8.4	TR007	3740	7.6
JB016	4730	8.4	TR008	2805	8.3
JB017	4785	8.5	TR009	NA	NA
JB018	4840	8.0	TR010	3575	7.6

* *Total Dissolved Salts*

Table 5.5 Riparian zone vegetation strata cover

Section	Upper-storey	Middle-storey	Under-storey	Section or tributary	Upper-storey	Middle-storey	Under-storey
JB001	0	0	0	JB019	2	1	0
JB002	2	1	3	JB020	2	1	0
JB003	2	1	0	JB021	2	1	0
JB004	1	0	0	JB022	2	1	0
JB005	2	1	0	JB023	3	1	0
JB006	2	0	0	JB024	3	2	1
JB007	2	0	0	JB025	2	2	0
JB008	2	0	0	JB026	2	1	0
JB009	2	0	0	TR001	2	0	0
JB010	0	0	0	TR002	2	1	0
JB011	1	0	0	TR003	2	1	0
JB012	2	0	0	TR004	1	0	0
JB013	2	0	0	TR005	2	0	0
JB014	2	0	0	TR006	1	0	0
JB015	2	1	0	TR007	3	3	2
JB016	2	1	0	TR008	1	0	0
JB017	2	1	0	TR009	NA	NA	NA
JB018	2	1	0	TR010	2	1	0

Note: 3 = continuous (>80%); 2 = patchy (20–80%); 1 = sparse (<20%); 0 = absent.

Table 5.6 Riparian zone vegetation health and groundcover

Section	Bare ground (%)	Leaf litter	Vegetation health	Section	Bare ground (%)	Leaf litter	Vegetation health
JB001	5	Minimal	Some dead trees	JB019	5	Minimal	Some sick trees
JB002	0	Deep cover	Some sick trees	JB020	5	Minimal	Some sick trees
JB003	0	Deep cover	Some sick trees	JB021	5	Good cover	Some sick trees
JB004	10–15	Minimal	Looks healthy	JB022	5	Good cover	Some sick trees
JB005	0	Good cover	Looks healthy	JB023	5	Minimal	Some sick trees
JB006	20	Minimal	Some sick trees	JB024	15	Good cover	Some sick trees
JB007	5	Good cover	Some sick trees	JB025	0	Good cover	Looks healthy
JB008	15	Minimal	Some sick trees	JB026	5	Good cover	Some sick trees
JB009	10	Minimal	Looks healthy	TR001	5	Good cover	Looks healthy
JB010	5	Absent	None	TR002	5	Minimal	Looks healthy
JB011	5	Minimal	Looks healthy	TR003	5	minimal	Looks healthy
JB012	0	Minimal	Looks healthy	TR004	0	Good cover	Looks healthy
JB013	5	Good cover	Looks healthy	TR005	45	Minimal	Some sick trees
JB014	5	Good cover	Looks healthy	TR006	45	Minimal	Looks healthy
JB015	5	Minimal	Looks healthy	TR007	0	Good cover	Some sick trees
JB016	5	Minimal	Many sick trees	TR008	45	Good cover	Some sick trees
JB017	5	Minimal	Many sick trees	TR009	NA	NA	NA
JB018	5	Minimal	Many sick trees	TR010	45	Good cover	Looks healthy

Appendix 6 Survey section descriptions

Note: LHS and RHS references relate to facing upstream.

Section	Description
JB001 Section length 200 m	The most upstream section of the survey commenced where a defined channel of Jimperding Brook was first observed. Upstream from this, there were sand seepages. This section was in poor condition due to the absence of riparian vegetation, salinity and a high level of spiny rush (*Juncus acutus*). A dam was located within the riparian zone although this was not causing a problem. The channel has been excavated to drain the deep sandy soils in an attempt to reduce waterlogging and salinity. A Road Reserve separated this from the next section.
JB002 Section length 750 m	There was one major meander in this section before a tributary entered the brook on the RHS. While this was not identified as a major tributary, it did have significant stream flow. A second tributary entered on the LHS at the downstream end of this section. Riparian vegetation was relatively healthy and there was a small but well-defined and stable waterway. The riparian zone had good fencing. The upper end of this section was salt-affected; however, there has been some surface water earthworks and revegetation to address the issue. The channel has been excavated for a limited section connecting with the channel earthworks in JB01.
JB003 Section length 560 m	A stable section of the brook was in good condition with one small area of salinity. The channel was braided and stabilised by saltwater couch (*Paspalum vaginatum*). The riparian zone was fenced. The only 'wetland' of the brook was on the LHS of this section. It was a small salt-affected area of surface water probably maintained by groundwater seepage (E 449703, N 6494301). Downstream from the wetland was an area of bulrush (*Typha* spp.) and veldt grass (*Ehrharta* spp.) that could threaten swamp paperbark (*Melaleuca raphiophylla*). Regeneration (E 449578, N 6494420). The channel was excavated in one location (E 449703 N 6494096). There was a single 60 cm culvert floodway constructed at the end of this section.
JB004 Section length 720 m	This section was a distinct contrast to JB003 as there was no stabilising saltwater couch (*Paspalum vaginatum*), the stream was no longer braided, it meandered significantly and was unfenced. It was generally in poor condition with severe channel bank erosion and some significant slumping. It was significant to note that the channel base was estimated to be 1.5 metres lower downstream of the culverted floodway compared to immediately upstream of it. This indicated that the culverted floodway has halted the upstream advance of gully-head erosion in the channel. Riparian vegetation was generally healthy although there were no signs of regeneration. One stand of golden wreath wattle (*Acacia saligna*) was grazed. There was a major tributary on the RHS and several minor tributaries. **Major tributary – TR001** This waterway was of moderate condition with a high level of weeds. Riparian vegetation was healthy but sparse with no middlestorey or understorey and was not fenced. The channel was not significantly eroded and did not have a sediment load at the confluence. There was no flow at the time of survey (27.09.06). Confluence was at E 449274 N 6494803.

Section	Description
JB005 Section length 760 m	The brook made a significant change in orientation to the west. There were sinuous meanders in the upper section but these diminished downstream. Riparian vegetation was in reasonable condition but was sparse. The waterway was fenced on the LHS only. There was an area of revegetation on the RHS. There was an old crossing just downstream from the section start and another old crossing with a patch of bulrush (*Typha* spp.) (E 449040, N 6495400). There was another patch of bulrush (*Typha* spp.) about 500 metres downstream (E 448955 N 6495473). There was one more washed out crossing downstream. The abandoned crossing suggests that it was constructed with adequate capacity but the channel altered with increased stream flow over time. It was also possible that gully-head erosion progressed up the channel affecting crossings.
JB006 Section length 1080 m	The upstream part of this section had healthy regeneration of flooded gum (*Eucalyptus rudis*) but salinity has affected the brook about 100 metres downstream (E 448417 N 6495612). A further 100 metres downstream there was major gully erosion that significantly affected the waterway (E 448369 N 6495616). This was indicative of the processes of change that have probably occurred to most of the channel downstream caused by increased flow and unstable riparian conditions. This was occurring in a section with quite extensive riparian and adjacent remnant vegetation but was exacerbated by a progressive area of salinity. The channel had a high meander pattern so was prone to further erosion. There was an exposed dolerite intrusion which was probably the cause of salinity upstream from it. A tributary entered on the RHS with relatively high steam flow (EC = 790 mS/m, pH = 7.9). This had an extensive area of bulrush (*Typha* spp.) upstream from Chitty Road and a high level of spiny rush (*Juncus acutus)*. This was one of the poorest sections of Jimperding Brook due to active salinity and gully erosion and was in greatest need of intervention management.
JB007 Section length 280 m	A small section with good riparian vegetation. There was one small ‘slug’ of coarse sand sediment in the channel and one area of bank slumping about 100 metres downstream. There was a small area of saline seepage associated with a LHS tributary (E 447564, N 6495710). The section was fenced on one side only. A distinct character of this section was an ‘ox-bow’ channel formation on the LHS.
JB008 Section length 910 m	This section had a sinuous meander pattern and was prone to erosion and bank subsidence. Riparian vegetation was sparse and had an old fence on one side only. It was generally in poor condition. There was one section affected with a saline seepage (E 447246 N 6496001) with erosion and dead wandoo trees (*Eucalyptus wandoo*). Further downstream was an old crossing near an extensive farm rubbish dump, including 37 car bodies, branding fluid tins and domestic ‘white goods’.
JB009 Section length 400 m	A relatively short section over two properties. The channel has a high meander pattern in this section with localised areas of bank undercutting and slumping. There was a local of area of dolerite and granite rock outcrop (E 446751 N 6496549). Riparian vegetation is healthy but sparse. There is some rubbish washed down from the disposal site upstream.
JB010 Section length 630 m	This section is significantly eroded and is generally in very poor condition. The Foreshore Condition Assessment describes this section as a ‘freely eroding ditch’. The Overall Stream Environmental Assessment results in a score of two out of a possible 55. There is no riparian vegetation and the waterway is not fenced. There is active bank erosion in many parts but particularly about 100 metres downstream (E 446496 N 6496712). Approximately 300 metres downstream was a saline seep with active gully erosion and spiny rush (*Juncus acutus)* adjacent to a recently constructed dam (E 446391 N 6496794).

Section	Description
JB011 Section length 540 m	This section was also in very poor condition with significant channel bank slumping. Riparian vegetation, although healthy, was sparse. The riparian zone was effectively not fenced although there was a boundary fence on the RHS adjacent to the waterway. Flooded gum (*Eucalyptus rudis*) was regenerating although affected by grazing. This section ended at Salt Valley Road where there were two box culverts.
JB012 Section length 980 m	This was a long section extending downstream from Salt Valley Road. The riparian zone was in moderate condition with quite extensive fenced riparian vegetation in healthy condition although the understorey was dominated by weeds. Approximately 30 metres downstream was a scour pool about one metre deep. A levee has been constructed on the LHS of this initial part presumably as earthworks to reduce road flooding. There was active gully erosion in the adjacent floodplain. Two major tributaries join Jimperding Brook on the RHS. It was understood that TR002 (Jim Crow Gully) has caused localised flooding in some years. There was an extensive area of active sheet erosion adjacent to an extensive area of spiny rush (*Juncus acutus)* near the confluence. A farm crossing (five small culverts) was near the confluence. There was also a minor tributary on the LHS with commercial clay pits approximately one km upstream. This section had a highly sinuous meander pattern with significant and extensive bank erosion. There was old farm rubbish dumped on the LHS 400 metres downstream. This was not a threat to waterway condition. A significant ox-bow meander occurred 1.3 km downstream (E 445522 N 649 7692). This was actively eroding. There was further erosion of adjacent floodways and the floodplain. There was a small billabong on the RHS 1.5 km downstream (E 445457 N 6498119). **Major tributary – TR002** This waterway was of poor condition with a high level of weeds and prone to erosion. Riparian vegetation was healthy but sparse with minimal middlestorey and no understorey. It was fenced effectively. There was a broad floodplain that had significant sheet erosion, but there was no sediment load at the confluence. There was flow at the time of survey (26.09.06), pH = 8.1, conductivity = 960 mS/m measured 200 metres upstream). Confluence was at E 445619 N 6497636. **Major tributary – TR003** This waterway was of poor condition with a high level of weeds and prone to erosion. Riparian vegetation was healthy but sparse with minimal middlestorey and no understorey. It was not fenced. There was localised erosion and sediment load at the confluence. There was flow at the time of survey (26.09.06), pH = 8.3, conductivity = 580 mS/m measured approximately 200 metres upstream). Confluence is at E 445439 N 6497808.

Section	Description
JB013 Section length 640 m	This section was generally in poor condition with sparse riparian vegetation. The dominant vegetation was healthy although there was no middle or understorey. The riparian zone was not fenced and there was continuous stock access. There was a billabong on the LHS near the start of this section. This had benthic algal growth. The channel had a strong meander pattern with localised bank erosion and sediment deposition for a significant extent. There was gully erosion in the floodplain. At 600 metres downstream, there was a one metre gradient drop caused by a log-jam (E445297 N 6498642). This indicated the potential risk for accelerated gully erosion in the channel. For example, if a fire destroyed this log-jam, the gully erosion would rapidly progress upstream. There was a dense patch of recently regenerated flooded gum (*Eucalyptus rudis*) 800 metres downstream. This was adjacent to an area of fringing vegetation that was regenerating but heavily grazed (Ph 68, E 445302 N 6498860).
JB014 Section length 890 m	This section was in poor condition with a high level of weeds and channel erosion. The riparian vegetation was sparse but healthy, and there was no middle or understorey. There was partial fencing on one side only. The channel had a highly sinuous meander pattern with extensive bank erosion and significant bank undercutting. There was a ford crossing 700 metres downstream (E 445328 N 6499375).
JB015 Section length 1090 m	This section was in moderate condition with scattered but healthy regenerating vegetation overstorey. There was a sparse middlestorey and no understorey where weeds were dominant. It was partially fenced about 10 per cent of the length on both sides). The channel had moderate meanders, minimal erosion and no sediment deposition. The banks were exposed in sections but with a high level of embedded cobbles. These probably stabilised the banks and minimised erosion. This section was characterised by pool and riffle sequences. The riffles were of cobblestones. The cobbles do not extend more than 1.3 km downstream. There was one significant pool near the start of this section. There was one major tributary (TR004) and several minor tributaries on both sides. There was a fence and farm crossing 1.1 km downstream. There was also some rubbish (fencing wire). **Major tributary – TR004** This waterway was of poor condition with a high level of weeds; however, the channel was probably stable. Riparian vegetation was healthy but very sparse with no middlestorey or understorey. It was not fenced. There was flow at the time of survey (26.09.06), pH = 7.8, conductivity = 120 mS/m measured 200 metres upstream of the confluence). Confluence is at E 445278 N 6499788.
JB016 Section length 700 m	This section is classified as in poor condition with high weed levels. The upper story is sparse and is significantly affected by Jarrah Leaf Miner. This was the first observation of this impact on flooded gum (*Eucalyptus rudis*) in the survey (going downstream). However, flooded gum (*Eucalyptus rudis*) was regenerating. There was only sparse middlestory and the native vegetation understorey was absent. There was a poor fence on the RHS. There was one area of bulrush (*Typha* spp.) near the start of this section. The channel had a moderate meander pattern with minimal erosion. There was a sediment bar 100 metres downstream. There were many riffles.

Section	Description
JB017 Section length 340 m	This was a relatively short section that was in moderate condition but was dominated by weeds. Flooded gum (*Eucalyptus rudis*) was significantly affected by Jarrah Leaf Miner but was regenerating. The riparian vegetation was limited in extent, had sparse middlestorey and no understorey. There was partial fencing on the LHS. There was a low meander pattern with localised bank under-cutting. There was no sediment. This section ended at Toodyay Road.
JB018 Section length 690 m	This section was in poor condition due to weeds and was prone to erosion. Flooded gum (*Eucalyptus rudis*) was affected by Jarrah Leaf Miner but was regenerating. It was noted for this section that the flooded gum (*Eucalyptus rudis*) regeneration seemed to be declining as there were no saplings higher than 1.5 metres. The middlestorey was sparse and there was no understorey. There was fencing both sides although spaced 200 metres from the waterway with areas of pasture such that livestock were actually fenced into the river. Cattle were causing high impact on the channel, bank and riparian vegetation. There was one significant meander but it was otherwise a subdued pattern with high bank erosion. There was minimal sediment and many riffles. It was noted during this section that the dimensions of the pools in the pool and riffle sequences were increasing as the survey progressed downstream.
JB019 Section length 760 m	This section was in poor condition due to weeds and was prone to erosion. The flooded gum (*Eucalyptus rudis*) overstorey was extensive but scattered and was affected by Jarrah Leaf Miner. The middlestorey was sparse and there was no understorey. This section was not fenced. The channel bank had significant slumping and localised erosion and sediment deposition. There was a significant anabranch and raised terrace floodplain upstream of and associated with the confluence of TR005. At the confluence of TR004, there was a significant eroding channel bank that had a height of approximately three metres (E 443973 N 6502767). There was also a slug of fine sediment at this location. The tributary had significant gully erosion. At the downstream end of this section, there was a dominant breakaway ridge on the RHS with a wandoo (*Eucalyptus wandoo*) vegetation association. **Major tributary – TR005** (Jingaling Brook) This waterway was of poor condition with a high level of weeds and prone to erosion. Riparian vegetation was sparse with no middlestorey or understorey. Jarrah Leaf Miner was affecting flooded gum (*Eucalyptus rudis*). It was not fenced. The channel was significantly eroding due to a hydraulic head drop at the confluence. This has caused the tributary to braid into at least five channels each of which had some level of active gully head erosion. There was flow at the time of survey (27.09.06), pH = 8.1, conductivity = 330 mS/m measured 200 metres upstream from the confluence). Confluence is at E 444086 N 6502398. **Major tributary – TR006** (Gabidine Brook) This waterway was of poor condition with a high level of weeds and prone to gully erosion. Riparian vegetation was healthy but very sparse with no middlestorey or understorey. It was not fenced. There was a one-metre-deep gully head erosion extending 200 metres up the tributary from the confluence. There was a sediment slug in Jimperding Brook at the confluence. This was adjacent to the three-metre bank erosion face in Jimperding Brook. There was flow at the time of survey (27.09.06), pH = 7.6, conductivity = 490 mS/m measured 200 metres upstream from the confluence). Confluence is at E 443973 N 6502675.

Section	Description
JB020 Section length 1330 m	This section commenced with the influence of the wandoo (*Eucalyptus* wandoo) ridge on the RHS but from there the riparian vegetation was of very limited extent and the section was generally in poor condition. Flooded gum (*Eucalyptus rudis*) was affected by Jarrah Leaf Miner although regeneration was occurring. This section was not fenced. There was a significant area of remnant natural vegetation on the LHS, north of the brook associated with a commercial stone quarry. The section had a moderate meander pattern but with significant bank erosion in the form of bank subsidence and slumping. There was one very significant bank collapse 1.2 km downstream (E 443155 N 6503400). The banks appeared to be stabilised by cobblestones at the upstream end of this section. There was an old crossing 800 metres downstream where debris indicated a recent flood level (E 443526 N 6503322) There was a heavy vehicle crossing 1.1 km downstream (E 443273 N 6503380). There were many small tributaries both sides.
JB021 Section length 650 m	This section was in moderate condition although prone to erosion. Riparian vegetation was sparse although this section was near remnant vegetation associated with the quarry (LHS). Although flooded gum (*Eucalyptus rudis*) was affected by Jarrah Leaf Miner it was regenerating. Although there was only partial fencing in poor condition (RHS), there was limited stock access. The RHS would require re-fencing if stocked. There was one major channel meander but otherwise the pattern was of low sinuosity. There was significant bank slumping. The first observed slug of coarse sediment for the survey was 800 metres downstream (E 442401 N 6503344). There was a floodway on the LHS at this location. There was a minor tributary on the RHS 300 metres downstream with spiny rush (*Juncus acutus)* (E 442780 N 6503276). A major tributary (TR007) occurred 400 metres downstream on the LHS (E 442608 N 6503349). The section ended with major culvert crossing that was impounding water upstream. **Major tributary – TR007** This waterway was of good condition with a relatively low level of weeds and erosion risk. Riparian vegetation had well-structured natural vegetation with high species richness. There was some Jarrah Leaf Miner effect. It was not fenced. There was flow at the time of survey (26.09.06), pH = 7.6, conductivity = 680 mS/m measured approximately 200 metres upstream). Confluence was at E 442608 N 6503349.
JB022 Section length 1680 m	This was a relatively long section in moderate condition due to a high level of weeds and being prone to erosion. However, it was also a highly scenic section of Jimperding Brook with very extensive remnant natural vegetation north of the brook and good access. Riparian vegetation was sparse with no understorey. Flooded gum (*Eucalyptus rudis*) and golden wreath wattle (*Acacia saligna*) were regenerating. Jarrah Leaf Miner continued to affect the overstorey. The section was not fenced although there was probably low stock access at least on the LHS. There was a moderate meander pattern but there was also significant bank erosion due to undercutting. Sediment occurred in localised areas within the channel.

Section	Description
JB022 (continued)	A caravan was washed downstream during a recent flood. There were places where parts of the caravan occurred further downstream that indicated the level of the flood. Approximately 200 metres downstream, there was a formed road parallel and north of the brook. At this location, there was bulrush (*Typha* spp.) and spiny rush (*Juncus acutus*). There was a small area of pithy sword-sedge (*Lepidosperma longitudinale*) 600 metres downstream (441991 N 6503586). There was a major tributary (TR008) on the RHS 1.7 km downstream. This had no flow, however the channel had significant gully erosion and was undermining trees (E 441305 N 6504102) **Major tributary – TR008** This waterway was of poor condition with a high level of weeds. Riparian vegetation was very sparse with no middlestorey or understorey. There was some Jarrah Leaf Miner impact. It was not fenced. There was a significant gully head actively eroding upstream. There was flow at the time of survey (26.09.06), pH = 5.1, conductivity = 830 mS/m measured at Lovers Lane). Confluence was at E 445619 N 6497636.
JB023 Section length 1780 m	This section was in moderate condition with a high level of weeds; however, it did have good floodway and bank vegetation and one part was classified as being only slightly disturbed. This occurred 1.7 km downstream where foreshore vegetation was species rich (E 439777 N 6504531). While riparian vegetation was patchy, there was extensive natural vegetation north of the brook. The riparian zone was not fenced although there was probably no stock access. Jarrah Leaf Miner affects flooded gum (*Eucalyptus rudis*). It was interesting to note that swamp paperbark (*Melaleuca raphiophylla*), which was mostly absent upstream, was commonly occurring and relatively large in growth form in this section. The channel had a major meander pattern but it is of low sinuosity. There was significant bank erosion due to undercutting. Sediment had localised occurrence. There were many small riffles, some spaced only 15–50 metres apart. There was a vehicle crossing 600 metres downstream where there was also a large cobblestone delta (E 440724 N 6504647). There was a scenic site 1.1 km downstream with good foreshore vegetation (113 E 440317 N 6504701). Debris formed an island 1.4 km downstream (E 440042 N 6504547). There was a small amount or fencing wire rubbish. The section ended with a culverted floodway (Lovers Lane). **Major tributaries – TR009 and TR010** (Little Jimperding Brook) These waterways entered Jimperding Brook 30 metres from one another and were of moderate condition with a high level of weeds. Riparian vegetation was healthy but sparse with minimal middlestorey and no understorey. They were fenced effectively. There was a significant gully head actively eroding on Little Jimperding Brook. Water quality monitoring at the time of survey (26.09.06), pH = 7.6, conductivity = 650 mS/m measured 150 metres upstream. Confluence was at E 439709 N 6504555.

Section	Description
JB024 Section length 300 m	This section was in excellent condition with substantial vegetation extending to the north from the riparian zone. Flooded gum (*Eucalyptus rudis*) was affected by Jarrah Leaf Miner. In this section there was a native vegetation understorey. The section was not fenced although there was no stock access. An area of pithy sword-sedge (*Lepidosperma longitudinale*) occurred in this section (E 439613 N 6504651). There was no meander pattern and no channel erosion or sediment deposition. A terraced floodway existed. This section had high scenic value.
JB025 Section length 810 m	This section was of moderate condition due to weeds and existing erosion. The section had very sparse mature natural vegetation; however, there has been significant revegetation (E 439685 N 6505430) and the lower parts were actively regenerating. This section had good fencing. There was no Jarrah Leaf Miner and vegetation was healthy. There was a very broad meander pattern with very low sinuosity. The section had many riffles. There was localised bank erosion and sedimentation. A sediment slug occurred 100 metres downstream. There was significant stone walling on the LHS adjacent to Cobblers Pool Road bridge.
JB026 Section length 270 m	This section was on Crown Land from Cobblers Pool Road to the confluence with the Avon River. The rail bridge crossed in this section. There was also the public picnic area established by the Deepdale Catchment Group. The section was in moderate condition with a high level of weeds and significant sediment deposition. Riparian vegetation was patchy and had some senescent mature trees. There was one major meander. Jimperding Pool extends upstream from the confluence with the Avon River.

Appendix 7 Riparian zone native plants and weeds

Native Plants

Common Name	Scientific Name
flooded gum	*Eucalyptus rudis*
wandoo	*Eucalyptus wandoo*
York gum	*Eucalyptus loxophleba*
golden wreath wattle	*Acacia saligna*
prickly moses	*Acacia pulchella*
jam	*Acacia acuminata*
swamp paperbark	*Melaleuca raphiophylla*
swamp sheoak	*Casuarina obesa*
marri	*Corymbia calophylla*
grass tree	*Xanthorrhoea preissii*
needlebush	*Hakea preissii*
karri hazel	*Tremalium floribundum*
buttercup	*Hibbertia hypericoides*
zamia	*Macrozamia reidlei*
pithy sword-sedge	*Lepidosperma longitudinale*

Weeds

Common Name	Scientific Name
spiny rush	*Juncus acutus*
cape tulip	*Homeria* spp.
soursob	*Oxalis pes-caprae*
Paterson's curse	*Echium plantegenium*
wild oats	*Avena* spp.
wild radish	*Raphanus raphanistrum*
deadly nightshade	*Solanum nigrum*
perennial veldt grass	*Ehrharta calycina*
capeweed	*Arctotheca calendula*
annual ryegrass	*Lolium* spp.
barley grass	*Hordium leporiumi*
medic	*Trifolium* spp.
bulrush	*Typha* spp.

Appendix 8 Bird species richness

Bird Species	Survey sections																									
	JB001	JB002	JB003	JB004	JB005	JB006	JB007	JB008	JB009	JB010	JB011	JB012	JB013	JB014	JB015	JB016	JB017	JB018	JB019	JB020	JB021	JB022	JB023	JB024	JB025	JB026	**Total**
Australian Shelduck (*Tadorna tadornoidies*)										✓																	**1**
Black Duck (*Anas superciliosa*)					✓					✓			✓				✓	✓		✓		✓					**7**
Wood Duck (*Chenonetta jubata*)								✓						✓	✓					✓	✓		✓				**6**
White-faced Heron (*Egretta novaehollandiae*)			✓											✓									✓				**3**
Australian Dotterel (*Peltohyas australis*)										✓																	**1**
Galah (*Elophus roseicapilla*)															✓								✓	✓	✓		**4**
Corella (*Cacatua* spp)										✓								✓									**2**
Ring-necked Parrot (*Platycercus zonarius*)		✓					✓		✓			✓	✓	✓	✓			✓		✓	✓		✓				**11**
Fan-tailed Cuckoo (*Cacomantis castaneiventris*)		✓					✓	✓															✓				**4**
Sacred Kingfisher (*Todiramphus sanctus*)					✓							✓					✓	✓				✓			✓		**6**
Striated Pardalote (*Pardalotus rubricatus*)										✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓				**12**
Weebill (*Smicronis brevirostris* race *occidentalis*)				✓		✓	✓	✓		✓	✓	✓		✓	✓				✓			✓		✓			**12**
Western Gerygone (*Gerygone fusca*)		✓		✓		✓		✓		✓		✓		✓		✓		✓			✓	✓	✓				**12**
Yellow-rumped Thornbill (*Acanthiza chrysorrhoa*)										✓		✓				✓			✓			✓					**5**
Red Wattle-bird (*Anthochaera carunculata*)																	✓										**1**
Brown Honeyeater (*Lichmera indistincta*)		✓		✓				✓				✓									✓						**5**
Scarlet Robin (*Petroica multicolor*)																						✓					**1**

Bird Species	Survey sections																									
	JB001	JB002	JB003	JB004	JB005	JB006	JB007	JB008	JB009	JB010	JB011	JB012	JB013	JB014	JB015	JB016	JB017	JB018	JB019	JB020	JB021	JB022	JB023	JB024	JB025	JB026	**Total**
Grey Shrike-thrush (*Colluricincla harmonica*)		✓				✓	✓					✓				✓				✓							**6**
Rufous Whistler (*Pachycephala rufiventris*)		✓						✓			✓			✓								✓	✓		✓	✓	**8**
Grey Fantail (*Rhipidura fuliginosa*)						✓			✓	✓				✓	✓	✓						✓			✓		**8**
Willie Wagtail (*Rhipidura leucophrys*)		✓													✓												**2**
Black-faced Cuckoo shrike (*Coracina novaehollandiae*)											✓							✓	✓				✓				**4**
Australian Magpie (*Gymnorhina tibicen*)					✓																		✓				**2**
Australian Raven (*Corvus coronoides*)							✓	✓															✓				**3**
Laughing Kookaburra (*Dacelo gigas*)		✓											✓	✓				✓				✓	✓				**6**
Common Bronzewing (*Phaps chalcoptera*)				✓																							**1**
Splendid Fairy-wren (*Malurus splendens*)					✓																	✓					**2**
Magpie-lark (*Grallina cyanoleuca*)						✓												✓									**2**
Black Cockatoo (*Calyptorhynchus* spp.)							✓																				**1**
Pallid Cuckoo (*Cuculus pallidus*)									✓			✓						✓	✓								**4**
Shining Bronze Cuckoo (*Chrysococcyx lucidus*)																			✓								**1**
Grey-breasted White-eye (*Zosterops lateralis*)															✓									✓			**2**
Songlark (*Cincloramphus* spp.)																		✓									**1**
Total	**0**	**8**	**1**	**4**	**4**	**5**	**6**	**7**	**3**	**9**	**4**	**9**	**4**	**9**	**8**	**4**	**3**	**11**	**6**	**5**	**5**	**11**	**12**	**3**	**4**	**1**	

Appendix 9 Overall stream environmental health rating explanatory information

Overall Environmental Rating	Excellent	Good	Moderate	Poor	Very poor
Habitat diversity	3 or more habitat zones. Some permanent water.	2 habitat zones. Some permanent water.	Mainly one habitat type with permanent water, or range of habitats with no permanent water.	Mainly one habitat type with no permanent water.	Stream channellised.
Bank stability and sedimentation	No erosion, subsidence or sediment deposits. Dense vegetation cover of banks and verge. No disturbance.	No significant erosion, subsidence or sediment deposits in floodway or on lower banks. May be some soil exposure and vegetation thinning on upper bank and verge.	Good vegetation cover. Localised erosion, bank collapse and sediment heaps only. Verges may have sparse vegetation cover.	Extensive active erosion and sediment heaps. Bare banks and verges common. Banks may be collapsing.	Almost continuous erosion. Over 50% of banks collapsing. Sediment heaps line or fill much of the floodway. Little or no vegetation cover.
Stream cover	Abundant cover: shade, overhanging vegetation, snags, leaf litter, rocks and/or aquatic vegetation.	Abundant shade and overhanging vegetation. Some instream cover.	Some permanent shade and overhanging vegetation. Some instream cover.	Channel mainly clear. Little permanent shade or instream cover.	Virtually no shade or instream cover.
Verge vegetation	Healthy undisturbed native vegetation. Verges more than 20 m wide.	Mainly healthy undisturbed native vegetation. Verges less than 20 m wide.	Good vegetation cover, but mixture of native & exotic species. Verges 20 m or more.	Narrow verges only (<20m wide), mainly exotic vegetation.	Mostly bare ground or exotic ground covers (i.e. pasture, gardens or weed infestations, but no trees).
Floodway and bank vegetation	Healthy undisturbed native vegetation. Virtually no weeds. No disturbance.	Mainly healthy undisturbed native vegetation. Some weeds. No recent disturbance.	Good vegetation cover, but mixture of native & exotic species. Localised clearing. Little recent disturbance.	Mainly exotic ground cover. Obvious site disturbance.	Mostly bare ground or exotic ground covers (i.e. pasture, gardens or weed infestations, but no trees).

Source: Pen and Scott, 1995

Appendix 10 Examples of fence condition

Fencing Status – Examples of Fence Condition

Fence condition: POOR

Fence condition: MODERATE

Fence condition: GOOD

Fence Condition Photographs: Courtesy of the Department of Water

Appendix 11 Avon Waterways Fire Policy

Recovery Statement Number 1

FIRE

Introduction

The Avon Waterways Committee (AWC) is an organisation formed to assist the community and government agencies to sustainably manage the waterways within the Avon River Basin, within a framework of natural resource management. It has a mandate to continue the progression of the Avon River Management Programme, developed by its predecessor, the Avon River Management Authority (ARMA).

It has resolved to evolve the policies developed by ARMA as a statutory authority into more 'user friendly' position statements, called **Recovery Statements**, and to develop new statements for issues as they arise.

The AWC, in developing these documents, have agreed that the *'Principles of River Management'* written by the late Jim Masters OA, and other sound scientific principals will underpin each Statement. Further, they recognise that each document must be consistent with the Avon Catchment Council's *Natural Resource Management Strategy for the Avon River Basin.*

The following document is a draft *Recovery Statement* on '**FIRE**.'

Objectives

The long-term objective of the Avon Waterways Committee is to restore the natural functioning and vegetation of the Avon River and its major tributaries. Arising out of this aim, the Committee has four objectives related to fire:

1 To protect riverine ecosystems from the damaging effects of uncontrolled fire.

2 To use controlled fire for regeneration in accordance with management plans.

3 To manage the fire hazard along the river, so as to minimise the threat of wildfire's to adjoining assets and property.

4 To work cooperatively with local governments, fire brigades and neighbours with respect to fire management and development of Fire Management Plans.

Background

Fire is a natural factor in most Australian ecosystems. It can be started by lightning as well as by humans. The native bush is adapted to occasional fire; plants and animals either survive the fire, or regenerate following it. Many native plant species regenerate best after fire (although along the Avon River, regeneration events are also associated with floods).

Different types of native bush are adapted to different fire regimes. We have no knowledge of the 'natural' fire regime that would have occurred in the Avon valley before agricultural development, but it can be inferred from the presence of fire tender species such as swamp sheoak (*Casuarina obesa*) that fires may not have naturally occurred more frequently than every 15 or 20 years.

However, the strip of bush along the Avon River and its tributaries is no longer in its natural state. The surrounding country has been largely cleared and converted to crop land, pasture and urban development, limiting opportunity for recolonisation of burnt areas by native birds and animals.

Many weeds (especially exotic annual grasses) are thickly established in the bush, while in some places the native herbivores have been displaced by sheep.

While fire is a natural factor in the bush, it can be a damaging agency in degraded bush. In particular, frequent fires enhance further weed development that in turn leads to higher annual fire hazards. Fire is a useful (indeed often essential) agent for bushland regeneration, but if it occurs too frequently, it can eliminate some native species and if it is too intense, it can burn down valuable habitat trees and accelerate erosion along the river banks.

Uncontrolled summer fires are also a threat to human values. Along the Avon River are several towns, minor settlements, farms businesses, bridges, powerlines, railways, tourist sites and historic buildings. These assets need to be protected from bushfires, including fires that may start in the river system.

The AWC has no significant resources at this stage to carry out fire management programs or to fight fires. We are therefore dependent upon the assistance of local Bushfire brigades and neighbours; equally they are dependent upon us to ensure our policies and river management plans are practical as well as visionary.

Strategies

In order to achieve its objectives, AWC will:

1 Undertake a Wildfire Threat Analysis of the river system. This will be done in conjunction with local authorities and experienced Bushfire personnel in each district. The purpose will be to identify all the important values that are potentially threatened by a fire starting in the river system.

2 Develop fire management plans to cover the areas of the river adjacent to identified high value sites and adjacent land as necessary. These plans will deal with issues such as access, firebreaks, fire suppression plans and hazard reduction, and will set out the various responsibilities for decision-making by those involved in doing the work which is prescribed. All plans will be undertaken with full community involvement. Final plans must be submitted to the AWC for consideration, and a recommendation will be made to the Water and Rivers Commission (WRC) for endorsement if appropriate.

3 Aim to keep fire permanently out of as much of the riverine system as possible, except where fire is used for hazard reduction, regeneration or control of weeds or feral animals under the terms of an approved management plan.

4 Allow the use of controlled fire, or selective herbicides to control annual grass fuels in areas where hazard reduction is approved to protect a high value site. In the case of controlled burning, a prescription must be prepared which specifies season and intensity of fire, the measure to be taken to ensure the fire is made safe, and that mopping up and patrolling is undertaken to protect old trees, hollow logs etc. In the case of herbicide spraying, a prescription must be prepared which specifies the frequency, chemical to be used, the rate and time of application and the measures to be taken to protect non-target species or guard against off-site effects.

   All controlled burning must be in accordance with the Bush Fires Act *and meet local government requirements, and all prescriptions must be submitted to the AWC for consideration, and a recommendation will be made to the WRC for endorsement if appropriate.*

5 Not allow uncontrolled grazing by sheep, cattle, goats, pigs or horses in the river system in areas controlled by WRC. Some limited controlled grazing may be approved during an interim periods in which other hazard reduction measures are being developed. Proposals to graze WRC-controlled land must be submitted to the AWC for consideration, and a recommendation will be made to the WRC for endorsement if appropriate.

   Owners of riverine vegetation will be encouraged to phase out or limit grazing on their lands in favour of less destructive measures of hazard reduction.

   New weed invasion will be minimised by minimising all forms of soil disturbance along the river. This especially applies to roads and firebreaks, off-road vehicle use and urban development, none of which may take place along the river without approval of WRC.

6 Permit the mowing or slashing of weeds in some areas close to towns, buildings or other constructions so as to break down a tall grassy fire hazard. Prescriptions covering the proposed work must be submitted to WRC for approval.

7 Encourage neighbours to the river to make their own properties fire-safe, rather than rely on fire hazard reduction along the river. This will be achieved through education campaigns, including detailed discussion with property owners and the involvement of neighbours in the preparation of fire management plans for the river system.

   AWC will also support measures promoted by Landcare groups to minimise stubble burning on farmlands adjacent to the waterways.

8 Encourage research to be undertaken on the management of fire and on fire ecology along the Avon River. AWC wishes to recover the full suite of native plants and animals that once occurred in the bush in this area, but at the same time we wish to ensure neighbouring assets are protected. AWC will assist scientists from government agencies and universities who are prepared to work on research projects that help to achieve this aim.

9 Monitor all areas burnt. Where good regeneration of desirable species has occurred, areas will be set aside from prescribed burning for a sufficient period to enable the young plants to establish, flower and seed.

10 Strongly support volunteer fire brigades located along the river, to ensure they are properly equipped and organised. This support will take the form of collaborative submissions to Local Authorities and the Bush Fires Service, until we are in a position to provide direct financial support.

11 Identify potential sources of fire in or adjacent to the river system. Where there are obvious problem sites (e.g. smouldering rubbish tips) the site manager will be approached to fix the problem. If necessary AWC will ask local authorities or the Bush Fire Service to enforce the *Bush Fires Act* to eliminate potential sources of fire.

   Open fires will not be permitted in camp grounds or other recreational areas controlled by WRC along the river during restricted or prohibited burning periods, generally between the months of September and May.

12 Seek endorsement of this Recovery Statement, and all fire management plans developed for the river system from local authorities, neighbours and relevant government agencies (especially the Bush Fire Service).

13 Ensure that all fire management plans and regimes that are developed are consistent with the ACC Natural Resource Management Strategy

Review

The Recovery Statement will be reviewed annually.

Alan Cole
Chairman, Avon Waterways Committee
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