AVON WATERWAYS COMMITTEE
RIVER RECOVERY PLAN
Sections 1 and 2 – 'Avon Gorge' and 'Deepdale Valley'

prepared by

Viv Read & Associates
for
Water and Rivers Commission
and
Avon Waterways Committee

As of 31 December 2001 the name of the Avon River Management Authority has changed to Avon Waterways Committee

WATER AND RIVERS COMMISSION
RIVER RECOVERY PLAN
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Avon Waterways Committee

We welcome your feedback

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Cover Photographs:
Top – Pristine section of Avon Gorge
Bottom – Sediment filled riverbed
Photographs courtesy of Ecoscape

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Contents

Acknowledgments ii

Reference details ii

Preface v

1 Introduction 1

1.1 Recovering the Avon River 1

1.2 The Distinctive Character of the Avon 1

1.2.1 Natural drainage for the Avon River Basin 1

1.2.2 River flow 1

1.2.3 Floods and flood management 2

1.2.4 The inland catchments 2

1.2.5 The river pools 2

1.2.6 Biological diversity 2

2 Description of river sections 1 and 2 4

2.1 Physical description 4

2.1.1 Adjacent landscape 4

2.1.2 River channel 4

2.1.3 Streamflow and salinity levels 4

2.1.4 Riparian Vegetation 5

2.1.5 Pools 5

2.1.6 Tributaries 7

2.1.7 Land use, infrastructure and community interest 8

3 River channel survey results 10

3.1 Sediments and channel stability 10

3.2 Vegetation condition 10

3.3 General condition 10

4 River recovery planning 11

4.1 A 'Vision' for the River 11

4.2 Local Management Objectives 11

5 Management actions 12

5.1 A local river profile 12

5.2 River pools and sediments 13

5.3 The riparian zone 14

5.4 Macro-corridors for biodiversity 15

5.5 Stream salinity, nutrients and pollution 16

5.6 Access and use of the river 16

5.7 Roles and responsibilities 17

6 Implementation of the recovery plan 18

7 Recovery plan summary 21

References 23

Appendix one: Management sections of the Avon River 24

Appendix two: Major confluences and pools for each section of the Avon River 25

Appendix three: Summary survey information for River Sections 1 and 2 26

Summary for Section 1 26

I Main overstorey species present 26
II Vegetation death 27
III Fencing 27
IV Other native species present 27
V Weed species present 27
VI Vegetation condition 27
VII Regeneration 27
VIII Disturbance factors 27

Summary for Section 2 28

I Main overstorey species present 28
II Vegetation death 28
III Fencing 28
IV Other natives species present 28
V Weed species present 29
VI Vegetation condition 29
VII Regeneration 29
VIII Disturbance factors 29

Appendix four: Summary of streamflow and water quality records for Walyunga gauging station 30

Publication feedback form 33

Maps

1 River Recovery Plan Sections vi
2 Avon River Basin Catchment 3
3 Sections 1 and 2 9

Preface

This Recovery Plan covers two important sections of the river between the Avon Valley National Park and Deepdale Road, near West Toodyay bridge. Sections 1 and 2 include four major pools and the confluence of four major tributaries. The Avon is scenic in these sections as it descends through a hilly landscape towards the Swan Coastal Plain. It is well recognised by those who travel east from Perth by train. These sections are also renown by those involved in the long-running 'Avon Descent' both for the challenging 'Ti-tree Thickets' and for the overnight campsite at Cobblers Pool.

The Avon River has suffered a few setbacks over the past 50 years. The effects of sediment filling river pools following the River Training Scheme, which was intended to reduce flooding, is well known. However there are other threats to this once majestic river. Algae often bloom in the remaining river pools during summer due to there being too many nutrients, and ever-increasing salinity is also a problem for the river.

The Avon Waterways Committee (AWC) was formed in January 2002 as a community-based sub-committee to the Board of the Water and Rivers Commission to provide advice on waterways issues. The AWC will also advise the Avon Catchment Council on waterway management issues.

A strategic approach to river management is outlined in the 'Avon River Management Programme' developed by the former Avon River Management Authority. Their Mission for waterway management is '*…to restore and manage the natural functions of the Avon River system for the long-term benefit of the community.*' Members of the AWC are optimistic about making a difference.

An important step in management of the Avon River was to identify 18 sections of the main channel for planning purposes. Recovery Plans will be prepared for all sections. Management of the major tributaries will also be considered.

The purpose of the Recovery Plan for Sections 1 and 2 is to carefully consider the options for management of those key issues that threaten the health of the river. A Recovery Team including landholders along the river, interested community members, AWC members and Water and Rivers Commission representatives have met to prepare the plan. The AWC is keen to encourage this partnership approach to continue beyond the plan in order to ensure good local river management.

The river has suffered enough. Now is the time for us to do what we can to return it to the magical place that some can remember. I look forward to continuing interest in the implementation of this plan.

Alan Cole
Chairman, Avon Waterways Committee

Map 1: River Recovery Plan Sections

1 Introduction

1.1 Recovering the Avon River

The Avon River Management Programme outlines a strategic approach for recovery of the river from its current poor health. One key strategy is to segment the main channel of the Avon River into 18 sections for management (Map 1. River sections are described in Appendix One).

This Recovery Plan is for approximately 22 km of the Avon River in Sections 1 and 2 that occurs between the Avon Valley National Park and Deepdale Road located 7 km downstream from the town of Toodyay in the south-west of Western Australia.

A comprehensive management survey for all sections of the Avon River was completed during 1996. Detailed site information was recorded at 500m intervals for the entire 191 km of main channel length of the river. Additional surveys of the river pools were undertaken. This information helps to identify the relative importance of management issues for the complete river system. A summary of information from the survey for Sections 1 and 2 is provided in Appendix 3.

The recovery planning process is based on a partnership approach that links landholders along the river, government agencies and the broader community to achieve common goals. It is important to first understand the river as part of the Avon River Basin.

1.2 The distinctive character of the Avon

1.2.1 Natural drainage for the Avon River Basin

The Avon River Basin is a major Australian river system that is dominant in the central wheatbelt of the Southern Land Division in Western Australia. It covers an area of over 120 000 km^2, which is larger than the area of Tasmania. It extends north of Wongan Hills, south of Lake Grace and east of Southern Cross (Map 2).

The Avon River Basin is also significant because it drains to the Swan-Canning Estuary that is central to the character of the State's capital city, Perth.

The Avon river basin differs to those in other countries. The inland areas of the basin have low rainfall and low landscape gradient. Both rainfall and gradient increase downstream. Most rivers start in mountains or hills with high rainfall, and discharge to a drier coastal area with a low gradient floodplain or delta.

The Avon River and the Swan River are in fact the same river. There is no 'confluence'. The two names simply represent an historical anomaly. The Avon is taken as that section of the river inland of the entry of the Wooroloo Brook at Walyunga. The main channel of the river extends upstream to Wickepin. The South Branch of the Avon begins near Pingelly, flows through Brookton and joins the main river channel downstream of the Yenyening Lakes (Map 2).

The major tributaries of the Avon River downstream from the Yenyening Lakes are:

- South Branch, which rises near Pingelly
- Dale River (including Talbot Brook);
- Mackie River;
- Bland's Brook;
- Spencer's Brook;
- The Mortlock Rivers (North, South and East branches);
- Wongamine Brook;
- Harper's Brook;
- Boyagerring Brook;
- Toodyay/Yulgan Brook;
- Jimperding Brook;
- Julimar Brook;
- Red Swamp Brook;
- Brockman River;
- Wooroloo Brook.

1.2.2 River flow

The winter Avon usually commences to flow in April after the onset of winter rains and with falling temperatures and evaporation. In most years flow diminishes or ceases before Christmas. At 'Broun's Farm' gauging station (between Beverley and York downstream from the Dale River confluence) the river has significant flow on average for 286 days or 78% of the year. At Walyunga, where the Avon becomes the Swan River, the average flow is 310 days or 85% of the year. In a dry year, the river above 'Broun's

Farm' contributes only 12% of total river flow; in a wet year this can rise to over 40%.

The rate of flow of the Avon River is estimated to have increased by a factor of 3 to 4 since the River Training Scheme and the clearing of the catchment.

1.2.3 Floods and flood management

The major flood years have been: 1910, 1917, 1926, 1930, 1945, 1946, 1955, 1958, 1963, 1964, 1983 and 2000.

Flooding of riverside towns (Beverley, York, Northam and Toodyay) and of agricultural land along the river, was the principal concern that led to the River Training Scheme. This scheme involved:

- removal of channel vegetation and debris to a width of 60 metres;
- removal of dead trees, logs and debris which impaired the river flow;
- ripping of the river bed to induce erosion of a deeper watercourse; and
- removal of minor kinks and bends in the river.

The success of the scheme in ameliorating townsite flooding is unresolved. No floods of more than 50-year magnitude have occurred since the works were completed, perhaps because rainfall has generally been lower than average over this period.

1.2.4 The inland catchments

There are four catchments that make up the Avon River Basin (Map 2).

- The Avon
- The Mortlock
- The Yilgarn
- The Lockhart

The Yilgarn and Lockhart catchments, which drain to the Avon through the Yenyening Lakes, have low or intermittent flow through drainage lines that are usually comprised of chains of shallow salt lakes. The contribution to water flow in the Avon River from these catchments is generally less than 10% although the contribution of salt is high.

1.2.5 The river pools

The Avon River between the Avon Valley National Park and the Yenyening Lakes originally had 26 major pools that were about 70 metres wide and varied in length from 370 metres to 2 kilometres. Some were over 10 metres deep.

Many of the pools are now filling with sediment and are subject to eutrophication due to nutrient enrichment. (Jim Davies & Associates. Avon River Pool Survey 1997).

The following pools are now totally filled:

Mile Pool, Egoline Pool, Muresk Pool, Deepdale Pool, Cold Harbour Pool, Mt Hardy Pool and Burlong Pool

The following pools are almost filled:

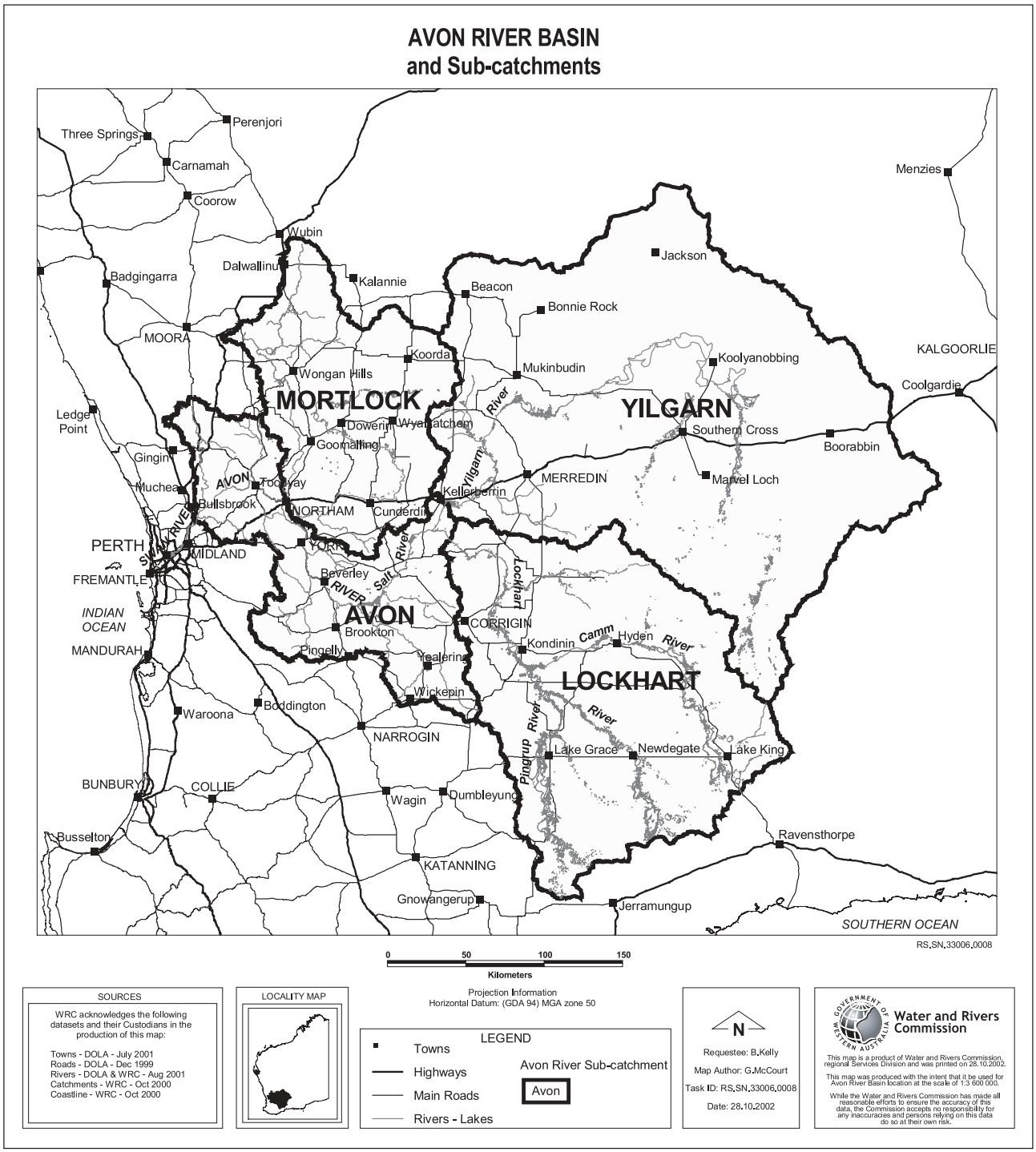
Speldhurst Pool, Tipperary Pool, Yangedine Pool, Katrine Pool, Oakover Pool and Jimperding Pool

1.2.6 Biological diversity

A very high proportion of the Avon River Basin has been cleared of natural vegetation for agriculture. The original ecosystems are now represented by roadside verges, patches of bush in reserves, or on farms in agricultural areas. Fringing vegetation of the Avon River, its tributaries and lakes provide one thin corridor for connection of these remnants.

The river is also significant in this altered landscape as summer and drought refuge for wildlife.

The river, and in particular the pools, are ecosystems that have adapted to fluctuating environmental conditions. However increasing salinity, sediments and nutrient enrichment and/or a changing flow regime still threaten these ecosystems.



Map 2: Avon River Basin catchment

2 Description of river sections 1 and 2

2.1 Physical description

2.1.1 Adjacent landscape

The Avon River drains through a valley ranging from 4 to 10 km in width in a well dissected landscape described as the Zone of Rejuvenated Drainage (Lantzke and Fulton, 1992). The elevation of the valley is from 90 m up to approximately 340 m Australian Height Datum (AHD).

The regional geology and general landscape physiology are well described by Lantzke and Fulton (1992). They also describe five landscape units relevant to the area:

Avon – alluvial terraces and floodplains adjacent to the Avon and lower Mortlock Rivers and Wongamine Brook with red loamy, grey clayey and orange sandy soils. Slopes are generally less than 1%.

Michibin – steep, irregular hills with slopes of 2-12% containing rocky, red and brownish loamy soils formed from freshly exposed bedrock. Commonly occurs on mid-slopes adjacent to rock outcrops.

York – steep hilly landscape with slopes of 3-12% that contain red and brown greyish loamy soils formed from freshly exposed bedrock.

Steep Rocky Hills – areas of bare rocky hills with steep slopes (10% to over 30%) containing generally shallow rocky red and brownish grey loamy soils.

Hamersley – narrow minor drainage lines generally within the York landscape unit and leading down to major drainage systems. They contain waterlogged greyish loamy soils and have slopes of 1-6%.

The Avon unit is effectively the river floodplain where soils are derived from former river channels or deposited by floods. This unit is limited to one small section east of the river extending down from Deepdale Road and is generally less than 200 m in width. Some of this area will be subject to flooding. All other landscape units adjacent to the river are steep hills.

These sections of the river are without a significant floodplain due to the relatively recent development of the steep, rocky adjacent landscape and due to the relatively steep riverbed gradient that allows floodwaters to discharge rapidly.

2.1.2 River channel

The river is orientated south from Deepdale Road for 2.5 km then trends westward with one broad meander that encompasses Cobblers Pool. The total channel length from Deepdale Road to the Avon Valley National Park is 19 km.

The river bed gradient is approximately 0.25% for Section 1 and 0.08% for Section 2. Table 1 shows that the river gradient for Section 1 is significantly higher than for other sections upstream as it commences the descent through the Darling Scarp.

Table 1: Avon River gradient from the Avon Valley National Park upstream to Northam

Avon River Section	Length (km)	Height difference (m)	Gradient (%)
Avon Valley National Park (boundary) to Jimperding Brook (Section 1)	7.73	19.0	0.246
Jimperding Brook to Deepdale Road (Section 2)	8.14	6.4	0.079
Deepdale Road to Goomalling Road bridge (Section 3)	9.16	7.4	0.081
Goomalling Road bridge to Glen Avon Weir (Section 4)	11.30	11.2	0.099
Glen Avon Weir to Northam Town Pool weir (Section 5)	17.45	8.7	0.050

Prior to the River Training Scheme, the river channel was braided (many inter-twining channels). Training works upstream from Cobblers Pool during the 1960s converted this to a single channel approximately 60 m wide. Significant sediment mobilisation has occurred with Deepdale Pool now completely filled by a sand slug that is 6.5 km in length (2/2.8 to 2/9.3 – Ecoscape Avon River Channel Survey 1996). Current fluvial processes are re-establishing braided drainage.

The river bed is 1-1.5 m deeper than the original bed level in some places although this varies considerably. Channel bed erosion is limited in depth by cemented clays.

2.1.3 Stream flow and salinity levels

A stream gauging station is located at Walyunga National Park, 28 km downstream from the commencement of Section 1. Records date back to 1970 for Walyunga Gauging Station Ref. 616011. Water and Rivers Commission maintains the station and records.

Total annual stream flow ranges from 95 million cubic metres in 1979 to 1270 million cubic metres in 1974. The average flow volume is approximately 360 million cubic metres. The monthly flow of 170.9 million cubic metres for January 2000 is the highest summer flow and 534.5 million cubic metres for August 1974 is the highest winter flow recorded for this station.

Conductivity records kept for Walyunga Gauging Station show that the salinity of stream flow in summer (approx. 6000 mg/L) is about twice that of winter flow. These records include flow from both the Brockman River and Woorooloo Brook which are less saline than the Avon, so the salinity and flow through Sections 1 and 2 can be expected to be generally higher.

About 50 years ago, the river was suitable for watering horses at any location along these two sections and was used for irrigating citrus orchards (Gaven Donegan, *pers. comm.*). The river is no longer used for stock-water or irrigation due to increasing salinity. The 'January 2000' flood flow was of high salinity causing shrubs to die and tree trunks to be stained by salt.

2.1.4 Riparian vegetation

The natural river vegetation in Sections 1 and 2 is different to that of the adjacent landscape. It is dominated by Flooded Gums (*Eucalyptus rudis*), Swamp Sheoak (*Casuarina obesa*) and Swamp Paperbark (*Melaleuca raphiophylla*).

The riparian community structure is altering. Due to changes in water quality, some vegetation species are becoming more dominant, and others are decreasing or disappearing. The Avon River Survey (Ecoscape, 1996) shows low to medium regeneration for *E. rudis, M. rhaphiophylla* and *C. obesa*. Weeds that dominate the understorey may be retarding natural regeneration.

Appendix Three includes a description of the riparian vegetation condition.

2.1.5 Pools

There are four significant pools within these sections of the Avon River. (See Map 3). They are Deepdale Pool, Jimperding Pool (incorrectly named Diving Pool in previous reports), Long Pool and Cobblers Pool. Many other smaller pools are well known to the local community although many are now filled with sediment. These include Crooked Pool (named because of the river bend; it is now full of sediment), Diving Pool, Markey Pool, Duck S--- Pool (just upstream of Cobblers Pool), Grandfathers Pool, Rocky Basin Pool and Cut-throat Pool (now known as the 'Super-chute' by canoeists). A map showing all pools within these two sections of the river has been prepared as an action of this plan. Table 2 shows the characteristics of the main pools.

Deepdale Pool: Prior to the River Training Scheme, Deepdale Pool was used for swimming, fishing (for cobblers and mullet) and was suitable for stock-water. The pool filled with sediments soon after the River Training Scheme was completed in this section, and surveyed as such in 1977.

The sediments in this pool are described as sand and although there has been no nutrient analysis, the sediment nutrient load can be assumed to be quite low.

Table 2: Characteristics of major river pools

	Deepdale	Jimperding	Long	Cobblers
1996 length (m)	Filled with sediment	920	1 060	350
1978 length (m)	0	3.11	No data	No data
1996 depth (m)	0	0.82	3.19	2.50
1996 Unfilled Volume (m^3)		12 000	62 000	30 000
1996 Salinity (mg/L)		9 152	7 891	7 145
1996 Phosphorus, (sediments mg/g)		0.056	0.066	0.135
1996 Phosphorus, (water – mg/L)		0.025	0.028	0.020

Information source: JDA (1997)

Photo 1: Deepdale Pool, circa 1950, used for boating and swimming prior to the River Training Scheme

Photo courtesy Helen Heath

Photo 2: Deepdale Pool filled with sediment

Photo courtesy Ecoscape

The condition of the riparian vegetation is not declining but also is not significantly regenerating perhaps because the river is not fenced in this section.

Jimperding Pool: The pool upstream from Jimperding Brook has been incorrectly named Diving Pool in previous reports. Diving Pool is downstream from the confluence and is now filled with sediment (Gaven Donegan, pers. comm.).

Jimperding Pool is approximately 920 metres in length and is now generally less than 0.5 metres deep. This has decreased from a depth of 3.1 metres in 1977. The pool was about half filled (approximately 12 000m^3) with medium to coarse sand in 1996 (JDA, 1997). The nutrient load is quite low. The pool has in-filled in the central section but has unfilled volume in the upstream and downstream ends.

Flooded Gums (*E. rudis*) and Swamp Paperbarks (*M. raphiophylla*) are regenerating. Sheoaks (*Casuarina obesa*) are absent from the riparian vegetation.

Long Pool: The length of this pool is approximately 1 km. It is confined by a rock bar at the downstream end below which is the confluence of Malkup Brook. There is also a rock outcrop within the pool.

Long Pool was more than four metres deep at the upstream end in 1981 (Kirk McKenzie pers. comm.). Survey information shows that the pool varies in depth from 1.5 metres to 3.0 metres and is about half filled (approximately 60 000 m^3 of unfilled volume) with coarse sand (JDA, 1997). Local observations indicate that this pool is rapidly filling with sediment.

E. rudis and *M. raphiophylla* are regenerating in the riparian vegetation.

Cobblers Pool: This pool is best known as the over-night campsite for the Avon Descent. It is 350 metres in length and 2.5 metres deep with limited sediment infill (unfilled volume of approximately 30 000 m^3).

2.1.6 Tributaries

The major tributaries to the Avon in Section 1 are Julimar Brook, Mortingup Brook, Munnapin Brook and Malkup Brook.

The confluence of Jimperding Brook (historically known as Jumperding Brook) is the point of separation of the two river sections. Jimperding Brook falls five metres in less than 400 metres prior to the confluence with the Avon River – a gradient of 1.29% (12.9 metres per kilometre).

Photo 3: Sediment in the downstream end of Jimperding Pool *Photo courtesy Viv Read*

Photo 4: Sediment infill to Long Pool *Photo courtesy Viv Read*

This suggests significant potential for sediment transport. Cobbles in the bed of the Avon River just downstream from the confluence indicate the sediment transport capacity of the brook. The sediment transport potential of other smaller tributaries will also be high in this landscape.

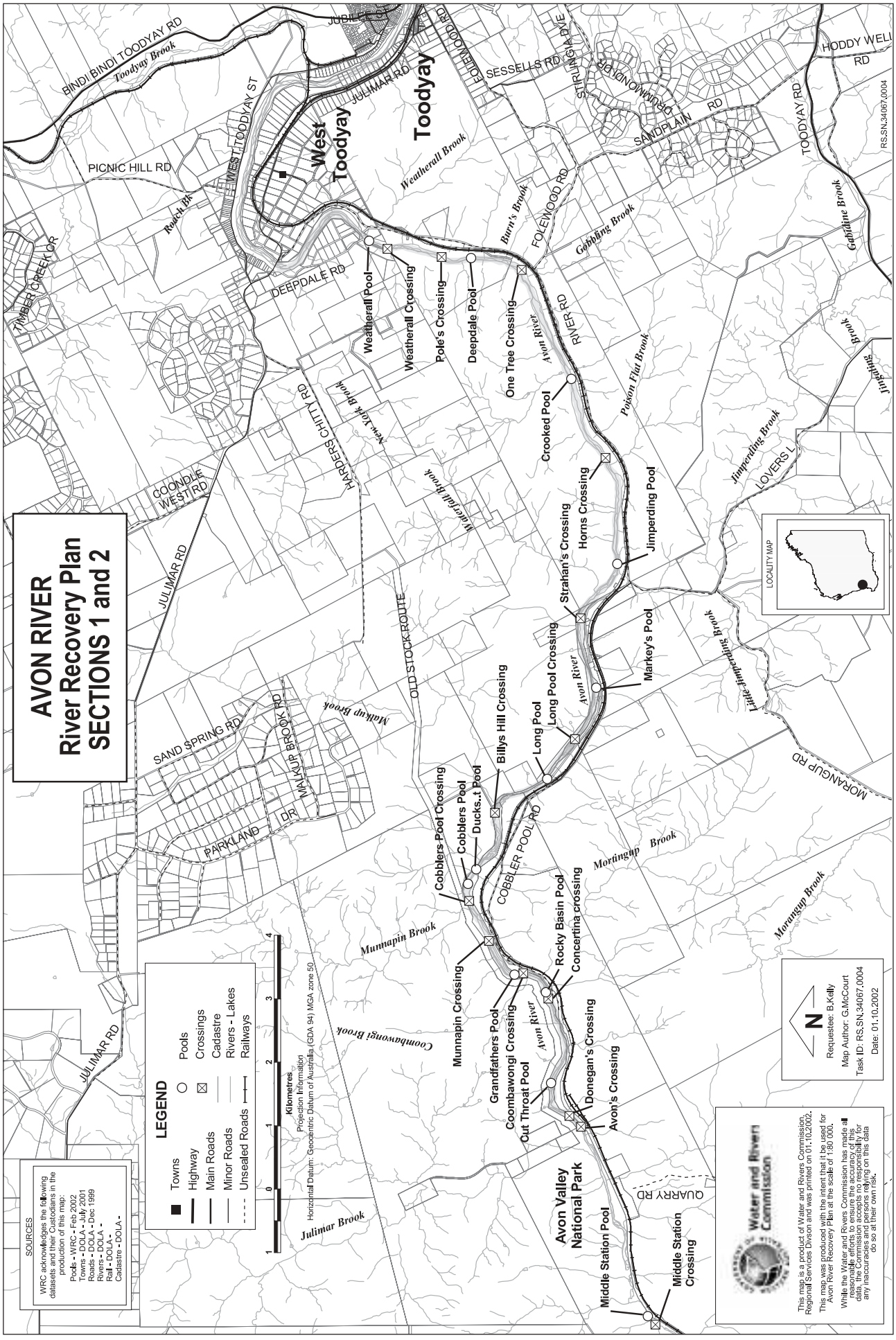
2.1.7 Land use, infrastructure and community interest

Land adjacent to the Avon River in this section is mostly used for agriculture or has been sub-divided for small-scale hobby farms. Section 1 extends into the Avon Valley National Park. There are currently no intensive animal or processing industries close to the riparian zone. A substantial quarry is located adjacent to national park but is no longer in use. There are no towns in these sections of the river.

River Road, Cobblers Pool Road and the railway are located adjacent to the river. There are only limited road crossings now, however there are many historic crossings no longer in use.

The Deepdale Catchment Group formed to undertake a range of catchment and waterway management actions. Rehabilitation of Jimperding Brook has been a significant project. The Toodyay Friends of the River also has strong interest in river management.

Photo 5: River crossing for property access at the upstream end of Long Pool *Photo courtesy Viv Read*



Map 3: Avon River Recovery Plan Sections 1 and 2

3 River channel survey results

A comprehensive survey of the 18 sections of the main channel of the Avon River was undertaken during 1996 (Ecoscape, 1996), a total distance of 191 km. Records and observations were made at 500 m intervals. The complete river channel survey results have been summarised by Black (1998). Appendices 1 and 2 show significant features of Sections 1 and 2. Appendix 3 provides a descriptive summary from the survey for the two river sections (Ecoscape, 1996). The key findings are considered here.

3.1 Sediments and channel stability

The river survey shows that the banks are stable at 96% of the sites in Section 1, compared with 65% for Section 2. It is unlikely that the lower section is a significant source of sediments while the upper section is probably contributing to sedimentation.

At the time of the survey, Section 1 had very stable bed conditions (all sites were considered stable) while Section 2 had the least stable bed conditions for all river sections (Figure 1). This reflects that Section 2 was altered during the River Training Scheme while Section 1 was not. Significant sand slugs were observed at 65% of sites for Section 2 but at none for Section 1. The differences are due in part to channel bed gradient (see Table 1) but also due to altered river channel characteristics.

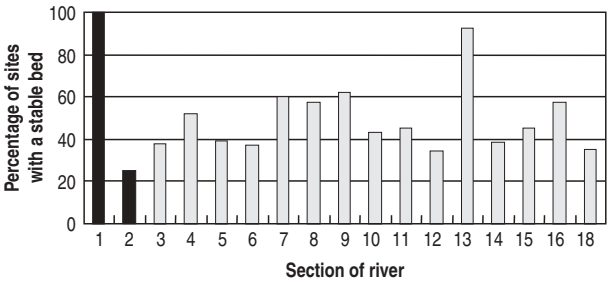


Figure 1: Bed stability along the Avon River

3.2 Vegetation condition

The survey showed that the dominant riparian vegetation species (the Flooded Gum *Eucalyptus rudis,* Swamp Paperbark *Melaleuca raphiophylla* and Sheoak *Casuarina obesa*) were healthy although regeneration was relatively low. The Sheoak had lowest regeneration in Section 1 and the Flooded Gum had lowest regeneration in Section 2. The composition of the vegetation community does not suggest significant change as appears to be occurring in the Avon upstream from Northam.

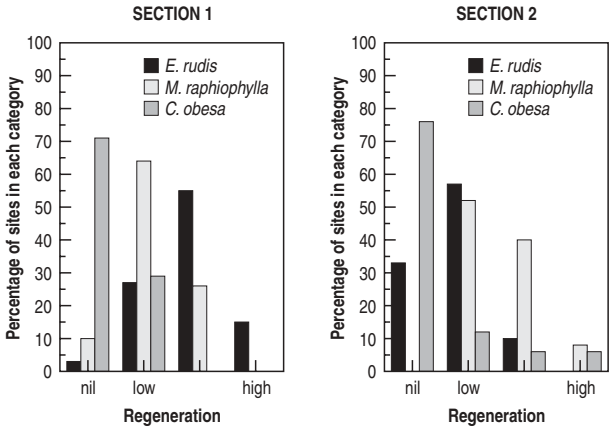


Figure 2: Riparian vegetation regeneration for Sections 1 and 2

The weeds in these river sections are listed in Appendix 3.

At the time of the survey, the occurrence of stock in the river was very low for Section 1 (12% of sites) and very high for Section 2 (90% of sites).

3.3 General Condition

An index of the general condition of the Avon River sections based on management criteria measured during the 1996 river survey shows that Section 1 ranks second best of the 18 sections, while Section 2 has the lowest ranking of all sections (Black, 1998). The low bed stability, high sediment load and high incidence of stock in the river are major contributors to the high need for management in Section 2.

4 River recovery planning

The mission of the Avon Waterways Committee (AWC) is to restore and manage the natural functions of the Avon River system for the long-term benefit of the community. AWC also recognises adjacent landholder issues with river management such as fire risk and stock grazing. The preferred approach to river recovery is by agreement between landowners along the river and with those with direct community interest for management actions that are compatible with the Management Program for the Avon River and that also meet individual needs.

Recovery planning for the Avon Gorge and Deepdale Valley sections has been through a series of meetings, river walks and individual property inspections during April-June, 2002. Individual and site specific information was integrated with river channel survey information, river policies and management guidelines to develop the draft Recovery Plan. An interim Recovery Team, including landowners, interested community members and WRC staff, provided direction for this process.

The Avon River Recovery Plans provide a blue-print partnership arrangement between the Water and Rivers Commission, the Avon Waterways Committee and a Recovery Team specific to sections of the river. A plan is developed for a period of 5 years but is set in a 20-year time-frame.

The Recovery Plan consists of :

- A local vision for these sections of the river in 10-20 years time,
- A set of local management objectives,
- Identification of key management issues,
- Management actions that respond to the issues, and
- An implementation schedule.

People who met to develop the Recovery Plan for Sections 1 and 2 (the Recovery Team) preferred the geographic titles of 'Avon Gorge' for Section 1 and 'Deepdale Valley' for Section 2. These are adopted for the plan.

4.1 A 'Vision' for the river

The Avon River Management Programme includes a broad vision for the complete Avon River system. With this in mind, the Avon Gorge/Deepdale Valley Recovery Team has the following vision for local management:

'The character of the Avon River between West Toodyay and the Avon Valley National Park is recognised as being tranquil. It is a place with a clear sense of history that reflects on the original glory of the river when there were deep pools suitable for swimming and fishing for cobbler and mullet. The memory of irrigating orange orchards from the river remains. There are well-known stories about stockmen and bushrangers and early settlers.

The river is accepted as a living ecosystem. It has healthy natural vegetation with few weeds. It is well suited for bird breeding. Long Pool is a recognised demonstration of good river management.

Regional planning has integrated the river within the agricultural and semi-rural landscape. Specific areas that are valued for conservation, recreation, Aboriginal and more recent heritage are identified. Corridors that link with the national park are recognised, particularly for wildlife and walk trails.

People recreate in ways that are compatible with the values of the river valley. Easy public access is arranged and travel by train through the valley is popular. Private property is respected and the risks associated with public liability are minimised.

The river is a tribute to its former glory.'

4.2 Local management objectives

Five objectives identified for management through the recovery planning process are:

- To retain the natural river characteristics wherever possible and ensure that management and use of the river is 'in keeping' with these characteristics.
- To identify and promote the historic attributes of the river.
- To understand the processes that threaten the river's natural and historic characteristics, especially sedimentation, and take appropriate action to reduce further river degradation.
- To develop a high-profile site for demonstration of good river management.
- To arrange consistent management of the river between current landholders and land managers, and for future owners or managers.

5 Management actions

The key management issues to be considered in recovery planning were derived from meetings with the Recovery Team and field survey as well as from the Avon River Channel Survey reports and the Avon River Management Programme.

The 17 issues that were identified are shown in Table 3. Recovery Team members ranked the issues according to perceived importance. The table shows the relative priority as well as the average score and the range of scores for each issue (based on the opinions of 12 members). The priority ranking is a relative guide only for management. While it is difficult to separate some of the issues, it is clear that managing sediment and the river pools is a high priority. The Avon Descent is ranked low because the way that the event is currently managed, it is not perceived to be an issue requiring attention.

Table 3: Recovery Team priorities for Key Management Issues

Issue (in priority order)	Average score	Highest score	Lowest score
1. Sediments	9.4	10	6
2. River pools	9.4	10	8
3. Stream salinity	9.2	10	7
4. Riparian vegetation management	8.2	10	2
5. Recovery Team role	8	10	1
6. Bird breeding	8	10	6
7. Nutrients and pollution	7.9	10	2
8. Public access	6.7	9	3
9. Environmental flow requirements	6.4	10	3
10. Land use change	6.4	10	2
11. River profile	6.4	10	1
12. Statutory context	6.3	10	1
13. Fire	5.9	10	2
14. Feral animals	5.8	10	1
15. Flooding	5.6	10	1
16. Avon Descent	5.2	10	1
17. River crossings	5.2	10	2

Importance score (1 – low, 10 – high) – based on resource allocation

The issues identified by the Recovery Team are grouped into six Key Management Areas and the preferred management actions are outlined in the following sections.

5.1 A local river profile

Issue description

The distinctive Avon landscape of a meandering river through towering hills leading towards the rugged terrain of the river's descent over the Darling Scarp, is a major community asset. It is valued by those who live in or near this landscape and by those who visit, particularly during the period of the Avon Descent boating event. It is also appreciated by many who commute by train and interstate visitors arriving by the Indian-Pacific railway.

The river landscape also provides an important link from the broad agricultural catchment, through the Avon Valley National Park to the urban areas of the Swan Coastal Plain. The river itself provides the 'common thread' between these landscapes.

The vegetation and pools characterise the river. Granite outcrops are a feature of some pools and are important to local legends about early river use by settlers, stockmen and bushrangers. Most pools and many rocks have local names that reflect the rich historic and cultural values of the landscape. These values are well recognised locally but not by many others. They are at risk of being diminished or lost.

The focused attention on the competitive boating event each year is progressively re-defining the river culture. New names are used for river features that ignore the accepted local name and are not derived from the past.

The vision developed by the Recovery Team is based on recognition of the tranquil nature of the landscape and that has a clear sense of history. A range of actions are proposed to achieve the locally preferred river and landscape character.

Action 1.1 Advise key stakeholders of the preferred use of the terms 'Avon Gorge' for Section 1 and 'Deepdale Valley' for Section 2 of the Avon River.

Action 1.2 Prepare a draft map of Sections 1 and 2 that identifies all Avon River pool names and historic places.

Photo 6: Sediments trapped in the braided channel of the 'Avon Gorge' river section *Photo courtesy Viv Read*

Action 1.3 Invite local public comment on the draft map and seek endorsement of the locally preferred names from the Avon Waterways Committee.

Action 1.4 Liaise with key stakeholder groups (including the Avon Descent Management Committee) for adoption of locally preferred names.

Action 1.5 Seek funding for development of an oral history and photographic record of the river and landscape.

Action 1.6 Prepare public information that uses historic information and landscape images to represent the locally preferred river and landscape character.

Information could be presented as posters, pamphlets, newsletter articles (including the information circulated for the 'Avon Descent') or local, State and national press stories.

Action 1.7 Develop a series of large signs of historic information that develop the river and landscape character.

Action 1.8 Prepare an overlay to the river landscape map showing current land ownership.

5.2 River Pools and Sediments

Issue description

Sedimentation

The river pools in the 'Deepdale Valley' section have filled with sediment. Deepdale Pool was completely filled by the 1970s soon after the River Training Scheme works. Jimperding Pool has substantially filled. There is a very high bed load of coarse sediments in this section. The source of sediments is from river channel erosion downstream from Extracts Weir and from tributaries. The proportion contributed by tributaries is not established, but is expected to be relatively small compared to the existing bed load. The main source of sediments is expected to be from erosion of the river bed and banks.

Smaller pools in the 'Avon Gorge' section are filled with sediment (e.g. Diving Pool) however, Long Pool and Cobblers Pool remain with significant water volume. The steeper gradient of this section of the river provides stream flow with a greater capacity to transport sediment. This section of the river was not altered during the River

Training Scheme so it has retained a braided stream channel with dense vegetation that arrests sediment movement (Photo 6).

Long Pool seems at significant risk of total sediment infill. The high river values of this pool would be lost. Cobblers Pool does not seem to be at risk of sedimentation although this should be verified. The potential for sedimentation from Malkup Brook should be established.

Action 2.1 Undertake a study of the relative proportion of sediments derived from catchments compared with river channel erosion for the Avon River downstream from Extracts Weir.

The rate at which sediments are transported is also not well established. This is important to understand the potential for sediments to fill remaining pool volume and the potential for coarse sediments to be transported to the upper reaches of the Swan River. Significant sedimentation of these areas could eventually result in increased local flooding. Detailed gradient, sediment and flow analyses are required to assess sediment mobility.

Action 2.2 Develop a detailed river bed gradient profile based on the Digital Elevation Models (DEMs) for the river.

Action 2.3 Prepare a risk assessment of the potential for bed load sediments to fill the remaining river pool volume and for coarse sediments to be transported to the Swan Coastal Plain.

Sediment management

Removal of sediment to reduce the risk to river pools and the Swan River is possible although expensive. An assessment of the commercial value of the river sediments in these sections (undertaken by Boral Construction Materials) show that the sediments are not suitable for commercial use so there are no current options to reduce the costs of sediment excavation.

If the public benefit justifies the costs of sediment removal, this could be done by excavating river pools (Long Pool is best suited for this) or by constructing sediment traps at locations where the river has a low gradient and there is easy vehicle access.

Action 2.4 Undertake a cost-benefit analysis of sediment removal from the river downstream from Extracts Weir.

Action 2.5 Arrange a survey of sediments in Long Pool (comparable with the 1996 river pool survey).

Action 2.6 Identify locations suitable for trapping and removal of sediments.

Vegetation is often the best option for stabilising sediment in the long term. Perennial plants should be encouraged to establish on unconsolidated sediments by controlling livestock access to the river. Salt Water Couch (*Paspalum vaginatum*) is an effective coloniser of unconsolidated sands and trapping mobile sediments. The spread of couch within the river system is significant in reducing the risk of further erosion of the river channel and sedimentation of river pools.

'Long Pool' river management demonstration

The Recovery Team has identified Long Pool as the best location to demonstrate good river management. It retains significant river values although it is at risk of further sedimentation. There is only limited public access to the pool, however arrangements can be made to increase its demonstration value.

There is potential for the aquatic ecosystem and associated threatening processes of Long Pool to be well understood by organised surveys. It would be beneficial to have an information base for the pool that is comparable with that for Gwambygine Pool, located on the Avon River upstream from York (VRA, 2001). A Management Plan similar to that for Gwambygine Pool should be prepared to provide a clear management context prior to surveys or studies of the aquatic and riparian ecosystems.

Action 2.7 Prepare a Management Plan for the proposed monitoring and demonstration site at Long Pool.

5.3 The riparian zone

Issue description

The riparian zone refers to the area of land bordering a waterway, where the structure, function and composition of the landscape are influenced by the waterway.

It includes the river channel, flood ways and floodplain. Management options for this area are limited but the preferred approach is to allow the natural functions of the river ecosystem to prevail (WRC, 1999).

While the characteristics and condition of the two sections of river differ significantly, riparian zone management will be similar for both.

Controlling stock access

Controlling stock access to the riparian zone by fencing is the most effective form of management. It allows for natural regeneration of vegetation. For some properties, total exclusion is acceptable. For others, a significant proportion of the property is within the riparian zone and grazing there is an important part of the farming enterprise. Expectations of a reduction in farm enterprise potential to provide public benefits without compensation are considered onerous by the Recovery Team. Limited grazing by sheep is considered acceptable with the understanding that the area is not grazed during periods that will significantly damage riparian vegetation. Grazing by goats, cattle or horses in the riparian zone is likely to cause unacceptable damage to vegetation.

Action 3.1 Arrange for the riparian zone on agricultural land in both river sections to have stock-proof fencing.

Fire control

Although not a high priority issue for some who live along the river, consideration of fire risk to others is important, especially where private and public assets are at risk.

Reducing the fuel load in the riparian zone by occasional grazing is sometimes proposed although the damage to vegetation may outweigh the benefits considering that most of the fuel load is in the perennial vegetation. Limited control burns in areas near private and public assets are consistent with the AWC management guidelines for fire.

Good access for fire suppression is the best form of fire control in the riparian zone. Reducing the causes of fire, particularly associated with railways and occasional tourists, is important.

Action 3.2 Liaise with Toodyay Chief Fire Control Officers and CALM to ensure current access for fire suppression in the river is adequate.

Action 3.3 Identify zones near private and public assets for fuel reduction by cool burns or controlled grazing. A distance of 250 metres either side of the asset is suggested.

Action 3.4 Liaise with Westrail for fire risk reduction.

Weeds

Although few significant weeds requiring management action were identified during the 1996 river survey (Appendix 3), Bridal Creeper, Tamarisk, Castor Oil, Arum Lily and Watsonia are known to occur in these two sections.

Action 3.5 Undertake weed surveys of the riparian zone to identify and map specific areas requiring control measures.

Action 3.6 Arrange for eradication of Bridal Creeper and Tamarix from these two river sections.

Feral, semi-domestic and native animals

There is concern about the potential for damage to the riparian zone by goats, cats, foxes and pigs. As rural residential land use increases, the potential for semi-domesticated animals to become troublesome in the river will also increase. Pigs are currently a problem near the river in the national park.

The native Long-billed Corellas (*Cacatua pastinator*) and Australian Ringneck (or Twenty Eight) Parrots (*Barnadius zonarius*) are also considered to be damaging to the river environment by occupying breeding hollows and destroying vegetation. Culling the populations of some species may become attractive although this is restricted under legislation. Shooting of Declared birds (Category A7) under the *Agriculture and Related Resources Protection Act* is allowed in some local government areas.

Action 3.7 Advise landowners adjacent to the river of the potential for damage to the riparian zone by semi-domestic animals.

Action 3.8 Review options to control populations of feral and native animals.

5.4 Macro-corridors for biodiversity

Issue Description

The Avon River provides summer and drought refuge for aquatic and terrestrial wildlife in a substantially altered landscape. It also provides a corridor for movement or relocation of species and for gene-flow through interacting populations of species. The function of the river environment for movement of plant and animal species or for genetic material is not well established although it is expected to be significant. The potential for the river to connect many remnants of bush on private land and in reserves is high. The biodiversity value of the river corridor is emphasised when there is significant disturbance, such as by fire, and re-colonisation occurs from adjacent areas.

The river is connected to a large area of bushland where it enters the Avon Valley National Park. Further downstream, the river is a part of the Walyunga National Park. Between

these two secured conservation areas is the privately-owned Paruna Sanctuary initiated and managed by the Australian Wildlife Conservancy. The linkage of this river corridor includes the transition from the Avon to the Swan River and connects the rural Avon landscape with the Swan Coastal Plain.

The existing concept of a corridor for enhanced biodiversity value can be extended upstream from the Avon Valley National Park through the 'Avon Gorge' and 'Deepdale Valley'. A concept design plan and guidelines for management for this extension should be developed in consultation with the Department of Conservation and Land Management (CALM) Avon Catchment Council (ACC) and the Australian Wildlife Conservancy. The range of issues that should be considered includes:

- Opportunities for linking adjacent remnant natural vegetation, particularly by waterway ecosystem reconstruction.
- Coordinated weed and feral animal control.
- Unified approach to control of problem native species.
- Coordinated communications and signage to promote biodiversity values associated with the corridor.
- Select an appropriate macro-corridor title ('Avon Bio-link' is suggested).

Action 4.1 Liaise with CALM, ACC and Australian Wildlife Conservancy to further develop the 'Avon Bio-link' macro-corridor opportunity.

Action 4.2 Prepare the 'Avon Bio-link' Concept Plan and Management Guidelines.

5.5 Stream salinity, nutrients and pollution

Issue description

Salinity

Summer flow in the Avon River has salt concentration of about 6000 mg/L (section 2.1.3). A longer-term increasing trend is not evident at present (Peter Muirden, WRC *pers. comm.*) although is expected as the landscape becomes more salt affected (up to 30% of Avon landscapes may eventually become salt-affected). Rural drainage for salinity control in inland areas of the Avon River Basin could add to an increasing stream flow salinity trend. Direct salt-load discharge from drainage is not expected to increase in these two sections of the river.

The potential for impact on the riverine ecosystem due to increasing stream-flow salinity is not well established.

There is little evidence that salinity due to local groundwater rise is affecting the riverine ecosystem within these two sections. The potential for this to occur in the future is low.

Action 5.1 Undertake routine monitoring information within the two sections to identify long-term trends for stream-flow salinity.

Action 5.2 Undertake monitoring of water salinity in Long Pool as a part of the demonstration site development.

Nutrients and pollutants

The potential for nutrient and pollutant contamination of the river within these two river sections is related to agricultural and semi-rural land use. Management of this risk is best undertaken through catchment group action, particularly for rehabilitation of the nutrient filtering capability of waterways.

Action 5.3 Assess the Avon River confluence of each tributary, for potential to filter nutrients through floodplain or fringing vegetation.

Action 5.4 Liaise with the Toodyay LCDC and associated catchment groups to extend local Best Practice for reducing soil and nutrient loss from catchments that contribute to the Avon River.

5.6 Access and use of the river

Issue description

Private access and use

Access to some private properties on the north and western side of the river is restricted. Photo 5 shows the four-wheel drive access to one property at a time when there is no river flow. A substantially longer access route is taken during high-flow periods. Maintenance of this crossing is important for the property.

The requirement for property access will increase as land adjacent to the river is subdivided however there should not be an expectation of access rights by river crossings. The Town Planning Scheme for the Shire of Toodyay and proposals for land sub-division should allow for property

access with least impact upon the river environment. New river crossings should be determined primarily by the access needs for fire suppression.

Some properties with land on both sides of the river require access for stock crossings. The current practice to use West Toodyay Bridge for stock management is becoming a public risk as traffic is increasing. Integrating the purposes of stock crossing, access for fire suppression and a structure to arrest sediment transport for an additional river crossing could be considered.

Action 6.1 Liaise with the Shire of Toodyay to ensure that increasing settlement density adjacent to the Avon River is planned in a way that provides access without additional impact upon the river.

Action 6.2 Evaluate options for an additional river crossing for livestock and fire control as an alternative to use of the West Toodyay Bridge.

5.7 Roles and responsibilities

Issue Description

Land ownership or vesting

The river in the 'Avon Gorge' and 'Deepdale Valley' sections is adjoined by private land, the Avon Valley National Park, Crown reserves, railway reserve, road reserves, a former road in the floodplain and a stock route (no longer in use).

Not all boundaries are well defined. While some properties have titles that include the bed and banks of the river (although not the water resources), most are defined by the 'high water mark'. This is an approximate alignment that generally excludes the river channel but includes the floodplain in the area of the title.

The process of land sub-division provides an opportunity for a Foreshore Reserve, Foreshore Management Agreement or a Restricted Covenant to be formed under the *Town Planning and Development Act (1928)*. Reserves are vested with the local government authority or with WRC by the Department of Land Administration (DOLA) and may be leased to adjacent landholders with conditions for management. A Foreshore Management Agreement is a condition of approval for sub-division applied to the riparian zone. A Restricted Covenant on the land title ensures specific management arrangements for the riparian zone.

The existing rail and road reserves are well-defined. A former road adjacent to the river is evident although the status of its tenure is uncertain. Similarly, the status of a former stock route near the river is not clear.

Action 7.1 Prepare a cadastral database that shows the land tenure of private and public land.

River management roles

Other bodies have river management roles in addition to those who directly own or manage the land.

WRC has statutory responsibility for river management under the *Waterways Conservation Act (1975)* and the *Rights in Water and Irrigation Act (1914)*. These restrict actions that will degrade the river and its environment. Licenses are required for developments, such as river crossings, within the proclaimed area of the river. WRC aims to engender good river management according to the Avon River Management Programme particularly by encouraging best-practice actions.

The Avon Waterways Committee (AWC) is community-based and provides advice to WRC for management of waterways in the Avon River Basin. This advice is also relevant to the Avon Catchment Council (ACC), which is the leading partnership group for natural resource management in the Avon River Basin.

The Department of Conservation and Land Management (CALM) is responsible for river management within the Avon Valley National Park. It also has responsibility for flora and fauna under the *Wildlife Conservation Act (1950).*

Community groups also have important roles in natural resource management. The Deepdale Catchment Group, formed through the Toodyay Land Conservation District Committee (LCDC) has undertaken a range of projects, including rehabilitation of Jimperding Brook. The Toodyay Friends of the River is an active group with well-developed skills in faunal survey and weed management.

A consistent approach to river management for these river sections requires specialist leadership by a group that represents the interests, roles and responsibilities of those involved. Formation of a Recovery Team is proposed based on a partnership arrangement between the Deepdale Catchment Group and the Toodyay Friends of the River. The Recovery Team should perform as a sub-committee to this partnership with a local leader.

The key role of the Recovery Team would be to arrange implementation of this Avon River Recovery Plan.

Action 7.2 A Recovery Team for the 'Avon Gorge' and 'Deepdale Valley' river sections be formed as a sub-committee of a partnership between the Deepdale Catchment Group and the Toodyay Friends of the River.

6 Implementation of the recovery plan

An appropriate implementation schedule is outlined in the following Table.

Action	Priority (1)	Responsibility (2)	Notes
Local River Profile			
Action 1.1: Advise key stakeholders of the preferred use of the terms 'Avon Gorge' for Section 1 and 'Deepdale Valley' for Section 2 of the Avon River.	**H**	RT/AWC/WRC	Include AWC, WRC, ACC, SRT, Shire of Toodyay, CALM, Australian Wildlife Conservancy, ADMC, DPID, tourist bureaus, local residents and catchment groups.
Action 1.2: Prepare a draft map of S 1/2 that identifies all Avon River pool names and historic places.	**H**	RT/WRC	
Action 1.3: Invite local public comment on the draft map and seek endorsement of the locally preferred names from the Avon Waterways Committee.	**H**	RT	
Action 1.4: Liaise with key stakeholder groups for adoption of locally preferred names.	**H**	RT	Include groups as above.
Action 1.5: Seek funding for development of an oral history and photographic record of the river and landscape.	**M**	WRC	
Action 1.6: Prepare public information that uses historic information and landscape images to represent the locally preferred river and landscape character	**M**	RT/WRC	Information could be presented as posters, pamphlets, newsletter articles (including the information circulated for the 'Avon Descent') or local, state and national press stories.
Action 1.7: Develop a series of large signs of historic information that develop the river and landscape character.	**M**	RT/WRC	Signage could be arranged with new initiatives for the 'Avon Ascent' program.
Action 1.8: Prepare an overlay to the river landscape map showing current land ownership	**M**	RT	

Implementation Schedule continued overleaf…

… Implementation Schedule continued

Action	Priority (1)	Responsibility (2)	Notes
River Pools and Sedimentation			
Action 2.1: Undertake a study of the relative proportion of sediments derived from catchments compared with river channel erosion for the Avon River downstream from Extracts Weir.	**H**	WRC	Assessment of the potential for sedimentation from Jimperding Brook and Malkup Brook are particularly significant.
Action 2.2: Develop a detailed river bed gradient profile based on the Digital Elevation Models (DEMs) for the river.	**H**	WRC	
Action 2.3: Prepare a risk assessment of the potential for bed load sediments to fill the remaining river pool volume and for coarse sediments to be transported to the Swan Coastal Plain.	**H**	WRC/SRT	Liaison with SRT and local government authorities required.
Action 2.4: Undertake a cost-benefit analysis of sediment removal from the river downstream from Extracts Weir.	**H**	WRC	Include the on-site benefits to river pools and the off-set benefits to the Swan River.
Action 2.5: Arrange a survey of sediments in Long Pool (comparable with the 1996 river pool survey).	**M**	WRC	Survey of other pools is optional.
Action 2.6: Identify locations suitable for trapping and removal of sediments.	**M**	RT/WRC	Consider also sites suitable for fire suppression access and property access.
Action 2.7: Prepare a Management Plan for the proposed monitoring and demonstration site at Long Pool.	**H**	RT/WRC	Issues to be considered include fauna, flora and invertebrate inventories, monitoring, sediment management, bank erosion, weeds, revegetation and public access.
Riparian Zone Management			
Action 3.1: Arrange for the riparian zone on agricultural land in both river sections to have stock-proof fencing.	**H**	RT/WRC	Arrangements also required to ensure that stock from sections that are to be occasionally grazed do not stray further along the river.
Action 3.2: Liaise with Toodyay Chief Fire Control Officers and CALM to ensure current access for fire suppression in the river is adequate.	**H**	RT	
Action 3.3: Identify zones near private and public assets for fuel reduction by cool burns or controlled grazing. A distance of 250 metres either side of the asset is suggested.	**M**	RT	Consistent with the AWC Management Guideline for fire.
Action 3.4: Liaise with Westrail for fire risk reduction.	**M**	RT/WRC	
Action 3.5: Undertake weed surveys of the riparian zone to map specific areas requiring control measures.	**H**	RT	Standard procedures developed by the Weed Action Network are appropriate.
Action 3.6*:* Arrange for eradication of Bridal Creeper and Tamarix from these two river sections.	**H**	RT/TFR	Include recent initiatives for biological control.
Action 3.7: Advise landowners adjacent to the river of the potential for damage to the riparian zone by semi-domestic animals.	**M**	RT	
Action 3.8: Review options to control populations of feral and native animals.	**M**	RT	Refer to Hussey and Wallace (1993).

Implementation Schedule continued overleaf…

… Implementation Schedule continued

Action	Priority (1)	Responsibility (2)	Notes
Macro-corridors for Biodiversity			
Action 4.1: Liaise with CALM and Australian Wildlife Conservancy to further develop the 'Avon Bio-link' macro-corridor opportunity.	**M**	RT/WRC	
Action 4.2: Prepare the 'Avon Bio-link' Concept Plan and Management Guidelines	**M**	WRC/CALM	Integrate with ACC initiatives for management of biodiversity.
Stream Salinity, Nutrients and Pollution			
Action 5.1: Undertake routine monitoring information within the two sections to identify long-term trends for stream-flow salinity.	**M**	WRC	Calibrate in relation to established conductivity monitoring.
Action 5.2: Undertake monitoring of water salinity in Long Pool as a part of the demonstration site development.	**M**	RT/WRC	Ensure consistency with monitoring for Gwambygine Pool. (River Conservation Society, York).
Action 5.3: Assess the confluence of each tributary for potential to filter nutrients through floodplain or fringing vegetation	**H**	RT/WRC	
Action 5.4: Liaise with the Toodyay LCDC and associated catchment groups to extend local Best Practice for reducing soil and nutrient loss from catchments that contribute to the Avon River.	**M**	RT/DCG	Liaison with initiatives of the Avon Catchment Council required.
Public Access and Use of the River			
Action 6.1: Liaise with the Shire of Toodyay to ensure that increasing settlement density adjacent to the Avon River is planned in a way that provides access without additional impact upon the river.	**H**	RT/WRC	
Action 6.2: Evaluate options for an additional river crossing for livestock as an alternative to use of the West Toodyay Bridge.	**H**	RT/WRC	
Roles and Responsibilities			
Action 7.1: Prepare a cadastral database that shows the land tenure of private and public land.	**M**	RT/WRC	Database to be maintained through the Avon Catchment Council Information Network.
Action 7.2: A Recovery Team for the 'Avon Gorge' and 'Deepdale Valley' river sections be formed as a Sub-committee of a partnership between the Deepdale Catchment Group and the Toodyay Friends of the River.	**H**	DCG/TFR	Team leadership and group support arrangements should be an early priority.

(1) **H** = highest priority,
M = medium and
L = lower priority.

(2) RT = Recovery Team
TS = Shire of Toodyay
AWC = Avon Waterways Committee
SRT = Swan River Trust
WRC = Water and Rivers Commission
ACC = Avon Catchment Council
TFR = Toodyay Friends of the River
DCG = Deepdale Catchment Group
CALM = Department Conservation and Land Management
ACCIN = Avon Catchment Council Information Network

7 Recovery plan summary

VISION

'The character of the Avon River between West Toodyay and the Avon Valley National Park is recognised as being tranquil. It is a place with a clear sense of history that reflects on the original glory of the river when there were deep pools suitable for swimming and fishing for cobbler and mullet. The memory of irrigating orange orchards from the river remains. There are well-known stories about stockmen and bushrangers and early settlers.The river is accepted as a living ecosystem. It has healthy natural vegetation with few weeds. It is well suited for bird breeding. Long Pool is a recognised demonstration of good river management.Regional planning has integrated the river within the agricultural and semi-rural landscape. Specific areas that are valued for conservation, recreation, aboriginal and more recent heritage are identified. Corridors that link with the national park are recognised, particularly for wildlife and walk trails.People recreate in ways that are compatible with the values of the river valley. Easy public access is arranged and travel by train through the valley is popular. Private property is respected and the risks associated with public liability are minimised.The river is a tribute to its former glory.'

The **five objectives** identified for management through the recovery planning process are:

- To retain the natural river characteristics wherever possible and ensure that management and use of the river is 'in keeping' with these characteristics.
- To identify and promote the historic attributes of the river.
- To understand the processes that threaten the river's natural and historic characteristics, especially sedimentation, and take appropriate action to reduce further river degradation
- To develop a high-profile site for demonstration of good river management.
- To arrange consistent management of the river between current landholders and land managers, and for future owners or managers.

Actions for Key Management Issues

Local River Profile

Action 1.1: Advise key stakeholders of the preferred use of the terms 'Avon Gorge' for Section 1 and 'Deepdale Valley' for Section 2 of the Avon River.

Action 1.2: Prepare a draft map that identifies all Avon River pool names and historic places.

Action 1.3: Arrange local public comment on the draft map and seek endorsement of the locally preferred names from the Avon Waterways Committee.

Action 1.4: Liaise with key stakeholder groups for adoption of locally preferred names.

Action 1.5: Seek funding for development of an oral history and photographic record of the river and landscape.

Action 1.6: Prepare public information that uses historic information and landscape images to represent the locally preferred river and landscape character.

Action 1.7: Arrange a series of large signs that show the historic information and develops the river and landscape character.

Action 1.8: Prepare an overlay to the river landscape map showing current land ownership.

River Pools and Sedimentation

Action 2.1: Arrange a study of the relative proportion of sediments derived from catchments compared with river channel erosion for the Avon River downstream from Extracts Weir.

Action 2.2: Arrange a detailed river bed gradient profile based on the Digital Elevation Models (DEM's) for the river.

Action 2.3: Prepare a risk assessment of the potential for bed load sediments to fill the remaining river pool volume and for coarse sediments to be transported to the Swan Coastal Plain.

Action 2.4: Arrange a cost-benefit analysis of sediment removal from the river downstream from Extracts Weir.

Action 2.5: Arrange a survey of sediments in Long Pool (comparable with the 1996 river pool survey).

Action 2.6: Identify locations suitable for trapping and removal of sediments.

Action 2.7: Prepare a Management Plan for the proposed monitoring and demonstration site at Long Pool.

Riparian Zone Management

Action 3.1: Arrange for the riparian zone on agricultural land in both river sections to have stock-proof fencing.

Action 3.2: Liaise with the Toodyay Chief Fire Control Officers and CALM to ensure current access for fire suppression in the river is adequate.

Action 3.3: Identify zones near private and public assets for fuel reduction by cool burns or controlled grazing. A distance of 250 metres either side of the asset is suggested.

Actions for Key Management Issues

Action 3.4: Liaise with Westrail for fire risk reduction.

Action 3.5: Undertake weed surveys of the riparian zone to map areas requiring control measures.

Action 3.6: Arrange for eradication of Bridal Creeper and Tamarix from these two river sections.

Action 3.7: Advise landowners adjacent to the river of the potential for damage to the riparian zone by semi-domestic animals.

Action 3.8: Review options to control populations of feral and native animals.

Macro-corridors for Biodiversity

Action 4.1: Liaise with CALM, ACC and Australian Wildlife Conservancy to further develop the 'Avon Bio-link' macro-corridor opportunity.

Action 4.2: Prepare the 'Avon Bio-link' Concept Plan and Management Guidelines.

Stream Salinity, Nutrients and Pollution

Action 5.1: Arrange routine monitoring information within the two sections to identify long-term trends for stream flow salinity.

Action 5.2: Arrange monitoring of water salinity in Long Pool as a part of the demonstration site development.

Action 5.3: Assess the confluence of each tributary for potential to filter nutrients through floodplain or fringing vegetation.

Action 5.4: Liaise with the Toodyay LCDC and associated catchment groups to extend local Best Practice for reducing soil and nutrient loss from catchments that contribute to the Avon River.

Public Access and Use of the River

Action 6.1: Liaise with the Shire of Toodyay to ensure that increasing settlement density adjacent to the Avon River is planned in a way that provides access without additional impact upon the river.

Action 6.2: Evaluate options for an additional river crossing for livestock as an alternative to use of the West Toodyay Bridge.

Roles and Responsibilities

Action 7.1: Prepare a cadastral database that shows the land tenure of private and public land.

Action 7.2: A Recovery Team for the 'Avon Gorge' and 'Deepdale Valley' river sections be formed as a Sub-committee of a partnership between the Deepdale Catchment Group and the Toodyay Friends of the River.

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Appendix one
Management sections of the Avon River

Section Name	Section Number	Description	Length (km)
Avon Gorge	**1**	**Upstream from Avon Valley National Park to confluence with Jimperding Brook**	**11.23**
Deepdale Valley	**2**	**Confluence of Jimperding Brook to Crossing of Deepdale Road**	**8.14**
Toodyay	3	Deepdale Road to Goomalling Road Bridge, including all of Toodyay Town upstream of the bridge on the south bank of the river	9.16
Extracts	4	Goomalling Bridge to Glen Avon Weir	11.3
Katrine	5	Glen Avon Weir to Northam Town Weir	17.45
Northam	6	Northam Town Weir to confluence with Spencer's Brook	10.13
Muresk	7	Spencer's Brook to Wilberforce Crossing	8.75
Wilberforce	8	Wilberforce Crossing to Burges Siding	9.08
York	9	Burges Siding to Balladong Road Bridge	12.05
Cold Harbour	10	Balladong Bridge to Gwambygine East Road	11.40
Gwambygine	11	Gwambygine East Road to Oakover Crossing	5.83
Dale River	12	Oakover Crossing to Edwards Crossing	12.09
Beverley	13	Top Beverley Road to Beverley-Mawson Road	6.81
Kokeby	14	Beverley-Mawson Road Bridge to confluence with Avon River South Branch	21.67
Jurakine	15	Avon River South Branch to Johnson Road	5.51
Qualandary Crossing	16	Johnson Road to Qualandary Crossing	12.17
Yenyenning Lakes	17	Upstream from Qualandary Crossing	Indeterminate
Brookton	18	Confluence Avon River South Branch to Brookton Townsite	18.46

Appendix two
Major confluences and pools for each section of the Avon River

Section	Confluences	Pools
1	**Julimar Spring (3.0), Mortingup Brook (6.5), Munnapin Brook (8.0), Malkup Brook.**	**Cobbler (9.0), Long (10.5 - 11.0).**
2	**Jimperding Brook (2.5).**	**Diving (2.5 - 3.0), Deepdale (8.0 - 8.5).**
3	Toodyay Brook (5.0), Boyagerring Brook (8.5).	Nil
4	Harpers Brook (2.5).	Red Banks (2.0), Millard (3.0 - 5.0).
5	Mistake Creek (4.0), Wongamine Brook (13.5), Mortlock River (17.5).	Glen Avon (0.5 - 1.5), Katrine (5.5 - 6.5), Egoline (7.5 - 8.5).
6	Spencers Brook (6.10).	Northam (0.5 - 1.0), Burlong (4.3 - 5.0).
7	Heal Brook (7.0).	Wilberforce (7.5).
8	Salmon Gully (5.0).	Mackie (3.5 - 4.0), Tipperary (8.5).
9	Nil	Tipperary (0.5 - 1.0), Meares (3.5), York One Mile (9.5), York Town (11.0)
10	Bland Brook (0.5), Mackie River (6.5).	Mt Hardy (2.5), Cold Harbour (4.0).
11	Nil	Gwambygine (1.0 - 1.5), Fleays (5.5).
12	Dale River (6.5).	Broun (4.5), Robins (10.0 - 10.5).
13	Nil	Speldhurst (2.0).
14	Wannering (6.0).	Beverley (0.5), Eyres (6.5 - 7.0).
15	Turkey Cock Gully (1.5), South and Eastern Branches of the Avon River (5.0), Monjerducking Gully (6.0).	Nil
16	Bally Bally Gully (6.0).	Nil
17	Separate assessment	Separate assessment
18	Mangiding Brook (8.5).	Nil

Note:

The number in parenthesis refers to the distance (in kilometres) at which the confluence or pool is located from the downstream boundary of each section.

Appendix three
Summary survey information for River Sections 1 and 2

(Information contained in *Avon River Survey Volume 2: Section Condition Summaries and Condition Matrices*, an unpublished report prepared by Ecoscape (Australia) Pty Ltd and Jim Davies and Associates Pty Ltd for the Avon River Management Authority, 1996)

SUMMARY FOR SECTION 1
Avon Valley National Park to Jimperding Brook Confluence (length 11.23 km)

Over this section there is a distinct change in the Avon River channel morphology from what has been described as the mature river system in the east to a young high energy channel whose course is determined by the surrounding geology and rock formations. Typically the river is heavily incised with the surrounding hill slopes rising steeply on both banks. There is an increase in the number of tributary channels compared to the sections upstream associated with this change in relief. Investigation of these tributaries has determined that erosion effects are not extensive and that on the right floodplain, where a series of culverts have been installed below the railway line, some form of erosion mediation structure has been installed, usually as a rock headwall. No training works were conducted in this section so the river bed remains largely in its original condition.

At the downstream extent of the survey the channel forms a series of short pools to 500 m long, interspaced by rapids. Bedrock forms the base of the channel and there are large volumes of deposited rock and gravel. Vegetation exists within the main flow channels on isolated alluvial bars and areas of rock accretion or on rock platforms.

From 1.7.5, around Munnapin Brook to the upstream extent of the section, the river is a braided system. Melaleuca thickets stabilise numerous alluvial islands within the main flow channel, with much of the channel bed covered in a deposit of rock and gravel. At Cobbler and Long Pools, the river bed material returns to a clay alluvium with only limited areas of exposed bedrock. At these pool sections the river forms a single channel narrowing to around 40 m. Much of Section 1 contains water throughout the year due to the large number of pool features.

Areas of sand deposition are limited to the most upstream of the cross-sections. The channel banks are stable over the entire section length due to much of the bank material being bedrock and with most alluvial banks being stabilised by vegetation and rock deposition. There are no salinity effects in this area. No bed condition rating is given in the section condition matrix in Section 1 due to this region of the river remaining untrained. A foreshore assessment would rate it largely in the A and B categories. The bed is stable with few areas of mobile or highly erodable sediments.

A natural rock weir at 1/7.0 has been developed by the dumping of rocks across the river bed to form a causeway. This structure has caused pooling of water upstream and the death of mature *E. rudis*.

Most of this section is located in the Avon Valley National Park, hence there is very little agricultural use of the land here. The ecosystem is in a much healthier and balanced state and none of the three main overstorey species seem to be dominating over the others.

1 Main overstorey species present

The main two overstorey species present are *Melaleuca rhaphiophylla* and *Eucalyptus rudis,* with *M. rhaphiophylla* growing in the relic braided channels and

at the waters edge, and the *E. rudis* growing beyond it and sometimes amongst the closed forest of *M. rhaphiophylla*. There was not much *C. obes*a present in this section, and at transects where this species was observed, it was always growing as a woodland and interspersed amongst the *M. rhaphiophylla-E rudis*.

II Vegetation death

No significant amounts of vegetation death were noted in this section.

III Fencing

Most transects in this section were not fenced off due to minimal use of land for agricultural purposes, since most of this section is located within the confines of the Avon Valley National Park. There were few transects which did border with land that was being used for grazing of livestock (mostly sheep, but also some cattle), and at these points there was visible evidence of grazed and trampled understorey if fences bordering the riparian zone were absent.

IV Other native species present

The Avon Valley National Park is located in a zone approaching the Darling Scarp, hence other species present in this section are species that also grow in the soils of the Darling Scarp, and associated with Jarrah-Wandoo forest. These species include *Acacia acuminata, A. pulchella, A. saligna, Astartea fascicularis, Astroloma glaucescens, Callistemon phoenicius*, the Bristly Cloak fern – *Cheilantes distans, Dryandra bipinntifida, D. sessilis, Eucalyptus marginata, E. wandoo, Jacksonia furcellata, Juncus pallidus, Leptospermum erubescens, Loxocarys flexuosa, Macrozamia reidlei, Xanthorrhea priessii* and an unidentified Restionaceous species.

V Weed species present

There are a few weed species present in this section, with most being annual or perennial grass species. Included are Corn Gromwell *(Buglossoides arvensis)* Stinkwort *(Dittrichia graveolens),* glaucous blue-green ground cover (i.d. from herbarium), Soursob (*Oxalis pes-caprae*) and Sorrel (*Rumex acetosella*).

The main active channel was mostly comprised of, and lined with, large granite boulders and outcrops. This seems to make it more difficult for *Melaleuca rhaphiophylla* to grow as prolifically in this section. In the transects closer to Section 2, there is more sand deposited in the relic braided channels (medium to coarse grained sand) around bases of *M .rhaphiophylla* and *E. rudis*. Growing up through the areas of sand deposition are very small amounts of *Atriplex prostrata, Frankenia pauciflora*, and *Sarcocornia quinqueflora.* It would see m as if the areas of heavy sand deposition are covering understorey species, hence less of the characteristic understorey is present.

VI Vegetation condition

Over the entire section, the vegetation condition was given a rating of B3-C1. This rating indicated that the component understorey vegetation wasmostly comprised of weed species, and that there was no erosion of the river banks visible.

VII Regeneration

The three main overstorey species have a low to medium regeneration rate (1-100 plants/ha to 100-500 plants/ha), with virtually no regeneration of *Casuarina obesa*, a low amount of *Melaleuca rhaphiophylla* regeneration and a medium amount of *Eucalyptus rudis* regeneration. Regenerating individuals of the three species formed mixed aged stands.

VIII Disturbance factors

The only sources of disturbance came from presence of livestock (sheep) in the riparian zone at transect numbers 1/10.5,1/11.0 and 1/12.0. Kangaroos, or evidence of kangaroos, was seen at transect numbers 1/1.5 to 1/2.5, 1/ 3.5 to 1/5.0, 1/8.0 and 1/8.5.

Located near this section is a quarry site with service corridors bordering the riparian zone, but there did not seem to be any point source discharges or effects on the river and its banks from this quarry site

At transect 1/4.5 there was visible evidence of a fire on the right bank, and there was vegetative regeneration of species and also some regeneration due to promoted seed germination.

SUMMARY FOR SECTION 2
Jimperding Brook Confluence to Deepdale Road (length 8.14 km)

Deepdale Pool at 2/8.0 represents the downstream extent of the River Training Scheme and there is a very noticeable increase in the vegetation levels within the river over sections 2/8.5-2/7.5. The characteristic broad trained Main Channel (M/C) which has undergone removal of vegetation and ripping and subsequently incised by 0.5-1 m or more is replaced by a braided network of interconnected channels. From 2/0.5-2/7.5 the braided system is characterised by alluvial islands vegetated principally by *Melaleuca* but also with mature stands of *E .rudis*. The bar features are typically 1-1.5 m in height and less than 100 m long.

These vegetated islands are now creating a major trap for eroded sand sediments transported from further upstream. The sand deposits and slugs throughout this section are the single largest volume of erodable sediments per unit area within the surveyed 200 km reach. The two pools, 'Diving' and 'Deepdale', are largely filled, the photographic record of 1983 indicates that Deepdale has been filled for at least 13 years.

Although there are areas of exposed bedrock within the channel and particularly on the banks, it is less extensive than in Section 1. The channel bed material is accreted sands over clay alluvium with increasing gravel and rock deposition over sections 2/9.0-2/10.0. The fringing vegetation is generally in good condition although the floodplain has been extensively cleared over cross-sections 2/3.0, 2/9.0 and 2/10.0. There is also evidence of stock access in many areas reducing the potential for regeneration. The bed of the channel is defined as stable or accreting with the banks being generally stable except at the confluences of Jimperding Brook (2/2.5) and the unnamed confluence at 2/9.5. There are no salinity effects evident at this section.

Most of this section was not trained in the Avon River Training Scheme, therefore the main active channel is a series of relic braided channels (RBC). Most of the surrounding land in this section is used for agricultural purposes (mostly grazing of sheep) and nearly all transect sections have fences on both sides of the riparian vegetation surrounding the river channel. Despite the presence of fences on both sides of the river, there was still evidence of stock in the river (sheep) and trampling and grazing of the understorey native and introduced species.

I Main overstorey species present

Melaleuca rhaphiophylla and *Eucalyptus rudis* were the two principle species growing in the relic braided channels (RBC) in close proximity to the river. There was not much *Casuarina obesa* present in this section, and at transects where this species was observed it was always growing as a woodland and interspersed amongst *M. rhaphiophylla-E. rudis*. *Eucalyptus wandoo* and *Acacia acuminata* were also present, but growing further back from the waters' edge up on the banks where the soil was better drained.

II Vegetation death

There was no obvious death of vegetation noted in this section.

III Fencing

Almost all transects surveyed in this section had fences bordering the riparian vegetation and the paddocks used for agricultural purposes (primarily, the grazing of sheep). Only a few of the transects did not have a fence bordering the riparian zone. Despite the presence of fences, the majority of which were in a good to medium condition, nearly all transects surveyed showed evidence of livestock (sheep) in the river and its immediate surrounds, and a grazing of understorey vegetation.

At the time of this survey, there had been no significant rainfall in the Avon area for at least six months, and virtually the only green vegetation visible was that of the river's riparian zone. Perhaps the property owner allowed access for their livestock to graze within the confines of the riparian zone at this time of very limited stock feed.

IV Other native species present

The main native species present at this section apart from the three principle overstorey species which form the riparian vegetation are *Acacia acuminata, A. saligna, Dryandra sessilis, Eucalyptus loxophleba, E. wandoo, Juncus pallidus* and *Xanthorrhoea preissii* at some transects. There were very little characteristic understorey species present in this section, only *Atriplex prostrata*. This was attributed to the presence of livestock in the river and

riparian zone, and also to the large amounts of medium grained sand deposited in the relic braided channels (RBC) and banking up against the closed forest of *Melaleuca rhaphiophylla* have been buried by the sand deposited from further upstream.

V Weed species present

The weed species growing in this section were seen to be mostly annual or perennial grass species. Other species present were Soursob (*Oxalis pes-caprae*), Stinkwort (*Dittrichia graveolens*), Sorrel (*Rumex acetosella*), Blackberry nightshade (*Solanum nigrum*), Corn Gromwell (*Buglossoides arvensis*), Common thornapple (*Datura stramonium*), and Umbrella Sedge (*Cyperus eragrotis*) and Saltwater couch (*Paspalum vaginatum*).

VI Vegetation condition

The entire section was given a rating of B3-C1, with the exception of the two transect sections (2/8.9 and 2/8.5) which were rated as C2. This latter rating indicated that there was some exposed soil at the section due to surface erosion (these two transects which were seen to be more degraded had one bank fenced off and the other bank was not fenced). There were sheep present in the river and grazing on the bank vegetation was visible, despite the fencing off of the riparian vegetation on one side. It is thought that the higher level of degradation present at these two transects compared to other transects of Section 2 was due to grazing and trampling of river bank understorey species by the sheep.

VII Regeneration

The regeneration of the overstorey species is at a nil to low rate for *Casuarina obesa* and *Eucalyptus rudis*, and a low to medium rate for *Melaleuca rhaphiophylla*. The regenerating individuals of the three species formed mixed aged stands.

VIII Disturbance factors

There was evidence of foxes (a fox den) at one transect (2/6.5), but the main disturbance factors in this section were due to presence of livestock in the river and grazing of the understorey vegetation.

Appendix four
Summary of streamflow and water quality records for Walyunga gauging station

Walyunga wq statistics

Reference	Variable Id	Unit	Minimum	Maximum	Average	No. of readings	First reading	Last Reading
616011								
Al (tot)	29	mg/L	0.100	0.200	0.150	2	28 May 1998	21 Jul 1998
Alkalinity (CO_3 CO_3)	332	mg/L	0.000	3.000	0.237	38	03 Jun 1981	28 Jul 1988
Alkalinity (HCO_3 HCO_3)	333	mg/L	40.000	165.000	97.684	38	03 Jun 1981	28 Jul 1988
Alkalinity (tot) (CaCO3)	23	mg/L	32.807	150.000	85.945	118	09 Jul 1970	21 Jul 1998
Analysis completion date	1256	yyyyddd				0	09 Jul 1970	14 Apr 1999
BOD	25	mg/L	2.000	240.000	35.962	13	11 Jun 1980	23 Oct 1985
Batch number	1255	(none)	6055.000	29701.000	22555.659	3970	01 Apr 1970	12 Oct 1999
CDO	27	mg/L	7.570	44.000	25.165	6	05 Aug 1996	21 Jul 1998
Ca (sol)	353	mg/L	27.000	125.000	72.024	41	11 Aug 1976	21 Jul 1998
Cd (sol)	342	mg/L	0.000	0.000	0.000	9	29 Apr 1981	13 Jul 1983
Chlorophyll A	9	mg/L	0.002	0.013	0.006	11	29 Apr 1981	23 Oct 1985
Cl (sol)	284	mg/L	377.230	7523.801	3155.089	705	01 Apr 1970	21 Jul 1998
Cloud cover	1125	%	20.000	20.000	20.000	1	05 Nov 1998	05 Nov 1998
Co (tot)	35	mg/L	0.002	0.002	0.002	5	10 Feb 1982	13 Jul 1983
Colour (hazen)	1059	Hu	10.000	100.000	49.615	13	20 Aug 1973	02 Jul 1986
Colour (true)	1181	Hu	5.000	330.000	32.642	944	09 Jul 1970	15 Sep 1998
Cond calc 25 deg C	21	µS/m	1170000.000	1170000.000	1170000.000	1	11 Aug 1976	11 Aug 1976
Cond uncomp (in situ)	1165	µS/m	45899.996	1632000.000	829142.875	21	05 Aug 1994	07 Dec 2000
Cond uncomp (lab)	1163	µS/m	143400.000	2970000.000	992818.622	3792	31 May 1973	05 Jul 1999
Cr (sol)	344	mg/L	0.000	0.001	0.001	5	10 Feb 1982	13 Jul 1983
Cu (sol)	345	mg/L	0.002	0.007	0.004	5	10 Feb 1982	13 Jul 1983
Date sample received	1257	yyyyddd				0	20 Mar 1992	14 Apr 1999
616011								
Discharge rate	1271	m^3/s	10.739	10.876	10.808	2	09 Jun 1982	20 Jun 1984
Discharge rate (estimated)	1270	m^3/s	6.651	25.470	16.867	5	31 May 1973	17 Oct 1973
Fe (tot)	38	mg/L	0.050	5.690	0.417	24	20 Mar 1992	21 Jul 1998
Hardness (tot)	278	mg/L	277.450	2010.000	1094.152	120	09 Jul 1970	21 Jul 1998
K (tot)	40	mg/L	7.000	28.000	14.028	40	03 Jun 1981	21 Jul 1998
LOI VSS	19	mg/L	0.500	31.000	4.294	54	23 Apr 1996	05 Nov 1998
Lab analysis number	1264	(none)	867.000	905154.000	453507.413	247	20 Mar 1992	14 Apr 1999
Longitudinal distance	1244	m	660.000	660.000	660.000	1	26 Jul 1983	26 Jul 1983
Mg (sol)	356	mg/L	51.000	318.000	173.475	40	03 Jun 1981	21 Jul 1998
Mn (sol)	57	mg/L	292.000	292.000	292.000	1	11 Aug 1976	11 Aug 1976
Mn (tot)	43	mg/L	0.040	0.660	0.079	24	20 Mar 1992	21 Jul 1998
N (ox sol)	1024	mg/L	0.530	0.530	0.530	1	05 Jul 1999	05 Jul 1999
N (tot kjeldahl)	5	mg/L	0.260	2.500	0.815	72	29 Apr 1981	05 Jul 1999
N (tot ox)	4	mg/L	0.005	2.809	0.246	238	06 Oct 1976	14 Apr 1999
N (tot)	6	mg/L	0.260	73.000	2.312	462	08 Jun 1987	10 Dec 2000
NH_3 N/NH_4 N (sol)	582	mg/L	0.005	0.900	0.130	248	16 Aug 1971	05 Jul 1999
NO_2 N (sol)	2	mg/L	0.010	0.084	0.028	8	23 Apr 1996	05 Jul 1999
NO_3 (sol)	467	mg/L	1.000	27.000	6.053	38	03 Jun 1981	28 Jul 1988
NO_3 N (sol)	3	mg/L	0.010	2.700	0.678	16	23 Apr 1996	05 Jul 1999
Na (sol)	357	mg/L	372.000	2422.000	1176.400	40	03 Jun 1981	21 Jul 1998
Ni (sol)	347	mg/L	0.002	0.002	0.002	5	10 Feb 1982	13 Jul 1983
O DO (in situ)	1033	mg/L	6.000	9.600	7.960	4	05 Nov 1998	07 Dec 2000

Reference	Variable Id	Unit	Minimum	Maximum	Average	No. of readings	First reading	Last Reading
616011								
O Do	63	mg/L	5.700	10.400	8.300	33	16 Aug 1971	14 Apr 1999
O Do %	62	%	76.800	76.800	76.800	1	05 Nov 1998	05 Nov 1998
Oxy dis conc (lab)	1194	mg/L	5.600	10.200	8.508	13	11 Jun 1980	23 Oct 1985
Oxy dis sat (lab)	1195	%	62.000	113.000	91.615	13	11 Jun 1980	23 Oct 1985
P (tot reactive sol)	225	mg/L	0.005	0.480	0.015	243	29 Apr 1981	05 Nov 1998
P (tot)	8	mg/L	0.002	1.200	0.063	497	16 Aug 1971	10 Dec 2000
PO_4 p (sol)	179	mg/L	0.002	0.009	0.004	4	02 Nov 1994	05 Jul 1999
Pb (sol)	348	mg/L	0.004	0.004	0.004	5	10 Feb 1982	13 Jul 1983
S (tot)	158	mg/L	68.800	158.000	113.400	2	28 May 1998	21 Jul 1998
SO_4 (tot)	541	mg/L	81.000	405.000	207.947	38	03 Jun 1981	28 Jul 1988
Salinity	61	ppt	5.500	5.500	5.500	1	05 Nov 1998	05 Nov 1998
Sample depth (below WSL)	1248	m	0.000	0.000	0.000	13	11 Jun 1980	23 Oct 1985
Secchi depth	1074	m	0.500	0.500	0.500	1	05 Nov 1998	05 Nov 1998
SiO_2 reactive (sol)	14	mg/L	3.000	14.000	8.250	40	03 Jun 1981	21 Jul 1998
SiO_2 Si (sol)	1397	mg/L	0.290	5.400	2.713	56	23 Apr 1996	22 Jul 1997
Suspended solids (EDI)	1154	mg/L	3.900	432.300	109.741	48	04 Jul 1974	28 Nov 1977
Suspended solids (ETR)	1155	mg/L	5.900	445.000	103.589	31	17 Aug 1971	24 Nov 1976
Suspended solids (gulp)	1156	mg/L	18.790	18.790	18.790	1	16 Aug 1984	16 Aug 1984
Suspended solids (pump)	1157	mg/L	5.520	116.100	50.335	15	19 Aug 1976	30 Aug 1977
Suspended solids < 63µ (EDI)	1149	mg/L	3.900	834.980	112.018	42	16 Dec 1976	26 Aug 1983
Suspended solids < 63µ (ETR)	1150	mg/L	3.300	56.500	16.720	5	09 Sep 1976	30 Jun 1980
Suspended solids < 63µ (gulp)	1151	mg/L	2.020	726.550	82.039	119	03 Aug 1977	23 Jan 1992
616011								
Suspended solids < 63µ (pump)	1159	mg/L	0.000	1333.800	24.455	2267	03 Sep 1976	21 Oct 1992
Suspended solids > 63µ (EDI)	1160	mg/L	0.000	116.100	15.018	41	30 May 1978	26 Aug 1983
Suspended solids > 63µ (ETR)	1158	mg/L	12.300	12.300	12.300	1	30 Jun 1980	30 Jun 1980
Suspended solids > 63µ (gulp)	1152	mg/L	0.210	23.650	4.378	20	16 May 1978	03 Oct 1978
Suspended solids > 63µ (pump)	1153	mg/L	0.010	86.330	7.034	44	11 Nov 1976	03 Oct 1978
TDSalts (sum of ions)	1218	mg/L	1290.000	7092.000	3849.289	38	03 Jun 1981	28 Jul 1988
TDSolids (calc @180°C) HCO_3	17	mg/L	6970.000	6970.000	6970.000	1	11 Aug 1976	11 Aug 1976
TDSolids (calc @180°C by cond)	1222	mg/L	2042.000	9918.000	5004.246	118	09 Jul 1970	01 Jan 1977
TSS	16	mg/L	1.000	1960.000	99.675	246	23 Apr 1996	10 Dec 2000
Tide status	1117	(none)	2.000	2.000	2.000	1	05 Nov 1998	05 Nov 1998
Transaction number	1241	(none)	83005.000	1998329.000	1893707.667	522	01 Apr 1970	15 Sep 1998
Turbidity	64	NTU	0.000	550.000	10.896	2725	11 Aug 1976	05 Jul 1999
Turbidity (JCU)	1193	JTU	25.000	25.000	25.000	114	09 Jul 1970	01 Jan 1977
Water level (SLE)	1275	m	9.770	16.634	11.240	728	09 Jul 1970	07 Dec 2000
Water level (SLE) (maximum)	1276	m	10.600	10.600	10.600	1	15 Jul 1997	15 Jul 1997
Water level status	1316	(none)				0	28 Jul 1977	19 Sep 2000
Water temperature (in situ)	59	deg C	8.700	31.000	16.485	568	09 Jul 1970	07 Dec 2000
Water temperature (test)	1166	deg C	16.500	34.200	24.534	3822	31 May 1973	05 Jul 1999
Wind speed	1123	n mile	0.000	0.000	0.000	1	05 Nov 1998	05 Nov 1998
Zn (sol)	360	mg/L	0.005	0.083	0.024	5	10 Feb 1982	13 Jul 1983
pH	22	(none)	0.000	8.700	7.654	556	09 Jul 1970	05 Jul 1999
pH (in situ)	1168	(none)	7.800	8.300	8.000	5	15 Sep 1998	07 Dec 2000

Walyunga monthly flow

Water and Rivers Commission **HYMONTH V60 Output 11.02.2002**

Station 616011 AVON RIVER — WALYUNGA Station 616011

Var from 10.00 STAGE — SL in metres

Var to 140.00 Minimum stream discharge in cubic metres/second

Figures are for period ending 2400 hours.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual minimum	Missing days	Year
1970	[ ]	[ ]	[ ]	[ ]	[0.356]	3.222'	7.133'	6.693'	4.003	0.852	0.059	0.000	[0.000]	134	1970
1971	[0.000]	0.000	0.000	0.447	0.332	1.898	1.936	3.581	3.367	2.766	0.730	0.056	[0.000]	11	1971
1972	0.000	0.000'	0.000'	0.000'	[0.000]	0.612"	4.450"	7.958"	3.103"	0.716'	0.025'	0.000	[0.000]	4	1972
1973	0.000	0.000	0.000	0.000	[0.000]	[ ]	[54.69]	18.45	14.10	4.916	0.324	0.028	[0.000]	61	1973
1974	0.000	0.000	0.000	0.000	1.760'	34.59'	55.57'	68.15 *	17.74'	7.578	0.843	0.075	0.000*	0	1974
1975	0.000	0.000	0.000	0.000	0.510	2.782	5.130'	16.85 '	7.899	2.012	0.434	0.027	0.000'	0	1975
1976	0.000	0.000"	0.021	0.035	0.357	1.168	1.883	2.664	4.271'	0.807'	0.362'	0.020'	0.000"	0	1976
1977	0.000'	0.000'	0.000	0.000	0.000	0.538	1.257	2.368	1.374	0.410	0.106	0.000	0.000'	0	1977
1978	0.000	0.000	0.000	0.000	0.092	1.401	7.656	8.654	4.514	0.502'	0.071'	0.019'	0.000'	0	1978
1979	0.000	0.000	0.019	0.029	0.174	1.232	4.407	3.011	2.301	0.347	0.157	0.002'	0.000'	0	1979
1980	0.000'	0.000	0.000	0.000*	0.078	1.082	4.532	7.414	3.146	1.402	0.223	0.020	0.000*	0	1980
1981	0.000	0.000	0.000	0.000'	[0.020]	[20.47]	16.40	25.28	6.629	1.774	0.836"	0.094	[0.000]	9	1981
1982	0.034'	0.035	0.006	[0.042]	0.071	1.082'	5.244"	11.99'	4.807	1.118	0.241	0.056	[0.006]	3	1982
1983	0.000'	0.000'	0.000	0.078	0.089	0.268	25.48	31.14	15.99	1.692	1.272	0.359	0.000'	0	1983
1984	0.031	0.000	[0.000]	[0.524]	1.712	11.12	9.216	12.85 "	8.128"	1.321	0.424	0.064	[0.000]	34	1984
1985	0.000	0.000	0.000	0.000	0.071*	0.464	3.754	7.306	4.038	0.640	0.054	0.010	0.000*	0	1985
1986	0.000	0.000	0.097	0.043	0.036	1.328	15.86	26.15	5.364	1.554	0.183	0.011	0.000	0	1986
1987	0.000	0.000	0.000	0.000	0.310	0.910"	7.079	11.87	4.954	1.056	0.159	0.043	0.000"	0	1987
1988	0.000	0.000	0.000	0.000	0.000	3.130	10.31	15.11	8.616	2.654	0.321	0.051	0.000	0	1988
1989	0.015	0.000	0.000	0.000	0.064	5.842	13.75	9.309	4.285	1.918	0.073	0.003	0.000	0	1989
1990	0.000	12.12	1.402"	0.598	0.149*	2.802*	2.370	13.16	6.102	1.775	0.188	0.011	0.000*	0	1990
1991	0.000	0.000*	0.000*	0.000	0.046	1.402	15.32	15.75	7.801	1.978	0.505*	0.053*	0.000*	0	1991
1992	0.008	0.006	0.012	0.089	0.469	0.779	15.37'	14.47*	29.15*	2.116	1.064	0.051	0.006*	0	1992
1993	0.000	0.000	0.000	0.061	0.237	3.982*	8.677*	13.75	7.279	1.645	0.344	0.001	0.000*	0	1993
1994	0.000	0.000	0.000	0.000	0.000	3.083	10.38	6.126	2.315	0.272	0.017	0.000	0.000	0	1994
1995	0.000	0.000	0.000	0.000	0.012	1.978	7.871	26.58 "	6.845"	2.773	0.536	0.097	0.000"	0	1995
1996	0.000	0.000	0.000	0.000	0.000	0.384	20.07	31.30	18.95	4.807"	1.566	0.073	0.000"	0	1996
1997	0.000	0.000	0.000*	0.032*	0.612	2.869	2.869	6.654	4.870'	0.763'	0.135'	0.000'	0.000*	0	1997
1998	0.000'	0.000"	0.000"	0.000"	0.022"	0.369"	10.78"	6.430"	10.81 "	0.276"	0.000"	0.000"	0.000"	0	1998
1999	0.000"	0.000"	0.000"	0.000"	0.048	15.29	23.75'	19.91	23.25	5.354'	0.511	0.016	0.000"	0	1999
2000	0.009"	1.118"	0.478	0.595	0.950	1.008	5.325	14.50	6.598	1.022	0.115	0.001	0.001"	0	2000
2001	0.000	0.000	0.000	0.000"	0.000"	[0.501]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[0.000]	208	2001
														464	**Total**
Mean	[0.003]	0.428*	[0.066]	[0.083]	[0.268]	[4.116]	[12.21]	15.01 *	8.149*	1.897"	0.383*	0.040*	[0.000]		**Mean**
Med.	[0.000]	0.000*	[0.000]	[0.000]	[0.074]	[1.401]	[7.871]	12.85 *	6.102*	1.554"	0.241*	0.020*			**Med.**
Max	[0.034]	12.12*	[1.402]	[0.598]	[1.760]	[34.59]	[55.57]	68.1*	29.15 *	7.578"	1.566*	0.359*	[0.006]		**Max**
Min	[0.000]	0.000*	[0.000]	[0.000]	[0.000]	[0.268]	[1.257]	2.368*	1.374*	0.272"	0.000*	0.000*	[0.000]		**Min**
OK	99%	100%	98%	98%	97%	97%	97%	100%	100%	100%	100%	100%	99%		**OK**
Cnt	31	31	31	31	32	31	31	31	31	31	31	31	32		**Cnt**

NOTES

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