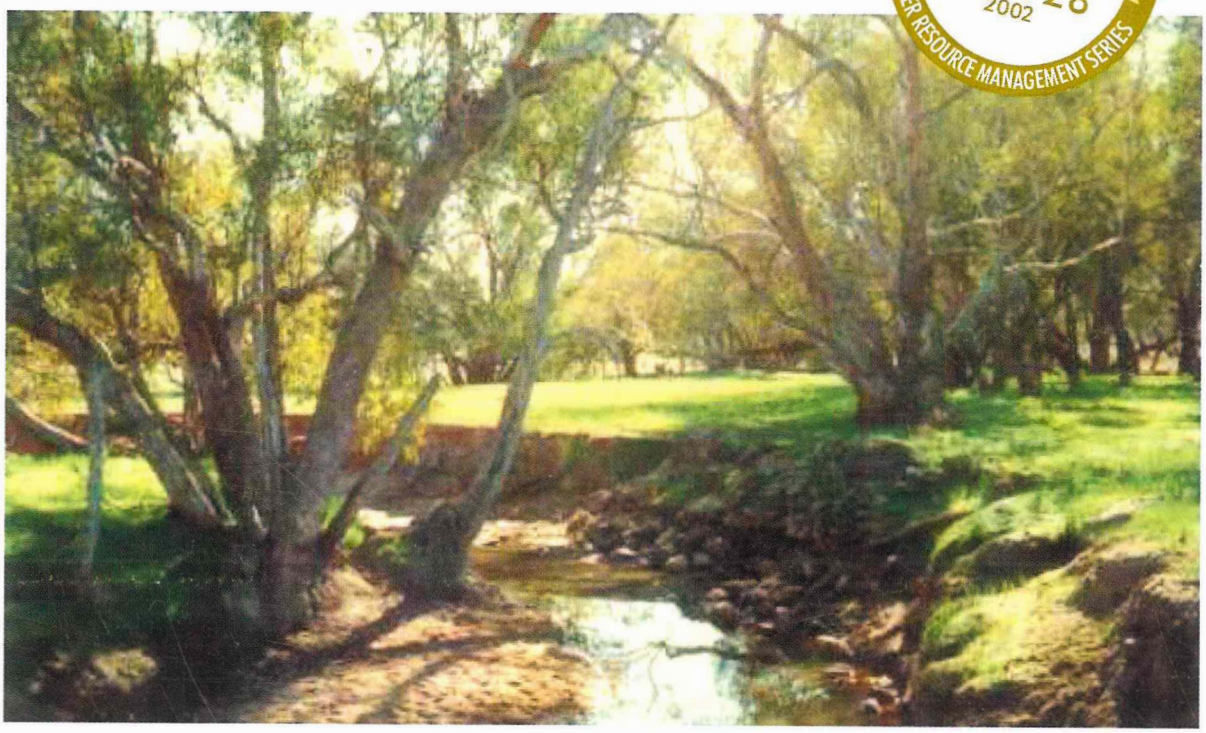
FORESHORE AND CHANNEL ASSESSMENT OF SPENCERS BROOK

WATER AND RIVERS COMMISSION REPORT
WRM 28
2002
WATER RESOURCE MANAGEMENT SERIES



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Cover Photograph: Rocks used to stabilise an eroding bank along Spencers Brook (Patricia Janssen, 2001).

FORESHORE AND CHANNEL ASSESSMENT OF SPENCERS BROOK

Jointly funded by

Natural Heritage Trust

Water and Rivers Commission

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REPORT NO. WRM 28
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Acknowledgments

This report was prepared by Patricia Janssen who acknowledges the funding provided by the Natural Heritage Trust for the project and the assistance and support from the following people:

- Landholders along Spencers Brook for their valuable information about the waterway and surrounding catchment, as well as assistance with the field surveys.
- John Wilding, Rex and May Wilson and Michael Letch for information regarding the Spencers Brook Catchment and history of the area.
- Gerry McCourt, Water and Rivers Commission for map production.
- Phyllis Graham, Catherine Walker, Bernard Kelly and Clare Taylor, Water and Rivers Commission for report editing.
- Dianelle Pisconeri for assistance with research and field assessments.
- Martin Revell, Water and Rivers Commission for project support and assistance and report editing.
- Brendan Oversby, Water and Rivers Commission for assistance with plant identification.

Photographs taken by Patricia Janssen.

Reference details

The recommended reference for this publication is: Water and Rivers Commission 2002, *Foreshore and Channel Assessment of Spencer Brook*. Water and Rivers Commission, Water Resource Management Series, No WRM 28.

ISBN 1-920687-28-9
ISSN 1326-6934

Text printed on 115gsm recycled stock,
Cover, 250gsm Sapphire Dull
November 2002

Foreword

Jointly funded by the Natural Heritage Trust and the Water and Rivers Commission, this project is part of the Avon Waterways Committee's (AWC), formerly the Avon River Management Authority's Avon Rivercare Program, a project undertaking management surveys of major tributaries feeding into the Avon River.

The objective of this project is to document the current condition and future management needs of Spencers Brook through consistent field surveys, in consultation with adjacent landholders and surrounding community. The project emphasises community consultation, with attempts made to involve landholders along the waterway in as many aspects of the survey as possible.

The Spencers Brook catchment drains part of the western portion of the Shire of Northam into the Avon River. Foreshore and channel assessments along Spencers Brook were undertaken between April and May 2001.

The purpose is to provide information to the people within the Spencers Brook Catchment who manage or have an interest in waterways. It is hoped that this information will encourage and assist the planning of management actions that can be undertaken by landholders and community groups from the areas surrounding the waterway.

As a result of development pressures and inappropriate landuse, many sections of the study area are under threat from degradation. A wide range of management issues, such as stock and vehicle access, erosion, feral animals and salinisation of the land and water, have been identified through field surveys and consultation with landholders along the waterway.

Management recommendations have been included to suggest ways in which the foreshore and channel conditions along the length of the brook can be improved to provide environmental, economic and social benefit to landholders and community members throughout the area.

Although this tributary of the Avon River has been surveyed in isolation to other major waterways, the long-term management of the riverine environment is dependent upon an integrated catchment approach, whereby landholders within the whole catchment are responsible for working together to improve the condition of the waterways. It is hoped that the results of this report will help to create a sense of ownership of the brook for the community as a whole and encourage integrated catchment management (ICM), conservation of the riverine environment and sustainable development.

"The future is not some place we are going to,
... it is a place we are creating.
The path to the future is not found,
... it is made."

Paul Ellyard
Author/Philosopher

Contents

Figures

Tables

Maps

Disclaimer:

These maps are the product of Water and Rivers Commission, Regional Services Division, and were printed on 25 September 2001. The maps were produced with the intent that they be used for information dissemination at the scale of 1:150 000. While the Water and Rivers Commission has made all reasonable efforts to ensure the accuracy of this data, the Commission accepts no responsibility for any inaccuracies and persons relying on this data do so at their own risk.

Introduction

Purpose of the survey

The purpose of this survey is to review the management along Spencers Brook and encourage landholders to undertake management strategies to improve and maintain the health of the waterway. This survey aims to assess and document the current uses, disturbances and health conditions of Spencers Brook and provide some guiding management recommendations. It is hoped that the results will promote an awareness of the need for an integrated approach to the management of the brook and surrounding lands.

Specific objectives of this project can be summarised as follows:

- To collect and provide a compilation of data regarding the condition of the Brook which can be used to prioritise future management;
- To highlight areas needing future rehabilitation, conservation and/or management;
- To provide a benchmark against which landholders and surrounding communities can monitor future river health and management activities;
- To educate landholders and the community about the causes of waterway degradation; and
- To provide a sound technical basis for future funding or project submissions.

One of the main goals associated with this assessment is to identify the key issues related to the future use and management of Spencers Brook and its tributaries. It is hoped that this data will eventually lead to a management or action plan for the channel, foreshore and catchment surrounding Spencers Brook to provide guidance and direction for future management of the waterway.

Study area

The Spencers Brook lies within the Avon Catchment, Western Australia, and is one of the larger tributaries feeding into the Avon River. The area assessed was located within the Shire of Northam. The Clackline Brook joins Spencers Brook, and the name change occurs at the confluence of these two tributaries with the Corolin Brook. Approximately 29km in total length, the waterway enters the Avon River approximately 8km south of the Northam townsite in the locality of Spencers Brook. The 356.94km^2 catchment drains the western portion of the Shire of Northam, the north-western portion of the Shire of York and the southern portion of the Shire of Toodyay.

The Clackline Brook begins west of Northam in Bakers Hill and flows east where it meets Spencers Brook (116º30’60”E 31º30’88”N). For the purpose of this study a part of the Clackline Brook (up to Refractory Road in Clackline) was incorporated into this survey of the Spencers Brook. Around 20km of waterway was surveyed – comprising approximately 11km of the Spencers Brook and 9km of Clackline Brook. For the purpose of this report, where reference is made to Spencers Brook, this portion of Clackline Brook is also included.

There are several minor tributaries feeding into Spencers Brook from around its catchment. The larger of these are Corolin Brook, Warranine Brook, Nanamullen Lake and Mokine Brook. There are also many smaller waterways draining the surrounding catchment.

Map 1 depicts the size of the Spencers Brook catchment and also shows the location of the brook and the extent of the Clackline Brook incorporated into this study. Map 2 shows the boundaries of each of the 27 sections that the waterway was broken into for the purpose of this assessment.

Historical description of Spencers Brook

Aboriginal heritage

Aboriginal families lived in the area surrounding Spencers Brook, with territories bordering the waterways. Hence, the land is likely to have important spiritual and cultural meaning to the current generation. Data from the Department of Land Administration and the Aboriginal Affairs Department indicates that there are no registered sites or communities of Aboriginal significance along Spencers Brook.

European heritage

The Avon region was explored by European settlers in 1830, when an expedition party led by Ensign Dale travelled overland from Guildford. The Avon Valley was settled by European farmers shortly after this in 1831 and the Northam region developed steadily over the next 50 years as land was released and settled. Northam was gazetted as a townsite in 1836 (Western Australian Planning Commission, 1999). The expansion of Northam was secured by the development of the Yilgarn railway through Northam (Moore et al, 1987).

Development of the land centred on the agricultural industry with the introduction of wheat and sheep/cattle farming to the catchment. Landuse along the waterway has changed little since European settlement, however in recent years there has been a tendency for land to be subdivided into smaller lots that have a focus on hobby farming and rural lifestyle. The region has grown into the centre of the wheatbelt region, providing a large range of goods and services to surrounding towns.

There are locations listed on the State Register of Heritage Places which are associated with European settlement of the area, and which are located within the Spencers Brook catchment. Appendix 1 provides a list of these places.

Catchment description

Population

Approximately 3 215 people live within the Shire of Northam according to the 1996 census of population (Western Australian Planning Commission, 1999), with approximately 350 landholders within the catchment surrounding Spencers and Clackline brooks. There are 21 landholders along the length of the brook.

Climate

The Shire of Northam experiences a Mediterranean type climate with hot, dry summers and cool, wet winters.

The Shire of Northam lies between the 500mm and 350mm isohyte with rainfall decreasing towards the east. Average annual rainfall for the Shire of Northam ranges from 9.7mm in January to 83.8mm in July.

Average daily maximum temperatures for the Northam region vary from 34.1˚C in January to 16.8˚C in July. The average daily minimum temperature for the Shire ranges from 17.2˚C in February to 5.4˚C in July. The highest maximum temperature for the Shire of Northam was recorded at 46.8˚C in the month of February and the lowest minimum temperature was recorded at –3.2˚C in July. The average daily evaporation rate (mm) ranges from 8.5mm in the month of January to 1.5mm in the month of July (Moore et al, 1987).

Geomorphology and soils

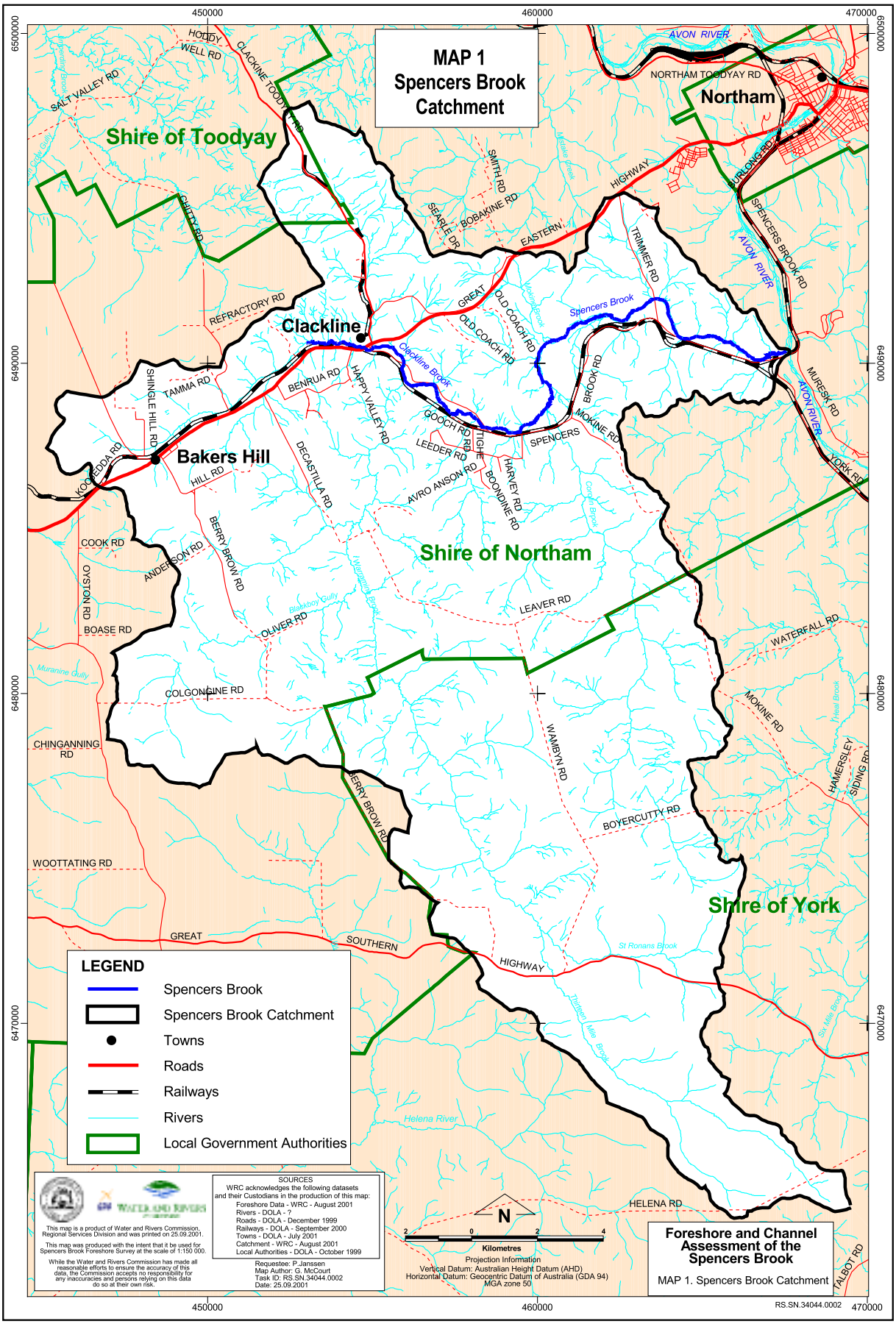
Spencers Brook lies within a dissected landscape with steeper, narrow valleys (known as the Zone of Rejuvenated Drainage), where waterways commonly flow during winter (Lantzke and Fulton, 1992).

Weathering and laterisation of the Yilgarn Block (which is of Archaean granite origin) has greatly influenced the soils of the Northam region. Many areas along the river valley are covered by sand overlying clay, whilst surrounding areas are covered by laterite and ironstone gravel (Piggott et al, 1995). An elevated ridge at Clackline depicts the change from undulating uplands of the Darling Plateau to the lowlands of the Avon Valley (Gunness, 1999)

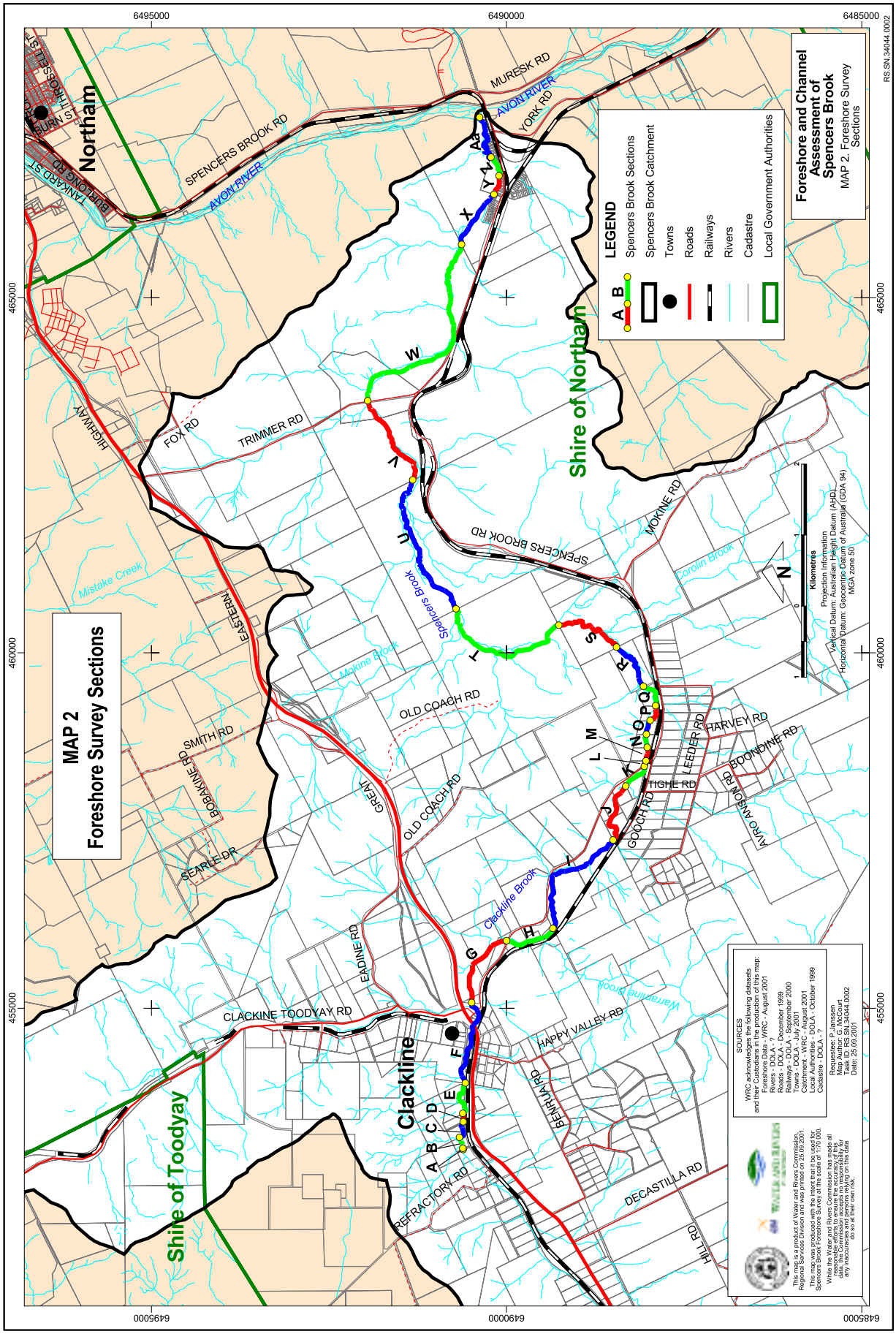
Map 3 shows the soil landscape systems of the Spencers Brook catchment, and depicts the dominant systems along Spencers Brook as the Avon Flats, Clackline, Jelcobine and Wundowie systems. The valley floors along the waterway are dominated by Avon Flats, Clackline and Jelcobine soil units. Appendix 2 provides definitions and associated characteristics of these soil landscape units.

The Avon Flats system is characterised by brown loamy earths, grey non-cracking clays, and deep brown sands. This system is commonly found along alluvial terraces and flats (Agriculture Western Australia, 1999).

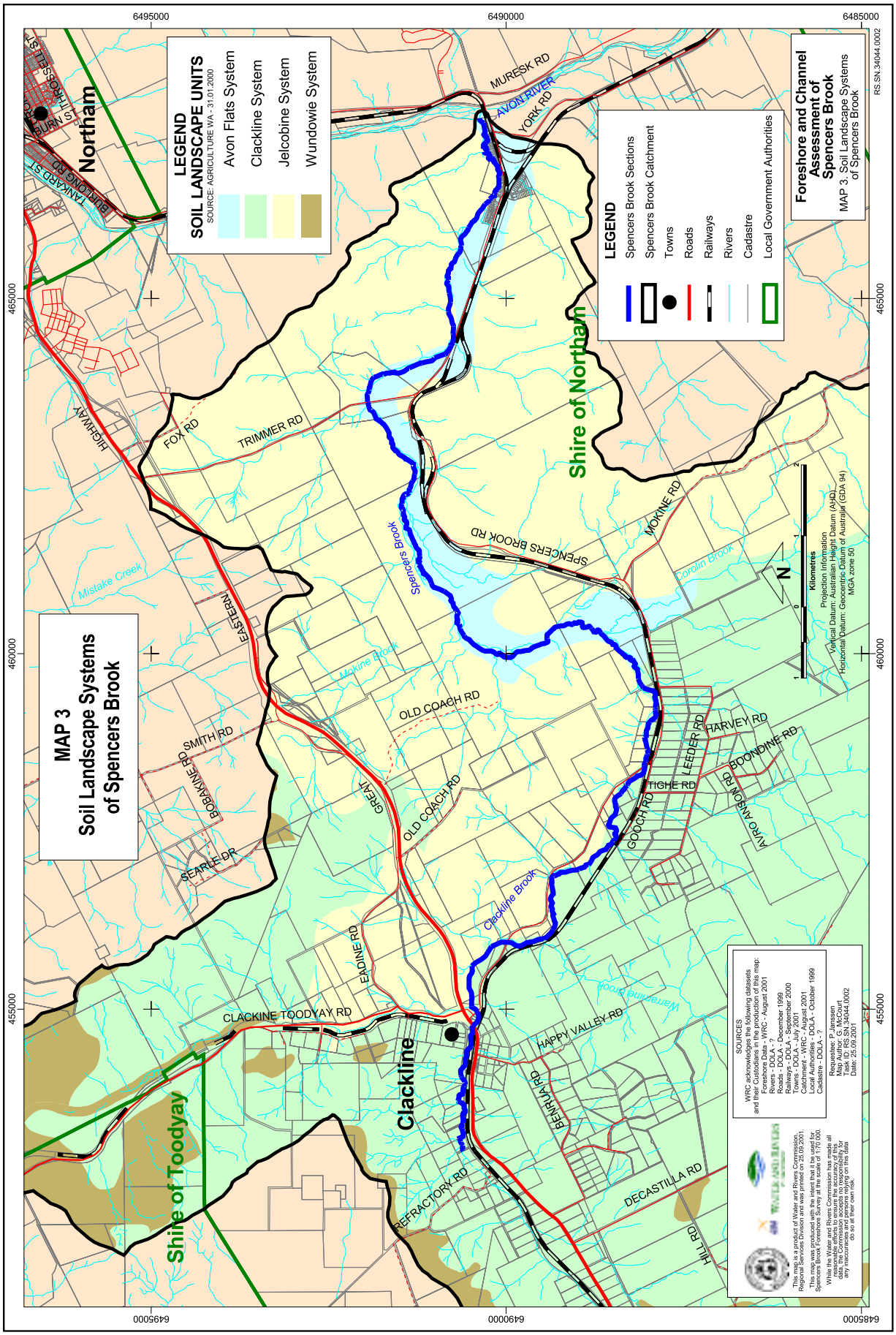
The Clackline soil system is located along the lower, mid and upper slopes of the surrounding catchment area and is characterised by shallow grey sandy duplexes, duplex sandy gravels, loamy gravels, shallow pale sands and red loamy duplexes. It is often limited to moderately dissected areas with gravelly slopes and ridges (Lantzke and Fulton, 1992).



Map 1. Spencers Brook catchment



Map 2. Foreshore survey sections



Map 3. Soil landscape systems

The Jelcobine system is located on the hill slopes but is defined by deep red and shallow sandy and loamy duplexes, deep grey sandy duplexes, bare rock and cracking and non-cracking clays (Lantzke and Fulton, 1992 and Agriculture Western Australia, 1999).

The Wundowie unit is defined by deep sandy gravels, duplex sandy gravels and shallow gravels. It is found in the higher areas of the catchment where lateritic plateaus with rocky outcrops are common (Agriculture Western Australia, 1999).

Hydrology

Spencers Brook is one of the many tributaries responsible for feeding saline water into the Avon River. This waterway flows actively after rainfall events, which usually means during winter, spring and early summer (Mulcahy and Hingston, 1961). Anecdotal evidence suggests that in the past there were deep pools that would hold water throughout the dry summer months and act as a refuge and habitat for terrestrial and aquatic fauna. These pools have now become shallow as a result of sediment deposition and no longer provide these important refuges for organisms during the dry summer months.

The variability of flow and the periodic flooding and drying of the waterway system is an important natural feature which many ecosystems are dependent upon for their long-term survival (Hansen, 1986). However, there has been a change in the frequency and magnitude of flooding and drying as a result of settlement and development within the catchment, and this has meant that many ecosystems have had to adapt to these variations or perish.

The floods of January 1999 and January 2000 show the effects of high unseasonal rainfall and the inability of Spencers Brook to deal with such a high influx of water. Runoff from the surrounding catchment was high due to the large areas of cleared land, and the overland flow carrying sediment that was deposited into the channel. Bank erosion is often a major contributor to sediment.

Vegetation

The catchment lies within the Dale Botanical Subdistrict of the Darling System. The flora of the region is diverse, with characteristics and species common to both inland and coastal floras, resulting from a significant drop in rainfall from Bakers Hill to Northam.

The banks of the brook are dominated by Flooded gum (*Eucalyptus rudis*), Wandoo (*Eucalyptus wandoo*) and Swamp paperbark (*Melaleuca rhaphiophylla*), vegetation that is typical of marginally saline (brackish) environments. Agricultural weeds such as Wild oats (Avena fatua) and Barley grass (*Hordeum leporinum*) are also common throughout the riverine environment. The weed species Couch, Watsonia, Cape tulip and Four o'clock are widespread, especially within the channel towards the upstream end of the waterway. Watsonia is particularly common throughout the Railway Reserve and the Clackline Nature Reserve.

A list of plant species recorded in both the Clackline Rail Reserve and the Clackline Nature Reserve is provided in Appendix 3. This list shows that in its more pristine condition this region can support the gazetted rare species of Spider Orchid, *Caladenia triangularis*. The species of *Lomandra nutans* has also been recorded in this area, where previously it was thought to only occur as far north as Narrogin. The *Lomandra spartea*, generally restricted to the Darling Scarp was also recorded within these reserves (Moore et al, 1987).

Catchment landuse and tenure

Landuse within the catchment is a combination of agricultural (with a focus on sheep/cattle and wheat) and smaller semi-rural properties. In recent years there has been an increase in hobby farming and rural lifestyle with the subdivision of many farms into smaller lots.

There are 2 landuse activities bordering the waterway that could be described as industrial. The old Clackline Refractory (brick works) is located along Refractory Road at the upstream end of the study area, while a feedlot is located on a property along the western side of Trimmer Road.

Most of Spencers Brook lies within private land ownership. There is increasing pressure to subdivide larger agricultural landholdings into smaller lots for uses such as rural residential, hobby farming and to cater for activities such as agroforestry and horticulture.

Many of the historical land titles along Spencers Brook award ownership to the centre of the brook (Hansen, 1986). In some cases ownership includes the waterway where land ownership stretches past the river boundary.

There are two reserves along Spencers Brook within the Shire of Northam. The Clackline Nature Reserve (No 32400) is vested in the Department of Conservation and Land Management with the designated purpose of conservation of flora and fauna. The Clackline Railway Reserve is Crown Land with some areas leased to local farmers and businesses (Gunness, 1999).

Survey methods

Community awareness and involvement

A letter of introduction was sent to landholders along Spencers Brook explaining the purpose of this survey. Arrangements were then made by phone for access onto properties to survey the Brook. Letters were also sent out to local landcare, rivercare, catchment and 'Friends' groups to allow them the opportunity to become involved in the assessment of Spencers Brook. Notices were placed in local newspapers advising of the project and inviting submissions from any member of the community.

Articles in the local newspaper, the Avon Valley Advocate, provided publicity about this project. Media releases were used to advise community members of the project and gave individuals and group members the opportunity to take part in field assessments.

A draft report was prepared and released for public comment, giving landholders and community members the opportunity to respond to report findings and the broad management recommendations that have been made. Comments received have been taken into consideration in the preparation of the final report.

Assessment technique

A *Foreshore and Channel Condition Assessment Form* was developed to standardise the field surveys and keep the collection of data consistent. The assessment template was based on the assessment techniques developed by Pen and Scott (1995); *Stream and Foreshore Assessment in Farming Areas*, with some variations included to meet the specific needs of this assessment. The survey form was divided into the following categories:

- general details;
- bank stability;
- waterways features;
- foreshore condition assessment;
- vegetation health (and coverage);
- fencing status;
- overall stream environmental rating (stream health);
- habitats;
- habitat diversity;
- landform types;
- evidence of management;
- management issues;
- vegetation; and
- water quality data (pH and electrical conductivity).

The primary focus of this assessment was the foreshore and channel areas of the Brook. The area studied includes the riverbed, channel embankments, floodway, verge, foreshore and land use adjacent to this waterway.

Foreshore and channel assessments were conducted by walking the length of each brook section and filling out the survey form (an example is provided in Appendix 4). In some instances, factors such as foreshore condition were averaged for the whole of a section with best and poorest conditions also recorded.

In all cases both sides of the brook were surveyed on one form and an average was determined for each assessment category. However, if each side of the waterway had differed greatly in either condition or surrounding landuse a separate survey sheet would have been completed for each side. Where assessment categories referred to each side of the waterway (ie fencing status on the left or right bank), surveys were conducted facing upstream.

The majority of assessment along Spencers Brook was observational. Foreshore and channel condition was assessed whilst walking along the waterway and recording on the assessment template. Photos have been taken at points of interest and can be used for future monitoring of the brook. Landholders were also asked about changes in waterway condition and health, fauna, past landuse and management of the waterway.

Where vegetation was not identified during field assessments, samples were taken for later identification. Books such as *Western Weeds* (Hussey et al, 1997) and *Trees and Shrubs for the Midlands and Northern Wheatbelt* (Wilcox et al, 1996), as well as the expertise

of Commission personnel was used to identify these specimens. *A Licence for Scientific or other Prescribed Purposes* was obtained from the Department of Conservation and Land Management giving permission to collect flora for scientific and identification purposes subject to certain conditions.

The use of a GPS unit (model Magellan GPS 315) allowed for points of interest to be recorded. Locations such as section start and end points were recorded to allow for accurate display of collated data on maps. Readings will also allow for accurate location of sections for future monitoring and management.

The assessment format used is comprehensive in recording foreshore and channel condition but does not require specialised knowledge or extensive technical assistance to complete. Hence, community groups, landholders and individuals without the aid of a qualified person can undertake assessments. The survey forms are sectionalised so that assessors can make use of sections relevant to their needs, whilst ignoring the other information. A blank assessment form is provided in Appendix 5 that can be copied and used by the community to assess waterways.

Method of analysis

A database has been set up to record information collected during foreshore and channel assessments. The database contains both numerical and written data taken directly from the survey forms. It does not include any anecdotal evidence supplied by landholders and other community sources. Only information that does not breach confidentiality has been included in this database.

Having information recorded in a database structure (as well as using a standardised assessment form) has allowed analysis to be performed between survey sections as well as along the whole watercourse. Queries within the database structure provided efficient collation of data that was then converted into spreadsheets for inclusion and interpretation in this report.

Five categories have been used throughout the field assessments to determine an overall stream environmental rating. Appendix 6 contains a table explaining the categories used to classify the stream condition and the overall health of the brook.

The overall stream environmental health rating is used to assess the ecological value of the individual brook sections and allows us to classify the health of the waterway. This rating system determines the current environmental condition of the waterway based on the six individual components listed below:

- floodway and bank vegetation;
- verge vegetation;
- stream cover;
- bank stability and sedimentation;
- habitat diversity; and
- surrounding landuse.

Depending on the rating (very poor up to excellent), points are allocated to each of these components and an overall stream environmental health rating is determined for each survey section. Appendix 6 provides a table that shows the points allocated to each individual component based on which rating the section received.

Results of the foreshore and channel assessment have been stored in a database that has been used to correlate figures for factors such as general foreshore condition and fencing along the brook. Data has been collated and is the source information from which maps have been produced. Key findings of Spencers Brook assessment have been summarised within this report.

Survey results

Anecdotal evidence as well as survey results indicate that Spencers Brook and its surrounding catchment has historically been subjected to a wide range of disturbances that have lead to a decline in health. Field observations indicate that the main forms of degradation present are bank erosion, sedimentation, and a decline in vegetation cover and health.

Bank and channel stability

Erosion, slumping and sedimentation all affect channel stability. Results indicate that the majority of sections (when rated in terms of the overall stream environmental health) were recorded as having poor bank stability and sedimentation. Field assessments of each river section evaluated factors that were used to determine channel stability:

- undercutting;
- firebreak/track washouts;
- subsidence;
- erosion;
- slumping; and
- sedimentation.

Channel stability is an average for the whole section and can be rated as shown in Table 1.

Channel stability affected	**% of Brook section**
Minimal	0-5
Localised	5-20
Significant	20-50
Severe	>50

Table 1. Rating system used to determine channel stability

Bank stability and sedimentation was determined as part of the overall stream environmental health rating, which indicated the average stream health of each survey section. It can also be used to give an idea of bed and bank stability. Figure 1 provides a collation of results for Spencers Brook which have been based on the information provided in Appendix 6.

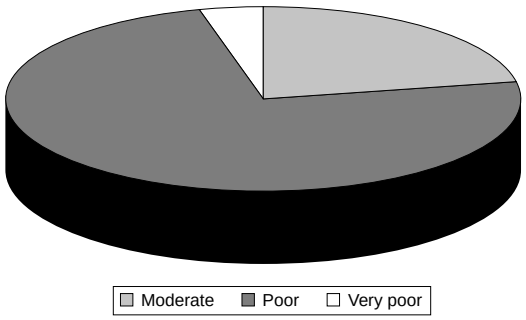


Figure 1. Bank stability and sedimentation ratings for Spencers Brook.

Bank stability and erosion were rated as moderate in 22% of sections (Figure 1). The majority of sections, 74%, were classified as poor and 4% as very poor (artificial bank stabilisation techniques were utilised in 22% of sections). Techniques such as log and rock walling have been employed along the banks to protect degraded areas from further erosion and undercutting. There were also some locations (ie. road bridges) where channel stabilisation had been undertaken as part of engineering structures for safety reasons and to support the construction of such features, not for protection of the waterway.

In many cases, alignment of road bridges to the waterway is restrictive to flow and consequential erosion and scouring of banks and channel beds may occur. In some areas (such as at the confluence of Spencers Brook with Warranine Brook) this has already begun.

Undercutting was recorded as being localised in 52% of sections, significant in 37% and severe in 11% of the sections.

Firebreak and track washouts were determined to be minimal along 30% of the sites and localised along 4%, while 66% of the sections had no tracks and firebreaks running in close proximity to the channel.

Subsidence (the sinking of ground that is not slope related) was recorded as being minimal in 70% of sites and localised in 22% of surveyed sites. The rest showed no signs of subsidence.

Erosion was recorded as being localised in 4% of sections, significant in 59% of sites and severe in 37% of the sections surveyed.

Slumping also affected the banks with ratings recorded as minimal in 56% and localised in 33% of sections. 11% of the sections were not affected by slumping at the time the assessments were carried out.

Sedimentation was another prominent component of degradation recorded along the brook with 4% of the sites recorded as minimal, 52% as localised, 40% as significant and 4% as severe. 55% of sites were recorded as having sand slugs.

The overall stability of the channel might be defined as moderate to poor (see Table 2) with over half of the sections being highly eroded and unstable with large deposits of sandy sediment. Mobile sediment deposits were identifiable along some areas of the channel, while there were also some areas along the riverbed that have been eroded down to the underlying clays.

Anecdotal evidence suggests that sediment within the Spencers Brook system is mobile. Field observations, supported by anecdotal evidence, determined that the floods of January 1999 and January 2000 caused erosion on the riverbed, banks and foreshore and fresh sediment was deposited along the banks and foreshore. Changes in foreshore and channel condition were reported by landholders and were supported by field observations.

Waterways features

The features of a waterway, such as pools and riffles can be linked to ecosystem diversity and waterway health. The presence of features such as rapids, anabranches, riffles, bridges, sand slugs and vegetated islands allow us to assess the health.

Survey results show that 70% of the sections were comprised of a single channel, while 30% were braided and 30% had anabranches running in close proximity to the brook. Sand slugs were evident in 55% of sections.

44% of the sections had natural riffles and 55% had shallow pools at the time of assessment. Pools will become shallower during the hotter summer months when the flow of water within the system stops.

Bridges cross the brook in 77% of sections. Of these crossings, 27% were located as parts of a driveway, while the other 73% were at junctions with roads. Another 30% of the sites had man-made crossing points to allow stock, vehicles and machinery to cross the waterway.

26% of sites had dams situated in close proximity to the waterway, 26% had smaller tributaries feeding into Spencers Brook from the surrounding catchment, and 30% had drains channelling water in from the surrounding landscape.

Foreshore condition

General foreshore condition

89% of sections were rated as having a general (or average) foreshore condition of C-grade. Essentially, a C-grade foreshore supports a limited diversity of trees over weeds or pasture. There may also be localised areas of bank erosion and subsidence (Pen and Scott, 1995). Appendix 7 provides an overview of all possible grades, from A1 through to D3.

7% of surveyed sections were rated as B-grade and 4% were rated as having a D-grade general foreshore condition rating. B-grade ratings were awarded to those sections with a more diverse cover of native vegetation being invaded by grassy weeds. Sections rated as D-grade were in great need of management, with the stream simply characterised as an eroding ditch or weed infested drain (Pen and Scott, 1995).

Best foreshore condition

The best foreshore condition recorded along each section varied greatly with 11% of the sites rated as B2, 29% as B3, 41% as C1, 15% as C2 and 4% as C3-grade (Map 4).

Results indicate that there was no distinct pattern and foreshore condition was largely related to past and current landuses throughout the catchment.

Poorest foreshore condition

Map 5 depicts the poorest foreshore conditions recorded in each section surveyed along Spencers Brook. The map indicates that there was less variation recorded in the poorest foreshore condition classifications with 59% of surveyed sections rating as C3, 30% as D1 and 11% as D2-grade.

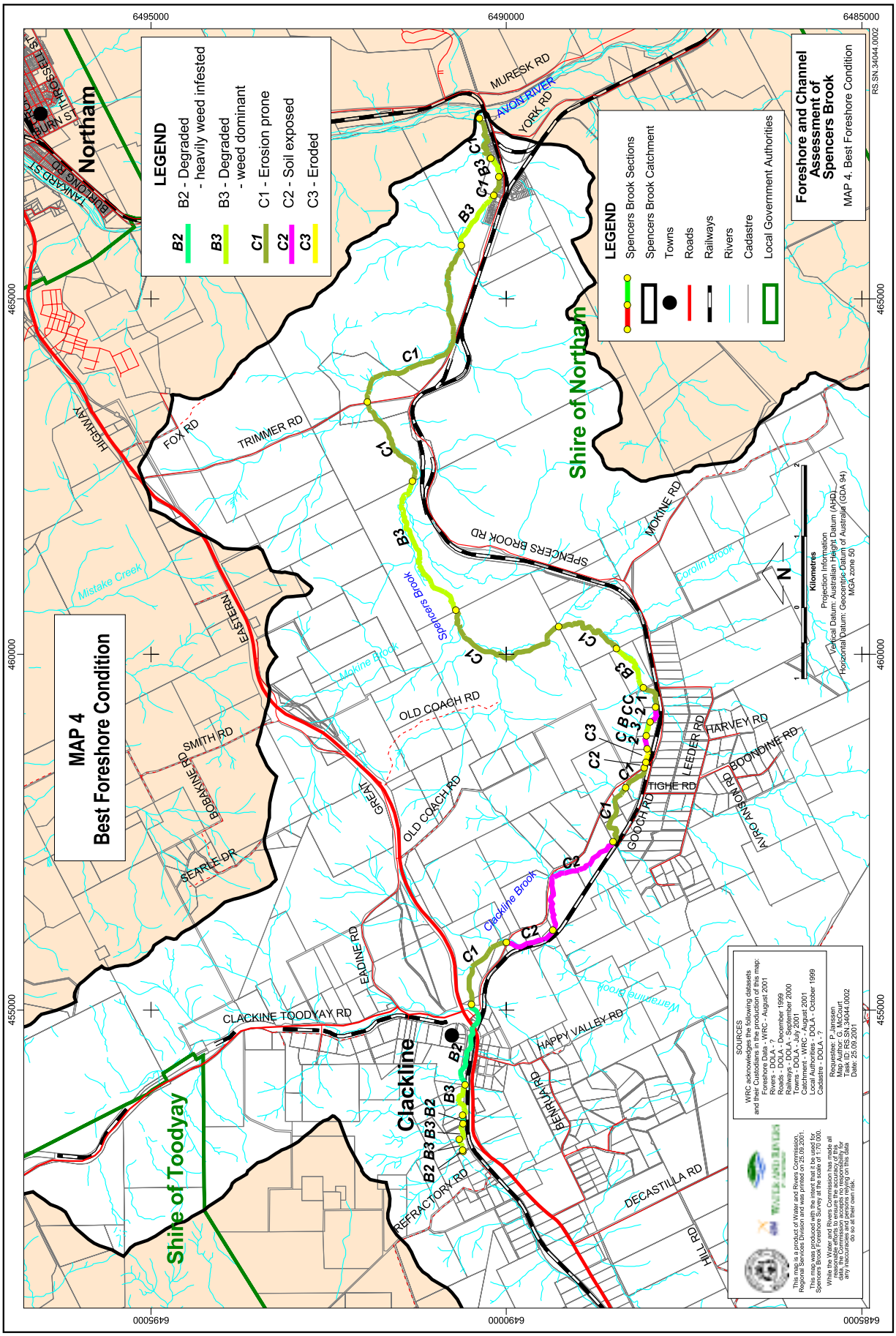
Foreshore vegetation

Presence of common species

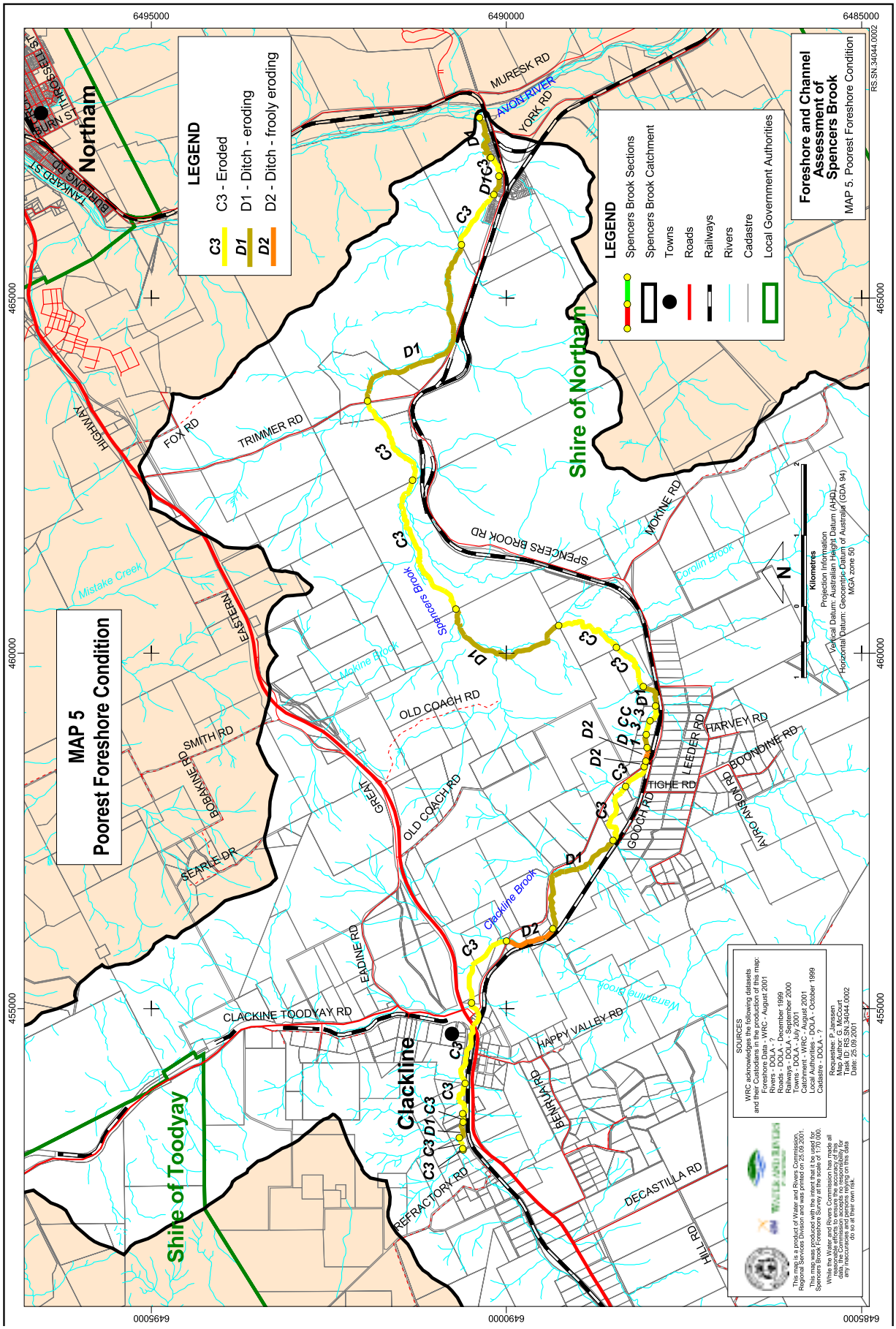
The most common overstorey species recorded along the Spencers Brook were Flooded gum (*Eucalyptus rudis*), Wandoo (*Eucalyptus Wandoo*) and Swamp paperbark (*Melaleuca rhaphiophylla*).

The most common understorey species recorded were weed species including Wild oats (*Avena fatua*), Couch (*Cynodon dactylon*), Barley grass (*Hordeum leporinum*), Soursob (*Oxalis pes-caprae*) and Watsonia (*Watsonia* sp.).

A section along Spencers Brook showing characteristics of an eroded bed and D-grade foreshore.



Map 4. Best foreshore condition



Map 5. Poorest foreshore condition

Field observations indicated that weed species were far more common than native species, with results showing that 55% of surveyed sections had an abundant occurrence of exotic vegetation (weeds), while 41% were recorded as frequent. Native vegetation, on the other hand, was recorded as frequent in 26% and occasional in 74% of surveyed sections.

Proportion of native species

Table 2 shows the occurrence of native plant species recorded during foreshore assessments along Spencers Brook.

Plant name		**% of sites where the species occurred**	**Occurrence of each species**		
Common name	**Scientific name**		**High**	**Medium**	**Low**
Acacia sp.	*Acacia* sp.	26	4	15	7
Bare twig rush	*Baumea juncea*	7	0	0	7
Creeping salt bush	*Atriplex semibaccata*	4	0	0	4
Flooded gum	*Eucalyptus rudis*	100	15	78	7
Foxtail mulga grass	*Neurrachne alopeciroides*	7	0	0	7
Golden wreath wattle	*Acacia saligna*	7	0	0	7
Grass tree	*Xanthorrhoea drummondii*	7	0	0	7
Green mulla mulla	*Ptilotus polystachyu*s	4	0	0	4
Hakea sp.	*Hakea* sp.	18	0	0	18
Jam tree	*Acacia acuminata*	40	0	18	22
Jointed twig rush	*Baumea articulata*	4	0	0	4
Knotted club rush	*Isolepis nodosa*	4	0	0	4
Needle bush	*Hakea preissii*	15	0	4	11
Samphire sp.	*Halosarcia* spp.	4	0	0	4
Shore rush	*Juncus kraussii*	19	0	0	19
Spiny flat sedge	*Cyprerus gymnocaulos*	4	0	0	4
Swamp paperbark	*Melaleuca rhaphiophylla*	89	0	22	67
Swamp sheoak	*Casuarina obesa*	22	0	0	22
Wandoo	*Eucalyptus wandoo*	63	0	7	56
York gum	*Eucalyptus loxophleba. var. loxophleba*	18	0	11	7

Table 2. Native species occurrence

Figure 2 shows that the majority of native species occurred in the overstorey and middlestorey with 93% of surveyed sections recorded as being comprised of between 81-100% native vegetation in their tree layer.

- Hakea seedlings were recorded at 9% of survey sections;
- Swamp sheoak seedlings were recorded at 9% of survey sections;

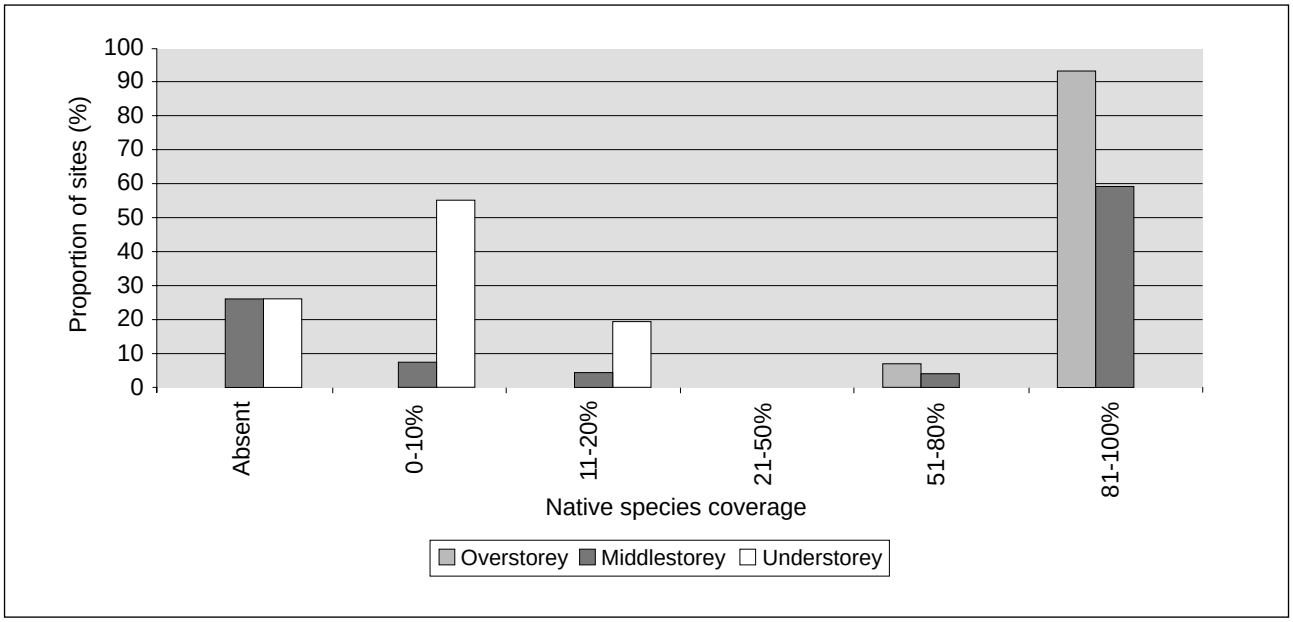


Figure 2. Proportion of native species in each vegetation layer

Of middle storey species present (shrubs and small trees), 59% of sites were recorded as having between 81-100% native vegetation. Ground cover (ie. grasses) was predominantly weed species with 55% of sites recording a cover of between 0-10% native species. Native understorey and middlestorey species were found to be absent in 26% of sections.

Regeneration of native species

Natural regeneration of tree species was observed at 48% of the survey sections. The following species were showing signs of natural regeneration amongst foreshore vegetation along Spencers Brook:

- Flooded gum seedlings were recorded at 36% of survey sections;
- Acacia seedlings were recorded at 32% of survey sections;
- Jam tree seedlings were recorded at 9% of survey sections; and
- Swamp paperbark seedlings were recorded at 5% of survey sections.

55% of sections showed evidence of plantings being undertaken as a part of landholders land management plan. Plantings consisted mainly of tree species.

Death of common native species

Vegetation health was determined to be moderate along most of Spencers Brook and tree death was obvious in many areas. As described above, there was a lack of middle storey plants in most areas and the ground cover was dominated in most instances by weed species.

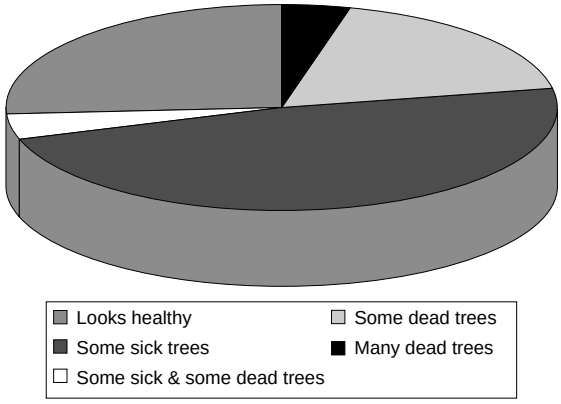


Figure 3. Vegetation health

Figure 3 shows that 48% of surveyed sections recorded some sick trees among the foreshore vegetation, while 18% of sites had some dead trees. Only 26% of sites were recorded as having healthy looking vegetation (ie. lots of leaves, natural regeneration of native species, lack of weeds, diversity of native species and a low level of disease and insects).

Vegetation cover

Field investigations determined that the majority of sites lacked a middlestorey (shrub layer) and supported a patchy upperstorey of tree species (Table 3).

	Proportion of vegetation cover			
	Absent (0%)	**Sparse (<20%)**	**Patchy (20-80%)**	**Continuous (>80%)**
Upperstorey (%)	0	7	74	19
Middlestorey (%)	19	59	22	0
Ground cover (%)	4	19	2255	

Table 3. Vegetation cover

The data in Table 3 shows that ground cover was the most dominant vegetation layer with 55% of sites recorded as being continuous and 22% as patchy. Middlestorey vegetation was absent in 19% of sites and sparse in 59% of sites. The upperstorey was dominantly recorded as being patchy (between 20% and 80% coverage), with 74% of the sections rated in this category.

All of the surveyed sections had a percentage of bare ground. Results indicated that 11% of sections had less than 10% bare ground, 37% of sections 11%-20% bare ground, 44% of sections between 21% and 50% bare ground, and only 7% with over 50% bare ground.

Results collated for stream cover as part of an evaluation to determine the overall stream environmental health rating indicate instream vegetation cover along the Brook. Stream cover was moderate in 78% of sections, meaning that there was some permanent shade and overhanging vegetation with some instream cover recorded (Pen and Scott, 1995). Good stream cover was recorded in 11% of sections, poor in 7% and very poor in 4% of surveyed sections.

Weeds

The most common weed species recorded along Spencers Brook were Barley grass (Hordeum leporinum), one and two leaf Cape tulip (Homeria sp.), Couch (Cynodon dactylon), Four o'clock (Oxalis purpurea), Soursob (Oxalis pes-caprae), Watsonia (Watsonia sp.), and Wild oats (Avena fatua). Wild oats was recorded as having a high occurrence in 85% of sections, while Barley grass, Couch and Soursob were all recorded in the majority of instances as having a moderate occurrence at the sites in which they were recorded. Table 4 shows the occurrence of the more common weeds found along Spencers Brook as a percentage of sections they occurred in.

	Weed species	Occurrence (% of sites)		
Common name	**Scientific name**	**High**	**Medium**	**Low**
Barley grass	*Hordeum leporinum*	26	37	4
Blowfly grass	*Briza maxima*	7	4	11
Bulrush	*Typha orientalis*	4	4	0
Cape tulip sp.	*Homeria* sp.	22	18	22
Capeweed	*Arctotheca calendula*	0	11	7
Clover sp.	*Trifolium* sp.	0	11	4
Couch	*Cynodon dactylon*	30	37	11
Dock (Sheep's sorrel)	*Rumex acetosella*	0	4	30
Fat hen	*Chenopodium album*	0	18	18
Fig tree	*Ficus* sp.	0	0	4
Four o'clock	*Oxalis purpurea*	11	22	30
Geranium	*Erodium* sp.	0	7	0
Guildford grass	*Romulea rosea*	15	7	0
Night shade	*Solanum* sp.	0	0	4
Patterson's curse	*Echium plantagineum*	0	0	11
Pine tree	*Pinus* sp.	0	4	0
Prickly sowthistle	*Sonchus asper*	0	7	7
Rye grass (annual)	*Lolium rigidum*	0	4	0
Soursob	*Oxalis pes-caprae*	18	30	15
Spike rush	*Juncus acutus*	0	0	4
Watsonia	*Watsonia* sp.	15	11	26
Wild oats	*Avena fatua*	85	15	0

Table 4. Common weed occurrence

Wild oats was by far the most dominant weed species, recorded in all survey sections, with a high occurrence in 85% of sites. Couch was recorded in 78% of sections, Barley grass in 67%, both Four o'clock and Soursob in 63% and Cape tulip in 62% of survey sections.

Pest plants

Pest plants are weed species that are seen as being a nuisance to the existing landuse. Local Government Authorities have the responsibility of administering the *Agriculture and Related Resources Protection Act 1976* and have the authority to enforce the control of such a species within its boundaries (Hussey et al, 1997). Two pest plant species were recorded amongst the foreshore vegetation along Spencers Brook, Dock (*Rumex acetosella.*) and Watsonia (*Watsonia* sp.). Dock was recorded in 34% of survey sections and Watsonia in 52%, with both species having a moderate to low occurrence in these areas.

Declared plants

Declared plants are those plants that are classified as a high management priority and that have the potential to become a major problem to the environment or to

agricultural activities. They are formally declared under the *Agriculture and Related Resources Protection Act 1976* administered by the Department of Agriculture. Under this Act, landholders are obliged to control any declared plants that occur within their properties (Hussey et al, 1997). Two declared plants, Cape tulip (one leaf) and Soursob, were sighted along Spencers Brook.

Cape tulip was recorded in 62% of sites with a high and medium occurrence in 22% and 18% of sites respectively. Soursob was recorded in 63% of survey sections and was classified as having a high occurrence in 18% of the sites in which it was recorded.

Habitat diversity

Field investigations determined the presence of potential habitat for both aquatic and terrestrial fauna. Results indicate that the most common habitat sources are trees and a variety of vegetation types, with these two habitat types recorded in 100% of surveyed sections. Other habitat types were also recorded, although not as frequently as the above.

Providing habitat for aquatic organisms such as invertebrates, reptiles and fish:

- instream logs were recorded along 92% of sections;
- protected basking sites (ie. debris and branches) were recorded at 88% of sections;
- meanders and pools were recorded along 77% of sections;
- instream cobbles and rocks were recorded along 59% of sections;
- cascades, rapids and riffles were recorded along 55% of sections;
- rushes (mostly non-native species) were recorded along 44% of sections; and
- emergent plants/soft substrate for eggs were recorded along 30% of sections.

Providing habitat for terrestrial animals such as invertebrates, birds, frogs, reptiles and mammals:

- trees were recorded along all sections;
- shrubs were recorded along 67% of sections; and
- dense streamside vegetation along 22% of sections.

Instream cover was moderate in 78% of sections when determined as part of the overall stream environmental health rating. There was often a mixture of leaf litter, rocks, branches and vegetation. Figure 4 shows the proportion of sections that had instream cover and that leaf litter was the most common instream cover and habitat type (at 100% of sites), followed by branches, occurring at 96% of sections.

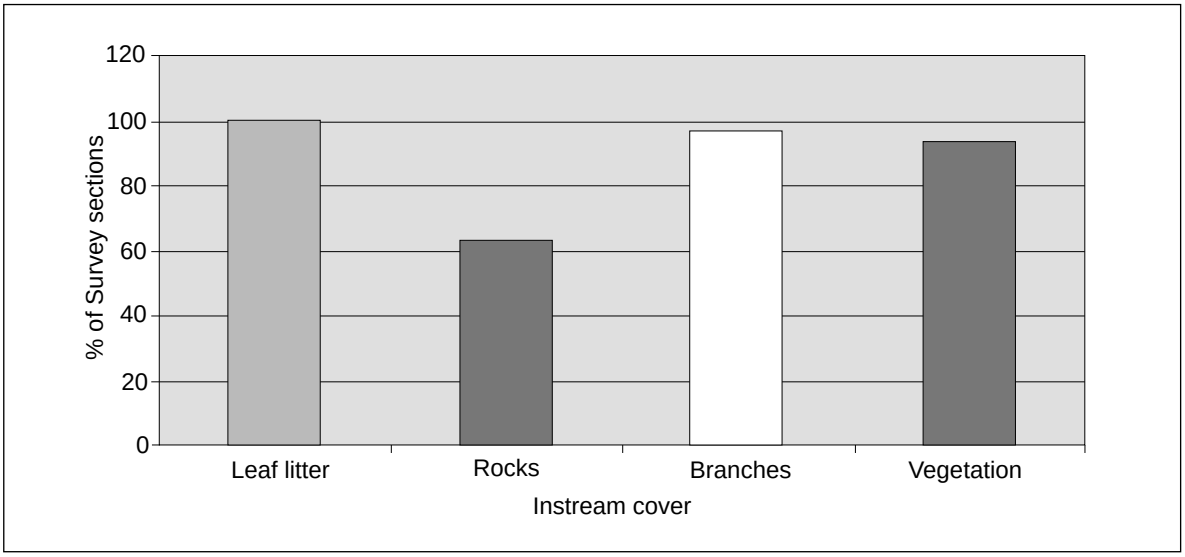


Figure 4. Proportion of instream cover

Foreshore habitat differs slightly to that within the stream channel. Leaf litter along the foreshore was classified as minimal in 74% of sections and good in 26%. Ratings used during assessment of the overall stream environmental health rating determined that the majority (81%) of Spencers Brook was rated as having moderate habitat diversity. This is defined as a stream section with a range of habitat types, but without permanent water (Water and Rivers Commission, 1999).

A variety of wildlife was observed while conducting field assessments along the waterway. The following is a list of fauna recorded in and around Spencers Brook:

- Ants
- Australian Shelduck
- Bees
- Beetles
- Birds
- Blue wren
- Brown honeyeaters
- Bull ants
- Butterflies
- Corvids
- Crickets
- Dragonflies
- Ducks
- Echidna
- Fantails
- Flies
- Foxes
- Frogs
- Gambusia
- Gilgies
- Grasshoppers
- Kangaroos
- Lizards
- Macroinvertebrates
- Magpies
- Mosquitoes
- Pink and grey galahs
- Rabbits
- Reptiles
- Scarlet Robins
- Scorpion
- Snakes
- Spiders
- White-faced heron
- Willie wagtails

Anecdotal evidence suggests that the variety of fauna in the past was more plentiful. Many landholders commented that foxes, and rabbits have become more common in recent years, and may account for the declining number of native fauna, such as possums, recorded during field assessments. Anecdotal evidence also suggests that long neck tortoises are found in some areas of the waterway and that guadas and tiger snakes are the most common snakes inhabiting the riparian zone along Spencers Brook. Appendix 8 shows a list of fauna species observed during a Department of Conservation and Land Management study of the Clackline Nature Reserve.

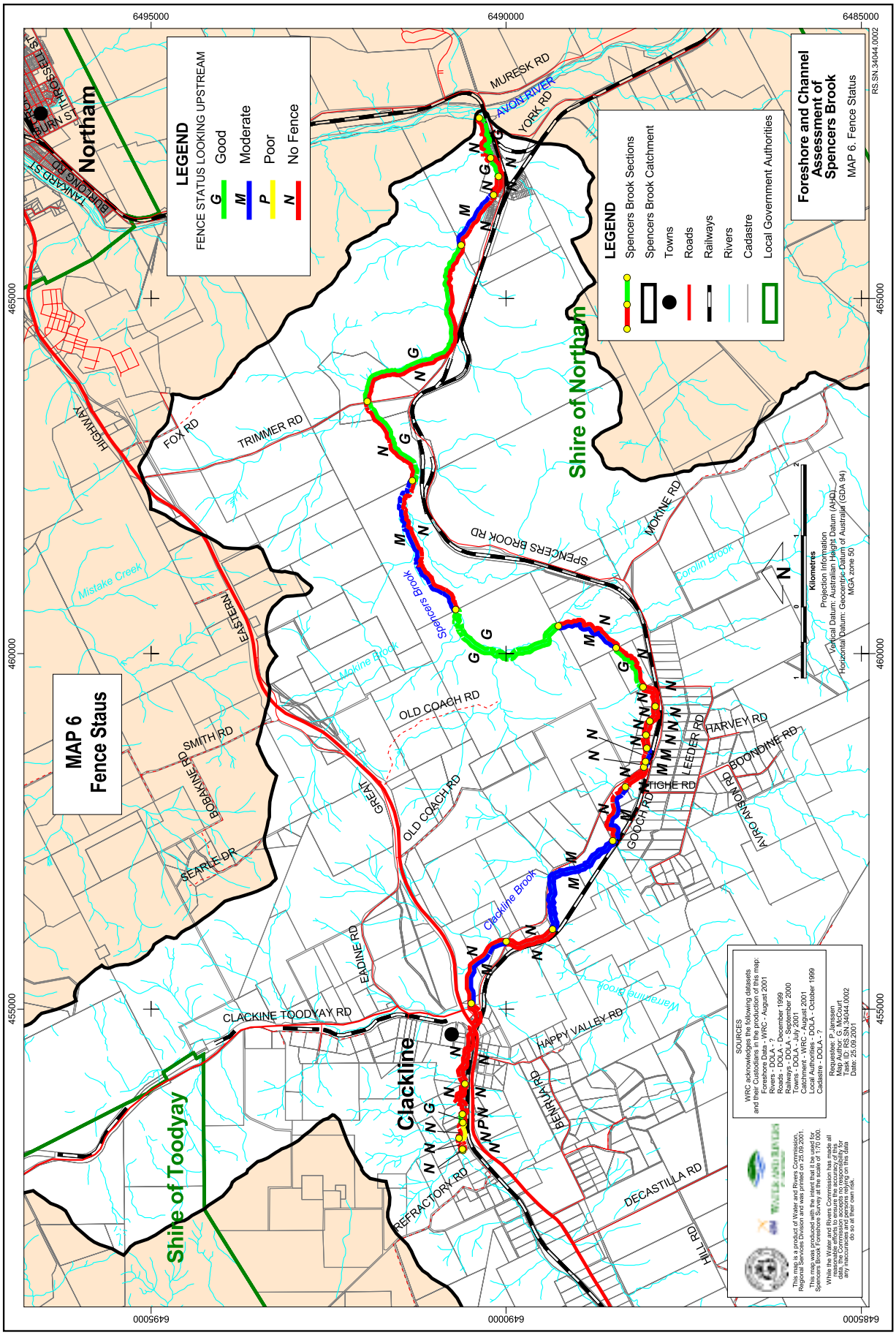
A seasonal change in water depth in Spencers Brook suggests that habitat would change significantly from one season to the next (eg. alterations in the level of exposure of logs, branches, rocks and sand slugs). During field assessments the channel was predominantly dry, but there was evidence of a significant fluctuation in water depth, such as exposed tree roots, dampness along banks, debris in trees, sediment and salt deposits, and bank erosion). As a result of a change in water levels and therefore habitat availability, the diversity and richness of fauna would also fluctuate. For instance, many birds would visit the waterway seasonally when water is available to fulfil food, shelter and nesting requirements.

Fencing status

Foreshore assessments determined that 59% of river sections were fenced on one or both sides (Map 6). When facing upstream 7% of sections were fenced on both sides, a further 26% of sites were fenced only along the left bank and 26% along the right bank, while 41% were not fenced at all. Results indicated that stock had access to the channel and riparian zone along 59% of the survey sections, and vehicles had access along 85%.

Of those areas that were fenced, 44% was in good condition, 50% was in moderate condition and 6% was in poor condition. Of the fencing style used along the fenced sections 12% were plain wire, 16% barbed wire, 6% electrified, 6% a combination of fabricated and electrified, 31% a combination of fabricated and barbed, 12% plain wire and electrified, and 17% plain with barbed wire. Appendix 9 provides a definition of each fencing style and examples of fence condition.

The position of the fence was also determined, with an approximation given for the distance of the fence line (left and right bank) from the bank of the waterway. Table 5 shows that the majority of fenced sections were fenced within 30 metres of the riverbank along the left bank, whereas only 11% of fenced sections along the right bank were fenced within 30m of the riverbank.



Map 6. Fence status

Distance of fence from riverbank (metres)	Proportion of sections in each category (%)	
	Left bank	Right bank
< 10	11	7
11 – 20	11	4
21 – 30	0	0
>30	11	22
Not fenced	67	67

Table 5. Fence position along Spencers Brook

Water quality

An assessment of the water quality along Spencers Brook was not obtainable during field assessments due to the intermittent nature of flow. Water was not flowing for the majority of the surveys and after this time, it was thought unfeasible to obtain samples that would show extreme readings for pH and salinity and not give a true indication of water quality along the brook.

Overall stream environmental health rating

The overall stream environmental health rating is a system used to determine the health of the waterway by rating health factors such as habitat diversity and verge vegetation.

The results in Figure 5 show that only 26% of the surveyed sections were classified as having a moderate stream health, 70% as poor and 4% as having very poor stream health. The dominantly poor health rating of the brook was mainly due to poor ratings in all categories with the exception of stream cover and habitat diversity of which 78% and 81% of sites respectively were rated as moderate, as shown in Table 6. Appendix 6 provides a description of each factor at each level of health.

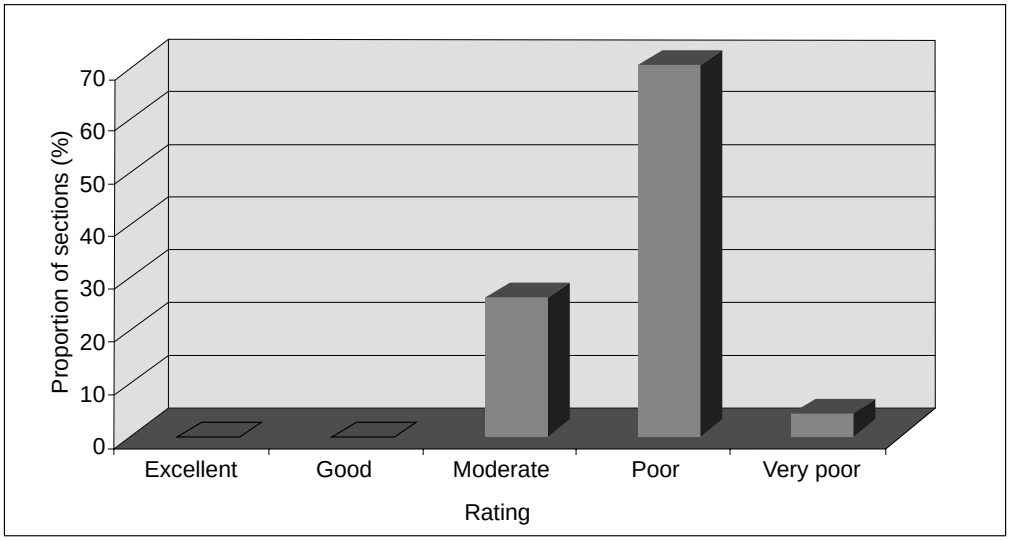


Figure 5. Overall stream environmental health ratings

Health factors	Proportion of sites rated in each category (%)				
	Excellent	Good	Moderate	Poor	Very Poor
Floodway and bank vegetation	0	0	26	70	4
Verge vegetation	0	0	26	74	0
Stream cover	0	11	78	7	4
Bank stability and erosion	0	0	22	74	4
Habitat diversity	0	0	81	15	4

Table 6. Proportion of sites in each environmental health category

As indicated in Table 6, no sections were classified as excellent in any of the categories, while only 11% of sections were rated as having good stream cover. Habitat diversity rated the best with 81% of sections being classified as having a moderate condition. Floodway and bank vegetation was classified as poor in 70% of sites, while both verge vegetation, and bank stability and erosion were rated as poor in 74% of sections. Only a small number of sections were classified as very poor as an indication of environmental stream health (with the exception of verge vegetation which had no recordings of very poor).

Disturbance

The riparian zone along Spencers Brook is subject to many disturbance factors that are contributing to the continual degradation of the channel and foreshore. The following gives a summary of the major disturbances observed during field surveys:

- All sections contained weed species;
- 85% of the surveyed sections were disturbed by feral animals;
- 85% of sections were accessible by vehicles;
- 74% of surveyed sections were affected by pollution (mainly due to animal manures and crop sprays);
- 70% of the surveyed sections had stock in the brook;
- 67% of surveyed sections had crossing points allowing stock and vehicle access across the brook;
- 48% of surveyed sections contained dumped rubbish; and
- 33% of the surveyed sections were influenced by service corridors (ie. roads and pipelines).

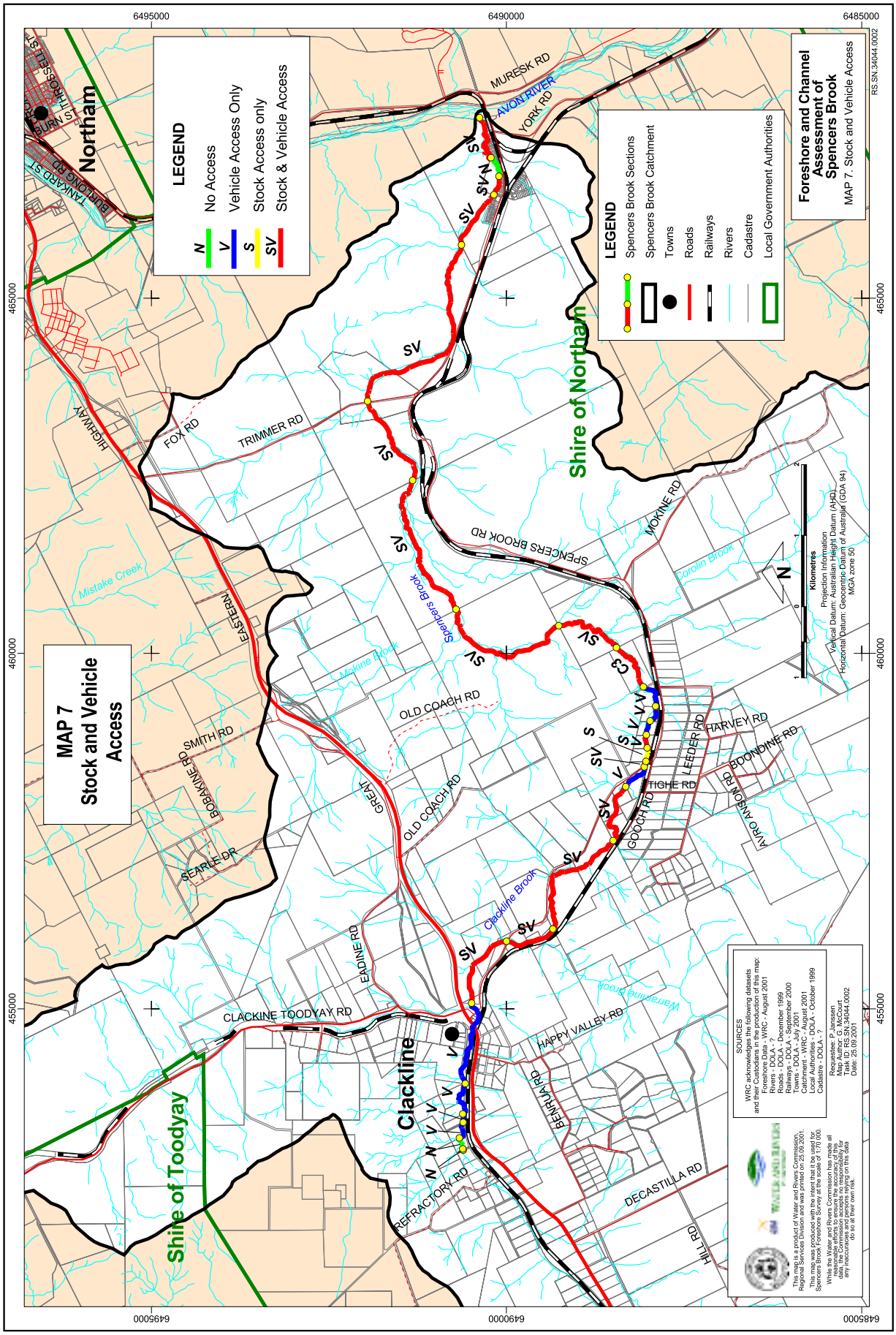
Map 7 represents all sites along the waterway where stock and vehicles have access to the foreshore and channel of the waterway. It should be noted that not all sites are grazed by stock all year round. Some sites are used only for a few months of the year while others are continually under pressure from stock grazing and trampling.

Evidence of management

Of the sections surveyed along Spencers Brook 85% showed some evidence of attempts at river management, although not on a large scale. The most common management control was fencing with 59% of sites having fences along one or both sides of the waterway. Other river management practices included:

- 37% of survey sections showed evidence of weed control;
- 26% of survey sections used firebreak control;
- 22% of survey sections showing evidence of tree planting;
- 18% of survey sections undertaking feral animal control (baiting);
- 11% of properties along the brook employing surface water management (contour banks) and dams;
- 7% of survey sections using man-made riffles to control sediment movement and water flow;
- bank stabilisation (such as log and rock walling) were employed in 7% of survey sections;
- 4% of sections using signage to demonstrate rehabilitation activities within the riparian zone; and
- 4% of survey sections being zoned with Reserve status.

Although survey data determined that only a low number of sections were employing feral animal control and weed control, anecdotal evidence suggested that these figures should be higher.



Map 7. Stock and vehicle access

Interpretation of survey results

Channel stability

Erosion and sedimentation have been determined to be the most serious concerns to channel stability along Spencers Brook. The severity of each is directly related to either past or present landuse along the waterway. Grazing of the riparian zone and trampling of riverine vegetation by stock is often responsible for causing bank and instream erosion. Cropping activities also lead to sedimentation by increased runoff from cleared paddocks carrying soil particles into the waterway. The removal of large woody debris from within the channel leads to reduced protection of the banks and foreshore areas, and combined with higher flow velocities, exacerbates erosion.

A high level of disturbance (resulting from incompatible landuse activities throughout the catchment) will result in erosion and bank scouring which can lead to incision and widening of river channels. The manual straightening of the channel will lead to disturbance and lowering of the channel bed, resulting in an increased flow velocity. This will increase the probability of erosion and incision of the streambed and banks. Increased bank erosion means that there is potentially more sediment available to be moved along the watercourse. Hence, a higher amount of sediment can be deposited in downstream areas amongst woody debris, riffles, on the inside of meander bends, and in areas of slower flow, such as pools, which are important summer refuges providing habitat for aquatic and terrestrial organisms.

In most cases the brook runs through the middle of property boundaries, but only 30% of survey sections were recorded as having man-made crossing points that were not driveways or road bridges. This means that in many sites there was no defined crossing point for vehicles and stock. These disturbances will continue to contribute to erosion of banks, verges and the riverbed.

Historically an unstable system, the stability of the channel, banks and floodplain has declined as a result of pressure from a mixture of past and present landuse practices. Stock access to the riparian zone has led to foreshore areas becoming devoid of vegetation that plays a role in channel stabilisation. Its intricate root network holds soil together to prevent erosion, subsidence and slumping of the banks and verges.

An example of severe bank erosion along Spencers Brook

Riparian vegetation reduces flow velocity and dissipates energy during flood events. Diminishing species density and diversity has been a great disadvantage in terms of flood mitigation. The loss of riparian vegetation as a result of bank erosion, stock and clearing may have contributed to the shallowing of the channel in some areas. This is likely to be the cause of the deeper pools filling with sediment and the consequent loss of habitat for fauna.

Waterways features and habitat diversity

The waterways features recorded during field observations along Spencers Brook are indicative of the health of the waterway, including habitat diversity and aquatic fauna.

Results indicate a variety of waterway features. The moderate number of small pools along the brook during the field assessments can be attributed to the seasonal nature of the waterway, and the variability of flow throughout the year. Sedimentation of the waterway can alter river habitats and may even destroy them in the long term.

The unstable nature of Spencers Brook, and consequent sedimentation, has largely contributed to the loss of pools within the system. The high number of sand slugs recorded along the length of the waterway combined with the shallowing of pools indicates a decline in habitat diversity. In some areas the sandy soils had been eroded within the riverbed, leaving exposed clay bed material which has also led to a loss of habitat.

Suspended sediment is deposited in areas of slower flow such as in pools, along rocks, cobbles and logs, covering features that provide habitat to aquatic fauna. When deposited on substrate surfaces, sediment will commonly hinder algal growth that is an important food source for many aquatic organisms living in the brook (Jackson, 1997).

The removal of large woody debris from within the brook has contributed to increased flow velocity, and, combined with a number of other factors such as head cutting and clearing within the catchment, has resulted in a higher incidence of erosion and sedimentation. This may explain the combination of deeply incised channel and shallow channel morphology that has become Spencers Brook.

Areas where erosion is localised and a variety of vegetation (such as the Shore rush) is growing along the banks and verges provide important habitat for terrestrial fauna. Species such as birds, frogs and lizards utilise the vegetation for nesting and breeding.

Instream cover is important for water quality and the dependent aquatic fauna. Results indicate that there is a reasonable level of instream cover from leaf litter, branches rocks and vegetation. However, this cover is patchy and often does not extend far into the waterway, leaving some areas of the channel devoid of any cover and shade. A lack of shade will allow the water temperatures to increase and may lead to a decline in aquatic fauna and an increase in algal growth.

All survey sections were recorded as having tree species present, although 48% of sites were found to have ‘some sick trees’ and 18% ‘some dead trees.’ This may be attributed to waterlogging and rising salinity levels throughout the catchment, but may also be an effect of the unusually dry summer of 2000/2001. The dead trees still provide an important range of habitat for terrestrial fauna. Woody debris found instream and along foreshore areas provides an important habitat for aquatic and terrestrial organisms. An example of habitats along a watercourse and the terrestrial and aquatic fauna that may be found in each is provided in Appendix 10.

Bridges and crossing points allow vehicles to pass in close proximity to the waterway, increasing the likelihood of pollution by fuel, oil and other contaminants. Poorly engineered structures can lead to problems such as increased erosive capacity and a decline in fish migration. Results indicate that service corridors (ie. roads, pipelines and powerlines) were classified as having a moderate management priority in 4% of survey sections and a low management priority in 8% of sections. Crossing points were recorded as having a high management priority in 4% of sections, moderate in 18% and low in 37% of sections.

Overhanging vegetation provides shade along a waterway

Foreshore condition

The high proportion of the Spencers Brook foreshore that has been rated as C-grade indicates the degraded state of the riverine environment. A number of factors have contributed to the decline in foreshore health and condition. These are:

- Surrounding agricultural landuse;
- Uncontrolled access of stock to riparian zones (overgrazing and trampling);
- A lack of surface water management;
- Removal of large woody debris; and
- Lack of waterways management practices.

The above factors may be attributed to historical landuse practices and a lack of community understanding about waterways management on a long term basis. The volatile nature of farming may also mean that land managers do not have the economic means to change farming practices and improve water management practices on their property.

Foreshore vegetation

A lack of riparian vegetation can adversely affect the health of a waterway. Riparian vegetation protects water quality and channel form by decreasing the amount of nutrient and sediment entering the brook, as well as reducing erosion of banks. Clearing of vegetation, weed invasion, disturbance by stock and salinisation all impact negatively on the health of riparian vegetation (Jackson, 1997).

The vegetation recorded along the foreshore is indicative of how salty the water within the brook is. All dominant tree species observed during field assessments (Flooded gum, Jam tree, Swamp paperbark, Swamp sheoak and Wandoo) have a low tolerance to salty conditions (WRC and ARMA, 1999). Table 7 shows what level of salinity and waterlogging each species can tolerate.

Species name	Salinity range	Waterlogging tolerance
Flooded gum	Fresh - brackish	High
Swamp paperbark	Fresh - brackish	Very high
Wandoo	Fresh - brackish	Low
Jam tree	Fresh - brackish	Low
Swamp sheoak	Fresh - saline	High

Table 7. Salinity and waterlogging tolerance of dominant tree species

The high numbers of Flooded gum (in 100% of sites) indicates that the water is brackish -acceptable for most stock and some irrigation (ANZECC, 1992). Flooded gum can only tolerate moderate salinity levels but has a high tolerance to waterlogged conditions. Swamp paperbark (recorded in 89% of sections) can only tolerate fresh-brackish conditions, but very high levels of waterlogging.

The shallow to moderately steep landscape of the Spencers Brook catchment, in conjunction with soil types, may mean that the foreshore is likely to be prone to waterlogging during the wetter months. Jam tree and Wandoo are more sensitive to the effects of waterlogging over a prolonged period, resulting in the death of these species before the impact of salinity effects them. This may account for the lack of these species in some areas, as well as the poor health of trees within the riparian zone.

The composition of native plant communities has been altered significantly as a result of past and present landuse (the introduction of crops, annual pasture plants and grazing animals) that have led to changes to the landscape (Walker, 1986). A decline in species richness and diversity of native understorey species has encouraged the spread of grass and pasture weeds such as Wild oats and Barley grass.

The current lack of native understorey species means that the nutrient stripping ability of the riparian zone is greatly reduced, leading to a higher level of nutrients entering the aquatic system. Nutrient enrichment and consequential algal blooms have the ability (directly and indirectly) to kill aquatic fauna.

Understorey vegetation is dominated by weed species, most of which have been introduced and spread by birds, stock, wind, and water erosion of soil particles containing seeds. Species such as Wild oats and Barley grass are agricultural weeds (related to the historical use of surrounding land for cropping and grazing) and have a high occurrence along most of the brook.

The dominance of weed species compared to native species is due to the continual overgrazing and trampling of the riverine environment, hindering the regeneration of the native species. Weeds species are quicker to adapt to fluctuations in the environment and an increasing level of salinity has led to the death of many native species, leaving room for weed species to invade. Numerous areas of bare ground, combined with an increase in shallow rooted exotic species has left the riparian zone susceptible to bank erosion and nutrient enrichment.

The intensity of grazing in those sections where stock had access to the riparian zone directly relates to the regeneration and survival of native seedlings. Regeneration of native seedlings was only observed at 48% of sections. In most cases the number of seedlings was low, especially within those sections where stock had access to the foreshore area.

Leaf litter and lichens are minimal along the majority of foreshore sections, however they still play an important role in stabilising the soil surface and assisting in the reduction of soil erosion and compaction. Both are helpful in retaining moisture within the soil and feeding nutrients back into the soils. Leaf litter and debris provide nesting, feeding and shelter sites for many terrestrial invertebrates (Abensperg-Traun, 1995).

It should be noted that the vegetation surveys conducted throughout foreshore and channel assessments are not conclusive. It is likely that there are other species present along the brook and it is recommended that future assessments include two separate vegetation surveys, at differing times of the year, to determine a more accurate list of species present. See Appendix 3 for a list of flora species recorded during two individual surveys of the Clackline Rail Reserve (by the Wildflower Society of WA in 1999, and the Clackline Nature Reserve in 1987 by the Department of Conservation and Land Management.

Watsonia and Couch are becoming invasive along many sections of Spencers Brook

Disturbance

The current condition of Spencers Brook is attributable to a number of past and present disturbances, the key ones being:

- current farming practices;
- stock access to waterways;
- vehicle access to waterways;
- feral animals;
- spread of weeds; and
- frequent fires associated with surrounding farming practices.

70% of survey sections were accessible to stock during the time assessments were conducted, however field observations and landholder comments suggest that the number of sites accessible to stock varies throughout the year. Approximately 59% of Spencers Brook is fenced on one or both sides. Many farmers graze stock along the waterway when there is a lack of feed and for other reasons such as reducing fire hazards. Over the years however, crop and livestock production has taken its toll on the landscape. Livestock access to the river channel and foreshore can lead to problems such as:

- foreshore and channel erosion;
- introduction and spread of weeds;
- trampling and eating of native vegetation (particularly regrowth);
- an increase in nutrients (animal faeces) being deposited into the waterway;
- a reduction in fringing vegetation;
- estabilisation and mobilisation of sediment; and
- loss of habitat for native fauna (through loss of vegetation as well as competition).

All of these factors combined contribute to the degraded state of the foreshore and channel of Spencers Brook. However, introducing stock to the landscape should not be seen as the only cause of land degradation within the catchment.

Weed distribution is closely linked to increased levels of disturbance in wetlands from activities that include clearing and grazing. Overgrazing of stock can also degrade the environment through soil compaction, increased nutrient levels, introduction of weed species, trampling of native wetland plants and the ringbarking of mature trees.

Feral animals may contribute to soil erosion; for example, rabbits burrow into the ground for nesting purposes and also eat vegetation. Birds nest in vegetation and also forage for food such as seeds and berries. Seeds are spread in bird droppings and easily

carried throughout the riparian zone where the moist conditions are suitable for weed growth.

Evidence of management

Results indicate that the level of management that has been undertaken to protect the brook is moderate. Anecdotal evidence suggests that landholders along Spencers Brook are aware of the benefits of long term management of the waterway. Economics is one of the main issues hindering development and adoption of on-ground management actions. The lack of financial resources available for landholders to direct into waterways management and the management of surrounding land may mean that there is a need for government and community groups to provide support and encouragement (Coates, 1987).

Fencing was used in over half of the sections, and in some areas firebreaks were also used to lower the chance of fire spreading across the waterway into cropped areas or close to buildings such as houses and sheds.

Priorities for management

Management along Spencers Brook has been prioritised with those issues needing urgent attention classified as having a high priority. Table 8 illustrates the issues that were determined to have a management priority and how each was rated as a matter of urgency.

Results in Table 8 indicate that the main issues for future management of Spencers Brook are erosion and stock access to the riparian zone, with 89% and 56% of sections , respectively, being recorded as requiring a high priority for management. Salinity and fire were seen to be of medium management priority in 67% and 58% of sections surveyed recorded (respectively), while vehicle access and feral animals were the largest low priority issues with 59% and 56% of sections (respectively) being classified in this category.

Management issue	% of survey sections requiring management		
	High	Medium	Low
Fire	11	58	31
Weeds	29	7	4
Erosion	89	11	0
Salinity	0	67	22
Stock access	56	11	4
Vehicle access	0	30	59
Rubbish	4	11	37
Pollution	0	33	44
Recreation	0	4	4
Garden refuse	0	0	4
Service corridors	0	11	26
Crossing point	4	18	37
Feral animals	7	26	56

Table 8. Priorities for management

Principles for waterways management

The need for management

The results of this channel and foreshore assessment indicated that there are many issues that need long term management if the health of Spencers Brook is to be improved. Results indicate that appropriate integrated catchment management practices need to be implemented.

Water supplies in rural Western Australia are limited, and are often affected by salinity and have limited use. The Spencer Brook catchment has a low supply of fresh water (surface and groundwater) to satisfy a wide range of competing needs, meaning that water resources need to be used and managed sustainably.

A management or action plan can be used to guide sustainable land and water use, at the same time looking after the riverine environment in conjunction with the economic needs of the landholders. A management or action plan can be devised for individual properties or the catchment as a whole, and includes such things as:

- identification and prioritisation of potential future threats;
- indications of community and landholder needs and desires;
- actions to address management issues; and
- develop an implementation plan outlining recommendations for action, timeframes and responsibilities for undertaking actions.

Management of waterways and land use should be closely related, as the two are interrelated (Weaving, 1994). Improved management of Spencers Brook and its surrounding catchment will not lead to the waterway being returned to its pristine, pre-European settlement condition, but will prevent further degradation and encourage the system to become healthier and more resilient in the long-term.

9 principles important for river management that are relevant to the management of Spencers Brook and other tributaries throughout the Avon River Catchment have been identified (Edgar, 2001).

1. Natural flow regimes, (intermittent drying of the channel), and the maintenance of water quality are fundamental to the health of inland river ecosystems.
2. Flooding is essential to floodplain ecosystem processes and also makes a significant contribution to pastoral activities.
3. Structures such as dams, weirs and levees can have a significant impact on the connectivity along rivers and between the river and its floodplain.
4. The integrated management of surface and groundwater supplies is important and needs to be undertaken on a catchment-wide scale.
5. New developments should be undertaken only after appraisal indicates they are economically viable and ecologically sustainable. Promoting greater water efficiency is essential to achieving sustainable industries.
6. High conservation value rivers and floodplains need to be identified, and in some cases, protected in an un-regulated state.
7. Rivers at risk of further degradation need to be identified, and priorities established for their rehabilitation.
8. Improved institutional and legal frameworks are needed to meet community river management aspirations.
9. With all parties making a commitment to work together, management regimes can be developed that are ecologically, economically, socially and culturally sustainable.

Waterways management should be undertaken with the objective of resolving competition between incompatible land uses to ensure that those values that are high or irreplaceable can be maintained. Efforts should be made to maintain and enhance the quality of the water in Spencers Brook and adjoining tributaries, in order to conserve ecological systems and meet the needs of present and future generations. Flexibility in the management plan is a must if it is to have the long-term ability to combine waterways conservation with

agricultural practices and semi-rural lifestyles which are highly dependent on climate and other environmental factors (Clement and Bennett, 1998).

A blank survey sheet is included in Appendix 5 for use by landholders, catchment groups, and community members who are interested in assessing the condition of their waterway to use for future monitoring and management purposes.

Management responsibilities

The concept of this foreshore and channel survey is to encourage management activities as well as providing a condition report on the brook. The successful management of a waterway entails the successful management of the surrounding landscape. It is important to understand that the landscape components within the Spencers Brook catchment are interrelated and hence need to be managed as a whole. Many issues throughout the catchment contribute to the current condition. Managing the waterway on its own can be likened to treating a problem but not preventing the cause. A catchment wide approach should be employed with a range of objectives to improve the health of the riverine environment. There are many smaller tributaries feeding into Spencers Brook that impact on the quality of water, as well as sediment loads, and channel and foreshore condition.

Maintaining a catchment group or 'Friends' group for the length of the brook is important to the long-term management of the waterway. Promoting the waterway as an asset to the community and encouraging community involvement on management may prove difficult. Small groups of landholders along the waterway and from within the surrounding catchment should be encouraged to join together to plan and implement river management actions, especially the portion running through the two reserves.

The Clackline Progress Association is interested in the management of the Clackline Nature Reserve and the Clackline Rail Reserve. The Avon Waterways Committee (AWC) (formerly the Avon River Management Authority), the Northam LCDC, Avon Valley Environmental Society and the Northam Friends of the River, are community groups aiming to promote and coordinate integrated catchment management within the Avon River Catchment for the surrounding community. The Avon Catchment Council (ACC) is the regional body that oversees natural resource management throughout the whole of the Avon Catchment. These groups have committed themselves to improving the health of the waterways and surrounding catchments, and may possess many resources and knowledge that will be useful in the future management of this waterway. These groups will require strong support from government agencies, Local Government Authorities, other catchment groups, landholders and the surrounding community if they are to contribute to the management of the whole catchment.

Management requirements

Weeds management

Weeds have many negative impacts on the riverine environment. They degrade the bushland along the waterway and are a fire hazard. Introduced species replace native vegetation, prevent the regeneration of native vegetation, and are often visually unattractive. They compete with native vegetation for space and water. The resulting loss of native species may lead to a change in the food and habitat source for native fauna, hence altering the food chain.

Many weeds are winter active, meaning that they die off (or become dormant) during summer. In areas of high weed coverage the dry grasses provide an excellent source of fuel for fire and may increase the possibility of the spread of a wildfire along the waterway corridor.

An integrated catchment management approach should be encouraged as the best way to deal with weeds. Weed control needs to focus on the immediate area as well as upstream areas where seeds can be easily transported downstream to susceptible areas. Information should be sought from the Environmental Weeds Action Network to develop a catchment-wide weed control strategy.

Landholders should undertake weed control by targeting the best areas and working towards the worst weed-infested areas. Focusing on invasive species as well as declared and pest plants will give a more productive outcome to weed control. Working from the edge of the weed infestation towards the centre, and removing the seed source followed by new growth is the most effective way to manage weed infestations. Working from upstream areas means that the likelihood of seeds and cuttings being washed downstream and recolonising in weed free areas is reduced significantly.

Weeds growing along road verges that run in close proximity to the waterway and its tributaries should also be controlled, so as to reduce the risk of spreading into surrounding riparian zones.

Some introduced species perform a useful role in rehabilitation and riverbank stabilisation. For example, Saltwater couch colonises bare areas along banks and verges and often is useful in stabilising the area that would otherwise be susceptible to erosion and undercutting. These species should be tolerated in the short term, but in the longer term they will need to be controlled before spreading too far. When undertaking weed management, weeds should only be removed from areas susceptible to erosion when revegetation is about to begin. Areas left bare for long periods can be eroded and may contribute to sedimentation within the waterway.

Riparian revegetation

The health of the bank and foreshore vegetation along a waterway is indicative of the health of the waterway. Riparian vegetation is an important component of the river ecosystem, and when salinity levels increase, for example, many plant species will die off and be replaced by more salt tolerant species.

Vegetation along waterways should be managed with a view to improving catchment health. Riparian vegetation improves waterway health by:

- providing habitat for native fauna;
- stabilising the channel bed, banks and verge;
- providing wildlife corridors allowing fauna to move along the river;
- providing shade over the waterway, thus providing a more favourable habitat and decreasing the likelihood of algal blooms;
- providing woody debris for habitat and bank stabilisation;
- filtering runoff from surrounding land to decrease nutrient input into the waterway; and
- protecting soils from wind and water erosion (Olsen and Skitmore, 1991).

Management works should be prioritised to gain the greatest benefit from the available resources. Protecting areas of good (weed free) riparian vegetation and working towards more degraded areas will be more economically viable for landholders (Price and Lovett, 1996b). It is more costly to rehabilitate a degraded area than to protect it before it becomes weed infested.

If revegetation of riparian areas takes place, it is important that stock do not have access to these areas of fringing vegetation. A fence around the revegetated area (or the riparian zone) is the most effective tool to prevent livestock grazing and trampling newly revegetated areas.

Where grazing of the riparian zone is necessary, the following rules should be followed to minimise disturbance and limit the environmental and economic losses associated with an unhealthy riverine system.

- Avoid grazing the riparian zone during the germination, growing and flowering times of the native plants, as well as during summer and autumn;
- Do not overstock the riparian zone. This will minimise the negative impact that grazing and trampling have on the productivity of this area, as well as the water quality within the brook; and
- Adjust stocking rates and the frequency of grazing within this zone to suit the carrying capacity of the land (Price and Lovett, 1999b).

Riparian vegetation plays an important role in protecting the waterway from degradation. Vegetation along banks, verges and foreshore areas can help to regulate the hydrological processes, filter nutrients from recharge water as well as nutrient cycling, and prevents soil erosion by overland flows of water and wind (Coates, 1987).

Revegetation is a common management tool being implemented along the riparian zone

Fire management

Annual weeds, such as grasses, dry out during the summer months and can pose a serious fire risk if not kept under control. Along Spencers Brook the vegetation exists as a corridor, and after frequent or uncontrolled fire, may be vulnerable due to the limited opportunity for recolonisation from surrounding areas (Underwood, 1995).

An abundance of weed species that die off during summer months means that the riparian zone along Spencers Brook is susceptible to fire, and hence a management plan to accommodate any risks needs to be decided upon and implemented. Fire can result in risk to persons and property, livelihood, weed invasion, loss of habitat for fauna, loss of some seed and an increase in erosion. Under controlled circumstances, when risks are reduced, fire can also benefit natural ecosystems. For example, fire provides the opportunity for many native plant species to germinate by providing the right conditions.

To reduce any serious threat of fire, it may be necessary to implement controlled grazing along some sections of the river (WRC and ARMA, 1999). This can reduce the threat of fire to those people living and farming along the waterway. A controlled fire regime can be a useful tool in the regeneration of native species growing within the riverine environment as many species have adapted to occasional fire and benefit from it.

Burning of vegetation and debris along the waterway foreshore and banks should be responsive to the condition of the vegetation, but it is important to remember that leaf litter and debris contribute important habitat for organisms, as well as protecting the soil from erosion. A set time regime should be put into place to monitor burning within the riparian zone. This will deter burning too frequently and minimise the damage caused by doing so (Price and Lovett, 1996a).

Firebreaks along foreshore verges are important to protect the fragile vegetation from unintentional fires that may result from crop and pasture burning in surrounding paddocks. To maintain effective fire control for the riparian zone, firebreaks and fencing should be upgraded and maintained along verge areas of the foreshore. When fencing for protection of riparian vegetation the firebreak should be located on the river side of the fence, as far away from the bank as possible. A firebreak on the river side of the fence will allow easy access to this zone, prevent stock from pushing the fence over to graze on the other side and reduce the need for fence repairs from fallen tree limbs..

The Avon Waterways Committee (AWC) has a fire policy that sets out the objectives for bushland management in and along the river. The main goals are to manage the fire problem along the waterway, while minimising the threat to the river environment and to neighbours. It is also a priority to educate river neighbours and encourage landholders to take responsibility for protecting their own assets. A copy of this policy is attached in Appendix 11.

Water quality

Poor water quality can significantly affect the health of the brook and its surrounding ecosystems. It is likely that the clearing of the land, associated with the agricultural development of the catchment, has had a negative impact on the health of this waterway. Combined with current land use practices, the clearing of vegetation has increased the sediment loads and possibly the salinity levels within the brook and its tributaries, adversely affecting the health of the riverine system (Schofield et al, 1988).

Restricting stock access from the brook will help to improve water quality. Stock, (sheep and cattle, along with goats and horses), are responsible for mobilising plant nutrients, that they distribute via their faeces (Swan River Trust, 1998). Controlled access will minimise the amount of manure within the waterway and limit nutrient enrichment.

Water resource management is best approached as a part of integrated catchment management. Managing each catchment area as a whole allows the diverse range of social, economic and ecological activities that affect a particular waterbody to be coordinated. Water and biological resources are firmly linked within the natural environment, and disruptions to either one can have significant implications on these resources and the environment as a whole (Australian Water Resources Council, 1992).

Development

Within the last decade there has been subdivision of land into smaller lots for rural lifestylers. This has occurred

mainly towards the middle and upstream sections of the brook. Many of the older land titles give ownership to the halfway mark of the brook, and in some cases where titles cross the river, ownership includes the whole river channel. This makes it difficult to encourage management of the waterway.

As landholdings are subdivided for resale, titles are changing and so is the ability of the Department of Environment, Water and Catchment Protection (formerly the Water and Rivers Commission) to encourage management of waterways. The Shire of Northam's Town Planning Scheme will determine future development of land within the region, in conjunction with recommendations from relevant agencies.

Applications for subdivision are sent to the Western Australian Planning Commission for assessment and for referral to relevant organisations (including the Department of Environment, Water and Catchment Protection) to provide advice. It is usual practice for a Foreshore Management Plan/Agreement to be requested where development and/or subdivision is planned for land surrounding a waterway. The agreement aims to protect the environmental, social and economic values associated with the channel and foreshore.

A small number of properties along Spencers Brook have houses, sheds and other buildings located close to the waterway, within the immediate floodplain. As small landholdings are becoming increasingly common within the catchment, it is important that landholders and planners are educated about the potential risks of flooding.

The flood regime within the Avon catchment tends to be approximately 10 years apart (Hansen, 1986). When planning development within the Spencers Brook catchment the flood regime needs to be taken into consideration so that damaged caused by floods is minimised. Development within flood-prone areas should be actively discouraged.

Any existing and future landuse should be guided by the Shire of Northam Town Planning Scheme, the Ministry of Planning and the Department of Environment, Water and Catchment Protection, while providing for the protection and enhancement of the environment and the catchment surrounding Spencers Brook.

Areas of cultural significance (both Aboriginal and non-Aboriginal) should be recorded and protected through the Town Planning Scheme to prevent any changes to landuse that may be detrimental to these sites. It should be noted that where Aboriginal sites may be affected by proposals for development and land use change, the requirements of the *Aboriginal Heritage Act, 1972* must be met (Western Australia Planning Commission, 1999). Any sites listed on the State Register of Heritage Places are protected by the *Heritage of Western Australia Act, 1990*, which determines certain requirements for individual sites in an effort to conserve the associated heritage values.

Large woody debris

Large woody debris (also known as snags) are branches, large limbs or whole trees which fall into the watercourse and either remain in place or move downstream where they come to rest. It is common for smaller debris and leaf litter washed downstream to become accumulated at these points, providing an important habitat for many aquatic organisms. A large portion of the length of Spencers Brook has been cleared of this material due to perceived risks of flooding and bank erosion, highlighting the need to educate people to the benefits of keeping the debris within the river system, and the disadvantages of removal.

Contrary to common belief, the removal of large woody debris does not reduce flood risk and will actually lead to bank and channel erosion caused by an increased flow velocity. The increased movement of sediment through the system will be deposited in pools and along floodplains and may lead to a decline in habitat, raised channel beds and increased threat to infrastructure such as low bridges. Reintroducing large woody debris to the system will increase river stability and provide a greater diversity of habitat for native fauna.

In areas where large woody debris has been removed, attempts should be made to add sufficient debris material to the waterway to return it to its natural load. By considering the amount of debris found in healthier parts of the brook (or in waterways in close proximity under the same conditions) assumptions can be made as to how much woody debris to return to the system (Price and Lovett, 1996b).

Sediment deposition

The goal of management is to minimise sediments entering the brook, to reduce the movement of sediment along the waterway, to stabilise the riverbanks and

channels, and to remove sediments from the brook at selected places.

Sediments comprise sand (the heavy, course fraction which is mostly carried as bedload), and silt (the finer fraction which is carried in suspension). Both are moving down the river channels to be deposited when the river velocity is slowed, either by natural pools, a natural obstruction, or by the drying up of the river in summer.

A riffle can either be natural (comprised of rocks and branches) or man-made (an engineer-designed low rock bar, or some other form of engineered structure). An engineered structure is usually located across the river at a strategic point with the aim of slowing river velocity. These structures can also become places where coarse sediments will be deposited and can later be removed.

Rocks can be used to stabilise the toes of banks to limit erosion

Fencing

When revegetating an area along the riparian zone it is important to exclude stock so that they do not eat and trample revegetated areas. Fencing is the easiest and cheapest means of excluding stock. It is recommended that stock be excluded from the planted area for at least three years to allow plants to grow and recolonise the area (Piggott et al, 1995). After this period the plants should be established and stock access, if allowed, should be controlled and properly managed.

Controlled grazing requires fencing to confine stock to the approved grazing area and to control the intensity of grazing. Fenced areas will regenerate naturally over time, or can be replanted with native trees and shrubs. The vegetation helps to reduce soil erosion along the river, and provides habitat for wildlife. Riparian vegetation is an effective way of preventing sediment entering the waterway.

Fences should be erected outside the riparian zone, as far away from the bank as possible, to exclude stock from the riparian zone (see Appendix 9). This will encourage the regeneration of native tree species and the growth of ground covers that will aid in stabilising the waterway banks and verges. Fencing of the zone should follow certain parameters if it is to be of benefit to both the environment and economic pursuits of the landholder.

The type of fence used should be suited to the flood regime. For example, drop fences will drop to the ground during flood events where pressure from water and debris builds up (see Appendix 9 for a description of fencing systems). Using the right type of fence makes more economic sense, as it decreases the need for repairs. Fencing along riparian zones should be located parallel to the waterway to minimise the impact of floodwaters on the fence. A good management tool is to develop a firebreak inside the riparian zone. Most importantly the type of fence used should be suited to the surrounding landuse if it is to have the maximum benefit of protecting the water resources for future use (Price and Lovett, 1996b).

Feral animals

Field observations and conversations with landholders along Spencers Brook determined that there are a high number of feral animals resident within the riparian and channel vegetation. The most common are rabbits and foxes, but feral cats have also been sighted on occasion. Feral animals take over habitats and prey on native fauna, they destroy native vegetation, increase the spread of weeds, contribute to bank destabilisation and erosion through burrowing into the soil, and are often a threat to livestock being grazed along foreshore and surrounding areas.

Management of feral animals should be approached as a whole throughout the catchment. There is no use in working to rid one property of pest animals to have them migrate from surrounding properties. There is a need for cross boundary management of feral animals to stop this happening. Surveys show that feral animal control (baiting) is already in practice along some areas of the waterway and surrounding landholdings. Controlling

weeds will also help to deter pest animals due to a lack of food, nesting and breeding sites.

Waste disposal

Field observations determined that along some sections of the brook it has been and still is commonplace to dispose of unwanted farm machinery, cars and chemical containers along the banks of the waterway. Refuse can cause pollution of the waterway and those into which it feeds (the Avon River) when oils, fuel and chemicals leach into the waterway and are moved downstream during periods of flow. Landholders should be encouraged not to dump unused items near the river by educating them on the risks involved in affecting the surrounding environment.

Education and awareness

For the long-term benefit of the riverine ecosystem, measures should be taken to educate landholders in an effort to promote understanding and awareness of the significance of waterways and their management for future use. Landholders along Spencers Brook were given the opportunity to take part in the foreshore and channel assessment, and it is important that involvement is on-going, especially in any future plans to improve the health of this waterway.

Catchment management and community action require awareness of the issues, education and information, technical advice and practical support. Local Government Authorities, as well as relevant government and non-government agencies need to provide support to these groups, while banding together to promote issues such as waterways management, integrated catchment management and land management to community members.

There is a wealth of information already learnt and gathered from other community, catchment and friends of groups which is valuable and can be passed on through establishing networks between groups in surrounding areas. The Avon Catchment Network provides a range of resources helpful to land and waterways management.

Concluding comments

This foreshore and channel assessment has been undertaken to provide landholders, interested community groups, Local Government Authorities and Government and non-Government agencies within the surrounding catchment an understanding of the current condition of the Spencers Brook channel and foreshore.

The survey process has been developed to suit the needs of this region and can be used by interested individuals, groups and organisations to gain an understanding of the condition of other waterways within their community. It is hoped that this process will be useful for these people to monitor the health and condition of this waterway into the future.

By using a standard methodology to gather information it is possible to compare and contrast foreshore conditions of the same area over time, or between different sites in the same survey season. Results can then be used to prioritise management needs, determine the impact of new disturbances and assess changes in foreshore and channel condition.

This document provides the results of the foreshore assessments undertaken along Spencers Brook. The main conclusion to draw from findings is that in many ways the health of the brook is suffering, both directly and indirectly, as a result of past and present landuse activities.

Historically land has been overused, but land use activities employed within the catchment are becoming more compatible and ecologically sustainable. In general Spencers Brook is described as a C-grade system, meaning that the foreshore vegetation support only trees over weeds or pasture. Bank erosion and subsidence may also occur in localised areas. The high sediment loads within the channel mean that the system is very mobile and unstable and is in need of rehabilitation.

There is a lack of native plants and an abundance of weeds. The most common native vegetation are trees with Flooded gum and Swamp paperbark being the most prevalent. Of the weed species invading the groundcover Wild oats, Couch and Barley grass were the most common during this assessment.

The major disturbances along the length of this watercourse are weeds, feral animals and pollution, as well as vehicle and stock access to the riparian zone. Observations determined that the issues in greatest need of management are weed invasion, stock access, fire, and salinisation of the waterway and surrounding land.

It should be noted that when planning to manage the Brook, there is a need to adopt a whole catchment approach rather than dealing with the waterway as an entity on its own. The need exists to assess competing land-uses and determine a compromise that allows for the rehabilitation and conservation of Spencers Brook along with sustainable and economically viable land use practices. This will lead to many economic, environmental and social advantages both now and into the future.

Future strategies to improve the ecological health of Spencers Brook need to be linked to the development of more sustainable farming systems within its catchment. If management of the riverine system is to be effective, degradation associated with Spencers Brook must be treated at the cause and not the symptom.

Management of this waterway requires knowledge and understanding of what factors are present and how they are effecting (either positively or negatively) the surrounding environment. This survey provides that information so that the community can work together to initiate an integrated approach to improving the health of Spencers Brook. The data collected throughout this foreshore and channel assessment is also an effective tool to monitor future changes in the stability and health of this waterway.

There is hope that with a greater understanding of the condition of Spencers Brook, community members will band together to try and recover some of the natural health and beauty of the waterway.

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Glossary

Anabranch A secondary channel of a river which splits from the main channel and then later rejoins.

Bank The steeper part of a waterway channel cross-section, which is usually considered to lie above the usual water level.

Barbed wire fence Any fence that is in part barbed wire.

Bed stability When the average elevation of the streambed does not change much through time.

Biodiversity The number, relative abundance and genetic diversity of life forms within an ecosystem.

Carrying capacity The maximum population of organisms or the maximum pressure than an environment can support on a sustainable basis over a given period of time.

Catchment The area of land drained by a waterway and its tributaries.

Channelisation The straightening of the river channel by erosional processes.

Contour farming Plowing and planting across the changing slope of land, rather than in straight lines, to help retain water and reduce soil erosion.

Debris Loose and unconsolidated material resulting from the disintegration of rocks, soil, vegetation or other material transported and deposited during erosion.

Declared plant Plants that are classified as high priority and which may become a major problem to the environment or to agricultural activities.

Degradation Specifically the general excavation of a streambed by erosional purposes over a number of years. Has a broader meaning of reduction in quality.

Electrical conductivity 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 they consist 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 organisms 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 (ie. not indigenous to the region).

Fabricated fence Includes rabbit netting, ringlock and hinge joint fences.

Floodplain A flat area adjacent to a waterway that is covered by floods every year or two.

Floodway & 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.

Habitat The specific region in which an organism or population of organisms live.

Large woody debris	A branch, tree or root system that has fallen into or is immersed (totally or partially) in a stream.
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.
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 landuse. 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.
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 a waterway, which leads to a decline in water quality.
Slumping	The mass failure of part of a stream bank.
Snags	Large woody debris such as logs and branches that fall into rivers.
Subsidence	The sinking of parts of the ground which are not slope related.
Terrestrial	Relating to land.
Turbidity	A measure of the suspended solids in the water.
Undercutting	The undermining or erosion of soil by water from underneath an existing landform (ie. riverbank), structure (ie, fence post) or vegetation (ie. 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 20m 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.
Weed	A plant growing where it is not wanted.

Appendix 1. Register of heritage places within Spencers Brook catchment

Place No.	Place Name	Location (LGA)	Construction Date	Place Type	Original Use	Current Use	Specific Theme	Listing Type	Status	Date Registered
3977	Old Cottage	Northam Shire	-	Individual building or group	Cottage	Cottage	-	Classified by the National Trust	Classified	02/12/1985
3978	Barn	Northam Shire	-	Individual building or group	Shed or barn	Shed or barn	-	Classified by the National Trust		
10910	Clackline Bridge or Viaduct	Northam Shire	1936	Other built type	Road: bridge	Road bridge	Road transport	Statewide Lge Timber Str Survey	Classified	02/12/1985
10911	Clackline Railway Platform	Northam Shire	-	Other structure	Rail: other	Vacant/ unused	Rail & light rail transport	Municipal Inventory	Completed	11/12/1998
10912	Clackline Refractory	Northam Shire	1898	Individual building or group	Brickworks	Brickworks	Manufacturing & processing	Municipal Inventory	Adopted	25/02/1998
10914	Fuel Storage Depot	Northam Shire	1940	Other structure	Other	Vacant/ used	World Wars & other wars	Municipal Inventory	Adopted	25/02/1998
10919	Mokine Homestead	Northam Shire	1876	Individual building or group	Homestead	Homestead	Grazing pastoralism & dairying	Municipal Inventory	Adopted	25/02/1998
10920	Mokine Stationmaster's House	Northam Shire	-	Individual building or group	Rail: housing or quarters	Single storey residence	Rail & light rail transport	Municipal Inventory	Adopted	25/02/1998
									Adopted	25/02/1998

Appendix 2. Soil landscape systems

MU_Symbol	MU_Name	MU_Landform	MU_Soil
257Af	Avon Flats System	Alluvial terraces and flats.	Browns loamy earths, grey non-cracking clays and brown deep sands.
253Cc	Clackline System	Moderately dissected areas with gravelly slopes and idges and minor rock outcrop.	Grey shallow sandy duplexes, duplex sandy gravels, loamy gravels, pale shallow sands and red shallow loamy duplexes.
257Jc	Jelcobine System	Major valleys with isolated lateritic remnants.	Red deep and shallow sandy and loamy duplexes, grey deep sandy duplexes, bare rock and cracking and non-cracking clays.
253Wn	Wundowie System	Lateritic plateau with some rock outcrops.	Deep sandy gravels, duplex sandy gravels and shallow gravels.

Appendix 3. Flora of the Clackline nature reserve (surveyed in 1986)

Common name	Botanical name
Rock Fern	*Cheilanthes austrotenuifolia*
	Pleurosorus rutifolius
Zamia	*Macrozamia riedlei*
Swamp Cypress	*Actinostrobus pyramidalis*
Spurred Arrowgrass	*Triglochin calcitrapa*
	Triglochin minutissima
Silvery Hair Grass	*Aira caryophyllea*
Grey-Beard Grass	*Amphipogon strictus*
	Amphipogon turbinatus
Wild Oat	*Avena fatua*
Quaking Grass	*Briza maxima*
Shivery Grass	*Briza minor*
Red Brome	*Bromus rubens*
	Danthonia pilosa
Annual Veldt Grass	*Eharharta longiflora*
Rye Grass	*Lolium* sp.
	Monachather paradoxa
	Neurachne alopecuroidea
Shaking Grass	*Poa drummondiana*
	Stipa semibarbata
	Gahnia drummondii
	Gahnia trifida
	Isolepis marginata
	Lepidosperma angustatum
Common Sword Sedge	*Lepidosperma longitudinale*
	Lepidosperma viscidum
	Mesomelaena stygia
Semaphore Sedge	*Mesomelaena tetragona*
	Schoenus Clandestinus
	Schoenus lanatus
	Schoenus sp. I
	Lepidobolus chetocephalus
	Loxocarya cinerea
	Loxocarya flexuosa
Cord Rush	*Restio megalotheca*
	Aphelia cyperoides
Painted Centrolepis	*Centrolepis aristata*
	Centrolepis pilosa
Wiry Centrolepis	*Centrolepis polygyna*
	Philydrella pygmaea
Toad rush	*Juncus bufonius*
Joint Leaf Rush	*Juncus holoschoenus*
Blue Tinsel Lily	*Calectasia cyanea*
	Lomandra caespitosa

Common name	Botanical name
Small Flowered Mat Rush	*Lomandra micrantha*
	Lomandra nutans
	Lomandra preissii
Silky Mat Rush	*Lomandra spartea*
Blackboy	*Xanthorrhoea drummondii*
Skirted Grass Tree	*Xanthorrhoea preissii*
Spreading Flax Lily	*Dianella revoluta*
Cluster-leaved Blind Grass	*Stypandra imbricata*
The Grass Lily	*Agrostocrinum scabrum*
	Arthropodium capillipes
	Arthropodium preissii
	Borya nitida
	Caesia parviflora
	Corynotheca micrantha
Blue Squill	*Chamescilla corymbosa*
	Laxmannia Grandiflora
	Laxmannia ramosa
	Laxmannia sessiliflora
	Laxmannia squarrosa
Many Flowered Fringe Lily	*Thysanotus multiflorus*
Twining Fringe Lily	*Thysanotus patersonii*
	Thysanotus Sparteus
Yellow Autumn Lily	*Tricoryne elatior*
Milkmaids	*Burchardia umbellata*
	Wurmbea tenella
Cat's Paw	*Anigozanthos humilis*
Mangle's Kangaroo Paw	*Anigozanthos manglesii*
Golden Conostylis	*Conostylis aurea*
Bristly Conostylis	*Conostylis setigera*
	Haemodorum paniculatum
	Haemodorum spicatum
	Tribonanthes Longipetala
	Tribonanthes violacea
	Hypoxis occidentalis
	Dioscorea hastifolia
Morning Iris	*Orthrosanthus laxus*
Purple Flag	*Patersonia occidentalis*
Onion Grass	*Romulea rosea*
Blue Beard	*Caladenia deformis*
Red Spider Orchid	*Caladenia Filamentosa*
White Spider Orchid	*Caladenia patersonii*

Common Name	Botanical Name
Shy Spider Orchid	*Caladenia triangularis*
Common Donkey Orchid	*Diuris longifolia*
Purple Enamel Orchid	*Elythranthera brunonis*
White Bunny Orchid	*Eriochilus dilatatus*
Hare Orchid	*Leporella Fimbriata*
Hare Orchid	*Lyperanthus serratus*
Red Beaks	*Lyperanthus nigricans*
Bird Orchid	*Pterostylis barbata*
Jug Orchid	*Pterostylis recurva*
Banded Greenhood	*Pterostylis vittata*
	Spiculea ciliata
Blue Lady Orchid	*Thelymitra antennifera*
	Thelymitra fuscolutea
Tamma	*Allocasuarina campestris*
Sheoak	*Allocasuarina huegeliana*
Shrub Sheoak	*Allocasuarina humilis*
Woolly bush	*Adenanthos attenuata*
Slender Banksia	*Banksia attenuata*
Bull Banksia	*Banksia grandis*
Menzies's Banksia	*Banksia menziesii*
Round Fruited Banksia	*Banksia sphaerocarpa*
Common Smoke Bush	*Conospermum stoechadis*
Prickly Dryandra	*Dryandra armata*
	Dryandra bipinnatifida
Pingle	*Dryandra carduacea*
	Dryandra fraseri
	Dryandra kippistiana
Couch Honypot	*Dryandra nivea*
Golden Dryandra	*Dryandra nobilis*
Many-headed Dryandra	*Dryandra polycephala*
King Dryandra	*Dryandra proteoides*
Parrot Dryandra	*Dryandra sessilis*
Woolly-flowered	*Grevillea pilulifera*
Grevillea	
Oak Leaf Grevillea	*Grevillea quercifolia*
	Grevillea trifida
	Grevillea vestita
Hedge-hog Hakea	*Hakea erinacea*
	Hakea incrassata
Honey Bush	*Hakea lissocarpha*
	Hakea loranthifolia
	Hakea marginata
Sea Urchin Hakea	*Hakea petiolaris*
	Hakea preissii
Harsh Hakea	*Hakea prostrata*
Candle Hakea	*Hakea ruscifolia*
	Hakea trifurcata

Common Name	Botanical Name
Wavy-leaved Hakea	*Hakea undulata*
Spreading Cone Bush	*Isopogon divergens*
Pincushion Cone Flower	*Isopogon dudius*
	Isopogon villosus
	Persoonia elliptica
Kauberry	*Persoonia quinquenervis*
	Persoonia trinervis
	Petrophile divaricata
	Petrophile ericifolia
Long-leaved Cone Bush	*Petrophile longifolia*
	Petrophile macrostachya
	Petrophile serruriae
	Petrophile trifida
Blueboy	*Stirlingia latifolia*
	Synaphea petiolaris
	Synaphea preissii
Mistletoe	*Amyema miquelii*
Christmas Tree	*Nuytsia floribunda*
Curled Dock	*Rumex crispus*
Curved Mulla Mulla	*Ptilotus declinatus*
	Ptilotus drummondii
Pom Poms	*Ptilotus manglesii*
	Ptilotus polystachyus
	Cassytha glabella
	Drosera bulbosa
	Drosera gigantea
	Drosera glanduligera
	Drosera leucoblasta
	Drosera macrantha
Pinkrainbow or	*Drosera menziesii*
Menzies Sundew	
Pale Sundew	*Drosera pallida*
	Drosera subhirtella
	Drosera zonaria
Dense Stonecrop	*Crassula colorata*
Jam Tree	*Acacia acuminata*
Glowing Wattle	*Acacia celastrifolia*
	Acacia lasiocalyx
Gum Wattle	*Acacia microbotrya*
	Acacia preissiana
Prickly Moses	*Acacia pulchella*
	Acacia saligna
	Acacia squamata
	Acacia urophylla
	Acacia willdenowiana
	Bossiaea eriocarpa
Thorny Bitter Pea	*Daviesia decurrens*

Common name	Botanical name
York Road Poison	*Gastrolobium calycinum*
Sandplain Poison	*Gastrolobium microcarpum*
Boat-leaved Poison	*Gastrolobium obovatum*
Berry Poison	*Gastrolobium parvifolium*
Prickly Poison	*Gastrolobium spinosum*
Bullock Poison	*Gastrolobium trilobum*
Crinkle Leaf Poison	*Gastrolobium villosum*
	Gompholobium
	Knightianum
Holly-leaved Hovea	*Hovea chorizemifolia*
Devil's Pins	*Hovea pungens*
Common Hovea	*Hovea trisperma*
Common Lamb Poison	*Isotropis cuneifolia*
	Jacksonia carduacea
Holly Pea	*Jacksonia floribunda*
Stinkwood	*Jacksonia sternbergiana*
Red Runner	*Kennedia prostrata*
Bushy Kennedia	*Kennedia stilingii*
Wedgeleaf Oxylobium	*Oxylobium cuneatum*
Box Poison	*Oxylobium parviflorum*
	Erodium circutarium
Blue Heron's Bill	*Erodium cygnorum*
	Oxalis perennans
	Boronia busselliana
	Boronia ramosa
	Eriostemon spicatus
False Boronia	*Phyllanthus calycinus*
	Stackhousia pubescens
	Tripterococcus brunonis
	Dodonaea concinna
	Trymalium angustifolium
	Thomasia foliosa
	Hibbertia enveria
Yellow Buttercups	*Hibbertia hypericoides*
Mountain Primrose	*Hibbertia montana*
	Hibbertia polystachya
	Hibbertia rupicola
	Pimelea ciliata
	Astartea fascicularis
	Beaufortia elegans
	Beaufortia macrostemon
One-sided Bottlebrush	*Calothamnus quadrifidus*
	Calothamnus sanguineus
	Calytrix angulata
Summer Starflower	*Calytrix flavescens*
Pink Summer Starflower	*Calytrix fraseri*
	Eremaea pauciflora

Common name	Botanical name
Powderbark Wandoo	*Eucalyptus accedens*
Brown Mallet	*Eucalyptus astringens*
Marri	*Eucalyptus calophylla*
	Eucalyptus decurva
Jarrah	*Eucalyptus marginata*
Wandoo	*Eucalyptus wandoo*
White Myrtle	*Hypocalymma angustifolium*
	Kunzea recurva
	Leptospermum erubescens *Melaleuca holosericea*
	Melaleuca preissiana
Graceful Honeymyrtle	*Melaleuca radula*
	Pericalymma ellipticum
	Verticordia densiflora
	Verticordia serrata
	Gonocarpus pithyoides
Australian Carrot	*Daucus glochidiatus*
Prickfoot	*Eryngium vesiculosum*
	Homalosciadium homalocarpum
	Trachymene cyanopetala
	Trachymene ornata
Native Parsnip	*Trachymene pilos*
	Xanthosia huegelii
	Astroloma compactum
	Astroloma epacridis
	Astroloma pallidum
	Astroloma prostratum
	Leucopogon capitellatus
	Leucopogon propinguus
Curry Flower	*Lysinema ciliatum*
Common Pin Heath	*Styphelia tenuiflora*
	Anagallis arvensis
	Mitrasacme paradoxa
Common Centaury	*Centaurium erythraea*
	Cyanostegia lancelata
	Lachnostachys albicans
Hill River Lambstail	*Physopsis spicata*
Snake Bush	*Hemiandra pungens*
Round leaved Tobacco	*Nicotiana rotundifolia*
Black Nightshade	*Solanum nigrum*
Common Bartsia	*Parentucellia latifolia*
Australian Broome Rape	*Orobanche australiana*
Pink Petticoats	*Polypompholyx multifida*
	Opercularia vaginata
Annual Bluebell	*Wahlenbergia gracilenta*
Cape Bluebell	*Wahlenbergia capensis*

Common name	Botanical name
Woodbridge Poison	*Isotoma hypocrateriformis*
Slender lobelia	*Lobelia tenuior*
Winged-Stem Dampiera	*Dampiera alata*
Sparse-leaved Dampiera	*Dampiera oligophylla*
Cluster-leaf Goodenia	*Goodenia fasciculata*
	Goodenia filiformis
Blue Lechenaultia	*Leschenaultia biloba*
Felted Verreauxia	*Verreauxia reinwardtii*
Midget Stylewort	*Levenhookia pusilla*
Common Stylewort	*Levenhookia stipitata*
Pink Fountain	*Stylidium brunonianum*
Triggerplant	
	Stylidium bulbiferum
Book Triggerplant	*Stylidium calcaratum*
Milkmaid Triggerplant	*Stylidium caricifolium*
Common Butterfly	*Stylidium piliferum*
Triggerplant	
	Stylidium repens
	Chrysocoryne pusilla
Swan River Daisy	*Brachycome iberidifolia*
	Centaurea melitensis

Common name	Botanical name
Water Buttons	*Cotula coronopifolia*
Stinkweed	*Dittrichia graveolens*
Golden Everlastings	*Helichrysum bracteatum*
Satin Everlasting	*Helichrysum leucopsidum*
Flatweed	*Hypochaeris radicata*
	Lagenifera huegelii
Purple Daisy Bush	*Olearia rudis*
	Osteospermum clandestinum
	Pithocarpa achilleoides
	Podotheca angustifolia
	Pseudognaphalium
	luteo-album
	Quinetia urvillei
	Sonchus oleraceus
	Siloxerus humifusus
Native Gerbra	*Trichocline spathulata*
Ursinia	*Ursinia anthemoides*
	Waitzia aurea

Source: Moore et al 1987, and Gunness, 1999.

Appendix 4. Completed tributary assessment form

Please note that the information contained in this completed assessment form is an example only.

Foreshore and channel condition assessment form

For property and paddock scale surveys

General details

Recorder's Name: P. Janssen

Survey Date: 10 July 2001

Tributary Name: Spencers brook

Section Number: SB001

Catchment Name: Avon Catchment

Length of Section: 1.2Km

Sub-catchment Name: Spencers Brook Catchment

Shire: Northam

Nearest Road Intersection: Spencers Brook Road and Trimmer Road

GPS (start of survey section) E: 509320 N: 6459158

GPS (end of survey section) E: 508091 N: 6459597

Landholder contacted: Yes ✗ No ❒

Bank(s) surveyed (facing upstream)

Landholder consent obtained: Yes ✗ No ❒

left ❒ right ❒ both ✗

Landholder present during survey: Yes ❒ No ✗

Landholder: Jack and Jill Brown

Contact Number: 9555 5555

Property address: Lot 89 River Road, Riverville

Bank stability

Proportion of bank affected (% of survey area)	Undercutting	Firebreak/trackw washouts	Subsidence	Erosion	Slumping	Sedimentation
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 ✗ Dam ❒ Riffle
❒ Braided channel ❒ Groundwater ❒ Bridge
❒ Pool ❒ Rapids ✗ Sand slugs
❒ Wetlands ❒ Annabranch ❒ Vegetated islands
❒ Other

……..

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 - rate between A1 and D3)

General: C Best: C2 Poorest: D1

Vegetation health

❒ Looks healthy ❒ Some sick trees ❒ Many sick or dying trees ✗ Some dead trees ❒ Many dead trees

Are there any tree seedlings or saplings present?: ✗ Yes ❒ No Species: Acacia sp., Flooded gum

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

Bare ground: % cover: 35%

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

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

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

Vegetation cover

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

Proportion of native species

	Proportion (%) of native species
Overstorey	> 80%
Middlestorey	> 80%
Understorey	< 10%

Fencing status

Fence present? ✗ Yes ❒ No Fence condition: ❒ Good ✗ Moderate ❒ Poor

Fence style: ✗ Barbed wire ❒ Electric ✗ Fabricated ❒ Plain wire

Fence position (approximate distance [m] from river bank): LB: 10 – 15m RB: ~ 30m

Stock access to foreshore: ✗ Yes ❒ No Vehicle access to foreshore: ✗ Yes ❒ No

Crossing Point: ❒ Yes ✗ No

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 = 15 Environmental rating = Poor

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

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 streamside 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?

Salt crystals along the bank.
Bank erosion.
Debris in trees and along fence lines.
Flood channels.

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

Algea.
High sediment load.
Limited overhanging vegetation.
Salt crystals.
Discolouration of water.

Any wildlife (or evidence of presence) observed?

Birds, ducks, flies, rabbits, dragonflies, ants, spiders, snakes, lizards

Landform types

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

Moderately steep valley with granite outcrops.

Evidence of management

Tick the appropriate boxes:

❒ Prescribed burning

✗ Firebreak control

✗ Fencing

❒ Nest boxes

❒ Other:……

❒ Recreational facilities (e.g. rubbish bins, BBQ's, benches)

❒ Signs

❒ Planting

❒ Weed control

❒ Erosion control

❒ Earthworks

❒ Dredging

Management issues

Tick the appropriate priority box for each management issue.

Issue	Priority		
	High	Medium	Low
Fire	✗		
Disease			
Weeds	✗		
Erosion	✗		
Salinity	✗		
Stock access	✗		
Vehicle access		✗	
Rubbish			
Pollution		✗	

Issue	Priority		
	High	Medium	Low
Recreation			
Garden refuse			
Service corridors			
Crossing point			✗
Feral animals		✗	
Point source discharge			
Pumps or off-take pipes			
Dam/weir			
Cultural features			

Vegetation

Plant name	Abundance (H,M,L)	Plant name	Abundance (H,M,L)
York gum	M	Golden wreath wattle	L
Soursob	M	Four o'clock	H
Wild oats	H	Samphire	L
Swamp sheoak	M	Grass tree	L
Barley grass	H		
Needlebush	L		
Thistle	L		
Rye Grass	L		
Swamp paperbark	L		
Flooded gum	M		
Couch	M		

Water quality data

Sample number	pH	Conductivity mS/cm	Temperature ºC	Location
1	8.33	41.4	22.1	482821 E 6465810 N
2	8.06	39.2	23.8	482834 E 6465873 N

GPS coordinates

Coordinate	Description
LMK01	Start point of survey section
LMK02	Start of large sand slug
LMK03	End of large sand slug
LMK04	Area of many sick and/or dead trees
LMK05	End of survey section

Photos

1. Channel condition
2. Sand slug
3. Dying foreshore vegetation
4. Infestation of *Juncus acuta*
5. Foreshore condition
6. Fence condition
7. Stock in river
8. Bank erosion

Appendix 5.
Tributary assessment form

Foreshore and channel condition assessment form

For property and paddock scale surveys

General details

Recorder's Name:..... Survey Date:.....

Tributary Name:..... Section Number:.....

Catchment Name:..... Length of Section:.....

Sub-catchment Name:..... Shire:.....

Nearest Road Intersection:.....

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/trackw washouts	Subsidence	Erosion	Slumping	Sedimentation
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 ❒ Dam ❒ Riffle
❒ Braided channel ❒ Groundwater ❒ Bridge
❒ Pool ❒ Rapids ❒ Sand slugs
❒ Wetlands ❒ Annabranch ❒ Vegetated islands
❒ Other

……..

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 - rate between A1 and D3)

General: Best: Poorest:

Vegetation health

❒ Looks healthy ❒ Some sick trees ❒ 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

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	

Fencing status

Fence present? ❒ Yes ❒ No Fence condition: ❒ Good ❒ Moderate ❒ Poor

Fence style: ❒ Barbed wire ❒ Electric ❒ Fabricated ❒ Plain wire

Fence position (approximate distance [m] from river bank): LB:..... RB:.....

Stock access to foreshore: ❒ Yes ❒ No Vehicle access to foreshore: ❒ Yes ❒ No

Crossing Point: ❒ Yes ❒ No

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 = ☐ Environmental rating = ...

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

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 streamside 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?

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

Any wildlife (or evidence of presence) observed?

Landform types

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

Evidence of management

Tick the appropriate boxes:

❒ Prescribed burning

❒ Firebreak control

❒ Fencing

❒ Nest boxes

❒ Recreational facilities (e.g. rubbish bins, BBQ's, benches)

❒ Signs

❒ Planting

❒ Weed control

❒ Erosion control

❒ Earthworks

❒ Dredging

❒ Other:……

Management issues

Tick the appropriate priority box for each management issue.

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

Issue	Priority		
	High	Medium	Low
Recreation			
Garden refuse			
Service corridors			
Crossing point			
Feral animals			
Point source discharge			
Pumps or off-take pipes			
Dam/weir			
Cultural features			

Vegetation

Plant name	Abundance (H,M,L)	Plant name	Abundance (H,M,L)

Water quality data

Sample Number	pH	Conductivity mS/cm	Temperature ºC	Location

GPS coordinates

Coordinate	Description

Photos

Appendix 6. Overall stream environmental health rating

Living streams survey: Information to determine environmental ratings of streamlines

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 & 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 20m wide.	Mainly healthy undisturbed native vegetation. Verges less than 20m wide.	Good vegetation cover, but mixture of native & exotic species. Verges 20m or more.	Narrow verges only (<20m wide), mainly exotic vegetation.	Mostly bare ground or exotic ground covers (ie. pasture, gardens or weed infestations, but no trees).
Floodway & 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 (ie. pasture, gardens or weed infestations, but no trees).
	Excellent	**Good**	**Moderate**	**Poor**	**Very poor**

Source: Pen and Scott, 1995

Overall stream environmental health rating: Points system

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 = ☐ Environmental rating = ...

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

Appendix 7. Foreshore assessment grading system

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.

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.

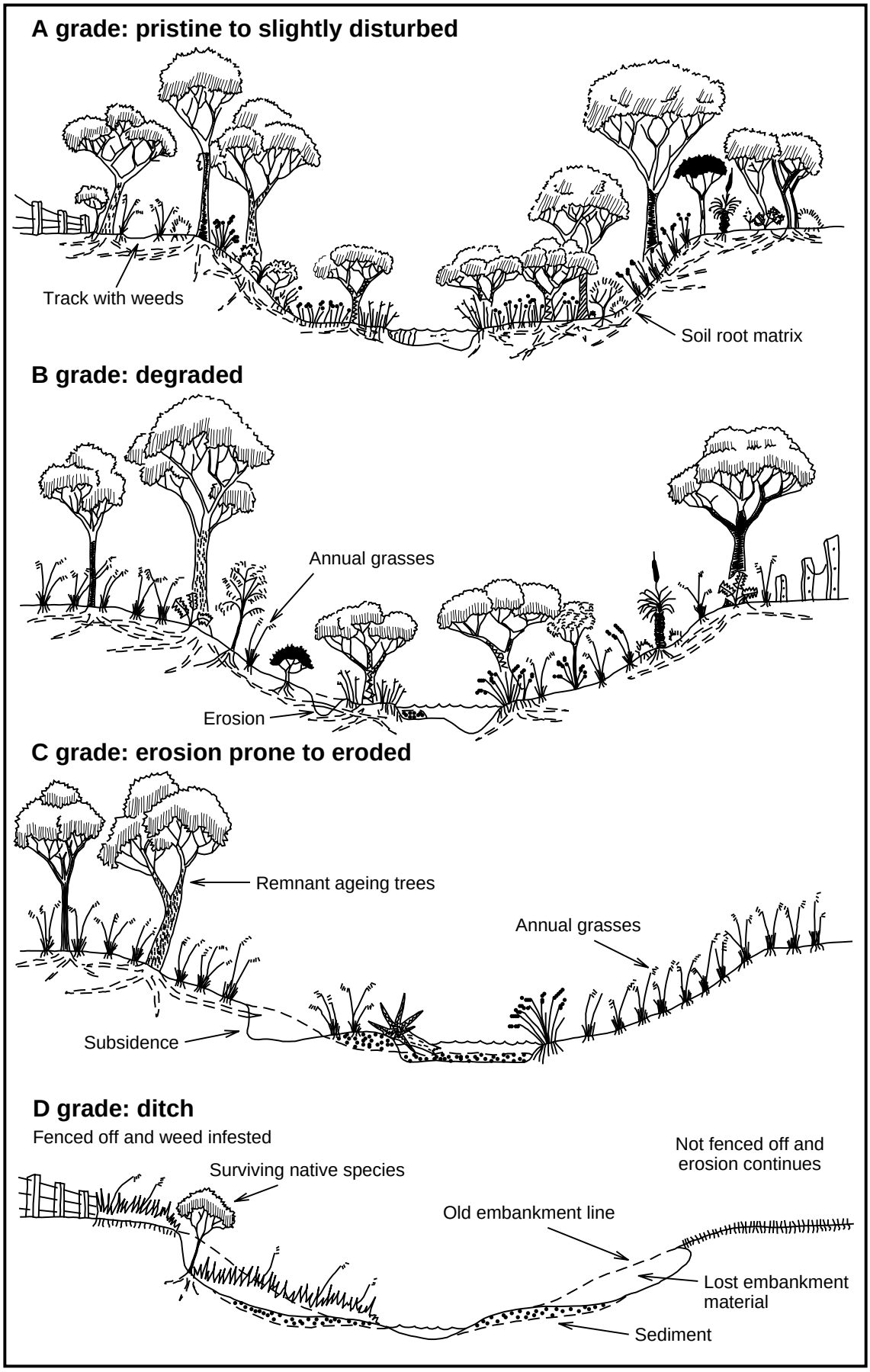
D Grade

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.



Source: Water and Rivers Commission, 1999

Appendix 8. Fauna of the Clackline nature reserve

Fauna (excluding birds) surveyed in 1985

Common name	Botanical name
Monotremes	
Echidna	*Tachyglossus aculeatus*
Marsupials	
Western Grey Kangaroo	
Western Brush Wallaby	*Macropus irma*
Euro	*Macropus robustus*
Introduced Mammals	
Rabbit	*Oryctolagus cuniculus*
Southern Frogs	
Spotted Burrowing Frog	*Heleioporus albopunctatus*
Western Banjo	*Limnodynastes dorsalis*
Humming Frog	*Neobatrachus pelobatoides*
Guenther's Toadlet	*Pseudophryne guentheri*
	Ranidella sp.
Geckos	
Clawless Gecko	*Crenadactylus ocellatus*
Wood Gecko	*Diplodactylus granariensis*
	Gehyra variegata
Barking Gecko	*Phyllurus millii*
Legless Lizards	
	Aprasia repens
	Delma fraseri
Burton's Snake-lizard	*Lialis burtonis*

Common name	Botanical name
Dragon Lizards	
Western Bearded Dragon	*Pogona minor*
Goannas/Monitors	
Bungarra	*Varanus gouldii*
Racehorse Goanna	*Varanus tristis*
Skinks	
Wood Skink	*Cryptoblepharus*
	plagiocephalus
	Egernia multiscutata
	Lerista distinguenda
	Menetia greyii
Bobtail	*Tiliqua rugosa*
Blind Snakes	
	Ramphotyphlops australis
Pythons	
Carpet python	*Python spilotus*
Elapid Snakes	
Gould's Snake	*Rhinoplocephalus gouldii*
Bandy Bandy	*Vermicella bertholdi*
Half-girdled Snake	*Vermicella semifasciata*

Source: Moore et al, 1987.

Birds surveyed in 1985

Common name	Biological name
Emus	
Emu	*Dromaius novaehollandiae*
Large Raptors	
Brown Goshawke	*Accipiter fasciatus*
Wedge-tailed Eagle	*Aquila audax*
Little Eagle	*Hieraaetus morphnoides*
Falcons	
Brown Falcon	*Falco berigora*
Australian Kestrel	*Falco cenchroides*
Quails	
Stubble Quail	*Coturnix novaezelandiae*
Pigeons	
Common Bronzewing	*Phaps chalcoptera*
Cockatoos	
White-tailed Black-Cockatoo	*Calyptorhynchus baudinii*
Galah	*Cacatua roseicapilla*
Parrots	
Red-capped Parrot	*Purpureicephalus spurius*
Port Lincoln Ringneck	*Barnardius zonarius*
Cuckoos	
Pallid Cuckoo	*Cuculus pallidus*
Fan-tailed Cuckoo	*Cuculus pyrrhophanus*
Owls	
Southern Boobook	*Nixon novaeseelandiae*
Frogmouths	
Tawny Frogmouth	*Podargus strigoides*
Kingfishers	
Laughing Kookaburra	*Dacelo novaeguineae*
Bee-Eaters	
Rainbow Bee-eater	*Merops ornatus*
Swallows	
White-backed Swallow	*Cheramoeca leucosternum*
Tree Martin	*Cecropis nigricans*
Pipits	
Richard's Pipit	*Anthus novaeseelandiae*
Cuckoo-Shrikes	
Black-faced	*Coracina novaehollandiae*
Cuckoo-shrike	
White-winged Triller	*Lalage sueurii*

Common name	Biological name
Robins/Whistlers/ Monarchs/Fantails	
Scarlet Robin	*Petroica multicolor*
Red-capped Robin	*Petroica goodenovii*
Western Yellow Robin	*Eopsaltria griseogularis*
Golden Whistler	*Pachycephala pectoralis*
Rufous Whistler	*Pachycephala rufiventris*
Grey Shrike-thrush	*Colluricincla harmonica*
Grey Fantail	*Rhipidura fuliginosa*
Wrens	
Splendid Fairy-wren	*Malurus splendens*
Australian Warblers	
Weebill	*Smicrornis brevirostris*
Western Gerygone	*Gerygone fusca*
Inland Thornbill Western Thornbill	*Acanthiza apicalis* *Acanthiza inornata*
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*
Treecreepers	
Rufous Treecreeper	*Climacteris rufa*
Honeyeaters	
Red Wattlebird	*Anthochaera carunculata*
Little Wattlebird	*Anthochaera chrysoptera*
White-naped Honeyeater	*Melithreptus lunatus*
Brown Honeyeater	*Lichmera indistincta*
New Holland Honeyeater	*Phylidonyris novaehollandiae*
White-cheeked Honeyeater	*Phylidonyris nigra*
Tawny-crowned Honeyeater	*Phylidonyris melanops*
Western Spinebill	*Acanthorhynchus superiliosus*
Pardalotes	
Striated Pardalote	*Pardalote striatus*
White-eyes	
Silvereye	*Zosterops lateralis*
Woodswallows	
Dusky Woodswallow	*Artamus cyanopterus*
Butcherbirds/Magpie	
Australian Magpie	*Gymnorhina tibicen*
Grey Currawong	*Strepera versicolor*
Crows/Ravens	
Australian Raven	*Corvus coronoides*

Source: Moore et al, 1987.

Appendix 9. Fencing styles and placement

Barbed wire fence: Any fence that is part barded wire, usually in conjunction with plain wire and droppers and which is not electrified is classified a barded wire fence. Barded wire deters stock from rubbing, which is the main cause of fence damage.

Electric fence: Electric fencing uses a high voltage pulse to deter animals, for both feral animals and stock. Electric fencing has been most commonly used in conjunction with conventional fencing, enhancing its effectiveness and, in case of heavy stock, reducing fence damage.

Fabricated fence: includes rabbit netting, ringlock and hinge point fences

Plain wire fence: Plain wire fences consist of multiple strands of plain wire, which collect less flood debris and are less prone to flood damage. Provided corner and end strainer assemblies allow wires to be tensioned correctly, post and dropper numbers can be reduced, resulting in considerable savings.

Drop fences: Drop fences are designed to be either manually dropped before a flood, or dropped at anchor points under the pressure of floodwater and debris.

Hanging fence: Hanging fences are suspended fences made out of steel cable or multi-stranded high tensile wire. The purpose of these fences is to keep animals from walking along waterways to bypass fence lines.

Source: Australian Wire Industries, 1993

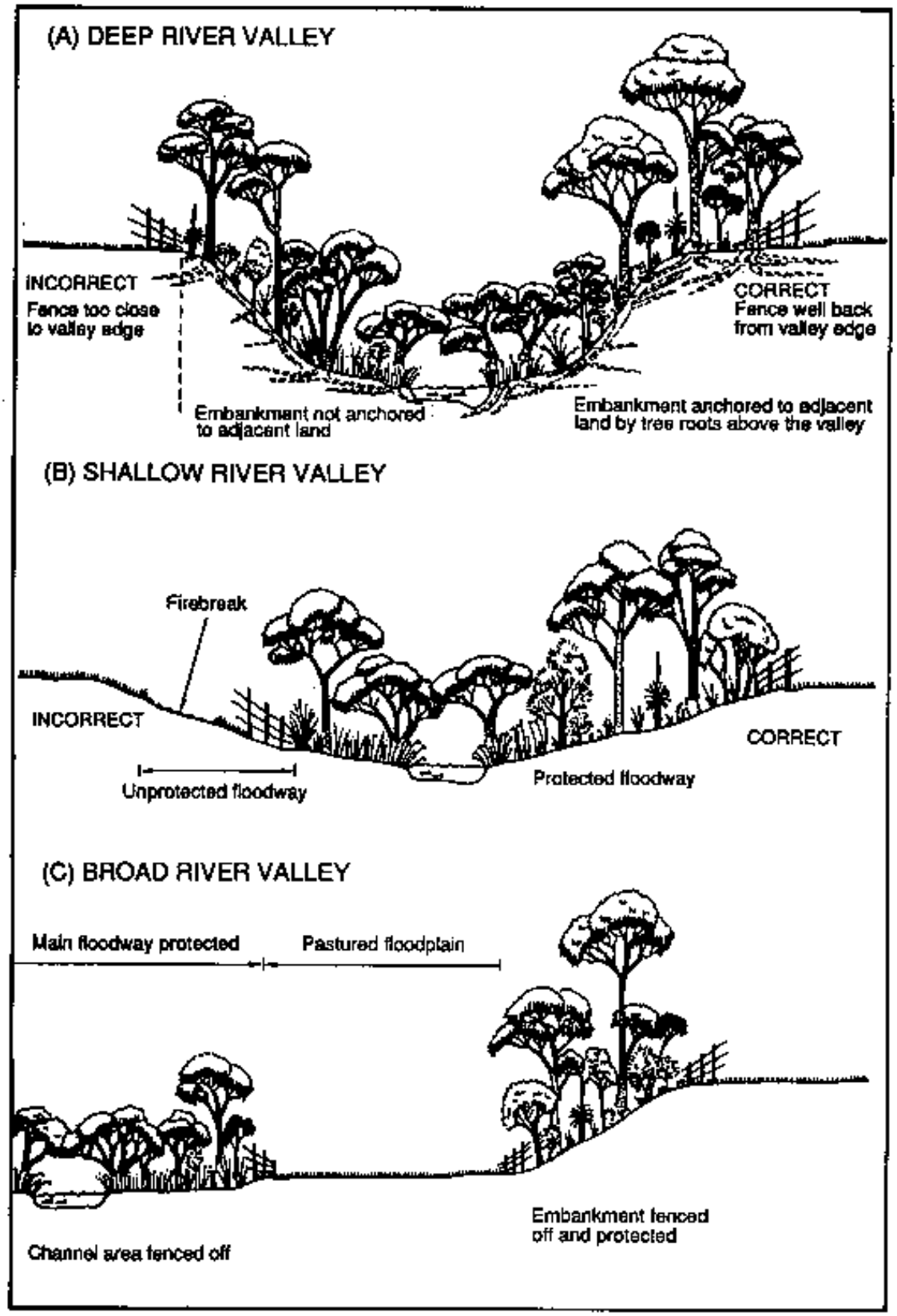
Fencing status – examples of fence condition

Fence condition: POOR

Fence condition: MODERATE

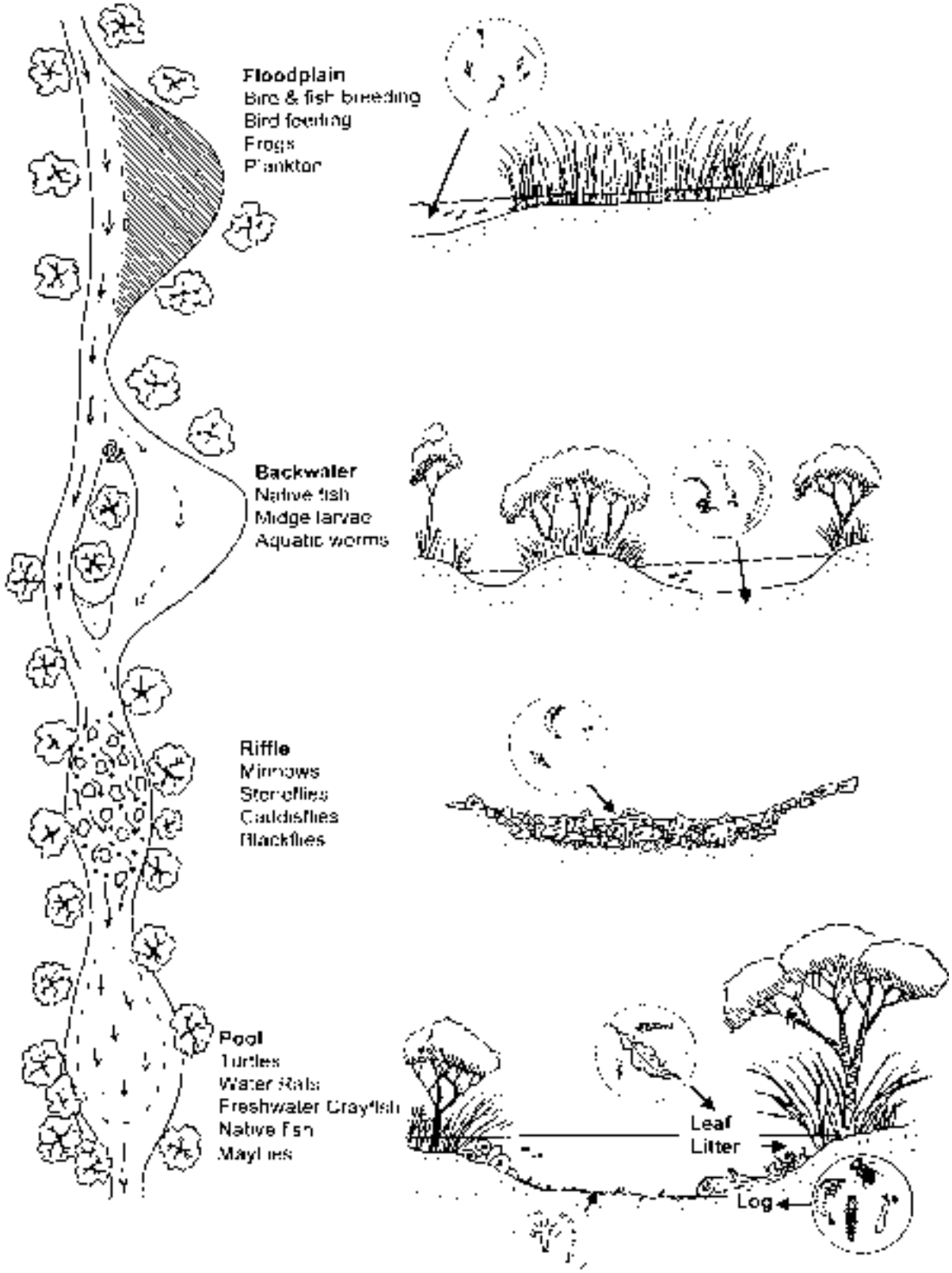
Fence condition: GOOD

The correct and incorrect placement of fences in relation to the river valley



Source: Water and Rivers Commission, (2000), Water Notes: Livestock management: Fence location and grazing control, *WN18, Water and Rivers Commission, Perth, Western Australia.*

Appendix 10. Habitats found along waterways



Source: Water and Rivers Commission, (2000), Water Notes: Habitats or rivers and creeks, *WN8, Water and Rivers Commission, Perth, Western Australia.*

Appendix 11. Avon Waterways Committee (AWC) Fire Policy

Avon Waterways Committee

Policy Number 1

FIRE

Objectives

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

- To protect riverine ecosystems from the damaging effects of uncontrolled fire:
- To use controlled fire for regeneration in accordance with management plans;
- To manage the fire hazard along the river, so as to minimise the threat of wildfire's to adjoining assets and property, and;
- To work cooperatively with Local Governments, Bush Fire Brigades and neighbours with respect to fire management.

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 which 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 and pasture, 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.

Whilst 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 which 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 which 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 Location Authorities and experienced Bushfire personnel in each district. The purpose will be to identify all the important values which 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 will be approved by AWC.

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 protection old trees, hollow logs etc. In the case of herbicide spraying, a prescription must be prepared which specifies the chemical to be used, the rate an time of application and the measures to be taken to protect non-target species or guard against off-site effects.
5. All controlled burning must be in accordance with the Bush Fires Act and meet Local Government requirements, and all prescriptions must be approved by AWC.
6. Uncontrolled grazing by sheep, cattle, goats, pigs or horses will not be permitted in the river system in areas controlled by AWC. Some limited controlled grazing may be approved during an interim periods in which other hazard reduction measures are being developed. Proposals to graze AWC-controlled land must be approved by AWC.
7. Owners of riverine vegetation will be encouraged to phase out grazing on their lands in favour of less destructive measures of hazard reduction.
8. 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 an urban development, none of which may take place along the river without approval of AWC.
9. 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 AWC to approval.
10. Encourage neighbours to the river to make their own properties fire-safe, rather than relay 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.
11. AWC will also support measures promoted by Landcare groups to minimise stubble burning on farmlands adjacent to the waterways.
12. 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 which 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 which help to achieve this aim.
13. Monitor areas burnt. Where good regeneration of desirable species has occurred, areas will be set aside from fire for a sufficient period to enable the young plants to flower and seed.
14. AWC will strongly support volunteer Bush Fire Brigades located along the river, to ensure they are properly equipped and organised. This support will take the form of supportive submissions to Local Authorities and the Bush Fires Board, until we are in a position to provide direct financial support.
15. Potential sources of fire in or adjacent to the river system will be identified. Where there are obvious problem sites (eg, smouldering rubbish tips) the site-manager will be approached to fix the problem. If necessary AWC will ask Local Authorities to enforce the Bush Fires Act to eliminate potential sources of fire.
16. Open fires will not be permitted in camp grounds or other recreational areas controlled by AWC along the river between the months of September and May.
17. AWC will seek endorsement of this policy, and all fire management plans developed for the river system from local authorities, neighbours and relevant government agencies (especially the Bush Fires Board).

The policy will be reviewed annually.