GOVERNMENT OF WESTERN AUSTRALIA

Foreshore and Channel assessment of the Toodyay Brook

Water Resource Management Series

Water and Rivers Commission Report WRM 22

2001

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Cover photograph: Toodyay Brook showing channel condition [Taken by Patricia Janssen]

Foreshore and Channel assessment of the Toodyay Brook

Water and Rivers Commission

Avon River Management Authority

Natural Heritage Trust

Water and Rivers Commission
Report No WRM 22
February 2001

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Preface

This channel and foreshore assessment is a joint project between the Natural Heritage Trust, Water and Rivers Commission and the Avon River Management Authority. As part of the Avon Rivercare Program this survey is part of a larger project to undertake the management surveys of major tributaries feeding into the Avon River. Foreshore and channel assessments along Toodyay Brook were undertaken between March and June 2000.

The aim of this project is to document the current condition and management needs of the Toodyay Brook, through consistent field surveys, in consultation with adjacent landholders. An emphasis of this project is community consultation, with attempts made to involve landholders along the Brook in as many aspects as possible.

A management survey of the Toodyay Brook channel and foreshore has now been completed. It is hoped that this information will lead to the planning of a program of management actions that can be easily undertaken by landholders and community groups from the areas surrounding the Brook.

This report describes the current condition of both the channel and foreshore along the Toodyay Brook, focusing on surrounding landuse, current disturbances and management practices that are already in place.

"A healthy catchment is one that can recover from perturbations. It is economically viable and environmentally self-sustaining."

Plate 1. Foreshore condition along Toodyay Brook

Live as if you die tomorrow
Farm as if you live forever
Old English proverb

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Disclamer:

These maps are the product of Water and Rivers Commission, Regional Services Division, (with the exception of Maps 2 and 3 which were produced by AgWest), and were printed on 29 September 2000. The maps were produced with the intent that they be used for information dissemination at the scale of 1:85 000. 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.

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Summary

This survey of channel and foreshore condition along Toodyay Brook is part of a larger project to undertake management surveys of major tributaries feeding into the Avon River.

Many sections of the study area are under threat of degradation as a result of development pressures and inappropriate landuse. A wide range of management issues have been identified through field surveys and consultation with landholders. Erosion has been classified as having a high priority for management in 74% of surveyed sites. In general, there is not much evidence of waterways management and stock have access to the foreshore and channel in 87% of the survey sections. The waterway and surrounding land has significant natural and cultural heritage characteristics. The majority of the study area is in great need of rehabilitation and conservation.

This report will give landholders, community members and other stakeholders the opportunity to increase their awareness of the current condition of the Toodyay Brook which has been classified as having a "poor" Overall Stream Environmental Health rating in 76% of the sections. Management recommendations have been included to suggest ways in which the foreshore and channel conditions along the length of the waterway can be improved to provide an environmental, economic and social benefit to landholders and community members in the surrounding area.

Although this tributary of the Avon River has been surveyed in isolation to other waterways, the management of the riverine environment is dependent upon an integrated catchment approach, whereby landholders within the whole catchment are responsible for working together to improve the condition of the Brook.

Introduction

Purpose of the survey

The purpose of conducting foreshore and channel assessments along the Toodyay Brook was to determine the current uses, disturbances and health of the riverine system. This survey focuses on vegetation condition, channel condition (ie. erosion and sedimentation), landuse and water quality (pH and salinity).

Information collected during this survey is expected to give landholders, community members and land managers a clear indication of what is happening to the Brook. In addition, this report provides information on how to manage the waterway before it becomes too degraded to be of benefit to landholders along the waterway.

The aim of this project was not to make decisions on future management, but to provide a set of data that will enable land managers to better assess what is happening within the catchment. These surveys provide baseline information against which future changes in water quality and foreshore condition can be compared. The overall objective is to encourage a better understanding of the importance of the waterway and how best to manage it for the long-term benefit of its users.

Historical description of the Toodyay Brook

Aboriginal heritage

To quote Rica Erickson from her book *Old Toodyay and Newcastle*, "The Toodyay Valley was known to the Aborigines as the haunt of the great magic snake." The Toodyay Brook has great spiritual importance to the Aboriginal people as a course travelled by the Waugal (a spirit being from the Aboriginal dreaming) when making its way from Bolgart through the waterways to Burlong Pool, upstream of Northam along the Avon River, during the summer months.

It is uncertain which Aboriginal tribes lived in the area, but it is believed that there were a few tribes whose territory lay adjacent to the Brook. The Toodyay Brook, along with other waterways, has spiritual and cultural significance to the Aboriginal people. In the past the Noongar tribes of the area used the Brook as a source of food and shelter, as well as a place to meet (Malcolm, 2000).

Map 1 shows that there is one registered site of Aboriginal significance located along the Toodyay Brook that has been included on the Aboriginal heritage register for importance as a mythological site. It is an area along the northern portion of the waterway that has been registered with the Aboriginal Affairs Department for having historical significance to Aboriginal people. The mythological site has interim status on the Aboriginal heritage register and is open to public access with no restrictions.

European heritage

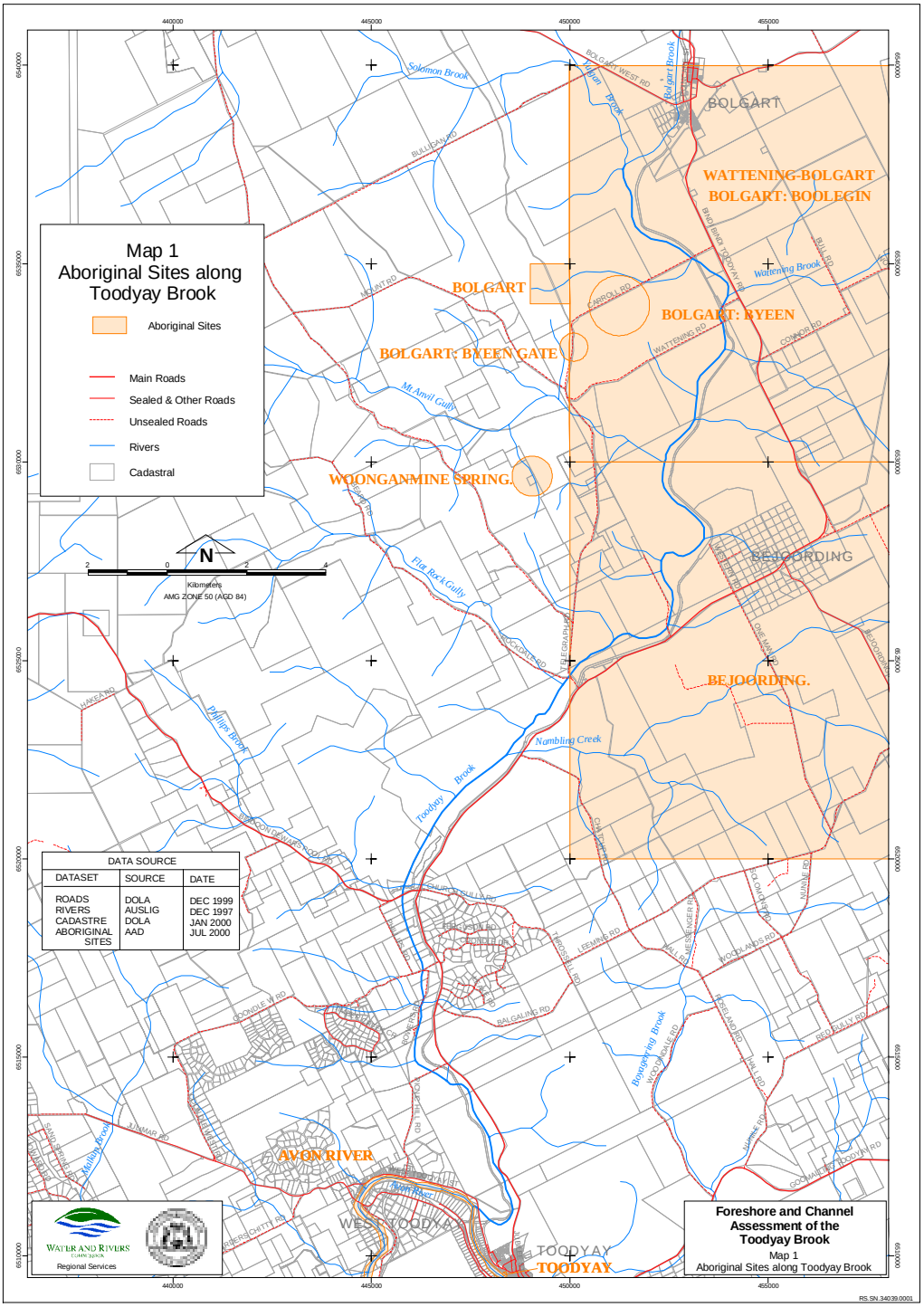
The first European settlers inhabited the land surrounding the Toodyay Brook in the 1830s and most land had been distributed via government grants by the mid 1800s. Figure 1 shows the distribution of freehold land along the Toodyay Brook in 1849.

Development of the Toodyay region, especially along the Toodyay Brook, dates back to the early 1830s (Erickson, 1974). Since that time the area has become a significant location for agricultural production, namely, cropping and grazing. Some of the most prominent of these early settlers were the Hamersley, Phillips and Drummond families.

European settlers of the Toodyay and surrounding areas knew the area in which the Toodyay Brook flowed as the Toodyay Valley. Approximately forty-five kilometres in length, this floodplain valley was considered to be some of the best land for agricultural and farming practices (Erickson, 1974).

Landuse along this waterway has changed little since European settlement. Agricultural land uses such as cropping and grazing of sheep and cattle are still the dominant activities. Recently, there has been some subdivision of properties into smaller lots that now have a focus on hobby farming and rural lifestyle.

In regards to European heritage the valley surrounding Toodyay Brook is significant. A small centre located at Culham was once the centre for a lot of activity


Map 1
Aboriginal Sites along Toodyay Brook
Aboriginal Sites
Main Roads
Sealed & Other Roads
Unsealed Roads
Rivers
Cadastral
N
Kilometers
AMG ZONE 50 (AGD 84)
DATA SOURCE
DATASET | SOURCE | DATE
ROADS | DOLA | DEC 1999
RIVERS | AUSLIG | DEC 1997
CADASTRE | DOLA | JAN 2000
ABORIGINAL SITES | AAD | JUL 2000
WATTENING-BOLGART
BOLGART: BOOLEGIN
BOLGART
BOLGART: BYEEN
BOLGART: BYEEN GATE
WOONGANMINE SPRING.
BEJOORDING.
AVON RIVER
TOODYAY
Soldiman Brook
Wattening Brook
Mt Amil Gully
Fig Rock Gully
Nambling Creek
Toodyay Brook
Phillips Brook
Bowgan Hill Brook
Water and Rivers Commission
Regional Services
Foreshore and Channel Assessment of the Toodyay Brook
Map 1
Aboriginal Sites along Toodyay Brook
RS.SN.34039.0001

involving farmers from the surrounding area, such as cricket and tennis, as well as the railway siding (Martin, pers. comm, 2000). Culham Church is located along Bindi Bindi Road, slightly north of Dewars Pool Road and is an important historical site for the people of Toodyay. The church held weekly congregations on a Sunday, and was attended by surrounding families from the Toodyay Valley.

Dewars Pool was named after a man who drowned while crossing the Brook. The Dewars family originated in Gingin area, and the father was swept away during a flood whilst attempting to cross the waterway without a bridge being present. Dewars Pool also has some significance in relation to past activities along the Brook. The pool itself was a place used for picnics and recreation by surrounding residents. Slightly downstream of Dewars Pool Road the pool was also used as a community sheep dip that was used by farmers in the area (Martin, pers. comm, 2000).

Anecdotal evidence suggests that the CWA hall used to be located along the Toodyay Brook just north of Coondle siding. The hall was taken down in approximately 1936 and moved to the Toodyay township (Martin, pers. comm. 2000).

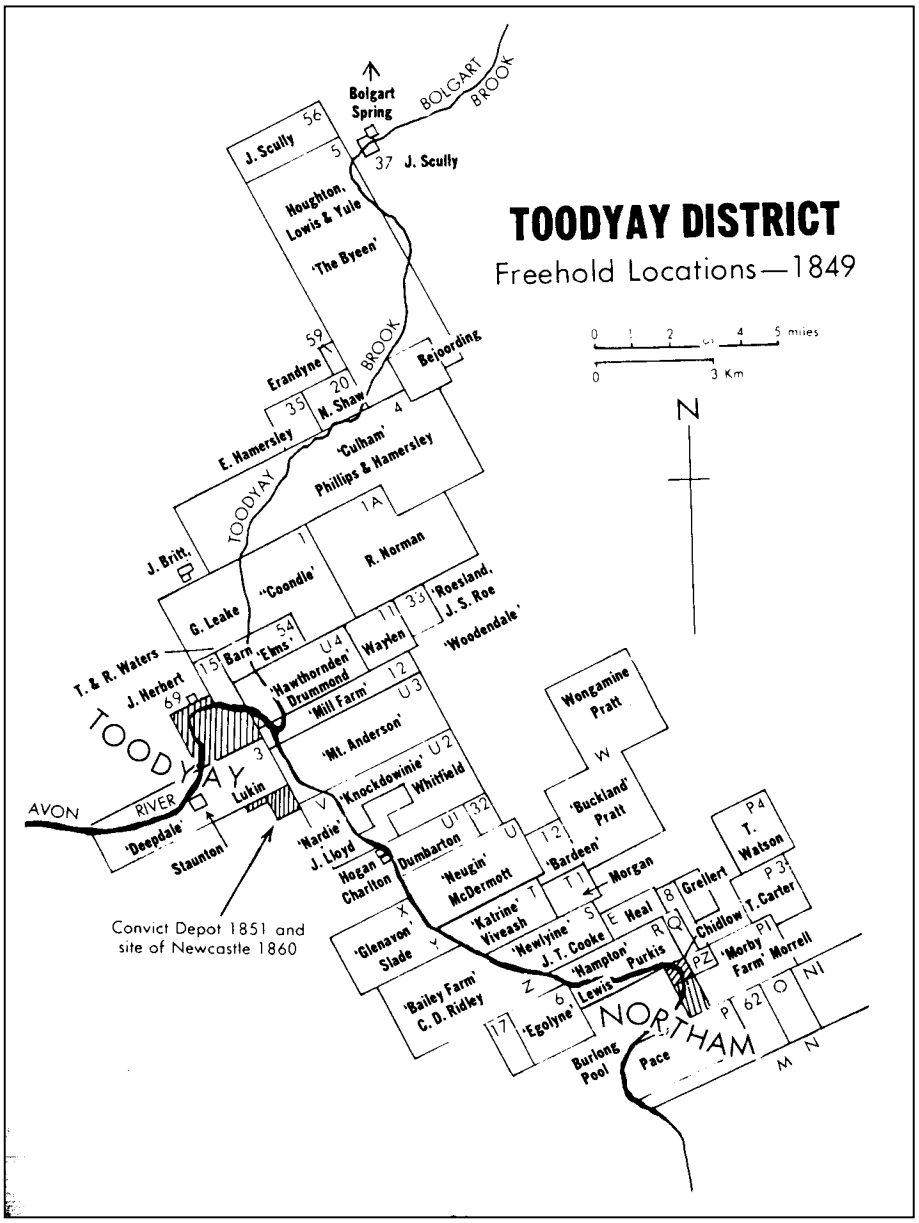


Figure 1. Freehold locations along Toodyay Brook – 1849 ***(Erickson, 1974)***

Catchment description

Population

The 1996 census of population determined that there were an estimated 3,363 people residing within the Shire of Toodyay (Western Australian Planning Commission, 1999).

Location

The study region predominantly lies within the Shire of Toodyay, and to a lesser extent, the Shire of Victoria Plains. Map 2 shows the location of the Brook in relation to the townsites of Toodyay and Bolgart.

The Toodyay Brook is one of the major tributaries feeding into the Avon River. The waterway runs from Bolgart (where the Yulgan, Solomon and Bolgart Brooks feed into it), south into the Avon River in West Toodyay.

Climate

Climate experienced in Toodyay is Mediterranean. It is characterised by cool, wet winters and hot, dry summers.

Toodyay does not have a weather recording station, so Figures 2 and 3 are based on the yearly temperature trends at Northam, the closest weather recording station to Toodyay. These charts show that temperatures vary from being warm (16ºC) to hot (34ºC) in summer, to cold (4ºC) in winter. It is not unusual for frost to be recorded during cold winter nights (Avon River System Management Committee and Waterways Commission, 1993).

Toodyay Brook lies between the 450 – 650mm rainfall isohyet. The town of Northam lies in the 435mm isohyet but has a similar rainfall pattern to Toodyay, with the only difference being that Toodyay experiences a slightly heavier annual rainfall. The majority of annual rainfall falls between May and September (as shown in Figure 4), with the summer months experiencing a rapid decline.

As expected the high temperatures and low rainfall during the summer months mean that evaporation is highest during the summer months. Figure 5 shows the trend of average daily evaporation taken from a recording station in Northam.

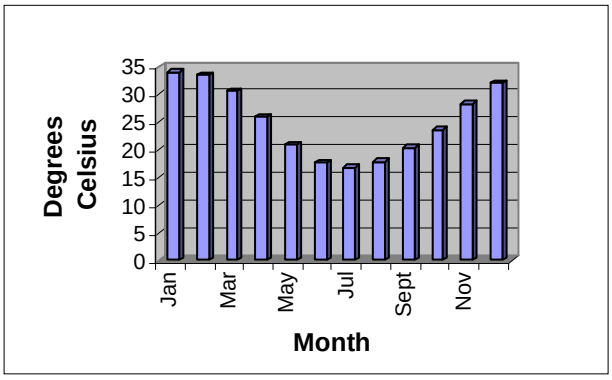


Figure 2. Average daily maximum temperatures - Northam *(Bureau of Meteorology, 1981)*

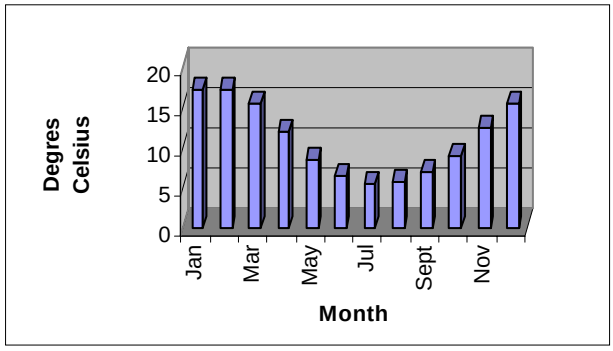


Figure 3. Average daily minimum temperatures - Northam *(Bureau of Meteorology, 1981)*

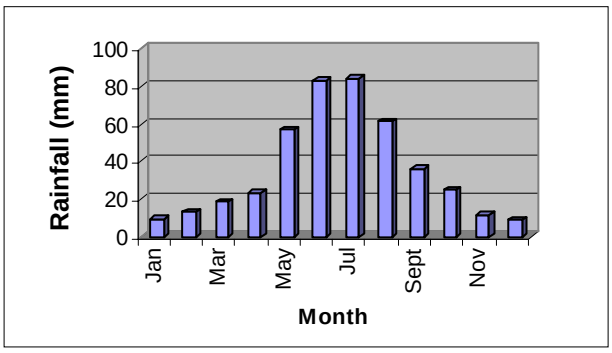


Figure 4. Average rainfall – Northam *(Bureau of Meteorology, 1981)*

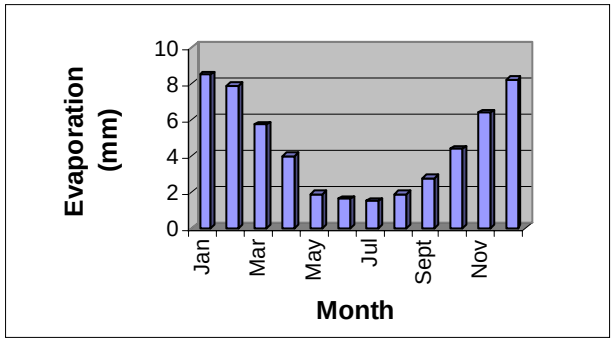


Figure 5. Average daily evaporation – Northam *(Bureau of Meteorology, 1981)*

Geomorphology and soils

Toodyay lies to the east of the Darling Scarp on the Yilgarn Block, which is an old and relatively stable plate of archaean granite and metamorphic rocks (Avon River System Management Committee and Waterways Commission, 1993).

The Toodyay Brook lies within the Avon Catchment, the western portion of the Avon River Drainage Basin. The waterway lies within the Zone of Rejuvenated Drainage, supporting a landscape of hills and moderately steeper valleys. (Lantzke, 1993).

The soils are underlain by the gneissic rocks which form the Jimperding Metamorphic Belt, a part of the Yilgarn Craton, and have been heavily eroded during the past (Weaving 1999). The valley floors surrounding the waterway are rocky slopes with granite and dolerite outcrops that have been exposed due to past erosion.

Map 3 shows that Toodyay Brook flows through the soil-landscape system classified as the Avon Flats System. This system is characterised by alluvial terraces and flats with brown loamy earths, grey non-cracking clays and deep brown sands the most common soil types. The surrounding landscape is classified as the Jelcobine System. Major valleys with isolated lateritic remnants dominate this soil-landscape system. Soils vary and may be deep red and shallow sandy and loamy duplexes, deep grey sandy duplexes, bare rock or cracking and non-cracking clays (AgWA, 1999). Appendix 1 provides an explanation of all the soil-landscape systems shown on Map 3.

Hydrology – floods

The Toodyay Brook feeds into the Avon River from the North. The catchment is described as being well-watered meaning that the waterway has fewer days without flow during the summer months.

A study by Binnie and Partners (1985) has produced a table showing years in which historic floods occurred on the Avon since rainfall measurements began in 1877. Table 1 has been adapted to show those years in which floods occurred within the Toodyay region along the Avon River. It is assumed (but not known for sure) that flood events along the Avon in these years was in relation to flood events along the Toodyay Brook. Figures have been estimated from rainfall figures.

Table 1. Major historic floods along the Avon River

Year	Rainfall (m^3/s)
1910	592
1917	631
1926	713
1930	677
1945	616
1946	413
1955	756
1958	745
1963	507
1964	483
1983	455

Most recently there have been flood events during January of this year (2000) in which the Toodyay Brook was flowing well above its capacity. A lot of damage was done along the banks and within the channel, and the waterway is still carrying the debris and scars of this unseasonable flood event.

Vegetation

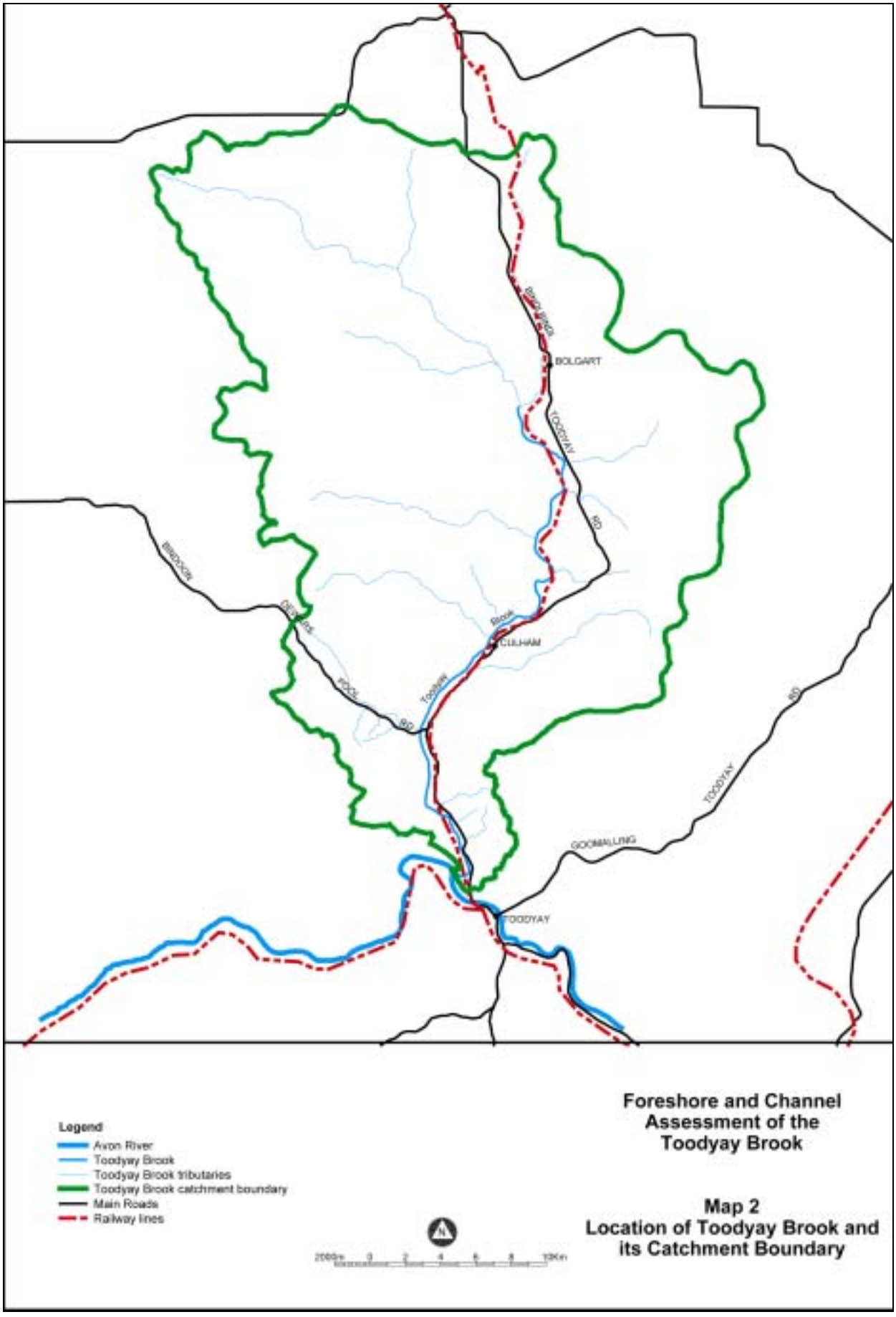
The vegetation system within which the Toodyay Brook lies is denoted as the York Vegetation System. This system is incorporated in the Avon Botanical District and is a part of the South-western Botanical Province.

This vegetation system is defined as being predominantly York Gum (*Eucalyptus loxophleba*) with Wandoo (*Eucalyptus wandoo*) being common. Jam Tree (*Acacia acuminata*) and Needle Tree (*Hakea preissii*) are also associated with the York Vegetation System (Lantzke, 1993). Flooded Gum (*Eucalyptus rudis*) is also very common, and is the most prominent Eucalypt that has been observed growing along the Toodyay Brook.

The Shire of Toodyay is a transitional zone between the wetter coastal regions and the drier interior of Australia. Hence, the vegetation supported by the region is a complex mixture of both vegetation found in the wetter south west and that of the drier interior (Caperson, 1975).

Catchment landuse and tenure

Toodyay Brook is set in an agricultural context, however there are some pockets that are becoming rural residential at an increasing rate. Dryland agriculture dominates landuse throughout the Toodyay Valley with sheep and cattle grazing, combined with cropping, the favoured activities. Map 4 provides a general overview

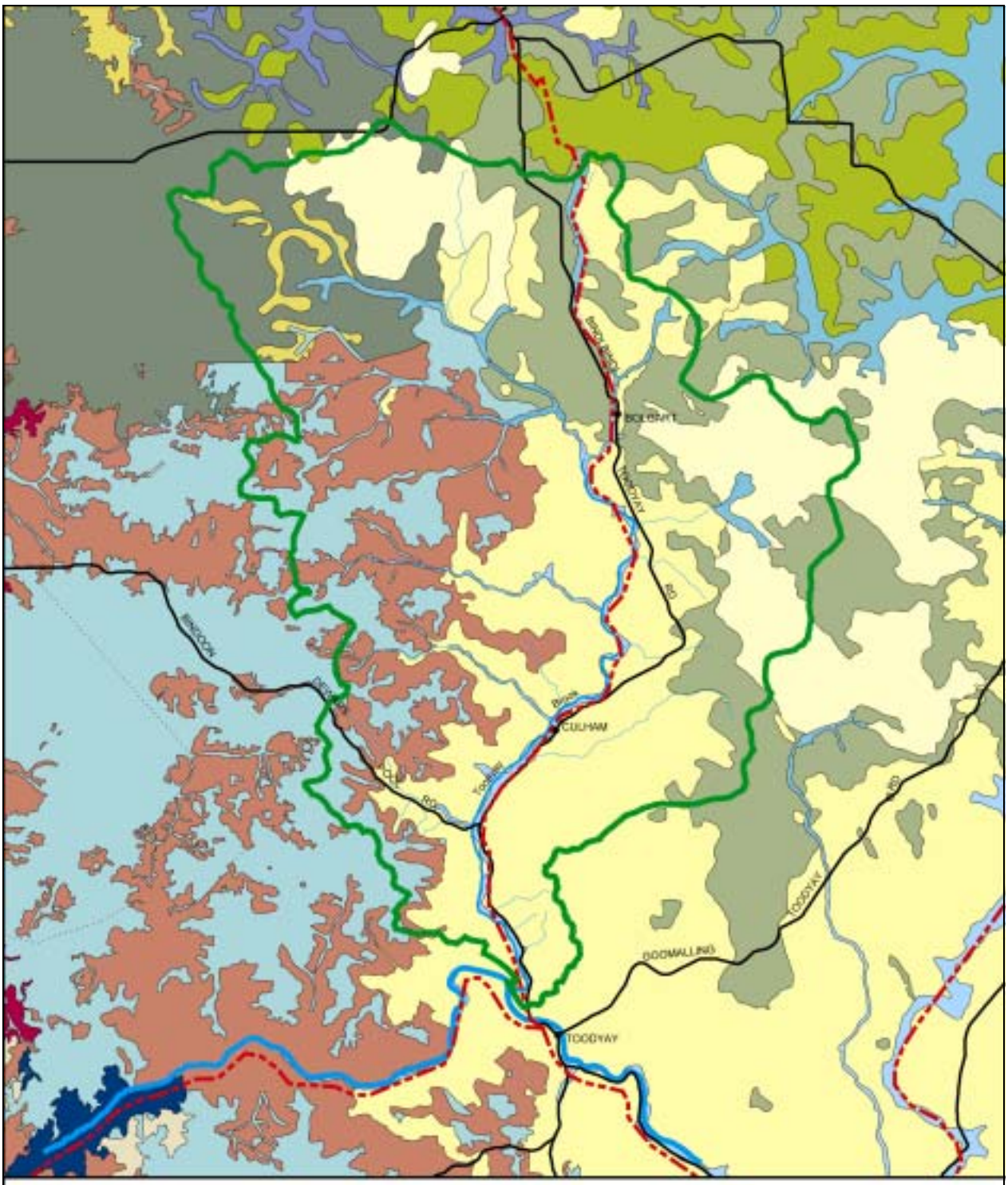

BOLGART
TOODYAY
GOOMALLING
TOODYAY
Legend
Avon River
Toodyay Brook
Toodyay Brook tributaries
Toodyay Brook catchment boundary
Main Roads
Railway lines
Foreshore and Channel Assessment of the Toodyay Brook
Map 2
Location of Toodyay Brook and its Catchment Boundary

of landuse along the Toodyay Brook whereby all properties abutting the waterway (as well as the majority within the catchment) are classified as rural 1-6.

In most instances the Brook runs through private property and legislation allows that where titles extend across the waterway the landholder has ownership of the portion of the waterway running through their property. In total there are 23 properties through which the Toodyay Brook runs. All are privately owned, although one section includes a water reserve that is vested with the Water and Rivers Commission. Another section (Dewars Pool) is vested with the Shire of Toodyay.

There is no formal recreation infrastructure within the areas adjacent to the waterway, as the majority of adjoining land is privately owned. There is however an informal recreation structure within each property boundary. Many landholders frequent the waterway for passive recreation such as walking and bird watching. Some people utilise the degraded waterway as a place for motorbike riding, horse riding and four-wheel driving.

In many cases it was observed during field investigations, that the waterway has commonly been used as a place to dispose of items regarded as rubbish. For example, numerous car bodies, tractors and machinery parts, along with fence posts, wire and animal carcasses were found dumped along the Toodyay Brook.



2000m 0 2 4 6 8 10Km

Soils legend

- Clackline System
- Udamong System
- Wundowie System
- Yarawindah System
- Darling Plateau System
- Murray Valleys System
- Avon Flats System
- Greenhills System
- Goomalling System
- Jelcobine System
- Morbinning System
- Phillips Sandplain System

Legend

- Avon River
- Toodyay Brook
- Toodyay Brook tributaries
- Toodyay Brook catchment boundary
- Main Roads
- Railway lines

Foreshore and Channel Assessment of the Toodyay Brook

Map 3
Soil Landscape Systems of the Toodyay Brook Catchment

Survey methods

Community involvement

Landholders along the Toodyay Brook were contacted by phone and/or letter to explain the purpose and aim of this waterway assessment. Individuals were asked to take part in the foreshore and channel assessments if they were interested and available.

Advertisements were placed in the local newspapers (The Avon Valley Advocate and the Toodyay Herald) to introduce this project to the community and to ask for expressions of interest from people who were interested in becoming involved in foreshore and channel assessments along the Toodyay Brook.

Assessment technique

To begin with, an assessment template was written up and a trial survey undertaken to determine the effectiveness of the survey format. The assessment template was based on the assessment techniques developed by Pen and Scott in their 1995 publication of *Stream Foreshore Assessment in Farming Areas*, with some variations included to meet the specific needs of this assessment.

Surveys were conducted along the whole length of the Toodyay Brook and sections were divided by property boundaries. In the case of a property being large in comparison to some of the smaller rural-residential properties along the waterway, the sections were determined by paddock boundaries. This made the final results easier to compare for the length of the Brook as the extremities in section length were considerably reduced. In total, the length of the Brook was divided into 38 survey sections, some delineated by property boundaries and others by paddock perimeters.

Foreshore and channel assessments were conducted by walking the length of the brook section and filling out the survey form (a copy is provided in Appendix 2). In some instances factors such as foreshore condition were averaged for the whole of a section with best and worst conditions within that section recorded too. Both sides of the waterway were surveyed and recorded on the same sheet. However, if each side of the waterway had differed greatly in either condition or surrounding landuse, then a separate survey would have been completed for each side. Where assessment referred to each side of the waterway (ie. fencing status on left or right side), surveys were conducted facing upstream.

Assessment of both the channel and foreshore was largely observational. Condition was assessed whilst walking along the tributary and recording answers on the assessment template. Appendix 3 shows an example of a completed survey form. Photos were taken at points of interest and have been used in later assessment of the waterway and its foreshore.

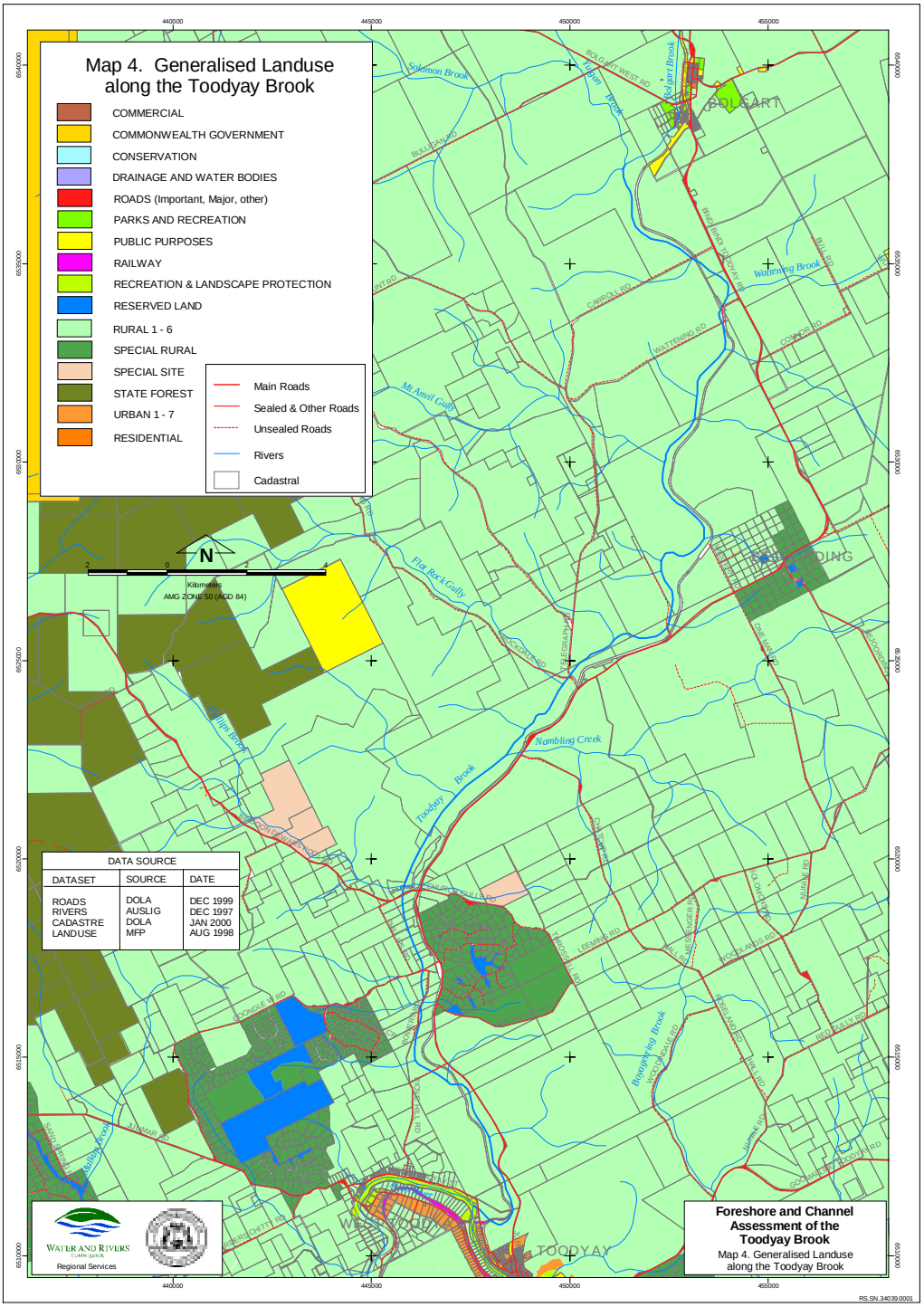
In some cases vegetation samples were taken to identify species that were not identified during field investigations. Books such as *Western Weeds* (Hussey *et al*, 1997), as well as the expertise of Commission personnel was used to identify these specimens. It should be noted that a *Licence for Scientific or other Prescribed Purposes* was obtained from the Department of Conservation and Land Management. This licence gives permission for the collection of flora subject to certain conditions.

Water samples were taken at random points along the waterway to provide a snap shot of the current pH and salinity levels of the Brook. Samples were taken during the course of the site assessment and were then taken back to the office for analysis. A Conductivity-Salinity-pH-Temp Meter (model MC-81) was used to determine electrical conductivity and pH readings for the water samples.

Method of analysis

Five categories have been used throughout the field assessments to determine an Overall Stream Environmental Health rating. Appendix 4 contains a table showing the categories used to classify the stream condition and the rating system used.

The Living Stream Survey is used to assess the ecological value of individual brook sections and allows us to determine an overall stream environmental rating which is a classification of the health of a waterway.


Map 4. Generalised Landuse along the Toodyay Brook
COMMERCIAL
COMMONWEALTH GOVERNMENT
CONSERVATION
DRAINAGE AND WATER BODIES
ROADS (Important, Major, other)
PARKS AND RECREATION
PUBLIC PURPOSES
RAILWAY
RECREATION & LANDSCAPE PROTECTION
RESERVED LAND
RURAL 1 - 6
SPECIAL RURAL
SPECIAL SITE
STATE FOREST
URBAN 1 - 7
RESIDENTIAL
Main Roads
Sealed & Other Roads
Unsealed Roads
Rivers
Cadastral
N
Kilometers
AMG ZONE 50 (AGD 84)
DATA SOURCE
DATASET
SOURCE
DATE
ROADS
RIVERS
CADASTRE
LANDUSE
DOLA
AUSLIG
DOLA
MFP
DEC 1999
DEC 1997
JAN 2000
AUG 1998
BOLGART
TOODYAY
Foreshore and Channel Assessment of the Toodyay Brook
Map 4. Generalised Landuse along the Toodyay Brook
WATER AND RIVERS COMMISSION
Regional Services
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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 sediment;
- habitat diversity; and
- surrounding landuse.

Depending on the rating (from very poor up to excellent), points are allocated to each of these components and an overall stream environmental rating is determined. Appendix 4 provides a table that shows the points allocated to each individual component based on which rating the section received.

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

Survey results

Channel stability

Bank and bed stability

Channel stability is affected by erosion, slumping and sedimentation. The percentage of channel stability along each brook section was measured by evaluating the following components:

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

Field assessments of each Brook section evaluated the above components determining channel stability as an average for the whole section, rating them as shown in Table 2.

Table 2. Rating system used to determine channel stability

Rating	% of Brook section affected
Minimal	0-5%
Localised	5-20%
Significant	20-50%
Severe	>50%

Results indicate that in most instances the various components have been rated as localised, however both erosion and sedimentation have been recorded as having a higher occurrence. The overall stability of the channel might be defined as moderate with some areas being very stable, while others are highly eroded and unstable.

The charts in Appendix 5 show that the majority of these components (undercutting, major undercutting, firebreak/track washouts, subsidence and slumping) have been recorded as either minimal or localised, meaning that less than 20% of these sections are affected by these activities. Both erosion and sedimentation were recorded as being significant or severe in over 50% of the sections surveyed along the Toodyay Brook. During field investigations, erosion was recorded as having a high priority for management in 74% of the survey sections.

Figure 6 shows the percentage of occurrence of all components relating to channel disturbance. The results show that the worst disturbance factors along the Toodyay Brook are erosion and sedimentation. Erosion was recorded as severe in 34% (13 of the 38 sections surveyed) and significant in 37% (14 sections). No sections surveyed along the Brook were rated as having minimal erosion.

Plate 2: Bank erosion along the Toodyay Brook

Sedimentation along the waterway is not as severe as the erosion problems, but still one of the major processes affecting channel stability. 26% (10 survey sections) were rated as severe and 32% (12 sections) rated as significant. A higher portion of surveyed sections (42%) were recorded as having only localised sedimentation problems, but the higher percentage of recordings lies in the two categories showing that more than 50% of the section is affected by sedimentation. No surveyed sections were recorded as having minimal sedimentation deposits.

In some areas along the waterway, bed material has been eroded down to the underlying clays, whilst in some sections sediment loads within the channel are extremely high and large sediment deposits (sand slugs) have formed across part of the channel.

The majority of surveyed sections (92%) experienced either minimal or localised major undercutting and slumping. Figure 6 shows that firebreak/track washouts were not recorded as being significant or severe in any of the surveyed areas, but 68% of the sections did experience minimal or localised washouts along tracks and firebreaks.

None of the 38 sections surveyed along the Toodyay Brook had artificial stabilisation along the banks. There were, however, some locations (ie. crossing points and bridges) where channel stabilisation had been undertaken to support the construction of such features. No techniques have been employed along the banks to protect degraded areas from further erosion and undercutting.

The Living Streams Survey, which was undertaken during the field surveys to determine the Overall Stream Environmental Health rating, can also give us an indication of the overall rating for bank stability and sedimentation along the Toodyay Brook. Figure 7 provides a collation of results showing the bank stability and sedimentation ratings recorded for Toodyay Brook which have been based on the information provided in Table 3.

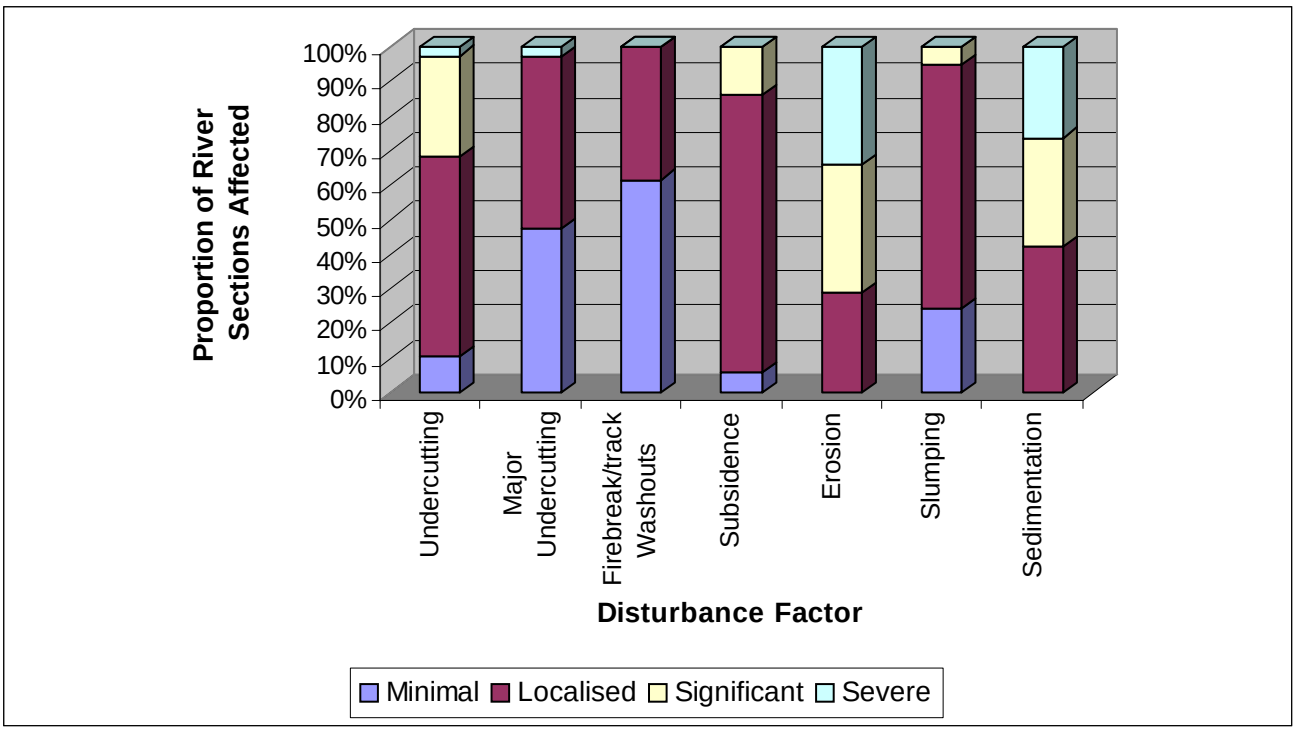


Figure 6. Proportion of channel disturbance along Toodyay Brook

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

Rating	Bank stability and sedimentation
Excellent	No erosion, subsidence or sediment deposits. Dense vegetation cover of 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 upper bank and verge.
Moderate	Good vegetation cover. Localised erosion, bank collapse and sediment heaps only. Verges 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.

Figure 7 shows that 55% of surveyed sections were rated as having moderate bank stability and erosion. This means that vegetation cover was good, but might have been sparse along verges, while there were areas of localised erosion, bank collapse and sediment slugs (Pen and Scott, 1995). 37% of sites were recorded as having poor bank stability and erosion, defined by severe active erosion and sediment heaps with collapsing banks, with bare banks and verges common. Only 5% of the sections were classified as good, 3% as very poor and 0% as being in excellent condition.

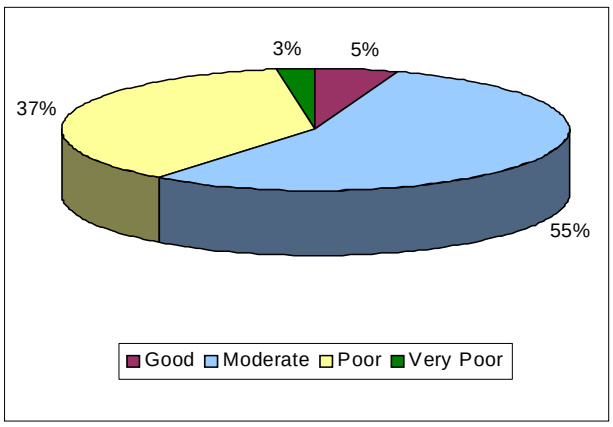


Figure 7. Bank stability and sedimentation ratings for Toodyay Brook

Results indicated that the majority of sections were recorded as being either moderate or poor in regards to bank stability and sedimentation when rated in terms of Overall Stream Environmental Health.

Waterways features

The features of a waterway often indicate the health of the riverine system. They allow us to assess, to some degree, the health of the waterway and determine options for future management.

Of all the sections surveyed along the length of the Toodyay Brook 82% were braided channels, 26% had anabranches running in close proximity to the Brook, and 34% had drains channelling water into the main waterway from the surrounding landscape.

Figure 8 shows that the most common features recorded during field observations of Toodyay Brook were sand slugs (occurring at 89% of sections) and riffles (at 87% of the sites).

Bridges were present in 39% of the surveyed sections. Some were road bridges and some were points at which landholders could cross their own properties. A few of the bridges were run down and are not in use. 21% of survey sections have man-made crossing points across the waterway where there has been obvious construction work undertaken to create the crossing.

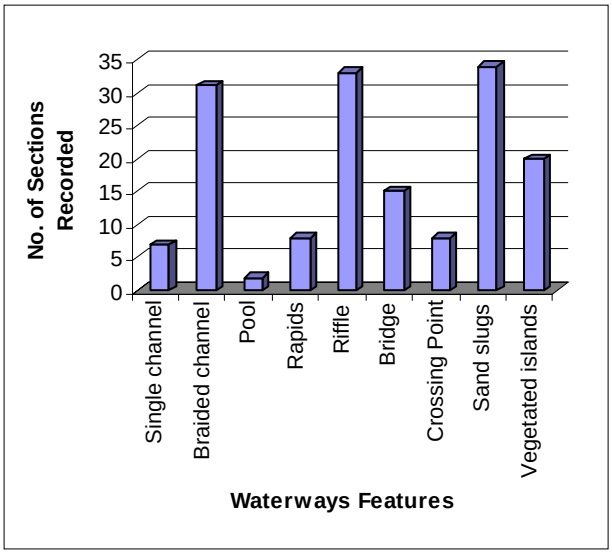


Figure 8. Waterways features recorded along Toodyay Brook

Foreshore condition

General foreshore condition

As shown in Map 5, 95% of sections were rated as having a general foreshore condition of C-grade. The basic definition of C-grade is that the foreshore supports only trees over weeds or pasture. Bank erosion and subsidence may occur in localised areas along the channel (Pen and Scott, 1995).

Of the 38 sections surveyed along the Brook, 95% were rated as C-grade. Only 5% of the surveyed sections were recorded as having a B-grade general foreshore condition, meaning that they were in slightly better condition than the rest of the tributary. (Appendix 6 provides definitions of foreshore condition ratings that have been used throughout this project).

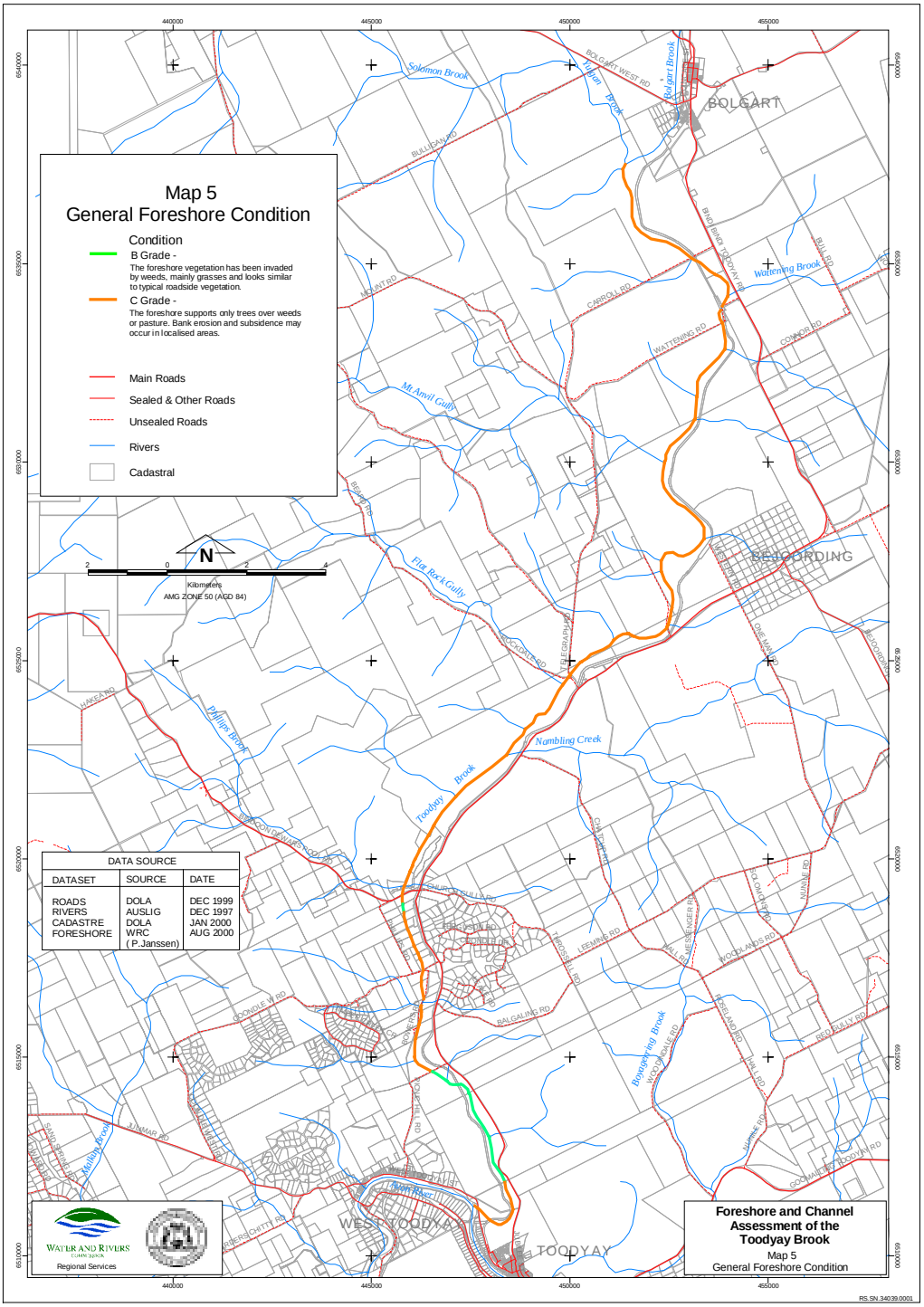
Best foreshore condition

The best and worst conditions observed within each section were also recorded. As depicted in Map 6, the best rating received was B1, meaning that the site was degraded but that native species were still more prevalent than weeds. The majority of the brook was rated as B1 at its best condition, whereas some sites around Bejoording were rated as BS, and some situated near the Bindoon-Dewars Pool Road were rated as C2.

Poorest foreshore condition

Map 7 shows the poorest foreshore conditions recorded along the waterway. The poorest foreshore condition recorded was a rating of D2, located upstream of Bindoon-Dewars Pool Road. This is defined as a freely eroding ditch where riparian vegetation has disappeared, and erosion is significant along with undercutting and subsidence. There are large sand slugs along the waterway (Pen and Scott, 1995). The majority of sites were given a poorest rating of C3 (eroded) and D1 (ditch – eroding) for foreshore condition.

Plate 3. A typical D-grade foreshore


Map 5
General Foreshore Condition
Condition
B Grade -
The foreshore vegetation has been invaded by weeds, mainly grasses and looks similar to typical roadside vegetation.
C Grade -
The foreshore supports only trees over weeds or pasture. Bank erosion and subsidence may occur in localised areas.
Main Roads
Sealed & Other Roads
Unsealed Roads
Rivers
Cadastral
N
2 0 2 4
Kilometers
AMG ZONE 50 (AGD 84)
DATA SOURCE
DATASET SOURCE DATE
ROADS DOLA DEC 1999
RIVERS AUSLIG DEC 1997
CADASTRE DOLA JAN 2000
FORESHORE WRC AUG 2000
(P.Janssen)
BOLGART
BEECHORDING
WEST TODDYAY
TODDYAY
Soldiman Brook
Bolgart Brook
Wattening Brook
Mt Amil Gully
Fig Rock Gully
Nambling Creek
Toodyay Brook
Phillips Brook
Bowgan Hill Brook
Millbillup Brook
Foreshore and Channel Assessment of the Toodyay Brook
Map 5
General Foreshore Condition
WATER AND RIVERS COMMISSION
Regional Services
RS.SN.34039.0001

Foreshore vegetation

Presence of common species

The most common overstorey species recorded along the Toodyay Brook were Swamp Sheoak (*Casuarina obesa*), Swamp Paperbark (*Melaleuca rhaphiophylla*) and Flooded Gum (*Eucalyptus rudis*). Table 4 shows the occurrence of native plant species along Toodyay Brook.

Table 4. Native species occurrence along Toodyay Brook

Plant name	No. of sites where the species occurred
Common Spike Rush	1
Jam Tree	12
Flooded Gum	23
Marine Couch	1
Mohan	8
Needlebush	12
Salmon Gum	2
Spiny Flat Sedge	19
Swamp Paperbark	22
Swamp Sheoak	31
Wandoo	5
York Gum	14

Results show that 82% of the surveyed sections contained Swamp Sheoak, 58% contained Swamp Paperbark and 61% Flooded Gum. The most common native sedge was the Spiny Flat Sedge (*Cyperus gymnocaulis*) which was recorded in 50% of sections surveyed along the Brook. The second most common was the Spikerush (*Juncus acutus*), a weed species which was recorded in 26% of sections.

Field observations determined that the occurrence of Flooded Gum and Mohan (*Hakea preissii*) were higher upstream along the Toodyay Brook whilst the presence of York Gum (*Eucalyptus loxophleba*) was highest along the middle sections of the waterway. Appendix 7 provides a list of both native and exotic vegetation that was recorded along the Toodyay Brook during field investigations.

Proportion of native species

Field observations determined that the majority of native species occurred in the overstorey (tree layer). Tree species such as Flooded Gum and Swamp Paperbark were common amongst the foreshore vegetation. Figure 9 shows that of the three vegetation layers, the overstorey supported a higher percentage of native species, with 92% of surveyed sites falling into this category. 55% of the sites were recorded as having between 5% and 20% native species in the vegetation comprising the ground layer.

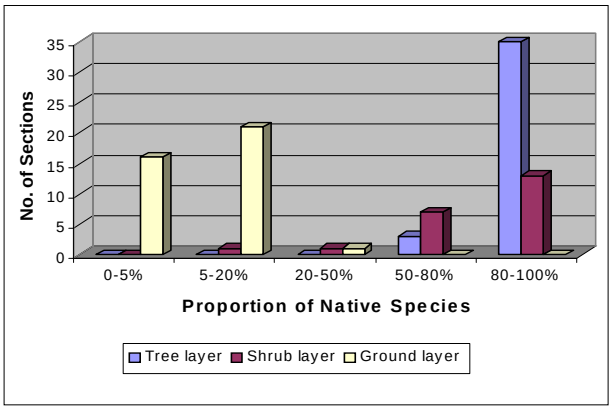


Figure 9. Proportion of native species in each vegetation layer

Regeneration of native species

Regeneration of tree species was observed at 66% of the survey sections. A range of different seedlings were recorded along this tributary. The following species were showing signs of regeneration amongst foreshore vegetation along the Toodyay Brook:

- Flooded Gum seedlings were recorded at 47% of the survey sections;
- Swamp Paperbark seedlings were recorded at 24% of the survey sections;
- Mohan seedlings were recorded at 18% of the survey sections;
- Jam Tree (*Acacia acuminata*) seedlings were recorded at 11% of the survey sections;
- Swamp Sheoak seedlings were recorded at 8% of the survey sections; and
- York Gum seedlings were recorded at 3% of the survey sections.

Death of common native species

Vegetation health along the Toodyay Brook was generally fairly good, but tree death was high in many areas. There was a lack of middlestorey plants in most areas and the understorey was dominated in most instances by weed species.

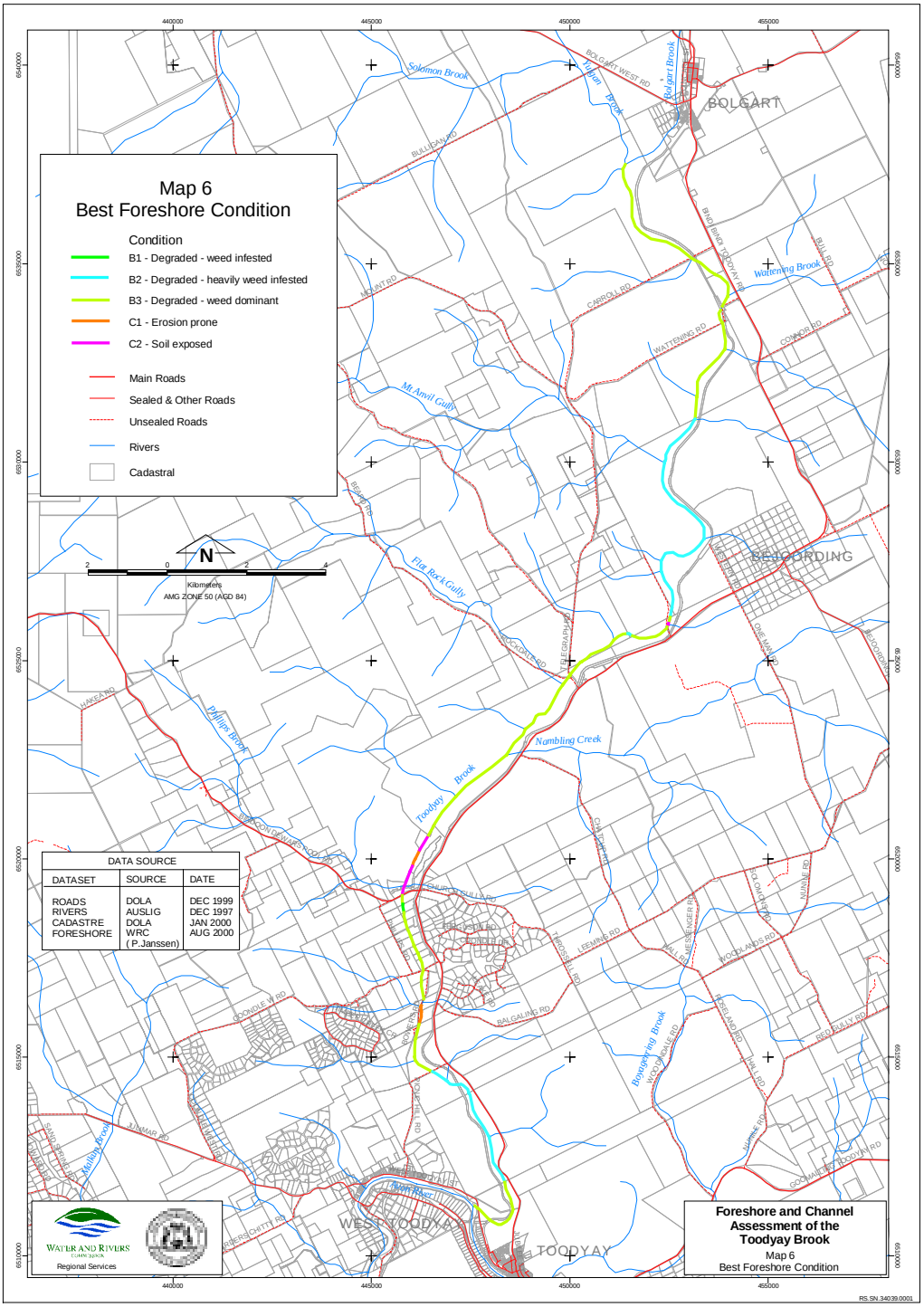

Map 6
Best Foreshore Condition
Condition
B1 - Degraded - weed infested
B2 - Degraded - heavily weed infested
B3 - Degraded - weed dominant
C1 - Erosion prone
C2 - Soil exposed
Main Roads
Sealed & Other Roads
Unsealed Roads
Rivers
Cadastral
N
2 0 2 4
Kilometers
AMG ZONE 50 (AGD 84)
DATA SOURCE
DATASET SOURCE DATE
ROADS DOLA DEC 1999
RIVERS AUSLIG DEC 1997
CADASTRE DOLA JAN 2000
FORESHORE WRC AUG 2000
(P.Janssen)
Soldiman Brook
Bolgart Brook
Wattening Brook
Mt Amil Gully
Fig Rock Gully
Nambling Creek
Toodyay Brook
Phillips Brook
Bowgada Brook
Millbin Brook
BOLGART
BEDFORDING
WEST TOODYAY
TOODYAY
Water and Rivers Commission
Regional Services
Foreshore and Channel Assessment of the Toodyay Brook
Map 6
Best Foreshore Condition
RS.SN.34039.0001

Figure 10 shows that the majority of sections surveyed along the Toodyay Brook had some dead trees. Of the surveyed sections 55% were recorded as having some dead trees, 34% as having some sick trees, and 11% as looking healthy.

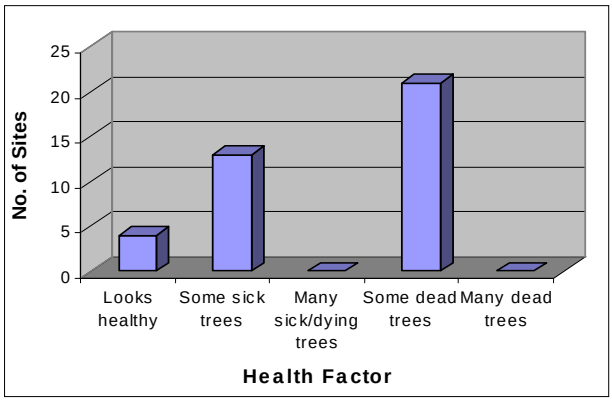


Figure 10. Vegetation health

Vegetation cover

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

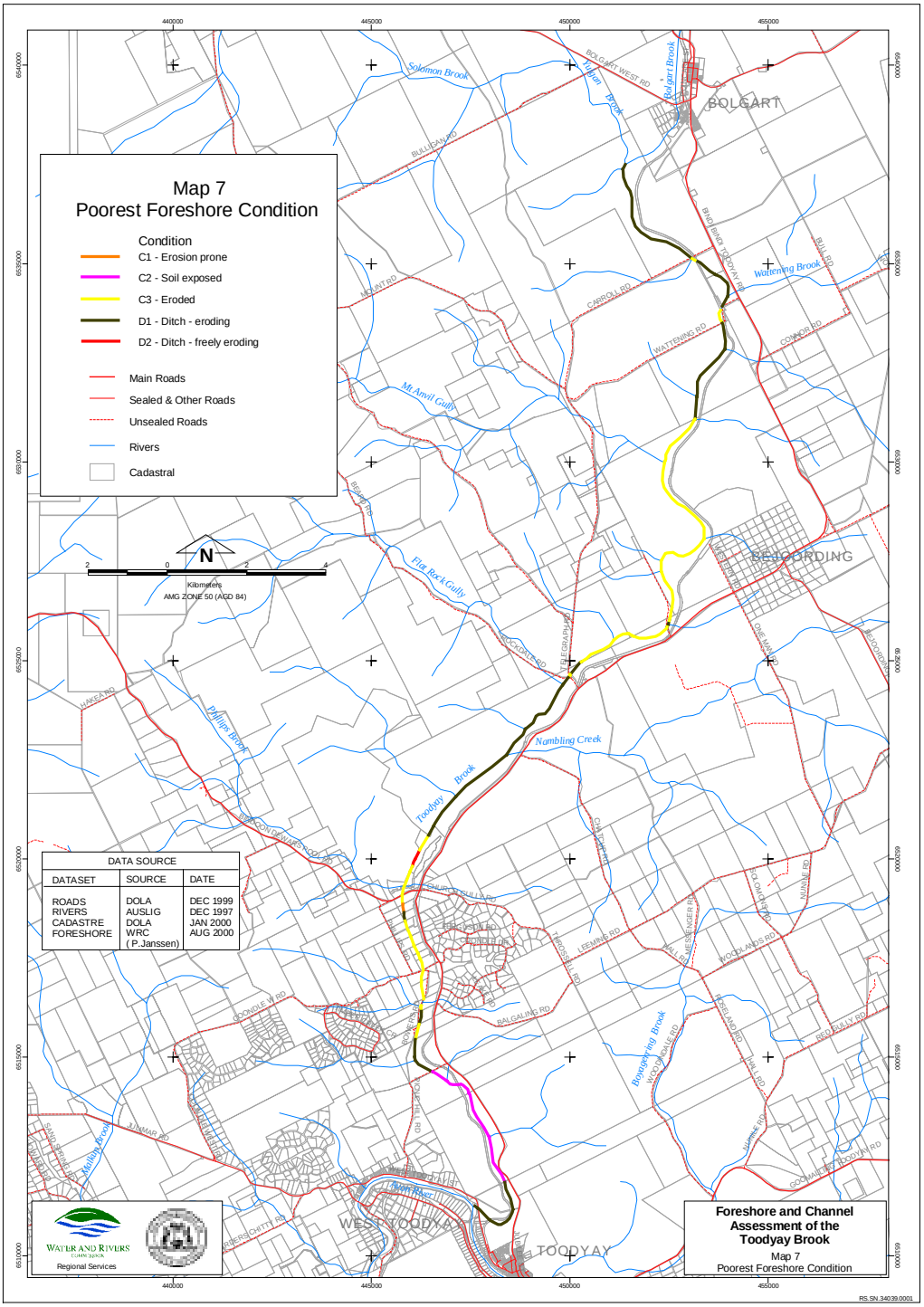
Table 5. Vegetation cover along Toodyay Brook

Vegetation cover		Tree cover	Shrub cover	Ground cover
Absent	(0%)	0	14	0
Sparse	(<20%)	4	14	2
Patchy	(20-80%)	34	10	13
Continuous	(>80%)	0	0	23

The data in Table 5 shows that the middle storey was absent in 37% of the surveyed sections. Ground coverage was recorded as continuous in 61% of sites, meaning that vegetation coverage was above 80%. The overstorey were dominantly recorded as being patchy (between 20 and 80% coverage), with 89% of the sections rated as patchy.

Figure 11 depicts results collated for stream cover during a survey to determine the Overall Stream Environmental Rating. 84% of the sections were rated as having a moderate stream cover, meaning that there is some permanent shade and overhanging vegetation with some instream cover (Pen and Scott, 1995). 8% were rated as poor, 5% as good and 3% as having very poor stream cover. No sites were recorded as having an excellent stream cover.

Plate 4. Death of overstorey vegetation along the foreshore of Toodyay Brook


Map 7
Poorest Foreshore Condition
Condition
C1 - Erosion prone
C2 - Soil exposed
C3 - Eroded
D1 - Ditch - eroding
D2 - Ditch - freely eroding
Main Roads
Sealed & Other Roads
Unsealed Roads
Rivers
Cadastral
N
2 0 2 4
Kilometers
AMG ZONE 50 (AGD 84)
DATA SOURCE
DATASET SOURCE DATE
ROADS DOLA DEC 1999
RIVERS AUSLIG DEC 1997
CADASTRE DOLA JAN 2000
FORESHORE WRC (P.Janssen) AUG 2000
WATER AND RIVERS COMMISSION
Regional Services
Foreshore and Channel Assessment of the Toodyay Brook
Map 7
Poorest Foreshore Condition
RS.SN.34039.0001
BOLGART
BEHOORDING
WEST TOODYAY
TOODYAY
Soldiman Brook
Bolgart Brook
Wattening Brook
Mt Amil Gully
Fig Rock Gully
Nambling Creek
Toodyay Brook
Phillips Brook
Millbillup Brook
Bowgada Brook
Toodyay River
440000
445000
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6540000
6535000
6530000
6525000
6520000
6515000
6510000

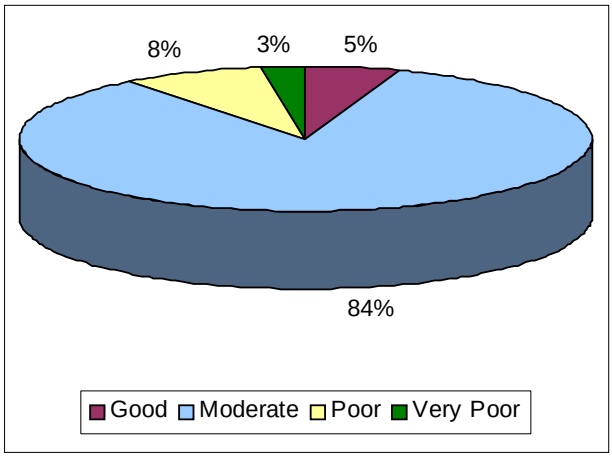


Figure 11. Vegetation cover along Toodyay Brook

The majority of sites were rated as having poor verge vegetation. This means that most survey sections had only narrow verges of less than 20 metres with vegetation being mainly exotic weed species (Pen and Scott, 1995).

Weeds

The most common weeds occurring along the Toodyay Brook are Barley Grass (*Hordeum leporinum*), Couch (*Cynodon dactylon*), Guildford Grass (*Romulea rosea*), Patterson's Curse (*Echium plantagineum*), Soursob (*Oxalis pes-caprae*) and Wild Oat (*Avena fatua*). All of these species, with the exception of Patterson's Curse, were recorded in the majority of instances as having a 'high' occurrence at the sites in which they were recorded. Table 6 shows the occurrence of the commonly recorded weeds along Toodyay Brook. See Appendix 7 for a complete list of exotic species recorded along this waterway during this investigation.

Patterson's Curse was more commonly found in areas of agricultural activity (grazing and cropping), while Fat Hen Weed was of higher occurrence along the smaller properties classified as having a rural residential landuse.

The change of season during the survey period would account for the differing numbers of species. Weeds such as Barley Grass, Caltrop (*Tribulus terrestris*) and Wild Oat die off towards the end of summer and therefore declined in number throughout the duration of the field surveys. Others such as Watsonia, Soursob and Guildford Grass rely on the cooler, wetter weather and hence, became more common during the latter part of the waterway assessments.

It should be noted that the vegetation surveys conducted throughout foreshore and channel assessments are not conclusive. There is likely to be other species present along the Brook and it is recommended that future assessments include two separate vegetation surveys, one in autumn and one in spring, to determine a more accurate list of species present.

Pest plants

Pest Plants are weed species that are seen as being a nuisance to the existing landuse, such as agriculture. Local Government Authorities have the responsibility of administering the Agriculture and Related Resources Protection Act and have the authority to enforce the control of such species within its boundaries (Hussey *et al*, 1997). Six Pest Plant species have been recorded amongst the foreshore vegetation along Toodyay Brook - Watsonia, Caltrop, Doublegee, Dock, Wild Melon and

Table 6. Common weed occurrence along Toodyay Brook

Weed name	Occurrence			Number of sites the species was recorded in
	High	Medium	Low	
Barley Grass	13	10	0	23
Blowfly Grass	8	2	2	12
Couch	7	11	0	18
Fat Hen Weed	5	4	6	15
Guildford Grass	17	10	0	27
Patterson's Curse	5	17	6	28
Dock	0	5	10	15
Soursob	30	6	1	37
Spike Rush	1	0	9	10
Wild Oat	21	10	1	32

Turnip Weed. The following gives an indication of the extent of these plants along the surveyed waterway:

- 13% of sections surveyed contained Watsonia
- 5% of sections surveyed contained Caltrop
- 3% of sections surveyed contained Doublegee
- 39% of sections surveyed contained Dock
- 21% of sections surveyed contained Wild Melon
- 18% of sections surveyed contained Turnip Weed

Declared plants

Declared plants are those plants which are classified as high priority for management and which may become a major problem to the environment or to agricultural activities. They are formally declared under the Agriculture and Related Resources Protection Act which is administered by Agriculture Western Australia. Landholders are obliged, under this act, to control any Declared Plants that occur within their properties (Hussey *et al*, 1997). Three Declared Plants were sighted along the Toodyay Brook, these being Doublegee (also classified as a Pest Plant), Patterson's Curse and Soursob. The following indicates the number of survey sections in which these species were recorded:

- 3% of the sections contained Doublegee
- 74% of the sections contained Patterson's Curse
- 97% of the sections contained Soursob

Habitat diversity

92% of the sections were classified as having minimal leaf litter coverage. 5% supported good cover and 3% were recorded as having no leaf litter at all.

Figure 12 shows that the majority (55%) of survey sections were recorded as having 10% or less bare ground along the waterway verge. 29% of the sites had between 11% and 25% bare ground, whilst no sections were dominantly clear of all ground covers.

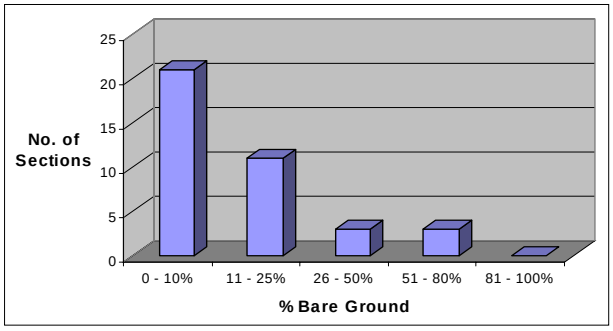


Figure 12. Percentage of bare ground along Toodyay Brook

Appendix 8 shows that a range of habitats along waterways will provide a home to a diverse range of aquatic and terrestrial fauna such as birds, frogs, macroinvertebrates and turtles. Field investigations determined the presence of potential habitat for both aquatic and terrestrial fauna along Toodyay Brook. Figure 13 shows that the most common habitat recorded were trees, with 100% of the surveyed sections having at least some tree coverage within the riparian zone. The second most common habitat type were instream logs (common in 95% of sections), followed closely by cascades, rapids and riffles which were recorded at 89% of the surveyed sections. The least common habitat type was dense streamside vegetation that only occurred at 13% of the sections surveyed.

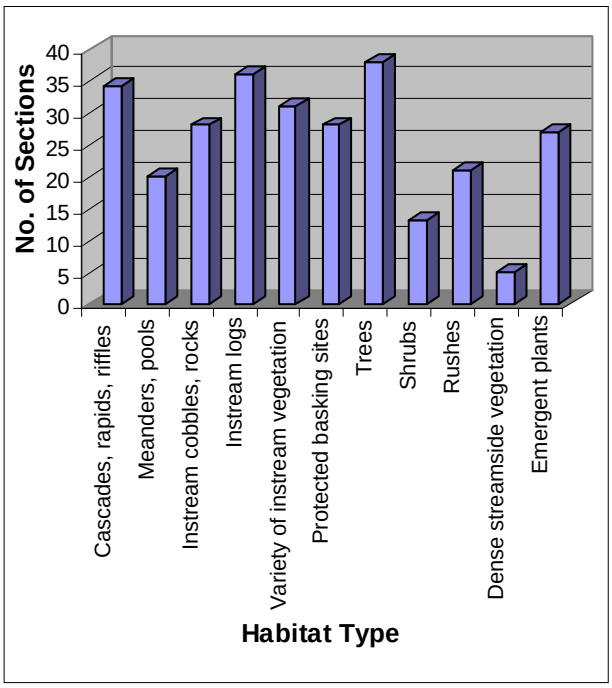


Figure 13. Occurrence of habitat types along Toodyay Brook

The Living Stream Survey determined that only 5% of the sites were recorded as having good habitat diversity, while 68% were classified as moderate. Good habitat diversity along streamlines is defined as having 2 habitat zones with some permanent water, and moderate habitat diversity as having either mainly one habitat type with permanent water, or a range of habitats with no permanent water (Pen and Scott, 1995).

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

- Frogs
- Birds
- Ducks
- Spiders
- Rabbits
- Caterpillars
- Ants
- Locusts
- Goannas
- Kangaroos
- Feral cats
- Foxes
- Water rats
- Minnows
- Lizards
- Butterflies
- Hawke
- White Cockatoos
- Bees
- Mosquitoes
- Dragonflies
- Midges
- Australian Ringneck
- Crows
- Geese
- Gilgies
- Pink & Grey Galahs

Anecdotal evidence suggests that the area was more plentiful with a variety of fauna in the past. Many people commented that people used to catch cobbler from the waterway, but nowadays it is very rare to see any. Tadpoles, gilgies and turtles seem to be less common now than they were in years gone by.

Landholders along the Toodyay Brook have commented that a diverse group of fauna can still be observed living along the brook. Mountain ducks are still common in and around the waters of Toodyay Brook, as well as guadas and tiger snakes (Martin, pers. comm, 2000). Many landholders along the Brook commented that water rats, possums and kookaburras are still common inhabitants of the riverine environment.

Fencing status

Field investigations determined that 32% of the sites surveyed were fenced on both sides, 16% were fenced on one side, and 52% of the sites surveyed were not fenced at all.

Although a large portion of the Toodyay Brook was fenced on one or both sides, in many cases the purpose of the fence was not to exclude stock from the waterway and foreshore area, but to act as a paddock boundary and keep stock in. Only a small portion of the sections surveyed had fenced the riparian zone with the intention of keeping stock away from the riverine environment.

Of the areas that were fenced, the majority was in relatively good condition. The following summarises what is shown in Map 8:

- Of the sections that were fenced, 50% was in good condition
- Of the sections that were fenced, 44% was in moderate condition
- Of the sections that were fenced, 6% was in poor condition

Fencing styles used varied along the length of the waterway. Appendix 9 gives a definition of each fencing style and the following depicts the proportion of each style that was observed along the waterway during field surveys:

- 67% of the fenced sites used fabricated fencing
- 22% of the fenced sites used barbed wire
- 11% of the fenced sites used electric fencing

Water quality

Water quality along the Toodyay Brook varies as the water moves downstream. Figures 14 and 15 show the results of water samples taken from the Toodyay Brook during field assessments. The sample numbers show movement along the waterway from downstream (sample number 1) through to the upstream survey sites. The results recorded during the surveys provide a "snap shot" of water quality parameters (pH and electrical conductivity) at a certain point in time.

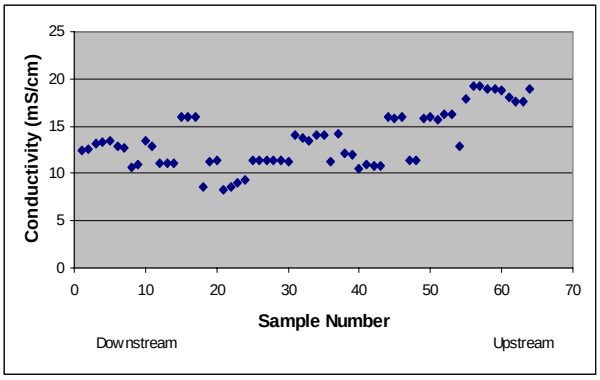
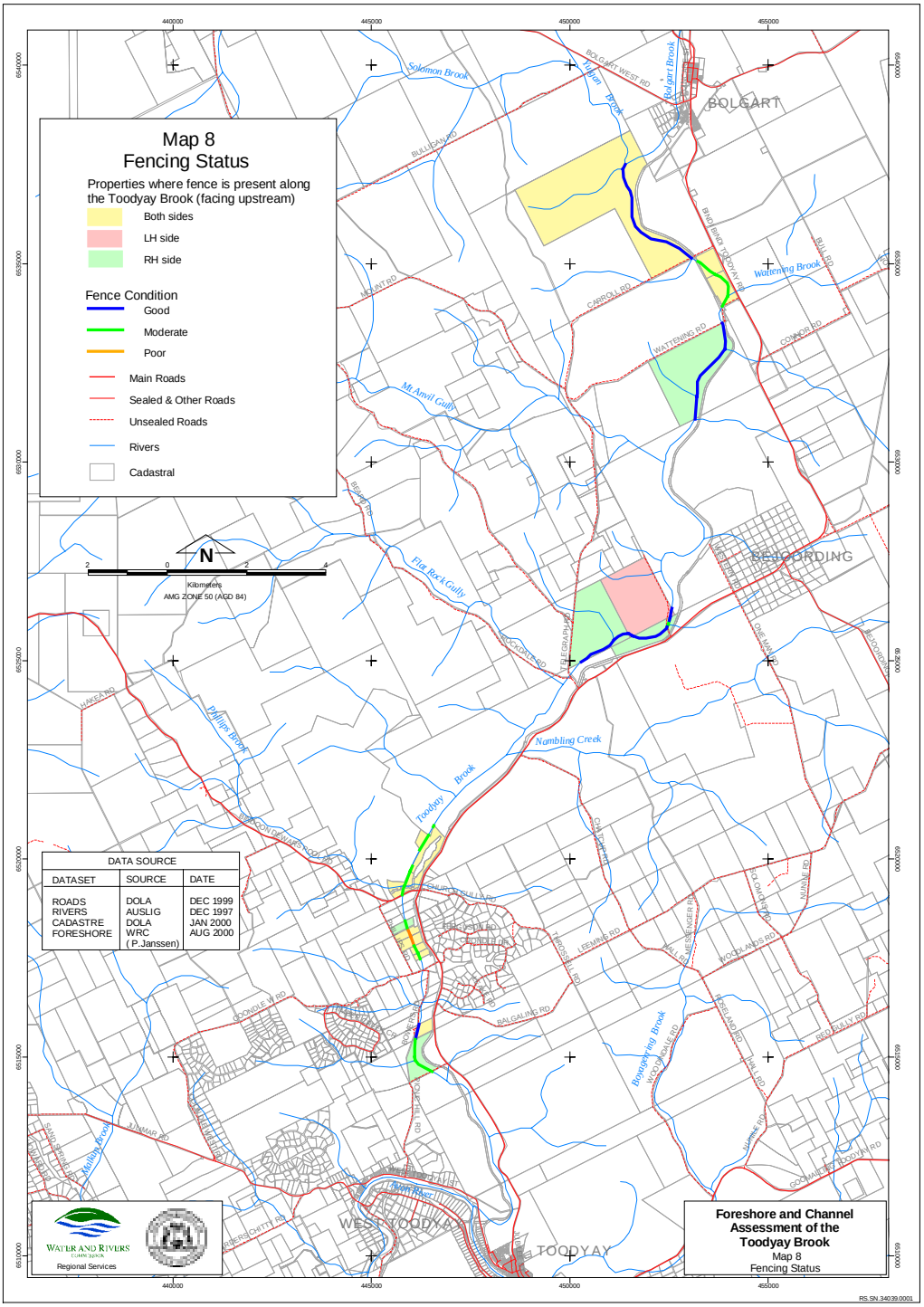


Figure 14. Electrical conductivity along Toodyay Brook – May 2000

Figure 14 depicts the electrical conductivity (EC) that was recorded along the Brook. The highest conductivity recording was 19.3mS/cm, sample 56, which occurred in the upstream survey sections along the Brook, while the lowest recorded conductivity was 8.31mS/cm, (sample number 21), which occurred mid-way along the waterway. The average electrical conductivity (as a result of averaging all conductivity recordings along the Toodyay Brook) was 13.52mS/cm.


Map 8
Fencing Status
Properties where fence is present along the Toodyay Brook (facing upstream)
Both sides
LH side
RH side
Fence Condition
Good
Moderate
Poor
Main Roads
Sealed & Other Roads
Unsealed Roads
Rivers
Cadastral
N
Kilometers
AMG ZONE 50 (AGD 84)
DATA SOURCE
DATASET | SOURCE | DATE
ROADS | DOLA | DEC 1999
RIVERS | AUSLIG | DEC 1997
CADASTRE | DOLA | JAN 2000
FORESHORE | WRC (P.Janssen) | AUG 2000
WATER AND RIVERS COMMISSION
Regional Services
Foreshore and Channel Assessment of the Toodyay Brook
Map 8
Fencing Status
RS.SN.34039.0001
BOLGART
BEDFORDING
WEST TOODYAY
TOODYAY
Soldiman Brook
Bolgart Brook
Wattening Brook
Mt Amil Gully
Fig Rock Gully
Phillips Brook
Nambling Creek
Toodyay Brook
Bowgan Hill Brook
Millbillup Brook
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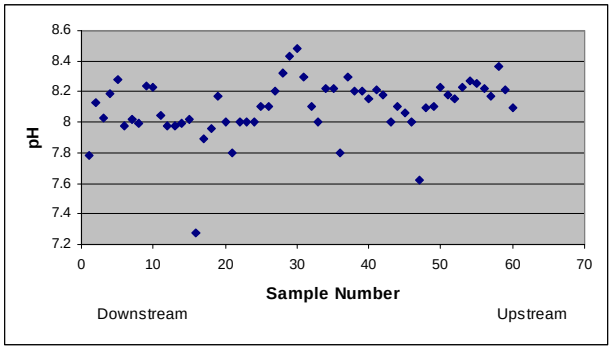


Figure 15. pH Levels along Toodyay Brook – May 2000

Figure 15 shows the variation in pH levels recorded during field assessments of watercourse. The lowest pH recorded was 7.28, (sample number 16), while the highest was 8.48 (sample number 30). Both were recorded in sections located approximately mid-way along the length of the tributary. The average pH for all samples taken from the Brook was 8.10.

Overall stream environmental health rating

Figure 16 depicts that 18% of the surveyed sections were classified as having moderate stream health, 76% as having poor stream health, and 5% as having a very poor stream health. No section was rated as excellent or good. This was mainly due to lower ratings in the verge vegetation, surrounding landuse and floodway and bank vegetation categories.

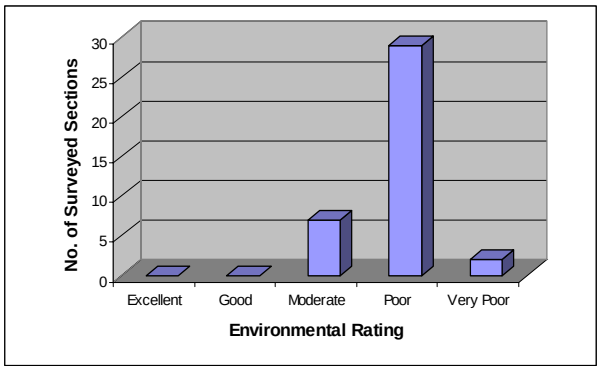


Figure 16. Overall stream environmental health ratings for Toodyay Brook

Survey results show that the Toodyay Brook has been classified as having a poor Overall Stream Environmental Health rating. When looking at the points scored by each section, the majority of sections that were rated as "poor" were close to being rated as moderate. Map 9 provides a visual representation of the ratings recorded along the Brook.

Disturbance

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

- 87% of the surveyed sections had stock in the Brook;
- 32% of the surveyed sections were disturbed by feral animals;
- 53% of the surveyed sections contained dumped rubbish;
- 58% of the surveyed sections were influenced by service corridors (roads and railway lines);
- 92% of the sections surveyed were accessible by vehicle; and
- Fire was seen to be of low management priority in 55% of the sections surveyed.

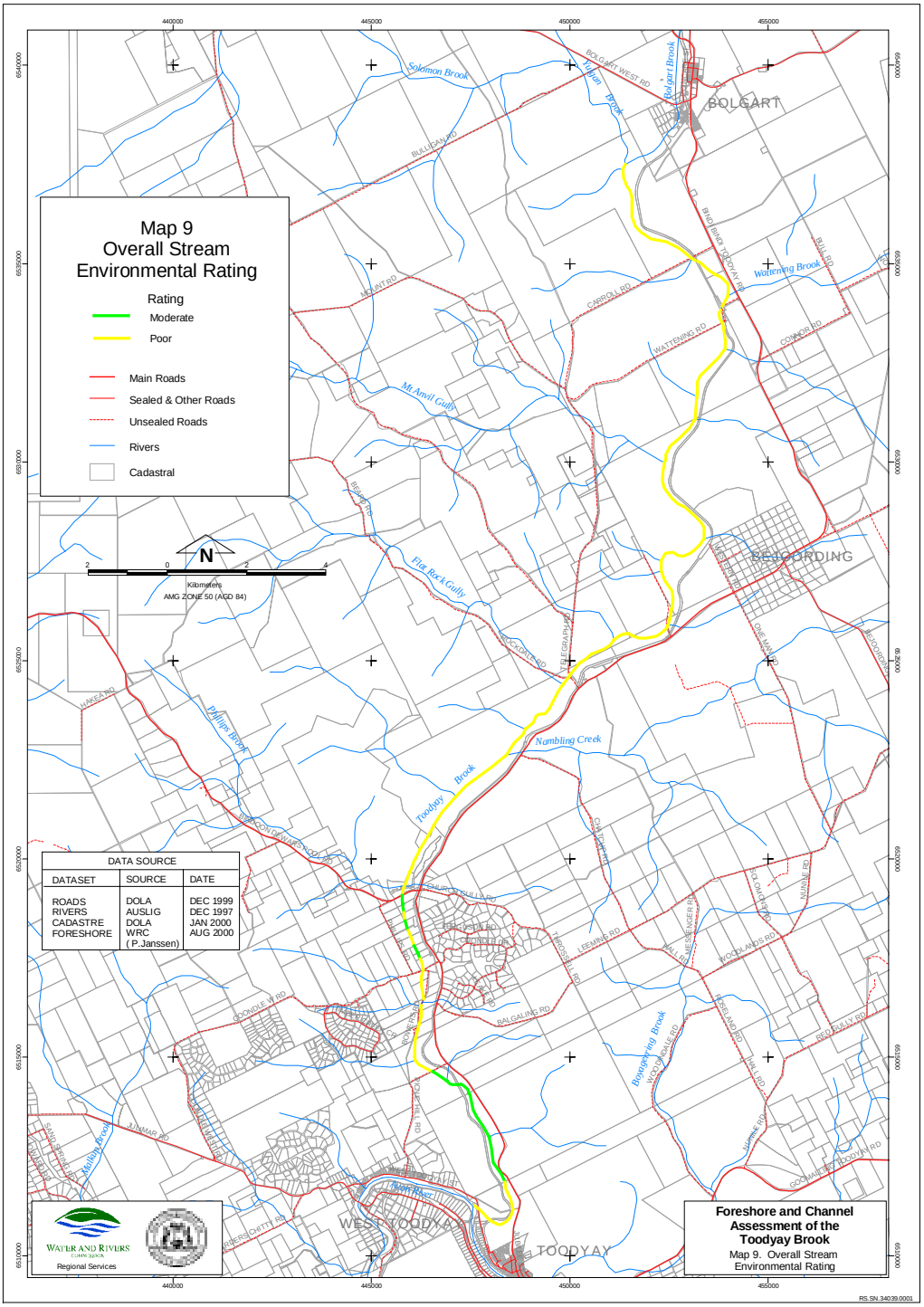
Map 10 represents all sites along the waterway where stock had access to the foreshore and banks of the Brook. It should be noted that not all sites are grazed by stock all year round. Some sites are used for only a few month of the year while others are continuously under pressure from stock.

Evidence of management

Management of the channel and foreshore is not occurring on a large scale, but there are some isolated incidences of management efforts. The most common management effort was firebreak control edging the riparian zone with 39% of surveyed sites using firebreaks to prevent fires from spreading into the riparian zone. The second-most common management control was fencing with 47% of assessed areas having fences along the Brook. There were also other attempts at river management, with:

- 11% of survey sections having evidence of tree planting;
- 5% of survey sections attempting weed control; and
- 16% of survey sections undertaking feral animal control (baiting).

Of the 38 sections surveyed, 29% showed no evidence of attempts at river management.


Map 9
Overall Stream
Environmental Rating
Rating
Moderate
Poor
Main Roads
Sealed & Other Roads
Unsealed Roads
Rivers
Cadastral
N
2 0 2 4
Kilometers
AMG ZONE 50 (AGD 84)
DATA SOURCE
DATASET | SOURCE | DATE
ROADS | DOLA | DEC 1999
RIVERS | AUSLIG | DEC 1997
CADASTRE | DOLA | JAN 2000
FORESHORE | WRC (P.Janssen) | AUG 2000
BOLGART
BEDFORDING
WEST TODDYAY
TODDYAY
Soldiers Brook
Bolgart Brook
Wattening Brook
Mt Amil Gully
Fig Rock Gully
Phillips Brook
Nambling Creek
Toodyay Brook
Bowgada Brook
Millbillup Brook
Water and Rivers Commission
Regional Services
Foreshore and Channel Assessment of the Toodyay Brook
Map 9. Overall Stream Environmental Rating
RS.SN.34039.0001

Interpretation of survey results

Channel stability

The severe levels of erosion and sedimentation recorded along the length of the Toodyay Brook are directly related to past and present land use factors. Overgrazing of the riparian zone, trampling of the area by stock, removal of woody debris and increased runoff from cleared paddocks surrounding the Brook all contribute to the high level of bank and instream erosion.

Erosion of the banks leads to the channelisation of the waterway, which in turn, leads to an increased flow velocity. A higher rate of flow is responsible for further erosion and incision of the streambed and banks, and the movement of sediment downstream where it is deposited amongst woody debris, riffles and in areas of slower flow.

The high level of erosion means that the sediment load within the waterway will be higher, and this correlates with the severe sedimentation observed along many areas of the Brook.

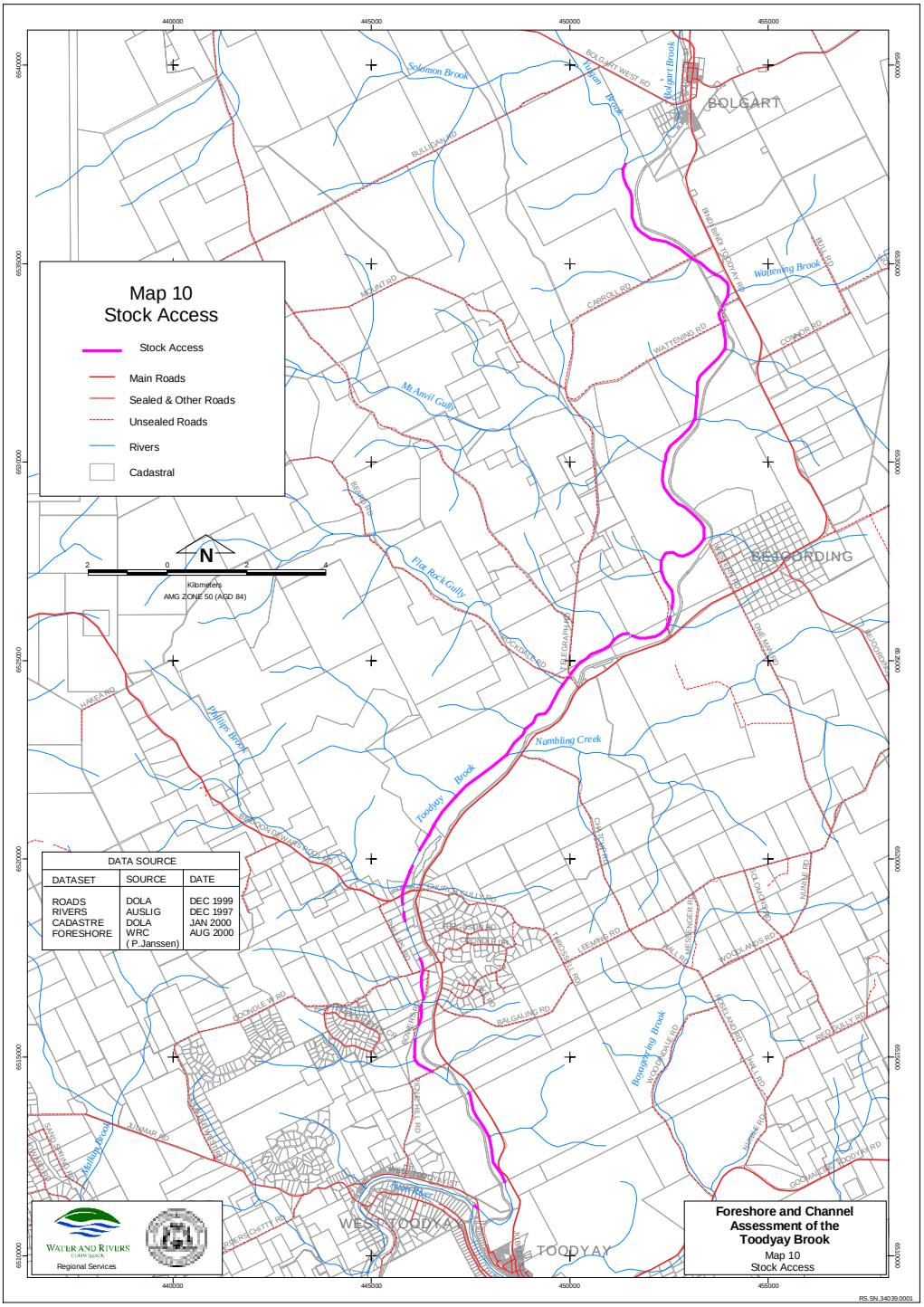
Bank erosion along the Brook has lead to a loss of riparian vegetation. It may also be responsible for the shallowing and widening of the river channel in many areas. This contributes to a decline in the number of deeper pools found along the tributary, adversely affecting aquatic fauna due to a decline in the availability of habitat during periods of low flow (Jackson, 1997).

Waterways features and habitat diversity

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

Results show that there are a high number of sand slugs which, combined with a low number of pools, indicates a decline in habitat diversity. In some areas the streambed was eroded down to the bed material which has also led to a loss of habitat.

Plate 5. Severe erosion and sedimentation along the Toodyay Brook


Map 10
Stock Access
Stock Access
Main Roads
Sealed & Other Roads
Unsealed Roads
Rivers
Cadastral
N
2 0 2 4
Kilometers
AMG ZONE 50 (AGD 84)
DATA SOURCE
DATASET | SOURCE | DATE
ROADS | DOLA | DEC 1999
RIVERS | AUSLIG | DEC 1997
CADASTRE | DOLA | JAN 2000
FORESHORE | WRC (P.Janssen) | AUG 2000
WATER AND RIVERS COMMISSION
Regional Services
Foreshore and Channel Assessment of the Toodyay Brook
Map 10
Stock Access
BOLGART
BEDFORDING
WEST TOODYAY
TOODYAY
Soldiman Brook
Bolgart Brook
Wattening Brook
Mt Amil Gully
Fig Rock Gully
Nambling Creek
Toodyay Brook
Phillips Brook
Bowgan Hill Brook
Millbin Brook
Avon River
440000
445000
450000
455000
6540000
6535000
6530000
6525000
6520000
6515000
6510000
RS.SN.34039.0001

As discussed earlier, a high level of sedimentation was recorded in numerous locations along the Toodyay Brook. Sedimentation can alter river habitats and may even remove them altogether. Suspended sediment is deposited into pools and often buries cobbles and logs that provide important habitat to aquatic fauna. Deposition of sediment upon substrate surfaces will prevent algal growth, (the base of many aquatic food chains) and have an adverse effect on the biodiversity of aquatic fauna found within the Brook (Jackson, 1997).

87% of surveyed sections along the Toodyay Brook were recorded as having riffles, where in most instances they consisted of logs and/or rocks. These 'snags' are likely to provide habitat for a variety of aquatic faunas.

Along this tributary there are many secondary channels, areas close to the Brook which are seasonally flooded. These may provide seasonal habitat during the winter months for terrestrial and aquatic organisms such as frogs, wading birds, gilgies and small macroinvertebrates.

Instream and verge vegetation is likely to provide a source of food, shelter and breeding/nesting sites for aquatic and terrestrial fauna. Most surveyed sections have trees within the riparian zone, although there are some areas where foreshore vegetation was void, with the exception of some groundcover. 55% of sites were recorded as having some dead trees, which can be attributed to waterlogging and rising salinity levels. Although dead and no longer providing a food source, these trees provide an important range of habitat for terrestrial organisms such as lizards, spiders and birds. Appendix 8 shows an example of important habitats along waterways, and provides examples of some of the terrestrial and aquatic organisms that may be found within each habitat type.

Foreshore condition

Foreshore condition is largely related to the surrounding landuse, disturbances (past and present) and management protocols that are in place. The general condition is C-grade, which indicates that the long-term agricultural history and associated practices have been negatively impacting on the riverine environment. This, combined with an ignorance of river management has lead to a continuing decline in the condition of foreshore vegetation, a loss of habitat and an increase in channel and bank erosion.

Foreshore vegetation

Riparian vegetation affects water quality and channel form, by reducing both sediment and runoff into streams and erosion of banks. Riparian vegetation is impacted by clearing, invasion by exotic species, disturbance by stock and by salinisation (Jackson, 1997).

Changes to the landscape resulting from the introduction of crops, annual pasture plants and grazing animals (cattle, sheep and goats) have lead to a substantial change in the composition of native plant communities (Walker, 1986). The removal of native understorey and trees by cropping and grazing has resulted in many areas becoming basically devoid of native annual grasses, whilst encouraging the spread of grass and pasture weeds (ie. Patterson's Curse, Guildford Grass and Wild Oat).

Flooded gum (*Eucalyptus rudis*) is susceptible to salinity, hence the rising level of salinity along the Toodyay Brook has led to a decline in the number of this species growing within the riparian zone. As would be expected, the more dominant species is the Swamp sheoak (*Casuarina obesa*) which can tolerate much higher levels of salinity. Swamp paperbark (*Melaleuca rhaphiophylla*) can also tolerate low to moderate salinity levels, but will tend to die as salt concentrations increase.

Fringing vegetation plays an important role in the health of a waterway. It provides shade that keeps water temperatures lower, providing a more favourable habitat for instream fauna. It also stabilises banks and helps reduce erosion by water within the channel as well as overland flow from the surrounding catchment which is directed towards the waterway. Riparian vegetation traps sediment suspended within the water and from surrounding runoff and therefore performs an important function of filtering sediment from within the waterway, and from water entering the stream from neighbouring landscapes.

Wetland plants perform a number of important functions in relation to the health of the waterway. Native wetland species such as the Spiny Flat Sedge (*Cyperus gymnocaulis*) have the ability to strip nutrients from water entering the Brook from the surrounding agricultural landscape. The current lack of native understorey species means that the nutrient stripping ability of the riparian zone is greatly reduced, leading

to a higher level of nutrients entering the aquatic system. This may have adverse impacts on the system as it may lead to the death of some aquatic fauna, both directly and indirectly, by contributing to nutrient enrichment and consequent algal blooms.

Field surveys indicate that the level of native riparian vegetation coverage is low, particularly along the banks. There are many areas of bare ground and a high coverage of shallow rooted exotic species (such as Soursob), which do not provide protection from bank erosion and sediment entering the waterway from the surrounding landscape.

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

Water quality

Electrical conductivity is used to measure dissolved salts within a body of water. The dissolved salts conduct a charge (electrical conductivity) allowing for estimates of salinity to be made (Swan River Trust, undated). Anecdotal evidence suggests that there are fresh water soaks throughout the Brook, which might account for the variation in salinity levels along the length of the waterway.

Salt concentrations will also fluctuate with varying water levels along the Brook due to the effect of dilution. This makes valid comparisons of salinity readings between sites difficult. For the purpose of this report, conductivity readings were measured to provide a "snap shot" indication of the salinity levels of Toodyay Brook at a particular point in time, and should be interpreted with respect to this.

Table 7 provides an estimate of water quality based on ranges of conductivity. The average electrical conductivity recorded for the length of the Toodyay Brook was 13.52mS/cm which classifies the water in the Brook as being low saline. This is likely to be a result of past and present landuse. The clearing of native vegetation (that was replaced with shallow rooted crop and pasture species) led to a rise in the water table which mobilised soil salt and enabled it to leach through to the surrounding waterways. Appendix 10 provides some examples of plant and animal tolerances to various levels of salinity.

Table 7. Classification for environmental water salinity

Water quality status	Conductivity range (mS/cm)
Fresh	< 1
Marginal	1 – 2
Brackish	2 – 9
Low saline	9 – 20
High saline	20 – 45
Hyper saline	> 45

The acidity or alkalinity of waterways is measured by a pH scale from 0 to 14 (see Figure 17). A pH less than 7 indicates the water is acidic; 7 is neutral, and above 7 is alkaline or basic. The natural pH of waterways varies from one location to another because the value depends heavily on the soil and rocks over which the water moves (Swan River Trust, undated).

pH is an important environmental indicator. At extremely high or low pH values water becomes unsuitable for most organisms. A change of more than 0.5pH units from the natural seasonal maximum or minimum can also potentially threaten flora and fauna living within the waterway (ANZECC, 1992).

The average pH (8.10) recorded for the length of the Toodyay Brook was within the Australian Water Quality Guidelines recommended for drinking purposes (between 6.5 and 8.5). It was also within the acceptable level for freshwater aquatic biota protection (between 6.5 and 9.0) (ANZECC, 1992). The highest and lowest pH values (8.48 and 7.28 respectively) show that the range of values recorded was not high.

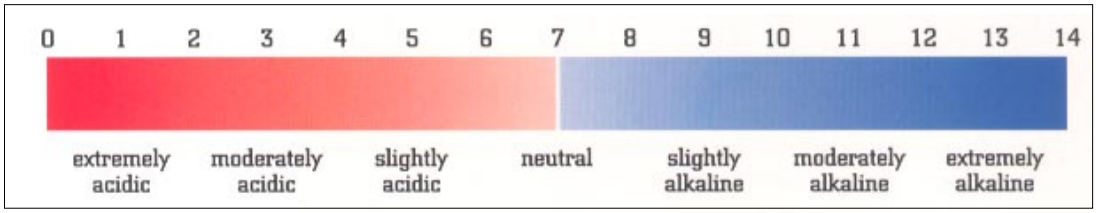


Figure 17. pH scale

Water quality is determined by a variety of parameters. Often these are interrelated, and many vary seasonally. Instream and bank vegetation provides shade for the waterway, regulating its health and limiting the occurrence and severity of algal blooms.

Disturbance

Toodyay Brook can attribute its current condition on a number of past and present disturbances, the key ones being:

- Current farming practices;
- Stock access to waterways;
- Drainage water directed into the waterway and surrounding foreshore vegetation from adjacent roads, changing hydrology and resulting in weed invasion;
- The alignment of the railway line, in many places, within 30 metres of the waterway;
- Overpasses associated with the railway line;
- Crossing points;
- Alignment of Bindi Bindi Road and other minor roads in close proximity to the Brook;
- Frequent fires associated with surrounding farming practices; and
- Railway sidings.

The exclusion of stock from the riparian zone usually requires the erection of a fence. Approximately 47% of the Toodyay Brook is fenced on one or both sides, however, the purpose of these fences was generally not to exclude stock from the waterway, but to provide paddock boundaries.

Livestock access was the most common disturbance factor recorded during surveys along the Brook, with approximately 87% of sites being heavily affected by cattle and sheep. The unrestricted access of these animals to the channel and bank has contributed to the large erosion and sedimentation problems recorded along the Brook. Allowing sheep and cattle to graze along the riverbanks leads to a loss of native vegetation and also helps spread weed species from one part of the property to another. Trampling of the surrounding vegetation and movement of stock through waterways also causes erosion.

Stock may contribute to soil compaction through trampling, as well as a decline in water quality due to manure entering the watercourse either directly or indirectly (through runoff).

Evidence of management

Results showed that there is only a small portion of landholders undertaking measures to improve the health of the Brook and the surrounding riparian zone. In most cases, those who have fenced the waterway have not done so to exclude stock from the riverine environment.

There has been a limited number of landholders along the Toodyay Brook who have undertaken waterways management practices, which may be attributed to the lack of community education and awareness about river management.

Plate 6. Cattle crossing the waterway cause channel and bank erosion

Principles for waterways management

The need for management

The results of this survey indicate a high need for the implementation of appropriate integrated catchment management practices. The purpose of this report is to determine and document the current condition of the Brook 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 of the Toodyay Brook riparian zone and surrounding catchment.

It is hoped that this data will eventually lead to a management or action plan for the catchment surrounding the Toodyay Brook to provide guidance and direction for future management of the waterway.

In rural areas of Western Australia, water resources must be managed sustainably in order that a number of competing needs and demands can be satisfied. These include:

- water for agricultural and pastoral purposes;
- control of flooding and erosion;
- management of soil and water salinity; and
- protection of the environmental values of the stream and surrounding riparian environment (Clement and Bennett, 1998).

A management or action plan should include such things as:

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

Management responsibilities

It is recognised that to manage a waterway successfully there is a need to look after the surrounding native vegetation. The interaction of land components means that any plan to successfully manage the Toodyay Brook will need to manage these components as a whole, and not as individual components.

Management options should not be undertaken in isolation. They should be considered as a combination of objectives implemented as part of a catchment wide approach (integrated catchment management) to improving the health of the riverine system. Toodyay Brook should also not be managed as an entity on its own. Managers should recognise that there are many smaller tributaries feeding in to the Brook which have a vast impact on the quality of water, as well as sediment loads, and channel and foreshore condition.

The establishment of a Friends group for the Toodyay Brook, as well as the contribution of other management groups such as the Phillips Brook Catchment Group (Inc), is vital for the long-term management of the waterway. These groups will require strong support (from government agencies, Local Government Authorities, landholders and the surrounding community) if they are to contribute to the management of the whole catchment.

The objective of management is to resolve competition between incompatible land uses to ensure that those values that are high or irreplaceable are maintained. Efforts should be made to maintain and enhance the quality of the water in Toodyay Brook and adjoining tributaries, in order to conserve ecological systems and meet the needs of present and future generations.

The management system must be able to balance conflicting uses and be flexible enough to respond quickly to changed circumstances or demands (Clement and Bennett, 1998). A flexible plan of management will increase the effectiveness of long term management when dealing with agricultural practices which as highly dependent on climate and other environmental factors.

Management requirements

Weeds management

Weed control should be undertaken with landholders focusing management practices on the best areas and working towards the worst areas. They should focus on declared and pest species, as well as those invasive weeds.

The best way to deal with weeds is to remove the source of seed and then remove any new growth. In most cases it is most effective to work from the edge of the weed infestation towards the centre, and from upstream so that seeds and cuttings do not wash downstream and recolonise areas that have already been subject to weed control.

An integrated catchment management approach should be encouraged as the best way to deal with weeds. Control of weeds needs to be implemented within the immediate area, as well as in upstream areas that provide a source of seeds that 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.

Potentially invasive weeds growing along road verges and along service corridors (access tracks, roads and railway lines) should also be controlled.

Riparian revegetation

Riparian vegetation is an important component of the river ecosystem. In many cases the health of the bank and foreshore vegetation is a good indicator the health of the waterway. For example, when the waterway becomes too saline for certain species, they often die off and are replaced by other more salt tolerant species. A lack of bank and verge vegetation will leave the banks susceptible to erosion and cutting.

Riparian vegetation performs several functions in protecting the health of the river ecosystem (Olsen and Skitmore, 1991) such as those listed below:

- Foreshore and bank vegetation provides important nesting and breeding sites for aquatic and terrestrial fauna;
- Riparian vegetation provides shade over the waterway, thus providing a more favourable habitat for instream fauna;
- The roots and leaf litter from plants help to stabilise the river channel, banks and verge;
- Instream and bank vegetation provides an effective filter for both nutrients and sediment; and
- Woody debris provides important instream habitat and is also useful for bank stabilisation.

Land managers should aim to protect areas of riparian vegetation which are currently in good condition, before working their way out to degraded sites. It is more economically viable to look after the good (weed free) areas rather than committing resources (materials, time and money) to their rehabilitation after they become degraded (Price and Lovett, 1999b). However, this does not mean that degraded areas should be neglected. It means that management works should be prioritised to gain the greatest benefit from available resources.

Fencing of riparian zones is an important management tool that should be used to prevent livestock grazing and trampling of the delicate areas fringing the waterway.

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 Brook; and
- Adjust stocking rates and the frequency of grazing within this zone to suit the carrying capacity of the land (Price and Lovett, 1999b).

Fire management

Fire creates bare open ground, which is ideal for the germination of many weed species. Hence, frequent burning of the riparian zone will lead to rapid invasion of the areas by weeds species.

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 many 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, 1999a).

Firebreaks should be upgraded and maintained along verge areas of the foreshore. An effective firebreak will protect the fragile vegetation from unintentional fires that result from burning of crop and pasture areas. When fencing for protection of riparian vegetation the firebreak should be located on the brook side of the fence, as far away from the bank as possible. A firebreak on the brook side of the fence will allow good access to this zone, and prevents stock pushing the fence over to graze on the other side.

Water quality

The water quality data that was collected during this survey was a "snap shot" showing pH and conductivity of the waterway at a particular point in time. In relation to long-term management this data is useful because it gives an indication of water quality which can be compared to past data taken from the same tributary. If a management plan is to be written up to protect the long-term health of the waterway, water quality should be monitored on a regular basis to determine seasonal fluctuations. Comprehensive monitoring should test physical, chemical and biological parameters including salinity, pH, temperature, flow rate, nutrient levels, sediment loads and macroinvertebrates.

Poor water quality can cause major problems for the health of river and stream ecosystems. Clearing of native vegetation to allow for agricultural development of land surrounding the Toodyay Brook through the Toodyay Valley has had a large impact on the health of the waterway, largely impacting on the sediment loads and the salinity levels of the water (Schofield et al, 1988).

Restriction of stock from the waterway will lead to better water quality. Sheep and cattle are responsible for mobilising plant nutrients, which they distribute via their faeces (Swan River Trust, 1998). Controlled access will minimise the amount of manure within the waterway and hence limit nutrient enrichment of the Brook.

Exclusion of stock from the waterway will prevent the erosion of banks and channel by trampling and crossing of the waterway by animals. Deterring stock movement through the Brook will limit the affect on the turbidity and hence the decline in water quality. (See Appendix 9 for a description of different types of fencing).

Surrounding agricultural land should be managed to minimise the adverse impacts on the Toodyay Brook. Seasonal overstocking of paddocks will lead to the denudation of vegetation and an acceleration of soil erosion. The loose soil particles will be carried into the waterway during periods of rain and wind. Stocking rates should be adjusted to suit the carrying capacity of the land if the production of crops and pasture, as well as an improvement in water quality, is required.

Fertiliser and pesticide sprays applied to crops and pasture can also be washed into the waterway and lead to a decline in the quality of water. Land managers should apply these sprays in accordance with directions provided by the manufacturer. Chemicals should be used appropriately, such as before periods of rain so that the chemicals have a chance to be absorbed by the plants and are not washed straight into the Brook.

Development

A small number of properties along the Brook have houses, sheds and other buildings located close to the waterway, within the immediate floodplain. As the valley is becoming increasingly popular for hobby farmers and those seeking a country weekend escape, it is important that landholders and planners are educated about the potential risks of flooding.

Any future development of land within the region would be through the Shire of Toodyay. Applications for subdivision will be sent to the Western Australia Planning Commission for assessment. These organisations will refer the plans to other relevant agencies including the Water and Rivers Commission and the Avon River Management Authority. Where land development/subdivision is planned for land surrounding waterways it is likely that a Foreshore Management Plan/Agreement will be requested to protect the environmental, social and economic values associated with the channel and foreshore.

Any existing and future landuse should be guided by the Shire of Toodyay Town Planning Scheme, the Ministry of Planning and the Water and Rivers Commission, whilst providing for the protection and enhancement of the environment and the catchment surrounding the Toodyay Brook.

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.

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. This debris often becomes a point of accumulation for smaller debris and leaf litter that is being washed downstream. The collection of debris provides an important habitat for many aquatic organisms. In many instances the Brook has been cleared of this material because many people believe the large woody debris contributes to flooding and bank erosion.

Removal of large woody debris will lead to an increased flow velocity that will cause damage through bank and channel erosion, and the movement of sediments that will be deposited in pools and floodplains. Reintroducing large debris to the system may be undertaken to increase river stability and provide a greater diversity of habitat for native fauna.

Landholders should endeavour to keep the large woody debris in the brook system to ensure a diverse range of habitats for fauna living in the riverine environment. In areas where large woody debris has been removed attempts should be made to add sufficient debris material to the waterway to return it to its natural load. By considering the amount of debris found in healthier parts of the brook (or in rivers 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, 1999b).

Fencing

Fences should be erected along the riparian zone, as far away from the bank as possible, to exclude stock from the stream system. 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. The regeneration of the riparian zone is dependent upon the exclusion of stock from the waterway. Fencing of the zone should follow certain parameters if it is to be of benefit to both the environment and economic pursuits of the landholder.

The type of fence used should be suited to the flood regime. For example, drop fences will drop to the ground during flood events where pressure from water and debris builds up (see Appendix 9 for a description of fence types). In the long-term this is more economical because fences rarely have to be repaired after flood events, they only need to be hung back up. Fences along riparian zones should be located parallel to the Brook 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, 1999b).

Concluding comments

This foreshore and channel assessment has been undertaken to provide interested community groups, Local Government Authorities and private landholders in and around the Toodyay Valley an understanding of the condition of the Toodyay Brook.

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 condition of the waterway into the future.

By using a standard methodology to gather information it is possible to compare and contrast foreshore condition 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/or assess improvements in foreshore and channel condition.

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

The need exists to assess competing landuses and determine a compromise which allows for the rehabilitation and conservation of Toodyay Brook along with sustainable landuse practices (agriculture in most cases) to gain the highest possible advantages (economic, environmental and social) for both now and into the future.

The recorded C-grade condition for the majority of the waterway is related to past and present disturbances, a lack of current management practices, and an overall ignorance of the general community to the benefits of protecting and renewing the high environmental values associated with the Brook.

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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.

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.

Flood plain A flat area adjacent to a waterbody that is covered by floods every year or two.

Floodwayand 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.

Appendix 1

Guide to Soil-landscape systems in the Toodyay Brook Catchment

Source: Agriculture Western Australia, 1999

MU_Symbol	MU_ Name	MU_Landform	MU_Soil
253Cc	Clackline System	Moderately dissected areas with gravelly slopes and ridges and minor rock outcrop.	Grey shallow sandy duplexes, duplex sandy gravels, loamy gravels, pale shallow sands and red shallow loamy duplexes.
253Ug	Udamong System	Partially stripped lateritic plateau.	Loamy gravels and shallow gravels.
253Wn	Wundowie System	Lateritic plateau with some rock outcrops.	Deep sandy gravels, duplex sandy gravels and shallow gravels.
253Yh	Yarawindah System	Dissected lateritic plateau with some rock outcrops.	Loamy gravels, brown loamy earths and grey shallow loamy duplexes and brown deep loamy duplexes.
255Dp	Darling Plateau System	Lateritic plateau.	Duplex sandy gravels, loamy gravels and wet soils.
255Mv	Murray Valleys System	Deeply incised valleys.	Friable red/brown loamy earths, brown loamy earths, loamy gravels, brown deep loamy duplexes, duplex sandy gravels and stony soils.
257Af	Avon Flats System	Alluvial terraces and flats.	Brown loamy earths, grey non-cracking clays and brown deep sands.
257Gh	Greenhills System	Undulating terrain.	Grey deep sandy duplexes, red deep sandy duplexes and red deep loamy duplexes.
257Go	Goomalling System	Poorly drained valley flats.	Grey deep sandy duplexes, alkaline grey deep sandy duplexes and saline wet soils.
257Jc	Jelcobine System	Major valleys with isolated lateritic remnants.	Red deep and shallow sandy and loamy duplexes, grey deep sandy duplexes, bare rock and cracking and non-cracking clays.
257Mb	Morbinning System	Undulating sandplain remnants, breakaways and slopes.	Grey deep sandy duplexes (often alkaline), pale deep sands and yellow sandy earths.
257Ps	Phillips Sandplain System	Gently undulating sandplain with poorly drained seepage areas and lakes.	Pale deep sands, yellow sandy earths and yellow deep sands.

Appendix 2

Tributary assessment form

Property Scale Assessment

General Details

Tributary Name: .....

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

River Section Number: ..... Length of Section: .....

Catchment Name: .....

Subcatchment Name: .....

Shire Name: .....

Nearest Road Intersection: .....

Aerial Photo Reference: .....

Number on Location Map: ..... GPS Reference: N .....

E .....

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	Major undercutting	Firebreak/track washouts	Subsidence	Erosion	Slumping	Sedimentation
0-5% Minimal							
5-20% Localised							
20-50% Significant							
>50% Severe							

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

Give details:

Waterways Features

- ☐ Single channel
- ☐ Braided channel
- ☐ Pool
- ☐ Wetlands
- ☐ Weir
- ☐ Groundwater
- ☐ Billabong
- ☐ Rapids
- ☐ Riffle
- ☐ Bridge
- ☐ Sand slugs
- ☐ Vegetated islands
- ☐ Other .....

Description:

Foreshore Condition Assessment

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

(Choose one of the above - rate between A1 and D3)

General: ..... Best: ..... Poorest: .....

Foreshore Vegetation

Floodway & bank vegetation: ☐ Excellent ☐ Good ☐ Moderate ☐ Poor ☐ Very poor

Verge vegetation: ☐ Excellent ☐ Good ☐ Moderate ☐ Poor ☐ Very poor

Stream cover: ☐ Excellent ☐ Good ☐ Moderate ☐ Poor ☐ Very poor

Bank stability & erosion: ☐ Excellent ☐ Good ☐ Moderate ☐ Poor ☐ Very poor

Habitat diversity: ☐ Excellent ☐ Good ☐ Moderate ☐ Poor ☐ Very poor

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	

Comments:

Vegetation Health

☐ Looks healthy ☐ Some sick trees ☐ Many sick or dying trees ☐ Some dead trees ☐ Many dead trees

Leaf Litter

☐ Absent ☐ Minimal cover ☐ Good cover ☐ Deep cover

Are there any tree seedlings or saplings present?: ☐ Yes ☐ No

Bare Ground: % cover .....

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?

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

Landform Types

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

Fencing Status

Fence present? ☐ Yes ☐ No

Fence condition: ☐ Good ☐ Moderate ☐ Poor

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

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

Stock access to foreshore: ☐ Yes ☐ No

Vehicle access to foreshore: ☐ Yes ☐ No

Crossing Point: ☐ Yes ☐ No

Surrounding Landuse

Tick the box which best describes the surrounding landuse

- ☐ Conservation reserve
- ☐ Rural residential
- ☐ Urban
- ☐ Remnant bush
- ☐ Agriculture
- ☐ Commercial/industrial

Details:

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			
Recreation			
Garden Refuse			
Service Corridors			
Stock in River			
Grazing			
Crossing point			
Feral Animals			
Point source discharge			
Pumps or off-take pipes			
Dam/weir			
Hydrological disturbance			
Vandalism			
Antisocial behaviour			
Cultural Features			

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: .....

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)
Rural residential (4)
Urban (2)
Remnant bush (6)
Agricultural (2)
Commercial/industrial (1)

Total score = ☐

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

Environmental rating = ...

Vegetation

Plant Name	Abundance (high, medium, low)

Water Quality Data

Sample Number	pH	Conductivity	Temperature

Photos

Photo Number	Description

Appendix 3

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

Property Scale Assessment

General Details

Tributary Name: Toodyay Brook

Recorder's Name: P. Janssen

Survey Date: 2 April 2000

River Section Number: TB014

Length of Section: 1.5 Km

Catchment Name: Avon River

Subcatchment Name: Toodyay Brook

Shire Name: Toodyay

Nearest Road Intersection: Bindi Bindi Road and Coondle West Road

Aerial Photo Reference: WA3668 5263

Number on Location Map: 9

GPS Reference: N 6467071
E 491642

Landholder contacted: Yes ✓ No ☐
Landholder consent obtained: Yes ✓ No ☐
Landholder present during survey: Yes ☐ No ✓

Bank(s) surveyed (facing upstream)
left ☐ right ☐ both ✓

Landholder: John and Sandra Smith

Contact Number: 9574 1111

Property address: Toodyay-Bindi Bindi Road, Toodyay

Bank Stability

Proportion of bank affected (% of survey area)	Undercutting	Major undercutting	Firebreak/track washouts	Subsidence	Erosion	Slumping	Sedimentation
0-5% Minimal			✓				
5-20% Localised		✓		✓		✓	✓
20-50% Significant	✓				✓		
>50% Severe							

Are the banks subject to any artificial stabilisation?: ☐ Yes ✓ No
Give details:

Waterways Features

☐ Single channel
✓ Braided channel
☐ Pool
☐ Wetlands
☐ Weir
☐ Groundwater
☐ Billabong

☐ Rapids
✓ Riffle
☐ Bridge
✓ Sand slugs
✓ Vegetated islands
✓ Other: Drains

Description: Large anabranch coming off the main channel.
Lots of log and rock riffles.

Foreshore Condition Assessment

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

(Choose one of the above - rate between A1 and D3)

General: C Best: B3 Poorest: D1

Foreshore Vegetation

Floodway & bank vegetation: ☐ Excellent ☐ Good ☐ Moderate ✓ Poor ☐ Very poor

Verge vegetation: ☐ Excellent ☐ Good ☐ Moderate ✓ Poor ☐ Very poor

Stream cover: ☐ Excellent ☐ Good ✓ Moderate ☐ Poor ☐ Very poor

Bank stability & erosion: ☐ Excellent ☐ Good ✓ Moderate ☐ Poor ☐ Very poor

Habitat diversity: ☐ Excellent ✓ Good ☐ Moderate ☐ Poor ☐ Very poor

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	70%
Understorey	10%

Comments:

The only native understorey was the Spiny Flat Sedge (*Cyperus gymnocaulis*)

Vegetation Health

☐ Looks healthy ✓ Some sick trees ☐ Many sick or dying trees ☐ Some dead trees ☐ Many dead trees

Leaf Litter

☐ Absent ✓ Minimal cover ☐ Good cover ☐ Deep cover

Are there any tree seedlings or saplings present?: ✓ Yes ☐ No Flooded gum

Bare Ground: % cover: 5%

Habitat Diversity

Any data or observations on variation in water depth?

Exposed tree roots. Anabranches and other flood channels.
Debris along floodplain and in trees. Bank erosion and cutting.

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

Sheep/cattle manure in and around waterway.
Foam on water surface - indicating salt. Moderate sediment load.
Discolouration of water. Algea.

Any wildlife (or evidence of presence) observed?

Frogs
Dragonflys
Birds
Ducks
Spiders
Butterflies
Rabbits
Catarpillars
Foxes
Minows
Gilgies
Ants
Flies

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

Landform Types

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

Steep incised valley.
Rocky outcrops of dolerite and granite.

Fencing Status

Fence present? ✓ Yes □ No

Fence condition: □ Good ✓ Moderate □ Poor

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

Fence position (approximate distance [m] from river bank): LB = 10m RB = 25m

Stock access to foreshore: ✓ Yes □ No

Vehicle access to foreshore: ✓ Yes □ No

Crossing Point: □ Yes ✓ No

Surrounding Landuse

Tick the box which best describes the surrounding landuse

- ☐ Conservation reserve
- ☐ Rural residential
- ☐ Urban
- ☐ Remnant bush
- ✓ Agriculture
- ☐ Commercial/industrial

Details:

Sheep and cattle grazing.
Some cropping activities further away from the watercourse.

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		✓	
Recreation			
Garden Refuse			
Service Corridors	✓		
Stock in River	✓		
Grazing	✓		
Crossing point		✓	
Feral Animals		✓	
Point source discharge			
Pumps or off-take pipes			
Dam/weir			
Hydrological disturbance			
Vandalism			
Antisocial behaviour			
Cultural Features			

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: Feral animal baiting

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)
Rural residential (4)
Urban (2)
Remnant bush (6)
Agricultural (2)
Commercial/industrial (1)

Total score = 19

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

Environmental rating = Poor

Vegetation

Plant Name	Abundance (high, medium, low)
Guildford grass	H
Soursob	H
Barley grass	M
Eucalyptus rudis	M
Cyperus gymnocaulis	L
Wild oat	M
Pattersons Curse	M
Melaleuca rhaphyphilla	L
Wild turnip	M
Watsonia	H
Caltrop	M
Fat hen weed	M
Erodium	H
Cape tulip	M
Wild raddish	L
Juncus acuta	L
Jam tree	L

Water Quality Data

Sample Number	pH	Conductivity	Temperature
1	7.78	12.5mS/cm	19.6°C
2	8.13	12.6mS/cm	19.7°C
3	7.82	12.1mS/cm	20.2°C

Photos

Photo Number	Description
1	Foreshore condition
2	Riffle
3	Debris in waterway
4	Dying foreshore vegetation
5	Channel condition
6	Bank erosion
7	Surrounding landuse
8	Foreshore condition
9	Crossing
10	Stock in river
11	Weed coverage
12	Channel condition
13	Sediment slugs
14	Regeneration of *Eucalyptus rudis*

Appendix 4

Overall stream environmental health rating

Living Streams Survey: Information to determine environmental ratings of streamlines (Pen and Scott, 1995)

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

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)
Rural residential (4)
Urban (2)
Remnant bush (6)
Agricultural (2)
Commercial/industrial (1)

Total score = ☐

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

Environmental rating = ...

Appendix 5

Charts depicting channel stability

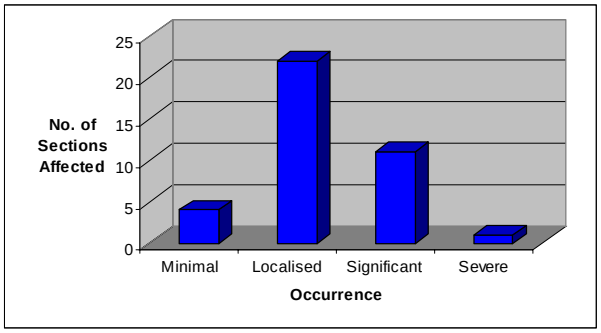


Chart 1. Extent of Undercutting along Toodyay Brook

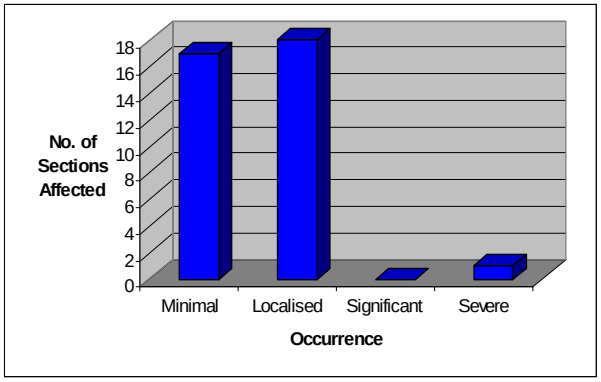


Chart 2. Extent of Major Undercutting along Toodyay Brook

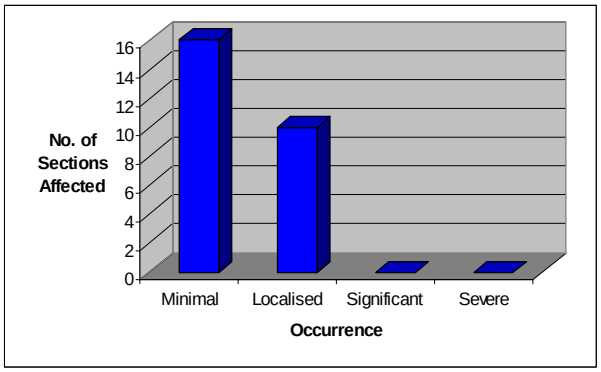


Chart 3. Extent of Firebreak/track Washouts along Toodyay Brook

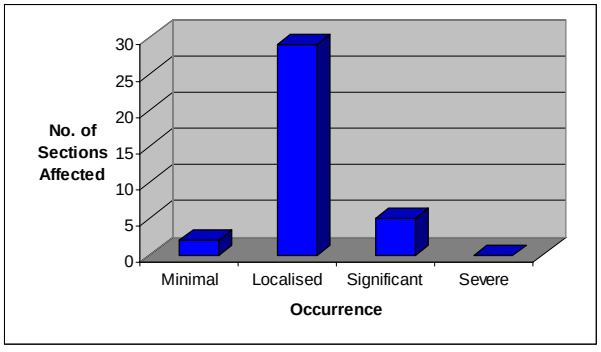


Chart 4. Extent of Subsidence along Toodyay Brook

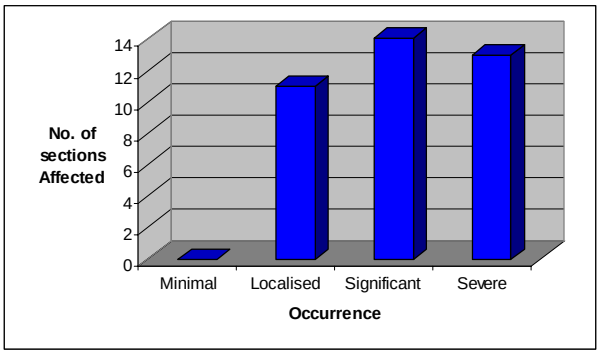


Chart 5. Extent of Erosion along Toodyay Brook

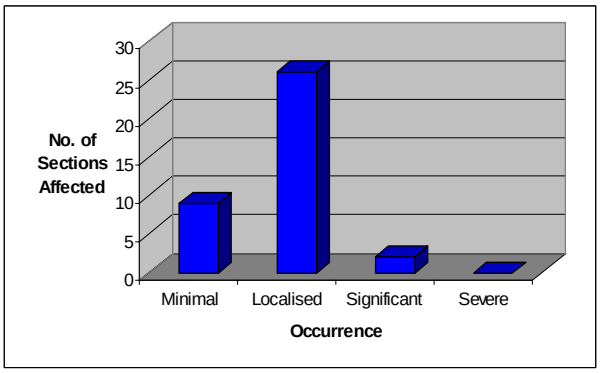


Chart 6. Extent of Slumping along Toodyay Brook

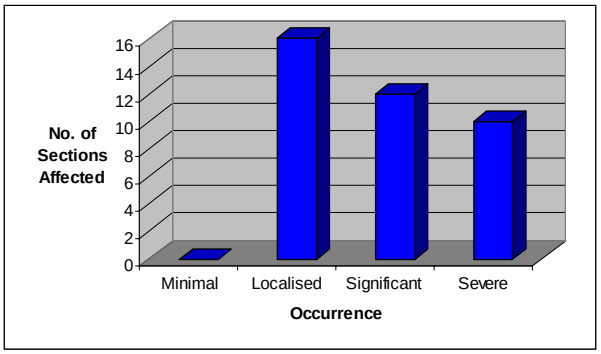


Chart 7. Extent of Sedimentation along Toodyay Brook

Appendix 6

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

The 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, but there are 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

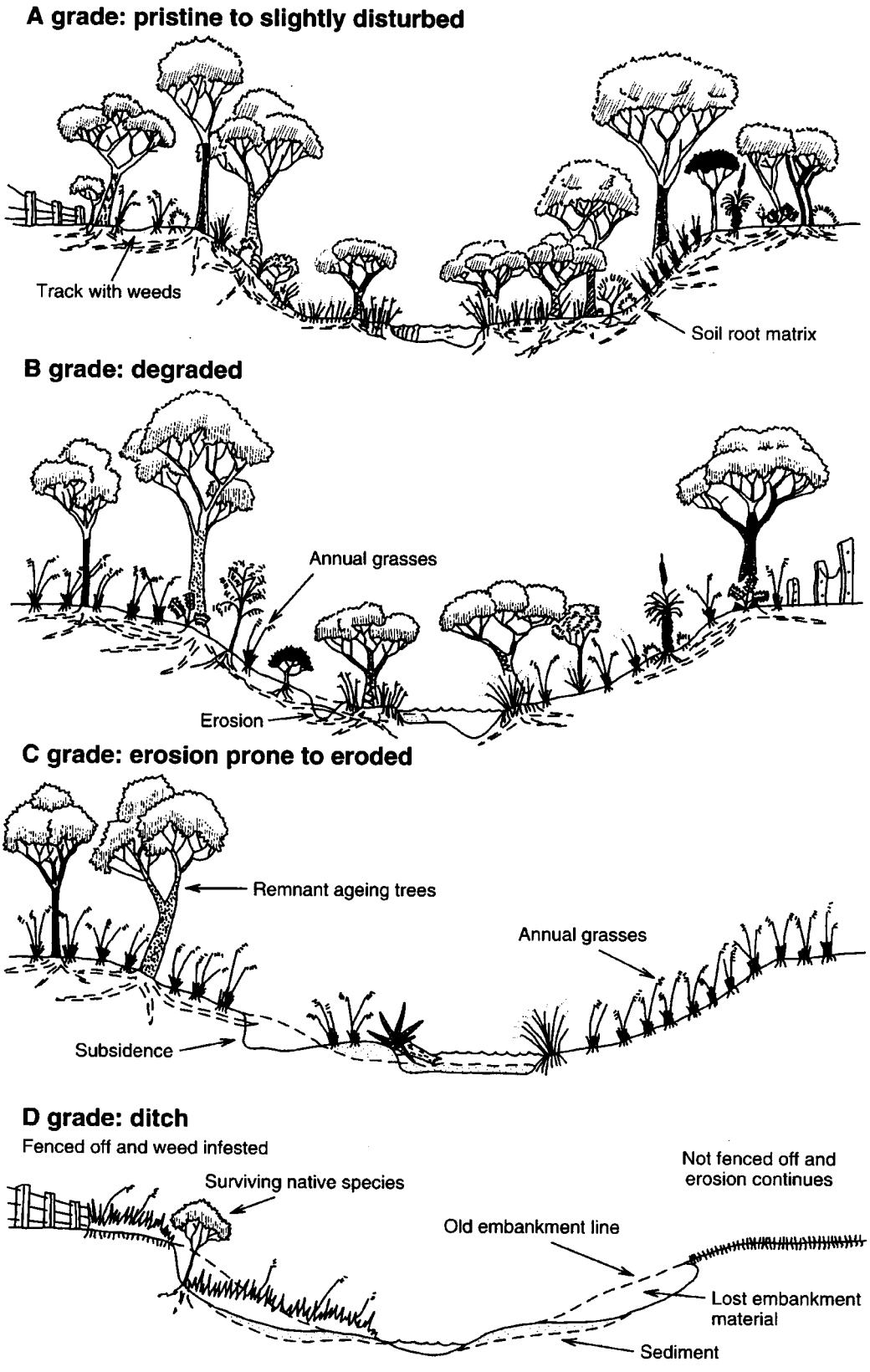
There is not enough fringing vegetation to control erosion. Remaining trees and shrubs act to impede erosion in some areas, but are doomed to be undermined eventually.

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 7

Vegetation recorded along Toodyay Brook

Native vegetation found along Toodyay Brook

Common Name	Scientific Name
Common spikerush	*Eleocharis acuta*
Creeping brook weed	*Samolus repens*
Flooded gum	*Eucalyptus rudis*
Jam tree	*Acacia acuminata*
-	*Lobelia alata*
Marine couch	*Sporobolus virginicus*
Mohan	*Melaleuca viminea*
Needlebush	*Hakea preissii*
Salmon gum	*Eucalyptus salmonophloia*
Smooth heliotrope	*Heliotropium curassavicum*
Spiny flat sedge	*Cyperus gymnocaulis*
Swamp paperbark	*Melaleuca rhaphiophylla*
Swamp sheoak	*Casuarina obesa*
Wandoo (White gum)	*Eucalyptus wandoo*
Waterbuttons	*Cotula coronopifolia*
York gum	*Eucalyptus loxophleba*

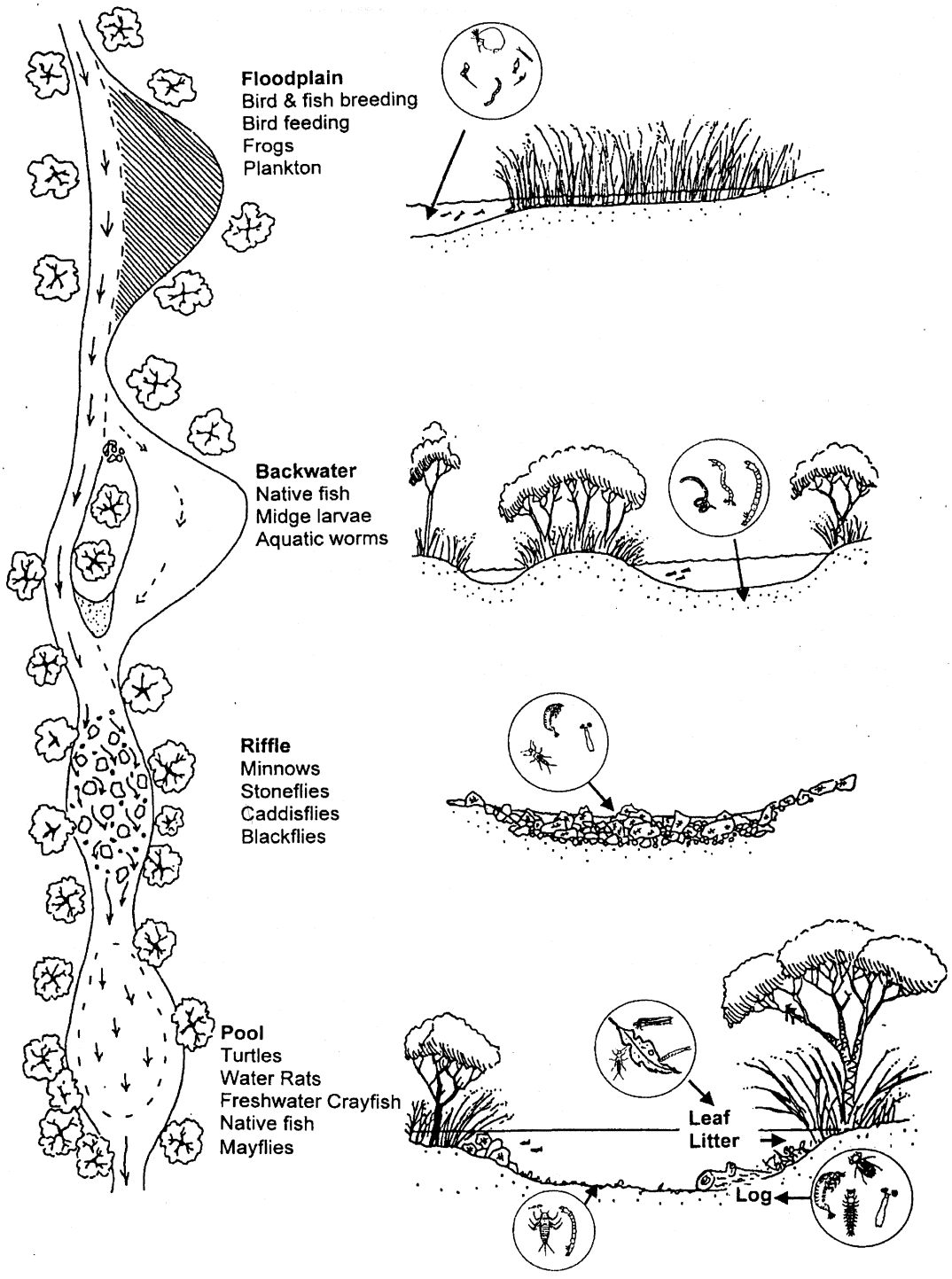
Weeds found along Toodyay Brook

Common Name	Scientific Name
Bamboo	*Arundo donax*
Barley grass	*Hordeum leporinum*
Blowfly grass	*Briza maxima*
Bridal creeper	*Asparagus asparagoides*
Bulrush	*Typha*
Caltrop	*Tribulus terrestris*
Corkscrews	*Erodium botrys*
Couch	*Cynodon dactylon*
Doublegee	*Emex australis*
Fat hen	*Chenopodium album*
Flatweed	*Hypochaeris radicata*
Guildford grass	*Romulea rosea*
-	*Oxalis hirta*
Patterson's curse	*Echium plantagineum*
Sheep's sorrel (dock)	*Rumex acetosella*
Soft brome	*Bromus hordeaceus*
Sour sob	*Oxalis pes-caprae*
Spike rush	*Juncus acutus*
Stinkwort	*Dittrichia graveolens*
Turnip weed	*Rapistrum rugosum*
Watsonia	*Watsonia sp.*
Wild oat	*Avena fatua*
Wild melon	*Citrullus lanatus*
Wild radish	*Raphanus raphanistrum*
Wire weed	*Polygonum aviculare*

Appendix 8

Habitats found along waterways

Source: Water and Rivers Commission, 2000



Appendix 9

Fencing types

Barbed wire fence

Any fence that is in part barbed wire and which is not electrified.

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 with four plain wires of which two are electric.

Fabricated fence

Includes rabbit netting, ringlock and hinge point fences.

Plain wire fence

Consists of multiple strands of plain wire.

Drop fence

Designed to be either manually dropped before a flood, or dropped at anchor points under the pressure of floodwater and debris.

Hanging fence

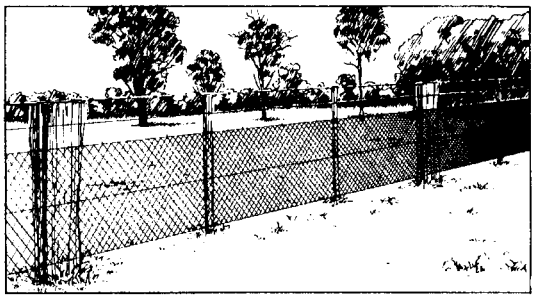
A suspended fence made of steel cable or multi-stranded, high tensile wire, where the purpose is to keep animals from walking along waterways to bypass fencelines.

Types of Fencing Systems

Traditional Fencing

A traditional or conventional fence contains one or more of the following elements:

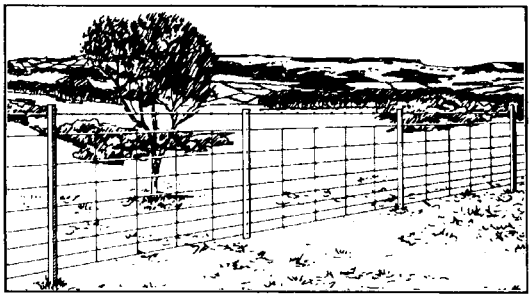
1. Posts spaced at close intervals.
2. A mixture of post types, e.g. timber and steel.
3. Line posts of unnecessarily large dimensions.
4. Soft wires, either plain or barbed.
5. Wire tensioned by guesswork.
6. Plain wires firmly stapled to posts or wires run through bored holes in wooden posts.
7. Inefficient strainer assemblies.



Suspension Fencing

This type of fence is characterised by:

1. Strainer assemblies designed and constructed to minimise movement.
2. High tensile wire.
3. Widely spaced posts of uniform type.
4. Long strains.
5. Suspended droppers.
6. Measured tension on wires.



In appearance, suspension fencing differs from traditional or conventional fencing in the considerably wider spacing of the posts. In function, impact loads imposed on a suspension fence are mainly transferred to the strainer assemblies via the wire, whilst in conventional fences most of the loads are borne by the line posts nearest the point of impact.

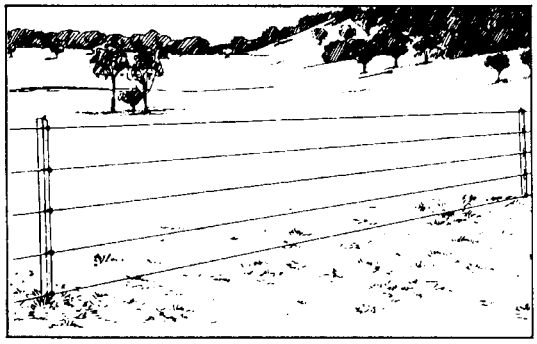
The benefits of suspension fencing are lower costs for materials and labour, and in most instances, equivalent or better stock control.

Fences should constitute a barrier to stock and vermin under normal conditions. To attempt to provide 100 percent security may be justified in vermin or disease control programmes. However, in most livestock management situations, it is more economical to slaughter or sell rogue animals than erect over-engineered conventional fencing throughout the property.

Electric Fencing

Electric fencing is similar to suspension fencing except that it uses electrified plain wires to deter animals from touching the fence. An energiser is used to power the fence, sending out a high voltage pulse about once every second. Care must be taken however to build the fence properly: attempts to short-cut recommended designs will lead to failure. Because the fence uses an electric shock to deter animals it can be somewhat lighter in construction than a conventional fence, but this shouldn't be taken to extremes.

When planning electric fencing, consider not only the animals to be controlled but also the terrain. In the past, many 'permanent' electric fences were built too lightly for the conditions and have therefore failed.



Because electric fencing uses a high voltage pulse it has proved very suitable for the control of feral animals such as kangaroos, pigs and dogs as well as domestic stock. In general, however, electric fencing has been most commonly used in conjunction with conventional and suspension fencing, enhancing its effectiveness and, in the case of heavy stock, reducing fence damage.

Some farmers have found a need to change their stock management slightly when they adopted electric fencing. No longer can they force a mob of sheep into a corner, nor can they run the stock hard along a fence. In some cases conventional fencing may prove more suitable. Conventional fencing should be used in areas where stock pressures are high, i.e. near sheds and yards, although a single offset wire on the inside of a bull paddock can be very effective.

Source: Australian Wire Industries, 1993

Appendix 10

Salinity data

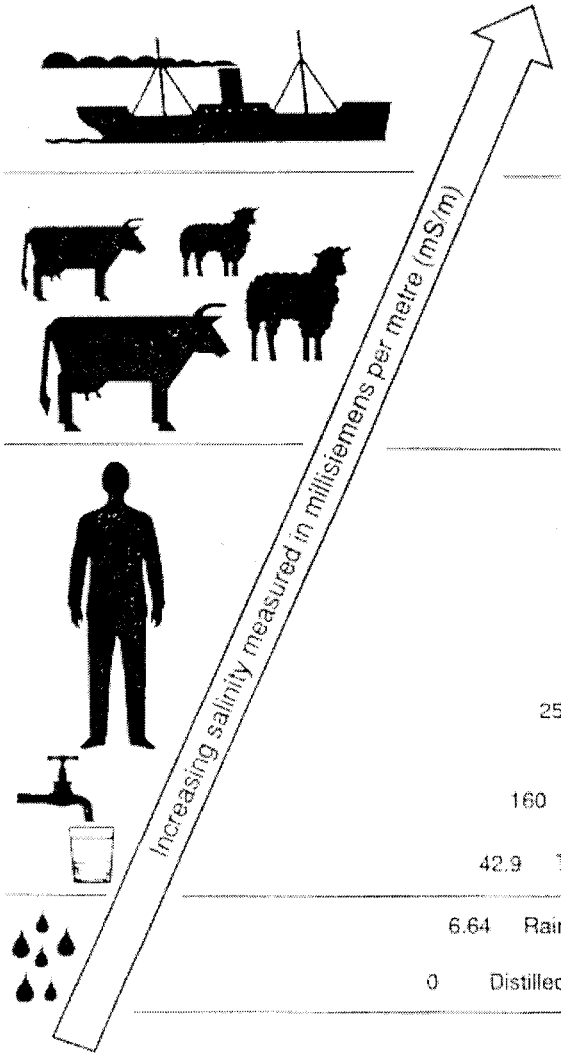
Salt Tolerance Ranges

Electrical Conductivity	Water Status	Use
0 - 1 mS/cm	Fresh	Fresh water suitable for human consumption.
1 – 2 mS/cm	Marginal	Acceptable as drinking water and for most irrigation (ranging with crop type, soil type and level of drainage).
2 – 9 mS/cm	Brackish	Acceptable for most stock and some irrigation.
9 – 20 mS/cm	Low Saline	Limited farm use. 10 mS/cm Maximum drinking water for horses. 11 mS/cm Maximum drinking water for lambs, weaners and breeder ewes. 16.5 mS/cm Maximum drinking water for beef cattle. 23 mS/cm Unacceptable for most stock use unless during emergency – maximum drinking water for sheep.
20 – 45 mS/cm	High Saline	
> 45 mS/cm	Hyper Saline	

Compiled by Stephanie Cobb (Avon Coordinator, Ribbons of Blue) July 2000. Based on 'National Water Quality Management Strategy' ANZECC Guidelines for Fresh and Marine Waters (1992).

EXAMPLES OF WATER SALINITY LEVELS AND RECOMMENDED MAXIMA FOR DOMESTIC AND FARM USE

EC (Electrical Conductivity), mS/m



55,000 Dead Sea

5,800 Pacific Ocean

2,300 Maximum for drinking water for sheep

1,650 Maximum for drinking water for beef cattle

1,100 Maximum for drinking water for lambs, weaners and breeder ewes

1,000 Maximum for drinking water for horses

750 Maximum for drinking water for pigs

580 Maximum for drinking water for milking cows and poultry

250 Maximum for drinking water for human beings

160 Maximum for hot water systems

42.9 Tap water Katanning May 1992

6.64 Rain water Katanning May 1992

0 Distilled water

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