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PRIMARY INDUSTRIES,
WATER *and* ENVIRONMENT

Tasmania

Hydrological Analysis of the Coal River Catchment

A report forming part of the requirements for State of Rivers reporting

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The Water Resources Division provides a focus for water management and water development in Tasmania through a diverse range of functions including the design of policy and regulatory frameworks to ensure sustainable use of the surface water and groundwater resources; monitoring, assessment and reporting on the condition of the State's freshwater resources; facilitation of infrastructure development projects to ensure the efficient and sustainable supply of water; and implementation of the *Water Management Act 1999*, related legislation and the State Water Development Plan.

TABLE OF CONTENTS

Hydrological Analysis of the Coal River Catchment

1. Historical Background

1.1 Catchments and Drainage Systems

The Coal River catchment (Figure 1.1) is located in the southeast of the state and occupies an area of approximately 540 km^2 (920 km^2 inclusive Pitt Water). It is bordered by the Little Swanport and Prosser River catchments in the east, the Jordan River catchment in the west, and the Macquarie River catchment in the north.

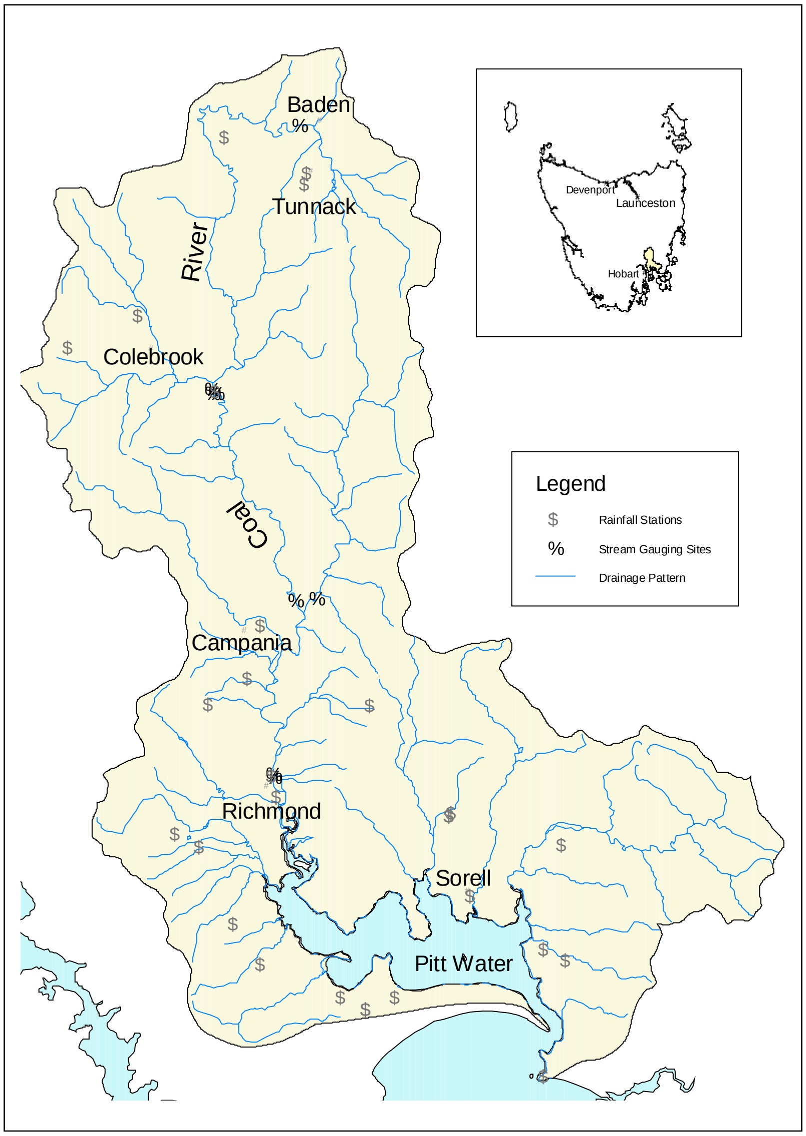

Figure 1.1 Location and hydrological set up of the Coal River catchment.

The Coal River originates on a range of hills east of Tunnack. It winds its way south through undulating terrain before flowing into Craigbourne Dam. From there the regulated river flows south through the Coal River valley, accepting unregulated inflows from its two main tributaries Native Hut and White Kangaroo Rivulets before flowing through Richmond and into Pitt Water. Prior to the construction of the Craigbourne Dam in 1986, the Coal River was ephemeral for its entire length and usually dry during summer (November-April). Historical records indicate that stream flow was generally highly dependent on rainfall resulting from easterly winds bringing moist air over the catchment.

1.2 Rainfall

The Coal River catchment is one of the driest catchments in the Tasmania with annual rainfall averaging from 500 mm to 700 mm across the catchment. The distribution of rainfall is largely controlled by the topography, with higher rainfall occurring around the upland areas in the north, west and east of the catchment. Average monthly rainfall varies between 37 mm and 71 mm as shown for Tunnack, Colebrook and Richmond in Figure 1.2. Due to its location in the rain shadow of the mountainous areas in the state's west, the Coal River catchment does not receive rain from the westerly weather that is largely responsible for rainfall in most other regions of Tasmania.

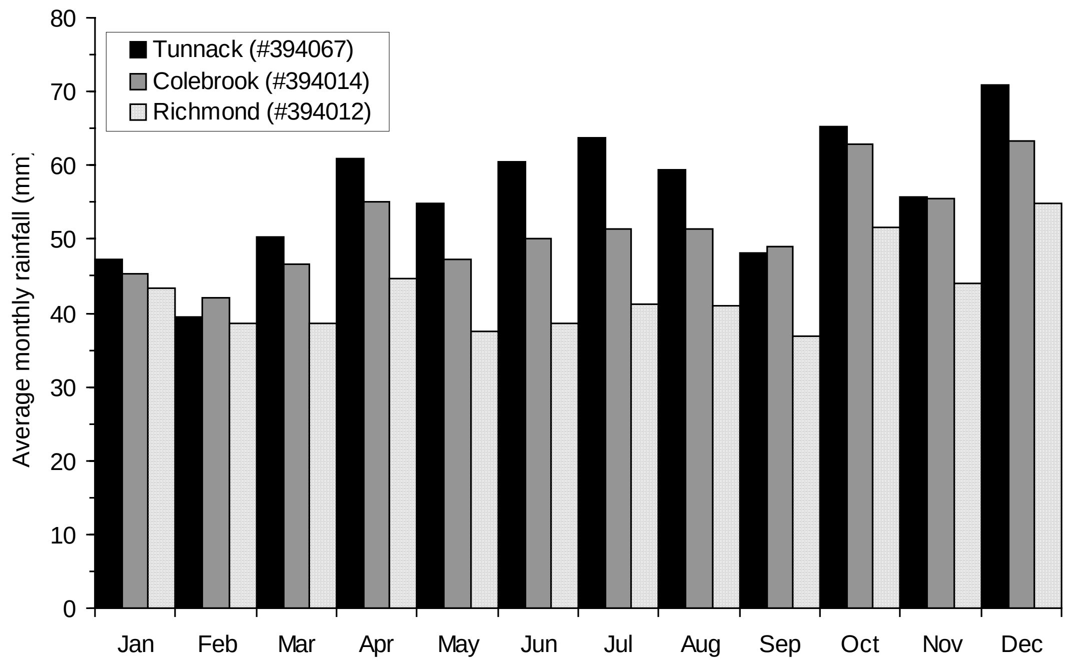

Figure 2.1 Monthly rainfall at selected sites in the Coal River catchment.

1.3 Water Usage and Diversions

Land use practices in the Coal River catchment include pasture, irrigated cropland, forestry, conservation, recreation and rural residential development. Water resources in the Coal River catchment are heavily dependent upon highly variable rainfall and groundwater baseflow. In-stream and off-stream farm dams have traditionally provided the major irrigation and stock water supply over the drier summer period. The South East Irrigation Scheme (SEIS) largely controls the water distribution and usage in the Coal River catchment through Stage 1 and Stage 2 of the irrigation scheme.

The Stage 1 scheme comprises of the Craigbourne Dam at upper Coal River near Colebrook. The dam was built in 1986 and has a full supply level capacity of 12,500 ML with a lake surface area of approximately 6.2 km^2 and a catchment area of around 24,700 ha. During 2000-2001, a total of 2,997 ML (1515 ML from Stage 1 and 1482 ML from Stage 2) were delivered to irrigate 1915 ha of cropland in the valley (RWSC, 2001). The largest water use was for dam filling (442 ML) and irrigation of poppy crops (440 ML).

The Stage 2 scheme consists of 4,222 ha of the catchment area, of which 3,210 ha is considered suitable for irrigation. This stage initially consisted of a pump station on the bank of the Coal River at Richmond, and 26 km of buried pipeline, delivering water to the Richmond, Middle Tea Tree and Cambridge areas. During 2000-2001, construction of the new Daisy Bank Dam to feed Hobart Water's supply into the Stage 2 scheme was completed. The supply from this dam is currently considered sufficient to meet the irrigation demand from land within Stage 2 of the scheme. A summary of the water allocations in the Coal River catchment is presented in Table 1.1.

Table 1.1 A Summary of water allocations in the Coal River catchment.

Source	**Intended Use**	**Licensed Volume (ML)**
Coal River & tributaries	Irrigation	16951
	Stock & Domestic	1042
	Total	17993

Data source: WIMS: Water Information Management System, http://wims.dpiwe.tas.gov.au .

2. Hydrological Monitoring in the Catchment

2.1 Rainfall Monitoring

The Bureau of Meteorology currently monitors 17 rainfall stations in the Coal River catchment (Table 2.1). Historical records are also available from a number of other stations that are no longer operational. The rainfall data can also be accessed from the Internet site http://www.bom.gov.au or from the regional Bureau of Meteorology office at Hobart.

Table 2.1 Bureau of Meteorology rainfall stations in the Coal River catchment

Station	**Station Name**	**AHD (m)**	**Start Record**	**Status**
93050	Tunnack (Blue Horizon)	420	30/06/1990	Current
94007	Cambridge (aerodrome)	10	31/10/1944	29/05/1958
94008	Hobart airport	4	31/05/1958	Current
94009	Campania (The Pines)	55	31/03/1923	22/05/1996
94012	Richmond (lowlands)	10	31/03/1920	Current
94014	Colebrook (The Meadows)	225	31/08/1911	Current
94055	Richmond (Brookbank)	40	30/06/1916	Current
94063	Sorell (Whitlea)	10	31/10/1887	Current
94064	Wattle Hill	100	31/08/1933	Current
94067	Tunnack post office	460	12/07/1922	29/12/1989
94088	Park Beach	20	31/12/1961	Current
94109	Tea tree (Ring farm)		31/12/1906	30/11/1934
94110	Richmond (Inverguharity)		30/11/1885	25/06/1929
94115	Orielton		31/12/1964	25/02/1967
94128	Orielton (park)		28/02/1967	24/02/1969
94130	Orielton (east Orielton Road)	40	28/02/1969	Current
94136	Cambridge (Craigow)		31/12/1908	28/06/1912
94156	Cambridge (Milford)	15	31/12/1890	29/07/1958
94170	Cambridge (The Cottage)	40	30/04/1986	Current
94177	Richmond (Strathayr)	85	31/07/1988	Current
94181	Lewisham (Forcett House)	25	28/02/1981	31/12/1999
94182	Craigbourne dam (Coal River)	150	31/08/1991	Current
94183	Richmond (Coal River)	20	30/03/1996	Current
94190	Yarlington (Blacks Pinnacle)	595	31/03/1994	Current
94195	Tunnack fire station	462	13/08/1997	Current
94212	Campania (Kincora)	45	11/04/2000	Current
94215	Forcett(old Forcett Road)	35	31/12/1999	Current

AHD: Australian Height Datum in metres.

2.2 River Flow Monitoring

There are currently four stream gauging sites operational in the Coal River catchment. Short and discontinuous sets of flow records also exist for a number of sites in the catchment (Table 2.2). The bulk of the historical data however, contains zero flow and is therefore unsuitable for meaningful hydrological analyses. Most of the sites are also located downstream of the Craigbourne Dam and have received regulated flows since 1986. For future hydrological assessment of the catchment, continued monitoring of sites 3202, 3203, 3208 and 3209 are considered important in driving accurate yield accounting and sustainable water management in the catchment.

Table 2.2 Stream flow monitoring sites in the Coal River catchment

Site	Site Name	Area (km^2)	Start Record	End Record
3201	Coal River at Craigbourne Road	247	06/07/1961	01/01/1981
3202	Coal River upstream White Kangaroo Rt	303	23/07/1963	20/8/1993
3203	Coal River at Baden	53.2	13/07/1971	Current
3204	Coal River at Craigbourne		01/01/1980	08/01/1986
3205	Cross Rivulet at University Farm	9	01/01/1981	31/12/1981
3206	Coal River downstream Craigbourne Dam		20/10/1986	Current
3208	Coal River at Richmond[#]	536	07/06/1989	Current
3209	White Kangaroo Rt upstream Coal River	110	08/05/1990	Current

Record includes location 2 (Creese's Weir, 07/06/1989-30/12/1993)

3. Catchment Yields and Distribution of Flows

3.1 Catchment Yields

The historical annual discharge in the upper Coal River catchment at Baden (3203) is shown in Figure 3.1. Blank sections in the figures indicate periods for which there was no flow or no data recorded. Discharge volumes are variable, but show a cyclic annual high approximately every 10 years (eg. in the year 1976, 1986 and 1996). The record indicates that overall discharge appears to be in decline, a trend that has also been found in the nearby Jordan River. The annual discharge at Baden range from 400 - 20,000 ML, with an annual average of 7,000 ML. The projected yield for the catchment (including Pitt Water) is approximately 128,000 ML. However, the available surface water yield may be much less since a significant amount may be lost to groundwater recharge. The Coal River catchment being dry for most of the summer season, a very high proportion of rainfall will infiltrate to groundwater storage. The groundwater resources of the Coal River basin are estimated at 8,200,000 ML, the bulk of which is saline water and is not suitable for domestic and irrigation use (Leaman, 1971).

The summer and winter seasonal flow pattern in the Coal River is highly variable (Figure 3.2). Flow volumes are generally low with long periods of zero flow. The winter flow volumes range from 250 to 17,500 ML and are significantly higher than the summer flows. Summer flows range from 20 to 14,000 ML with a mean flow volume of 2,000 ML. The average estimated total catchment yields were 35,000 ML and 85,000 ML for summer and winter periods respectively.

As a result of the reversal of seasonal flow conditions (high summer/low winter) in the Coal River created by the Craigbourne Dam, accurate available yield volumes cannot be assessed. Regulated yield volumes in the Coal River downstream of the Craigbourne Dam are likely to be considerably less during winter seasons when upstream runoff is captured for storage. Any increase in yield at Coal River at Richmond (#3208) is likely to be mainly due to seasonal inflow from Native Hutt and White Kangaroo Rivulets and cumulative baseflow. The allocation of environmental flow and long-term projection of water quality with respect to pollutant mass loading may not be possible because of the irregularity of flow conditions.

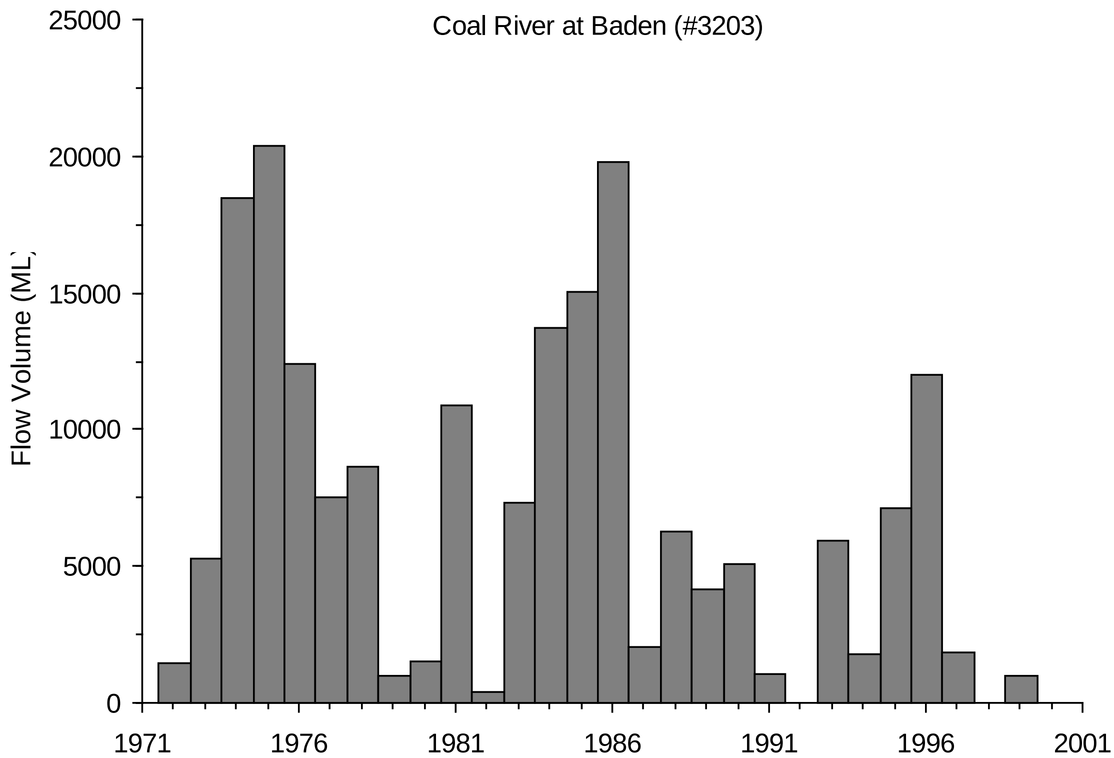

Figure 3.1 Annual flow volumes in the Coal River at Baden.

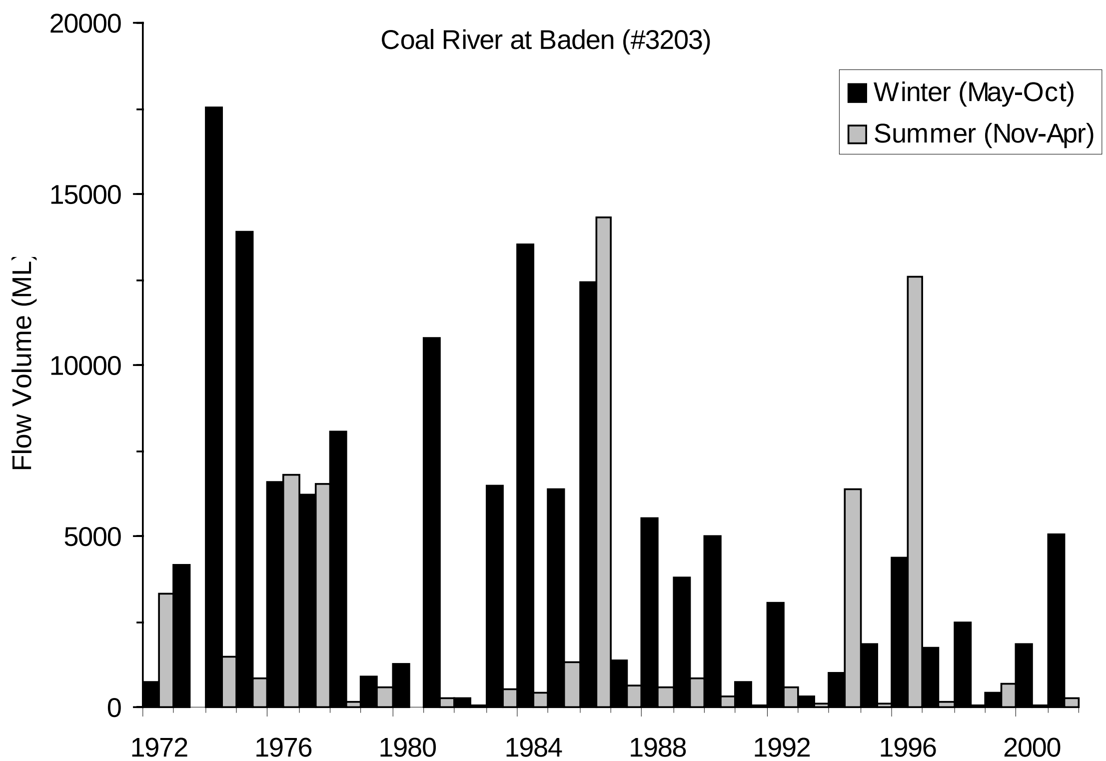

Figure 3.2 Seasonal flow volumes in the Coal River at Baden.

3.2 Monthly Yields

The variability of flows within each month in the Coal River catchment is demonstrated in Figure 3.3, which provides box and whisker plots of monthly average flow data from the Coal River at Baden. Due to common discontinuity in data sets and frequent zero flow events, the figure is intended only to display the general pattern of monthly median natural flows. The horizontal line across the box represents the median flow whereas the bottom and top edges of the box mark the first and third quartiles respectively. The ends of the whiskers show the spread of 95% of the data. The crosses beyond the whiskers indicate high and low outliers.

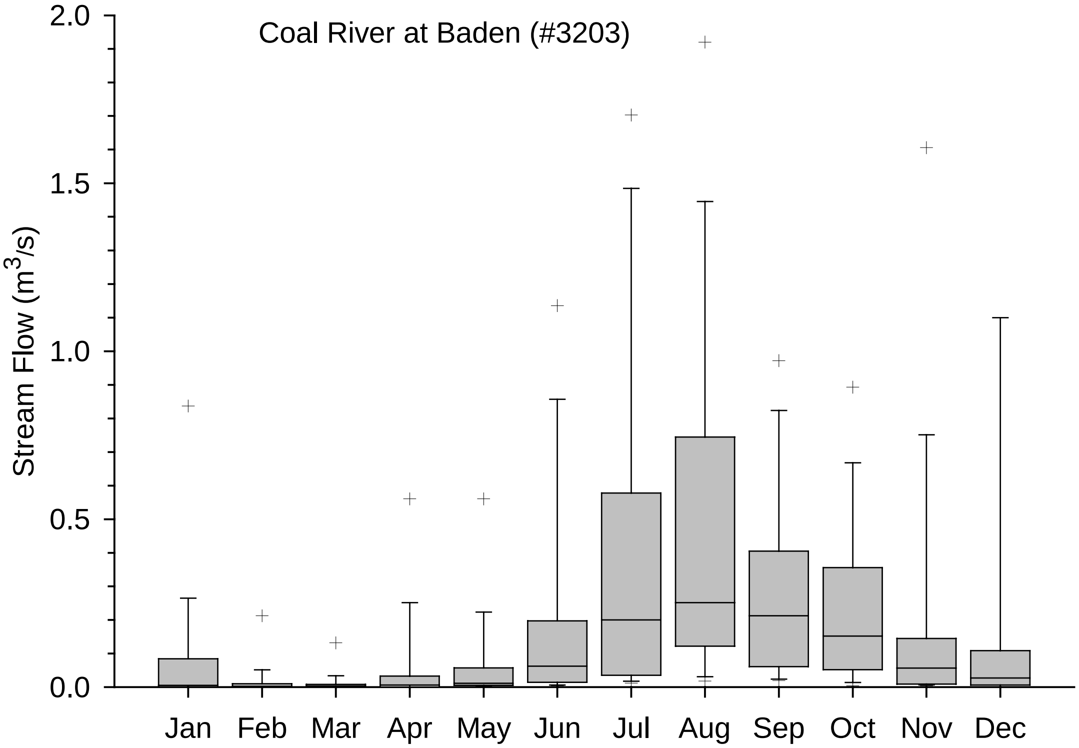

Figure 3.3 Monthly flow analysis from Coal River at Baden.

The box and whisker plots presented in Figure 3.3 show that peak flows occur during the late-winter (July-August) and low or zero flows occur during the late-summer (February-March). The median monthly flows from all the stream flow monitoring sites in the Coal River (Table 2.2) are generally lower than 1.0 m^3/s. Natural flows from Coal River at Baden (#3203), Coal River at Craigbourne Road (#3201) and White Kangaroo Rivulet upstream Coal River (#3209) show a roughly seasonal variation in monthly flows. Sites that receive regulated flows downstream of the Craigbourne Dam do not demonstrate this seasonal pattern. There is however an indication of gradual pick up in average monthly winter flow volumes at lower reaches of the Coal River (#3208) as a result of increased inflow from White Kangaroo (#3209) and Native Hutt Rivulets.

4. Comparison between Study Period and Historical Data

Figure 4.1 compares the monthly average flows experienced at the Coal River at Baden (#3203) and Richmond (#3208) sites during the study period (1999-2001) and the historical record. The overall monthly average flows at Baden were generally about 50% lower during the study period compared to the historical average flows (Figure 4.1a). Lower than average summer flows at Baden site indicated a relatively dry period was experienced in the upper reaches of the Coal catchment during the study period. This pattern is not observed at Richmond as a result of flow regulation from Craigbourne Dam (Figure 4.1b). Summer flows at Richmond site are higher than winter flows as a result of water release from the Craigbourne Dam during the irrigation season.

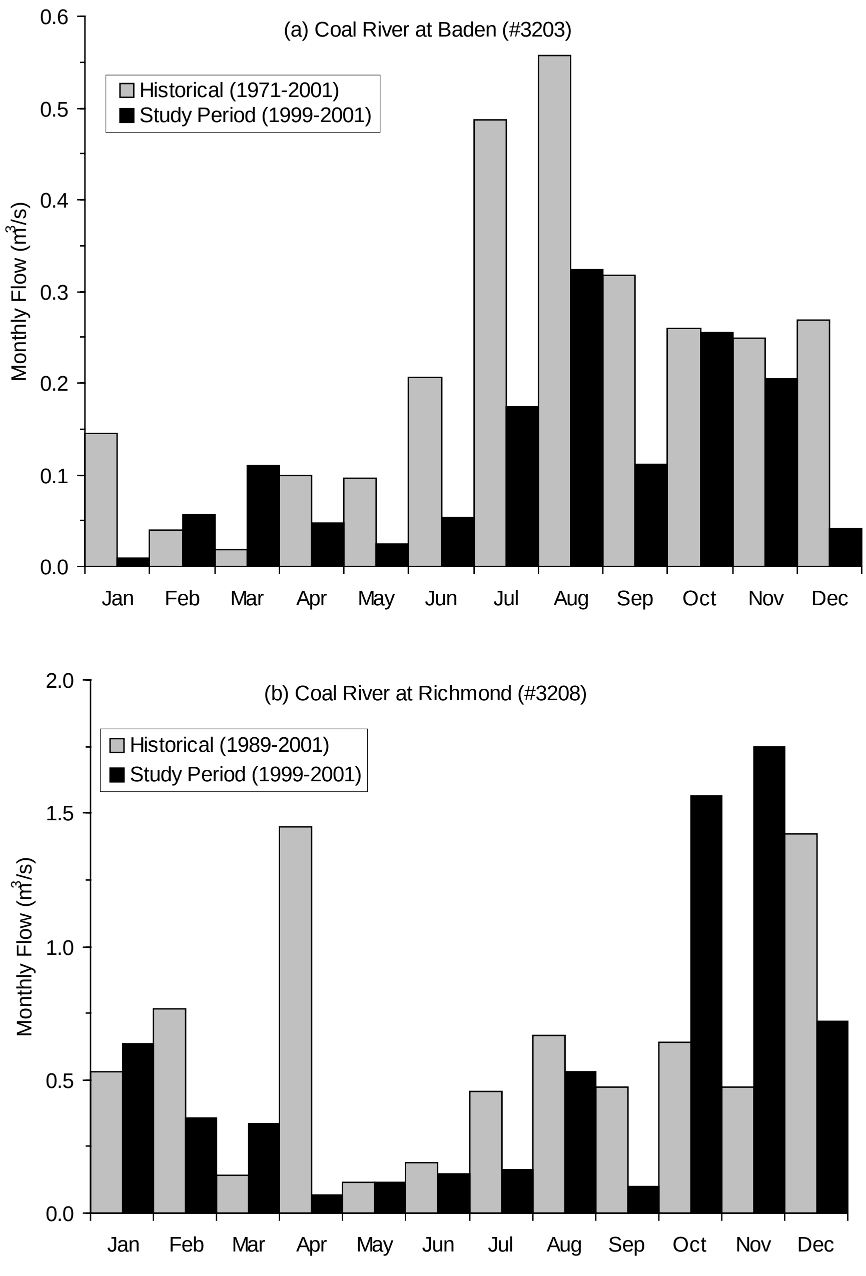

Figure 4.1 Comparison of monthly flows for the (a) Coal River at Baden and (b) Coal River at Richmond.

White Kangaroo Rivulet was relatively dry or had very low flow throughout the study period (except for a peak flow event in December). Coal River at Richmond (#3208) experienced significantly lower flows during the winter seasons of the study period except for anomalous higher flow during the October-November period (Figure 4.1b) which could be attributed to a peak flow effect from White Kangaroo Rivulet.

5. Recessions and Low Flows

Segments of peak flow hydrographs covering the study period were analysed to describe the recession flows for the Coal River at Baden (#3203). The recession curves are segments of hydrographs that show how the water storage in the river decreases over time following peak river flows. Using several recession segments for the analysis, a 'recession curve' can be generated which represents the basic pattern of decrease of flow in the river. The recession curve also reflects the groundwater discharge to the river and how groundwater storage influences and sustains baseflows in rivers.

The winter and summer recession curves for the Coal River at Baden are presented in Figure 5.1. The upper part of both recession curves is comprised mostly of surface water flow. With time, the surface flow contribution gradually decreases until the flow is comprised almost entirely of groundwater flow (or base flow) which is depicted on the lower section of the curves.

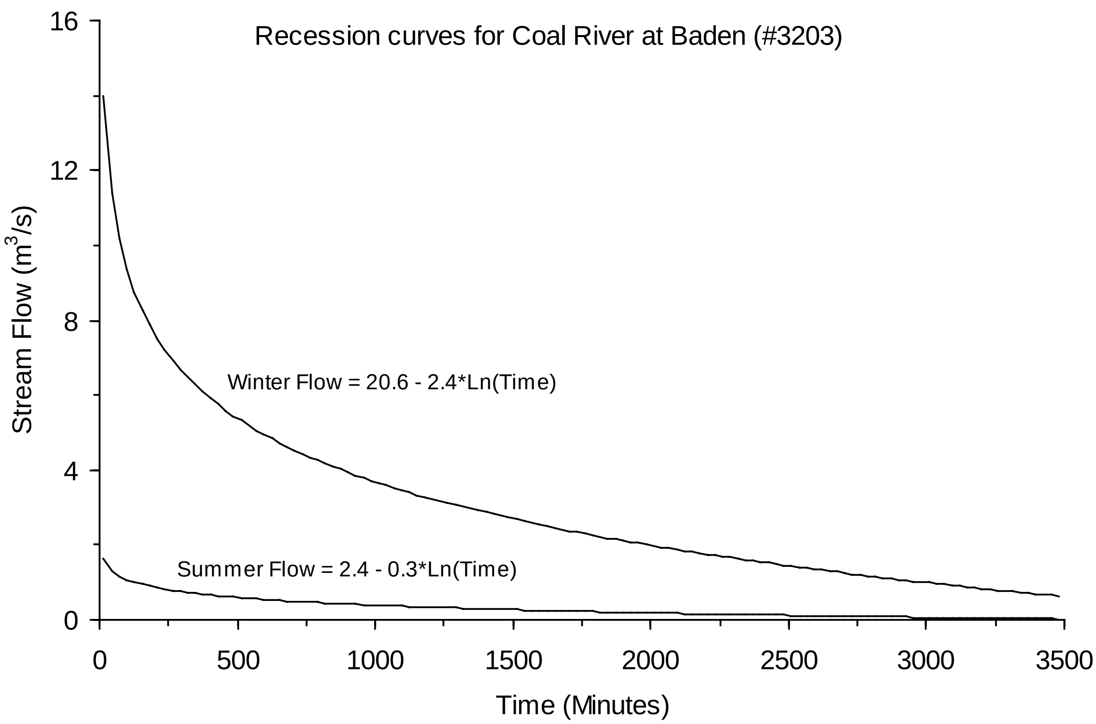

Figure 5.1 Recession curves for Coal River at Baden.

The flow recession at Coal River at Baden roughly follows a lognormal fitted curves described by the following equations:

*Winter Flow = 20.6 - 2.4*Ln(Time in minutes),* $R^2 = 0.96$

*Summer Flow = 2.4 - 0.3*Ln(Time in minutes),* $R^2 = 0.95$

The curves demonstrate that it takes approximately only 3000 minutes (2 days) for the flow to recede from 15 m^3/s to 1 m^3/s during winter. During the summer, the Coal River at Baden was relatively dry, with flow contribution comprising mostly of base flow that remained less than 1.0 m^3/s.

Recession curves were also analysed for natural flow site at White Kangaroo Rivulet (#3209) and the corresponding equations for summer and winter peak flow are given below:

*Winter Flow = 99.5 - 12.1*Ln(Time in Minutes),* $R^2=0.90$

*Summer Flow = 51.9 - 6.3*Ln(Time in Minutes),* $R^2=0.92$

The recession periods for White Kangaroo Rivulet were relatively short and comparable to that of Coal at Baden. However, the peak to base flows volumes were considerably higher. The summer and winter flow recessions for White Kangaroo Rivulet were from 35 m^3/s to 5 m^3/s and 60 m^3/s to 5 m^3/s respectively.

Low flow frequency curves were derived for the Coal at Baden site (#3203) to indicate the probability of minimum flow occurrence over various durations (Figure 5.2). Since the bulk of the flow data contains zero flows, conditional frequency curves were derived. Conditional probability greater than 50% was found adequate for depicting probable low flows at selected duration periods. As an example of how to read this graph; the probability that a minimum average daily flow of 0.05 m^3/s will occur in any given year for a 60 day period is approximately 87%, while over a longer period such as 90 days this probability decreases to around 80%. The probability that flows will drop below this level for 30 days or more in any given year is 100%.

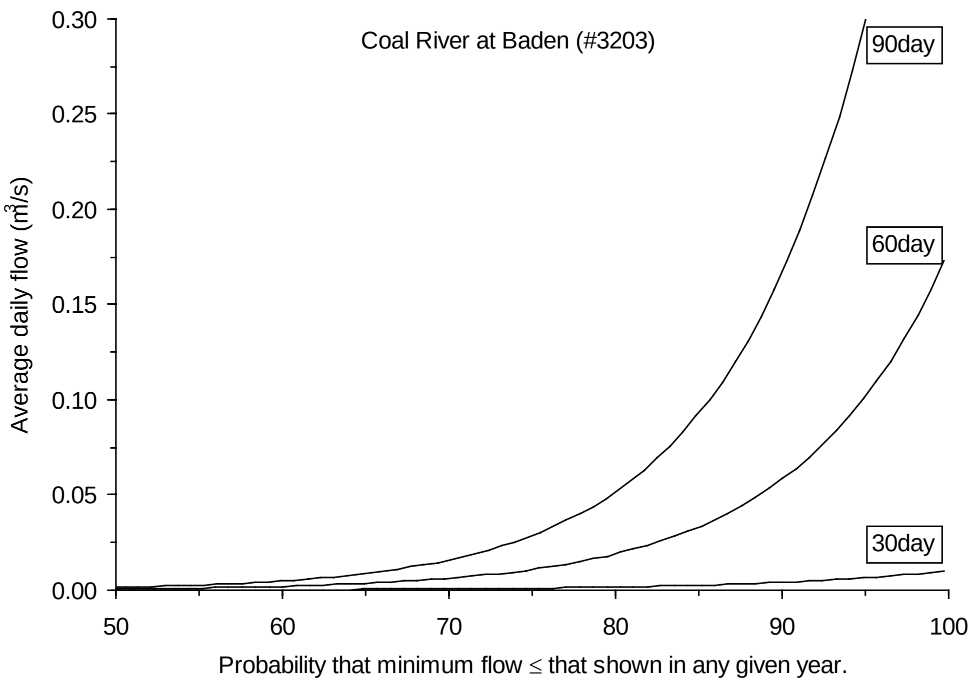

Figure 5.2 Low flow frequency curves for Coal River at Baden.

The occurrence of low flows downstream of the Craigbourne Dam is entirely dependent on releases from the dam, therefore the minimum flows are not representative of natural flow events. Comparison of low flows for sites downstream of the Craigbourne Dam is shown in Table 5.1.

Table 5.1 Predicted low flows at 80% probability for selected sites.

Site Name	**Flow duration (days)**		
	30	**60**	**90**
	Average daily minimum flow volume (m^3/s)		
Coal River d/s Craigbourne dam	nd	0.25	0.30
White Kangaroo Rivulet at Stratford	nd	0.01	0.04
Coal River at Richmond	0.14	0.19	0.26

nd = not determined.

Low flow conditions in Coal River are strongly related to the occurrence of drought in the catchment. The low flow analysis has implications for the establishment of environmental flow allocation and assessment of pollutant mass loading for the Coal River catchment.

6. Floods

Flood frequency analysis was undertaken for the Coal River at Baden gauging site to indicate the likelihood of floods in the catchment. The result of this analysis is presented in Figure 6.1. Due to the regulated nature of the flow, flood frequency analysis cannot be performed on data from gauging sites downstream of Craigbourne Dam, and flow data records from White Kangaroo Rivulet are insufficient for meaningful flood frequency analysis.

An example of how to read this graph in Figure 6.1 is that the magnitude of 1 in 10 year flood event in this part of the catchment is approximately 37 m^3/s. The historical annual peak floods at this location ranged from 2 m^3/s to 49 m^3/s over the 30 years of record (1972-2001). During the study period, the highest discharge was 12 m^3/s (0.71 m river level), which occurred on 12 October 2001. Discharge of this magnitude is equivalent to about a 1 in 2 year flood event and is considered a common event.

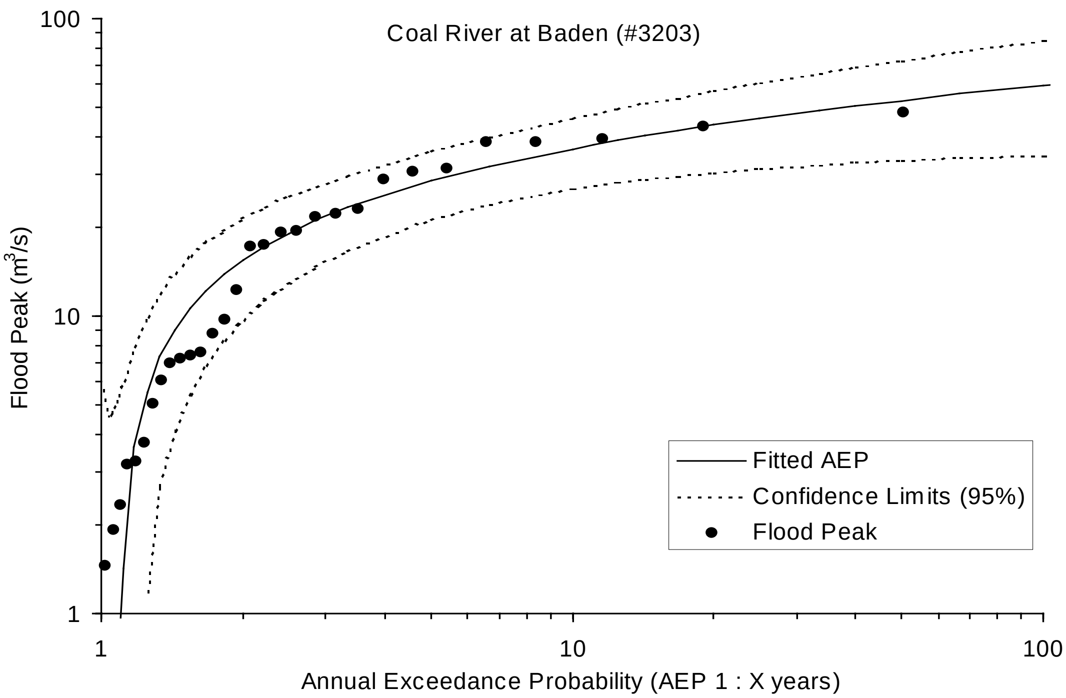

Figure 6.1 Flood frequency curve for Coal River at Baden.

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