AVON WATERWAYS COMMITTEE
RIVER RECOVERY PLAN
Sections 7, 8 and 9 – Mile Pool to Spencers Brook

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 9
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Acknowledgments

The Recovery Plan for Sections 7, 8 and 9 of the Avon River between Mile Pool near York and Spencers Brook has been prepared through local consultative processes with contributions from many individuals, families, groups and organisations. Those who made contributions through the meetings were David and Chris Boyle, Margie Barrett-Lennard, Rob Barton, Tony Clack (York River Conservation Society), Alan Cole and Wayne Clarke (Avon Waterways Committee), John Janes and John Dymond (Muresk Institute of Agriculture), Phyllis Graham (WRC), Walter Johnston, Bert Llewellyn (Northam Shire Council), Cicely Howell (York River Conservation Society), Bernard Kelly (WRC), Liz Manning (Landcare Co-ordinator, York), Eric Metcalf, Angela Plichota, Mike Scott (Shire of York), Tony Tanner and Brian Whittington (Avon Catchment Council).

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Avon Waterways Committee

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Cover Photograph:
Jetty stumps by Jangaling Pool at Muresk
Photograph courtesy of Viv Read

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Dedication to Dr Luke Pen

Dr Luke Pen *photo courtesy WA Newspapers*

This Recovery Plan is dedicated to the late Dr Luke Pen in appreciation of his devotion to river management in Western Australia.

Luke was well known to many who live along the Avon River. He is remembered well for his enthusiastic and informative presentations about river ecology on many occasions. His knowledge of river processes has been of benefit to us all.

Luke's passion for the Avon River commenced as a young student during frequent school holiday visits to the farm of the Norbertine Monks at 'Kerry Downs'. His major early work focus was on the Kalgan River along the South Coast, but Luke would often return to the Avon to assist with a range of projects.

While still a young man, Luke suffered from illness which he valiantly fought but eventually lost. His significant contribution to our understanding of the Avon River is appreciated.

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Preface

The Avon River between York and Spencers Brook is distinctive in many ways. It is gently meandering and set within the rolling hills of the Avon Valley that many know well. Increasing numbers of people gain a birds-eye view as they skydive to a base by the river. Many others drive the two scenic routes either side of the river.

Importantly, many of our leading agriculturalists are trained at Muresk Institute of Agriculture, which is located adjacent to the river. This is a good opportunity to build the link of agricultural practices within the catchment to the health of the river.

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

While all pools on the Avon have been affected by sediments and salinity, Wilberforce Pool is one that has suffered least. Tipperary Pool and Mackies Pool continue to appear attractive although they are now significantly filled with sediment.

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

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 have now been 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 sections between towns are also complete or well advanced in preparation.

The Recovery Plan for Sections 7, 8 and 9 covers an important part of the river between Spencers Brook and the town of York. These sections include 8 river pools and the confluence of the 37 tributaries.

The purpose of the Recovery Plan for Sections 7, 8 and 9 is to provide a guide for management actions by those who live by the river or have a strong interest in river management. Landholders along the river, interested community members, AWC members and Water and Rivers Commission representatives have met to prepare the plan. The AWC is keen to encourage this partnership approach to continue beyond the plan in order to ensure good local river management.

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

Alan Cole
Chairman, Avon Waterways Committee

Map 1: River Recovery Plan Sections

1 Introduction

1.1 Recovering the Avon River

The Avon River Management Programme outlines a strategic approach for recovery of the river from its current poor health. One key strategy is to segment the main channel of the Avon River into 18 sections for management (Map 1. River recovery sections are described in Appendix one). This Recovery Plan is for approximately 29 km of the Avon River in Sections 7, 8 and 9 that occurs from the Spencers Brook bridge, 10 km upstream of the town of Northam to the Mile Pool located downstream from the town of York 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 191 km 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 7, 8 and 9 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 receive low rainfall and have 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 is 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 and flows through Brookton and joins the main river channel downstream of the Yenyening Lakes (Map 1).

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
- Bland's Brook
- Spencer's Brook
- The Mortlock River (North, South and East branches)
- Wongamine Brook
- Harper's Brook
- Boyagerring Brook
- Toodyay/Yulgan Brook
- Jimperding Brook
- Julimar Brook
- Red Swamp Brook
- Brockman River
- Wooroloo Brook

1.2.2 River flow

The winter Avon usually commences to flow in April after the onset of winter rains and with falling temperatures and evaporation. In most years flow diminishes or ceases before Christmas. At 'Broun's Farm' gauging station (between Beverley and York downstream from the Dale River confluence) the river has significant flow on average for

286 days or 78% of the year. At Walyunga, where the Avon becomes the Swan River, the average flow is 310 days or 85% of the year. In a dry year, the river above 'Broun's Farm' contributes only 12% of total river flow; in a wet year this can rise to over 40%.

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

1.2.3 Floods and flood management

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

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

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

The scheme was implemented during the 1960s in these sections of the river.

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

1.2.4 The inland catchments

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

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

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 from the lakes is generally less than 10% although the contribution to salt load is high.

1.2.5 The river pools

The Avon River between the Avon Valley National Park and the Yenyening Lakes had 26 major pools recorded that were about 70 metres wide and varied in length from 370 metres to 2 kilometres. Some were over 10 metres deep. Many other smaller pools are remembered locally but are not well recorded.

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

The following pools are now totally filled:

One Mile Pool, Egoline Pool, Jangaling (Muresk) Pool, Deepdale Pool, Cold Harbour Pool, Mt. Hardy Pool and Burlong Pool

The following pools are almost filled:

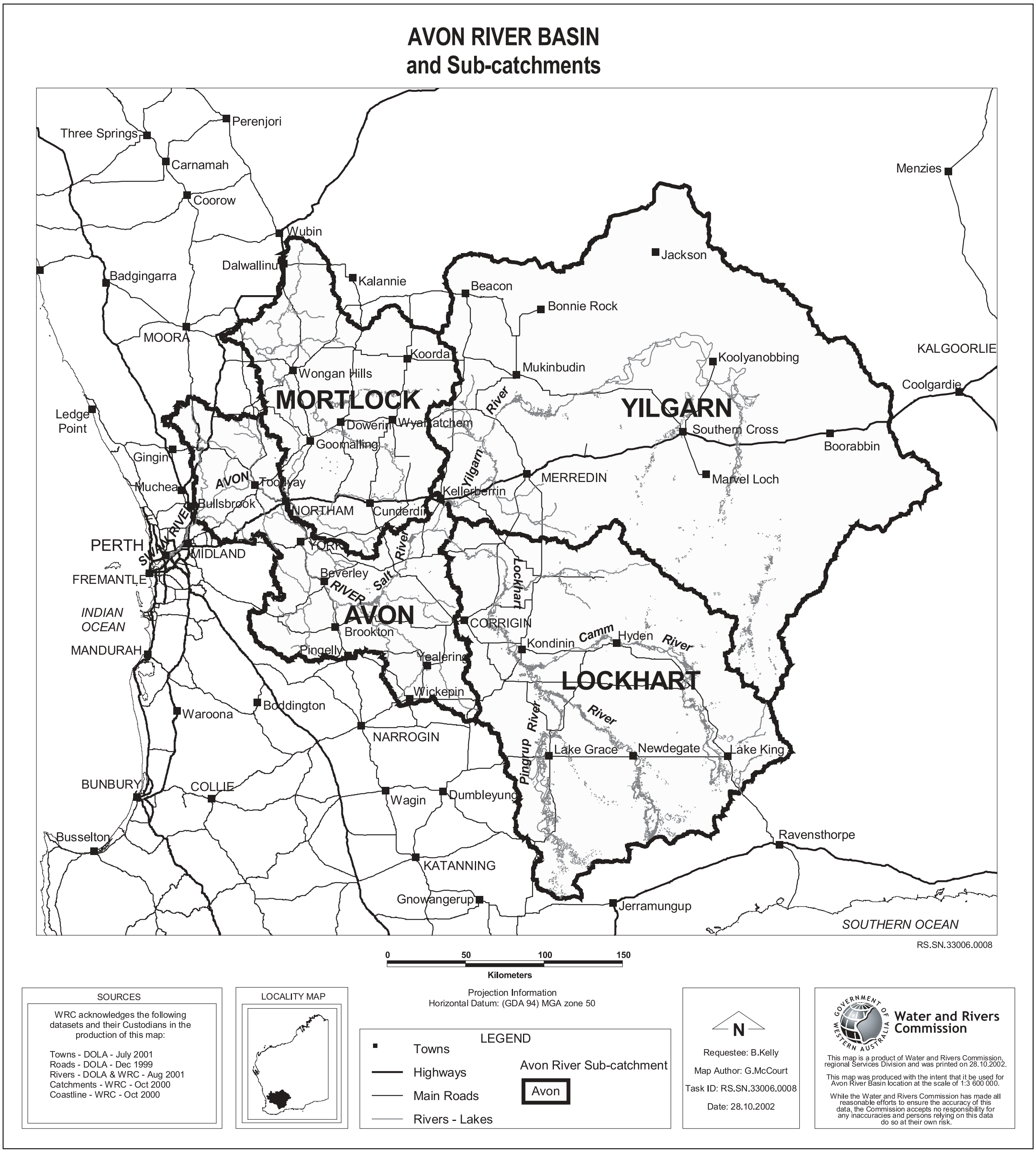
Speldhurst Pool, Tipperary Pool, Yangedine Pool, Katrine Pool, Oakover Pool and Jumperding Pool

1.2.6 Biological Diversity

A very high proportion of the Avon River Basin has been cleared of natural vegetation for agriculture. The original ecosystems are now represented by 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 evolved and adapted to changes in environmental conditions over millenia. In recent times, the ecosystems have become modified due to landuse pressures. Some of the threats to the river include increasing salinity, sediments and nutrient enrichment.



Map 2: Avon River Basin catchment

2 Description of river sections 7, 8 and 9

2.1 Physical description

2.1.1 Adjacent Landscape

The Avon River drains through a valley ranging 3-22 km in width in a well-dissected landscape described as the Zone of Rejuvenated Drainage (Lantzke and Fulton, 1992). The elevation of the valley is from 150-170 m up to approximately 300 m Australian Height Datum (AHD). Table 1 shows a range of elevation peaks that delineate the tributaries to the river.

Table 1: Elevation of conspicuous peaks between York and Spencers Brook

South-west of the Avon River	**Height** (m AHD)
Mt Bakewell (in the Dyott Range)	457
Mt Mackie	294
Doris Hill	386
Taylors Hill	380
Boonaring Hill	317
Granite Hill	276
North-east of the Avon River	**Height** (m AHD)
Mt Brown	310
Red knob	254
Ragged Rock Hill	259
Mt Mary	271

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 River with red loamy, grey clayey and orange sandy soils. Slopes are generally less than 1%.

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

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

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

The Avon landscape unit effectively defines the river floodplain – it is formed primarily by river (alluvial) processes. The soils are from former river channels or were deposited by floods. This unit is almost continuous on both sides of the river from York to the Spencers Brook Bridge and extends out from the river by up to two kilometres. Other landscape units adjacent to the river are generally steep with shallow soils and some 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 although flood backwaters can inundate a larger area, particularly the broad valley floors of tributaries.

The Steep Rocky Hills unit is significant in determining the morphology of the river. The river is confined by rocky slopes either side where this landscape unit frequently occurs. The most significant influence of geology on the river in these sections is the major redirection of the channel east from a north-west orientation caused by the Dyott Range (including Mt Bakewell) near York.

2.1.2 River Channel

The river flows from the broad sweeping bend around Mt Bakewell towards the north-west and flows without major meanders for a length of 14 km. From Mackie Pool, the river trends 4.5 km west to Wilberforce Pool with one bend. It is then orientated north-west for 7.5 km to Spencers Brook Bridge, again without major meanders. The channel length from Mile Pool to Spencers Brook 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 streamflow. 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.

Photo 1: Aerial view of the Avon River upstream from Muresk *Photo courtesy Muresk Institute of Agriculture*

Photo 2: Characteristics of the pre-training braided river channel *Photo courtesy of Ecoscape*

Photo 3: The scoured river channel after the training scheme *Photo courtesy of Ecoscape*

The riverbed 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.

Local observations suggest that significant flooding has not occurred since 1955 due to the River Training Scheme, although there have not been major floods during this period.

Within the bed of the river, the location of the base flow stream changes 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 convex banks and straight river reaches. Where sediment deposition is extensive and being stabilised by natural vegetative regeneration, early stages of a new braided channel formation are developing.

The river bed gradient is approximately 0.8 metres/km (0.08%) from Spencers Brook bridge to the Muresk Swinging Bridge (detailed elevation data is available for this section). This is the same as the general gradient from Beverley to Toodyay.

There are no weirs that affect riverbed gradient in these sections.

2.1.3 Streamflow

A stream gauging station ('Brouns Farm' Ref. 615014) is located on the Avon River 2.16 km downstream from the Dale River confluence for which records date back to November 1975. The station and records are maintained by the Water and Rivers Commission.

Total annual streamflow at 'Brouns Farm' ranges from 13.7 million cubic metres in 1979 to 413.8 million cubic metres in 1983. The average flow volume is 61 million cubic metres. The monthly flow of 126.4 million cubic metres for January 2000 was one of the highest recorded for this station (higher flows recorded in July of 1983 and 1996).

There is also a gauging station at Northam for which the total annual streamflow ranges from 21.86 million cubic metres in 1980 to 511.7 million cubic metres in 1983. The average flow volume is approximately 160 million cubic metres.

Photo 4: Stabilised island formed from sediments adjacent to recent scouring of the river bank

Photo courtesy Viv Read, August 2002

The monthly flows of 110.8 million cubic metres for January 2000 and 106.1 million cubic metres for February 2000 are the highest for summer. They are also 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).

The average annual flow volume at Walyunga is 360 million cubic metres. The Avon at Brouns Farms contributes 17% of total flow and Northam (which does not include the Mortlock River) contributes 44% of total flow.

Mean monthly flow rates shown in Appendix Four (p 46) indicate the periods of high flow but it is the maximum flow rates shown in Appendix Four (p 47) 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).

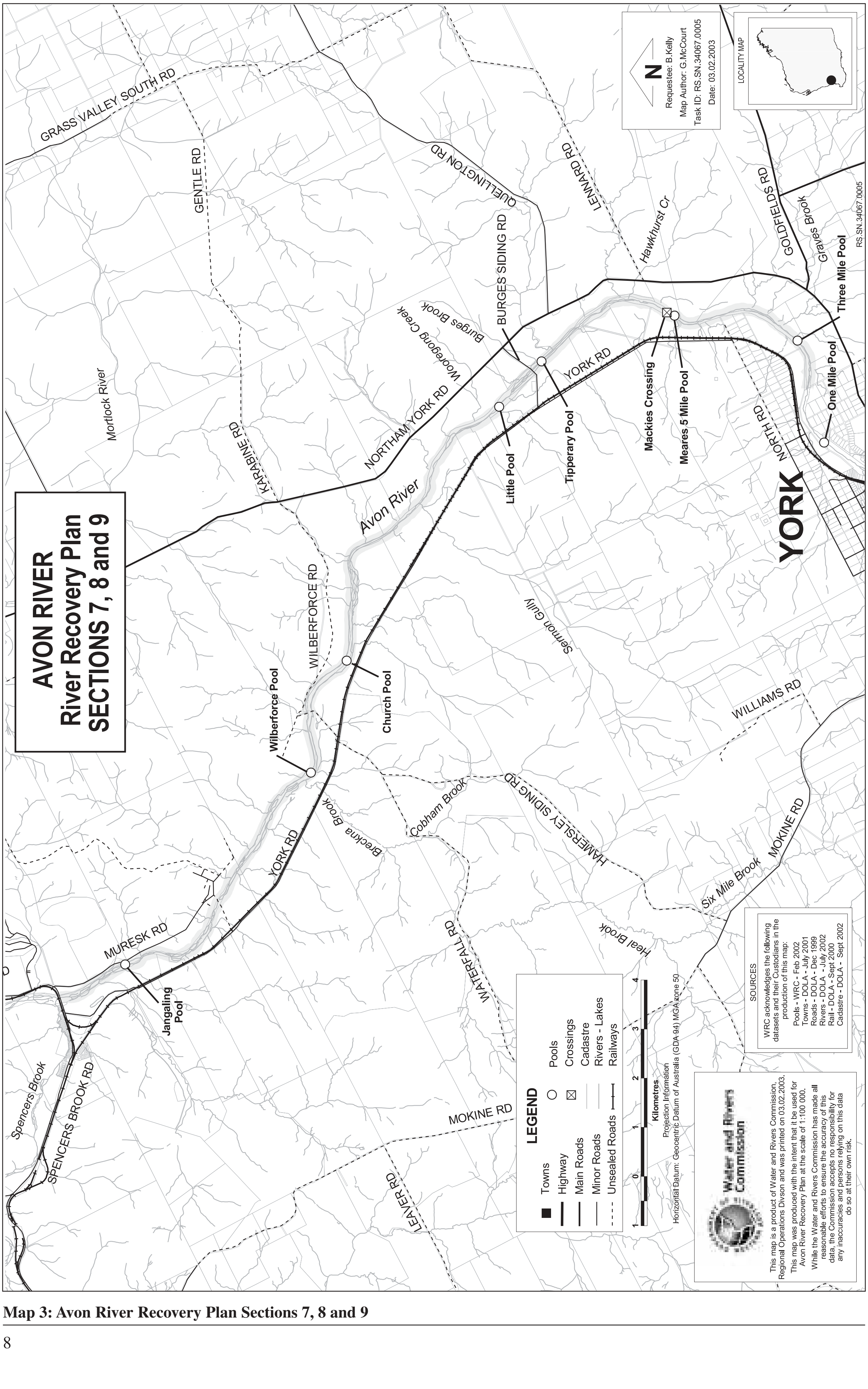
2.1.4 Riparian vegetation

The natural river vegetation in Sections 7, 8 and 9 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 altering. The Avon River Survey (Ecoscape, 1996) shows low regeneration for *E. rudis, M. rhaphiophylla* and low to medium regeneration for *C. obesa*. Weeds that dominate the understorey may be retarding 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. It may also cause salinity to increase altering conditions in favour of *C. obesa.*

2.1.5 Pools

There were 9 significant pools within these sections of the Avon River shown on Map 3. They are **Jangaling (also known as Muresk) Pool, Wilberforce Pool**, **Church (also known as Mackie, Chapel or Sermon) Pool**, **Little Pool, Hamersley Pool, Tipperary Pool, Meares 5-Mile Pool, Three-mile Pool and Mile Pool.** The physical dimensions for six of these pools are shown in Table 2 (note that there is no survey information for Little Pool or Three-mile Pool).



Map 3: Avon River Recovery Plan Sections 7, 8 and 9

Table 2: Characteristics of the major River Pools within Sections 7, 8 and 9

	Jangaling	Wilberforce	Church	Tipperary	Meares	Mile Pool
1960 length (m)	695	998	1235	1180	380	591
1985 length (m)	390	930	1265	1250	390	390
1992 length (m)	Dry	900	1220	1300	400	330
1996 length (m)	Dry	820	750	340	350	Dry
1960 depth (m)	No data	6.49	No data	No data	No data	No data
1974 depth (m)	No data	6.00	No data	No data	No data	No data
1978 depth (m)	No data	No data	No data	2.35	No data	2.67
1996 depth (m)	No data	4.35	2.4	1.32	1.25	No data
1996 Filled Volume (m^3)	68 000	4 000	98 000	148 000	28 000	58 000
1996 Unfilled Volume (m^3)	0	164 000	69 000	27 000	12 000	0
1996 Salinity (mg/L)		12 100	16 500	25 520	21 442	
1996 Phosphorus – sediments (mg/g)		0.262	0.246	0.350	0.076	
1996 Phosphorus – water (mg/L)		0.056	0.135	1.176	0.133	

Information source: JDA (1997)

Little Pool is estimated to have been 1 km in length (Ashley Morgan, *pers. comm.*). Combined with the six recorded pools, the total pool length was 20.7% of the river for these sections of the Avon in 1960. The 1996 survey shows that pool length was reduced to 7.8% of river length. Jangaling Pool and Little Pool have completely filled with sediment. Church and Tipperary pools have reduced considerably in length while Wilberforce and Meares pools have maintained their length. All pools have become considerably shallower. Only Wilberforce Pool has maintained depth (maximum depth was 4.35 metres in 1996) although this is approximately 2 metres shallower than during 1960. Wilberforce Pool has an unfilled volume of 164 000 m^3, which is a ratio of 41:1 to filled volume. It is the highest unfilled volume ratio of all Avon River pools. (Glen Avon Pool has an unfilled pool volume ration of 10:1).

Jim Masters and Bill Hamersley kept bird records of Hamersley Pool in the early 1980s.

Jangaling Pool: this pool was popular for swimming by many, including students at Muresk, until the early 1970s. Sections of a jetty remain by the pool (cover photo). Table 2 shows that the pool filled quickly following bulldozing for the River Training Scheme and was completely filled by the 1992 survey.

Wilberforce Pool: remains as a long pool with depth mostly greater than three metres. The bed of the pool is mostly clay. Sedimentation of this pool has been minimal because of Church Pool, about three kilometres upstream, detaining mobilised coarse sediments. Tributaries to the river between these pools are relatively small. The unfilled volume was measured as more than 97% of total pool volume during the 1996 pool survey.

The dominant fringing vegetation of Wilberforce Pool remains but is of minimal width, is without understorey, and regeneration is low due primarily to uncontrolled access by sheep and cattle. Photo 5 shows the size of a former Flooded Gum (*E. rudis*) that did regenerate following logging. Some of the mature sheoak (*C. obesa*) have degenerated due to mistletoe infestations. Mistletoe, though an indigenous parasite, is an indicator of poor ecosystem health when it extensively affects a vegetation community.

Church Pool: this pool is referred to as Mackies Pool in surveys and reports but is known locally as Church Pool due to a church previously located on the bank. This pool has filled with a 400-metre coarse sand slug and is now generally quite shallow. Only 41% of total pool volume is without sediment as measured during the 1996 pool survey.

One tributary (approximately 700 ha catchment area) discharges directly to Church Pool. The gradient of this tributary is relatively high (an average of 2.4%). It is actively eroding and contributing to the sediment load of the pool.

Photo 5: Mature Flooded Gum regeneration near Wilberforce Pool *Photo courtesy Viv Read*

Fringing vegetation is of minimal width and has limited understorey.

Little Pool: the location of this pool is 1.5 km downstream from the Burges Siding bridge, although it is not well known. It was approximately 1 km in length but was filled with sediment by 1976. Prior to this, it had "…*unbelievable numbers of birds with hundreds and hundreds of nests*." (Ashley Morgan, *pers. comm.*).

Tipperary Pool: this formerly substantial pool is now filled with over 148 000 m^3 of sediment. Only 15% of total pool volume was unfilled with sediment as measured during the 1996 pool survey. A significant tributary with a catchment area of approximately 1800 ha discharges directly to the pool. This tributary has an average gradient of 1.56% and has been actively eroding. Considerable sections of the tributary channel are stabilised by the invasive weed Spiny Rush (*Juncus acutus*).

Fringing vegetation is of minimal width although it has been enhanced by the 30 m wide revegetation of agricultural land along the western bank. This was carried out by the River Conservation Society in the early 1990s.

Meares Pool: although the length of this pool has not decreased significantly, it is quite shallow. The 1996 pool survey showed there to be only 12 000 m^3 of unfilled volume. Most sediment has cumulated on the eastern bank.

Fringing vegetation is of minimal width and has low regeneration on both banks of the pool.

Water quality monitoring at the pool during 1995 and 1998 showed high levels of total nitrogen and total phosphorus. Algal blooms were recorded (Unpub. WRC data). The pH of pool water was quite alkaline (pH of 9.0-10.0).

Cobbler was last caught in the pool in 1966. The pool was affected by the River Training Scheme as from 1968 (D. Boyle *pers. comm.*).

Meares Pool is attractive and suitable for public access from Mackies Crossing, located at the downstream end.

Three-mile Pool: there is little recorded information available about this pool. It is located on an anabranch to the Avon River and has not been significantly affected by the River Training Scheme (David Boyle, *pers. comm.*). Previous surveys have assumed it to be filled with sediment because it was not found on the main channel.

Photo 6: The east bank of Meares Pool without fringing vegetation *Photo courtesy Viv Read*

Photo 7: Mackies Crossing located downstream from Meares Pool *Photo courtesy Viv Read*

Photo 8: Waterfall on Breckna Brook *Photo courtesy Viv Read*

Photo 9: Active erosion of the Breckna Brook channel on the river floodplain ***Photo courtesy Viv Read***

Table 3: Avon River frontage for properties within Sections 7, 8 and 9

Owners/Managers	Property name	LGA	Location numbers	South-west bank (km)	North-east bank (km)
Bill Linke	*Little Parenti*	N	4	2.41	
Bill and Irene Barton		N	8		1.11
Curtin University of Technology	*Muresk*	N	28376. 28377	2.96	3.36
Wilberforce Pastoral Company Pty Ltd (Walter Johnston)	*Wilberforce*	Y	4, 149	8.37	8.20
Rory and Linda Curtin	*Kerry Downs*	Y	5 (1355)	2.69	
Portsmouth Pty Ltd (Vic Parrin/John Smart)	*Avon Valley Farm*	Y	4,0 (Pt 4)		4.13
Ashley Morgan		Y	1, Y1	0.35	
Warralong Nominees Pty Ltd		Y	2	0.45	
G and T Burgess		Y	660		0.61
Eric Metcalf	*Hay Plant*	Y	664	1.25	
Mick and Cheryl Deboni	*Pretty Twisted*	Y	15 (1621)		
M and P Emmett	*Tipperary*	Y	10		0.61
Tony Tanner		Y	Lt 7 (1620)	1.04	
Humphrey's Holdings Pty Ltd		Y	665		2.51
(Dennis Humphreys)					
Lynton Foster	*Brooklands*	Y	10	0.36	
Whitby Holdings Pty Ltd (John Seaman)	*Skydive Express*	Y	9	0.71	
John and Margie Barrett-Lennard	*Mobedine*	Y	1		0.66
David and Chris Boyle	*Hawkhurst*	Y	4, 11, 0, 3, 8, 1	3.44	2.68
Silvia and Angus Davidson		Y	148	0.22	
Lou and Enid Kosta		Y	Y27	0.43	
Shire of York	*M'cycle track*	Y	R121	0.58	
Shire of York	*Waste transfer station*	Y	R121	2.30	
Shire of York	*Airfield*	Y	R13323	1.40	
Shire of York	*Rec/Drainage*	Y	R45885		0.73
Shire of York	*Rec/Drainage*	Y	R45886		0.69

Note: (1) N = Northam Shire, Y = York Shire

Mile Pool: surveys show that this small pool has reduced in length, although it remains with significant depth and is locally popular for picnics (Tony Clack *pers. comm.*).

2.1.6 Tributaries

The Avon River between York and Spencers Brook is distinctive due to the high density of tributaries on both sides. Although only 29 km in length, there are fifteen tributaries on the south-western side and twenty-two on the north-eastern side.

The largest tributary on the south-western side is Heal Brook with a total catchment area of approximately 12 000 ha. It is a composite of Six-mile Brook, Boyercutty Brook, Breckna Brook, Waterfall Brook and Cobham Brook. The confluence with the Avon River is immediately downstream of Wilberforce Pool. The channel of this tributary is actively eroding through the floodplain of Avon River. Relatively high sediment transport in this tributary is evident from casual observations at the significant waterfall approximately 4 km upstream from the river confluence.

Sermon Gully, with a catchment area of approximately 2 700 ha, is also larger than most other tributaries on the south-western side of the river. Although this tributary has an average waterway gradient of approximately 1.5%, it contributes only minimal sediment to the Avon River due largely to it being relatively stable through the floodplain and because it discharges gradually through the floodplain, not directly into the river channel.

Most other tributaries on the south-western side are less than 500 ha in catchment area.

Tributaries on the north-eastern side of the river are small (100-500 ha) – only two exceed 1000 ha in catchment area. This is caused by the watershed for the Mortlock River being approximately 3 km from the channel of the Avon River on this side of the river.

The landscape relief for catchments on the north-eastern side is generally about 50 metres less than on the south-western side.

2.1.7 Land Use, infrastructure and community interest

Land use adjacent to the Avon River in this section is mostly agriculture although the number of diversified uses of land is increasing. Table 3 lists landholders with river frontage.

The range of land uses other than agriculture is listed below.

Shire of Northam

Equestrian
Agricultural education (Muresk)

Shire of York

Wrought iron fabrication
Hay processing
Skydiving
Land subdivision for rural-residential use
Waste transfer station (near former waste disposal site)
Trail bike circuit
Community and private air strips
River walk and other contemplative recreation.

Management of the river also has local and broader community interest. The River Conservation Society based in York has been established for over 12 years with a keen interest in the river. There are also Land Conservation District Committees for the Shires of Northam and York.

3 River channel survey results

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

3.1 Channel stability and sediments

The river survey shows that 96% of the banks of the channel in Section 9 are stable, 65% in Section 8, but only 47% in Section 7. Figure 1 shows how these compare with all river sections. All sections had similar bed stability and were generally more stable than other sections of the river (Figure 2).

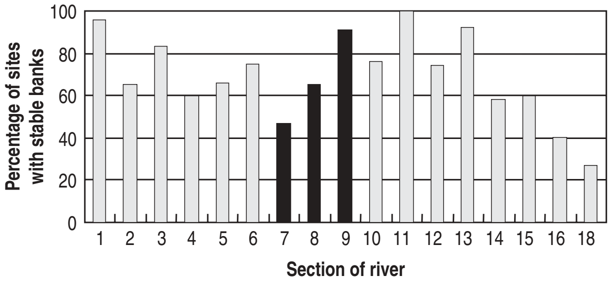


Figure 1: Bank stability along the Avon River
(from Black, 1997a)

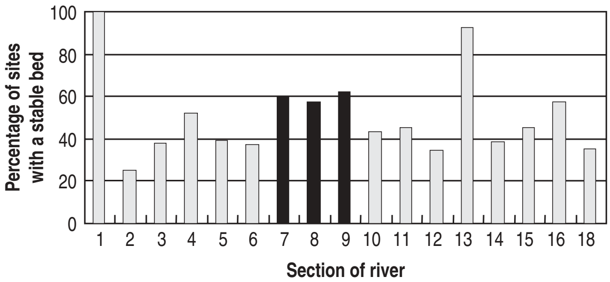


Figure 2: Bed stability along the Avon River
(from Black, 1997a)

The occurrence of bed sediments ('slugs') in the river was generally low although there were more in Section 7 (Figure 3). Each of the three sections had scour channels at approximately 20% of the sites. (Figure 4).

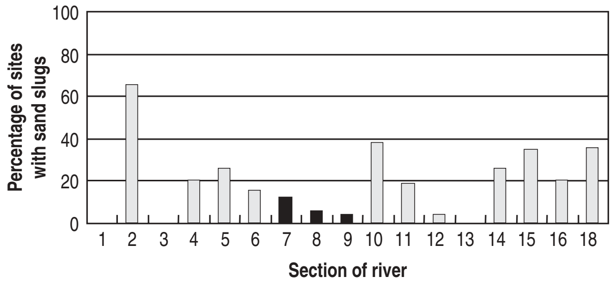


Figure 3: Sediment 'slugs' along the Avon River
(from Black, 1997a)

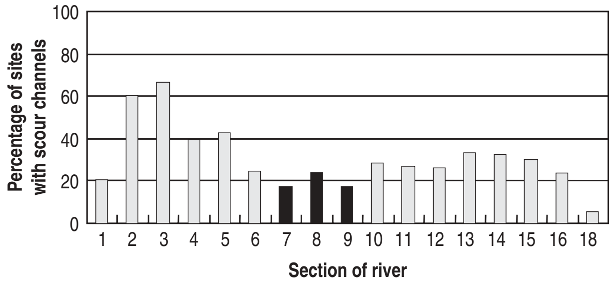


Figure 4: Scour channels along the Avon River
(from Black, 1997a)

3.2 Vegetation Condition

The survey showed the generally low to medium regeneration for *Eucalyptus rudis* (Flooded Gum) and *Melaleuca raphiophylla* (Paperbark) particularly for Sections 7 and 8. Regeneration of *Casuarina obesa* (Sheoak) was medium to high at many sites. Figure 5 (a, b and c) shows the observed regeneration of the dominant riparian vegetation at for the three sections.

3.3 Disturbance

The survey recorded stock in the river in 82%, 72% and 70% of sites for Section 7, 8 and 9 respectively. This is generally higher than for most sections of the river.

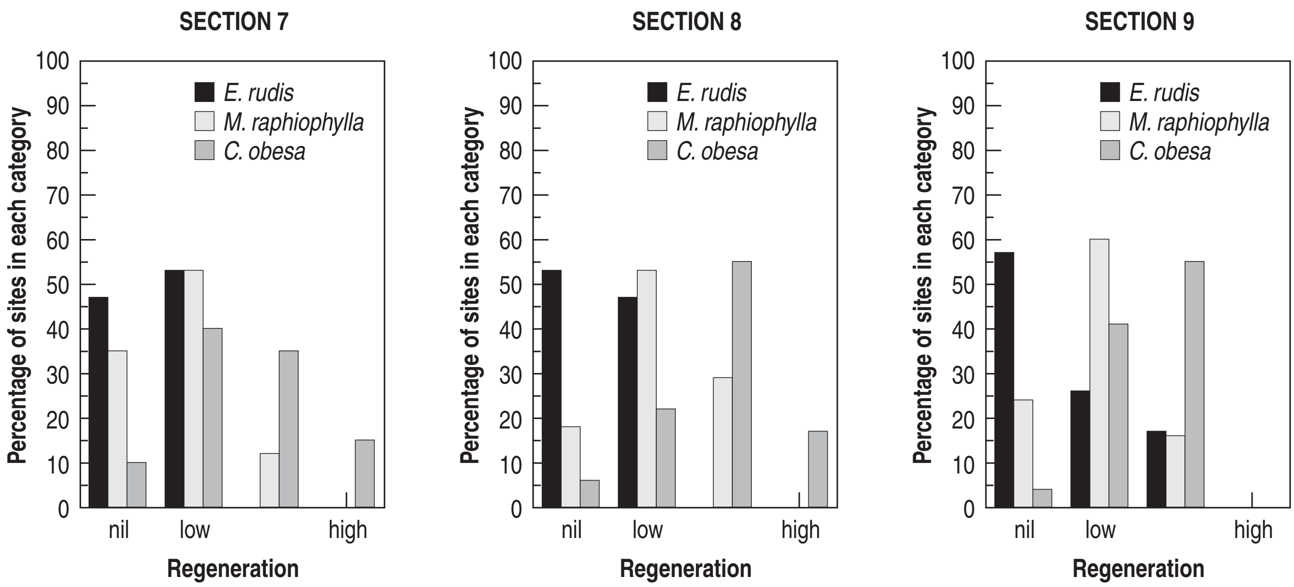


Figure 5 (a, b and c) Regeneration of dominant riparian vegetation in Sections 7, 8 and 9 (from Black, 1997)

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 meetings with landholders and members of community groups, 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. Interested landowners, community members and WRC staff provided direction for this process.

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

The Recovery Plan consists of:

- a local Vision for 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.

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, a vision for local management for the Mile Pool to Spencers Brook Recovery Team is:

"The Avon River from 'Mile Pool' near York to Spencers Brook is recognised as being cared for by those who live alongside and others in the community. All existing river pools are maintained as healthy ecosystems that attract wildlife. The river vista of Meares Pool from Mackies Crossing and of Tipperary Pool from Burges Siding Bridge remains attractive. Meares Pool is managed with priority to maintain permanent water. Mile Pool is enhanced and attractive for public use.

Black Swans continue to use the pools as migratory 'stop-overs'. The vegetation along the river remains healthy and supports diverse birdlife.

People who enjoy the river have good access for walks, picnics and canoeing especially between York and Mackies Crossing. A self-guided walk trail and a bridle track are developed at Muresk. Destructive use of the riverbed has stopped. Public risk is minimal and private property is respected.

The river is fenced to control stock access. Occasional grazing by sheep to reduce fire risk occurs when the potential to damage natural vegetation is least. Priority weeds are controlled. Unwanted animals, especially foxes, rabbits and long-billed corellas are controlled by co-ordinated community effort.

Tributaries to the river are well managed by active catchment groups. Sediment and nutrient discharge to the river is minimal. Best practice for tributary management is well demonstrated."

4.2 Local management objectives

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

- To retain the natural attributes and river characteristics where-ever possible.
- To understand the processes that have caused the river and its pools to deteriorate.
- To reduce the risk of further river degradation.
- To arrange consistent management of the river between current landholders and land managers, and for future owners or managers.
- To communicate good river management to others.

5 Management actions

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

The 20 key management issues that were identified are shown in Table 4. People who attended meetings 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 7 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 fencing the river is a high priority.

Table 4: Recovery Team priorities for Key Management Issues

Issue (in priority order)	Average score	Highest score	Lowest score
1. Fencing the river to control grazing	**8.7**	10	6
2. Catchment management	**8.6**	10	7
3. Fire	**8.5**	10	5
4. Sediments	**8.0**	10	6
5. River pools	**6.7**	10	1
6. Birds and aquatic life	**6.5**	9	4
7. Planning	**6.4**	8	5
8. River vegetation	**6.2**	9	2
9. Unwanted animals and weeds	**6.2**	8	5
10. Monitoring	**6.2**	7	5
11. Recovery Team role	**5.8**	8	1
12. Potential pollution	**5.3**	8	3
13. Recreation	**5.2**	8	3
14. Floods and the floodplain	**5.2**	7	4
15. River crossings	**5.0**	7	2
16. Cultural and heritage values	**5.0**	7	3
17. Identifying river characteristics and landscape values	**4.8**	6	2
18. Education and information	**4.4**	7	1
19. Water impoundment	**3.8**	5	1
20. Public access	**3.4**	7	0

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

5.1 River fencing and vegetation management

Natural vegetation adjacent to the river varies considerably in health and regeneration. Several locations have riparian vegetation in excellent condition and are remnant examples of a former healthy river ecosystem (e.g. upstream of the Swinging Bridge at Muresk and the west bank of Mackie Pool). In other areas, the vegetation is regenerating towards a healthy ecosystem (e.g. at the confluence of Sermon Brook with the river) demonstrating the capacity of the river to recover. Other locations have regeneration dominated by Sheoak (*Casuarina obesa*) indicating changed environmental conditions.

Major features of the current river vegetation are that Flooded Gums (*Eucalyptus rudis*) are in decline and there is a limited range of understorey species.

Significant factors that are causing riparian vegetation to change are:

- **Changed groundwater conditions:** Since the River training Scheme, the floodplain is inundated less frequently. The river channel has eroded to a depth of 1-1.5m and now acts as a regional drain to shallow groundwater aquifers. This is a possible cause of mature Flooded Gums becoming degenerate.
- **Increasing soil salinity:** Occasional inundation of the floodplain with quite saline water increases soil salinity. There is also evidence of saline groundwater discharging in the riverbed and banks. Sheoak are more salt-tolerant than other dominant species.
- **Livestock grazing:** Uncontrolled access by livestock to the river limits the capacity for vegetation to regenerate. The diversity of understorey species is particularly limited. Differences between grazed and un-grazed sections of the river are distinct. Cattle, goat and horses are generally more destructive than sheep. They are also more likely to add to bank erosion.
- **Weeds:** Significant infestations of annual weeds, especially Wild Oats and Soursob, suppress natural regeneration.

Photo 10: A mature stand of fringing vegetation with balanced regeneration *Photo courtesy Viv Read*

Photo 11: Fringing vegetation dominated by Sheoak (*Casuarina obesa*) *Photo courtesy Viv Read*

- **Fire:** Uncontrolled hot fires kill mature trees and provide conditions suitable for rapid regeneration of weeds (especially Wild Oats) and single dominant species.
- **Parasites and pathogens:** An unhealthy ecosystem is vulnerable to infestation by a range of potentially destructive organisms. One example is of mature Sheoak being heavily infested by Mistletoe. This parasite can occur in high concentrations in some areas due to loss of midslope vegetation.

Of those factors that determine change to the river vegetation, management of grazing, fire and weeds is effective. In some situations, tributaries can be diverted to discharge to the floodplain to recharge shallow aquifers. The ability to manage other factors locally is limited.

5.1.1 Fencing to control grazing

Fencing the river to control stock access is the most effective management tool.

The river should be fenced both sides without permanent transverse fencing within the river channel. Convenient access for farm management, weed control and fire suppression is required.

The net benefit to river vegetation is highest in the long term if stock is permanently excluded. However, it is recognised that some grazing may be beneficial to reduce annual weeds. Local management experience to determine the balance between weed control and native vegetation regeneration is best. Where necessary, short periods of grazing during early seed-set of annual weeds is suggested.

Action 1.1: Arrange for the river to be permanently well fenced on both sides allowing reasonable access for farm management, weed control and fire suppression.

Action 1.2: Develop local 'Best Practice' for occasional grazing of river vegetation where it is required and arrange revision of this practice as better knowledge and information is acquired.

5.1.2 Managing fire risk

Tolerance of fire risk varies considerably between current landholders along the river. Opinions range from the river being a high-risk "fire tunnel" to it being only an occasional problem that can be managed. The perceptions of risk are generally based on the value of property that may be damaged and the time and resources required for fire suppression (fires in the river are difficult to access and may smoulder for weeks after the fire).

The Avon Waterways Committee promotes a Fire Policy, produced by the former Avon River Management Authority and available from Water and Rivers Commission, Northam. This policy recognises fire as a natural factor in the bush, but also that uncontrolled summer fires are a threat to human values. The policy states that fire should be kept out of the riverine ecosystem permanently but in areas identified with high human values, there should be management for fire risk reduction. The policy also includes practical guidelines that are relevant to the Mile Pool to Spencers Brook section of the Avon River. This policy suggests preparation of a Wildfire Threat Analysis to identify areas of human value at risk.

Fuel Load Reduction

The risks of fire in these sections of the river are relatively high due to fuel load. Dry annual grasses (especially wild oats) are volatile but the dry woody vegetation and leaves with high volatile oils are the major fuel load. Stand densities of up to 1000 stems/ha were reported from the Avon River Survey (Ecoscape and JDA, 1996). General fuel load reduction for the river is not a feasible option.

Measures to reduce annual weeds in the river adjacent to valued areas are considered acceptable. A fuel reduction zone on the bank of the river adjacent to the asset and 250 metres either side of it is suggested. A cool late-spring fuel reduction burn compliant with the Bush Fires Act is recommended. The frequency should be in accordance with annual fuel load. A control burn about one year in five is expected. Herbicides are difficult to apply in the riverine environment. Canopy closure will eventually suppress annual weeds in other areas. Natural thinning of native plants by competition will eventually occur. The controlled burns will remove the dry material that this process causes in the areas of risk. After a wildfire event immediate steps should be taken to direct seed with native species before wild oats takes over.

Action 1.3: Fuel Reduction Zones to be identified for those human-value assets at risk from uncontrolled fire. Cool fuel reduction burns can be undertaken in these areas at a frequency in accordance with annual fuel load.

Action 1.4: That the Recovery Team take advice from the Chief Fire Control Officers for the Shires of York and Northam for identification of fire risk areas and control burn practices.

Fire Risk Reduction

Factors causing some fires have reduced with improved farm machinery and railway rolling stock. A recent fire was caused by sparks from an electricity pole. The

Photo 12: Spiny Rush (*Juncus acutus*) established in Sermon Brook *Photo courtesy Viv Read*

increasing risk of uncontrolled fire ignition is from negligent campers, people on picnics, riverside party fires, stubble burning and other new land users uninformed about fire risk. Wilful arson is possible but would be uncommon. Lightning is a consistent risk.

The major requirement is to inform visitors and new land owners of the risks and consequences of fire, particularly for the period from October to April. Display or distribution of clear information about fire is required.

Action 1.5: Information about the risk of fire to be regularly disseminated to landholders adjacent to the river and surrounding district, particularly to more densely populated areas.

Action 1.6: Clear signage to outline fire risks and restrictions be erected and maintained at identified public assess, picnic or other high use areas (particularly at Muresk, Burges Siding bridge, Mackies and at Mile Pool).

Fire Suppression

Effective fire suppression in the river environment is difficult. Wildfire initiated in the river or transgressing from agricultural land can advance rapidly along the river, depending largely upon wind conditions. Fire leaving the river can be controlled by tenders providing there are gates between paddocks and properties. Access should be suitable for heavy vehicle crossing and be suitable for back-burning into the face of an on-coming fire.

These sections of the river have good public roads on both sides and there are three major crossings so there should not be a requirement for additional transverse river crossings for fire suppression purposes. There is also a good river crossing at the Muresk Swinging Bridge. A former crossing near Jangaling Pool (Logues Crossing) could be considered if addition access in this area is required.

Action 1.7: The Recovery Team to ensure that all fences parallel and transverse to the river have gates suitable for fire control access and that vehicle access along the river is clear and unhindered.

5.1.3 Controlling weeds in the river

In addition to annual weeds, there is a significant threat to the river environment by the rapid spread of Spiny Rush (*Juncus acutus*). This rush currently chokes smaller tributaries and is a contaminant to wool. Control is difficult but there has been some success with glyphosphate

Photo 13: Bridal Creeper in fringing vegetation near York *Photo courtesy Viv Read*

herbicides. Notes available from the Northam Office of the Water and Rivers Commission outline the options. (Landcare Notes PP 0004, Natural Resources and Environment, Victoria, 1998).

Although not recorded during the river survey, Bridal Creeper does occur at locations adjacent to the Springbett Airstrip and Mile Pool near York. This should be eradicated. The Northam office of Water and Rivers Commission should be consulted for effective eradication methods.

Action 1.8: Undertake trials for the control of Spiny Rush (*Juncus acutus*) in tributaries adjacent to the Avon River.

Action 1.9: Eradicate Bridal Creeper with methods trialed in the Avon River at Toodyay.

5.1.4 Increasing natural regeneration

Natural regeneration can be enhanced. There is potential for rapid regeneration following fire or soil disturbance (due to weed seed removal with the topsoil). Smoked water is also suggested. Trials for these options are suggested.

If nursery stock plants are to be used for revegetation, local provenances should be used. A local seed orchard is being developed on the river adjacent to the York Airstrip (Liz Manning *pers. comm.*). Natural regeneration should be favoured over revegetation in the river environment because of the difficulty of selecting suitable sites for tree planting considering the changing conditions. However, some sites are unlikely to naturally regenerate soon and seem well suited to direct seeding (e.g. on land recently fenced adjacent to the river on Avon Valley Farms.

Action 1.10: Arrange natural regeneration trials that include fire, smoked water and soil disturbance to enhance natural regeneration.

Action 1.11: Arrange a demonstration of direct seeding of agricultural land fenced into the river ecosystem.

5.1.5 Fallen trees and branches

Fallen trees, branches and other debris in the river environment, especially after floods or fire, are considered by some as a problem because of difficulty in mustering to retrieve stock from the river. It is also considered to be an increased fire risk and an impediment to streamflow.

A healthy ecosystem should have a detrital trophic level (organisms that live off dead or decaying plants and animals). Detritivores have an important role in decomposing organic ecosystem waste and cycling nutrients through the system. They are themselves a source of food to other trophic levels (e.g. termites being food to echidnas). While some logs and branches may cause

Photo 14: Fallen trees and debris in the river ecosystem *Photo courtesy Viv Read*

management problems, they are a component of healthy ecosystem recovery. Logs that divert streamflow in a way that is causing significant erosion or direct floodwaters to human assets may be realigned parallel to the stream banks, rather than removed altogether.

5.2 Tributary management

A preliminary landscape analysis reveals 37 tributaries to the Avon River between Mile Pool and Spencers Brook bridge. With the exception of one relatively large tributary (Heal Brook and its minor tributary, Breckna Brook, with a catchment area of approximately 12 000 ha), all are small. Only six others exceed 1000 ha, most are in the 200-450 ha catchment area range. This is significant because most tributaries are contained entirely on individual properties or perhaps with one neighbouring property. Their management is mostly an individual responsibility and does not require cooperative catchment action.

Some tributaries are quite steep (average gradient of 2.0% or more) and have potential to erode and transport sediment towards the river.

Not all tributaries have been assessed for their condition at their confluence with the river. The 1996 River Survey reported on seven of the tributaries. They vary considerably in characteristics that are important for river management. Some of these are:

- Active channel or gully-head erosion near the confluence with the river.
- Channel gradient.
- Mobile bed-load sediments originating from the catchment.
- Water quality, particularly salinity and suspended sediments (and the associated nutrient load).
- Point of discharge (to the floodplain or directly to the river).
- Weed dispersal (especially for Spiny Rush).
- Remnant riparian vegetation (important for filtering nutrients and sediments, controlling channel erosion and shading out some weeds. It may also be suitable for regional wildlife corridors).

These tributary characteristics should be systematically assessed.

Action 2.1: Prepare a detailed (GIS) map of tributaries to these sections of the Avon River.

Action 2.2: Arrange a systematic survey of the key characteristics that are significant to river management.

Photo 15: Active erosion of Breckna Brook at the confluence with the river *Photo courtesy Viv Read*

5.2.1 Tributary channel erosion

Some of the tributaries are eroding. The most active erosion is in the lower reaches of Breckna Brook. The catchment area for this tributary is large and there are many smaller tributaries within the catchment. Soils are generally shallow above bedrock so run-off rates are high. This tributary carries a relatively high sediment load. As the waterway of the tributary traverses the floodplain, it is actively eroding (photographs 15 and 16). The processes of erosion will continue as the channel adjusts shape to accommodate increased catchment run-off and changed hydraulic gradient with the lowered bed of the Avon River. Access by sheep and cattle to the channel is exacerbating erosion. This tributary flows directly to the river.

In comparison, the channel of Sermon Brook is relatively stable and retains a natural meander pattern across the floodplain. This tributary has a smaller catchment area (about 2 700 ha) compared with Breckna Brook. The bed of the Avon River at the confluence of this tributary retains cobbles from previous erosion processes (well before clearing of the catchment for agriculture). This suggests that the riverbed in this location has not significantly eroded, so there is not a significant hydraulic head differential to cause channel erosion in the tributary. Discharge from Sermon Brook is via a channel through the floodplain and is unlikely to transport significant sediment loads.

One tributary flows directly to Church Pool on the north-east side. It is a small tributary (about 300 ha) that contributes significantly to sediments in the pool. If streamflow is relatively fresh, the tributary could be diverted upstream to discharge onto the adjacent floodplain. If it is saline, a sediment trap could be constructed (for which regular maintenance would be required). Revegetation of lower sections of the tributary would also arrest sediment transport.

The first downstream tributary on the north-east side discharges to the river near Jangaling Pool. This tributary has a catchment area of about 200 ha. Although the tributary channel is not eroding, streamflow could be diverted downstream to the floodplain to avoid possible sedimentation of the river from soil loss in the catchment.

The major tributary to Tipperary Pool from the north-east side has a catchment area of approximately 1800 ha. The channel near the confluence of the tributary with the river is deep although most erosion may have occurred prior to catchment clearing. Spiny Rush has spread to most of the channel of this tributary and has stabilised sediments. The

Photo 16: Channel erosion under-cutting fringing vegetation on Breckna Brook *Photo courtesy Viv Read*

lower section of the tributary could be established with locally occurring vegetation.

Many of the smaller tributaries on the north-eastern side discharge into floodways or anabranches of the Avon River where sediments are trapped or filtered.

Action 2.3: Arrange fencing, revegetation and streamflow or erosion control structures for Breckna Brook as it traverses the floodplain.

Action 2.4: Coordinate catchment management action to minimise peak run-off rates and sediment loss from the Breckna Brook catchment.

Action 2.5: Arrange fencing for the lower section of Sermon Gully.

Action 2.6: Develop Sermon Gully as a demonstration site for preferred tributary discharge processes and riparian vegetation regeneration.

Action 2.7: Measure the salinity of the tributary to Church Pool (north-east side) and assess the options for sediment management (streamflow diversion of sediment detention).

Action 2.8: Divert streamflow from the tributary near Jangaling Pool downstream to the floodplain (small diversion structure near the confluence required).

5.2.2 Tributary water quality monitoring

The salinity of streamflow from the tributaries is expected to vary considerably. Tributaries with catchments of shallow soil over bedrock are likely to be relatively fresh. Those with larger catchments that extend to areas with deeper soil profiles and high salt storage are likely to be more saline. Tributaries with fresh streamflow should discharge to the floodplain rather than directly to the river channel.

Action 2.9: Arrange ‘snap-shot’ monitoring of tributaries discharging directly to the Avon River so as to identify those that are relatively fresh.

5.2.3 Managing Spiny Rush

Spiny Rush (*Juncus acutis*) occurs in many tributaries and appears to spread rapidly. While it does stabilise sediments in tributary channels, it retards regeneration of other vegetation. This introduced weed is difficult to control.

The preferred management approach is to pre-empt its establishment with healthy riparian vegetation that has good canopy closure and strata of dense native sedges or rushes. Spiny Rush does not regenerate well when shaded.

Action 2.10: Arrange fencing and revegetation of the lower sections of tributaries (approximately 1 km suggested) where there is limited occurrence but potential for invasion by Spiny Rush (Sermon Brook is a good example).

5.2.4 Other natural vegetation in tributaries

Some tributaries have good remnant riparian vegetation although it is mostly the dominant tree species with little or no understorey. Very little of this vegetation is managed with fencing. Some tributaries have well-established vegetation due to previous tree-planting efforts (e.g. the waterway near the buildings on Avon Valley Farm north-east of the river) and are well stabilised.

Potential exists for bio-geographic linkage between the Avon and Mortlock river systems though corridors of vegetation that encompass riparian, rocky outcrop and other patches of remnant vegetation. There is current local initiative to develop this opportunity (Cecily Howell, *pers. comm.*). Support for development of wildlife corridors could be sought through Land for Wildlife, CALM, CSIRO (Division of Sustainable Ecosystems) or the Avon Catchment Council.

Action 2.11: Identify the full potential for regional bio-geographic linkage associated with these sections of the Avon River and seek support for their development.

5.3 River pool and sediment management

The River Training Scheme caused substantial scour of the riverbed and erosion of the spoil that was deposited in 'windrows' during the river bulldozing process. Stream-flow velocity is now higher than prior to river training and as a result, sediment transport is substantially greater. The combined effect of these processes is that there has been massive sediment mobilisation in the river and the pools have filled rapidly. Jangaling Pool and Little Pool have filled. Tipperary Pool and Church pools are substantially filled.

Meares Pool is curved and has filled by sediment deposition of the inside (eastern) bank. It is likely that scouring by faster streamflow against the outside (western) bank has prevented this pool being completely filled with sediment.

Wilberforce Pool is the least filled of all pools on the Avon River. This is due in part to Mackie Pool and Church Pool being upstream (and trapping sediments) and also because tributaries to the pool do not appear to be eroding. It is fortunate for this pool that Breckna Brook discharges downstream of it. Limited survey information suggests that Wilberforce Pool has lower salinity than other pools (Table 2). There may be fresh seepage to this pool.

The remaining pools continue to support a rich and diverse aquatic fauna and flora which is attuned to the range of temperature, salinity and streamflow velocity which would severely challenge other, less well adapted aquatic ecosystems. The pools also support a terrestrial invertebrate population that is not found in the summer-dry braided reaches of fringing vegetation. Hence the diversity and abundance of landbirds as well as deep-water and shallow-water carnivorous and herbivorous waterbirds.

5.3.1 Sediment management

The 1996 River Survey shows there to be relatively few major sand 'slugs' in the river (Figure 3) although more were measured in Section 7 than for the other two sections. Section 9 has the most stable riverbed as sediments are stabilised by couch (*Paspalum spp.*), *Frankenia pauciflora, Bolboschoenus caldwellii, Cyperous gymnocaulis* and other colonising species. The river channel is re-forming as a braided drainage pattern.

The flood in January 2000 caused the river channel and banks to erode in many places. This erosion during floods is generally unavoidable although vegetative cover on the bed and banks will reduce the risk.

There is little additional action that can be taken to further stabilise river-bed sediments in these sections of the river other than fencing to control stock access (ensuring that stock are not in the dry river bed) and actively discouraging access to the river-bed by horses and vehicles.

Removal of sediments from pools is costly. For example, full excavation of sediments from Tipperary Pool could be in excess of $0.75m. Excavation of sediments does not guarantee that a permanent pool can be maintained, as other sediments will continue to be transported in stream-flow.

The opportunity exists to excavate sediments from Meares Pool in a more cost-effective way. Removal of 28,000 m^3 by excavation from the east bank would provide increased pool capacity that would be maintained in part by the scouring processes on the west side. With good public access to the pool from Mackies Crossing, the public amenity from these works would be relatively high.

Action 3.1: Ensure livestock, including horses and vehicles, are not disturbing sediment stabilisation processes in the dry river bed.

Action 3.2: Evaluate options for excavation of sediments from Meares Pool.

5.3.2 Pool vegetation

Fringing vegetation along pools is generally limited in width and not regenerating. For example, the very narrow width of riparian vegetation of the south-west side of Wilberforce Pool is the major limitation to the values of this pool. The functions of fringing vegetation are important for ecological processes in the pools (such as modifying water temperatures) and for wildlife habitat.

Actions taken by the River Conservation Society and landholders have increased the width of fringing vegetation at Tipperary Pool by 30 metres.

Action 3.3: Arrange to protect remnant fringing vegetation and to increase the width in narrow sections of vegetation at Wilberforce, Church, Meares and Mile pools.

5.3.3 Water and bird life

Prior to the early 1970s, Avon River pools supported very substantial water bird populations through breeding periods (Ashley Morgan, *pers. comm.*). Sediment infill of pools and increased river salinity has significantly reduced opportunities for water birds although many birds of forest environments continue to use the fringing vegetation. A local 'indicator' of river health would be the continued or increased presence of those waterbirds that feed on fish, gilgies and frogs. Examples include the Little Pied Cormorant, which dives for its prey (indicating deep water), or the White faced Heron, which is also carnivorous but hunts in shallow water. Waterbirds which feed on waterweed and plankton also use deep water but can continue to feed in very shallow water. Their continued presence (including the presence of Black Swans) in the absence of the carnivorous species would indicate a significant loss in species diversity within the waterbody. Over the last decade Black Swans, hitherto uncommon, have been seen more frequently. They may have been introduced to Tipperary pool for ornamental purposes. (Cicely Howell, *pers. comm.*).

The abundance and diversity of birds provides a good indication of the health of the aquatic ecosystems and adjacent fringing vegetation. Previous bird survey information during the 1987-92 period for Hamersley, Wilberforce and Mackie Pools is kept in the York Conservation Resource Centre and there is considerable local knowledge. Ongoing systematic bird surveys would provide and good index of ecosystem health. Assistance could be sought from Birds Australia and CSIRO (Division of Sustainable Ecosystems).

Action 3.4: Support the long-term systematic bird survey program run by the River Conservation Society.

5.3.4 River pool names

Confusion over pool names is at risk of incorrect information being used for management over time. For example, 'Mackies Pool' is one of the names used for Church Pool but also became the name used for Meares Pool (because of its proximity to Mackies Crossing) during a water quality survey. The preferred names are those that have historic relevance and are used most commonly by those who live locally.

The preferred names of the river pools (in downstream order) are: Mile Pool, Three Mile Pool, Meares Pool (otherwise known as Meares Five Mile Pool), Tipperary Pool, Little Pool, Church Pool (otherwise known as Mackies, Chapel or Sermon Pool), Wilberforce Pool, Hamersley Pool and Jangaling Pool (otherwise known as Muresk Pool).

Action 3.5: Prepare a map of the river from Mile Pool to Spencers Brook that shows locally agreed river pool names.

5.4 River, landscape, cultural and heritage values

5.4.1 Historic values

The Avon Valley landscape is well recognised in Western Australia and has rich historic, cultural and heritage values. Local perceptions of these values are represented in the booklet "*Reflections on the Avon*" (Moore, S., 2000). Heritage values that are recognised locally include substantial homesteads, shepherd's huts and places of worship. Some of these values are represented in the book *"The Dempsters"* (Erickson, 1978) and in the photographs of Edward Tours Hamersley (The York Society, 2001). Aboriginal cultural values as understood by aboriginal people are not well recorded for this area, although there are several publications for the York district by Sylvia Hallam (UWA) on this subject.

The Swinging Bridge at Muresk, built in 1926 for student access to the college, is currently unsafe for use. An assessment of the feasibility to reconstruct the bridge to safe standards is proposed. Access across the bridge would provide a significant complement to river walks suggested for this area.

5.4.2 Future values

The profile of rivers as indicators of catchment health will increase in time. The focus on the Avon will increase due to its proximity to Perth and to the increasing awareness of biodiversity issues not only in Perth but also in the communities along the banks of the Avon. The opportunity

Photo 17: The Swinging Bridge at Muresk *Photo courtesy Ecoscape*

exists to further link rivercare awareness to sustainable land use practice. The direct involvement of Muresk Institute of Agriculture with the river increases the opportunity for this to occur, as does association with the Avon Ascent Programme for environmental education.

Developing ‘Clean and Green’ agriculture as a regional marketing image should be associated with increasing health of the Avon River. The linkage should be made by use of ‘Indicators for Agriculture’ that reflect river health. Measures of sediments, nutrients and weed infestations should be considered as suitable indicators.

With increasing interest in engineering options to manage salinity in the greater Avon Catchment, there is potential for future ecological values of the river system to be altered due to discharge of excessively saline or excessively acidic water. The opportunity exists to establish clear ecological indicators of river health and to establish the tolerance limits of the river ecosystem as a ‘receiving wetland’ for discharge water from drainage or groundwater pumping schemes in order to ensure the health of existing aquatic systems is not compromised.

Action 4.1: Promote the Avon River as an indicator of ‘catchment health’ and link with environmental monitoring and marketing opportunities for regional agriculture and other land uses.

5.5 Wanted and unwanted animals

As a result of clearing natural vegetation for agriculture, bulldozing the river for flood control, and the introduction of foreign plants and animals, landscape ecosystems have altered significantly. Many native mammals have disappeared, bird communities have altered and aquatic life is less. As examples, numbats, black bitterns and cobblers are no longer found in this area. Also of community concern is the very sharp decline in the water-rat population in spite of improving conditions. It has been suggested that the species of Long necked Tortoise found in Avon Pools differs from the species found on the Swan coastal plain (Dr Gerald Kuchling, UWA) Gilgie numbers are threatened by competition from yabbie species from the Eastern States. Other amphibian and reptile species have declined, but numbers could improve following better water quality control and riparian revegetation. Possum numbers are surprisingly low. (C. Howell, *pers. comm.*). Of recent concern is the rapid increase of Long-billed Corellas and Twenty-eight Parrots. Historic changes in bird fauna are well described by the late Jim Masters in *The Avon Valley: the Naturalists' View* (Walker, 1986).

The corellas are of general concern along the river for the damage they cause to the trees. The Shire of York is liaising with the Department of Conservation and Land Management to consider options for control.

There is also concern about foxes, cats, Black rats and rabbits along the river. Through either direct predation or competition for resources, these are the primary cause of the decline of many native species. Current management methods for pest animal control are providing spectacular results for re-colonisation of previous native species. It is possible that this could also occur in landscape ecosystems associated with the river. Coordinated baiting or shooting of foxes, cats and rabbits along the river could be arranged.

Action 5.1: Liaise with The Department of Conservation and Land Management and the Agricultural Protection Board to develop strategies for pest animal reduction, particularly for Long-billed Corellas, Twenty-eight Parrots, foxes, cats and rabbits.

Action 5.2 Assess initiatives for private bush and other environmental support that have potential to assess landscape and river ecosystem opportunities for increased faunal diversity or re-introduction of specific native species.

5.6 Potential pollutants

There are no major potential point source polluters along these sections of the river. However, there is only very limited information available about the sites that do have some potential to pollute. The sites or land uses with potential to be detrimental to the health of the river by pollution are described.

5.6.1 Nutrient loss from agricultural land

Phosphates and nitrates are the major nutrients controlling plant growth in aquatic ecosystems. In excess, eutrophic conditions in river pools may occur. The major source of excess nutrients is from agricultural land although most soils associated with the river environment have high phosphorus retention capacity. Phosphorus transported to waterways is in particulate form attached to soil eroded from catchments. Nitrogen is transported in solution.

Agricultural practice has changed in recent years in ways that reduce soil loss. Minimising tillage, contour farming, soil-specific management, retaining stubble and avoiding over-grazing all reduce sediment loss. Wide adoption of these practices is required. Further on-farm action is required to implement graded interception drainage on slopes and to rehabilitate waterways. These actions reduce run-off velocity (hence soil loss capacity) and provide in-stream filtration. These are responsibilities of individual farmers and Land Conservation District Committees or catchment groups. No direct action by the river section Recovery Team is required.

There has been considerable concern about the contribution of nutrients from the Avon River Basin to the Swan-Canning estuary. This was emphasised as a result of flooding of the Avon River during January 2000. Soil eroded from bare paddocks was transported to the estuary. The warmer fresh, nutrient-rich water overlaid the saline estuary water causing conditions such that the river was closed for human use in the metropolitan area. A total load of 35 tonnes of phosphorus and 800 tonnes of nitrogen were deposited in the estuary between January 23 and March 1, as measured at Walyunga (Muirden, 2000).

Water quality sampling for a period from 1987 to 1992 showed that the Avon River contributed 32% (20 tonnes) on average of the total phosphorus load to the Swan-Canning estuary annually. This compares with 42% (26 tonnes) from the considerably smaller catchment of Ellen Brook (Donahue *et al.,* 1994). For the same period, the Avon River contributed on average 55% (400 tonnes) of the total nitrogen load to the estuary. This compares with 10% (80 tonnes) from Ellen Brook (Donahue *et al.,* 1994). The total phosphorus and total nitrogen status of the Avon River contribution to the Swan-Canning Estuary is considered to be low (SRT, 2000).

The average total mass of phosphorus in water of the pools of these sections of the Avon River as measured during the 1996 River Pool Survey was approximately 15kg (JDA, 1996). Although small compared with the amount discharged to the Swan River during a flood, these levels are sufficiently high to cause eutrophication of the river pools.

Action 6.1: Liaise with the Avon Catchment Council, Land Conservation District Committees and associated catchment groups to ensure that agricultural practices minimise soil and nutrient loss and that the potential for impact of excess nutrients on the river both locally and in Perth under flood conditions is well known.

5.6.2 Muresk waste water treatment plant

The wastewater treatment plant at Muresk Institute of Agriculture may have potential to pollute the river as it is located near and discharges directly to the river environment. It has a design capacity (for 350 people) which is less than the residential capacity of the college (450 people) and it is a secondary treatment plant so does not fully remove nutrients from discharge water.

The potential for this plant to pollute remains uncertain. Riparian vegetation downstream from the plant is healthy and grasses are perennially green so some of the discharged nutrients are assimilated within the ecosystem. A monitoring strategy developed in 1996 and implemented in a minimal way has not enabled the pollution risk to be established. Additionally, there is no monitoring of groundwater quality and the potential for the plant to discharge into local aquifers remains unknown.

The wastewater treatment plant at Muresk is not licensed by the Department of Environmental Protection.

The Muresk Institute of Agriculture has responded to the potential pollution risk with the aim of reducing total water use by 40%. Waste from laboratories is managed through dilution tanks. The number of people in residence (currently less than 200) is below the design capacity of the treatment plant, however occasional events with increased residential numbers could exceed the design capacity. Stormwater management is separate to the wastewater treatment plant.

The opportunity exists to demonstrate 'best practice' for wastewater treatment at this site. The tributary that flows near the Muresk shearing shed enters the Avon River adjacent to the treatment plant. Overflow from the plant is discharged into this tributary. This tributary has a catchment area of approximately 700 ha and an average waterway gradient of approximately 2.9%. Discharge at the confluence is to the floodplain. The combined potential for sedimentation and associated nutrient loss from the catchment and nutrient-rich waste water discharge from the treatment plant could be managed within designed filtration and nutrient stripping pondage at the site between the shearing shed, the treatment plan and the river. The proposed practices are used commonly with other industries and in other states.

Action 6.2: Revise the monitoring strategy for the Muresk wastewater treatment plant to ensure the full pollution potential from this site can be clearly established.

Action 6.3: Develop the filtration and nutrient stripping demonstration site opportunity for the Shearing Shed tributary at Muresk.

5.6.3 York waste disposal site

The former open waste disposal site located adjacent to the Avon River downstream from the town of York has been replaced by a waste transfer station. The potential for the new facilities to pollute the river is minimal but the on-going pollution potential from the former waste site is not monitored and remains unknown.

5.6.4 Industries adjacent to the river

The small number of industries located adjacent to the river, including hay processing and steel works, are not considered to have significant potential to pollute the river.

The residential facilities for the skydiving enterprise are located more than 500 metres from the river and waste water is managed through an *in situ* Bio-cycle© treatment plant.

5.6.5 Farm and other rubbish disposal

Dumping of rubbish into creeks or the river was a previous traditional practice, which should now not occur. There are places where farm rubbish has been covered with soil on the floodplain. Other areas have considerable amounts of rolled fencing wire discarded in the river. Farm tips should be located in clay soils and at a substantial distance from the river. Chemical drums should not be stored where they can leak or be washed to the river during floods. Landholders should be encouraged to make use of the Drum Muster facility.

There is a considerable amount of discarded 'poly-pipe' near the river adjacent to Mile Pool. Removal of this pipe will remove the risk of it being washed downstream in the river.

Action 6.4: Ensure private rubbish tips and other waste disposal sites near creeks or the river are not being used.

5.7 Planning land use in the floodplain

Recent subdivision of agricultural has occurred near York (an area now described as "Riverland Heights"). This development has established sediment detention pondage to reduce impacts on the river environment. Other sub-division proposals adjacent to the river are being considered. Planning for these proposals should adopt the principle that there be net-benefit to river values.

Other use of the floodplain, including increased crop production, should be undertaken with the understanding that these areas will be subject to occasional flooding and there should not be approval for works that reduce the capacity of the floodplain to accommodate future floods.

5.8 Public access and recreational use

5.8.1 Public access opportunities

There are limited opportunities for public access to the Avon River. All towns along the river have good public access facilities but there are only few opportunities between the towns. There is enhanced public access to the river by the recently constructed 'River Walk' downstream from York as far as Mile Pool.

There are good vistas of the river and pools from both Mackies Crossing and Burges Siding bridge. While there are only limited opportunities for public access to the river, both locations have the potential for increased access.

Photo 18: Coils of wire dumped in the river *Photo courtesy Viv Read*

Bridge works have been scheduled to be undertaken at Mackies Crossing. This provides an opportunity to add to public access near Meares Pool by providing a small parking area, a picnic area and suitable signage.

Similarly, public access could be increased near Tipperary Pool at Burges Siding bridge. Land in reserve (vested with the Department of Land Administration) may be suitable.

Increasing public access to the river near private property could increase the risk of vandalism, theft or fire. Planning for public access should consider these issues.

Muresk Institute of Agriculture is also a significant opportunity for public access. The historic Swinging Bridge where there currently is sealed road access and established parking was previously a popular site for viewing the river in flood. The bridge is now closed for use because of public risk due to damaged infrastructure. An engineering assessment would establish the feasibility of repairing the bridge so as to be again suitable for public use. With or without the bridge, this location is well suited for an interpretive river walk.

Action 7.1: Assess the public access opportunity at Mackies Crossing and if suitable, plan for it's development in association with replacement works for the crossing and other rehabilitation works for Meares Pool.

Action 7.2: Liaise with DOLA to assess the option for use of the reserve on Lot 11 for public access to the river.

Action 7.3 Assess the feasibility of repairing Muresk's Swinging Bridge suitable for public use and developing a river walk trail.

5.8.2 Recreational use of the river environment

Many people recognise the river environment as a place of tranquillity and recreate there by walking or other passive involvements. This currently occurs near York and at Muresk.

Other people use the river actively by driving four-wheel drive vehicles and motorbikes on the bed and banks of the river. This occurs commonly near Spencers Brook Bridge. Use of these vehicles in the river reduces chances of river recovery.

Horses are occasionally ridden in the riverbed, particularly near the Muresk Institute of Agriculture. While they will

Photo 19: Detention pondage for rural-residential development near York *Photo courtesy Viv Read*

have little effect on the scoured clay riverbed, regular riding on sandy sediments will reduce their stability. An equally pleasant bridle trail could be established on the floodplain.

Some use of the river for canoeing is acceptable although this will be restricted by low streamflow, so is unlikely to cause significant problems. There is a good opportunity to establish a recognised canoe course from York to Mackies Crossing for periods of high streamflow. This section is a low-risk course with good vehicle access. It is also a good demonstration of the river recovery processes that are best seen from a canoe on the river.

Powerboats should be discouraged as they disturb water birds to a great extent and are inconsistent with the tranquil characteristics of the river.

Action 7.4: Arrange to restrict access for off-road vehicle use in the river near Spencers Brook.

Action 7.5: Arrange to relocate equestrian use of the river at Muresk Institute of Agriculture from the bed to the floodplain or an alternative landscape position.

Action 7.6: Assess options for developing a recognised canoe course from York to Mackies Crossing with suitable facilities and signage about river recovery processes.

5.8.3 River information opportunities

Many people attracted to the river would like to know more about its history, floods, flora, fauna and ecological functions. Suitable signage could provide this information and further notes about management for river recovery.

Opportunities exist for suitable river signage at the York 'River Walk' (where a general river management information sign is established), Mackies Crossing, the skydiving facilities, and at the Muresk Institute of Agriculture.

Action 7.7: Develop information relevant to these sections of the Avon River and arrange for suitable signs at suggested locations.

5.9 Recovery team role

A Recovery Team lead by landholders adjacent these sections of the river should be formed. The Water and Rivers Commission will provide support to this team.

The key role of the local Recovery Team would be 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 River Conservation Society and others with an interest in river management is recommended.

The proposed Recovery Team should be informally structured but should have an identified leader. This role should be undertaken by a landholder adjacent tot the river. 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.

Action 7.1: A Recovery Team be established with membership of landholders and representatives of the River Conservation Society, the Water and Rivers Commission and other with an interest in river management.

6 Implementation of the recovery plan

An appropriate Implementation Schedule is outline in the following Table.

Action	Priority (1)	Responsibility (2)	Notes
1. River Pools and Sediments			
Action 1.1: Arrange for the river to be permanently well fenced on both sides allowing reasonable access for farm management, weed control and fire suppression.	**H**	LH/MPSB	A limited supply of fencing materials is available from the Water and Rivers Commission in Northam.
Action 1.2: Develop local 'Best Practice' for occasional grazing of river vegetation where it is required and arrange revision of this practice as better knowledge and information is acquired.	**H**	MPSB	Recovery Team should revise this practice annually.
Action 1.3: Fuel Reduction Zones to be identified for those human-value assets at risk from uncontrolled fire. Cool fuel reduction burns can be undertaken in these areas at a frequency in accordance with annual fuel load.	**M**	MPSB	Recovery Team should monitor and review the effectiveness of burning practice for fuel reduction.
Action 1.4: The Recovery Team take advice from the Chief Fire Control Officers for the Shires of York and Northam for identification of fire risk areas and control burn practices.	**M**	MPSB	
Action 1.5: Clear signage to outline fire risks and restrictions be erected and maintained at identified public assess, picnic or other high use areas (particularly at Muresk, Burges Siding bridge, Mackies and at Mile Pool).	**M**	YS	
Action 1.6: The Recovery Team to ensure that all fences transverse to the river have gates suitable for fire control access and that vehicle access along the river is clear and unhindered.	**M**	LH/MPSB	
Action 1.7: Arrange trials for the control of Spiny Rush (*Juncus acutus*) in tributaries adjacent to the Avon River.	**H**	WRC/MPSB	Sermon Brook is a suitable site of demonstration of control methods.
Action 1.8: Eradicate Bridal Creeper with methods applied in the Avon River at Toodyay.	**M**	LH/MPSB	
Action 1.9: Arrange natural regeneration trials that include fire, smoked water and soil disturbance to enhance natural regeneration are recommended.	**M**	WRC/MPSB/ YRCS	
Action 1.10: Arrange a demonstration of direct seeding of agricultural land fenced into the river ecosystem.	**M**	WRC/MPSB/ YRCS	

Implementation Schedule continued overleaf…

… Implementation Schedule continued

Action	Priority (1)	Responsibility (2)	Notes
2. Tributary Management			
Action 2.1: Prepare a detailed (GIS) map of tributaries to these sections of the Avon River.	H	WRC	
Action 2.2: Arrange a systematic survey of the key tributary characteristics that are significant to river management.	H	WRC/MPSB	
Action 2.3: Arrange fencing, revegetation and stream flow or erosion control structures for Breckna Brook as it traverses the floodplain.	H	LH/MPSB/WRC	
Action 2.4: Coordinate catchment management action to minimise peak run-off rates and sediment loss from the Breckna Brook catchment.	H	YLCDC	
Action 2.5: Arrange fencing for the lower section of Sermon Gully.	H	LH/MPSB	
Action 2.6: Develop Sermon Gully as a demonstration site for preferred tributary discharge processes and riparian vegetation regeneration.	M	MPSB/WRC	
Action 2.7: Measure the salinity of the tributary to Church Pool (north-east side) and assess the options for sediment management (stream flow diversion of sediment detention).	H	LH/WRC	
Action 2.8: Divert stream flow from the tributary near Jangaling Pool downstream to the floodplain (small diversion structure near the confluence required).	M	MIA/WRC	While the channel is not eroding, this is a good opportunity to divert stream flow to the floodplain to assist regeneration of fringing vegetation.
Action 2.9: Arrange 'Snap-shot' monitoring of tributaries discharging directly to the Avon River so as to identify those that are relatively fresh.	H	WRC/MPSB	
Action 2.10: Arrange fencing and revegetation of the lower sections of tributaries (approximately 1 km suggested) with limited occurrence but high risk of Spiny Rush invasion.	M	LH/MPSB	
Action 2.11: Identify the full potential for regional biogeographical linkage associated with these sections of the Avon River and seek support for their development.	M	WRC/ACC/YRCS	Landholders between the Avon and Mortlock are currently establishing a wildlife corridor.
3. River Pool and Sediments Management			
Action 3.1: Ensure livestock, including horses, and vehicles are not disturbing sediment stabilisation processes in the dry riverbed.	H	LH/MSB	
Action 3.2: Evaluate options for excavation of sediments from Meares Pool.	H	WRC	

Implementation Schedule continued overleaf…

… Implementation Schedule continued

Action	Priority (1)	Responsibility (2)	Notes
Action 3.3: Arrange to increase the width of fringing vegetation in narrow sections and to protect the remnant fringing vegetation of Wilberforce, Church, Meares and Mile pools.	**H**	LH/MPSB/YRCS	Landholders and the York River Conservation Society have established supplementary plantings at Tipperary Pool.
Action 3.4: Support the long-term systematic bird survey program run by the YRCS.	**M**	YRCS/WRC	Although not a high priority, it would offer many benefits for monitoring river health.
Action 3.5: Prepare a map of the river from Mile Pool to Spencers Brook that shows locally agreed river pool names.	**H**	MPSB/WRC	The Recovery Team should negotiate local agreement for the preferred name for the pool referred to here as Church Pool.
4. River, landscape, cultural and heritage values			
Action 4.1: Promote the Avon River as an indicator of 'catchment health' and link with environmental monitoring and marketing opportunities for regional agriculture and other land uses.	**H**	ACC	
5. Wanted and Unwanted Animals			
Action 5.1: Liaise with The Department of Conservation and Land Management and the Agricultural Protection Board to develop strategies for pest animal reduction, particularly for Long-billed Corellas, Twenty-eight Parrots, foxes, cats and rabbits.	**H**	YS/NS/MPSB	
Action 5.2: Assess initiatives for private bush and other environmental support that have potential to assess landscape and river ecosystem opportunities for increased faunal diversity or re-introduction of specific native species.	**M/L**	LH	There is a range of initiatives for re-introductions within WA. A similar project on or near the Avon would require approvals, dedication and funds for predator-proof fencing.
6. Potential pollutants			
Action 6.1: Liaise with the Avon Catchment Council, Land Conservation District Committees and associated catchment groups to ensure that agricultural practices minimise soil and nutrient loss and that the potential for impact of excess nutrients on the river both locally and in Perth under flood conditions is well known.	**H**	MPSB/ACC	
Action 6.2: Revise the monitoring strategy for the Muresk wastewater treatment plant to ensure the full pollution potential from this site can be clearly established.	**H**	MIA/WRC	
Action 6.3: Develop the filtration and nutrient stripping demonstration site opportunity for the Shearing Shed tributary at Muresk.	**H**	MIA/WRC	
Action 6.4: Ensure private rubbish tips and other waste disposal sites near creeks or the river are not being used.	**H**	MPSB/NS/YS	This action should be linked with local 'Drum Muster' arrangements.

Implementation Schedule continued overleaf…

… Implementation Schedule continued

Action	Priority (1)	Responsibility (2)	Notes
7. Public Access and Recreation			
Action 7.1: Assess the public access opportunity at Mackies Crossing and if suitable, plan for it development in association with replacement works for the crossing and rehabilitation works for Meares Pool.	**M**	MPSB/YS	
Action 7.2: Liaise with DOLA to assess the option for use of the reserve on Lot 11 for public access to the river.	**M**	WRC/MPSB	
Action 7.3: Assess the feasibility of repairing Muresk's Swinging suitable for public use and developing a river walk trail.	**M**	MIA	
Action 7.4: Arrange to restrict access for off-road vehicle use in the river near Spencers Brook.	**H**	NS	
Action 7.5: Arrange to relocate equestrian use of the river at Muresk Institute of Agriculture from the bed to the floodplain or an alternative landscape position.	**M**	MIA	
Action 7.6: Assess options for developing a recognised canoe course with suitable facilities and signage about river recovery processes from York to Mackies Crossing.	**M**	YS/MPSB	
Action 7.7: Develop information relevant to these sections of the Avon River and arrange for suitable signs at suggested locations.	**H**	WRC/MPSB	
8. Recovery Team Role			
Action 8.1: A Recovery Team be established with membership of landholders and representatives of the River Conservation Society, the Water and Rivers Commission and others with an interest in river management.	**H**	WRC	

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

(2) MPSB = Mile Pool/Spencers Brook Recovery Team

RCS = River Conservation Society Inc.

NS = Shire of Northam

YS = Shire of York

AWC = Avon Waterways Committee

WRC = Water and Rivers Commission

ACC = Avon Catchment Council

YLCDC = York Land Conservation District

LH = Landholder

MIA = Muresk Institute of Agriculture

7 Recovery plan summary

VISION

The **Mile Pool–Spencers Brook Recovery Team** has the following vision for river management: *"The Avon River from 'Mile Pool' near York to Spencers Brook is recognised as being cared for by those who live alongside and others in the community. All existing river pools are maintained as healthy ecosystems that attract wildlife. The river vista of Meares Pool from Mackies Crossing and of Tipperary Pool from Burges Siding Crossing remains attractive. Meares Pool is managed with priority to maintain permanent water. Mile Pool is enhanced and attractive for public use.Black Swans continue to use the pools as migratory 'stop-overs'. The vegetation along the river remains healthy and supports diverse birdlife.People who enjoy the river have good access for walks, picnics and canoeing especially between York and Mackies Crossing. A self-guided walk trail and a bridle track are developed at Muresk. Destructive use of the riverbed has stopped. Public risk is minimal and private property is respected.The river is fenced to control stock access. Occasional grazing by sheep to reduce fire risk occurs when the potential to damage natural vegetation is least. Priority weeds are controlled. Unwanted animals, especially foxes, rabbits and long-billed corellas are controlled by co-ordinated community effort.Tributaries to the river are well managed by active catchment groups. Sediment and nutrient discharge to the river is minimal. Best practice for tributary management is well demonstrated."*

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

- To retain the natural attributes and river characteristics where-ever possible
- To understand the processes that have caused the river to deteriorate
- To reduce the risk of further river degradation
- To arrange consistent management of the river between current landholders and land managers, and for future owners or managers
- To communicate good river management to others.

Actions for Key Management Issues

River Fencing and Vegetation Management

Action 1.1: Arrange for the river to be permanently well fenced on both sides allowing reasonable access for farm management, weed control and fire suppression.

Action 1.2: Develop local 'Best Practice' for occasional grazing of river vegetation where it is required and allow revision of this practice as better knowledge and information is acquired.

Action 1.3: Fuel Reduction Zones to be identified for those human value assets at risk from uncontrolled fire. Cool fuel reduction burns can be undertaken in these areas at a frequency in accordance with annual fuel load.

Action 1.4: The Recovery Team take advice from the Chief Fire Control Officers for the Shires of York and Northam for identification of fire risk areas and control burn practices.

Action 1.5: Clear signage to outline fire risks and restrictions be erected and maintained at identified public assess, picnic or other high use areas (particularly at Muresk, Burgess Siding bridge, Mackies and at Mile Pool).

Action 1.6: The Recovery Team to ensure that all fences transverse to the river have gates suitable for fire control access and that vehicle access along the river is clear and unhindered.

Action 1.7: Arrange trials for the control of Spiny Rush (*Juncus acutus*) in tributaries adjacent to the Avon River.

Action 1.8: Eradicate Bridal Creeper with methods applied in the Avon River at Toodyay.

Action 1.9: Arrange natural regeneration trials that include fire, smoked water and soil disturbance to enhance natural regeneration are recommended.

Action 1.10: Arrange a demonstration of direct seeding of agricultural land fenced into the river ecosystem.

Tributary Management

Action 2.1: Prepare a detailed (GIS) map of tributaries to these sections of the Avon River.

***Action 2.2*:** Arrange a systematic survey of the key characteristics that are significant to river management.

Action 2.3: Arrange fencing, revegetation and streamflow or erosion control structures for Breckna Brook as it traverses the floodplain.

Action 2.4: Coordinate catchment management action to minimise peak run-off rates and sediment loss from the Breckna Brook catchment.

Action 2.5: Arrange fencing for the lower section of Sermon Gully.

Action 2.6: Develop Sermon Gully as a demonstration site for preferred tributary discharge processes and riparian vegetation regeneration.

Actions for Key Management Issues

Action 2.7: Measure the salinity of the tributary to Church Pool (north-east side) and assess the options for sediment management (streamflow diversion of sediment detention).

Action 2.8: Divert streamflow from the tributary near Jangaling Pool downstream to the floodplain (small diversion structure near the confluence required).

Action 2.9: Arrange 'Snap-shot' monitoring of tributaries discharging directly to the Avon River so as to identify those that are relatively fresh.

Action 2.10: Arrange fencing and revegetation of the lower sections of tributaries (approximately 1 km suggested) with limited occurrence but high risk of Spiny Rush invasion (Sermon Brook is a good example).

Action 2.11: Identify the full potential for regional biogeographical linkage associated with these sections of the Avon River and seek support for their development.

River Pool and Sediments Management

Action 3.1: Ensure livestock, including horses, and vehicles are not disturbing sediment stabilisation processes in the dry riverbed.

Action 3.2: Evaluate options for excavation of sediments from Meares Pool.

Action 3.3: Arrange to increase the width in narrow sections and to protect remnant fringing vegetation of Wilberforce, Church, Meares and Mile pools.

Action 3.4: Support the long-term systematic bird survey program run by the River Conservation Society.

Action 3.5: Prepare a map of the river from Mile Pool to Spencers Brook that shows locally agreed river pool names.

River, landscape, cultural and heritage values

Action 4.1: Promote the Avon River as an indicator of 'catchment health' and link with environmental monitoring and marketing opportunities for regional agriculture and other land uses.

Wanted and Unwanted Animals

Action 5.1: Liaise with The Department of Conservation and Land Management and the Agricultural Protection Board to develop strategies for pest animal reduction, particularly for Long-billed Corellas, Twenty-eight Parrots, foxes, cats and rabbits.

Action 5.2: Assess initiatives for private bush and other environmental support that have potential to assess landscape and river ecosystem opportunities for increased faunal diversity or re-introduction of specific native species.

Actions for Key Management Issues

Potential pollutants

Action 6.1: Liaise with the Avon Catchment Council, Land Conservation District Committees and associated catchment groups to ensure that agricultural practices minimise soil and nutrient loss and that the potential for impact of excess nutrients on the river both locally and in Perth under flood conditions is well known.

Action 6.2: Revise the monitoring strategy for the Muresk wastewater treatment plant to ensure the full pollution potential from this site can be clearly established.

Action 6.3: Develop the filtration and nutrient stripping demonstration site opportunity for the Shearing Shed tributary at Muresk.

Action 6.4: Ensure private rubbish tips and other waster disposal sites near creeks or the river are not being used.

Public Access and Recreational Use

Action 7.1: Assess the public access opportunity at Mackies Crossing and if suitable, plan for it development in association with replacement works for the crossing and rehabilitation works for Meares Pool.

Actions for Key Management Issues

Action 7.2: Liaise with DOLA to assess the option for use of the reserve on Lot 11 for public access to the river.

Action 7.3: Assess the feasibility of repairing Muresk's Swinging suitable for public use and developing a river walk trail.

Action 7.4: Arrange to restrict access for off-road vehicle use in the river near Spencers Brook.

Action 7.5: Arrange to relocate equestrian use of the river at Muresk Institute of Agriculture from the bed to the floodplain or an alternative landscape position.

Action 7.6: Assess options for developing a recognised canoe course with suitable facilities and signage bout river recovery processes from York to Mackies Crossing.

Action 7.7: Develop information relevant to these sections of the Avon River and arrange for suitable signs at suggested locations.

Recovery Team Role

Action 7.1: A Recovery Team be established with membership of landholders and representatives of the River Conservation Society, the Water and Rivers Commission and others with an interest in river management.

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Appendix one
Management sections of the Avon River

Section Name	Section Number	Description	Length (km)
Avon Gorge	1	Upstream from Avon Valley National Park to confluence with Jimperding Brook	11.23
Deepdale Valley	2	Confluence of Jimperding Brook to Crossing of Deepdale Road	8.14
Toodyay	3	Deepdale Road to Goomalling Road Bridge, including all of Toodyay Town upstream of the bridge on the south bank of the river	9.16
Extracts	4	Goomalling 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 7, 8 and 9

(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 7: 7/0-7/8.5
Spencers Brook to Wilberforce Crossing

Main overstorey species present

All three overstorey species are present throughout the section, with different species dominating at different transect sections. *Eucalyptus rudis* dominates transects from 7/4.5-7/7.0 inclusive. *Melaleuca rhaphiophylla* is more dominated at transect numbers 7/2.0, 7/4.0-7/5.0, 7/6.0, 7//7.5 and 7/8.0. *Casuarina obesa* dominates at transect number 7/0.5-5-7/1.5 and 7/2.5-7/4.0.

Vegetation death

There is no significant level of vegetation death observed at any transects in this section.

Fencing

Transects 7/0.5-7/3.5, 7/4.5, 7/7.5 and 7/8.5 had fences present on both banks. Transect numbers 7/4.0 and 7/5.0-7/7.0 had a fence present on only one bank, and the transect at 7/8.0 had no fences at all bordering the riparian vegetation. These fences bordering the riparian zone were all in a good to medium condition.

Other native species present

The native understorey species present which stabilise the river banks are; *Atriplex prostrata, Frankenia pauciflora, Sarcocornia quinqueflora* and *Sporobolus virginicus*. *Juncus pallidus* is also present on the banks. The other species composing the overstorey were; *Acacia acuminata, A.saligna* and *Hakea Preissii*.

Weed species present

Annual and perennial grass species were also present in this section as well as; Tall fleabane *(Conyza albida)*, Spiny Rush (*Juncus acutus*), Soursob *(Oxalis pes-caprae)*, Sorrel (*Rumex acetosella*), and Saltwater Couch *(Paspalum vaginatum)* which was present in equal quantities with the other native understorey species and provided stability for the river banks.

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-C1 indicating that the understorey was principally composed of weeds but there was no surface erosion. Some transects (7/1.0-7/2.0, 7/4.5 and 7/7.5) were assigned a vegetation condition of C1-C2 which showed that these sections were further degraded with exposed soil due to surface erosion and an understorey composed solely of weeds.

Regeneration

Both *Eucalyptus rudis* and *Melaleuca rhaphiophylla* had a low rate of regeneration (1-100 plants/ha), whilst the *Casuarina obesa* had a low to medium rate of regeneration (1-100 plants/ha to 100-500 plants/ha). The regenerating individuals of all three species formed mixed aged stands.

Disturbance factors

The presence of livestock in the river channel and riparian zone was observed at most of the transects (7/0.5, 7/1.5-7/2.5, 7/3.5-7/4.5, 7/5.5-7/8.5). The livestock were usually sheep or cattle, but a few transects also showed signs of horse presence. The presence of feral animals (rabbits and foxes) was noted at a few of the transects. There were transect numbers; 7/1.5, 7/2.0, 7/5.5, 7/6.0 and 7/7.5. No rubbish dumping or service corridors beside the river were seen at any of the transect sections surveyed. Another possible disturbance factor in this section was the presence of kangaroos at some of the transect (7/4.5-7/5.5, 7/7.5 and 7/8.5)

SECTION 8: 8/0.5-8/8.5
Wilberforce Crossing to Burges Siding

Main overstorey species present

All three overstorey species are present throughout the section, with species dominating at different transect sections. *Melaleuca rhaphiophylla* is seen to be the most dominant species at many of the transect sections, these were transects 8/05-8/3.0, 8/4.5, 8/7.0 and 8/8.5. *Casuarina obesa* was dominating some of the transects also, these were numbers 8/3.5, 8/5.0, 8/6.0, 8/6.5 and 8/8.0. *Eucalyptus rudis* was rarely the dominant overstorey species at any of the transects and usually formed a woodland, sometimes an open forest.

Vegetation death

No significant level of vegetation death was observed at any transect in this section.

Fencing

Most of the transects surveyed had fencing on both sides of the riparian vegetation lining the main active channel. Only one transect was observed with no fencing at all bordering the river riparian vegetation (8/3.5). The remaining transects (8/1.0-8/2.0 and 8/8.5) had a fence on only one side of the main channel. Most of the fences bordering riparian vegetation were in a medium condition, with a few in good condition and a few in a poor condition allowing livestock to pass them.

Other native species present

The native understorey species present which act to stabilise the river's banks are; *Atriplex prostrat*a, Frankenia pauciflora, Sarcocornia quinqueflora and Sporobolus virginicus. Juncus pallidus is also present on the banks. The other species composing the overstorey were; *Acacia acuminata, A.saligna, Eucalyptus loxophleba* and *Hakea preissii.*

Weed species present

Annual and perennial grass species were present at this section, as well as Tall fleabane (Conyza albida), Spiny Rush *(Juncus acutus*), Soursobs (*Oxalis pes-caprae*), Sorrel (R*umex acetosella*), and Saltwater Couch (Paspalum vaginatum) which was present in equal quantities with the other native understorey species and provided stability for the river banks.

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

Nearly all transects in this section were given a vegetation condition of B3-C1 indicating that the understorey vegetation was principally composed of weeds but there was no surface erosion. One transect (8/6.0) was rated as B2-B3 which indicated that the understorey was mostly weeds but there were move native understorey species present here than other transects. The remainder of the transects ere classified with C1-C2 vegetation condition (8/0.5, 8/3.0, 8/4.0 and 8/4.5) showing that there were only weeds in the understorey and some exposed soil due to surface erosion.

Regeneration

Eucalyptus rudis was not seen to be regenerating well at this section. Many of the transects had nil regeneration, and the remainder had a low rate of regeneration. *Melaleuca rhaphiophylla* had a low to medium rate of regeneration (1-100 plants/ha) over all the transect sections. *Casuarina obesa* had the best rate of regeneration of the three overstorey species, medium (100-500 plants/ha) at all of the transects. All regenerating individuals of the three species formed mixed aged stands, except for one even aged stand of *Casuarina obesa* at transect number 8/2.5 and one even aged stand of *Eucalyptus rudis* at transect number 8/3.0. The even aged stands were attributed to flood situations as all individuals were located very close together and were of the same age and height. The fruiting bodies of both *Eucalyptus rudis* and *Casuarina obesa* are quite buoyant and would float to the edge of the water in a flood situation, then germinate in an area up on the banks after being deposited their by the floodwaters.

Disturbance factors

The presence of livestock in the river channel and riparian zone was observed at most of the transects (8/0/5-8/5.0, 8/7.0, 8/8.0 and 8/8.5). Only sheep were seen in this section of the river. There was evidence of foxes (fox dens) at transects 8/0.5, 8/1.5, 8/3.0, 8/5.0 and 8/6.5. Rabbit warrens were seen only at transect 8/4.0 in this section of river. Another possible disturbance factor in this section was the presence of kangaroos at transects 8/5.0 and 8/5.5. Many sheep carcasses at 8/0.5 may be considered a source of pollution – rotting.

SECTION 9: 9/1.5-9/8.5
Burges Siding To One Mile Pool

Main overstorey species present

All three overstorey species are present throughout the section, with different species dominating at different transect sections. *Melaleuca rhaphiophylla* is seen to be the most dominant species at many of the transect sections, these were transect numbers 9/1.5-9/5.5, 9/6.5, 9/7.5, 9/10.0, 9/10/5 and 9/11.5. *Casuarina obesa* was dominant at only two transects, 9/0.5 transects and 9/9.0. *Eucalyptus rudis* was rarely the dominating overstorey species and usually formed woodland, sometimes an open forest.

Vegetation death

There was a significant level of vegetation death of *Eucalyptus rudis* observed at transects 9/1.5, 9/2.5 and 9/3.0.

Fencing

Half of the transects in this section had a fence present on only one side of the riparian zone. Transect numbers 9/0.5, 9/1.0 9/4.0-9/5.5, 9/8.5 and 9/9.0 had fencing present on both sides of the riparian zone, and transect numbers 9/11.0 and 9/11.5 had neither of the banks fenced off. Half of the fences bordering the riparian vegetation were in a good condition, and the other half were in a medium to poor condition some of which allowed livestock to pass into the riparian zone.

Other native species present

The native understorey species present which act to stabilise the river's banks are: *Atriplex prostrata, Frankenia pauciflora, Sarcocornia quinqueflora* and *Sporobolus virginicus. Juncus pallidus* is also present on the banks. The other species composing the overstorey were; *Acacia acuminata, A saligna, Eucalyptus loxophleba* and *Hakea preissii.*

Weed species present

Annual and perennial grass species were present at this section as well as: Perennial wild melon (*Citrullus colocynthis*), Umbrella Sedge (*Cyperus eragrotis*), Stinkwort *(Dittrichia graveolens),* African Boxthorn (*Lycium ferocissimum*), Bridal Creeper (*Myrsiphyllum asparagoides*), Soursob (*Oxalis pes-caprae*), Castor oil plant (*Ricinus communis*), Guildford Grass (*Romulea longiflora*), Sorrel (*Rumex acetosella*), Tamarisk (*Tamarix aphylla*). There is also Saltwater Couch (*Paspalum vaginatum*) which with the native understorey species provides riverbank stability.

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

The majority of the transects in this section were given a vegetation condition rating of B3-C1 indicating that the understorey vegetation was chiefly composed of weeds and there was no surface erosion. Transect sections 9/2.5, 9/7.5, 9/8.0,9/9.0 and 9/11.5 were rated as B2-B3. In these transects, the understorey had many weeds, but there were also native understorey species present. Transect sections 9/23.0, 9/5.5, 9/7.0, 9/9.5 and 9/11.0 were classified with a C1-C2 vegetation condition indicating that there were only weeds present in the understorey and some exposed soil due to surface erosion.

Regeneration

Eucalyptus rudis was not regenerating well at this section. The majority of transects had nil regeneration for this species, and transects 9/3.0, 9/4.0. 9/5.0-9/10.5 had a low regeneration rate. Melaleuca rhaphiophylla had a low rate of regeneration (1-100 plants/ha) at all transects surveyed in the section. The rate of regeneration for Casuarina obesa was the highest of all three of the overstorey species. This species had a low to medium regeneration rate (1-100 plants/ha). All regenerating individuals of Melaleuca rhaphiophylla and Eucalyptus rudis formed mixed aged stands. Most of the regenerating Casuarina obesa formed a mixed aged stand, but the regenerating individuals at transect sections 9/5.5, 9/8.0 and 9/9.5 were forming even aged stands.

Disturbance factors

There was evidence of livestock in the river channel and riparian zone (mostly sheep, but also evidence of horses) at every transect section except 9/1.5, 9/2.5, 9/6.5 9/7.5 and 9/8.0. The dumping of rubbish was noted at transect 9/7.0. At this transect there was a household dumping residential rubbish in the secondary active channel on the right bank. Approximately 250 metres from the main channel on the right bank is the site of the former town refuse dump at this same transect section.

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

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" ... 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

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' ... 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

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' ... Very good record — Corrections applied

* ... Estimated record

[... Not available

Avon River — Northam water quality 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

Publication feedback form

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