AVON WATERWAYS COMMITTEE
RIVER RECOVERY PLAN
Sections 4 and 5 – Northam to Toodyay

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
REPORT No RRP 8
OCTOBER 2002

Acknowledgments

The Recovery Plan for Sections 4 and 5 of the Avon River between Northam and Toodyay has been prepared through local consultative processes with contributions from many individuals, families, groups and organisations. Those who made regular contributions through the interim Recovery Team were John and Jeanette Masters, Bob and Roslyn Quin, Doug and Kath Morgan, Wayne and Desraé Clarke, Peter Weatherly, Pat Smith, Rex Warne, Nerrilyn and Abraham Agius, Rex Downie, Ross MacKenzie and Walter and Rae Kolb.

Meetings were hosted at the Katrine Barn by the Downie family, at the Avon Pottery by Bob and Roslyn Quin, at 'Glen Avon' by John and Jeanette Masters and by Lesley and Maurie Hill at 'Toodyay Lavender Estate'.

Bernard Kelly, Phyllis Graham, Martin Revell and staff at the Northam Office of the Water and Rivers Commission provided substantial support during the process.

Others who contributed to the planning process were:

Rex Adams (Avon Descent Management Committee), Annabelle Bushell, Lance and Elizabeth Bushell, Albert Chen, Alan Cole (Chair, Avon Waterways Committee), John Clarke, Dr Gen Che Ng, Michael and Mary Guest, Judy and Bruce Houston, Bethan Lloyd (Toodyay Landcare Coordinator), Tony Marwick, John and Brenda Morgan, Wayne Morgan, Michael Morrow, Ray Paynter, Trevor Sharman,

Iva Stejskal, Axel Strauss, Karen Tan and Max Trenorden, MLA, Member for Avon.

Reference details

The recommended reference for this publication is: Water and Rivers Commission and Avon Waterways Committee 2002, *River Recovery Plan, Sections 4 and 5 – Northam to Toodyay*, Water and Rivers Commission, River Recovery Plan Series No RRP 8

Avon Waterways Committee

We welcome your feedback

A publication feedback form can
be found at the back of this publication,
or online at www.wrc.wa.gov.au/public/feedback/

Cover Photograph:
Glen Avon Pool
Photograph courtesy of Ecoscape

ISBN 1-920687-07-6
ISSN 1441-5208

October 2002

Dedication to Jim Masters

Photo 1: Jim Masters *Dedication photo courtesy Bernard Kelly*

This Recovery Plan is dedicated to the late Jim Masters (OAM) in appreciation of his devotion to the Avon River and it's natural landscape and for his contribution towards understanding the river as a living entity.

Jim farmed with his family at 'Glen Avon' by the river between Northam and Toodyay. He was also outstanding as a naturalist and ornithologist. His clear understanding of the complex river ecosystem guided many people for river management. Jim would claim that his education came from attending the 'Katrine University' (ie the local natural environment)!

Five important principles of river management were developed by Jim Masters:

- Understand the nature of the river being protected
- Maintain the river's energy balance
- Base management on long-term observations
- Protect natural resources
- Respect the forces of nature.

In 1994, an Order of Australia was awarded to Jim in recognition of his contribution to conservation. His family has made land available to the Shire of Northam for a Reserve of the river ecosystem in honour of his efforts. He is remembered as the man of the river.

Contents

Figures

Maps

Photographs

Tables

Preface

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

The Avon Waterways Committee (AWC) was formed in 2001 as a community-based sub-committee of the Board of the Water and Rivers Commission to provide advice on waterways issues. The AWC will also provide advice to the Avon Catchment Council.

A strategic approach to river management is outlined in the 'Avon River Management Programme' developed by the former Avon River Management Authority. The 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 management. Recovery Plans are now being prepared for these sections. Management of the major tributaries will also be considered. River sections that include the towns of Toodyay, Northam, York, Beverley and Brookton are complete. Plans for those sections between towns are also complete or well advanced in preparation.

This Recovery Plan for Sections 4 and 5 covers an important part of the river between the Goomalling Road Bridge in Toodyay and the weir of Northam's Town Pool.

These Sections include 5 river pools and Extracts Weir. There is also the confluence of the Mortlock River near Northam, and of Wongamine Brook and two smaller tributaries downstream. The Avon is scenic in these sections as it descends through a hilly landscape. It is well recognised by those who travel east from Perth by train or along the roads between Northam and Toodyay. These sections are also well known to those involved in the long-running "Avon Descent" especially for the challenging rapids at Glen-Avon Pool and at Extracts Weir.

The purpose of the Recovery Plan for Sections 4 and 5 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 has 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.

These sections of the river have been the home and study area of the late Jim Masters (OAM). Jim has had a significant influence on river management in many ways. Importantly, he opposed the river training operations based on his understanding of the impact that it would have on the river ecosystem. This understanding, proven correct with time, assisted many with decisions about best management practice for the river. This Recovery Plan is dedicated to Jim Masters in memory of his efforts.

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. The sections are shown on Map 1 and described in Appendix one). This Recovery Plan is for almost 29 km of the Avon River in Sections 4 and 5 from the Goomalling Road bridge near Toodyay upstream to the constructed weir across the river in the town of Northam 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 500 metre intervals for the entire 191km of main channel length. Additional surveys were undertaken of the river pools. 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 4 and 5 is provided in Appendix Three.

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 has an area of 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 river basin differs to those in other countries. The outer 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, 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 waterway of the river is discernible upstream to Wickepin. The South Branch of the Avon arises near Pingelly flowing through Brookton and joins the main river channel downstream of the Yenyening Lakes, as shown on Map1.

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

- South Branch, which rises above Brookton
- Dale River (including Talbot Brook)
- Mackie River
- Blands Brook
- Spencers Brook
- The Mortlock Rivers (North, South and East branches)
- Wongamine Brook
- Harper 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 for 310 days or 85% of the year. In a dry year, the river above 'Broun's Farm' (near York) contributes only 12% of total river flow; in a wet year this can rise to over 40%.

The confluence of the Mortlock River (including the North, South and East branches) with the Avon is immediately downstream from Northam's River Pool weir. During wet years, the Mortlock contributes approximately 14% of total river flow (as measured at Walyunga), although this contribution is only about 3% of the total river flow in dry years (Harris, 1996).

On average, the total volume of river flow at the weir in Northam is 160 million m^3 (160 million cubic metres) compared with 360 million m^3 at Walyunga. The average contribution for the Mortlock River is approximately 24 million $m^{3.}$ These values vary considerably from year to year.

The rate of flow of the Avon River is estimated to be 4 times higher 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 lead to the River Training Scheme from the late 1950s to the early 1970s. 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;
- 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 a 50-year magnitude have occurred since the works were completed. This may be 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 as shown in Map 2.

These are:

- 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 usually comprise chains of shallow salt lakes. The contribution to water flow in the Avon River is generally less than 10% although the contribution of salt is high.

The Mortlock River consists of three major branches (north, east and south). The catchment area for these is 14% of the total area of the Avon River Basin. The Mortlock contributes significantly to the salt and nutrient loads of the Avon, and to flow during wet years.

1.2.5 The river pools

There 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. In addition, there were many smaller pools that are mostly now filled with sediment. Some are forgotten.

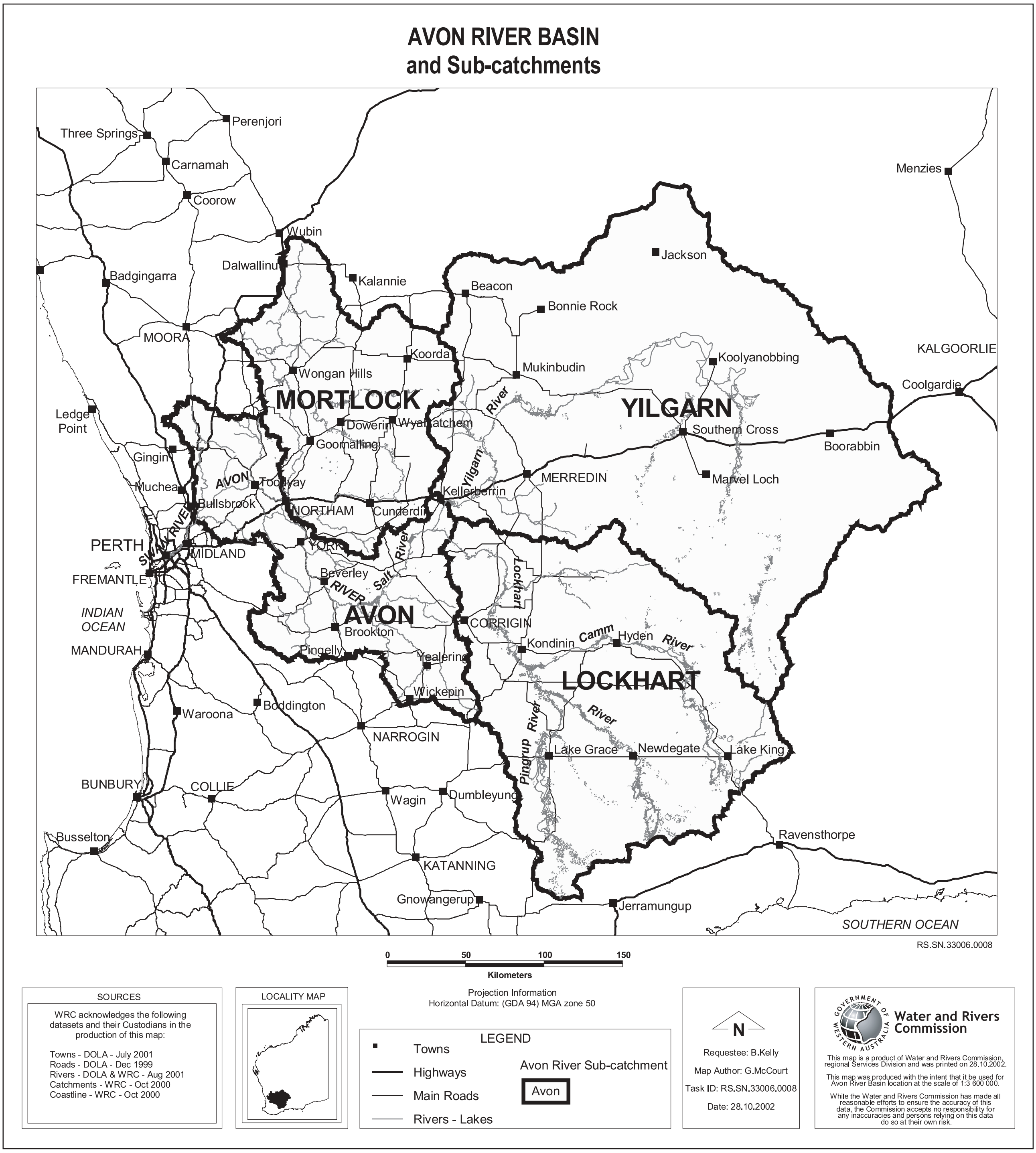
Many of the pools are now filling with sediment and are subject to eutrophication as a result of nutrient enrichment.

The following pools are now totally filled:

Mile Pool, Egoline Pool, Jangaling 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



Map 2: Avon River Basin catchment

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 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 a changing flow regime still threaten these ecosystems.

2 Description of river sections 4 and 5

2.1 Physical description

2.1.1 Adjacent landscape

The Avon River from Northam to Toodyay drains through a valley ranging from 2km to 6 km in width, although some of the tributaries, excluding the Mortlock, extend up to 20 km from the river. The well-dissected landscape is described as the Zone of Rejuvenated Drainage (Lantzke and Fulton, 1992). The elevation of the valley is from 128-144 m in the river bed up to approximately 300m Australian Height Datum (AHD) although some peaks are over 400m. Table 1 shows a range of bed elevation for some locations along the river. Table 2 shows a range of elevation peaks that bound tributaries to the river.

Table 1: Avon River bed elevation at locations between Northam and Toodyay

Location	**Elevation** (m AHD)
Below Northam's Town Pool weir	143.7
Great Eastern Highway By-pass	141.3
Katrine Causeway	135.1
Below Glen Avon weir	133.9
Dumbarton Road Bridge	130.3
Below Extracts weir	126.9
Red Banks Pool	125.9
Goomalling Road Bridge	123.7

The regional geology and general landscape physiology are well described by Lantzke and Fulton (1992). They also describe four 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 that 1%.

York – steep hilly landscape with slopes of 3-12% and contain red and brown greyish loamy soils formed from freshly exposed bedrock. Most arable agricultural land is within this unit.

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 landscape unit effectively defines the river floodplain – it was formed primarily by river (alluvial) processes. The soils are from former river channels or were deposited by floods. This unit generally alternates either side of the river and is at most 400 metres wide. Other landscape units adjacent to the river are generally steep with extensive rock outcrop. Flooding does occur within the Avon unit but not all is now subject to flooding. The active floodplain is generally defined by a river terrace

Table 2: Elevation of conspicuous peaks between Northam and Toodyay

South of the Avon River	**Elevation** (m AHD)	**North of the Avon River**	**Elevation** (m AHD)
Mount Ommanney	259	Mt Dick (in the Mortlock catchment)	286
Monday Hill	317	Iron Knob	295
Yeegolyne Katta	261	Wongamine Hill	259
Bobakine Hills	432	Nockdominie Hill	265
Noondeening Hill	249	Whitefield Hill	298
Gabiminga Hill	286		
Windmill Hill	263		
Mount Nardie	376		

although flood backwaters can inundate a larger area, particularly the broad valley floors of tributaries. A marker on the stone wall of a roadside shed at the historic Katrine Homestead shows the height of floodwaters during the 1872 flood, the biggest recorded Avon River flood. This provides a good visual indicator of the extent of potential valley flooding.

The Steep Rocky Hills unit is significant in determining the morphology of the river. The river is confined by rocky slopes either side downstream of the Katrine Causeway and again at the major meander 4.5 km upstream from the Goomalling Road bridge.

2.1.2 River channel

From the Northam's Town Pool Weir, the river re-orientates through 90 degrees to flow west. For the next 14 km, the river has significant meanders before trending north-west for a relatively straight 4 km section that includes Katrine and Glen Avon pools. It then orientates north for 3 km without meanders before trending towards the west through an acute meander for 6 km of diminishing sinuosity to the Goomalling Road bridge. Within this last section is the actively eroding river bank (locally referred to as "Red Banks") 500 metres downstream from 'Extracts' weir. Erosion is due to streamflow deflection from rock outcrop on the convex bank of a minor but acute meander. The total length of the river from the Northam Town Pool weir to the Goomalling Road bridge is approximately 29 km.

Prior to the River Training Scheme (RTS), the river channel was braided (many intertwining channels). Training works during the 1960s converted this to a single channel approximately 60 m wide. Bulldozer action to clear the channel during the RTS has resulted in heaped spoil deposition parallel to stream flow. In places, this performs as a levee restricting access of floodwaters to the adjacent floodplain. It also truncates some floodways and affects the discharge to the river of some tributaries.

The river bed is now generally 1-1.5 m deeper than the original bed level although this varies considerably. Channel bed erosion is limited in depth by cemented clays. Southwell (1993) has shown the extent of 'scour and fill' with bed sediments since the River Training Scheme.

Although landholders observe that significant flooding has not occurred since the River Training Scheme, there have not been conditions for major flood events during this period.

Within the river bed, base flow stream location varies with time due to there being highly mobile bed load sediments. These sediments are re-establishing new channel shape with stable sediment deposition on the inside banks of most meanders, particularly those between Northam and Katrine Pool. Where sediment deposition is extensive and is being stabilised by natural vegetative regeneration, early stages of a new braided channel formation are developing. There is a major unstabilised 'sand slug' 2.5 km in length in the meander that contained the former Egoline Pool.

The river bed gradient is approximately 0.69 metres/km (0.07%) for Sections 4 and 5. The general gradient from Beverley to Toodyay is 0.8 metres/km (0.08%).

Table 3 shows the gradient for each river section upstream from the Avon Valley National Park to Northam. It is significant to note that the gradient of Section 5 is half that of Section 4.

Table 3: 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

2.1.3 Stream flow

A stream gauging station (Ref. 615062) is located at the Northam weir river pool for which records date back to 1977. The station and the records are maintained by the Water and Rivers Commission.

Total annual stream flow ranges from 21.86 million m^3 in 1980 to 511.7 million m^3 in 1983. The average flow volume is approximately 160 million m^3. The average annual flow volume at Walyunga is 360 million m^3. The Avon at Northam contributes 44% of the flow, excluding flow from the Mortlock River).

The monthly flows of 110.8 million m^3 for January and 106.1 million m^3 for February 2000 are the highest for summer and are among the highest of all months recorded for this station (higher monthly flows were recorded in July of 1978, 1983 and 1996 and in August 1983).

Mean monthly flow rates shown in Appendix Four (p1) indicate the periods of high flow but it is the maximum flow rates shown in Appendix Four (p2) that indicate the potential for flood conditions. The flood in January 2000 had a 24 hour period peak flow of 210.2 cubic metres/second. This was estimated to be a 1:20 year summer event (Muirden, 2000).

Local observations suggest that high flow from the Mortlock River catchment affects the lower sections of the Avon earlier than high flow from upper Avon River sections (Doug Morgan, *pers. comm.*).

2.1.4 Riparian vegetation

The natural river vegetation in Sections 4 and 5 consists of a different plant community to that of the adjacent landscape. It is dominated by Flooded Gums (*Eucalyptus rudis*), Swamp Sheoak (*Casuarina obesa*) and Swamp paperbarks (*Melaleuca raphiophylla*).

The riparian community structure is changing. The Avon River Survey (Ecoscape, 1996) shows low to medium regeneration for *E. rudis, M. rhaphiophylla* and *C. obesa*. Weeds dominate the understorey and may retard natural regeneration.

Change may also be due to altered perched groundwater aquifer characteristics. This aquifer is recharged less frequently with reduced flooding which may be significant for initiating natural regeneration.

2.1.5 Pools

There are 5 significant pools within these sections of the Avon River. These are shown on Map 3. They are Egoline (now filled with sediment), Katrine, Glen Avon, Millards and Red Banks (also known as Lloyds) pools. The physical dimensions of these pools are shown in Table 4.

Glen Avon and Millards pools have the greatest length of all pools on the river. Glen Avon pool has the largest unfilled pool volume (325 000 m^3) which is a 10:1 ratio with filled volume. Only Wilberforce pool, between Northam and York, has a higher unfilled volume ration (41:1).

While some pools have filled with sediment, new pools are being scoured. Permanent scour pools are now located downstream of Glen Avon Weir (known locally as Tink's Pool), downstream of Extracts Weir (at the confluence of Harpers Brook), and downstream from the weir in Northam.

Egoline: This previously popular pool, once used for swimming, picnics and occasionally water skiing, filled soon after the River Training Scheme. The total pool volume, estimated to be 158 000 m^3, now contains coarse sediment. In addition, there is a 'sand slug' extending for

Table 4: Characteristics of major river pools

	Egoline	Katrine	Glen Avon	Millards	Red Banks
1960 length (m)	1100	640	1600	> 2200	No data
1996 length (m)	Filled with sediment	280	1750	1750	400
1955 depth (m)	6.63	3.96	4.58	5.48	No data
1973 depth (m)	2.82	No data	3.05	3.93	No data
1978 depth (m)	Dry	No data	2.68	3.37	6.7
1996 depth (m)	Dry	1.96	3.76	3.93	4.41
1996 filled volume (m^3)	158 000	62 000	32 000	310 000	
1996 unfilled volume (m^3)	0	20 000	325 000	210 000	32 000
1996 Salinity (mg/L)		18 157	14 373	16 955	7 003
1996 Phosphorus – sediments (mg/g)		0.076	0.388	0.196	No data
1996 Phosphorus – water (mg/L)		0.129	0.605	0.197	0.017

Information source: JDA (1997)

a length of 2.5 km which suggests that this section of the river has lower velocity stream flow causing sediment deposition.

Katrine: Medium-coarse sand has filled over two-thirds of the pool volume (total sediment volume of 62 000m^3). A relatively small amount of sediment (3 800 m^3) was excavated in 2001 for use in construction of the Great Eastern Highway By-pass. A survey of pool sediments shows that some are well suited for construction and other engineering works (Golder and Associates, 1999).

Viveash Reserve, a popular picnic site, is located adjacent to Katrine Pool.

Glen Avon: This pool is of significant length and water volume. Coarse sediments have been deposited in Katrine Pool rather than Glen Avon although some are now being deposited at the upstream end. Sediments in Glen Avon are primarily silt and clay with a very high nutrient load. Monitoring has shown that blue-green algae growth is minimal suggesting that the nutrients remain fixed in the sediments.

The original crossing at the downstream end of Glen Avon Pool was known as McDermott's Crossing. Last used in the 1920s, it was a natural rock bar which was raised by half a metre in the 1970s to protect Glen Avon Pool and the Katrine Bridge footings.

The pool is maintained by this constructed weir. Removal of the weir would cause massive channel erosion that would delete the pool and would probably mobilise sediments now contained within Katrine Pool. The weir has been damaged during flood events and required occasional maintenance.

Millards: This significant pool is maintained by Extracts Weir originally constructed to impound water for use in a former tannery located at the current industrial site. The pool has a significant sand slug in 500 metres of the upstream end, including some gravels that may have washed from road works for Sinclair's Crossing.

The pool is not fenced on the south-west side and cattle have had access causing damage to the bank and to riparian vegetation.

Red Banks (also known as Lloyds Pool): This is the only major pool on the Avon River that is circular due to active erosional processes caused by a conspicuous rock bar. There is only limited information available about this pool, however it is known that the pool was formed by the substantial raising in the late 1950s of the old Whitefield's Crossing (now known as Extract's Weir) to provide water for a tanning factory. The pool was popular for swimming. It now has an estimated unfilled volume of 32 000 m^3. It remains deep (approximately 5 metres) and has very steep (cliff-face) banks (5-8 metres above the water level). It is likely that this pool is self-scouring and may increase in size with time.

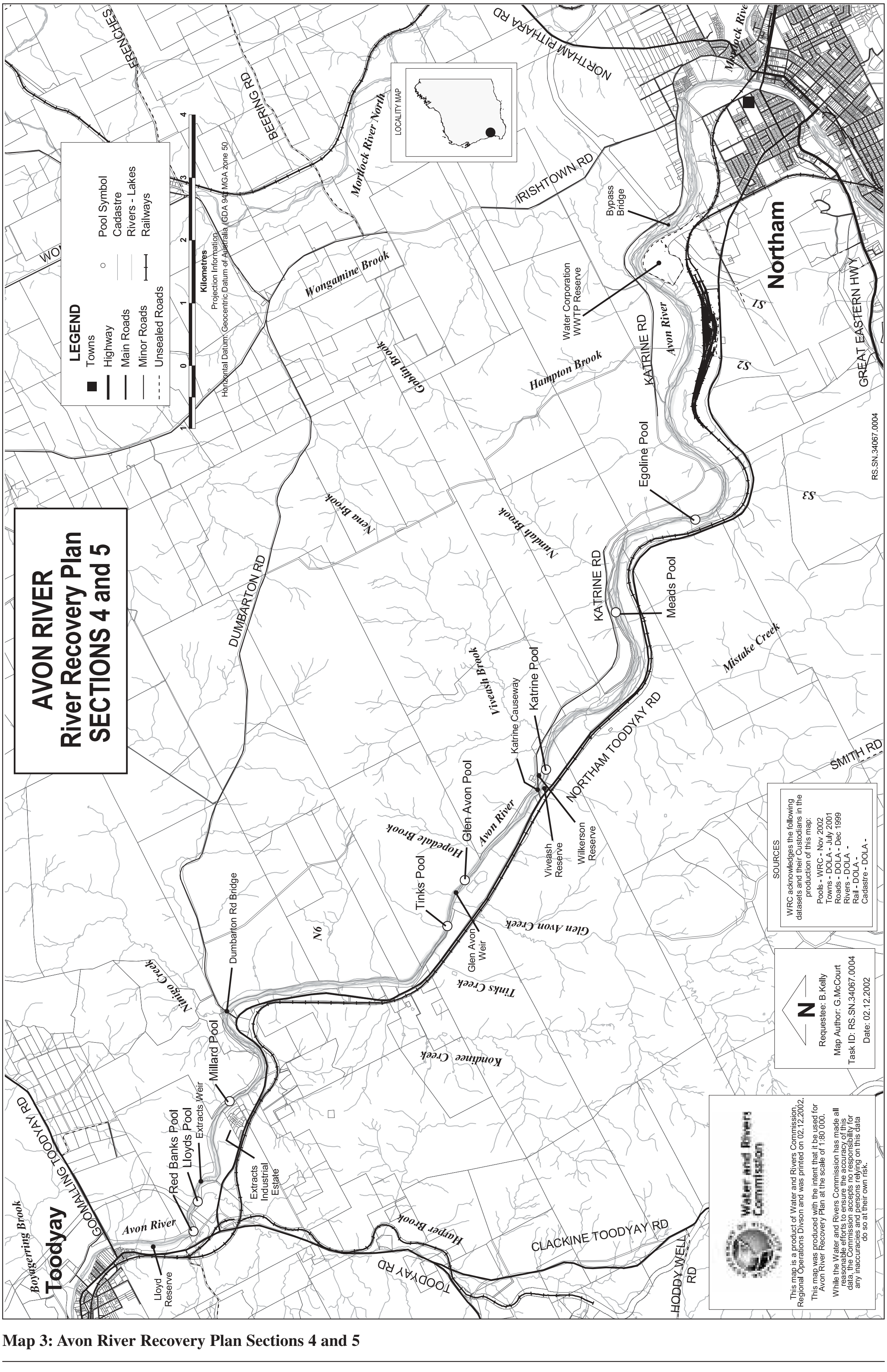
Photo 2: The eroding cliff-face river bank at 'Red Banks Pool'

Photo courtesy Viv Read

2.1.6 Tributaries

The major tributary is the Mortlock River, consisting of the North, South and East branches. This has a catchment area of 1 684 000 Ha. The contribution of flow to the Avon is small during dry years (about 3% of total flow at Walyunga) but is significant in wet years – about 14% of total flow (Harris, 1996).

Salinity in the Mortlock River is about twice that of the Avon River. The Mortlock contributes about 32% of the



Map 3: Avon River Recovery Plan Sections 4 and 5

total salt load at Walyunga. A 'Snapshot Survey' conducted during winter flow months in 1997 showed that the East Branch has the highest salinity, although readings were high downstream from Lake Ninan on the North Branch (Ryan and Cobb, 1999). The survey also showed that the Mortlock had higher phosphorous and nitrogen levels than those measured in the Avon. "Ribbons of Blue' monitoring (a long-term environmental education program undertaken though schools) shows that the nitrogen concentration was particularly high for the North Branch of the Mortlock River (Harris, 1996).

There are 14 other tributaries that range considerably in size and gradient. Seven are on the north side and seven are on the south side of the river. Table 5 lists these tributaries descending downstream for both sides. The tributaries are shown on Map 3.

Table 5: Tributaries to the Avon River between Northam and Toodyay

Tributary name (or reference number)	**Area** (Ha)[1]	**Stream channel gradient** (%)[2]	**Channel condition**
North of the river			
Mortlock River	1 684 000	0.12 (from Frenches Siding)	Eroded – discharges directly to the Avon.
Wongamine Brook	14 580	0.4	High sediment load – discharges directly to the Avon.
Hampton Brook	460	2.9	
Nundah Brook	250	3.3	
Viveash Brook	1010	3.6	
Hopedale Brook	170	7.0	Channel is 7 m wide and 2.5 m deep discharging directly into Glen Avon pool. Gully-head erosion extends more than 100 m upstream.
N6	270	6.0	
Ninigo Creek	3 310	1.7	Channel is 3 m wide and is not eroding significantly near confluence.
South of the river			
S1	240	2.8	Includes regional waste disposal site.
S2	200	3.3	
S3	330	3.3	
Mistake Creek	3 900	1.7	Channel is 5-6 m wide and 3 m deep with significant sediment deposition. Discharge is direct to the river.
Glen Avon Creek	1 660	2.7	Some channel erosion of the floodplain. Fresh stream flow is diverted to a dam.
Koondinee Creek	920	4.4	Channel is 4m wide and 2 m deep. It discharges to the floodplain. There is no erosion and no sand deposition.
Harpers Brook	2 970	2.3	A significant (2 metre deep) gully head is eroding from the confluence.

1 – approximate area digitally calculated from 1:50 000 topographic map.
2 – approximate gradient digitally calculated from 1:50 000 topographic map.

2.1.7 Land use, infrastructure and community interest

Land use adjacent to the Avon River is mostly agriculture, particularly north of the river. The range of other land uses is listed below.

Shire of Northam/Northam Town Council

South of the river

Recreation facilities
Pony club
Waste Water Treatment Plant and detention pondage
Cooperative Bulk Handling facilities
Westrail marshalling yards
Quarry
Tourist facilities ('Bed and Breakfast', pottery sales)

North of the river

Semi-rural housing development
Cemetery

Shire of Toodyay

South of the river

Light Industrial Area ('Extracts')
Concrete batching plant
Proposed land sub-division
Proposed heavy-vehicle road by-pass
Light steel fabrication
Nursery Supplies
Service Station

North of the river

Proposed 'cluster-farm' development
Proposed sub-division (Goomalling Road bridge)

Reserves that occur (or are proposed) adjacent to the river between Northam and Toodyay are:

Reserve	Loc. No.	Vesting
Jim Masters (proposed)		Shire of Northam
Viveash	R 39381	Shire of Northam
Waste Water Treatment	R 25729	Water Corporation
Wilkerson	R 41559	Shire of Northam
Lloyd Reserve	R 46827	Water and Rivers Commission
Avon River Foreshore	R44099	Waterways Commission
Avon River Foreshore	R39997	
Aboriginal Reserve near Northam	R 8313	Aboriginal Lands Trust – leased to Mulark
Extracts Reserve, Toodyay	R 32752	Shire of Toodyay
Multi-versity reserve	R 41559	Shire of Northam

There are 4 road crossings: the Great Eastern Highway By-pass, Katrine Causeway, Dumbarton Road and Goomalling Road. There is a railway crossing near Northam.

Members of the community have taken a strong interest in river management in both the Shires of Northam and Toodyay and the Town of Northam. Organisations with interests are:

Toodyay Friends of the River
Northam Friends of the River
Toodyay Naturalists Club
Avon Valley Environmental Society
Toodyay LCDC
Northam LCDC
Avon Descent Management Committee
Avon Catchment Council
Deepdale Catchment Group
Phillips Brook Catchment Group

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 191km. Records and observations were made at 500m intervals. The complete river channel survey results have been summarised by Black (1998). Appendices 1 and 2 show significant features of these sections. 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 60% of the banks of the channel in Section 4 and 66% of banks in Section 5 are stable, which is about average for all river sections (Figure 1).

Section 4 has about average bed stability (52%) while Section 5 has below average bed stability (39%). Significant sand slugs were observed at 20% of sites for Section 4 and 26% of sites for Section 5.

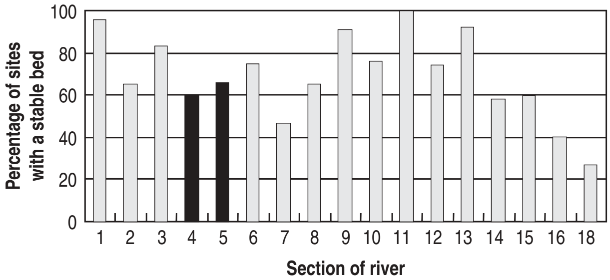


Figure 1: Bank stability along the Avon River (from Black, 1997a)

3.2 Vegetation condition

The survey showed the generally low to medium regeneration for *Eucalyptus rudis* (Flooded Gum) and

Photo 3: Unstabilised coarse sand in the river bed *Photo courtesy Ecoscape/JDA*

Photo 4: Cobbles in the river downstream from Red Banks Pool *Photo courtesy Ecoscape/JDA*

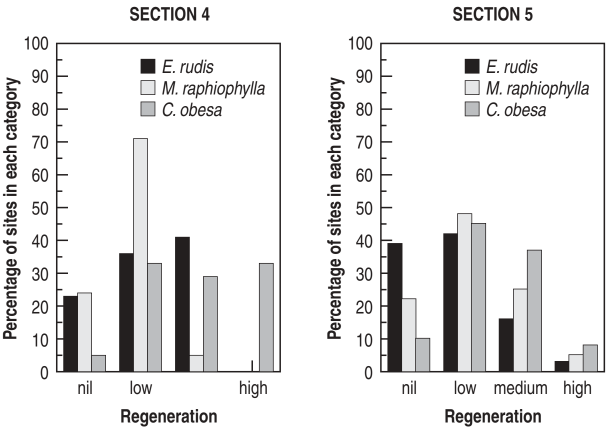


Figure 2: Regeneration of common vegetation species in Sections 4 and 5 (from Black, 1999)

Melaleuca raphiophylla (Paperbark) although Section 5 had some sites where regeneration was high for these species. Regeneration of *Casuarina obesa* (Sheoak) was medium to high, especially in Section 4. Figure 2 shows a range of regeneration measured for the three dominant species. Dead or dying trees were observed at 20% of sites in Section 4 and 9% of sites in Section 5. None of the three dominant over-storey species seem to be significantly in decline.

The conspicuous perennial weeds in these river sections are Tamarisk, Olive Trees and Bridal Creeper. All weeds are listed in Appendix 3.

3.3 Disturbance

Stock were recorded in 20% of sites in Section 4 and 48% of sites in Section 5. The percentage of sites that were fenced both sides of the river is 45% for Section 4 and 52% for Section 5. Rubbish, feral animals, effects of fire and service corridors were recorded in up to 11% of sites in both sections. A particularly hot fire in March 1998 which spread from Section 4 into Section 5 caused severe damage to vegetation.

4 River recovery planning

The mission of the Avon Waterways Committee 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. 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 has been through a series of 4 meetings, a river walk and individual property inspections during May-September, 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 (WRC), the Avon Waterways Committee and Recovery Teams specific to sections of the river. The plans are developed for a period of 5 years but are set in a 20-year time-frame.

This Recovery Plan consists of :

- A local Vision for this section 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 4 and 5 (the Recovery Team) preferred the geographic title of 'Northam to Toodyay' for Sections 4 and 5. This is 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 Northam-to-Toodyay Recovery Team has the following vision for local management:

Photo 5: Interim recovery team *Photo courtesy Viv Read*

"The Avon River between Northam and Toodyay is developing distinctive characteristics of permanent pools, seasonal flow, stable bed and banks and sustainable fringing vegetation following alteration during the 1960s for flood control. The river is gaining new balance – it has changed many times before.

The river is valued highly by those who live or travel near by. It is known to be biologically diverse and that a riparian fringe on either side is well protected. It is well understood that floods will occasionally require access to the floodplain.

The river is well managed. The 'Glen Avon' and 'Extracts' weirs are maintained for river-bed stability. The river is fenced and not grazed by domestic livestock. Adjacent creeks and their catchments contribute only minimal sediment and nutrients to the river.

People have easy access to enjoy the river. The Avon Descent is accepted as a traditional annual event that is important to Western Australia. Other recreation is compatible with the river environment. Private land is respected and the liability of public risk is well recognised.

Change to the use of land near the river is planned in a consistent way. Heritage values and entitlement are well understood and transparent negotiations for change provide a net benefit for the river."

4.2 Local management objectives

The four objectives identified for management for these sections through the recovery planning process are:

- To manage and protect the remaining river pools while allowing the river to establish a new balance
- To ensure the river is well fenced and not grazed.
- To ensure that tributaries to the river have reducing contributions of sediments and nutrients,
- 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 23 issues that were identified are shown in Table 6. 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 it is not perceived to be an issue requiring attention in the way that the event is currently managed.

The Key Management Issues are described according to the current understanding of the Recovery Team, and the preferred management actions to address these issues are outlined in the following sections.

Table 6: Recovery Team priorities for Key Management Issues

Issue (in priority order)	Average score	Highest score	Lowest score
1. River Pools	**9**	10	8
2. Funding	**8.8**	10	7
3. Sediments	**8.5**	10	7
4. Planning issues (state and local government)	**8.3**	10	5
5. Nutrients, pollution and hazardous spills	**7.8**	10	5
6. Fringing vegetation	**7.4**	10	1
7. River ownership/land resumption	**7.2**	10	2
8. Salinity	**7**	9	2
9. River characteristics and history	**7**	10	5
10. Catchments/tributaries	**7**	10	2
11. Recovery Team role	**6.5**	10	4
12. Fire	**6.4**	10	2
13. Fencing/Grazing	**6.4**	10	3
14. Public access	**5.4**	10	2
15. Recreation	**5.5**	10	2
16. Industrial development (including quarries)	**5.5**	8	2
17. Flooding	**5.3**	8	2
18. Corellas and Exotic species	**5.1**	9	2
19. Water resource management/allocation	**4.7**	9	2
20. Rubbish	**4.7**	8	1
21. Crossings	**4.5**	7	2
22. Roads and railways	**4.2**	6	2
23. 'Avon Descent'	**3.3**	6	1

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

5.1 River Pools and sediments

5.1.1 The original river pools

There were originally five significant river pools between Northam and Toodyay (listed in Table 4). A survey of the pools in 1960 show that their total length was more than 20% of the total river length for these sections. Three of the pools (Egoline, Glen Avon and Millards) were over 1 km in length. Two of the pools (Millards and Red Banks) were deeper than 6 metres. Smaller pools are remembered by local people but have not been recorded.

5.1.2 Sedimentation processes

The river channel between Northam and Toodyay was altered under the River Training Scheme during 1957/8. Sedimentation processes caused by river channel erosion and soil erosion following clearing in the catchment has caused the pools to fill with sediment. While some tributaries contribute noticeable amounts of sediment to the river, channel bed erosion is probably the most significant cause of river pool infill.

The total pool length is now only 14.4% of the river length. Egoline Pool is now completely filled. Katrine Pool has only 24.4% unfilled volume while Glen Avon is 91%

unfilled. The two pools are located close together and it is expected that if Katrine Pool fills completely, then Glen Avon Pool will fill more rapidly. Millards Pool has an unfilled volume of 40.4%.

Changes to Red Banks pool volume cannot be derived from available information, however the pool depth reduced by 2.3 metres between 1978 and 1996 (Table 4). The banks of this pool are actively eroding as are the banks of the river upstream at the confluence of Harpers Brook. It is possible that with time, the erosional processes will cause these two areas to combine and form a major new pool of considerable size and depth.

Appendix 5 shows the location of a series of cross-sectional survey transects and the amount of scour or fill that had occurred at each transect between 1955 (before the RTS) and 1973 (Southwell, 1993).

This shows that the bed was mostly scoured from Northam to the major meander before Egoline Pool and that there was significant deposition within the meander, due to reduced stream flow velocity because of the meander. This major sand 'slug' was also recorded during the river channel survey (Ecoscape, 1996). The channel downstream from Glen Avon Pool is mostly scoured.

5.1.3 Sediment management options

1) Sediment Excavation

The River Pool Survey (JDA, 1996) showed there to be 526 000 m^3 of sediment in the five river pools. This volume has probably increased since the survey. The community along these sections of the Avon River recognise that these changes are occurring and that the river will eventually become stable. The existing pools may fill with sediment but others are forming.

Removal of sediments is an option although it is expensive. The estimated cost to excavate all sediments from the five pools would be in excess of $2m – transport costs are additional.

A total of 3 800 m^3 of sediment were removed from Katrine Pool in 2001. This is less than 1% of the total volume of pool sediments in these river sections. The opportunity for cost-effective sediment removal may exist for Millards Pool, adjacent to Extracts Industrial Area, which includes a concrete batching plant. Sediments from Katrine Pool may also be suitable for commercial use.

2) Sediment 'Slug' stabilisation

The major sand 'slug' that is located near the former Egoline Pool can be stabilised by allowing salt water couch to colonise the river bed. This is best achieved by ensuring there is no stock access to this section of the river.

3) Construction of Sediment Traps

Construction of riffles across the river or excavation of the river bed to trap sediments has been trialled in other sections of the Avon River. A riffle has been constructed at Mongers Crossing downstream from Bland's Pool in York, and a sediment trap has been excavated in the former Burlong Pool upstream from Northam. Long-term arrangements for sediment removal are required for these to be effective.

A suggestion has been made for construction of a low weir near Dumbarton Bridge (R. MacKenzie, *pers. comm.)* in order to improve the visual amenity of the river. The existing boulders at Sinclair's Crossing currently impound some stream flow during winter. This crossing is no longer required for transport purposes as the Dumbarton Road bridge capacity has been recently increased.

This location is not well suited for installation of a riffle or sediment trap as it is located on a meander, however maintaining Sinclair's Crossing would assist with stream velocity reduction. There would need to be long-term arrangements for maintenance of the crossing and for removal of sediment in order to retain the anticipated visual amenity. Construction would need to be undertaken according to engineering design to avoid erosion of the channel around the crossing and diversion of stream flow. These processes could potentially cause damage to Dumbarton Road bridge.

The best opportunity for effective detention of coarse sediments is by excavation of existing sediments in Katrine Pool. This action would reduce the risk of significant infill to Glen Avon Pool and would also maintain or increase the visual amenity of the river from Viveash Reserve and Katrine Causeway.

Excess sediments in the river bed and in pools cause environmental degradation, however a high proportion of the sediments are well-sorted (ie of similar size) coarse sand that has value for a range of landscape development and construction purposes. Opportunities exist for development and support of new regional enterprises that

Photo 6: Glen Avon Weir *Photo courtesy Viv Read*

make commercial use of the sediment resources. One enterprise may be to remove and stockpile sediments from sand 'slugs' and the pools. Another could be to 'value-add' by local manufacture of specialised bricks or concrete structures (e.g. farm stock troughs). Support for regional enterprise development should be sought.

5.1.4 New pool formation

A new pool has formed downstream from Glen Avon Weir (locally called Tink's Pool) and there is a scour pool downstream from the weir in Northam. Additionally, there are erosion processes that may lead to formation of a major pool downstream from Extracts Weir. The formation of new pools seems to be directly linked to existing weir structures.

5.1.5 The role of existing weirs in river stability

It is important to note that the weirs now perform an important function in maintaining river stability. Damage to or removal of Glen Avon Weir would cause large-scale sediment mobilisation as the two metre hydraulic head differential would cause significant gully-head erosion in the river channel that could progress upstream for a considerable distance.

5.1.6 Public amenity

River pools in these sections are visible and attractive to the public. Millards Pool is seen from the Northam-Toodyay Road and both Glen Avon and Katrine pools are visible from the Katrine Causeway. The popular picnic spot at Viveash Reserve is adjacent to Katrine Pool. Complete infill of these pools would be a significant loss of public amenity.

5.1.7 Ecological values

River pools are of increasing importance for wildlife refuge as the fragmented Wheatbelt landscape becomes salt-affected. Both the water body of the pools and the fringing vegetation support differing suites of species. Knowledge of what to expect in each ecosystem provides a good benchmark to compare what may be observed over time. Birds are good indicators of ecosystem health.

Photo 7: The river bed elevation difference maintained by Glen Avon Weir *Photo courtesy of JDA/Ecoscape*

Photo 8: Extracts Weir below Millards Pool *Photo courtesy Viv Read*

Birds associated with the river between Northam and Toodyay have been well studied and recorded by the Masters family, the Toodyay Naturalists Club and the Toodyay Friends of the River. This information is well suited for on-going monitoring of river health.

There are recent reports of mullet again in this section of the river following the February 2000 flood. They have been observed in Red Banks Pool but not further upstream, suggesting that Extracts Weir is a barrier to their upstream dispersal. A suggestion to trial a 'fish ladder' has been made. Liaison with organisers of the "Avon Descent" event is required to ensure the installation does not increase public risk.

5.1.8 Cultural values

The cultural history of the Avon River between Northam and Toodyay, including Aboriginal and recent settlers, is both rich and varied. The range includes an Aboriginal birthing place and stone near the river, the Katrine Church (built in 1862) and Nardi cemetery near Millards Pool. There is good local knowledge of this history although it has not been recorded with respect to the river. The future character of the river should include the rich sense of cultural history.

Proposed action

Action 1.1 Arrange to prepare an annotated map showing the location and preferred names all river pools, tributaries and sites of cultural value through local consultation.

Action 1.2: Assess the feasibility of removing and stockpiling sediments from Katrine and Millard's pools for commercial use by local light industry.

Action 1.3: Liaise with the Wheatbelt Area Consultative Committee to develop regional enterprise opportunities for commercial use of river sediment.

Action 1.4: Ensure stock-proof fencing is maintained and stock are excluded from the river bed with the sediment 'slug' (near the former Egoline Pool).

Action 1.5: Undertake regular maintenance of existing river weirs to ensure low risk of breaching or stream flow diversion.

Action 1.6: Arrange a trail installation of a fish ladder at Extracts Weir.

5.2 Fringing vegetation

Healthy fringing vegetation is important to maintain ecosystem functions within the river environment. These include providing habitat for wildlife, moderating stream and pool water temperatures, stabilising soils and filtering nutrients and sediments. Fringing vegetation also slows floodwater velocity reducing damage to property and the river.

Actions of the River Training Scheme and grazing by stock have threatened the health of the Avon's riparian vegetation. The river bed has lowered by 1.0 – 1.5 metres as a result of river training. This has affected groundwater dynamics. As the floodplain is now less frequently inundated so recharge to a fresh, perched aquifer (shallow groundwater body) is less. The river channel now acts to drain the perched aquifer. Observations suggest that these altered conditions favour regeneration of *Casuarina obesa* (Sheoak) over *Eucalyptus rudis* (Flooded Gum) and *Melaleuca raphiophylla* (Paperbark). This trend is demonstrated in Figure 2. The river ecosystem should have a range of species regenerating rather than dominance by one species.

The recently formed Lloyd Reserve near Toodyay and the proposed Jim Masters Reserve at the Katrine causeway are examples of healthy and well-structured fringing vegetation. There is a mature but healthy stand of Flooded Gum in the lower reaches of Ninigo Creek.

Uncontrolled grazing significantly reduces the potential for vegetation regeneration. The Recovery Team prefers the river to be completely fenced and there be no grazing of the fringing vegetation. There is some concern about increasing fire risk due to annual weeds, particularly Wild Oats although there is clear demonstration of weeds being suppressed with canopy closure.

Other weeds, including Cape Tulip (*Homeria spp.*) and Soursob (*Oxalis pes-caprae*) should be controlled with careful herbicide use to allow fringing vegetation regeneration. Removal of non-native shrubs, such as Olive trees, is recommended.

Proposed action

Action 2.1: Ensure the river is well fenced and there is no access by stock to areas with fringing vegetation.

Action 2.2: Control or remove annual or perennial weeds that suppress or compete with natural vegetation.

Action 2.3 Arrange a demonstration of Flooded Gum regeneration on the lower reaches of Ninigo Creek.

5.3 Water quality

The quality of water in stream flow and the river pools has deteriorated significantly from natural conditions. Salinity has increased and in likely to continue to increase. Algal blooms are a common summer occurrence due to nutrient enrichment, and there are occasional pollution events including chemical spills and gross pollutants (eg from rubbish tips). Future threats to water quality may be from groundwater drainage for salinity control. Discharge water from drains in the Avon River Basin has very low pH (very acid) compared with the river pools that have high pH (very alkaline).

5.3.1 Salinity

Stream flow in the Avon River has increased from a range of approximately 400-3 000 mg/L to a range of approximately 5 000-20 000 mg/L since clearing in the catchment

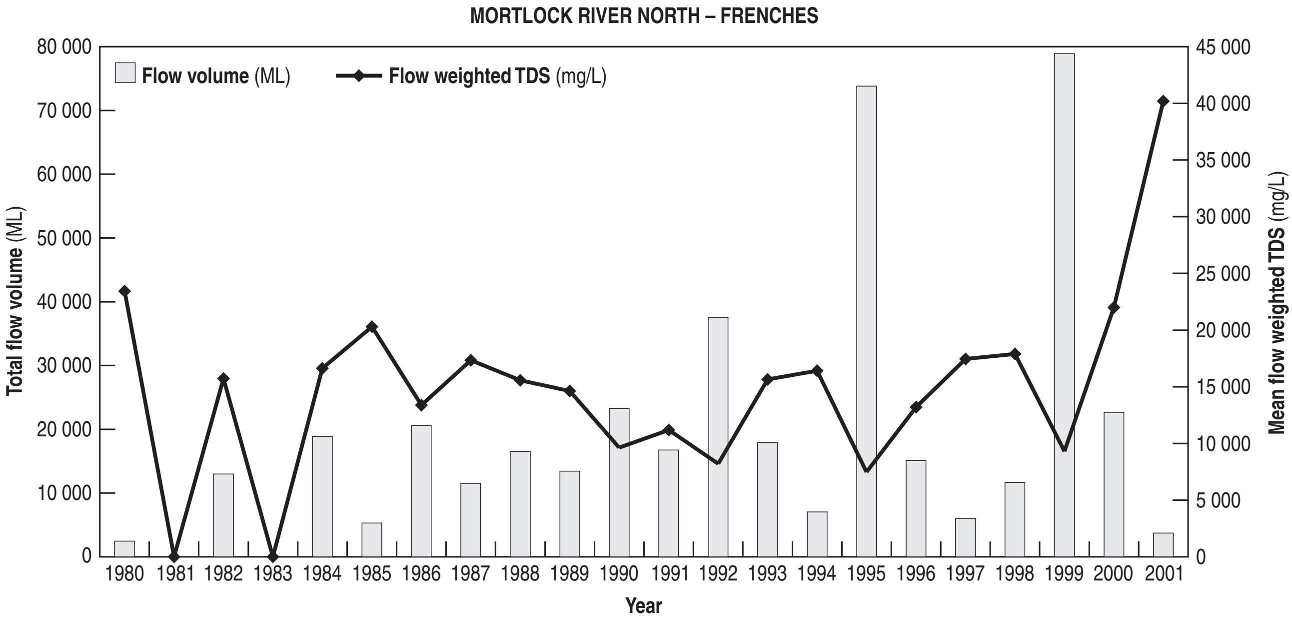


Figure 3: Salinity trends in the Mortlock River
Annual flow weighted TDS derived from discrete sample data versus annual total flow (1980 to 2001)

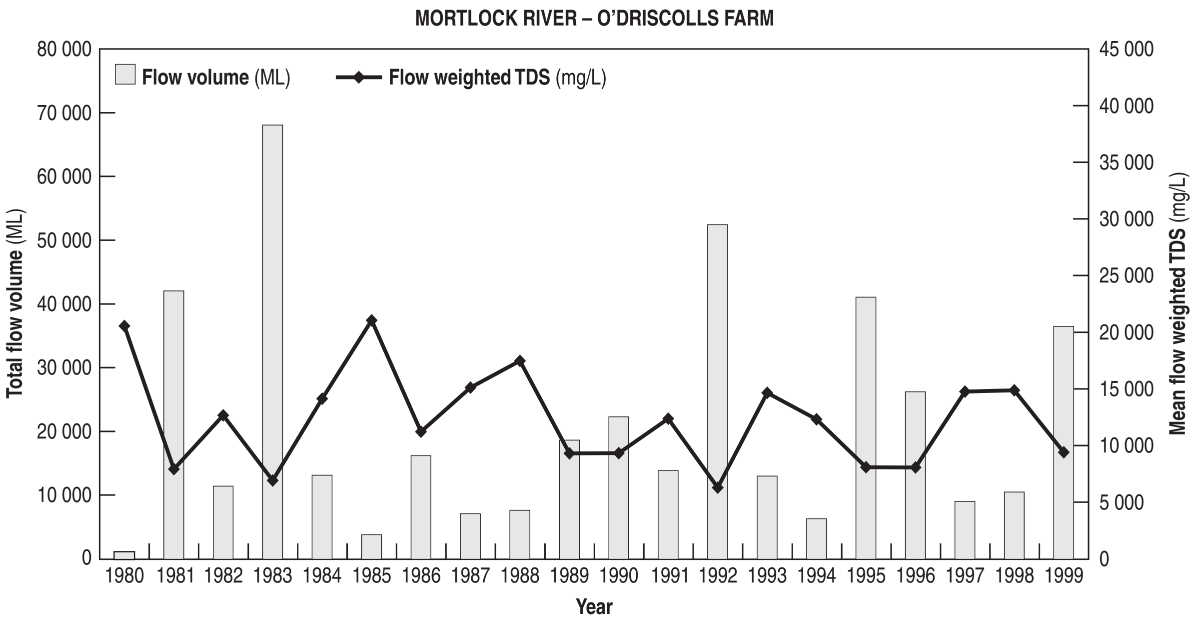


Figure 4: Salinity trends in the Mortlock River
Annual flow weighted TDS derived from discrete sample data versus annual total flow (1980 to 1999)

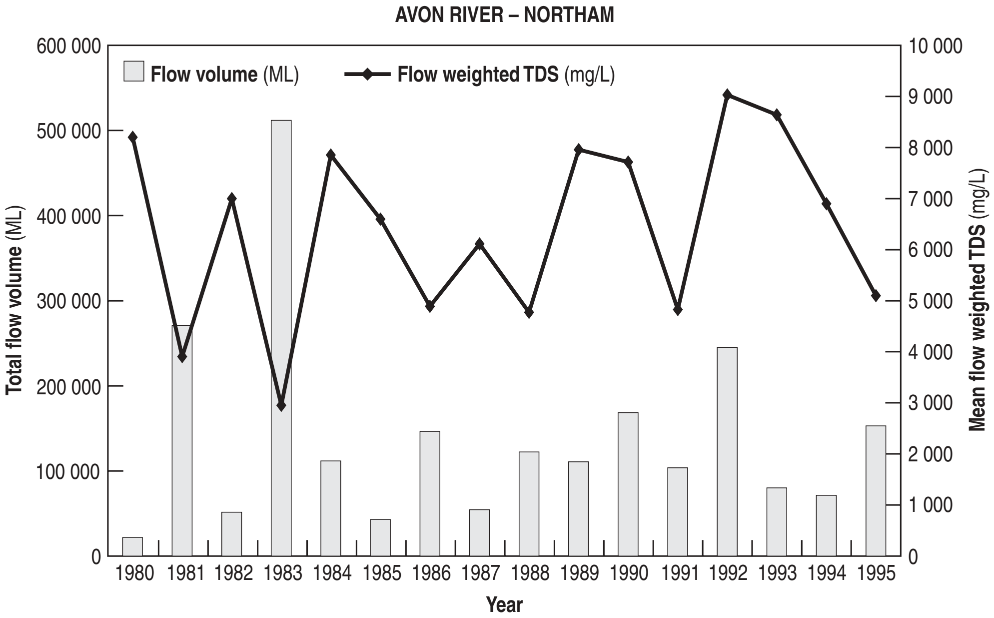


Figure 5: Salinity trends in the Avon River
Annual flow weighted TDS derived from discrete sample data versus annual total flow (1980 to 1995)

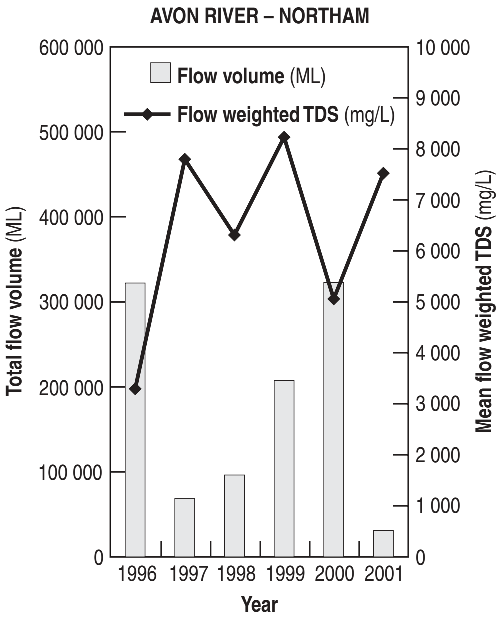


Figure 6: Salinity trends in the Avon River
Annual flow weighted TDS derived from continuous conductivity versus annual total flow (1996 to 2001)

for agriculture. Figures 3-6 show the increasing trend that has occurred.

The Mortlock River contributes approximately 32% of the total annual salt load measured at Walyunga. This is about 450 000 tonnes annually. It is expected that the relative contribution of salt load from the Mortlock River will increase with time as salinity in the catchment increases. It may take 50-100 years before maximum salinity discharge is reached.

Salinity in Wongamine Brook has not been consistently measured however it may be expected that winter flows are more saline than during spring or early summer due to extensive areas of deep sandy soils with fresh water aquifers in the upper catchment.

Salinity in Glen Avon Creek has been monitored for many years. It increased significantly during the 1970s from being relatively fresh to now having an average salt concentration of 5 140 mg/L.

The salinity of other tributaries to these sections of the river is not known. It is expected that the smaller tributaries may be relatively fresh. Understanding annual salinity trends in some of the tributaries would be of interest to the local community

There are currently no economically feasible options to significantly reduce salt load contributions to the Avon River.

5.3.2 pH of water

The preferred pH level in the river pools should be within the range of 6.5-9.0 and not fluctuate significantly. There is significant impact on aquatic ecosystems with low pH (less than 4.0). The pools are currently quite alkaline.

There is increasing interest in using drainage to reduce salinity on agricultural land. Groundwater discharge from drains within the Avon River Basin is generally very acid (pH measures of less than 3.0). It can be expected that drainage practice could increase significantly in the Mortlock catchment over then next decade. The potential for the anticipated discharge water to impact on the river pools in these sections of the Avon River is not known but should be considered.

5.3.3 Nutrients

Phosphorus and nitrogen are the major nutrients that have potential to cause water quality decline. Their impact is upon river pools during summer and on the Swan-Canning estuary.

Nutrient sampling undertaken at many locations in the catchment shows that concentrations are generally quite low, with the exception of the North Branch of the Mortlock River (Ribbons-of-Blue information, in Harris, 1996). Soils of the Avon and Mortlock catchments have very high phosphorus retention capacity, in contrast to the sandy soils of the Swan Coastal Plain. However, soil loss that is likely to occur during summer storm or flood events is likely to discharge significant nutrient loads from the catchment that is generally not represented in routine water quality monitoring.

A study of nutrient load contributions to the Swan-Canning Estuary for the 1987-1992 period (Donohue *et al.*, 1994) shows that 580 million m^3 are discharged to the estuary annually from a range of sources. Approximately 62% of this flow is from the Avon. An average total of 730 tonnes of nitrogen is discharged to the estuary annually of which 50% (365 tonnes) is from the Avon. Similarly, 70 tonnes of phosphorus is discharge annually of which 30% (21 tonnes) is from the Avon. These measures of nutrient loads from the Avon are likely to be under-estimates due to technical reasons (R. Donohue, WRC *pers. comm.)*.

The measures taken during the study are not representative of flood conditions. The Avon River flood event during February 2000 resulted in relatively fresh water with a high nutrient load entering the relatively warm water of the Swan-Canning Estuary causing algal blooms that were considered unsafe for human use of the river in Perth and access to the river was restricted.

Targets have been established for reduction in nutrient concentrations from various sources to the Swan-Canning Estuary. The Avon has not yet exceeded these targets (R. Donohue, WRC *pers. comm.)*.

The river pools differ significantly in their nutrient loads. Sediment size appears to be the major determinant of nutrient load. Pools with fine textured sediment have higher nutrient loads. Table 7 shows measure of nutrients in sediments and the water of river pools at the time of the river pool survey (JDA, 1996). This shows the sediment nutrient load in Glen Avon Pool to be exceptionally high (over 16 tonnes). The load of this pool is about double that for Millard's Pool and for Northam's River Pool. It is more than 30-times greater than the phosphorus load in Katrine Pool.

Table 7: Phosphorus (P) in river pool sediment and water (information derived from JDA, 1996)

River Pool	Total mass of P in sediments (kg)	Total mass of P in water (kg)	Average P concentration in water (mg/L)
Katrine	510	1.85	0.13
Glen Avon	16 296	80.00	0.60
Millards	8 232	16.10	0.20
Red Banks		0.30	0.20

The sediment nutrient load does not directly indicate the potential of algal blooms. High counts of cyanobacteria cells were recorded in Glen Avon Pool during 1994 but the counts were generally low in this pool during 1998 (WRC monitoring records). In contrast, algal blooms occurred in Katrine Pool during the summer of 1998. Disturbance of sediments in Glen Avon or Millard's pools could cause significant algal blooms and eutrophic conditions in these pools.

A significant potential source of nutrients to Glen Avon and Millard's pools is from the Waste Water Treatment Plant in Northam. These facilities serve the 7000 people in Northam producing approximately 1.4 x 10^3 m^3/day of sewage. Treated water is used to irrigate 32 ha of land for public amenity within the Town of Northam. A total of 92 ha of irrigated land is required to fully utilise treated waste water but this area is not available so excess effluent is discharged to the river. It is estimated that this discharge causes the concentration of nitrogen in river stream flow to increase by 1.45 mg/L and phosphorus by 0.032mg/L (WRC file note). It is also estimated that discharge to the river from the treatment plant contributes 4% of the total nitrogen load and 2% of the total phosphorus load from the Avon to the Swan-Canning Estuary (T. Zheng, Water Corporation, *correspondence to WRC*).

The Water Corporation intends to modify the current arrangements so that discharge to the river is less and only occurs during periods of high stream flow (in excess of 17×10^6 m^3/month). Works required for the modified arrangements are proposed for 2006. Monthly monitoring of nutrients and other chemical measures is proposed.

5.3.4 Chemicals and gross pollutants

There is some potential for chemical and gross pollutant contamination in these sections of the river. The locations with potential risk are:

- Spoil excavated from Northam's River Pool and stored (with substantial bunding) on Island Farm.
- The Cooperative Bulk Handling grain facilities near Northam (where chemicals are used to control insects)
- The Westrail marshalling yards (where a significant fuel spill occurred in 1998)
- Hazardous spills from road or rail (the railway is adjacent to the river for most of the length of these sections of the river)
- The Great Eastern Highway By-pass (including accidents by vehicles with potential contaminants).
- The Northam Waste Disposal Site (that receives waste from four other regional centres)
- Toodyay Industrial Park and other light industry adjacent to the river.
- Farm rubbish tips (eg on Ninigo Creek).

Of these sites, the Westrail Marshalling yards, the Northam Waste Disposal Site and Toodyay Industrial Park operate under Environmental Protection Act license conditions. Accidental spills are managed under emergency services arrangements. Action is required to reduce gross pollutant from farm rubbish tips.

Proposed action

Action 3.1: Arrange regular monitoring of salinity in Wongamine Brook, Mistake Creek, Glen Avon Creek, Ninigo Creek and Harpers Brook.

Action 3.2: Arrange an assessment of the potential and probability of impact due to occasional discharge of acidic drainage water into river pools during low flow events.

Action 3.3: Arrange for regular reporting (quarterly) to the local community about discharge from the Northam Waste Water Treatment Plant and the results of monitoring.

Action 3.4: Arrange for closure of all farm rubbish tips with potential to pollute the river and its tributaries and communicate the importance of not depositing rubbish in waterways.

5.4 Tributary and catchment management

The tributaries to these sections of the Avon River are described in Section 2.1.6 and in Table 5. There are more small tributaries than are identified in the table. More detailed mapping of these would be of interest locally. A survey of the confluence for each of these tributaries would identify management requirements not noted during the 1996 river channel survey or during the Recovery Planning process.

5.4.1 Mortlock River

Mortlock River is a major tributary to the Avon and contributes a significant proportion of flow, salt and nutrient load. The potential for increased salt load and discharge of acidic groundwater from drains to control salinity is recognised. Catchment management is a significant process underway in many although not all local catchments within the broader Mortlock catchment area. Actions required are coordinated through the Avon Catchment Council (ACC).

5.4.2 Wongamine Brook

A catchment management group exists for the Wongamine Brook catchment. A hydro-geological assessment to establish salinity risk has been undertaken and recommendations for catchment management actions made.

The channel of the brook near the confluence with the Avon River has a significant unstable bed load of coarse sand. The mobility of this sediment is not known although there has been one previous cross-sectional survey (undertaken by WRC).

5.4.3 Ninigo Creek

The catchment of Ninigo Creek and its own tributaries is relatively large. Some of the waterways stream flow is diverted to a farm dam. Below the dam, some sections of the creek channel are eroding although the lower section that is fenced is stable. A healthy stand of mature flooded gums exists although there is no regeneration at this location. An opportunity exists to demonstrate 'best

Photo 9: River bank erosion near the confluence of Harpers Brook *Photo courtesy Viv Read*

practice' for tributary management by fencing a section that extends from the Avon River to the confluence of the two creek tributaries (about 1 km) and revegetating or taking actions to encourage regeneration (soil disturbance, weed suppression or use of fire).

The relatively high level of public access to this site at 'Lavender Estate' provides a good opportunity to demonstrate community 'best practice' for tributary management.

5.4.4 Harpers Brook

The catchment for Harpers Brook is relatively steep and stream flow velocity in the channel is high. The channel meanders on the floodplain and discharges into the river downstream from Extracts Weir. A previous point of discharge has a small erosion gully. The current point of discharge has a large (2-4 metres deep) and very active erosion gully that is progressing back into the floodplain. Both of these erosion points should be controlled. Stream flow should be diverted away from the former discharge point (construction of a small diversion bank) and a drop structure should be constructed at the current point of discharge.

Photo 10: The active gully-head erosion on Harpers Brook *Photo courtesy Viv Read*

5.4.5 Mistake Creek

The catchment for Mistake creek has steep upper slopes that extend south to the great Eastern Highway and includes the Bobakine Hills. Previous sediment discharge from this tributary has formed a significant delta that has caused the river to meander. Since clearing of the catchment for agriculture, there is relatively high discharge of sediment from the creek channel directly to the river. This occurs less than 1 km upstream from Katrine Pool and is probably a significant cause of infill to the pool.

A coordinated effort is underway to fence and revegetate sections or Mistake Creek.

Proposed Action

Action 4.1: Arrange detailed mapping of the tributaries to these sections of the Avon River and survey of their confluences for management needs.

Action 4.2: Advise the Avon Catchment Council about the importance of the Mortlock River as a tributary to these sections of the Avon River and of the increasing potential of this tributary to affect the river values.

Action 4.3: Arrange a repeat survey of the sediment profile in Wongamine Brook to estimate sediment mobility.

Action 4.4: Initiate a demonstration and information site for ‘best practice’ lower tributary management on Ninigo Creek.

Action 4.5: Undertake erosion control works (diversion bank and drop structure) for Harpers Brook in the floodplain of the Avon River.

Action 4.6: Assess on-site options for discharge of Mistake Creek stream flow onto the floodplain instead of directly to the bed of the Avon River.

Action 4.7: Arrange fencing and revegetation of lower reaches of the creek channel to arrest sedimentation processes and to filter stream flow.

5.5 Land use and planning

5.5.1 Land ownership

Most land adjacent to the river between Northam and Toodyay is used for broad-scale agriculture and has been owned continuously by multiple generations of farming families. Over the past two decades, these sections of river have undergone a changing trend in landownership towards smaller properties. The uses range from semi-rural lifestyle to light industrial development. Four enterprises for service to tourism have developed during this period. This trend is expected to continue in both the Shires of Northam and Toodyay.

Not all property boundaries along the river 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 current status of landownership for the two river sections is not documented consistently in a way that is suitable for river management. This should be undertaken on a map base in a way that is consistent with information collation proposed in Action 1.1.

5.5.2 Reserves

Reserves that occur adjacent to the river are listed in Section 2.1.7. Creation of an additional reserve at the Katrine causeway on land currently owned by the Masters family will serve many purposes. Riparian vegetation on this land is a remaining example of a healthy stand of a Paperbark (*Melaleuca raphiophylla*) dominant plant community. The reserve will complement the existing Viveash and Wilkerson reserves and is an appropriate tribute to the late Jim Masters, a recognised champion of good river management.

5.5.3 Land sub-division processes

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.

Concerns about increased flood risk due to development in the floodplain of the river are addressed through statutory referral and advice processes.

An innovative sub-division of land to create a cluster-farm development concept at ‘Mountain Park’ has provided opportunities for sediment control within the catchment and management of the river foreshore.

Proposed Action

Action 5.1: Prepare a map and database of current landownership for the river between Northam and Toodyay in a format that is compatible with proposed Action 1.1.

Action 5.2: Arrange and support the proposal by the Masters family for creation of the 'Jim Masters Reserve' on land that is Location 201 with vesting through the Shire of Northam.

5.6 Fire management and river crossings

The risk of fire due to fuel load and poor access for fire suppression in the river is not a high priority for all who live along the sections between Northam and Toodyay, however consideration of fire risk to others is important, especially where private and public assets are at risk.

Limited control burns in areas near private and public assets is consistent with the AWC management guidelines for fire. This is preferred to grazing the river in these sections by the Recovery Team.

Access for fire suppression is the best form of fire control in the riparian zone. There are no direct river crossings between Northam and the Katrine causeway although with bitumen roads on either side of the river, good access for fire suppression is available.

Downstream from Katrine, access is restricted particularly on the north side of the river. New river access locations were established during a recent fire in the river, either side and both approximately 400 metres from Tink's Creek. There is also good access over Dumbarton Road bridge and emergency access for substantial four-wheel drive vehicles across Glen Avon Weir.

Reducing the causes of fire, particularly associated with railways and occasional tourists, is important.

Proposed Action

Action 6.1: Identify zones near private and public assets for fuel reduction by cool burns. A distance of 250 metres either side of the asset is suggested.

Action 6.2: Liaise with Westrail for fire risk reduction.

5.7 Control of weeds, feral and native animals

Weeds identified between Northam and Toodyay during the 1996 river survey are listed in Appendix Three. The Recovery Team has particular concern about the control of Bridal Creeper, Watsonia, African Box Thorn and Soursob. Spiny Rush has also become established in Section 4.

There is also increasing concern about the environmental damage caused by the native Long-billed Corellas (*Cacatua pastinator*). Culling the populations 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.

Foxes are also considered troublesome to some landowners with domestic animals. There is concern about the impact of cats on native animals.

Introduction of non-native fish (eg silver perch) to the river or tributaries could significantly impact upon existing aquatic ecosystems.

Coordinated action to control both foxes and problem native species should be initiated by the Recovery Team.

Proposed Action

Action 7.1: Map areas of the riparian zone requiring weed control measures and coordinate action to eradicate or at least manage priority species (Bridal Creeper, Watsonia, African Box Thorn, Soursob and Spiny Rush).

Action 7.2: Arrange for population control measures (shooting, baiting or breeding potential reduction) for the native Long-billed Corellas and for foxes and cats.

5.8 Public access and recreation

There is increasing public interest in having access to the river for passive and active recreation but there is also increasing concern by private landholders along the river about the risk of fire and public liability claims for negligence.

Tourists and local people see these sections of the river as they cross bridges and drive along adjoining roads. This is especially true for the part of the river in the Town of Northam. Little opportunity has been provided in the past for people to learn about and enjoy the river. Walk trails provide an excellent way for people to get close to the river to appreciate and learn about its ecology.

5.8.1 Trail options

Viveash Reserve provides well-established public access with developed picnic and toilet facilities. The recently formed Wilkerson Reserve and the proposed Jim Masters Reserve are closely linked and provide an excellent opportunity for development of a controlled walk trail that relates to the river environment. It is also linked to significant historic sites, including the Katrine Church, cemetery and homestead.

The Avon Valley Environment Society (AVES) has proposed a walk trail from the Northam weir to the Northam Bypass bridge. This represents an extension of the existing "Round the Bridges" trail in Northam, a popular trail used by dozens of walkers daily. The trail would include the Northam cemetery and a range of historic sites including Morby Cottage, an old church, Aboriginal birthing rocks, a former Government Well and the original townsite of Northam.

The 'Northam Trail Master Plan' (Maher Brampton Associates, 1998) outlines the 'Northam to Katrine Dual Use Path' option proposed as an option with the expectation that the International University at Katrine would be developed. The university development is now not expected to proceed.

The preferred option for walk trails with a focus on the river would be between the three reserves at Katrine. Information similar to that used at the 'Avon Ascent' environmental education sites as well as local information about the river could be displayed at suitable positions along the proposed trail. This option is suitable for a walk trail and should not be made available for use by horses or trail bikes. Responsibility for public liability will be with the trail developer.

5.8.2 The 'Avon Descent' and other recreational use of the river.

The Avon Descent is a major annual event that has well-established organisational arrangements that are generally acceptable to landholders along the river. Public access on private land is arranged for Extracts Weir.

Power boats are not permitted to use the river other than during this event and one additional day for event practice.

Canoeing on the river is popular and allows many people to better appreciate natural attributes of the river. Canoeing both river sections should be acceptable until the end of August but then should be discouraged from Katrine to Toodyay during spring to enable successful bird breeding. An organised canoe course from Northam to Katrine should be available at any time. Launch facilities could be installed below the weir in Northam and retrieval facilities installed at Katrine. Signs should be erected to encourage use of the river in ways that are compatible with the adjacent environment. Signs should also discourage use of the river when bird breeding may be affected.

Proposed Action

Action 8.1: Prepare initial concept plans for walk trails with information about the river within the reserves at Katrine and from Northam weir to Bypass bridge.

Action 8.2: Prepare an initial concept plan for a canoe course with information about the river from Northam to Katrine.

5.9 Recovery team role

The interim Recovery Team that has contributed to the preparation of the Northam to Toodyay Recovery Plan should continue to meet on a regular basis in order to arrange implementation of actions of the plan. All landholders should be considered members. Further membership of the team by representatives of the Northam Friends of the River, Toodyay Friends of the River and the Water and Rivers Commission is recommended.

The proposed Recovery Team should be informally structured but should have an identified leader. This role should be undertaken by a landholder. It is recommended that the Recovery Team have at least one meeting for all members each year. Smaller group meetings with respect to specific management issues could occur by arrangement.

6 Implementation of the recovery plan

An appropriate implementation schedule is outlined in the following Table.

Action	Priority (1)	Responsibility (2)	Notes
1. River Pools and Sediments			
Action 1.1: Arrange to prepare an annotated map showing the location and preferred names all river pools, tributaries and sites of cultural value through local consultation.	**M**	NTRT, NFR, TFR	Not urgent for management but is of specific interest and can be quite easily achieved.
Action 1.2: Assess the feasibility of removing and stockpiling sediments from Katrine and Millard's pools for commercial use by local light industry.	**H**	WRC, NTRT	The opportunity at Millards Pools is good although the sediments at Katrine Pool are better.
Action 1.3: Liaise with the Wheatbelt Area Consultative Committee to develop regional enterprise opportunities for commercial use of river sediment.	**H**	WRC, AWC	Two options are proposed in the plan.
Action 1.4: Ensure stock-proof fencing is maintained and that stock are excluded from the river bed with the sediment 'slug' (near the former Egoline Pool).	**H**	NTRT	
Action 1.5: Undertake regular maintenance of existing river weirs to ensure low risk of breaching or stream flow diversion.	**H**	NTRT, WRC	Annual inspections following winter stream flow and also following flood events are recommended.
Action 1.6: Arrange a trial installation of a fish ladder at Extracts Weir.	**M**	NTRT, WRC	A good opportunity exists while mullet are in the river.
2. Fringing Vegetation			
Action 2.1: Ensure the river is well fenced and there is no access by stock to areas with fringing vegetation.	**H**	NTRT, WRC	
Action 2.2: Control or remove annual or perennial weeds that suppress of compete with natural vegetation.	**H**	NTRT, NFR, TFR	
Action 2.3: Arrange a demonstration of Flooded Gum regeneration on the lower reaches of Ninigo Creek.	**M**	NTRT, landholders	Excellent demonstration opportunity, only minimum resources required.
3. Water Quality			
Action 3.1: Arrange regular monitoring of salinity in Wongamine Brook, Mistake Creek, Glen Avon Creek, Ninigo Creek and Harpers Brook.	**M**	NTRT, CLC	Long-term changes with assist with understanding management needs.
Action 3.2: Arrange an assessment of the potential for impact due to occasional discharge of acidic drainage water into river pools during low flow events.	**H**	WRC, AWC	This should also be undertaken for other river sections.

Implementation Schedule continued overleaf…

… Implementation Schedule continued

Action	Priority (1)	Responsibility (2)	Notes
Action 3.3: Arrange for regular reporting (quarterly) to the local community about discharge from the Northam Waste Water Treatment Plant and the results of monitoring.	**H**	WC, WRC	A brief report should be provided to the NTRT.
Action 3.4: Arrange for closure of all farm rubbish tips with potential to pollute the river and its tributaries and communicate the importance of not depositing rubbish in waterways.	**H**	NTRT, WRC	Information about a local 'Drum Muster' would also be useful.
4. Tributary and Catchment Management			
Action 4.1: Arrange detailed mapping of the tributaries to these sections of the Avon River and survey of their confluences for management needs.	**H**	NTRT, WRC	Use of the Emergency Services Plan for the Avon region will assist.
Action 4.2: Advise the Avon Catchment Council about the importance of the Mortlock River as a tributary to these sections of the Avon River and of the increasing potential of this tributary to affect the river values.	**M**	AWC	
Action 4.3: Arrange a repeat survey of the sediment profile in Wongamine Brook to estimate sediment mobility.	**M**	WRC	
Action 4.4: Initiate a demonstration and information site for 'best practice' lower tributary management on Ninigo Creek.	**M**	NTRT, WRC, CLC	Coordinate with Action 2.3.
Action 4.5: Undertake erosion control works (diversion bank and drop structure) for Harpers Brook in the floodplain of the Avon River.	**H**	NTHT, WRC, landholder	Follow-up inspections required to ensure the implemented works are effective over time.
Action 4.6: Assess on-site options for discharge of Mistake Creek stream flow onto the floodplain instead of directly to the bed of the Avon River.	**M**	WRC, CLC	
Action 4.7: Arrange fencing and revegetation of lower reaches of the creek channels to arrest sedimentation processes and to filter stream flow.	**H**	NTRT, WRC, CLC	This should follow assessment of tributaries in Action 4.1.
5. Land Use and Planning			
Action 5.1: Prepare a map and database of current land ownership for the river between Northam and Toodyay in a format that is compatible with the proposed Action 1.1.	**M**	NTRT, NFR, TFR	
Action 5.2: Arrange and support the proposal by the Masters family for creation of the 'Jim Masters Reserve' on land that is Location 201 with vesting through the Shire of Northam.	**H**	NTRT, WRC, NS	The opportunity for public access should be developed and promoted.

Implementation Schedule continued overleaf…

… Implementation Schedule continued

Action	Priority (1)	Responsibility (2)	Notes
6. Fire Management and River Crossings			
Action 6.1: Identify zones near private and public assets for fuel reduction by cool burns. A distance of 250 metres either side of the asset is suggested.	**M**	NTRT	
Action 6.2: Liaise with Westrail for fire risk reduction.	**M**	NTRT	
7. Control of Weeds, Feral and Native Animals			
Action 7.1: Map areas of the riparian zone requiring weed control measures and coordinate action to eradicate or at least manage priority species (Bridal Creeper, Watsonia, African Box Thorn, Soursob and Spiny Rush).	**H**	NTRT, NFR, TFR, CLC	
Action 7.2: Arrange for population control measures (shooting, baiting or breeding potential reduction) for the native Long-billed Corellas and for foxes and cats.	**H**	NTRT, CLC	Liaison with CALM and the Shire of York suggested.
8. Public Access and Recreation			
Action 8.1: Prepare initial concept plans for walk trails with information about the river within the reserves at Katrine and from Northam weir to Bypass bridge.	**M**	NTRT, NFR, NS	Linking with historic and cultural values along the river would add value to the trail.
Action 8.2: Prepare an initial concept plan for a canoe course with information about the river from Northam to Katrine.	**M**	NTRT, NFR, NTC, NS	Liaison with the Avon Descent Management Committee suggested.

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

(2) NTRT = Northam to Toodyay Recovery Team

NFR = Northam Friends of the River

TFR = Toodyay Friends of the River

NS = Shire of Northam

NTC = Northam Town Council

TS = Shire of Toodyay

AWC = Avon Waterways Committee

WRC = Water and Rivers Commission

ACC = Avon Catchment Council

ACN = Avon Catchment Network

CLC = Community Landcare Coordinator

WC = Water Corporation

7 Recovery plan summary

VISION

The **Northam to Toodyay River Recovery Team** has the following vision for river management:*'The Avon River between Northam and Toodyay is developing distinctive characteristics of permanent pools, seasonal flow, stable bed and banks and sustainable fringing vegetation following alteration during the 1960s for flood control. The river is gaining new balance – it has changed many times before.The river is valued highly by those who live or travel near by. It is known to be biologically diverse and that a riparian fringe on either side is well protected. It is well understood that floods will occasionally require access to the floodplain.The river is well managed. The 'Glen Avon' and 'Extracts' weirs are maintained for river-bed stability. The river is fenced and not grazed by domestic livestock. Adjacent creeks and their catchments contribute only minimal sediment and nutrients to the river. People have easy access to enjoy the river. The Avon Descent is accepted as a traditional annual event that is important to Western Australia. Other recreation is compatible with the river environment. Private land is respected and the liability of public risk is well recognised. Change to the use of land near the river is planned in a consistent way. Heritage values and entitlement are well understood and transparent negotiations for change provide a net benefit for the river.*'

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

- To manage and protect the remaining river pools while allowing the river to establish a new balance.
- To ensure the river is well fenced and not grazed.
- To ensure that tributaries to the river have reducing contributions of sediments and nutrients.
- To arrange consistent management of the river between current landholders and land managers, and for future owners or managers.

Actions for Key Management Issues

River Pools and Sediments

Action 1.1: Arrange to prepare an annotated map showing the location and preferred names all river pools, tributaries and sites of cultural value through local consultation.

Action 1.2: Assess the feasibility of removing and stockpiling sediments from Katrine and Millard's pools for commercial use by local light industry.

Action 1.3: Liaise with the Wheatbelt Area Consultative Committee to develop regional enterprise opportunities for commercial use of river sediment.

Action 1.4: Ensure stock-proof fencing is maintained and stock are excluded from the river bed with the sediment 'slug' (near the former Egoline Pool).

Action 1.5: Undertake regular maintenance of existing river weirs to ensure low risk of breaching or stream flow diversion.

Action 1.6: Arrange a trail installation of a fish ladder at Extracts Weir.

Fringing Vegetation

Action 2.1: Ensure the river is well fenced and there is no access by stock to areas with fringing vegetation.

Action 2.2: Control or remove annual or perennial weeds that suppress of compete with natural vegetation.

Action 2.3: Arrange a demonstration of Flooded Gum regeneration on the lower reaches of Ninigo Creek.

Water Quality

Action 3.1: Arrange regular monitoring of salinity in Wongamine Brook, Mistake Creek, Glen Avon Creek, Ninigo Creek and Harpers Brook.

Action 3.2: Arrange an assessment of the potential and probability of impact due to occasional discharge of acidic drainage water into river pools during low flow events.

Action 3.3: Arrange for regular reporting (quarterly) to the local community about discharge from the Northam Waste Water Treatment Plant and the results of monitoring.

Action 3.4: Arrange for closure of all farm rubbish tips with potential to pollute the river and its tributaries and communicate the importance of not depositing rubbish in waterways.

Tributary and Catchment Management

Action 4.1: Arrange detailed mapping of the tributaries to these sections of the Avon River and survey of their confluences for management needs.

Actions for Key Management Issues

Action 4.2: Advise the Avon Catchment Council about the importance of the Mortlock River as a tributary to these sections of the Avon River and of the increasing potential of this tributary to affect the river values.

Action 4.3: Arrange a repeat survey of the sediment profile in Wongamine Brook to estimate sediment mobility.

Action 4.4: Initiate a demonstration and information site for 'best practice' lower tributary management on Ninigo Creek.

Action 4.5: Undertake erosion control works (diversion bank and drop structure) for Harpers Brook in the floodplain of the Avon River.

Action 4.6: Assess on-site options for discharge of Mistake Creek stream flow onto the floodplain instead of directly to the bed of the Avon River.

Action 4.7: Arrange fencing and revegetation of lower reaches of the creek channel to arrest sedimentation processes and to filter stream flow.

Land Use and Planning

Action 5.1: Prepare a map and database of current landownership for the river between Northam and Toodyay in a format that is compatible with proposed Action 1.1.

Action 5.2: Arrange and support the proposal by the Masters family for creation of the 'Jim Masters Reserve' on land that is Location 201 with vesting through the Shire of Northam.

Fire Management and River Crossings

Action 6.1: Identify zones near private and public assets for fuel reduction by cool burns. A distance of 250 metres either side of the asset is suggested.

Action 6.2: Liaise with Westrail for fire risk reduction.

Control of Weeds, Feral and Native Animals

Action 7.1: Map areas of the riparian zone requiring weed control measures and coordinate action to eradicate or at least manage priority species (Bridal Creeper, Watsonia, African Box Thorn, Soursob and Spiny Rush).

Action 7.2: Arrange for population control measures (shooting, baiting or breeding potential reduction) for the native Long-billed Corellas and for foxes and cats.

Public Access and Recreation

Action 8.1: Prepare initial concept plans for walk trails with information about the river within the reserves at Katrine and Northam weir to Bypass bridge.

Action 8.2: Prepare an initial concept plan for a canoe course with information about the river from Northam to Katrine.

References

Black, J. (1998) *Avon River Channel Survey Summary.* Unpublished report, Water and Rivers Commission.

Donohue, R., Deeley, D., Robb, M., and Young, L. (1994) *Estimates of nutrient Streamload in the Swan-Canning Catchment.* Swan River Trust Report No 20, Oct. 1994.

Ecoscape and Jim Davies and Associates (1996) *Avon River Survey*. Report to the Avon River Management Authority

Harris, T. F. W. (1996) *The Avon: an Introduction.* An occasional report printed by the Water and Rivers Commission.

Golder and Associates, (1999) *Geotechnical Engineering Report for Katrine Pool.*

Jim Davies and Associates (1997) *Avon River Pool Survey.* Vol. 5 of Avon River Survey report to the Avon River Management Authority.

Maher Brampton Associates (1998) *Northam Trails Master Plan.* Report prepared for the Shire of Northam and the Town of Northam.

Muirden, P. (2000) *Avon River Flooding – January 2000. Hydrology report.* Water and Rivers Commission Report No HY 01.

Lantzke, N. C. and Fulton, I. M. (1992) *Soil Landscape Mapping of the Northam Region.* Agriculture WA Land Resource Series No 11.

Muirden, P. (unpublished) *Avon River Flooding – January 2000: Hydrology Report* Water and Rivers Commission.

Pen, L. J. (1999) *Managing Our Rivers: a Guide to the Nature and Management of the Streams of south-west Western Australia.* Water and Rivers Commission, Perth WA.

Pen, L. J. and Scott, M. (1995) *Stream Foreshore Assessment in farming Areas.* Blackwood Catchment Coordinating Group, Western Australia.

River Conservation Society Inc. (1999) *A Biological Survey of Gwambygine Pool: Report on a survey of Gwambygine Pool, Avon River, York. Period: January 1996 to June 1997*.

Ryan, C. and Cobb, S. (1999) *Avon Catchment Water Quality Snapshot Survey – June, July and August, 1997.* Water and Rivers Commission.

Southwell, C.E. (1993) *A preliminary study of the bedload regime response of the Avon River to channelisation.* Waterways Commission (Western Australia), Report No 36.

Swan River Trust (2000) *Sources of nutrients to the Swan and Canning rivers.* River Science Issue 5, December 2000.

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 Road Bridge to Glen Avon Weir**	**11.30**
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 Mile Pool	12.05
Cold Harbour	10	Mile Pool 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 Townsite	6.81
Kokeby	14	BeverleyTownsite 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 4 and 5

(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)

SECTION 4: 4/0.5-4/10.0 Goomalling Bridge to Glen Avon Weir

A dominant influence on the character of the river in this section is Extracts Weir which has caused large scale erosion of the channel downstream of Millards Pool. From 4/0.5-4/1.5.5 the trained channel is flat and eroded preferentially through an indurated clay bed in some areas exposing bedrock. There is deposition of rock over this area but only minor sand deposits. Scour pools are numerous. There is no overstorey regeneration within the Main Channel. (M/C).

At Extracts, the narrowing of the channel at the weir, the sinuous nature of the channel at this point, and the supercritical flows of water over the weir have resulted in large scale bank and bed erosion. Banks between 3 and 8m high from 4/2.5-4/2.0 are eroding and undercutting with erosion faces of typically 60-90°. The bed in some areas has incised by 3 or more metres with large areas of bedrock exposed within the channel. A tributary entering at 4/2.5 shows no significant erosion. Lloyds Pool has some sand accretion and there are rocks deposited across the channel.

A single channel exists over the distance from Millard pool at 4/5.0 to 4/2.0 with no secondary channels of relic braided channels (RBC). Millard Pool contains a 1.5km sand slug at the upstream end at 4/5.0 where the bed returns to indurated clay. Stock access has resulted in some bank erosion at the pool, this is not extensive.

Upstream of the pool to 4/8.0 the indurated clay bed is covered in deposits of rock and in some areas sand accretion with only one section at 4/7.0 eroding. There are several accreting bars to 200 m long that are generally without overstorey vegetation. There is only minor groundcover within the main channel and no regenerating overstorey. From 4/8.0 to section 4/10.0 there is a distinct low flow/scour channel within the M/C and large areas of groundcover stabilised accretion zones on both banks suitable for overstorey regeneration. The most upstream cross-sections have wide alluvial flats with numerous BC channels increasing the total width of the channel. The fringing vegetation over these areas remains uncleared and in good condition. The salinity effects in this section are restricted to salt weathering of the indurated clay bed.

I Main overstorey species present

All three overstorey species are present throughout the section, with one or the other species being dominant at differing transects. *Eucalyptus rudis* tends to dominate the transects at 4/1.5,4/2.5, 4/4.5, and 4/8.0. *Melaleuca rhaphiophylla* is more dominant at the transects 4/0.5, 4/1.5, and 4/6.0 = 4/10.0. *Casuarina obesa* dominates at transect numbers 4/0.5, 4/1.5, and 4/6.0 - 4/0.0.

II Vegetation death

Large amounts of dead vegetation (both over and understorey species) are visible on both banks between and including transects 4/3.0 to 4/4.5. It was also apparent at these transects that much of the overstorey had been cleared and the understorey was being grazed and trampled by livestock.

III Fencing

The transects from 4/4.5 to 4/3.5 inclusive had fences present on the left bank, but not on the right bank. Transects at 4/4.0 and 4/4.5 were not fenced on both banks. The remainder of the transect sections (4/5.0 to 4/10.0 inclusive) were fenced on both sides of the riparian zone lining the main channel.

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* parasitised by *Cassytha glabella, A. saligna, Dryandra sessilis, Eucalyptus loxophleba R, wandoo* some of which are parasitised by *Amyema miquelii*, *Hakea preissii, Juncus pallidus and Melaleuca preissiana*. The understorey species present which are responsible for stabilising the river banks are: *Atriplex prostrata, Frankenia pauciflora, Sarcocornia quinqueflora* and the introduced perennial grass species, *Paspalum vaginatum* (saltwater couch).

V Weed species present

There were annual and perennial grass weeds present in this section as well as: *Agave americana*, Umbrella sedge (*Cyperus eragrotis*), Stinkwort (*Dittrichia graveolens*), Corn Gromwell (*Buglossoides arvensis*), Bridal Creeper (*Myrsiphyllum asparagoides*), Olive (*Olea europaea*), Soursob (*Oxalis pes-caprae*), Spiny Rush (*Juncus acutus*), Sorrel (*Rumex acetosella*), Blackberry nightshade (*Solanum nigrum*) and Tamarisk (*Tamarix aphylla*) and the perennial grass species, *Paspalum vaginatum* (saltwater Couch).

VI Vegetation condition (according to the 1995 Penn and Scott assessment for the condition of riverbank vegetation)

The majority of the transects were given a vegetation condition of B3, with a few sections rated between B2-B3 (4/6.0, 4/3.0, 4/3.5 and 4/4.5. These ratings for vegetation conditions showed that most of the understorey was comprised of weeds and there was no exposed soil due to surface erosion.

VII Regeneration

The three main overstorey species have differing regeneration rates. *Eucalyptus rudis* was seen to have a low to medium regeneration rate (1-100 plants/ha to 100-500 plants/ha). The *Melaleuca rhaphiophylla* had a low regeneration rate (1-100 plants/ha) and *Casuarina obesa* had a medium regeneration rate (100-500 plants/ha). All regenerating individuals of the three species formed mixed aged stands.

VIII Disturbance factors

The main sources of disturbances at the transect sections that were not fenced off on both banks were from presence of livestock (sheep, cattle, horses) in the main channel and grazing and trampling of the understorey.

Presence of feral animals was noted at the transect sections 4/4.5 and 4/6.0. The animals observed were rabbits (rabbit warren) and geese which were near a private property. There was also evidence of kangaroo presence at many of the transect sections (4/1.0, 4/5.0-4/9.5. Rubbish dumping was visible at transect numbers 4/0.5 and 4/8.0. Service corridors alongside the river were present at transect sections 4/6.5 and 4/7.5. There was also some evidence of fire in the riparian zone at transect 4/6.0. Species that had been burnt were regenerating vegetatively (*Melaleuca rhaphiophylla*, *Eucalyptus loxophleba* and *Hakea preissii*.

SECTION 5: 5/0-5/17.5
Glen Avon Weir to Northam Town Pool Weir

Glen Avon pool extends for 1600 m upstream from 5/0.5 although there is continuous water in the river channel to Katrine Pool. The pool remains in better condition than the majority of these features over the surveyed length. Fringing overstorey vegetation is generally in good condition forming a closed canopy. Stock access has however removed much of the understorey cover which potentially reduces bank stability. A confluence 5/1.1 is actively eroding for 100 m into the channel bank and requires stabilising at the gully head.

Scouring of the river bed is evident downstream of Glen Avon weir and at Viveash Causeway but in both instances the channel has been partially stabilised by the dumping of rock at these structures. Immediately upstream of Viveash causeway is a 350 m sand slug on the left of the M/C, this feature cannot be stabilised by revegetation.

Upstream of Katrine Pool to 5/5.0 the total channel width increases to over 200 m wide where a district trained section of river of 50 m wide has extensive areas of regenerating overstorey. The trained channel has typically eroded preferentially, through an indurated clay bed, forming low flow/scour channels. The erosion bar features on either bank are no stabilised and accreting. Mistake Creek discharges into the river at 5/4.0 and forms a wide delta depositing rock, gravel and sand across the M/C. The tributary exhibits moderate levels of bank erosion.

From 5/5.6 to Egoline Pool there are a number of pool cross-sections separated by areas of trained channel which have wide floodplains and numerous RBC, vegetated with *Melaleuca* thickets. There is only limited accretion of sand and graves of this are. From the downstream extent of Egoline Pool at around 5/7.0 to 5/10.0 a sand slug is present within the M/C and within some of the RBC channels when they occur. Egoline Pool appears to be almost totally filled. A large centre bar 200 m long separates two trained channels at 5/10.0, the bar has no overstorey vegetation.

The main channel from 5/10.0 to 5/13.5 displays both areas of accretion and erosion with a larger percentage of the bed being exposed indurated clay. There is an increase in the number of bed features including bed dunes, bars and scour channels from what was a largely flat trained channel downstream. At 5/12.5 there is a noticeable effect of livestock in the channel reducing bank stability both on the channel margins and across the alluvial bars. There is a reduction in the regeneration levels of overstorey species over this reach.

From 5/14.0 to Northam Town Pool and the weir, the channel bed is eroded to an indurated clay bed with only minor accretion of sands in localised ares. The bed is preferentially eroding forming numerous scour channels with only isolated stable bed dunes. The presence of the weir is the determining factor on their higher rates of bed erosion. Bank erosion of the M/C over this reach is relatively minor due to there being only a few ares where bank height exceeds 0.5-1 m. A number of small alluvial bars stabilised by groundcovers and *C. obesa* are accreting sands at 5/17.0. At the confluence with the Mortlock River at 5/17.5 there was no evidence of significant sand sediment deposition. The banks of the Mortlock at the confluence appear stable.

Fringing vegetation is in good condition until section 5/14.0. From this point upstream to the weir the vegetation type alters with higher levels of *C. obesa*. There is little regeneration of overstorey species within the main channel upstream of 5/14.0 which corresponds to an increase in bed erosion levels. Salinity effects are largely not evident in the vegetation over this section but salt weathering of the bed material is evident from 5/14.0 upstream.

I Main overstorey species present

All three overstorey species are present throughout the section, with one or the other species dominating at different transects. *Eucalyptus rudis* is seen to dominate at transects 5/1.0, 5/1.5, 5/15.5 and 5/16.0. *Melaleuca rhaphiophylla* is dominant a the transects 5/3.0-5/4.0, 5/6.0 5/7.0-5.9.0, 5/10.0, 5/12.0, 5/14.5 and 5.15.0. *Casuarina obesa* dominates at transect numbers 5/2.0, 5/6.5, 5/13.0 and 5/13.5.

II Vegetation death

Transect sections 5/0.5 and 5/11.5 showed large amounts of vegetation death. All three of the overstorey species were present in low amounts (woodland), with many individuals of *Eucalyptus rudis* dead or dying. There was very little overstorey present at both these transects, as most had been grazed.

III Fencing

Approximately half of the transect sections had fencing present on both river banks, whilst the remainder of the transects were either not fenced at all or had fencing present on only one side of the main active channel (5/0.5, 5/2.0, 5/2.5, 5/9.0, 5/9.5, 5/10.5, 5/11.5, 5/14.5-5/16.5). Most of the fencing present in this section was in good to medium condition.

IV Other native species present

The understorey species present which stabilise the river banks are: *Atriplex prostrata*. *Frankenia pauciflora*, *Sarcocornia quinqueflora* and *Sporobolus virginicus*. The other overstorey species present are, *Acacia acuminata, A. saligna, Eucalyptus loxophleba, Hakea preissii, Juncus pallidus*.

V Weed species present

Annual and perennial grass species were present in this section as well as Perennial wild melon (*Citrullus colocynthis*), Tall fleabane (*Conyza albida*), Umbrella sedge (*Cyperus eragrotis*), Stink wort (*Dittrichia graveolens*), Spiny rush (*Juncus acutus*,) Winged Sea-Lavender (*Limonium thouinii*), Soursob (*Oxalis pes-caprae*), Wild radish (*Taphanus raphanistrum*), Blackberry nightshade (*Solanum nigrum*) the perennial grass species *Paspalum vaginatum* (Saltwater Couch) and glaucous Corn Gromwell (*Buglossoides arvensis*). At transect 5/3.0 on the left bank approximately 100-150 m from channel edge was an old planting of lavender (*Lavandula spp*.) and Geraldton Wax (*Chamaelaucium uncinatum*).

VI Vegetation condition (according to the 1995 Pen and Scott assessment for the condition of river bank vegetation)

The majority of the transects were given a vegetation condition of B3, indicating that these transects had mainly weeds as their understorey. Some transects were given a vegetation condition of B2-B3 where there were more native understorey species present (5/2.0, 5/3.5, 5/4.0, 5/5.5, 5/7.0, 5/14.5, 5/15.0 5/15.5, 5/17.0 and 5/17.5). The remainder of the transects were given a vegetation condition of B3-C1 where all the understorey species were weeds but there was no surface erosion present (transect numbers 5/0.5, 5/1.5, 5/5.0, 5/7 and 5/14.0).

VII Regeneration

All three of the main overstorey species have a low rate of regeneration (1-100 plants/ha.). Regenerating individuals of the three species formed mixed aged stands.

VIII Disturbance factors

Many of the transects which were not properly fenced on both banks had livestock (sheep only) present in the main active channel, and grazing of the understorey in this riparian zone was also visible. This occurred at transect numbers 5/0.5, 5/2.0, 5/7.5 - 5/9.5 and 5/10.5 - 5/13.5 Some evidence of dumping of rubbish was visible at transect numbers 5/4.0, 5/12.5 and 5/15.0. There were also signs of fire affecting (right bank) at 5/6.5 and 5/16.0 (on the left bank). *Melaleuca rhaphiophylla* is resprouting vegetatively at some of the transects affected by fire. There was also some noticeable seed germination of *Eucalyptus rudis* and/or *E.loxophleba* at one of the transects which had been affected by fire (5/5.0). Presence of foxes was noted at transect number 5/9.0 (fox den), and there was also the body of a dead cat in the riparian zone. Other sources of disturbance were the evidence of kangaroos at transect 5/6.5 and visible dirt bike tracks at transect 5/12.5.

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

Northam monthly flow

Water and Rivers Commission **HYMONTH V60 Output 03.12.2002**
Station 615062 AVON RIVER — NORTHAM Station 615062
Var from 10.00 STAGE — SL in metres
Var to 140.00 Mean stream discharge in cubic metres per second
Figures are for period starting 0 hours.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean monthly	Median monthly	Missing days	Year
1977	[ ]	[ ]	[0.000]	0.000	0.000	0.392"	0.749"	4.777"	0.627"	0.479'	0.719'	0.000'	[0.774]	[0.436]	88	1977
1978	0.000'	0.106'	0.031	0.000	0.662	2.206	47.11	9.944	3.840	1.252	0.014	0.000	5.431'	0.384'	0	1978
1979	0.052	0.000	0.000	0.000	0.556'	5.160'	5.874"	9.173*	1.780*	0.114*	0.000*	0.000	1.892*	0.083*	0	1979
1980	0.000	0.000	0.000	0.000	0.151'	1.369'	3.252'	1.901'	0.540	0.896	0.116	0.000	0.685'	0.134'	0	1980
1981	0.000	0.000	0.007	0.000	4.601	33.50"	22.27	35.31*	4.701	0.707	1.274	0.023'	8.534*	0.991*	0	1981
1982	3.396*	0.196"	0.000	0.000	0.072'	2.005'	3.167	6.254	2.802'	0.919	0.478	0.151	1.620*	0.698*	0	1982
1983	0.000	0.000	0.013	0.010	0.000*	21.42*	86.74	41.97	39.00'	1.912	1.828	0.174	16.09 *	1.001*	0	1983
1984	0.271	0.000	0.000	0.174	7.944	6.504	7.719	8.386'	9.873	1.089	0.306	0.000	3.522'	0.698'	0	1984
1985	0.000	0.000	0.000	0.000	0.000	0.283	4.886"	7.895	2.581	0.392	0.058	0.003	1.341"	0.031"	0	1985
1986	0.000	1.661*	0.314	0.002	0.799*	12.71	13.41	20.93'	4.438	0.909	0.208	0.001	4.616*	0.854*	0	1986
1987	0.000	0.000	0.000	0.000	1.190'	1.933'	5.615'	9.062	2.211	0.466'	0.032	0.013	1.710'	0.249'	0	1987
1988	0.000	0.000	0.000	0.000	0.791	7.936*	15.93'	13.38	4.177	3.083*	0.113	0.636	3.839*	0.714*	0	1988
1989	0.000	0.000	0.000	0.000	1.099	5.407	26.56	6.635*	1.210*	0.596	0.091	0.000	3.467*	0.343*	0	1989
1990	8.694	24.52	3.667	1.820	2.060	2.202	10.99	8.440	2.173	0.829	0.112	0.000	5.459	2.188	0	1990
1991	0.000	0.000	0.000	0.000	0.000	3.065	13.93	17.17	4.251	0.401	0.124	0.028	3.248	0.076	0	1991
1992	0.001	0.000	0.000	1.019	0.295	5.570	14.68	27.03	35.31	8.078	0.796	0.126	7.743	0.908	0	1992
1993	0.000	0.024	0.659	0.343	1.002	3.019	6.321	10.52"	6.730	1.098	0.526	0.015	2.522"	0.831"	0	1993
1994	0.000'	0.000'	0.000	0.000	0.954	5.845	10.04	7.664	2.165	0.226	0.007	0.000	2.242'	0.116'	0	1994
1995	0.000	0.000	0.000	0.000	0.673	5.447	28.04	13.36	5.071	4.563	0.277	0.002	4.787	0.475	0	1995
1996	0.000	0.000	0.000	0.000	0.000	8.987	56.18	42.09'	8.895'	2.654'	2.090'	0.060	10.08'	1.075'	0	1996
1997	0.000	0.000	0.699	2.564"	0.750	2.358	3.008	7.973	7.387	1.177	0.095	0.000	2.168"	0.964"	0	1997
1998	0.000	0.000	0.000	0.000*	0.000*	3.963*	6.043	9.360	15.85	1.382	0.053	0.000	3.054*	0.026*	0	1998
1999	0.212	0.000	0.000	0.000	1.749	10.59	24.67	18.30	14.56	7.153	0.852	0.181"	6.523"	1.301"	0	1999
2000	41.39	42.34	5.303	0.478*	0.629	2.233	14.49	8.604	7.346	0.624	0.080	0.000	10.29*	3.768*	0	2000
2001	0.000	0.000	0.000	0.000	0.000	0.268	0.984	8.087	1.541	0.682	0.051	0.002	0.968	0.027	0	2001
2002	0.000	0.000	0.000	0.000	0.046	0.654	2.486	1.892	1.344	[0.373]	[ ]	[ ]	[0.679]	[0.209]	78	2002
															166 Total	
Mean	2.161*	2.754*	[0.411]	0.246*	1.001*	5.963*	16.73"	13.69*	7.324*	[1.617]	0.412*	0.057"	[4.357]			**Mean**
Med	0.000*	0.000*	[0.000]	0.000*	0.646*	3.514*	10.52"	9.118*	4.214*	[0.902]	0.116*	0.002"		[0.548]		**Med**
Max	41.39*	42.34*	[5.303]	2.564*	7.944*	33.50*	86.74"	42.09*	39.00*	[8.078]	2.090*	0.636"	[16.09]			**Max**
Min	0.000*	0.000*	[0.000]	0.000*	0.000*	0.268*	0.749"	1.892*	0.540*	[0.114]	0.000*	0.000"	[0.679]			**Min**
OK	100%	100%	96%	100%	100%	100%	100%	100%	100%	98%	100%	100%	100%			**OK**
Cnt	25	25	26	26	26	26	26	26	26	26	25	25	26			**Cnt**

NOTES

All recorded data is continuous and reliable except where the following tags are used:

" ... Good record — Corrections/estimations
' ... Very good record — Corrections applied
* ... Estimated record
[... Not available

Water and Rivers Commission **HYMONTH V60 Output 03.12.2002**

Station 615062 AVON RIVER — NORTHAM Station 615062

Var from 10.00 STAGE — SL in metres

Var to 140.00 Maximum stream discharge in cubic metres per second

Figures are for period starting 0 hours

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual maximum	Missing days	Year
1977	[ ]	[ ]	[0.000]	0.000	0.000	1.778"	2.465"	22.31"	1.413"	7.057'	5.823'	0.000'	[22.31]	88	1977
1978	0.000'	0.925'	0.264	0.000	3.872	12.05	239.4	30.74	7.484	8.429	0.075	0.000	239.4'	0	1978
1979	0.721	0.000	0.000	0.000	4.184'	20.00'	10.34"	54.37*	4.595*	0.759*	0.001*	0.000	54.37*	0	1979
1980	0.000	0.000	0.000	0.000	0.839'	6.644'	6.808'	3.511'	1.720	5.672	0.839	0.000	6.808'	0	1980
1981	0.000	0.000	0.068	0.000	153.2	197.0"	113.3	108.7*	9.344	2.138	34.52	0.147'	197.0*	0	1981
1982	55.27*	1.299"	0.000	0.000	0.925'	5.598'	11.28	14.53	8.016'	3.798	4.264	1.991	55.27*	0	1982
1983	0.000	0.000	0.223	0.203	0.000*	280.2*	362.3	113.3	138.3'	5.672	8.198	4.345	362.3*	0	1983
1984	3.238	0.000	0.000	1.255	31.23	16.46	21.21	18.25'	97.25	2.331	1.306	0.018	97.25'	0	1984
1985	0.000	0.000	0.000	0.000	0.000	0.759	19.62"	17.56	6.444	1.255	0.310	0.044	19.62"	0	1985
1986	0.000	13.51*	2.609	0.026	3.653*	95.90	42.27	106.2'	7.953	2.465	0.665	0.013	106.2*	0	1986
1987	0.000	0.000	0.000	0.000	11.28'	5.598'	87.93'	42.72	5.219	2.025'	0.094	0.286	87.93'	0	1987
1988	0.013	0.000	0.000	0.000	2.138	23.62*	125.0'	53.69	9.779	20.26 *	0.385	5.219	125.0*	0	1988
1989	0.000	0.000	0.000	0.000	8.617	23.91	48.68	16.87*	2.465*	1.526	0.411	0.000	48.68*	0	1989
1990	196.2	61.50	15.19	4.888	8.523	4.345	43.83	29.38	4.026	2.015	0.439	0.000	196.2	0	1990
1991	0.000	0.000	0.000	0.000	0.000	8.617	40.76	89.22	14.27	1.060	0.562	0.498	89.22	0	1991
1992	0.035	0.000	0.000	7.615	0.683	40.38	36.96	65.67	59.54	18.58	4.888	0.595	65.67	0	1992
1993	0.000	0.243	11.50	0.759	3.948	20.77	14.66	32.73"	20.51	3.373	2.397	0.203	32.73"	0	1993
1994	0.000'	0.000'	0.000	0.000	15.93	19.75	24.97	54.37	9.344	0.595	0.083	0.000	54.37'	0	1994
1995	0.000	0.000	0.000	0.000	2.783	26.36	94.03	41.49	16.06	38.32	0.881	0.050	94.03	0	1995
1996	0.000	0.000	0.000	0.000	0.000	45.26	195.9	179.7'	18.45'	8.664'	13.45'	0.359	195.9'	0	1996
1997	0.000	0.000	19.62	17.00"	1.469	5.598	5.051	20.38	29.38	2.747	0.530	0.000	29.38"	0	1997
1998	0.000	0.000	0.000	0.000*	0.000*	16.19*	13.95	131.1	85.14	6.011	0.334	0.000	131.1*	0	1998
1999	14.66	0.012	0.000	0.000	15.86	25.59	70.70	57.93	34.69	24.56	3.725	5.897"	70.70"	0	1999
2000	175.7	106.4	11.71	2.400*	0.969	4.595	59.08	20.38	28.45	1.526	0.411	0.000	175.7*	0	2000
2001	0.000	0.000	0.000	0.000	0.000	0.630	20.88	32.23	3.442	3.653	0.286	0.032	32.23	0	2001
2002	0.000	0.000	0.000	0.000	0.243	1.306	5.219	4.595	5.598	[1.015]	[ ]	[ ]	[5.598]	78	2002
														166 Total	
Mean	17.84*	7.359*	[2.354]	1.314*	10.39*	34.96*	66.03"	52.39*	24.19*	[6.750]	3.395*	0.788"	[99.82]		**Mean**
Med	0.000*	0.000*	[0.000]	0.000*	1.803*	16.33*	38.86"	37.11*	9.344*	[3.060]	0.562*	0.032"			**Med**
Max	196.2*	106.4*	[19.62]	17.00*	153.2*	280.2*	362.3"	179.7*	138.3*	[38.32]	34.52*	5.897"	[362.3]		**Max**
Min	0.000*	0.000*	[0.000]	0.000*	0.000*	0.630*	2.465"	3.511*	1.413*	[0.595]	0.001*	0.000"	[5.598]		**Min**
OK	100%	100%	96%	100%	100%	100%	100%	100%	100%	98%	100%	100%	100%		**OK**
Cnt	25	25	26	26	26	26	26	26	26	26	25	25	26		**Cnt**

NOTES

All recorded data is continuous and reliable except where the following tags are used:

" ... Good record — Corrections/estimations

' ... Very good record — Corrections applied

* ... Estimated record

[... Not available

Water and Rivers Commission **HYMONTH V60 Output 03.12.2002**

Station 615062 AVON RIVER — NORTHAM Station 615062

Var from 10.00 STAGE — SL in metres

Var to 140.00 Minimum stream discharge in cubic metres per second

Figures are for period starting 0 hours

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual minimum	Missing days	Year
1977	[ ]	[ ]	[0.000]	0.000	0.000	0.000"	0.286"	0.468"	0.286"	0.018'	0.000'	0.000'	[0.000]	88	1977
1978	0.000'	0.000'	0.000	0.000	0.000	0.439	2.331	5.672	2.076	0.050	0.000	0.000	0.000'	0	1978
1979	0.000	0.000	0.000	0.000	0.000'	0.595'	2.331"	0.147*	0.665*	0.000*	0.000*	0.000	0.000*	0	1979
1980	0.000	0.000	0.000	0.000	0.000'	0.147'	1.155'	1.015'	0.147	0.032	0.000	0.000	0.000'	0	1980
1981	0.000	0.000	0.000	0.000	0.000	7.397"	4.264	8.336*	1.306	0.183	0.083	0.000'	0.000*	0	1981
1982	0.000*	0.000"	0.000	0.000	0.000'	0.122'	0.969	2.265	0.630'	0.094	0.002	0.000	0.000*	0	1982
1983	0.000	0.000	0.000	0.000	0.000*	0.000*	14.66	14.92	5.672'	0.310	0.108	0.000	0.000*	0	1983
1984	0.000	0.000	0.000	0.000	0.839	3.511	3.511	3.948'	2.076	0.094	0.011	0.000	0.000'	0	1984
1985	0.000	0.000	0.000	0.000	0.000	0.000	0.630"	2.747	1.204	0.028	0.000	0.000	0.000"	0	1985
1986	0.000	0.000*	0.023	0.000	0.000*	0.334	5.598	7.953'	1.155	0.122	0.013	0.000	0.000*	0	1986
1987	0.000	0.000	0.000	0.000	0.000'	0.243'	1.255'	2.946	0.969	0.040'	0.000	0.000	0.000'	0	1987
1988	0.000	0.000	0.000	0.000	0.000	0.665*	4.026'	4.511	1.837	0.286*	0.000	0.000	0.000*	0	1988
1989	0.000	0.000	0.000	0.000	0.000	1.896	5.312	2.465*	0.630*	0.183	0.000	0.000	0.000*	0	1989
1990	0.000	6.725	0.385	0.223	1.107	0.925	0.839	3.511	1.306	0.203	0.000	0.000	0.000	0	1990
1991	0.000	0.000	0.000	0.000	0.000	0.000	3.238	4.026	0.969	0.050	0.002	0.000	0.000	0	1991
1992	0.000	0.000	0.000	0.000	0.130	0.174	6.362	5.973	17.28	0.721	0.310	0.000	0.000	0	1992
1993	0.000	0.000	0.000	0.094	0.203	0.881	3.106	5.010"	1.837	0.147	0.122	0.000	0.000"	0	1993
1994	0.000'	0.000'	0.000	0.000	0.000	1.015	3.442	2.015	0.286	0.015	0.000	0.000	0.000'	0	1994
1995	0.000	0.000	0.000	0.000	0.000	0.264	1.778	5.821	1.155	0.223	0.032	0.000	0.000	0	1995
1996	0.000	0.000	0.000	0.000	0.000	0.000	7.881	9.779'	5.672'	0.647'	0.164'	0.000	0.000'	0	1996
1997	0.000	0.000	0.000	0.334"	0.223	0.925	0.759	1.896	2.015	0.203	0.000	0.000	0.000"	0	1997
1998	0.000	0.000	0.000	0.000*	0.000*	0.000*	2.639	1.497	3.305	0.094	0.000	0.000	0.000*	0	1998
1999	0.000	0.000	0.000	0.000	0.000	1.229	8.198	6.482	6.891	1.060	0.083	0.000"	0.000"	0	1999
2000	0.183	1.720	0.359	0.243*	0.223	0.243	1.580	4.184	1.469	0.083	0.000	0.000	0.000*	0	2000
2001	0.000	0.000	0.000	0.000	0.000	0.000	0.108	2.331	0.530	0.122	0.000	0.000	0.000	0	2001
2002	0.000	0.000	0.000	0.000	0.000	0.040	0.969	0.759	0.243	[0.094]	[ ]	[ ]	[0.000]	78	2002
														166 Total	
Mean	0.007*	0.338*	[0.029]	0.034*	0.105*	0.809*	3.355"	4.257*	2.370*	[0.196]	0.037*	0.000"	[0.000]		**Mean**
Med	0.000*	0.000*	[0.000]	0.000*	0.000*	0.253*	2.485"	3.730*	1.255*	[0.108]	0.000*	0.000"			**Med**
Max	0.183*	6.725*	[0.385]	0.334*	1.107*	7.397*	14.66"	14.92*	17.28*	[1.060]	0.310*	0.000"	[0.000]		**Max**
Min	0.000*	0.000*	[0.000]	0.000*	0.000*	0.000*	0.108"	0.147*	0.147*	[0.000]	0.000*	0.000"	[0.000]		**Min**
OK	100%	100%	96%	100%	100%	100%	100%	100%	100%	98%	100%	100%	100%		**OK**
Cnt	25	25	26	26	26	26	26	26	26	26	25	25	26		**Cnt**

NOTES

All recorded data is continuous and reliable except where the following tags are used:

" ... Good record — Corrections/estimations

' ... Very good record — Corrections applied

* ... Estimated record

[... Not available

Avon River monthly conductivity

Water and Rivers Commission **HYMONTH V60 Output 12.02.2002**

Station 615062 AVON RIVER — NORTHAM Station 615062

Var from 86.00 Conductivity uncompensated in-situ in cubic millisiemens per metre

Var to 85.00 Mean conductivity uncompensated in-situ in cubic millisiemens per metre

Figures are for period ending 2400 hours

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean monthly	Median monthly	Missing days	Year
1995	[ ]	[ ]	[ ]	[0.27]	940.14	1049.65	738.97	833.62	933.15	1021.38	1370.28	1713.03	[955.61]	[940.14]	118	1995
1996	2118.60	2672.37	1683.76	6.63	18.60	1468.97	582.69"	419.63"	640.81"	1011.27	1211.71	1513.38	1112.37"	1111.49"	0	1996
1997	1933.96	2297.60	2214.44*	2553.06*	2683.63'	1563.56'	1165.28'	868.53	833.05	1294.16'	1542.34	1430.15	1698.31*	1552.95*	0	1997
1998	0.73	0.00	0.00	76.73'	478.91	1540.39'	1107.34'	1226.15'	941.07'	[1041.03]	1409.51	1730.23	[796.01]	[991.05]	1	1998
1999	779.62	918.39	777.40	475.64	412.70	1622.17	1126.04	1017.07	956.80	1083.53	1293.44*	1536.27'	999.92*	986.94*	0	1999
2000	1011.25*	699.83	1829.35	[2289.65]	1923.80	1824.29	806.93	691.91	688.27	1008.98'	1251.32'	1399.33'	[1285.41]	[1131.28]	1	2000
2001	22.087'	0.363	0.153	0.148	0.049	[1281.99]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[217.465]	[0.258]	203	2001
															323 Total	
Mean	977.71*	1098.09	1084.18*	[771.73]	922.55'	[1478.72]	921.21"	842.82"	832.19"	[1076.72]	1346.43*	1553.73'	[1009.30]			**Mean**
Med	895.43*	809.11	1230.58*	[76.73]	478.91'	1540.39]	957.14"	851.07"	883.10"	[1031.20]	1331.86*	1524.83'		[1021.38]		**Med**
Max	2118.60*	2672.37	2214.44*	[2553.06]	2683.63'	[1824.29]	1165.28"	1226.15"	956.80"	1294.16]	1542.34*	1730.23'	[1698.31]			**Max**
Min	0.73*	0.00	0.00*	[0.15]	0.05'	[1049.65]	582.69"	419.63"	640.81"	[1008.98]	1211.71*	1399.33'	[217.47]			**Min**
OK	100%	100%	100%	86%	100%	91%	100%	100%	100%	99%	100%	100%	98%			**OK**
Cnt	6	6	6	7	7	7	6	6	6	6	6	6	7			**Cnt**

NOTES

All recorded data is continuous and reliable except where the following tags are used:

" ... Good record — Corrections/estimations

' ... Very good record — Corrections applied

* ... Estimated record

[... Not available

Avon River — Northam wq statistics

Station 615062 AVON RIVER — NORTHAM Station 615062

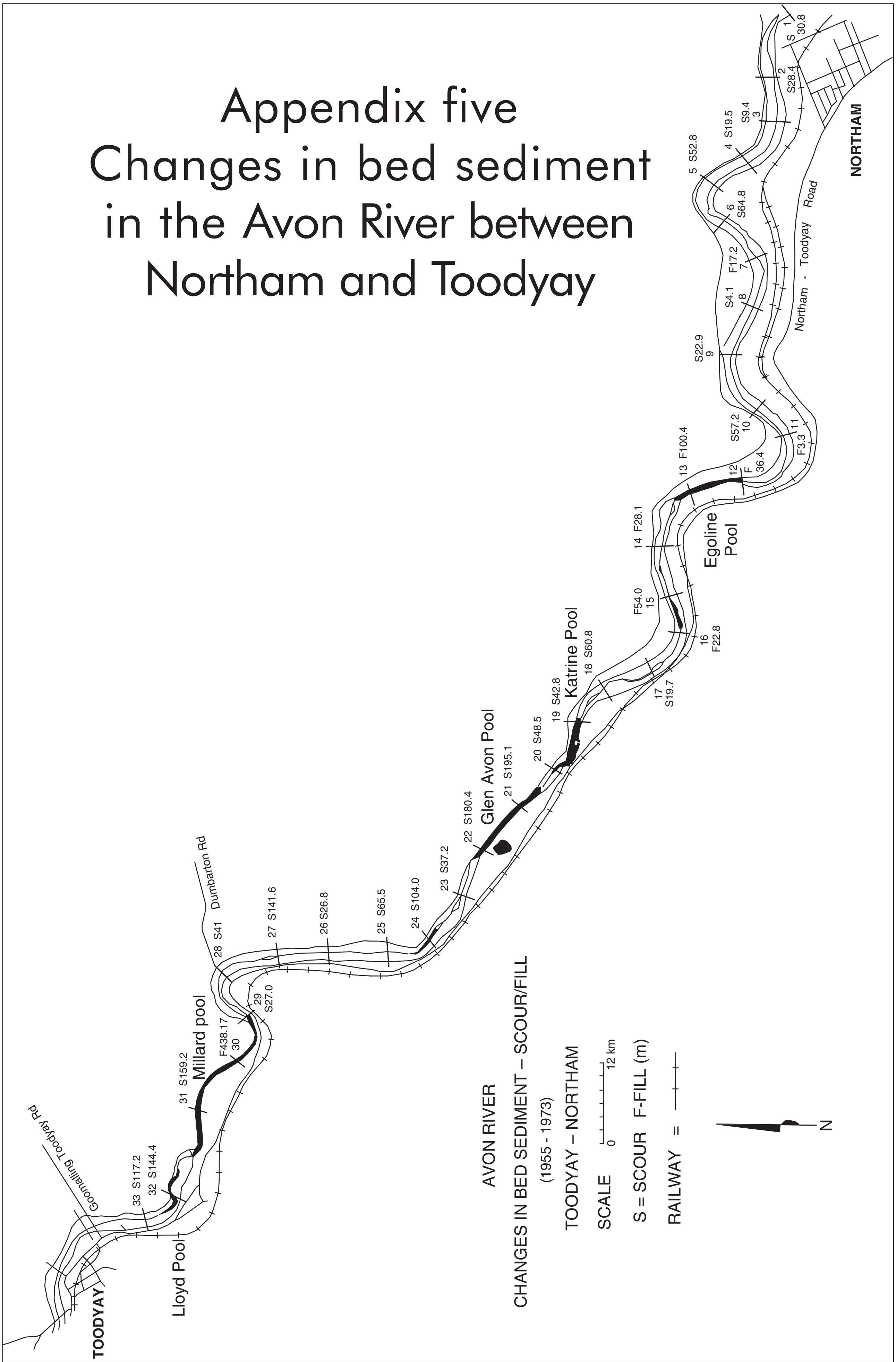
Reference	Variable	Unit	Minimum	Maximum	Average	No. of readings	First reading	Last Reading
615062								
Acidity ($CaCO_3$)	287	mg/L	4.546	4.546	4.546	1	08 Feb 2000	08 Feb 2000
Al (tot)	29	mg/L	0.100	0.620	0.384	5	16 Jun 1995	08 Feb 2000
Alkalinity ($C0_3$ -$CaCO_3$)	154	mg/L	1.000	1.000	1.000	1	08 Feb 2000	08 Feb 2000
Alkalinity (CO_3 -CO_3)	332	mg/L	0.000	9.000	1.000	17	27 May 1981	30 Aug 1988
Alkalinity (HCO_3 -$CaCO_3$)	277	mg/L	59.000	59.000	59.000	1	08 Feb 2000	08 Feb 2000
Alkalinity (HCO_3 -HCO_3)	333	mg/L	46.000	296.000	124.235	17	27 May 1981	30 Aug 1988
Alkalinity (tot) ($CaCO_3$)	23	mg/L	37.728	242.770	107.570	21	27 May 1981	11 Nov 1998
Analysis completion date	1256	yyyyddd				0	24 Jul 1973	25 Jan 1999
Batch number	1255	(none)	6077.000	29729.000	24797.414	1617	24 Jul 1973	25 Jan 1999
CDO	27	mg/L	7.330	133.000	21.116	16	20 Jun 1994	08 Feb 2000
Ca (sol)	353	mg/L	26.000	192.000	100.591	22	27 May 1981	08 Feb 2000
Cl (sol)	284	mg/L	604.000	8686.898	4947.660	411	24 Jul 1973	08 Feb 2000
Colour (TCU)	20	(none)	34.000	330.000	112.000	6	02 Jun 1999	08 Feb 2000
Colour (hazen)	1059	Hu	20.000	100.000	55.211	95	31 Aug 1973	23 Oct 1978
Colour (true)	1181	Hu	4.000	325.000	43.183	553	24 Jul 1973	25 Jan 1999
Cond calc 25 deg C	21	µS/m	1518000.000	1518000.000	1518000.000	1	07 Jun 1995	07 Jun 1995

Continued…

…continued

Reference	Variable	Unit	Minimum	Maximum	Average	No. of readings	First reading	Last Reading
Cond uncomp (in situ)	1165	μS/m	106100.000	2380000.000	1082013.047	92	08 Jun 1994	25 Oct 2001
Cond uncomp (lab)	1163	μS/m	130000.000	2870000.000	1294704.404	1704	24 Jul 1973	08 Feb 2000
Date sample received	1257	yyyyddd				0	04 May 1992	25 Jan 1999
Discharge rate	1271	m^3/s	0.000	10.180	9.589	19	10 Jul 1979	19 Jul 1982
Discharge rate (estimated)	1270	m^3/s	0.200	21.200	8.650	4	24 Jul 1973	16 Nov 1973
Fe (tot)	38	mg/L	0.050	0.570	0.244	14	04 May 1992	08 Feb 2000
615062								
Groundwater level (SLE)	1307	m	10.343	10.343	10.343	1	12 Jul 1995	12 Jul 1995
Hardness (tot)	278	mg/L	270.830	2603.400	1319.242	21	27 May 1981	11 Nov 1998
K (sol)	354	mg/L	21.000	21.000	21.000	1	08 Feb 2000	08 Feb 2000
K (tot)	40	mg/L	6.000	34.100	15.990	21	27 May 1981	11 Nov 1998
Lab analysis number	1264	(none)	205891.000	9503432.000	523016.353	329	04 May 1992	25 Jan 1999
Mg (sol)	356	mg/L	50.000	520.000	253.364	22	27 May 1981	08 Feb 2000
Mn (tot)	43	mg/L	0.008	0.120	0.055	14	04 May 1992	08 Feb 2000
N (ox sol)	1024	mg/L	0.017	1.452	0.734	2	02 Jun 1999	16 Jun 1999
N (tot kjeldahl)	5	mg/L	0.616	7.921	1.401	53	20 Jun 1994	16 Jun 1999
N (tot ox)	4	mg/L	0.002	4.245	0.329	52	20 Jun 1994	25 Jan 1999
N (tot persulfate)	279	mg/L	0.860	1.000	0.907	3	30 Aug 2001	25 Oct 2001
N (tot)	6	mg/L	0.780	10.115	1.659	73	30 Jun 1994	01 Aug 2001
NH_3-N/NH4-N (sol)	582	mg/L	0.004	1.240	0.129	43	20 Jun 1994	23 Jul 1998
NO_2-N (sol)	2	mg/L	0.002	0.045	0.009	8	11 Oct 1994	23 Jul 1998
NO_3 (sol)	467	mg/L	1.000	17.000	7.353	17	27 May 1981	30 Aug 1988
NO_3-N (sol)	3	mg/L	0.200	0.200	0.200	1	08 Feb 2000	08 Feb 2000
Na (sol)	357	mg/L	324.000	3030.000	1562.909	22	27 May 1981	08 Feb 2000
O - DO (in situ)	1033	mg/L	4.600	13.400	9.095	19	20 Jul 1999	07 Nov 2000
O Do	63	mg/L	3.600	16.900	9.618	11	20 Jun 1997	25 Oct 2001
O Do %	62	%	91.000	91.000	91.000	1	17 Sep 1998	17 Sep 1998
P (tot pers)	280	mg/L	0.020	0.040	0.027	3	30 Aug 2001	25 Oct 2001
P (tot)	8	mg/L	0.008	1.547	0.087	77	20 Jun 1994	01 Aug 2001
615062								
P total soluble	1176	mg/L	0.016	0.016	0.016	1	15 Aug 1997	15 Aug 1997
PO_4-p (sol)	179	mg/L	0.001	0.181	0.016	42	20 Jun 1994	23 Jul 1998
S (tot)	158	mg/L	122.000	213.000	154.500	4	16 Jun 1995	11 Nov 1998
SO_4 (sol)	50	mg/L	240.000	240.000	240.000	1	08 Feb 2000	08 Feb 2000
SO_4 (tot)	541	mg/L	75.000	485.000	232.294	17	27 May 1981	30 Aug 1988
SiO_2 reactive (sol)	14	mg/L	2.000	13.000	8.676	21	27 May 1981	11 Nov 1998
SiO_2-Si (sol)	1397	mg/L	1.300	1.300	1.300	1	08 Feb 2000	08 Feb 2000
Static water level	1053	m	3.544	3.720	3.650	3	20 Jul 1999	09 Nov 1999
Suspended solids (EDI)	1154	mg/L	21.520	30.200	25.983	6	19 Jul 1977	25 Aug 1977
Suspended solids (gulp)	1156	mg/L	12.780	26.250	18.333	3	15 Jul 1977	02 Sep 1980
Suspended solids < 63μ (EDI)	1149	mg/L	2.200	350.500	94.000	6	19 May 1978	08 Aug 1979
Suspended solids < 63μ (ETR)	1150	mg/L	16.100	16.100	16.100	1	25 Jun 1980	25 Jun 1980
Suspended solids < 63μ (gulp)	1151	mg/L	0.210	348.480	15.172	424	24 Feb 1978	11 Mar 1992
Suspended solids < 63μ (pump)	1159	mg/L	3.120	504.510	21.657	215	28 May 1981	02 Nov 1982
Suspended solids > 63μ (EDI)	1160	mg/L	0.600	15.300	7.383	6	19 May 1978	08 Aug 1979
Suspended solids > 63μ (ETR)	1158	mg/L	1.100	1.100	1.100	1	25 Jun 1980	25 Jun 1980
Suspended solids > 63μ (gulp)	1152	mg/L	0.010	10.830	3.263	8	30 May 1978	15 Aug 1978
TDSalts (sum of ions)	1218	mg/L	1152.000	10451.000	4846.412	17	27 May 1981	30 Aug 1988
TSS	16	mg/L	1.000	51.000	11.679	24	17 Aug 1999	25 Oct 2001
Transaction number	1241	(none)	83042.000	1999047.000	1525431.208	53	24 Jul 1973	15 Oct 1998
Turbidity	64	NTU	0.100	500.000	10.349	908	20 Jun 1977	23 May 2000
Water level (SLE)	1275	m	9.020	11.328	10.144	1356	20 Jun 1977	25 Oct 2001
615062								
Water level status	1316	(none)	0.000	0.000	0.000	1	14 Jul 1977	06 Jul 2001
Water temperature (in situ)	59	deg C	0.000	32.000	16.442	1540	24 Jul 1973	25 Oct 2001
Water temperature (test)	1166	deg C	14.200	26.700	24.291	1730	24 Jul 1973	08 Feb 2000
pH	22	(none)	6.300	9.700	7.880	530	20 Jun 1977	25 Oct 2001
pH (in situ)	1168	(none)	6.900	9.200	8.132	25	17 Aug 1998	07 Nov 2000

Appendix five
Changes in bed sediment in the Avon River between Northam and Toodyay



Map 4: Changes in bed sediment in the Avon River between Northam and Toodyay

Publication feedback form

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

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

Publication title: AVON WATERWAYS COMMITTEE, RIVER RECOVERY PLAN, SECTIONS 4 AND 5 – NORTHAM TO TOODYAY

How did you rate the quality of information?	1	2	3	4	5
How did you rate the design and presentation of this publication?	1	2	3	4	5

How can it be improved?

....

....

....

....

How effective did you find the tables and figures in communicating the data?	1	2	3	4	5

How can they be improved?

....

....

....

How did you rate this publication overall?	1	2	3	4	5

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

....

Please cut along the dotted line on the left and return your completed response to:

Publications Coordinator
Water and Rivers Commission
Level 2, Hyatt Centre
3 Plain Street
East Perth WA 6004
Facsimile: (08) 9278 0639