FORESHORE AND CHANNEL ASSESSMENT OF MORTLOCK RIVER NORTH

WATER AND RIVERS COMMISSION REPORT
WRM 39
2003
WATER RESOURCE MANAGEMENT SERIES

Water and Rivers Commission

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Cover Photograph: Riparian vegetation protecting the verge along a stretch of the Mortlock River North.

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Natural Heritage Trust
Helping Communities Helping Australia

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Foreword

Jointly funded by the Natural Heritage Trust and the Water and Rivers Commission, this project is part of the Avon Waterways Committee's (formerly the Avon River Management Authority) 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 needs of Mortlock River North through consistent field surveys, in consultation with adjacent landholders and surrounding community. The purpose emphasises community consultation, with attempts made to involve landholders along the waterway in as many aspects of the survey as possible.

The Mortlock River North catchment drains portions of the Shires of Northam, Goomalling, Wongan-Ballidu, Victoria Plains, Dalwallinu, Moora and the Town of Northam. Foreshore and channel assessments along Mortlock River North were undertaken between March and November 2002.

The purpose is to provide information to people within the Mortlock River North catchment who manage or have an interest in waterways. It is hoped that this information will encourage and assist in 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 river can be improved to provide environmental, economic and social benefit to landholders and community members throughout the area.

Although this tributary has been surveyed in isolation to other major waterways, the long-term management of the riverine environment depends on 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 River for the community as a whole and encourage integrated catchment management, 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

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Disclaimer:

These maps are the product of Water and Rivers Commission, Regional Services Division, and were printed on 29 January 2003. The maps were produced with the intent that they be used for information dissemination at the scale of 1:160 000. 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 highlight areas of degradation along the north branch of the Mortlock River and encourage landholders to undertake management strategies to increase the health of the waterway. Along with landholders, it is hoped that the community will see the need for an integrated approach to management of the brook and surrounding lands. Results will hopefully promote an awareness of the interrelated nature of landuse practices and the current state of the waterway.

The purpose of this survey is to assess and document the current uses, disturbances and health conditions of Mortlock River North and provide some guiding management recommendations. It is hoped that the information contained within this document will encourage landholders, Local Government Authorities and community members to use this data to undertake management along the channel, foreshore and surrounding catchment of the Mortlock River North.

Objectives of this project can be summarised as follows:

- To provide a compilation of data regarding the condition of the River 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 waterways 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 Mortlock River North and its tributaries. Whilst achieving this goal the objective was to involve the adjoining landholders and community members in the foreshore and channel assessment and to encourage awareness of the importance of waterways management and conservation.

It is hoped that this data will eventually lead to a management or action plan for the channel, foreshore and catchment surrounding Mortlock River North to provide guidance and direction for future management of the waterway.

Study area

The Mortlock River is one of the main systems feeding the Avon River. It is comprised of three branches; the North, South and East. Located in the Avon Catchment in Western Australia the Mortlock River North drains water from the surrounding catchment into the Mortlock River East in Northam. This waterway then drains into the Avon River (which has its source near Wickepin) to where it becomes the Swan River at the base of the Darling Scarp and eventually drains into the Indian Ocean. The area assessed is located within the Shires of Wongan-Ballidu, Goomalling and Northam. The Mortlock River North begins north-west of the Wongan Hills township and flows in a south-south-easterly direction where it meets the Mortlock River East approximately 2km east of Northam. For the purpose of this project it was assumed that the source of Mortlock River North is Lake Ninan which lies approximately 6.5km south-west of Wongan Hills townsite. Lake Hinze is occasionally referred to as the source of this tributary, as it will overflow in times of excessive rainfall and will flow into Lake Ninan. Map 1 depicts the size of the Mortlock River North catchment and also shows the location of the River in relation to main roads. The River drains water from the surrounding catchment (678 000km2 in size) into the Mortlock River East and then into the Avon River in Northam.

The primary focus of this assessment was the foreshore and channel areas of the River. The area studied includes the riverbed, channel embankments, floodway, verge, foreshore and land use adjacent to this waterway. It should be noted that when planning to manage Mortlock River North, there is a need to adopt a whole catchment approach rather than dealing with the waterway as an entity on its own.

Historical description of Mortlock River North

Aboriginal Heritage

Data from the Department of Land Administration and the Aboriginal Affairs Department shows that there are no registered sites or communities of Aboriginal significance along Mortlock River North. Anecdotal evidence suggests that there were once Aboriginal clans living in the area surrounding this River, with territories bordering the waterway. Past occupation of the land by Aboriginal people suggests that the land may have important spiritual and cultural meaning to the current generations of these tribes.

European Heritage

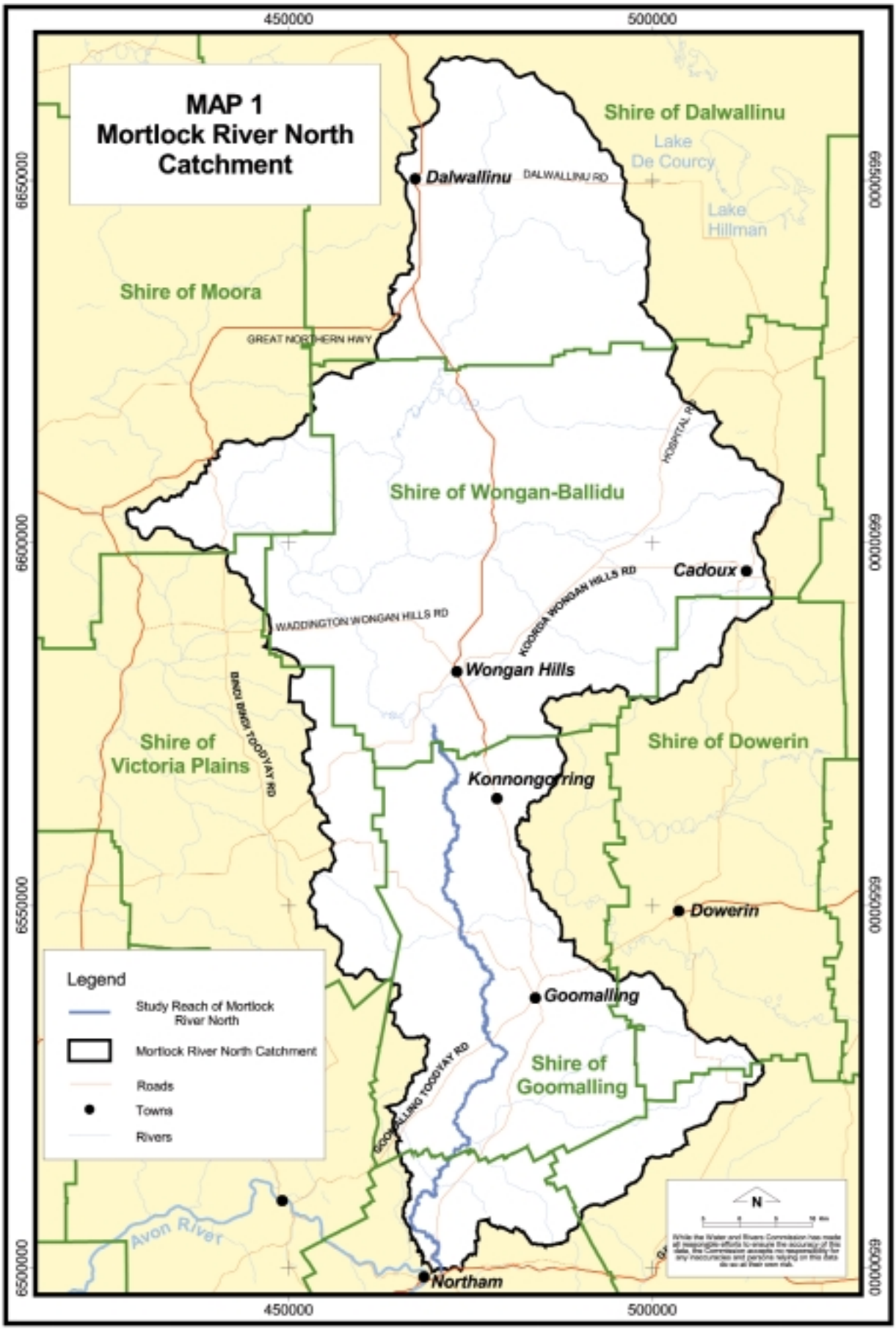
The Avon region was explored by European settlers in 1830, when an expedition party led by Ensign Dale travelled overland from Guildford. The Avon Valley was settled by European farmers shortly after this, in 1831, and the Northam and Goomalling regions developed steadily over the next 50 years as land was released and settled (Western Australian Planning Commission, 1999).

Development of the land centred on the agricultural industry with the introduction of wheat and sheep 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 in the Shire of Northam (particularly around Irishtown) to be subdivided into smaller lots that have a focus on hobby farming and rural lifestyle.

Catchment description

Population

The 2001 Australian census of population determined that there were an estimated 3696 people living within the Shire of Northam, 978 in Goomalling and 1573 people residing within the Shire of Wongan-Ballidu (Australian Bureau of Statistics, 2002). There are 44 landholders along the length of Mortlock River North.



Map 1. Mortlock River North Catchment

Table 1. Climatic averages (Source: Bureau of Meteorology, 2002)

Climatic Factor	**Shire of Wongan-Ballidu**	**Shire of Goomalling**	**Shire of Northam**
Average yearly rainfall	390.6mm	367.8mm	432.0mm
Average maximum temperatures	25.5°C	24.8°C	25.2°C
Average minimum temperatures	12.0°C	11.2°C	11.0°C
Average evaporation	N/A	N/A	4.5mm/day
Average wind speed (at 9am)	12.1km/hr	9.7km/hr	8.5km/hr

Climate

The Shires of Northam, Goomalling and Wongan-Ballidu all experience a Mediterranean type climate, with hot dry summers and mild wet winters. Table 1 gives a summary of climatic data for the 3 Shires through which the River flows.

Most of the Mortlock River North lies in an area of the catchment that receives a yearly rainfall of between 350mm (in the east) to 400mm (in the west). Closer to Northam, the River crosses the 400mm rainfall isohyet and rainfall may increase to 500mm annually (Lantzke and Fulton, undated).

Geomorphology and soils

The North branch of the Mortlock River lies within the Zone of Rejuvenated Drainage. The system is characterised by broad flat valleys with the channel undefined towards the northern end, gradually becoming a well-defined channel towards it's confluence with Mortlock River East. Dry for most of the year, the waterway commonly flows during winter.

Using the Lantzke and Fulton soil landscape data of the Mortlock River North catchment are dominated by Avon, York, Mortlock and Ewerts soil units with pockets of Eaton, Ulva and Yalanbee systems.

The Avon system is characterised by red loamy, grey clayey and orange sandy soils. These are found along alluvial terraces and floodplains adjacent to the southern half of the Mortlock River North. The York soil landscape unit is comprised of rocky, red and brownish grey loamy soils formed from freshly exposed bedrocks. These are found in the outer catchment along the mid and upper slopes of the landscape (Lantzke and Futon, 1992).

The Ewerts soil landscape unit is located along the hill slopes of the surrounding catchment area and is predominantly characterised by sand and loamy sand over yellowish clay soils. Mortlock system is located on the valley floors along the Mortlock River and its tributaries, and is characterised by sand over yellowish clay soils (Lantzke and Fulton, 1992).

Small scattered pockets of Eaton and Ulva soil landscape units are found around the Mortlock River North Catchment. Eaton soils are characterised by pale sandplain areas with poorly drained seepage areas and lakes. The Ulva system comprises yellow sandplain and gravelplain soils which are generally found along upland areas (Lantzke and Fulton, 1992).

Map 2 shows the distribution of soil units throughout the Mortlock River North catchment, while Appendix 1 provides a description to match the soil units used.

Hydrology

The Mortlock River system (comprising the North, East and South branches) is one of the many systems responsible for feeding saline water into the Avon River. A large catchment area, this waterway drains the northern part of the Shire of Northam, most of the Shires of Goomalling and Wongan – Ballidu, as well as the western portions of the Shires of Dowerin and Cunderdin and the eastern portions of the Shires of Toodyay and Victoria Plains.

There are several minor tributaries feeding into the North branch of the Mortlock River from around its catchment. The larger of these are Elyaring Brook, Woormenning Gully, Cockerding Brook, Yarramony Brook, Chitibin Brook, Jennapullin Brook and Southern Brook. There are also many smaller waterways and drainage lines draining the surrounding catchment.

The Mortlock system is seasonally active and flows intermittently after heavy rainfall events, which usually means during winter, spring and early summer. In many cases the channel is undefined and basically consists of a very wide shallow floodplain. In these cases, flow of water is often hard to determine during light rainfall, and may only be obvious along the downstream portion of the River where the channel is more defined.

Almost all of the catchment is cleared and in a wet year the system can contribute a large volume of flood water into the Avon River. Even without flood events, the waterways tend to flow strongly every year, especially in the downstream reaches.

There are now limited numbers of shallow pools along the length of the River, however 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 periodical flooding and drying of the waterway system are important historical features of the waterway which many ecosystems are dependent upon for their long-term survival (Hansen, 1986). However, there has been a change in the frequency 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.

Vegetation

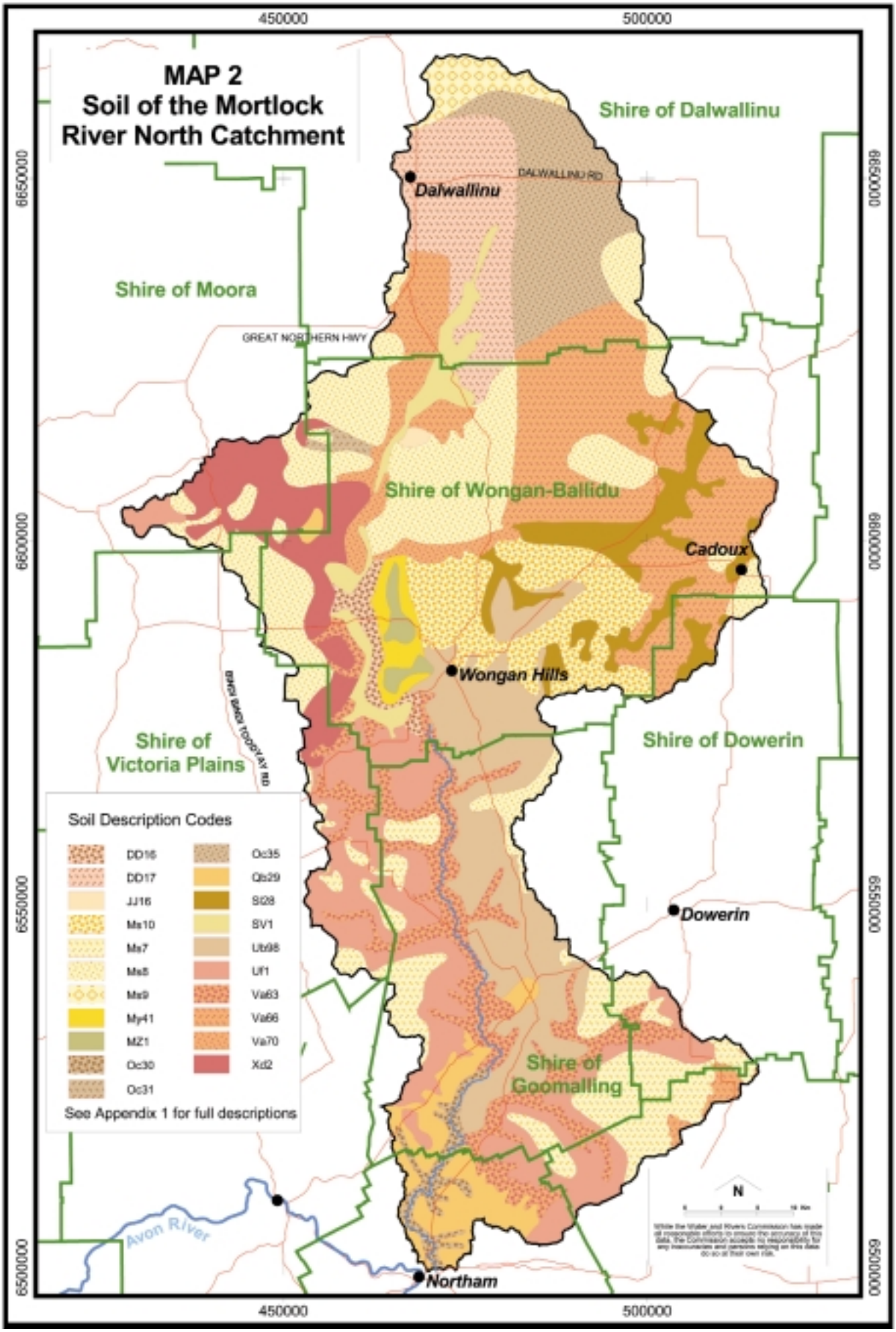
The banks of the River are dominated by Swamp sheoak (*Casuarina obesa*) with a patchy mix of Flooded gum (*Eucalyptus rudis*), both of which are tolerant of permanently wet soils and saline water (Swamp sheoak being more tolerant of higher salinity levels than Flooded gum). Jam wattle (*Acacia acuminata*) is found within the riparian zone, but further away from the channel, as it is less tolerant of saline waters. Agricultural weeds such as Barley grass (*Hordeum leporinum*), Wild oats (*Avena fatua*) and Rye grass (*Lolium rigidum*) are also common throughout the riverine environment. The weed species Capeweed (Arctotheca calendula), Fat hen (Chenopodium album), Patterson's curse (*Echium plantagineum*) and Soursob are widespread.

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 with the subdivision of many rural farms into smaller lots.

The majority of Mortlock River North lies within private land ownership, with a small percentage being reserves vested in Main Roads Department. In the past decade there has been 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, aquaculture and horticulture).

In most instances, historical land titles along Mortlock River North mean that ownership includes the waterway where land ownership stretches across the river. In a few cases, ownership of the waterway extends to the centre of the River.



Map 2. Soils of the Mortlock River North Catchment

Survey methods

Community awareness and involvement

A letter of introduction was sent to landholders along Mortlock River North explaining the purpose of this survey. Arrangements were then made by phone for access onto properties to survey the River. 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 Mortlock River North. 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, as did the project newsletter, Tributary Talk, which were sent to all stakeholders involved in 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.

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 in their 1995 publication; *Stream and Foreshore Assessment in Farming Area*s, 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;
- ideas for management;
- vegetation; and
- water quality data (pH and electrical conductivity).

Surveys were conducted along the length of Mortlock River North with survey sections being determined by paddock and property boundaries. The length of Mortlock River North was divided into 81 sections for the purpose of this survey.

Foreshore and channel assessments were conducted along the length of each River section and filling out the survey form (an example is provided in Appendix 2). 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 but 2 cases, both sides of the River 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. In 2 sections, ownership of left and right banks differed, so a separate survey sheet was used, creating 3 individual sections.

The majority of assessment along Mortlock River North was observational. Foreshore and channel condition was assessed whilst walking along the waterway and

recorded on the assessment template. Photos were taken at points of interest and will be used for future monitoring of the River and its foreshore. 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 Water and Rivers 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 GPS units (model Magellan GPS 315 and a Trimble Scoutmaster GPS Unit) 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 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 3 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 4 contains a table explaining the categories used to classify the stream condition and the overall health of the River.

The overall stream environmental health rating is used to assess the ecological value of the individual river 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 4 provides a table that shows the points allocated to each individual component based on the 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 River. Data has been collated and is the source information from which maps have been produced. Key findings of this Mortlock River North assessment have been summarised within this report.

Survey results

Anecdotal evidence as well as survey results indicate that Mortlock River North and its surrounding catchment has historically been subjected to a wide range of disturbances that have led to a decline in their health. Field observations indicate that the main forms of river 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. The following factors influencing both bank and channel stability were used in this assessment:

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

Field assessments of each river section evaluated the above factors that were used to determine channel stability. Channel stability is an average for the whole section and can be rated as shown in Table 2.

Table 2. Rating system used to determine channel stability

Channel Stability	**% of River Section Affected**
Minimal	0-5
Localised	5-20
Significant	20-50
Severe	>50

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 within this river system. Table 2 shows the rating system used to determine the bank stability and sedimentation ratings of each section, and Figure 1 provides a collation of results for Mortlock River North which have been based on the information provided in Table 2.

Table 3. Ratings used to determine bank stability and sedimentation (Pen and Scott, 1995)

Condition Rating	**Bank Stability and Sedimentation**
Excellent	No erosion, subsidence or sediment deposits. Dense vegetation cover on banks and verge. No disturbance.
Good	No significant erosion, subsidence or sediment deposits in floodway or on lower banks. May be some soil exposure and vegetation thinning on upperbank and verge.
Moderate	Good vegetation cover. Localised erosion, bank collapse and sediment heaps only. Verge may have sparse vegetation cover.
Poor	Extensive active erosion and sediment heaps. Bare banks and verges common. Banks may be collapsing.
Very Poor	Almost continuous erosion. Over 50% of banks collapsing. Sediment heaps line or fill much of the floodway. Little or no vegetation cover.

Results indicate that the majority of sections were recorded as having sedimentation and moderate bank stability when rated in terms of the overall stream environmental health.

Figure 1 shows that 52% of surveyed sections were rated as having moderate bank stability and sedimentation, with only 3% rated as good. A large number of sections (44%) were classified as poor and 1% as very poor. 8% of the surveyed sections were utilising artificial stabilisation techniques along the banks, meaning that 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.

Along Mortlock River North, undercutting was recorded as being minimal in 44% of sections, localised in 39% and significant in 5% and of the survey sections. It was not recorded in 12% of sections.

Firebreak and track washouts were determined to be minimal along 7% and localised along 1% of the sites, while the rest 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 52% of surveyed sites, localised in 16% and significant in 1% of sites, whereas the remaining sections showed no signs of subsidence.

Erosion was recorded as being minimal in 9% of sections, localised in 44% of sections, significant in 45% of sites and severe in 2% of the sections.

Gully erosion also affected the banks and verge areas with ratings recorded as minimal in 39%, localised in 10% of sections and significant in 2% of sites. 49% of the sections were not affected by gully erosion at the time the assessments were carried out.

Sedimentation was another prominent component of degradation recorded along the River with 19% of sections recording minimal sedimentation, 47% localised, 31% significant and 9% as severe.

The most significant components were erosion and sedimentation. The overall stability of the channel might be defined as poor (see Table 3) with over three quarters of survey sections being highly eroded and unstable with large deposits of coarse sand sediment. Sediment deposits were identifiable along many areas of the channel, while there were also some areas along the riverbed that have been eroded down to the underlying clays.

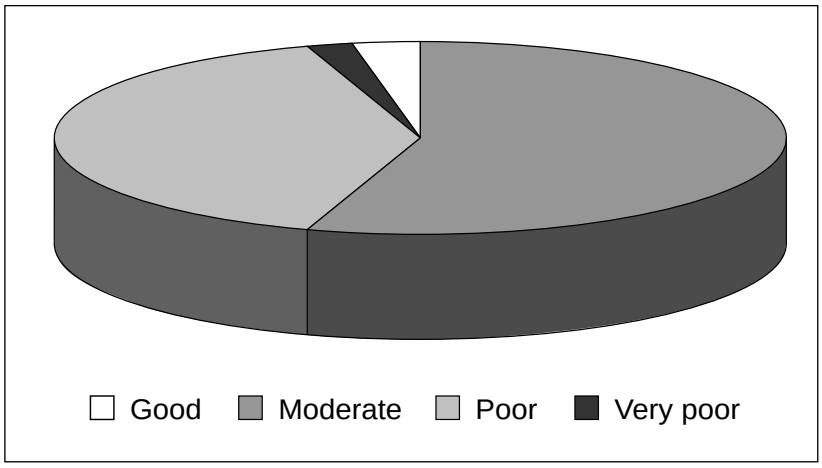


Figure 1. Bank stability and sedimentation ratings for Mortlock River North

Severe bank erosion occurs in some sections where the channel is more defined.

Waterways features

The features of a waterway often indicate the level of health associated with the riverine system. The presence of features such as pools, rapids, anabranches, riffles, bridges, sand slugs and vegetated islands allow us to assess, to some degree, the health of the waterway and determine options for future management.

Survey results show that 90% of the sections were comprised of a single channel, while 10% were braided. Of these sections, 35% had anabranches running in close proximity to the River. Sand slugs within the channel were recorded at 69% of sections.

2% of the sections had large natural riffles and 55% had shallow pools at the time of assessment. Some of these pools are likely to be non-existent during the hotter summer months when the flow of water within the system stops.

Only 1% of sites had dams situated in close proximity to the waterway, 20% had smaller tributaries feeding into Mortlock River North from the surrounding catchment, while a small number of properties had drains channelling water in from the surrounding landscape.

Foreshore condition

General foreshore condition

91% of sections were rated as having a general (or average) foreshore condition of C-grade, meaning that there was minimal vegetation diversity. 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 5 provides an overview of all possible grades, from A1 through to D3.

8% of surveyed sections were rated as B-grade and 1% were rated as having a D-grade general foreshore condition rating. B-grade ratings were awarded to those sections that were in slightly better condition than the rest of the River, 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 1% of the sites rated as B1, 9% as B2, 36% as B3, 42% as C1, 9% as C2 and 3% as C3-grade. Appendix 5 provides definitions of foreshore condition ratings that have been used throughout this assessment.

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

The poorest foreshore condition recorded within each survey section varied along the length of the waterway and was related to current and past landuse practices within adjoining properties and throughout the catchment as a whole. Poorest foreshore conditions were recorded as C1 in 6% of surveyed sections, C2 in 6% of sections, C3 in 41% of sections, D1 in 44% of sections and D2-grade in 3% of survey sections.

Foreshore vegetation

Presence of common species

The most common overstorey species recorded along Mortlock River North were Swamp sheoak (*Casuarina obesa*), Flooded gum (*Eucalyptus rudis*) and Jam wattle (*Acacia acuminata*).

The most common understorey species recorded were weed species including Wild oats (*Avena fatua*) and Barley grass (*Hordeum leporinum*), as well as native Samphire species (*Halosarcia* spp.).

Field observations indicated that weed species were far more common than native species, with results showing that 57% of surveyed sections had an abundant occurrence of exotic vegetation (weeds), while 38% were recorded as frequent. Native vegetation, on the other hand, was recorded as abundant in 10%, frequent in 78% and occasional in 12% of surveyed sections.

Proportion of native species

Table 4 shows the occurrence of native plant species recorded during foreshore assessments along Mortlock River North.

A D-grade section along the Mortlock River North foreshore

Table 4. Native species occurrence

Plant Name		**% of sites where the species occurred**	**Occurrence of each species (as a % of site where it occurred)**		
Common Name	**Scientific Name**		**High**	**Medium**	**Low**
Acacia sp.	*Acacia* sp.	28	0	5	95
-	*Actinostrobus pyramidalis*	4	0	4	0
Banksia	*Banksia* sp.	5	0	0	5
Broome Honeymyrtle	*Melaleuca uncinata*	8	0	33	67
Common heliotrope	*Heliotropium europaeum*	36	0	10	90
Creeping salt bush	*Atriplex semibaccata*	26	0	38	62
Flooded gum	*Eucalyptus rudis*	62	0	38	62
Jam wattle	*Acacia acuminata*	30	0	17	83
Melaleuca sp.	*Melaleuca* sp.	35	0	32	68
Needlebush	*Hakea preissii*	40	6	22	72
Ruby salt bush	*Enchylaena tomentosa*	26	24	33	43
Samphire sp.	*Halosarcia* spp.	78	48	29	22
Shore rush	*Juncus kraussii*	36	0	4	96
Spiny flat sedge	*Cyperus gymnocaulos*	24	2	21	79
Swamp paperbark	*Melaleuca rhaphiophylla*	18	0	0	100
Swamp sheoak	*Casuarina obesa*	79	13	70	17

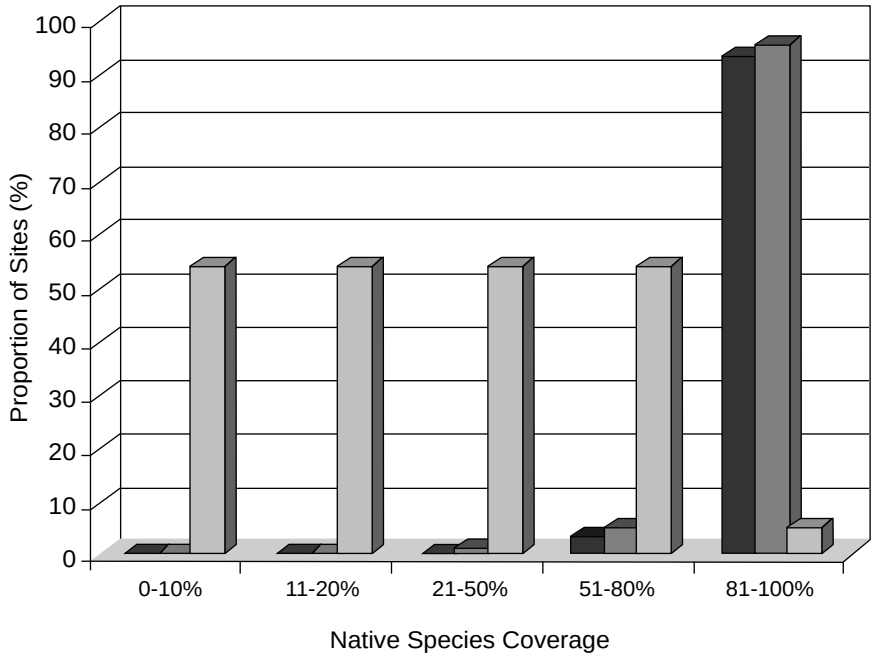


Figure 2. Proportion of native species in each vegetation layer

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

Of middlestorey species present (shrubs and small trees), 94% of sites were recorded as having between 81-100% native vegetation. Ground cover was predominantly weed species with 54% of sites recording a cover of between 0-10% native species. Native overstorey and middlestorey species were found to be absent in 5% and 4% of sections respectively.

Regeneration of native species

Natural regeneration of tree species was observed at 73% of the survey sections. The following species were showing signs of natural regeneration amongst foreshore vegetation along Mortlock River North:

- Swamp sheoak seedlings were recorded at 56% of survey sections;
- Flooded gum seedlings were recorded at 15% of survey sections;
- Needlebush seedlings were recorded at 14% of survey sections;
- Melaleuca sp. seedlings (including some Swamp paperbark) were recorded at 9% of survey sections;
- Acacia seedlings (including a few Jam trees) were recorded at 9% of survey sections; and
- Grevillea sp. were recorded at 1% of survey sections.

10% of sections showed evidence of plantings being undertaken along the riparian zone as a part of the landholders' land management plan. Plantings consisted mainly of tree species. In many cases, plantings had been undertaken further away from the river, in salt affected areas, and were not recorded as part of this survey. A number of landholders also indicated that they were also planning to plant native tree species within the riparian zone in the near future.

Death of common native species

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

Figure 3 shows that 11% of surveyed sections recorded some sick trees among the foreshore vegetation, while 31% of sites had some dead trees and many dead trees were observed in 14% of surveyed sites. 40% 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).

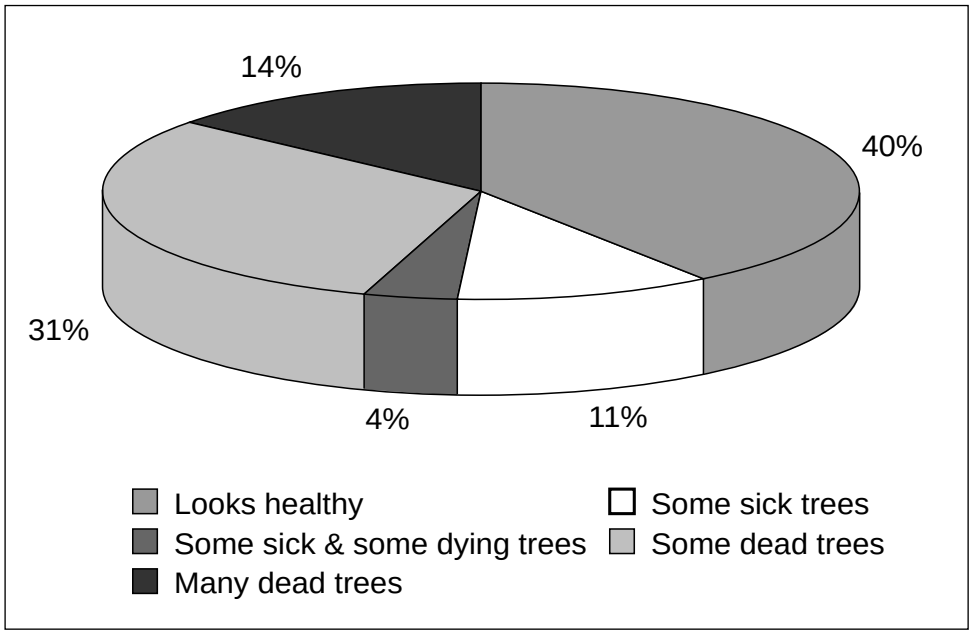


Figure 3. Vegetation health

Dead upperstorey vegetation is common due to rising salinity levels and waterlogging

Vegetation cover

Field investigations determined that the majority of sites were lacking a dense middlestorey (shrub layer) and were supporting a patchy or sparse upperstorey of tree species. Table 5 shows the percentage of surveyed sections that were classified as either absent, sparse, patchy or continuous (depending on the level of cover) in each vegetation layer.

The data in Table 5 shows that ground cover was the most dominant vegetation layer with 46% of sites recorded as being continuous and 51% as patchy. Middlestorey vegetation was absent in 5% of sites, sparse in 67% of sites and patchy in 28% of sites. The upperstorey was dominantly recorded as being patchy (between 20% and 80% coverage), with 65% of the sections rated in this category.

All of the surveyed sections had a percentage of bare ground. Results indicated that 40% of sections had less than 10% bare ground, 30% of sections between 11% and 20% bare ground, and 30% of sections between 21% and 50% bare ground. No sites were recorded as having over 50% bare ground. Leaf litter was recorded as being minimal throughout the foreshore in 79% of survey sections.

Results collated for stream cover as part of an evaluation to determine the overall stream environmental health rating indicate instream vegetation cover along the River. Stream cover was moderate in 58% of sections, meaning that there was some permanent shade and overhanging vegetation with some instream cover recorded (Pen and Scott, 1995). Poor stream cover was recorded in 30% of sections and very poor in 11% of surveyed sections. Only 1% of sites were recorded as

Table 5. Vegetation cover

	Proportion of Vegetation Cover			
	Absent (0%)	**Sparse (<20%)**	**Patchy (20-80%)**	**Continuous (>80%)**
Upperstorey (%)	5	30	65	0
Middlestorey (%)	5	67	28	0
Ground cover (%)	0	3	51	46

having good stream cover. The most common instream cover recorded along this waterways was leaf litter at 81% of sites, branches at 65% of sites, and vegetation (ie. sedges, samphire species and overhanging trees) which was recorded in 60% of surveyed sections. It should be noted that it is common for broad saline waterways to have minimal cover over the waterway.

Weeds

The most common weed species recorded along Mortlock River North were Barley grass (*Hordeum leporinum*), Wild oats (*Avena fatua*), Rye grass (*Lolium rigidum*) and Waterbuttons (*Cotula coronopifolia*). Barley grass was recorded as having a high occurrence in 35% of sections, while Rye grass and Wild oats were recorded in the majority of instances as having a moderate occurrence at the sites in which they were recorded. Waterbuttons were recorded as having a low occurrence in 37% of surveyed river sections. Table 6 shows the occurrence of the more common weeds found along Mortlock River North as a percentage of sections they occurred in.

Barley grass was by far the most dominant weed species, recorded in 86% of survey sections, with a high occurrence in 35% of sites. Wild oats was recorded in 78% of sections, Rye grass in 47%, Waterbuttons in 46% and Cape weed in 38% of survey sections. A medium occurrence of unidentified broad-leaf weeds was also recorded in 17% of 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). One species of pest plant was recorded amongst the foreshore vegetation along Mortlock River North. Pie melon (*Citrullus lanatus*) was recorded in 4% of survey sections with a low occurrence observed at each site.

Table 6. Common weed occurrence

Plant Name		**% of sites where the species occurred**	**Occurrence of each species** (as a % of site where it occurred)		
Common Name	**Scientific Name**		**High**	**Medium**	**Low**
Barley grass	*Hordeum leporinum*	86	35	30	21
Cape weed	*Arctotheca calendula*	38	5	15	18
Dandelion	*Taraxacum officinale*	17	0	0	17
Fat hen	*Chenopodium album*	25	0	1	24
Guildford grass	*Romulea rosea*	10	0	1	9
Patterson's curse	*Echium plantagineum*	28	0	0	28
Rye grass (annual)	*Lolium rigidum*	47	1	24	22
Saltwater couch	*Paspalum vaginatum*	22	1	5	16
Soursob	*Oxalis pes-caprae*	25	2	4	19
Spike rush	*Juncus acutus*	36	0	6	30
Two-leaf cape tulip	*Homeria miniata*	10	0	9	1
Watterbuttons	*Cotula coronopifolia*	46	0	16	30
Wild oats	*Avena fatua*	78	26	27	25

Declared plants

Declared plants are those plants that are classified as having 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 Agriculture Western Australia. Under this Act, landholders are obliged to control any declared plants that occur within their properties (Hussey et al, 1997). Five declared plants were sighted along Mortlock River North, these being one-leaf Cape tulip (*Homeria flaccida*), Paterson's curse (*Echium plantagineum*), Skeleton weed (*Chondrilla juncea*), Soursob (*Oxalis pes-caprae*), and two-leaf Cape tulip *(Homeria miniata*).

Patterson's curse was recorded in 28% of sites, with a low occurrence along each of these survey sections. Soursob was found at 24% of sections with the majority of these sections (24% of all survey sections) recording a low occurrence. Two-leaf cape tulip was recorded in 10% of sites with the majority recorded being classified as having a medium occurrence.

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 a variety of vegetation types, with this habitat type 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:

- protected basking sites (ie. debris and branches) were recorded at 98% of sections;
- meanders and pools were recorded along 70% of sections;
- rushes (a mixture of native and non-native species) were recorded along 69% of sections;
- instream logs were recorded along 64% of sections;
- a variety of instream and bank vegetation were recorded along 46% of sections;
- instream cobbles and rocks were recorded along 21% of sections;
- emergent plants/soft substrate for eggs were recorded along 20% of sections; and
- cascades, rapids and riffles were recorded along 10% of sections.

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

- trees were recorded along 96% of sections;
- shrubs were recorded along 84% of sections;
- dense streamside vegetation along 21% of sections; and
- dense protective vegetation along 15% of sections.

Instream cover was moderate in 58% 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 sites that had instream cover.

Figure 4 shows that leaf litter and branches were the most common form of instream cover and habitat type, occurring in 81% and 65% of sites respectively, followed by vegetation which was recorded at 60% of sections.

Foreshore habitat differs slightly to that within the stream channel. Leaf litter along the foreshore was classified as minimal in 79% of sections, good in 4% and absent in 17% of survey sections. Ratings used during assessment of the overall stream environmental health rating determined that the majority (97%) of Mortlock River North 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).

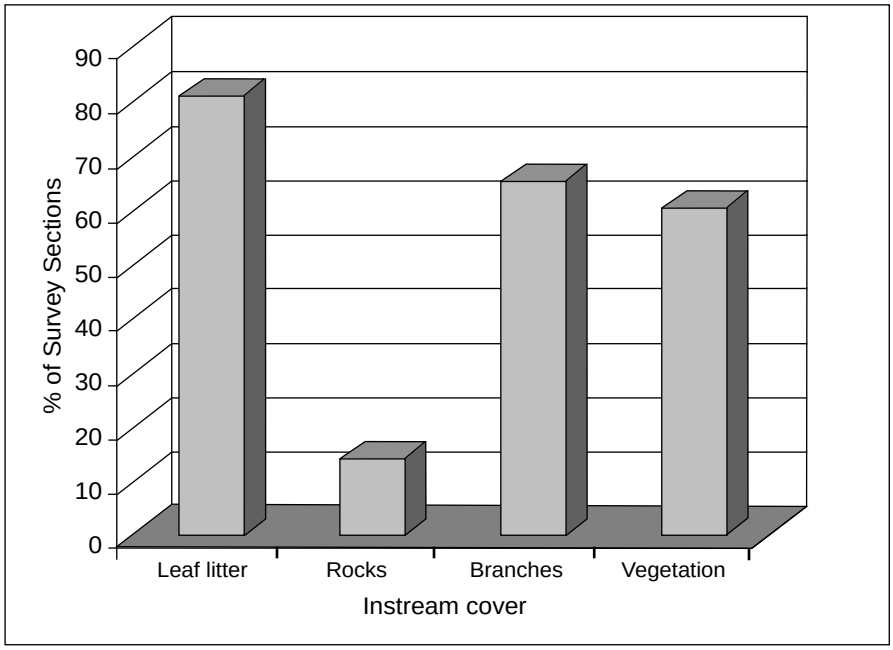


Figure 4. Proportion of instream cover

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

- Ants
- Australian Shelduck
- Bees
- Birds
- Bobtails
- Bullants
- Butterflies
- Cranes
- Crickets
- Dragonflies
- Ducks
- Fantails
- Feral cats
- Foxes
- Frogs
- Gambusia
- Kangaroos
- Lizards
- Macroinvertebrates
- Magpies
- Mosquitoes
- Pink and grey galahs
- Plovers
- Rabbits
- Rainbow honeyeaters
- Scarlet Robin
- Scorpions
- Snakes
- Spiders
- Trap door spiders
- Wedgetail eagles
- White cockatoos
- 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.

The seasonal drying and change in water depth in Mortlock River North 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 depth of water within the channel was low, when flowing, 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

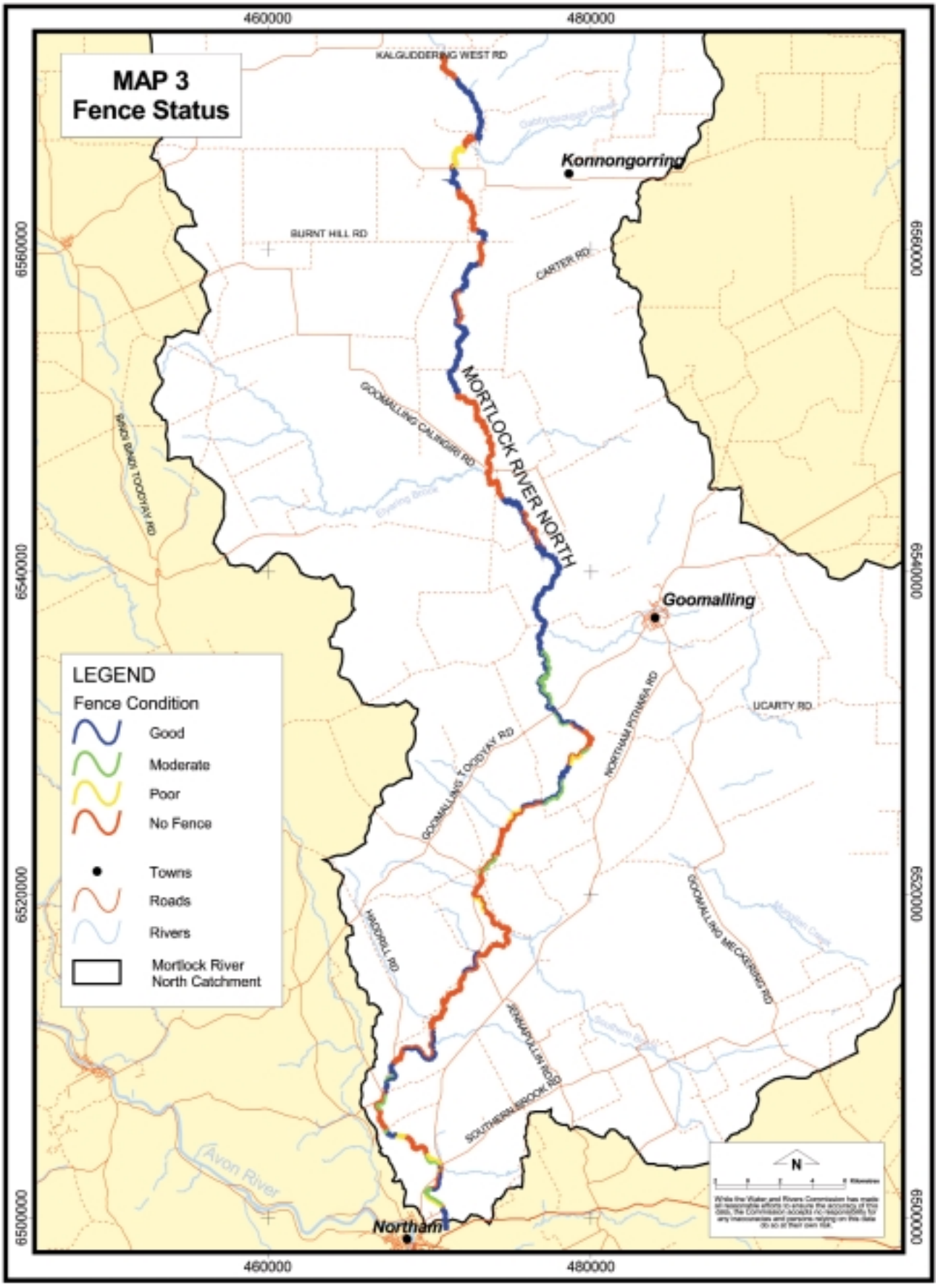
Foreshore assessments determined that 69% of river sections were fenced on one or both sides. When facing upstream 41% of sections were fenced on both sides, a further 16% of sites were fenced only along the left bank and 12% along the right bank, while 31% were not fenced at all. Map 3 provides a visual of fencing status along Mortlock River North. Results indicated that stock had access to the channel and riparian zone along 65% of the survey sections, and vehicles had access along 75%.

Of those areas that were fenced, 65% was in good condition, 19% was in moderate condition and 16% was in poor condition. Of the fencing style used along the fenced sections 13% were plain wire, 51% fabricated wire, 19% a combination of fabricated and barbed, 14% a combination of fabricated and plain wire and 3% a combination of plain, fabricated and barbed wire. Appendix 6 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 7 shows that the majority of fenced sections were fenced within 30 metres of the riverbank along the left and right banks.

Table 7. Fence position along Mortlock River North

Distance of fence from riverbank (metres)	**Proportion of sections in each category (%)**	
	Left bank	**Right bank**
< 10	8	15
11 – 20	6	14
21 – 30	10	4
>30	26	20
Not fenced	50	47



Map 3. Fence status

Water quality

We were unable to assess the water quality along Mortlock River North due to the lack of flow in the waterway during field assessments. Throughout the period of surveys, the waterway was mainly dry due to an unseasonably dry winter and drought condition. The flow was only slight during winter months, and therefore the river did not receive the winter flush it usually experiences. It was thought imprudent to obtain samples that would show extreme readings for pH and salinity and not be representative of water quality along the river.

However, water quality data is automatically recorded by unattended instruments (data loggers) on a continual basis from Water and Rivers Commission's gauging stations. One of these surface water gauging stations, is located on the Mortlock River North at Frenches Siding in the Shire of Northam approximately 10 km north of the Northam townsite.

Analysis of the data from this gauging station shows the annual flow weighted salinity from 1976 to 1997 is 13,400 mg/L. This can be expressed as electrical conductivity 2,436 mS/m. This concentration is considered high or saline. See Table 8.

Electrical conductivity is used to measure dissolved salts within a body of water. Estimates of salinity are made by measuring the electrical charge between dissolved salts (Swan River Trust, undated). Salt water conducts electricity at a faster rate than fresh water, so the higher the reading, the saltier the water. Dilution (due to varying water levels) effects the salt concentrations and can make valid comparisons of salinity readings between sites difficult.

The average pH recorded between 1975 and 2002 is pH 7.87, with a maximum of

pH 8.74 and a minimum of pH 6.70.

The acidity, or alkalinity, of waterways is measured by a pH scale ranging from 0 to 14 (Figure 5). As shown, a pH less than 7 indicates the water is acidic; 7 neutral and above 7 is alkaline or basic. The natural pH of a waterway will vary from one location to another because the value depends heavily on the soil and rocks over which the water moves (Swan River Trust, undated).

Site No: 615013
Site Name: FRENCHES
River/Location Name: MORTLOCK RIVER NORTH

Site Type	Latitude	Longitude	MGA Zone	MGA Easting	MGA Northing
Surface Water	-31.558762	116.655808	50	467334	6508419

Table 8. Classifications for environmental water salinity

Water Quality Classification	**EC Range (mS/m)**
Fresh	< 100
Marginal	100 – 200
Brackish	200 – 900
Low saline	900 – 2000
High saline	2000 – 4500
Hyper-saline	> 4500

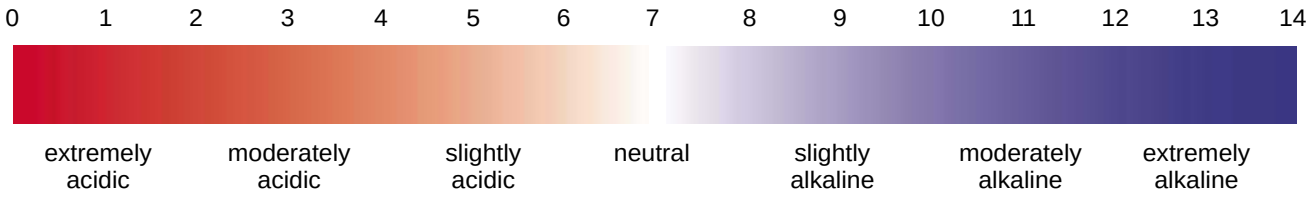


Figure 5. pH scale

pH is an important environmental indicator which can be used to monitor water health. A sample showing an extremely high or low pH value means that the water is unsuitable for most organisms, while a change in pH of more than 0.5 units from the natural seasonal minimum and maximums may be detrimental to flora and fauna living within the waterway (ANZECC, 1992).

In addition to automatic recording of data, regular grab samples are taken at the gauging station for laboratory analysis. Analysis of data shows that the average total nitrogen (TN) concentration recorded between 1994 and 2002 is 1.508 mg/L with a maximum of 4.100 mg/L and a minimum of 0.074 mg/L. The average total phosphorus (TP) concentration recorded between 1994 and 2002 is 0.128 mg/L with a maximum of 1.164 mg/L and a minimum of 0.010 mg/L.

This data is available on the Water and Rivers Commission's Water Information System (WIN). This information can be viewed on the Internet site *http://www.wrc.wa.gov.au/waterinf/wric/*

For total nitrogen (TN) a reading of 0 –1 is considered pristine, 3 – 6 very high, whilst 6 – 100 is extreme. For total phosphorus (TP), pristine is between 0 – 0.05, moderate 0.15 – 0.25, very high 0.40 – 3.0, whilst 3 – 12 is considered extreme.

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. Map 4 depicts the overall stream environmental health ratings that were determined along the length of the Mortlock River North.

The results in Figure 6 show that only 20% of the surveyed sections were classified as having a moderate stream health, 74% as poor and 6% as having very poor stream health. The dominantly poor health rating of the River was mainly due to poor ratings in all categories with the exception of stream cover and habitat diversity of which 65% and 88% of sites respectively were rated as moderate, as shown in Table 8. Appendix 4 provides a description of each factor at each level of health.

As indicated in Figure 6, no sections were classified as excellent in any of the categories, while only 1% of sections were rated as having good stream cover, 2% good bank stability and erosion, and 1% good habitat diversity. Habitat diversity rated the best with 97% of sections being classified as having a moderate condition. Stream cover and bank stability were recorded as moderate in 58% and 54% of surveyed sections respectively. Floodway and bank vegetation was classified as poor in 53% of sites, while stream cover was rated as very poor in 11% of sections.

Table 9. Proportion of sites in each environmental health category

Health Factors	**Proportion of sites rated in each category (%)**				
	Excellent	**Good**	**Moderate**	**Poor**	**Very Poor**
Floodway and bank vegetation	0	0	47	53	0
Verge vegetation	0	0	30	66	4
Stream cover	0	1	58	30	11
Bank stability and erosion	0	2	54	43	1
Habitat diversity	0	1	97	2	0

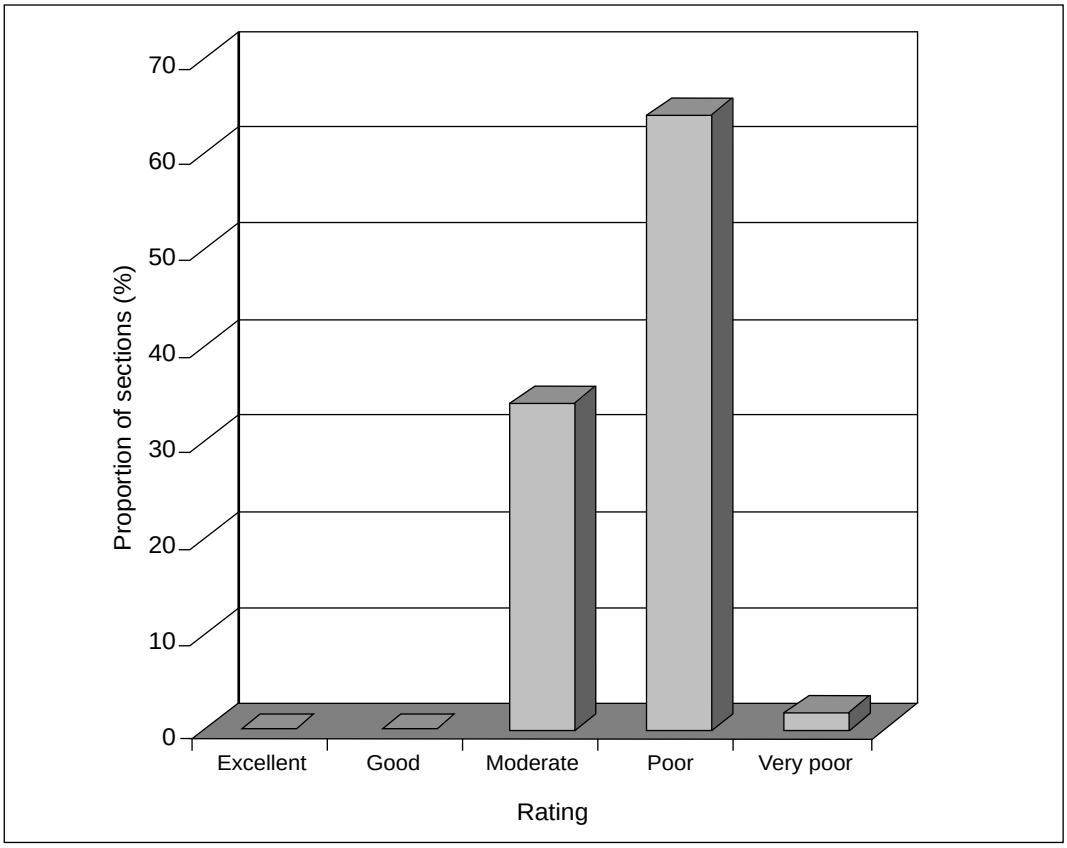
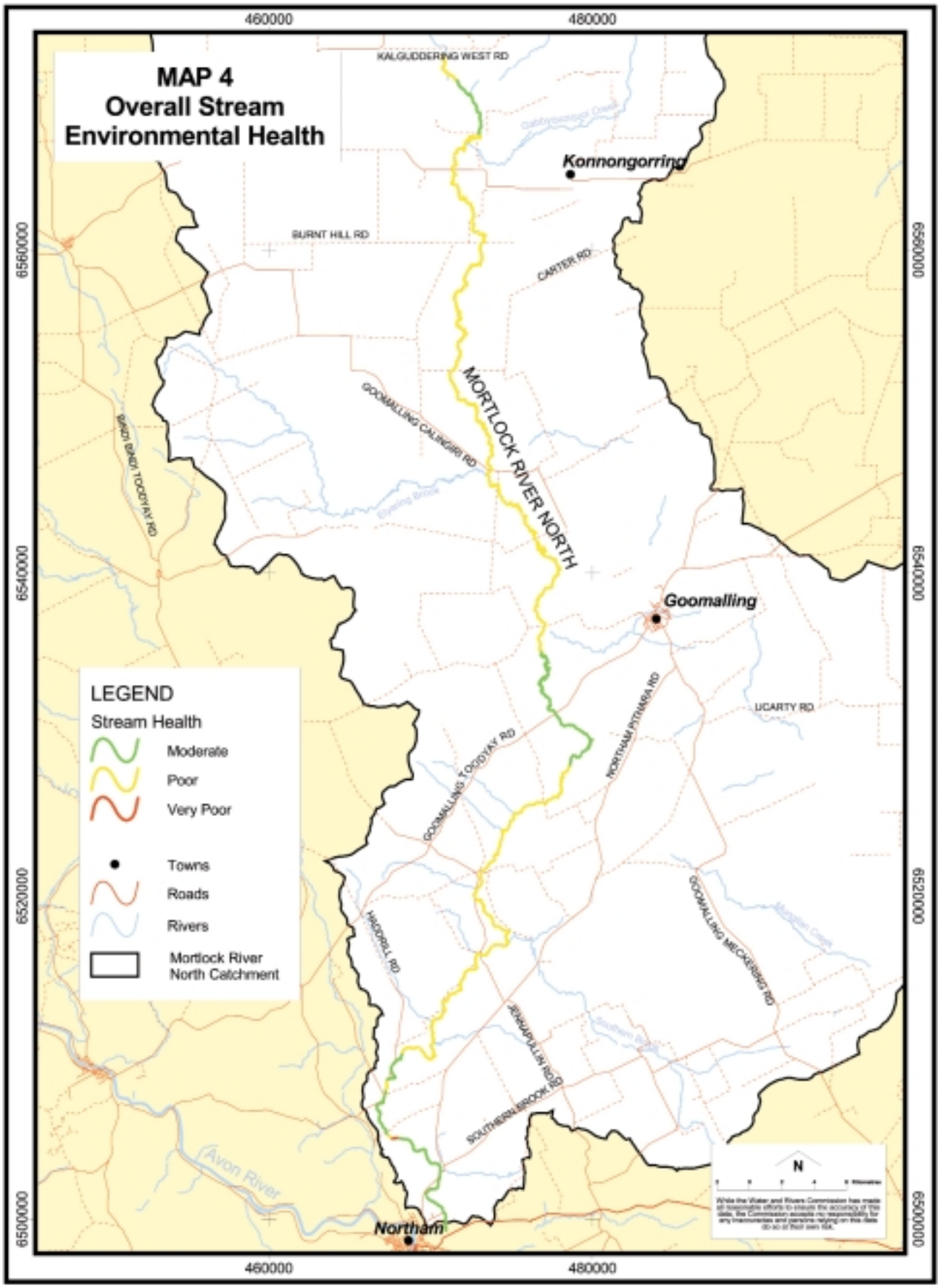


Figure 6. Overall stream environmental health ratings

Exposed tree roots along bank and verge indicate a low level of bank stability



Map 4. Overall stream environmental health

Disturbance

The riparian zone along Mortlock River North 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:

- 100% of sections contained weed species;
- 86% of the surveyed sections were disturbed by feral animals;
- 75% of sections were accessible by vehicles;
- 65% of the surveyed sections were accessible to stock;
- 49% of surveyed sections had crossing points allowing stock and vehicle access across the River;
- 38% of surveyed sections were affected by pollution (mainly due to animal manures and crop sprays);
- 33% of surveyed sections contained dumped rubbish and
- 3% of sites were recorded as being affected by point source discharge.

Map 5 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 Mortlock River North 80% showed some evidence of attempts at river management, although not always on a large scale. The most common management control was fencing with 69% of sites having fences along one or both sides of the waterway. There were also other attempts at river management, with:

- 35% of survey sections using firebreak control;
- 14% of survey sections showing evidence of erosion control;
- 10% of survey sections showing evidence of tree planting;
- 9% of survey sections undertaking feral animal control (baiting and shooting); and
- 8% of survey sections using bank stabilisation techniques (such as log and rock walling) to control bank erosion and undercutting.

Although survey data determined that only a low number of sections were employing feral animal control, anecdotal evidence suggested that these figures should be higher. Funding obtained through the Avon Catchment Council (as part of Natural Heritage Trust funding) by the Gabby Quoi Quoi Catchment Group and landholders along the River has provided an opportunity for subsidised fencing and revegetation along parts of the riparian zone.

Stock accessing the riparian zone eat vegetation, trample regrowth and exacerbate erosion of banks and riverbed.

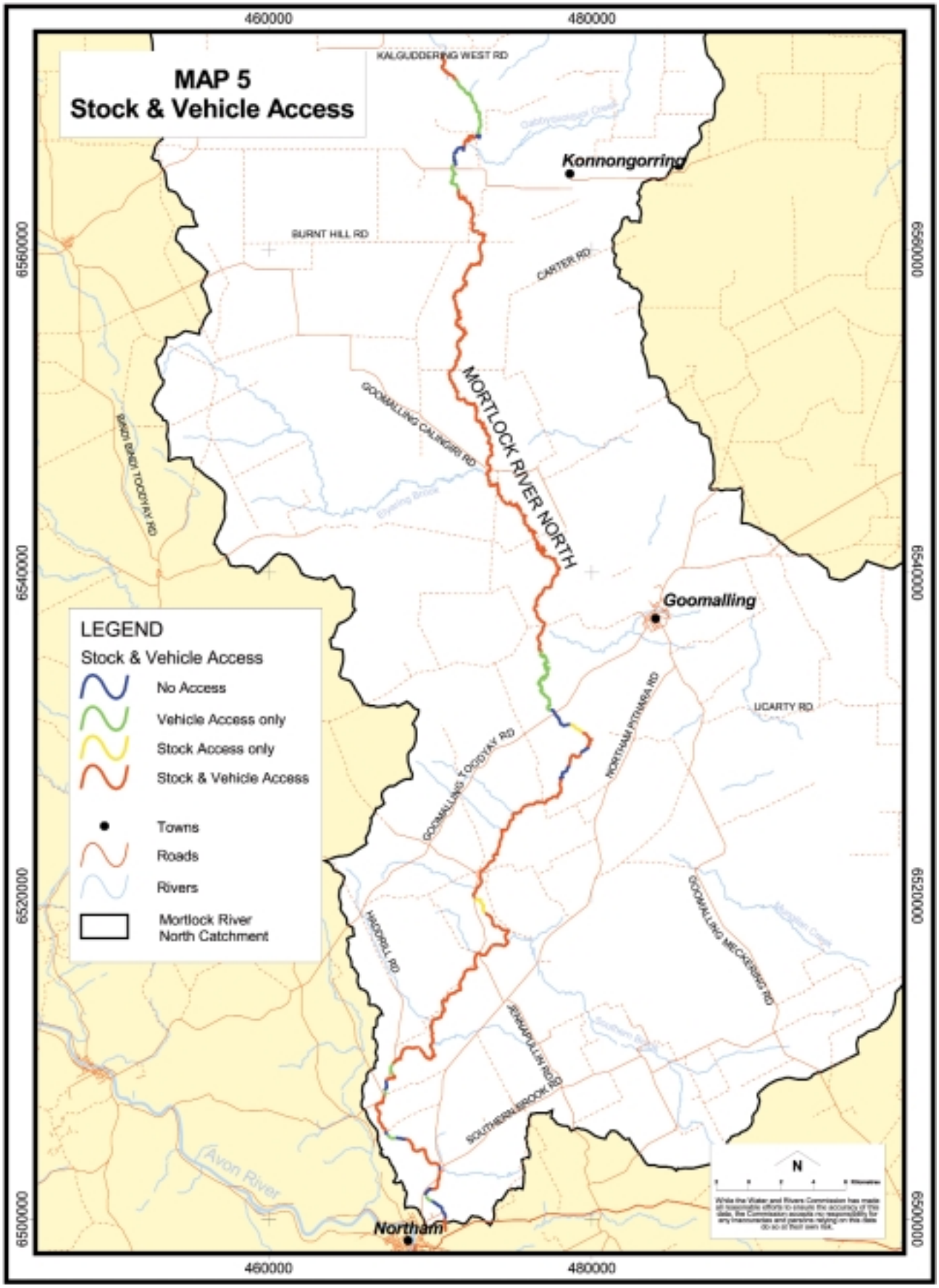
Priorities for management

Management along Mortlock River North has been prioritised with those issues needing urgent attention classified as having a high priority. Table 10 illustrates the issues that were determined to have a management priority and how each was rated as a matter of urgency.

Results in Table 10 indicate that the main issues for future management of Mortlock River North are salinity and erosion of the riparian zone, with 57% and 53% of sections, respectively, being recorded as requiring a high priority for management. Weeds and feral animals were seen to be of medium management priority in 62% and 38% of sections surveyed (respectively), while fire, feral animal control and vehicle access were the largest low priority issues with 53%, 42% and 41% of sections (respectively) being classified in this category.

Table 10. Priorities for management

Management issue	**% of survey sections requiring management**		
	High	**Medium**	**Low**
Fire	7	33	53
Weeds	28	62	9
Erosion	53	36	9
Salinity	57	20	10
Stock access	26	23	17
Vehicle access	0	23	41
Rubbish	2	10	37
Pollution	2	9	27
Service corridors	0	2	10
Crossing point	1	11	21
Feral animals	6	38	42
Point source discharge	2	1	0
Dam/weir	0	0	1
Cultural features	0	0	1



Map 5. 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 Mortlock River North. The severity of each is directly related to past and 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 causing soil erosion. The removal of large woody debris from within the channel has led to reduced protection of the banks and foreshore areas, allowing water to erode the banks and transport sediment within the channel.

A high level of disturbance 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 outside of meander bends, and in areas of slower flow, such as pools, which are important summer refuges providing habitat for aquatic and terrestrial organisms.

Cropping of the surrounding catchment means that land is left susceptible to erosion on a regular basis. Any wind or water moving across these paddocks will erode soil particles and deposit them at the lowest point in the landscape – the river channel.

In most cases the river runs through the middle of properties, but only 49% of survey sections were recorded as having man-made crossing points, with a high number of these being unconstructed tracks. 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.

Mortlock River North is an unstable system which has been exacerbated by the 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 major role in channel stabilisation. It's intricate root network holds soil together to prevent erosion, subsidence and slumping of the banks and verges.

Riparian vegetation also performs a necessary function in flood control by reducing flow velocity and dissipating energy (Water and Rivers Commission, 1997). Diminishing species density and diversity has been a great disadvantage in terms of flood mitigation. The floods of January 2000 show the effects of high unseasonal rainfall and the inability of the Mortlock River system 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 a lack of surface water management. Surface water management was absent in many of the surveyed sections, resulting in a large amount of overland flow carrying sediment into the channel where it was, and will continue to be, deposited at points of slower flow.

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 deeper pools filling with sediment and the subsequent loss of habitat for fauna.

Waterways features and habitat diversity

The waterways features recorded during field observations along Mortlock River North 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 river 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 be degradational as an increase in sediment can alter river habitats and may even remove them altogether.

The unstable nature of Mortlock River North, 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 have 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 River (Jackson, 1997).

Removal of large woody debris from within many sections of the River has allowed flow velocity to increase, resulting in a higher incidence of erosion and sedimentation. In some areas this has led to the widening and shallowing of the channel as banks are eroded and sediment is deposited in areas of slower flow.

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 moderate 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. The northern areas of the channel are little more than a wide floodplain and, due to high levels of waterlogging and salinity, do not support much of a middle or understorey of vegetation. A lack of shade will allow water temperature to increase and may lead to a decline in aquatic fauna and an increase in algal growth.

96% of survey sections were recorded as having tree species present, although 11% of sites were found to have ‘some sick trees,’ 31% ‘some dead trees’ and 14% ‘many dead trees.’ This may be attributed to waterlogging and rising salinity levels throughout the catchment. The dead trees and shrubs 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 8.

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. Structures such as bridges and crossing points are likely to change the flow of the waterway and may also lead to problems such as increased erosive capacity and a decline in fish migration. Results indicate that crossing points were recorded as having a high management priority in 17% of sections, moderate in 11% and low in 21% of sections.

Foreshore condition

The high proportion of Mortlock River North 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 systems; and
- a lack of integrated 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 land and water management practices on their property.

Foreshore vegetation

A lack of riparian vegetation will adversely affect the health of a waterway. Riparian vegetation assists in the protection of water quality and channel form by decreasing the amount of nutrients and sediments entering the river, 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).

Table 11. Salinity and waterlogging tolerance of dominant tree species

Species name	Salinity range	Waterlogging tolerance
Flooded gum	Fresh - brackish	High
Jam wattle	Fresh - brackish	Moderate
Swamp sheoak	Brackish - saline	High

The vegetation recorded along the foreshore is indicative of the salinity of the water within the river and surrounding catchment. Flooded gum and jam wattle have a low tolerance to salty conditions whereas swamp sheoak can tolerate saline conditions (WRC and ARMA, 1999). Table 11 shows what level of salinity and waterlogging each species can tolerate.

The high number of swamp sheoak (in 79% of sites) indicates that the water is brackish to saline (acceptable for most stock and some irrigation, to unacceptable for most stock) (ANZECC, 1992). Flooded gum can only tolerate moderate salinity levels but have a high tolerance to waterlogged conditions. Jam wattle (recorded in only 30% of sections) can only tolerate brackish conditions and seasonal waterlogging.

The shallow to moderately steep landscape of Mortlock River North catchment, in conjunction with soil types, may mean that the foreshore is likely to be prone to waterlogging during the wetter months and this would kill the Jam wattles before salinity. This may account for the lack of this 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 annual 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 higher concentrations of nutrients entering the aquatic system and the promotion of weed species. 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 river.

The high number of weed species compared to native species is due to 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. Weed species are also able to compete better with the native vegetation in the riparian zone, where moisture and nutrient levels are higher. 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 have access to the riparian zone directly relates to the regeneration and survival of native seedlings. Regeneration of native seedlings was observed at 73% of sections. In most cases the number of seedlings was moderate, but declined significantly in number within those sections where stock have access to the foreshore area.

A lack of fringing vegetation along most of the banks and verges has contributed to the increase in sediment and nutrients entering the waterway. Fringing vegetation plays an important role in filtering water entering the channel and keeping the waterway healthy (Water and Rivers Commission, 1997).

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 River 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.

Disturbance

The current condition of Mortlock River North 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.

65% 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 69% of Mortlock River North 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;
- destabilisation 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 Mortlock River North. 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 river was high. The small number of landholders who were not employing waterways management practices may be attributable to a lack of community education and awareness about river management. In many cases landholders indicated that cost was a major factor hindering further development and adoption of rivercare practices and actions.

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 infrastructure such as houses and sheds.

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 the river is to be improved. Results indicate a necessity for the implementation of appropriate integrated catchment management practices.

Water supplies in rural Western Australia are limited, and those in abundance are often affected by salinity and have limited use. Mortlock River North catchment has a limited supply of 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. The management or action plan can be devised for individuals or groups of properties and the catchment as a whole. The plan could include such things as:

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

Management of waterways and semi-rural land use should be closely related, as the interrelated nature of the two means that they have a wide range of effects on each other (Weaving, 1994). Management of Mortlock River North 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.

Principles important for inland river management that are relevant to the management of Mortlock River North and other tributaries throughout the Avon River catchment have been identified by 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 an important concept that 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.

Management responsibilities

The concept of this foreshore and channel survey is to encourage management activities as well as providing a condition report on the river. The successful management of a waterway entails the inclusion of the surrounding landscape. It is important to understand that the landscape components within the Mortlock River North catchment are interrelated and hence need to be managed as a whole.

The river should not be managed as an entity on its own as there are many issues throughout the catchment that contribute to the current condition. Managing the waterway on its own can be likened to treating a problem but not 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 Mortlock River North that impact on the water quality, as well as sediment loads, and channel and foreshore condition.

Maintaining a catchment group or Friends group for the length of the river 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 as Mortlock River North runs through mainly private landholdings. As the waterway is such a large and diverse system, 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.

The Avon Waterways Committee, Avon Catchment Council, Northam LCDC, Goomalling LCDC, Wongan-Ballidu LCDC and the Avon Valley Environmental Society, are community groups aiming to promote and coordinate integrated catchment management within the Avon River catchment for the surrounding community. 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.

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 Mortlock River North and adjoining tributaries, in order to conserve ecological systems and meet the needs of present and future generations. Flexibility in the management plan is essential 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 3 for use by landholders, catchment groups, or community members who are interested in assessing the condition of their waterway to use for future monitoring and management purposes.

Anecdotal evidence suggests that landholders along Mortlock River North are aware of the benefits of long term management of the waterway. Economics is one of the main issues hindering development 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).

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, or 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.

Weeds are also a fire hazard. 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 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 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 is often useful in stabilising areas 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 will be eroded and may contribute to sedimentation within the waterway. Planting of native species to replace weed species should be considered as an option when planning for revegetation. For example, Native couch (*Sporabolous virginicus*) can be used to replace Saltwater couch.

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;
- 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 river; and
- Adjust stocking rates and the frequency of grazing within this zone to suit the carrying capacity of the land (Price and Lovett, 1996b).

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 prevent soil erosion by overland flows of water and wind (Coates, 1987).

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 Mortlock River North 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 Mortlock River North is susceptible to fire, and hence a management plan to accommodate any risks needs to be decided upon and implemented. There are many disadvantages to fire, including risk to persons and property, livelihood, weed invasion, loss of habitat for fauna, loss of some seed, loss of peat soils and an increase in erosion. Under controlled circumstances, when risks are reduced, there are also benefits of fire to the natural system. 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. When uncontrolled and on too frequent a basis, fire may lead to a loss of habitat, an increased susceptibility to weed invasion, and can hinder management works if rehabilitation plantings and fences are burnt (Underwood, 1995).

If areas are burnt too frequently, there is a risk of weed invasion. Fire creates bare open ground which is ideal for the germination of weed species, and if fires become too frequent it is easy for weeds to out-compete native plants.

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, and prevent stock from pushing the fence over to graze on the other side.

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 9.

Water quality

Poor water quality can significantly affect the health of the river 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 river and its tributaries, adversely affecting the health of the riverine system (Schofield et al, 1988).

Restricting stock access from the river 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 some land into smaller lots for rural lifestylers. Many of the older land titles give ownership across the river and 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 (formerly the Water and Rivers Commission) to encourage management of waterways. Any future development of land within the region would be through the Town of Northam, Shires of Northam, Goomalling and Wongan-Ballidu.

Applications for subdivision are sent to the Western Australian Planning Commission for assessment and for referral to relevant organisations (including the Department of Environment), 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 Mortlock River North have houses, sheds and other buildings located close to the waterway, within the immediate floodplain. As smaller 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 Mortlock River North 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 either the Town or Shire Planning Schemes, the Ministry of Planning and the Department of Environment, while providing for the protection and enhancement of the environment and the catchment surrounding Mortlock River North.

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, aiming 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. Some areas along Mortlock River North have 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 river (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 river, to reduce the movement of sediment along the waterway, to stabilise the riverbanks and channels, and to remove sediments from the river at selected places.

Sediments comprise sand (the heavy, course fraction which is mostly carried in suspension), and silt (the finer fraction which is carried in solution). Both are moved 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. In many sections, landholders have constructed riffles to aid in sediment deposition.

A riffle is an engineer-designed low rock bar, or some other form of engineered structure, placed 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.

Fencing

When revegetating an area along the riparian zone it is important to exclude stock so that they do not eat and trample planted 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 for fire reduction grazing, should be minimised 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 control 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. 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. A good management tool is to develop a firebreak inside the riparian zone to allow for easy access and to prevent stock pushing fences down to gain access to vegetation.

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 5 for a description of fencing systems). Using the right type of fence is more economically viable, as it minimises the need for repairs. Fencing along riparian zones should be located parallel to the waterway to minimise the impact of floodwaters on the fence. 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 Mortlock River North 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 waterway 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 Mortlock River North 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 Council Information 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 Mortlock River North 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 Mortlock River North. The main conclusion to draw from findings is that in many ways the health of the River is suffering, both directly and indirectly, as a result of past and present landuse activities.

Mortlock River North is generally degraded. Historically land has been overused, but land use activities employed within the catchment are becoming more compatible and ecologically sustainable. There is hope that with a greater understanding of the condition of Mortlock River North, community members will band together to try and recover some of the natural health and beauty of the waterway.

In general Mortlock River North 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 swamp sheoak, flooded gum and jam wattle being the most prevalent. Of the weed species invading the groundcover, wild oats and barley grass were the most commonly observed 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 were weed invasion, stock access, and salinisation of the waterway and surrounding land.

The need exists to assess competing land-uses and determine a compromise that allows for the rehabilitation and conservation of Mortlock River North 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 Mortlock River North 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 Mortlock River North 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 affecting, 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 Mortlock River North. 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.

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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 one barbed wire, 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 point 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 a rangeland 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
Soils of the Mortlock River North Catchment

Soil Unit descriptions

DD16	Plains with some small lakes and lunettes: chief soils are brown calcareous earths (Gc1.22) in association with (Gn2.13) and (Dy3.4) soils.
DD17	Undulating land: chief soils are brown calcareous earths (Gc1.12) and (Gc1.22) with some low gilgais, and loamy red and yellow earths (Gn2.12) and (Gn2.2) with soil dominance varying locally between the (Gc) and (Gn) soils. Associated are flats of (Gn2.13) soils and small areas of the soils of adjoining units.
JJ16	Broken terrain characterised by rock outcrops (granitic bosses and tors) which may cover very large areas within the unit: shallow and often stony or gritty sandy soils (Uc4.11), (Uc4.33), and (Uc4.22) form a soil scree around the areas of bare rock. Associated are small areas of many other soils, such as (Dr2.62) and (Gc2.22); their occurrence reflects the chemistry of the individual rock outcrop. As mapped, small areas of units Va66 and Ms8 are included.
MZ1	Ranges and their slopes on granites, gneisses, and allied rocks: chief soils seem to be ironstone gravels with earthy (KS-Gn2.21) and (KS-Gn2.1) and sandy (KS-Uc2.12) matrices. Other soils may occur.
Ms7	Gently sloping to gently undulating plateau areas with long and very gentle slopes and, in places, abrupt erosional scarps: chief soils are (i) on gently convex slopes of the plateau, sandy yellow earths (Gn2.21) containing ironstone gravels and with clay D horizons; (ii) on depositional slopes flanking erosional sites, yellow earthy sands (Uc5.22) sometimes with ironstone gravels at depth; (iii) on erosional ridges and slopes, leached sands (Uc2.12) containing ironstone gravels and overlying mottled or pallid-zone clays; and (iv) sandy depressions of leached sands (Uc2.22) with some (Dy) soils. Soil dominance tends to vary locally between (i) and (iii). As mapped, areas of unit Uf1 are included.
Ms8	Gently sloping to gently undulating plateau areas or uplands with long and very gentle slopes and, in places, abrupt erosional scarps: chief soils are (i) on depositional slopes, sandy yellow earths (Gn2.21 and Gn2.22) containing some ironstone gravels, and yellow earthy sands (Uc5.22) often with ironstone gravels at depths below 6-7ft; and (ii) on erosional ridges and slopes, ironstone gravels (KS-Uc4.11) together with (Uc4.11) and (Uc2.12) (both containing ironstone gravels), all underlain by hardened mottled-zone material by depths of 12-24 in. Soil dominance tends to vary locally between (i) and (ii) but overall the soils of (i) seem to have a slight dominance over the soils of (ii). Associated are smaller areas of other soils, such as (Dy3.82) containing ironstone gravels in its surface horizons. As mapped, small areas of units JJ16, Va66, DD9, X17, and possibly Sl28 are included.
Ms9	Undulating terrain of a succession of plateau areas as for unit Ms8 and relatively narrow valley side slopes as for unit Oc35 with some small flats of (Dr2.33) soils: generally the sandy yellow earths (Gn2.21 and Gn2.22) and yellow earthy sands (Uc5.22) of unit Ms8 seem to be dominant but there are areas of soils common to both units mentioned above.

Ms10	Gently sloping to gently undulating plateau areas or uplands with long and very gentle slopes and, in places, abrupt erosional scarps: chief soils on depositional slopes are sandy, acidic, and neutral yellow earths (Gn2.21, Gn2.22, Gn2.25, and Gn2.35) and yellow earthy sands (Uc5.22), all containing some ironstone gravels or underlain by indurated ironstone gravel pans. Associated on erosional ridges and slopes are (Uc2.12), (Uc2.21), and (Uc4.11) soils all containing some ironstone gravels and underlain by indurated ironstone gravel pans or hardened mottled-zone materials. This unit is similar to unit Ms8 but seems to have a greater variety of yellow earth soils which, however, could be more extensive in some areas of unit Ms8 than present data indicate.
My41	Gently sloping areas flanking ranges: chief soils are neutral red earths (Gn2.12) with some patches of (KS-Gn2.21). Other soils may occur.
Oc30	River terraces: chief soils are hard alkaline red soils (Dr2.33). Associated are some (Dy3.43) soils; and small areas of other soils are likely. As mapped, areas of soils of unit Qb29 may be included.
Oc31	Broad flat valleys: chief soils are hard alkaline red soils (Dr2.33) with acid clay strata below about 5-6ft depth. Associated are small areas of other soils including gilgai formations along drainage-ways. As mapped, small areas of units Vb2, Sl28, DD9, and Va66 are included.
Oc35	Gently undulating to rolling terrain with some ridges and uneven slopes and with the variable presence of lateritic mesas and buttes; some granitic rock outcrops: chief soils are hard alkaline red soils (Dr2.33), (Dr2.63), (Dr2.73) with variable areas of (Dy) soils such as (Dy3.43), (Dy3.83), (Dy3.42), and (Dy3.41). Associated are some (Dr2.22) soils; patches of soils of unit Ms8; and some (Gn2.12) soils on slopes especially in the more northern and eastern areas of the unit.
Qb29	Rolling to hilly with some steep slopes; gneissic rock outcrops common: chief soils are hard neutral red soils (Dr2.22) with others such as (Dr2.62) and (Dr3.42). Associated are (Dy3.42) soils on slopes; patches of (Ug5.37) and (Ug5.2) soils with some gilgai also on slopes; colluvial slopes of (Gn2) soils such as (Gn2.12) and (Gn2.45); and variable areas of other soils seem likely. As mapped, areas of unit Uf1 and small areas of unit Oc30 may be included.
SV1	Saline valleys and salt lakes--salt-lake channels, mostly devoid of true soils, and their fringing areas; few freshwater lakes: common soils are gypseous and saline loams (Um1.1 and Um1.2) on riverine wash and usually underlain by clayey or sandy strata by about 12 in. Associated are various resalinised (Dy) soils such as (Dy4.83) on fringe areas, and dunes and lunettes of various sandy (Uc), silty (Um), and clayey (Uf) soils of slight profile development. Deposits of common salt, gypsum, lime, and alunite occur as do remnants of the old lateritic profile and occasionally outcrops of country rock.
Sl28	Broad flat valleys with small clay pans and salt-lake remnants in some localities: chief soils are hard alkaline yellow soils (Dy2.43 and Dy2.33) underlain by acid lateritic clays below depths of from 2 to 4 ft. Associated are small areas of (Dy5.43) soils in sandy localities; (Ug5.22) soils in areas where some low gilgai microrelief is present; some (Dy3.43) soils, especially in western valleys; and other soils on lunettes and dunes some of which are gypseous. As mapped, small areas of units Oc31, Vb2, DD9, and Va66 are included.
Ub98	1 Hilly with granitic and gneissic rock outcrops: chief soils are hard neutral yellow mottled soils (Dy3.4). Small areas of other soils are likely. As mapped, small areas of unit Ms8 may be included.

Uf1	Undulating terrain with ridges, spurs, and lateritic mesas and buttes: chief soils on the broad undulating ridges and spurs are hard, and also sandy, neutral, and also acidic, yellow mottled soils (Dy3.82 and Dy3.81), (Dy5.82 and Dy5.81), all containing ironstone gravels. Associated are a variety of soils on the shorter pediment slopes, including (Dr2.32), (Dr3.41), (Dy2.33), and others of similar form; and dissection products of the lateritic mesas and buttes. As mapped, small areas of unit Ms7 may occupy some drainage divides, unit Va63 traverse some drainage-ways, and unit Qb29 occur in localities of deeper dissection.
Va63	Valley plains and terraces: chief soils are hard alkaline yellow mottled soils (Dy3.43). Associated are small areas of a range of soils including (Dy3.42), and (Dr5.8) and (Dy5.8), both containing laterite or large amounts of ironstone gravels; and some (Dr2.4) and (Uc2.34) soils. As mapped, areas of adjoining units are included.
Va66	Gently undulating to rolling terrain with some ridges and uneven slopes; and with the variable presence of lateritic mesas and buttes and granitic tors and bosses: chief soils are hard alkaline yellow mottled soils (Dy3.43) and hard alkaline red soils (Dr2.33), (Dr3.33), and (Dr2.43), either of which may be dominant locally. Associated are a variety of soils, notably (Dy) soils such as (Dy3.82 and Dy3.83) and (Dr) soils such as (Dr3.32). Acid lateritic strata are common below 4-5 ft. As mapped, lateritic mesas and buttes of unit Ms8 soils are a constant feature, as are small granitic bosses and tors of unit JJ16 and minor valleys of units Sl28, Oc31, and Vb2. Western occurrences of this unit have some features transitional to unit Uf1, especially the larger areas of (Dy3.82) soils.
Va70	Valley plains and terraces: chief soils are hard alkaline yellow mottled soils (Dy3.43). Associated are small areas of other soils including (Gc1.22) and (Gc1.12) and the soils of adjoining units.
Xd2	Gently rolling terrain of smooth ridges and spurs separated by valleys showing recently developed salinity; breakaways occur infrequently: chief soils are sandy neutral yellow mottled soils (Dy5.82) containing some ironstone gravels. Associated are (Uc5.22) and (KS-Uc2.12) soils on the ridge crests with hardened mottled zone materials at depths of 12-30in.; (Dy3.43) soils on valley side slopes and valley floors; (Dr2.33) and (Dr2.43) soils on slopes; (Dr3.33) and (Dr3.43) soils on valley floors.

Source: CSIRO, 1967

Appendix 2

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 2002

Tributary Name: Mortlock River North

Section Number: MRN001

Catchment Name: Avon River Catchment

Length of Section: 1.8Km

Sub-catchment Name: Mortlock River Catchment

Shire: Goomalling

Nearest Road Intersection: Northam Pithara Road and Konnongorring West Road

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

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

Landholder contacted: Yes ✗ No ❒

Landholder consent obtained: Yes ✗ No ❒

Landholder present during survey: Yes ❒ No ✗

Bank(s) surveyed (facing upstream)
left ❒ right ❒ both ✗

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/track washouts	Subsidence	Erosion	Gully erosion	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
❒ Braided channel
✗ Pool
❒ Wetlands
❒ Other

✗ Dam
❒ Groundwater
❒ Rapids
❒ Annabranch

❒ Riffle
❒ Bridge
✗ Sand slugs
❒ Vegetated islands

.....

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

General: C Best: C1 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: Swamp sheoak, Needlebush

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

Bare Ground: % bare: 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	10-20%

Fencing status

Left bank

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

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

Right bank

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 (minimal shade).
Salt crystals.
Discolouration of water.

Any wildlife (or evidence of presence) observed?

Birds, ducks, flies, rabbits, foxes, 28 parrots, willie wag-tails, dragonflies, ants, spiders, snakes, lizards

Landform types

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

Shallow valley with low relief. Channel is little more than a wide floodplain.

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			7
Feral Animals		7	
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)
Cape tulip	L	Golden wreath wattle	L
Soursob	L	Couch	M
Wild oats	H	Samphire	L
Swamp sheoak	M	Needlebush	L
Barley grass	H	Ruby saltbush	M
Fat hen	L	Wild geranium	L
Thistle	L		
Sowthistle	L		
Swamp paperbark	L		
Flooded gum	L		

Water quality data

Sample Number	pH	Conductivity mS/cm	Temperature ºC	Location
1	8.33	18.4	22.1	482821 E 6465810 N
2	8.06	19.3	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. Foreshore condition
5. Fence condition
6. Stock in river
7. Bank erosion

Appendix 3

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/track washouts	Subsidence	Erosion	Gully erosion	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
❒ Braided channel
❒ Pool
❒ Wetlands
❒ Other

❒ Dam
❒ Groundwater
❒ Rapids
❒ Annabranch

❒ Riffle
❒ Bridge
❒ Sand slugs
❒ Vegetated islands

.....

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

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: % bare:.....

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

Left bank

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

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

Right bank

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 = ☐

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
❒ 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)

Water quality data

Sample Number	pH	Conductivity mS/cm	Temperature ºC	Location

GPS coordinates

Coordinate	Description

Photos

Appendix 4
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. Vergesmore 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 = ☐

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

Environmental rating = ……

Appendix 5
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.

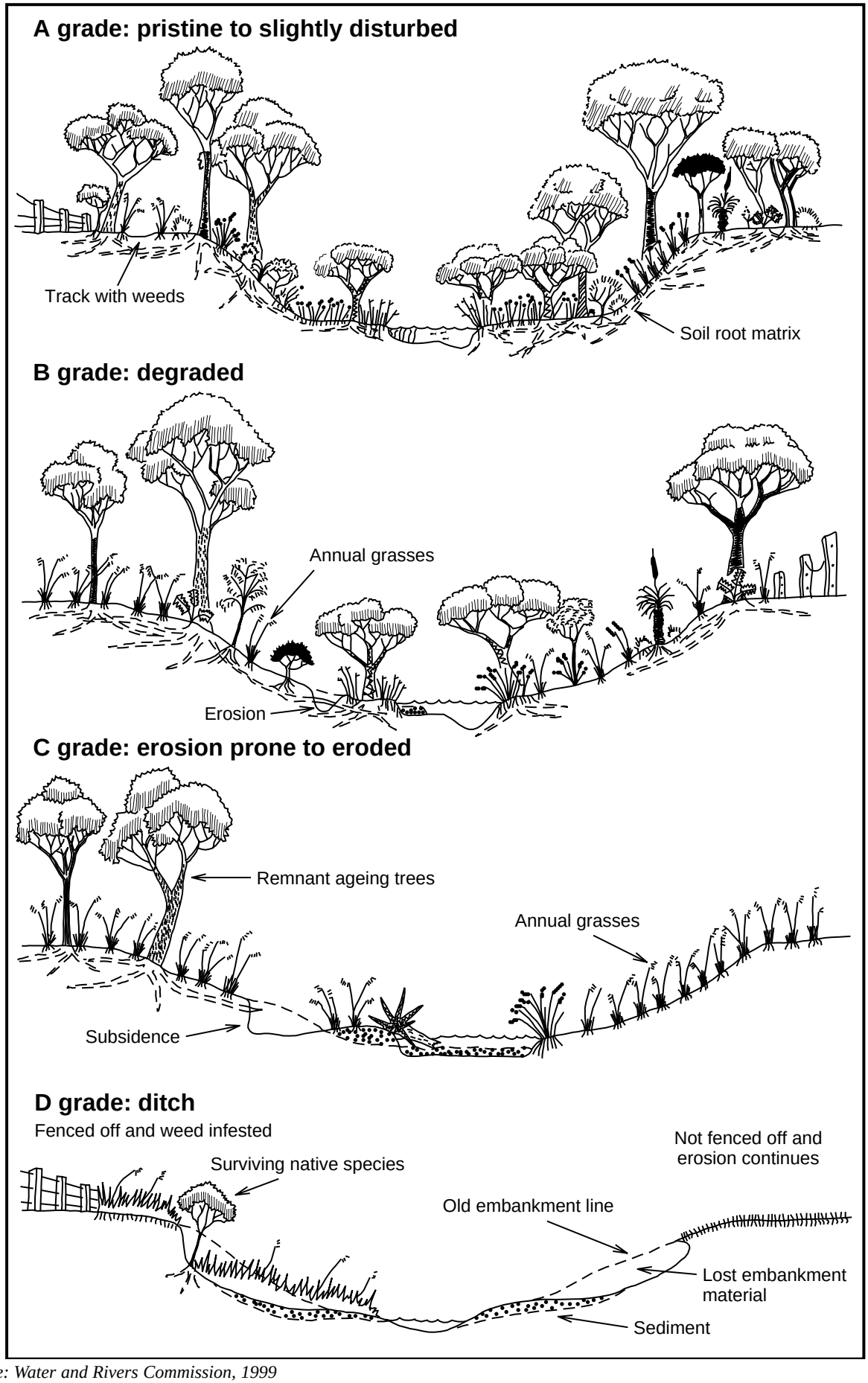
D Grade

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 6
Fencing styles

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

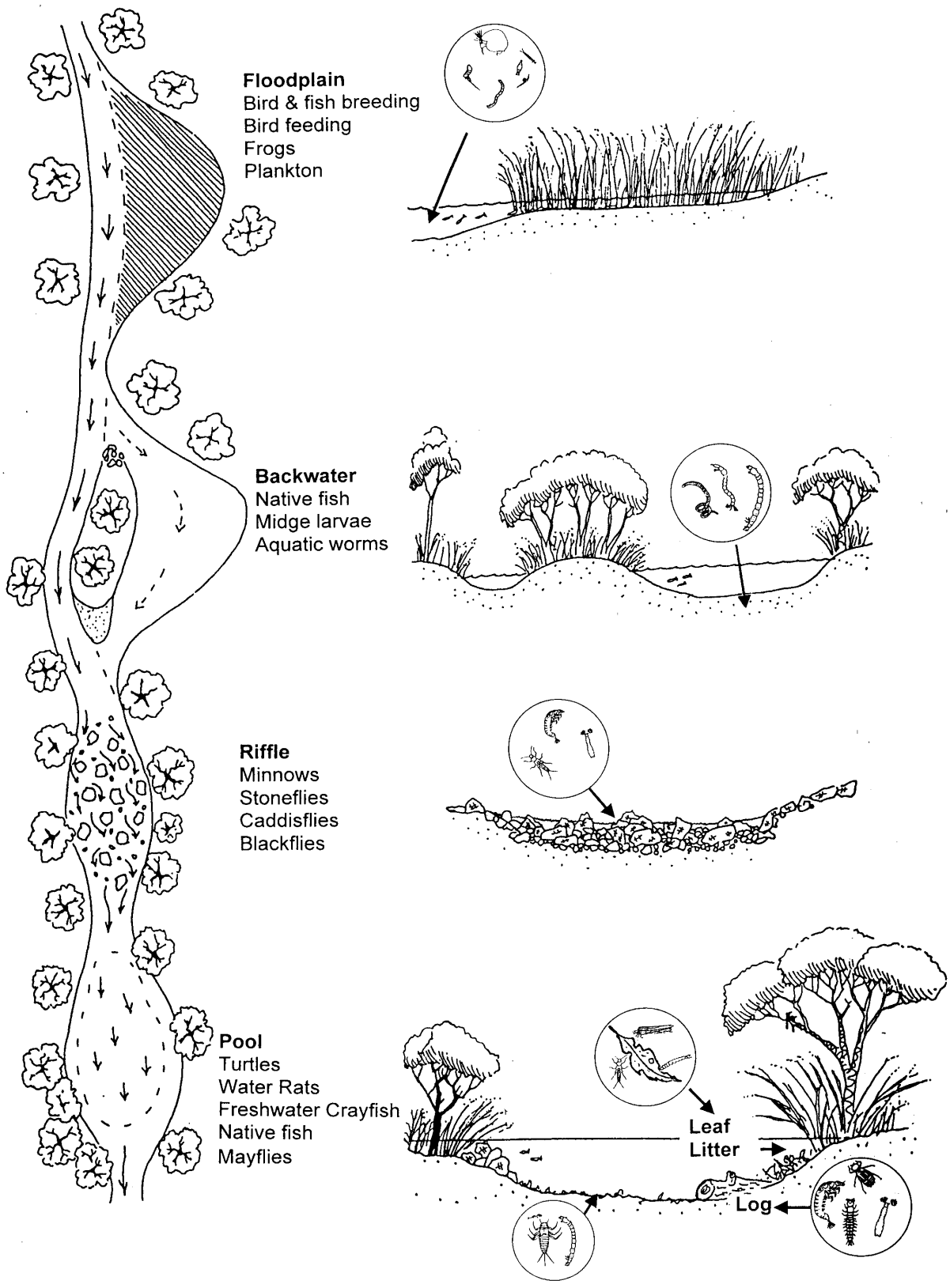
Fence condition: POOR

Fence condition: MODERATE

Fence condition: GOOD

Appendix 7

Habitats found along waterways



Source: Water and Rivers Commission, 2000.

Appendix 8

Avon Waterways Committee

Recovery Statement Number 1

FIRE

Introduction

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

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

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

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

Objectives

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

- 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, Fire Brigades and neighbours with respect to fire management and development of Fire Management Plans.

Background

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

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

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

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

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 that in turn leads to higher annual fire hazards. Fire is a useful (indeed often essential) agent for bushland regeneration, but if it occurs too frequently, it can eliminate some native species and if it is too intense, it can burn down valuable habitat trees and accelerate erosion along the river banks.

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

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

Strategies

In order to achieve its objectives, AWC will:

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

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

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

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

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

5. Uncontrolled in areas controlled by DoE. Some limited controlled grazing may be approved during an interim periods in which other hazard reduction measures are being developed. Proposals to graze DoE-controlled land must be submitted to the AWC for consideration, and a recommendation will be made to the DoE for endorsement if appropriate.

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

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

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

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

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

8. Encourage research to be undertaken on the management of fire and on fire ecology along the Avon River. AWC wishes to recover the full suite of native plants and animals that once occurred in the bush in this area, but at the same time we wish to

ensure neighbouring assets are protected. AWC will assist scientists from government agencies and universities who are prepared to work on research projects that help to achieve this aim.

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

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

11. 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 or the Bush Fire Service to enforce the Bush Fires Act to eliminate potential sources of fire.

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

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

13. AWC will ensure that all fire management plans and regimes that are developed are consistent with the ACC Natural Resource Management Strategy

Review

The Recovery Statement will be reviewed annually.

Publication feedback form

The Department of Environment welcomes feedback to help us to improve the quality and effectiveness of our publications. Your assistance in completing this form would be greatly appreciated.

Please consider each question carefully and rate them on a 1 to 5 scale, where 1 is poor and 5 is excellent (*please circle the appropriate number*).

Publication title ……

How did you rate the quality of information?

1 2 3 4 5

How did you rate the design and presentation of this publication?

1 2 3 4 5

How do you think the publication can be improved?

……
……
……

How effective did you find the tables and figures in communicating the data?

1 2 3 4 5

How can they be improved?

……
……
……

How did you rate this publication overall?

1 2 3 4 5

If you would like to see this publication in other formats, please specify. (Eg. CD)

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