Department of Water
Government of Western Australia

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Cowaramup Brook hydrology summary

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Surface Water Hydrology Series

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Subject of cover photograph: Cowaramup Brook at Study Reach 1 (by Mary-ann Coppolina)

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1 Introduction

Cowaramup Brook is located approximately 250 km south of Perth between Cape Naturaliste and Cape Leeuwin on the south-west coast of Western Australia (Figure 1). It discharges to the Indian Ocean at Gracetown. This report discusses the hydrology of the brook and will be used as an aid in developing ecological water requirements for the Cowaramup Brook catchment.

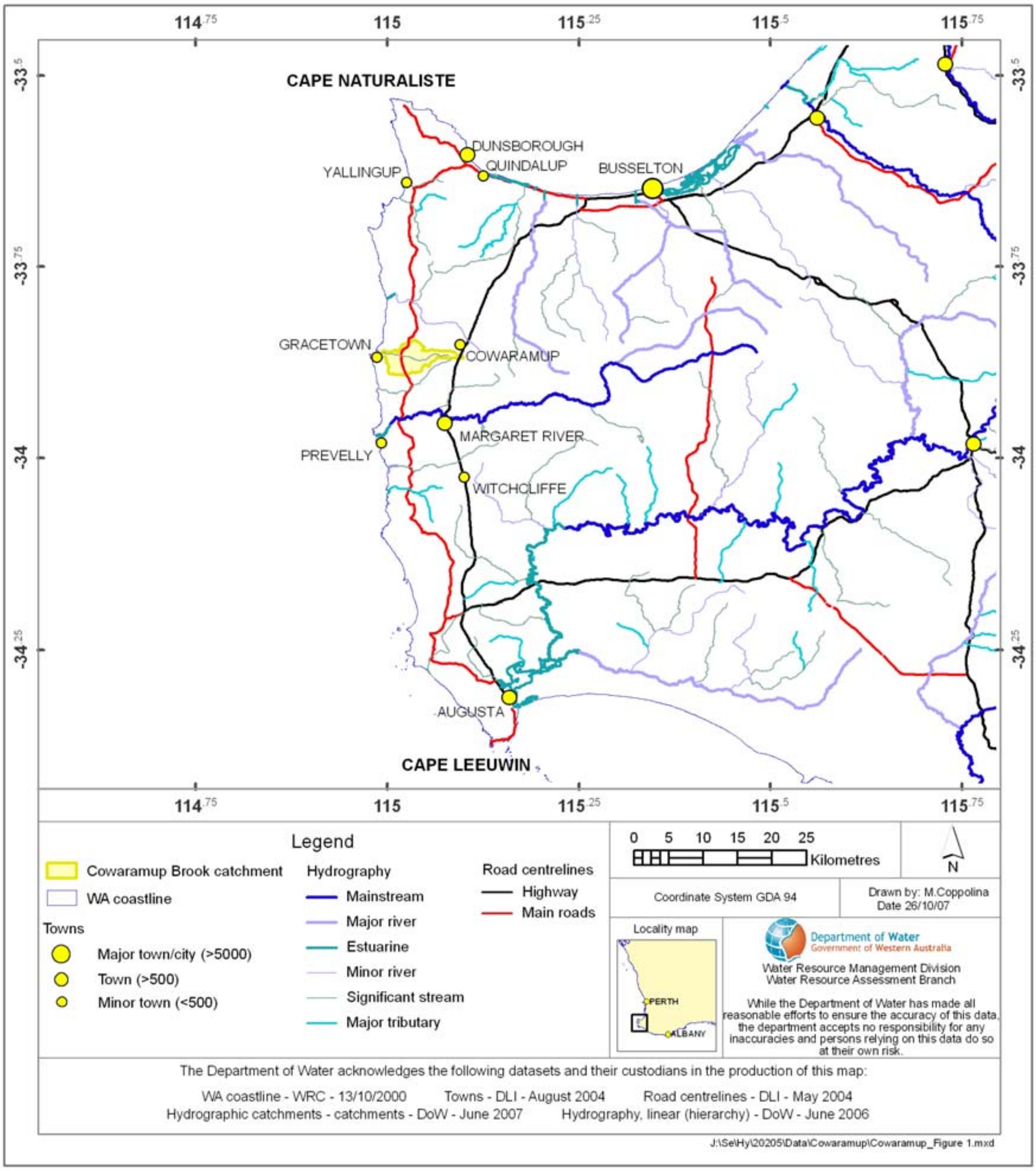

Figure 1 Location of Cowaramup Brook, south-west corner of Western Australia

2 Catchment description

The Cowaramup Brook catchment covers an area of 23.5 km^2, the town of Cowaramup lying on the Bussell Highway just north of the catchment's eastern boundary. The brook courses west and discharges to the Indian Ocean at Gracetown.

The catchment extends approximately 10 km inland, with the brook itself having a total stream length of just over 10 km. A single streamflow gauging station, Cowaramup Brook at Gracetown (610029), operates in the catchment. The gauging station began operation at the end of November 2004 (Figure 2). There are no meteorological stations in the catchment but there are many in close proximity. Figure 2 shows several stations that surround the catchment and that are considered later in the chapter in describing its climate.

2.1 Land use

The Cowaramup Brook catchment has been progressively cleared for farming, grazing and viticulture. By 1996, 58 per cent had been cleared. Most clearing in the region took place around 1925/1930 as part of Settlement Schemes (Tille & Lantzke 1990). Olive-growing is the dominant commercial land use in the catchment, with small areas also under cultivation for growing wine grapes and nuts.

Numerous dams have been constructed both on and off Cowaramup Brook in association with different land-use needs. A study is currently under way on the adjacent Wilyabrup Brook catchment to determine the impact of farm dams on the catchment water balance (Boniecka in prep.).

2.2 Geology

Cowaramup Brook lies in the Leeuwin Naturaliste region, which can be divided into two physiographic regions – the Leeuwin Naturaliste Coast and the Margaret River Plateau. The Leeuwin Naturaliste Coast is a 0.2–6 km strip of land along the Cape to Cape coast, while the Margaret River Plateau is 5 to 15 km wide and dissected by a series of valley systems (Tille & Lantzke 1990).

The major geological feature within the catchment is the Leeuwin Complex, which was formed in the Proterozoic period and consists of intensely deformed plutonic igneous rocks (Marnham et al. 2000). The Cowaramup, Caves Road and Quindalup regolith-landform systems overlie the complex (Marnham et al. 2000).

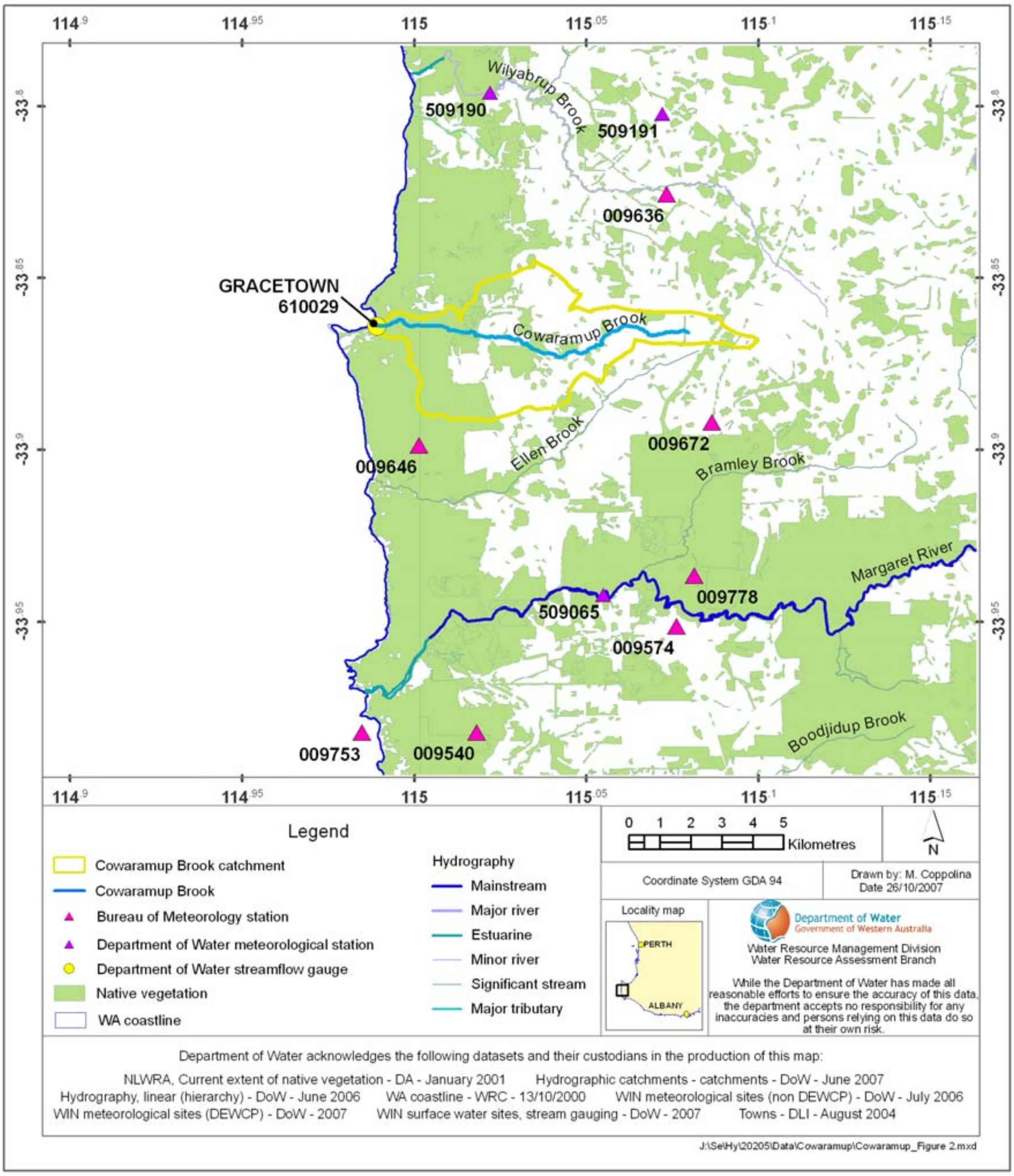

Figure 2 Cowaramup Brook catchment, showing streamflow and rainfall gauges and cleared area

The Spearwood regolith-landform system also occurs in the Cowaramup catchment (Marnham et al. 2000). Of the four, the Cowaramup system is dominant in the catchment (Figure 3). It consists of low hills and rises with gentle to moderate slopes (Marnham et al. 2000). The major streamlines in the catchment are within the Cowaramup system. The range of alluvial deposits in the streambeds includes boulders, silty clayey sand and fresh to slightly weathered bedrock. Granulite and granite outcrops are evident where the streambed is incised into the Proterozoic

Leeuwin Complex. These outcrops become more common toward the coast (Marnham et al. 2000).

The Quindalup and Caves Road systems occur near the coast, on the western side of the catchment. The Caves Road system contains thick podzolised sands composed almost entirely of quartz, while the Quindalup system contains shell and quartz sand (Marnham et al. 2000).

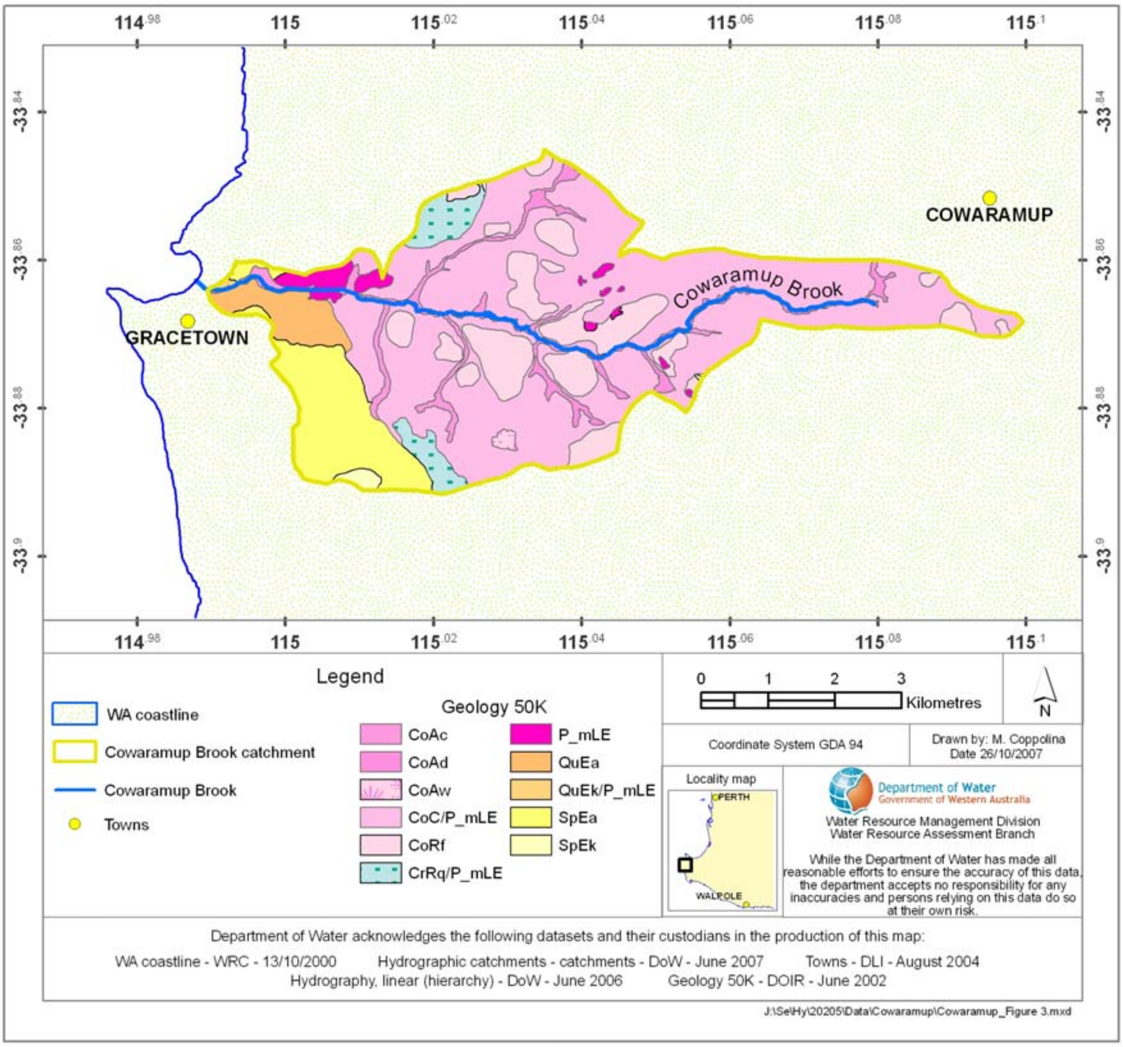

Figure 3 50K geology mapping of Cowaramup Brook catchment

2.3 Groundwater

Within the Cowaramup system (Margaret River Groundwater System) the groundwater tends to be brackish to saline and is generally low yielding (Marnham et al. 2000). Within the Quindalup and Spearwood systems (Leeuwin Naturaliste Coast Groundwater System), rapid channel flow occurs within the limestone, and a water table is often not developed (Marnham et al. 2000).

Despite this, there are numerous private bores across the catchment, the first recorded drilling having been undertaken in 1920 (Figure 4). Of the bores for which the Department of Water has records, the drilled depths range from 2.0 to 7.7 m below the ground surface. The majority of the private bores are used for livestock and/or domestic/household use. Fifteen of the bores had recorded static water levels, which in some cases were taken at the time of development while others were sampled in the late 1970s. The water levels ranged from 3.66 to 0.0 m below the ground surface. Salinity was also recorded at 16 of the bores; again, in some cases these records were taken at the time of development while others were sampled in the late 1970s. Salinities ranged from 120 to 1500 mg/L, with an average of 491 mg/L. In general, water with a salinity lower than 500 mg/L is considered to be fresh.

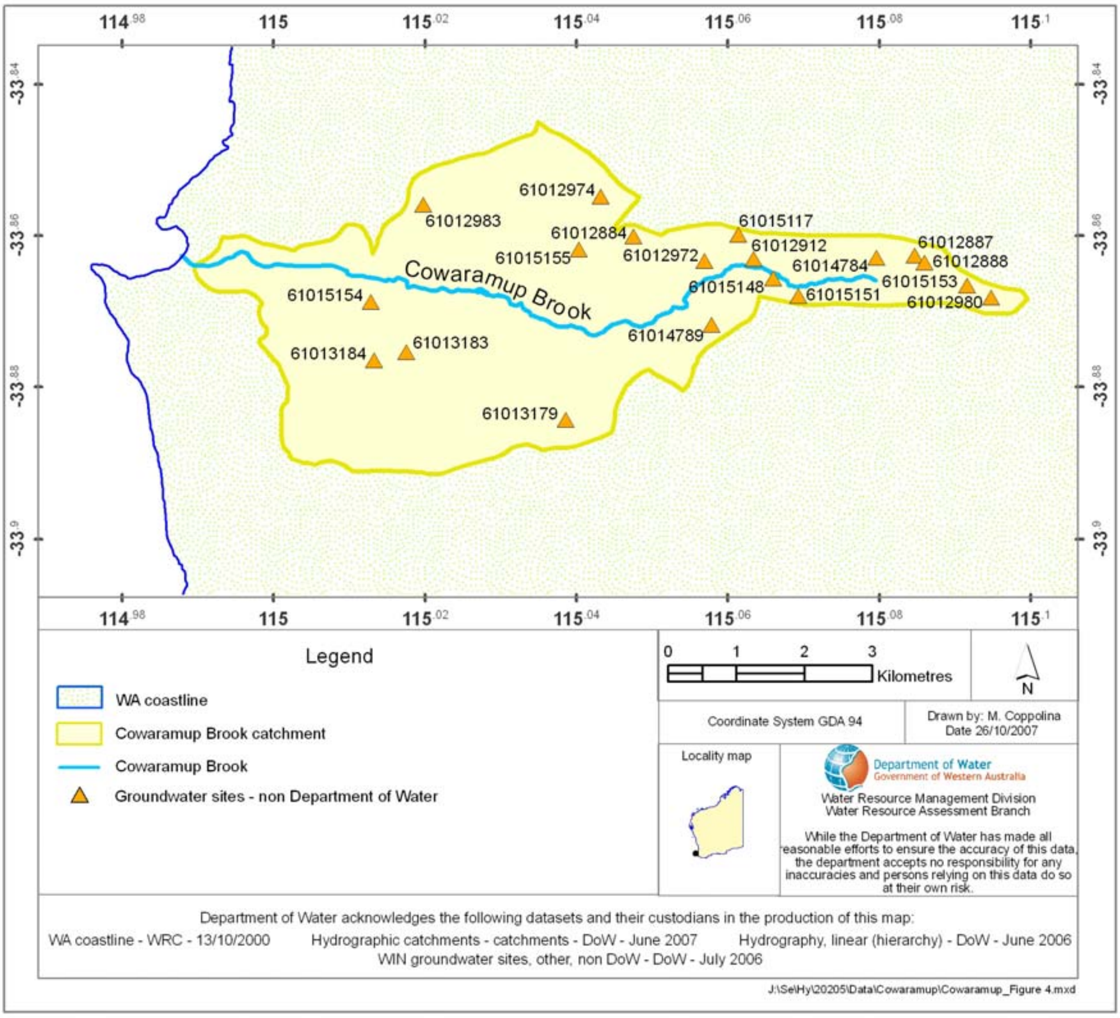

Figure 4 Private bores in the Cowaramup Brook catchment

2.4 Vegetation

Based on clearing figures from 1996, only 42 per cent of Cowaramup Brook catchment remains forested, approximately half of this occurring in Crown reserve National Parks. The remainder of the catchment would once have been covered in marri/jarrah forest, but the suitability of the land for several different land uses has led to a significant degree of clearing (Tille & Lantzke 1990).

The land on the western side of the catchment is under public tender, and the vegetation there is classified as being in very good condition (Connell et al. 1999). The majority of remnant vegetation in the catchment was classified in the report as being in good or very good condition, with only small pockets rated poor to fair (Connell et al. 1999).

3 Climate

Cowaramup Brook catchment has a temperate climate (based on the Köppen classification system), with a distinctly dry (and warm) summer and marked winter rainfall (Bureau of Meteorology 2006).

There are no rainfall stations operating within the Cowaramup Brook catchment, but there are many stations close by operated by the Bureau of Meteorology and the Department of Water (Figure 2). Ten close stations (within a 13 km radius of the catchment) were analysed so that a rainfall series for the catchment could be developed.

The standard period for analysis in studies such as this is 1975 to 2003 (Loh 2004), and a duration analysis on the 10 stations was conducted on this basis. Figure 5 shows the periods that the stations operated, the length of each record and the locations of large gaps in the data. (Due to the number of years shown on the graphs, only gaps greater than one month are visible.) In order to obtain a single representative rainfall series for the catchment, the Theissen polygon method was used. To provide an even coverage, stations 009636, 009574 and 509190 (with its record lengthened using a correlation with 009636) were selected to create this catchment rainfall series.

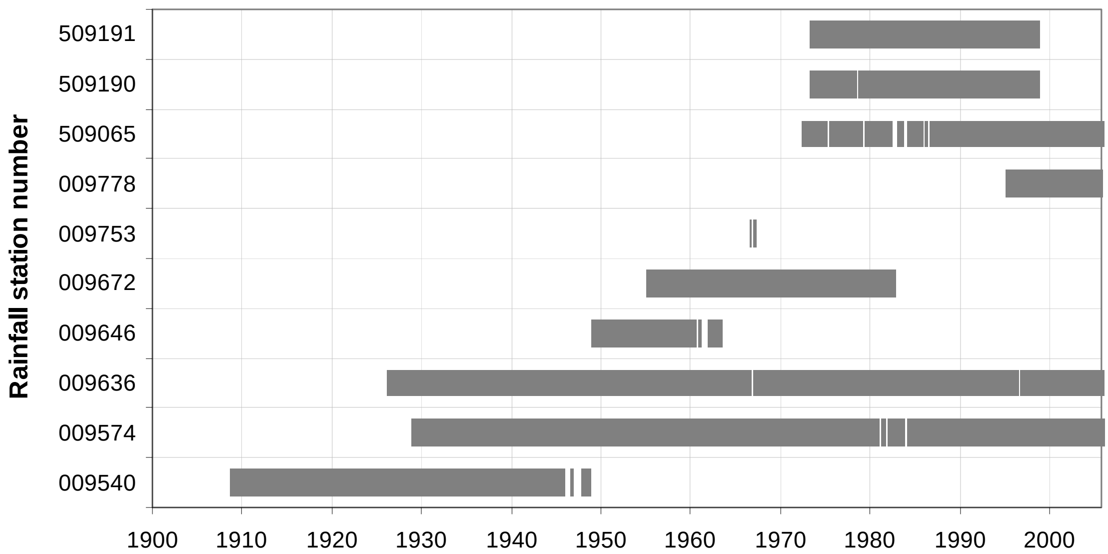

Figure 5 Record durations of 10 rainfall stations surrounding Cowaramup Brook catchment

Figure 6 shows the derived annual rainfall series for the Cowaramup Brook catchment. The wettest years experienced in the area were 1980, 1988 and 1996, while 1994 and 2001 were the driest. The mean annual rainfall for the catchment for 1975–2003 is 1000 mm.

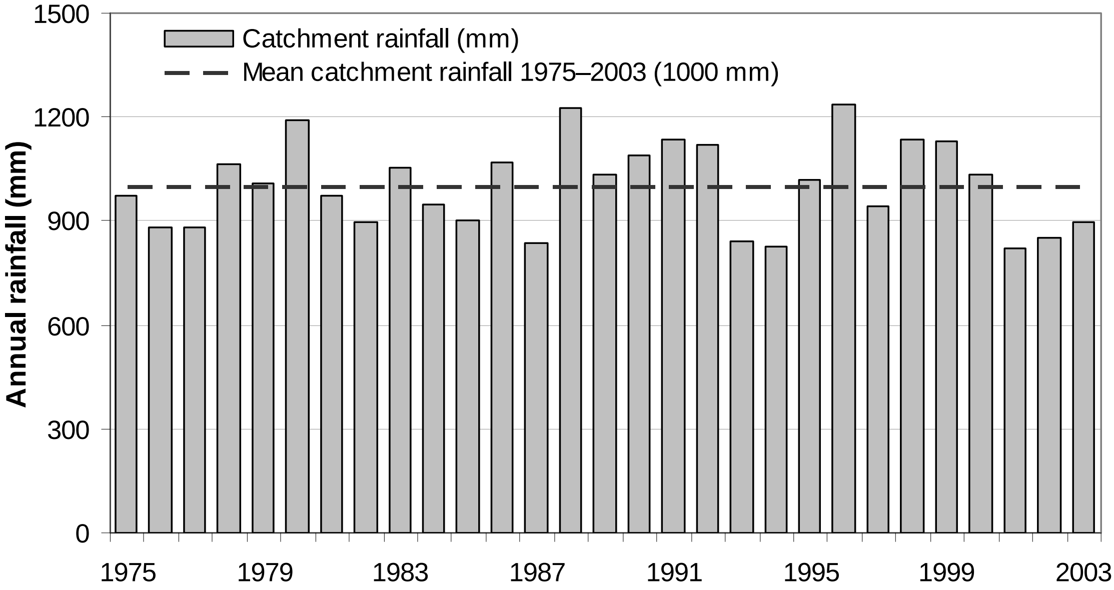

Figure 6 Annual rainfall for Cowaramup Brook catchment

The highly seasonal nature of the climate in the catchment is evident in the monthly breakdown of this series. Figure 7 shows the marked winter rainfall regime, where, on average, more than 100 mm falls each month from May to September (Figure 7). This period accounts for 78 per cent of the annual rainfall on the catchment.

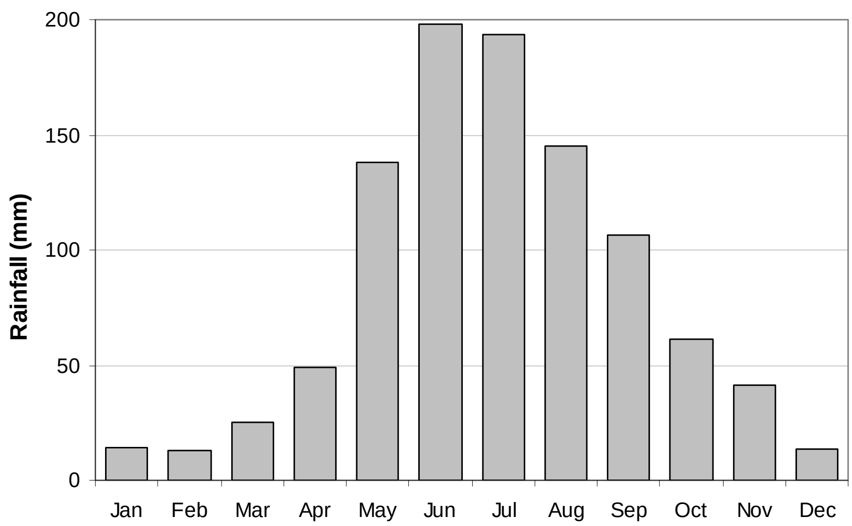

Figure 7 Monthly catchment rainfall averages for Cowaramup Brook catchment

Stations 009636 and 009574 began operation in the late 1920s. Periods of missing data in each record have been filled using the SILO dataset. Analysis at both stations revealed a similar pattern of rainfall change, where the plot of cumulative deviations from the mean changes from an increasing trend to a decreasing trend in the mid-1970s. Figure 8 shows the long-term analysis for station 009574. The long-term average (1929–1974) for this station was 1190 mm, while for the period 1975–2003 the average was only 1055 mm, a reduction of 12 per cent.

Stations 009636 and 009574 also record evaporation in the catchment. Average annual evaporation at 009636 for 1975–2003 was 1340 mm, with a range of 1210 mm to 1530 mm.

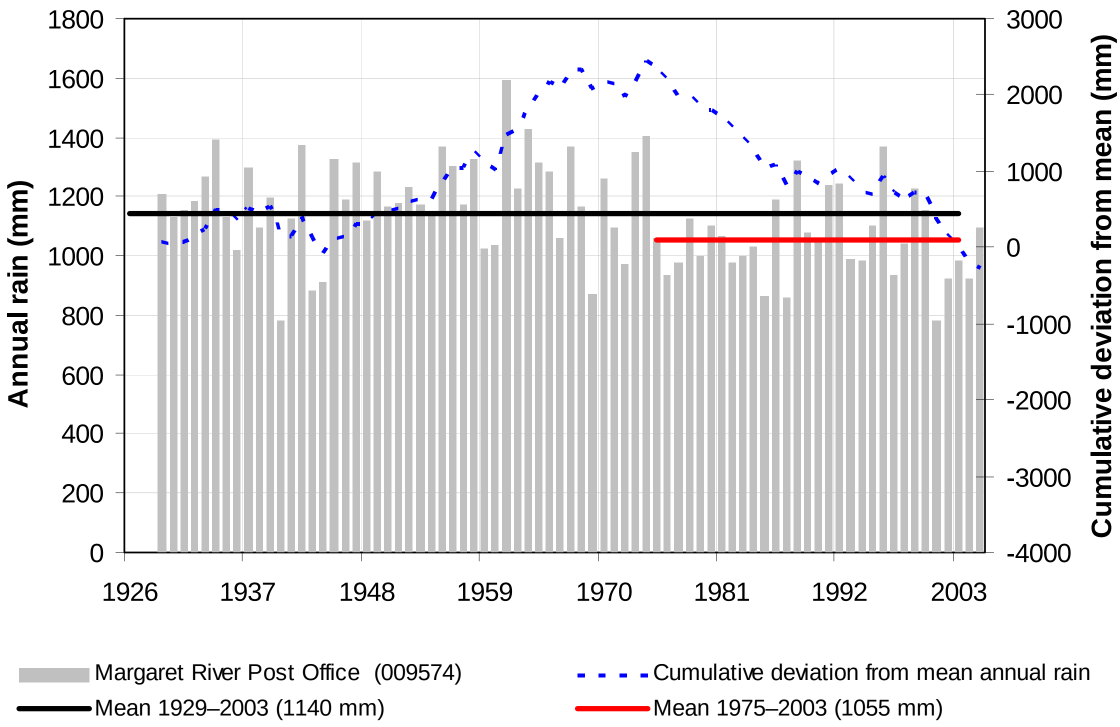

Figure 8 Long-term record at station 009574

4 Streamflow

One streamflow gauge operates along Cowaramup Brook. Located near the mouth of the brook, this station, 610029, records flow from 23.5 km^2 of the catchment (Figure 2). The station has been operating since the end of November 2004.

This component of the ecological water requirement process aims to develop a streamflow series for Cowaramup Brook for the standard analysis period (1975–2003). Due to the short period of record at 610029, it was not considered feasible to use a rainfall runoff model to generate the necessary data series. Instead, using the record available at the station (end November 2004 to end July 2006), a correlation was calculated between this and the record from nearby station 610006, located on Wilyabrup Brook.

Given that the catchments of the two brooks are quite close, receive similar rainfall and have similar soil and vegetation types, it is not surprising that a good correlation was found to exist between the two data sets. Figure 9 shows the daily series for each station over the period of common record and Figure 10 shows the results of the correlation using the 611 days available for comparison.

Based on this correlation, the daily streamflow record for 610006 was transformed to generate a daily streamflow record for 610029 for the standard analysis period (1975–2003). As a test, the record at 610006 was also transformed up to 2006 so that it could be compared to the observed data at 610029. Figure 11 shows the result, with the transformed series proving to be a good match in terms of magnitude and timing of events.

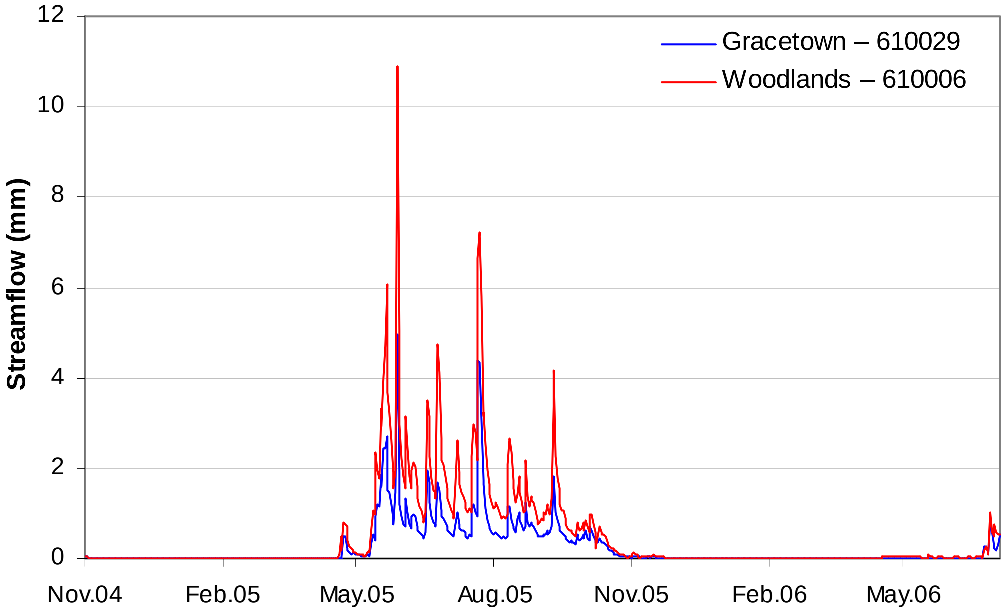

Figure 9 Daily records at 610029 and 610006

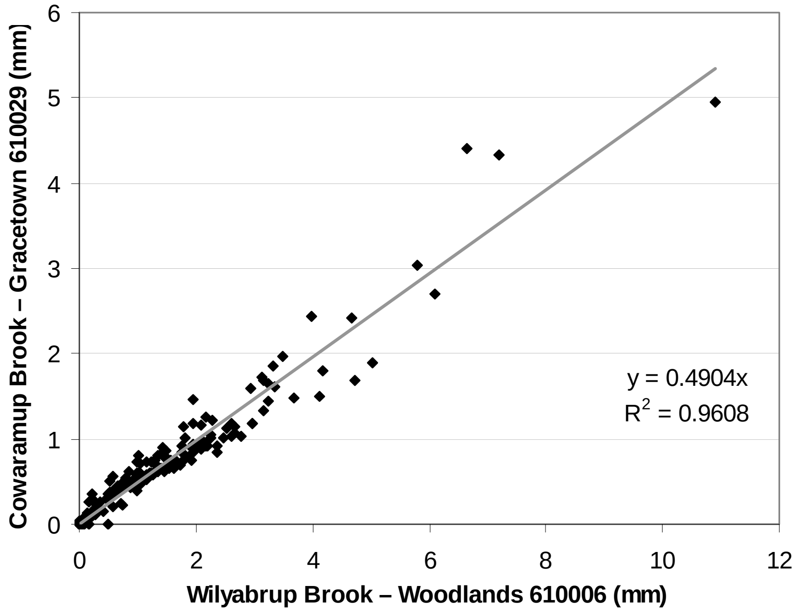

Figure 10 Correlation between stations 610029 and 610006 using data from end November 2004 to end July 2006

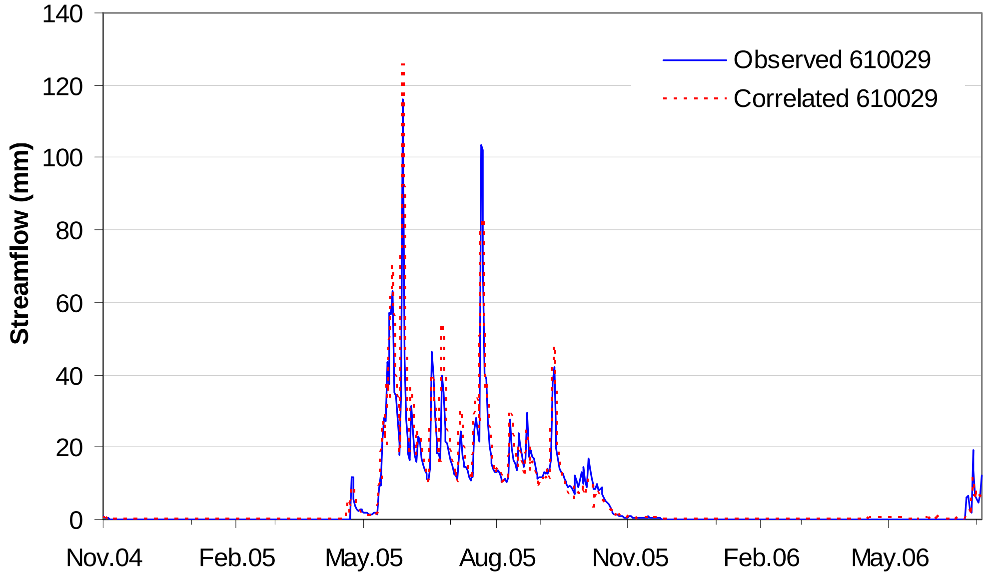

Figure 11 Verification of the compatibility of the transformed data series with the observed record at 610029 – Gracetown

4.1 Annual streamflow

Using these derived data, an annual-flow series was developed (Figure 12) and statistics were calculated for the flows at the Gracetown gauge for the standard analysis period (Table 1). The highest flow (5.38 GL) occurred in 1999, and was more than one and a half times greater than the 1975–2003 average flow of 3.35 GL. This average equates to a runoff of 142 mm/year and, when compared to the average rainfall for the period (1000 mm/year based on the catchment average rainfall), gives an annual runoff coefficient of 14.2 per cent. This coefficient is approximately half of that calculated for the Wilyabrup Brook catchment (27.5 per cent) and is probably related to the lower level of clearing in the Cowaramup Brook catchment.

The median and average flows in Table 1 are very similar. This similarity indicates an even distribution in the data. The annual coefficient of variation for the data was calculated as 0.36, which also indicates low variability in the annual-flow record.

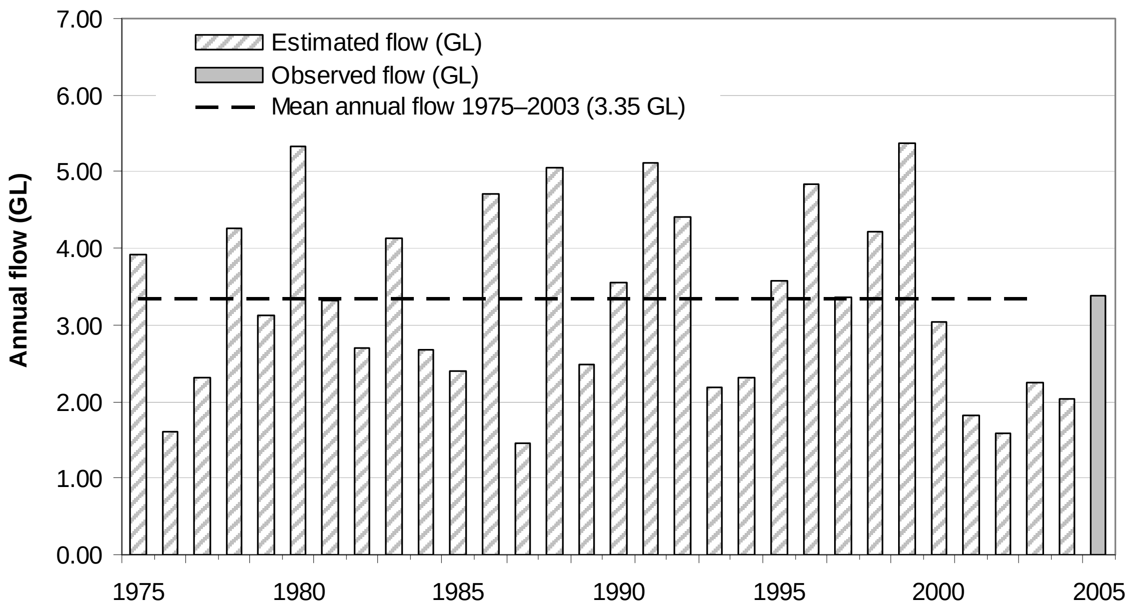

Figure 12 Annual streamflow at Gracetown – 610029

Table 1 Annual streamflow statistics at Gracetown – 610029

Statistic (1975–2003)	Value
Average (GL)	3.35
Median (GL)	3.32
Standard deviation (GL)	1.22
10th percentile (GL)	1.77
90th percentile (GL)	5.07
Coefficient of variation	0.36

4.2 Monthly streamflow

Streamflow in Cowaramup Brook is seasonal with, on average, 98 per cent of the flow occurring between June and October. The mean and median flows for these months were quite similar (Figure 13), indicating even distributions of the monthly streamflow totals around the mean.

In the summer and autumn months (December to May) there were large differences between the mean and median values. In these months the streamflow totals tend to be low but, due to weather events such as thunderstorms, there can be flows that significantly increase the total for a particular month. This skews the distribution and increases the mean monthly total.

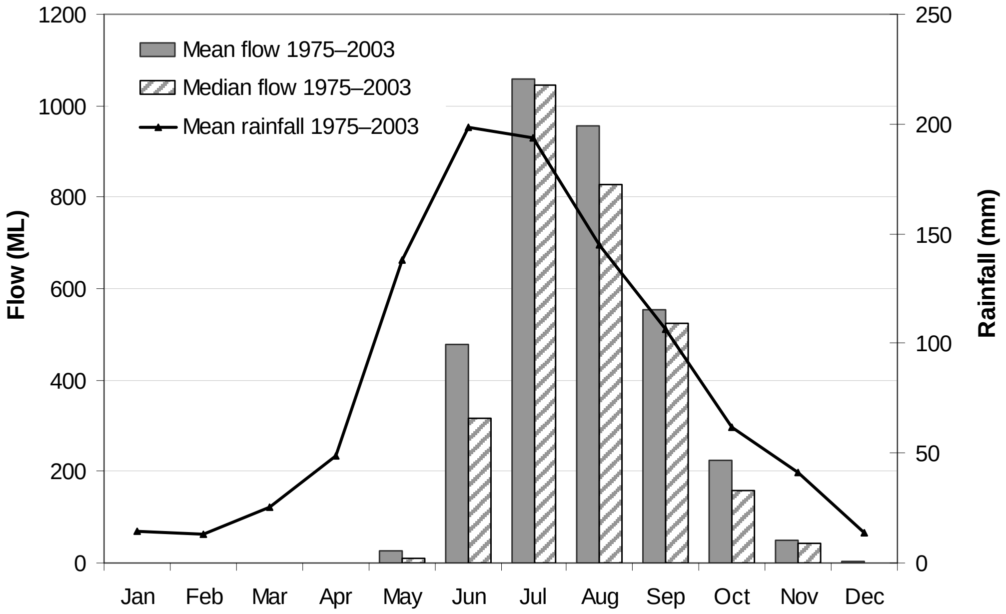

Figure 13 Mean and median streamflow at Gracetown and mean catchment rainfall

4.3 Daily streamflow

Flow-duration curves were calculated using daily data for both annual and monthly timesteps. For the annual analysis, daily flows for each year were ranked, assigned probabilities and then plotted (Figure 14). The grey lines indicate the yearly flow-duration curves, with the curve for the total period (1975–2003) being represented by the thick black line.

These curves can be used to describe the current flow regime and are important in the development of ecological flows. A significant interpretation to be gained from Figure 14, based on the total series plot, is that the brook flows at less than 0.01 ML/d for approximately 35 per cent of the time, this figure equating to just over 400 L/h or about 0.1 L/s.

The individual yearly flow-duration curves provide an indication of the variability in the Wilyabrup Brook flow regime. This variability occurs both vertically and horizontally around the flow-duration curve for the total period. Looking horizontally, flows greater than or equal to 1 ML/d are experienced over a range of 36 to 55 per cent of the time. Similarly, a vertical analysis of flows exceeded 50 per cent of the time shows they range from 0.007 to 1.76 ML/d.

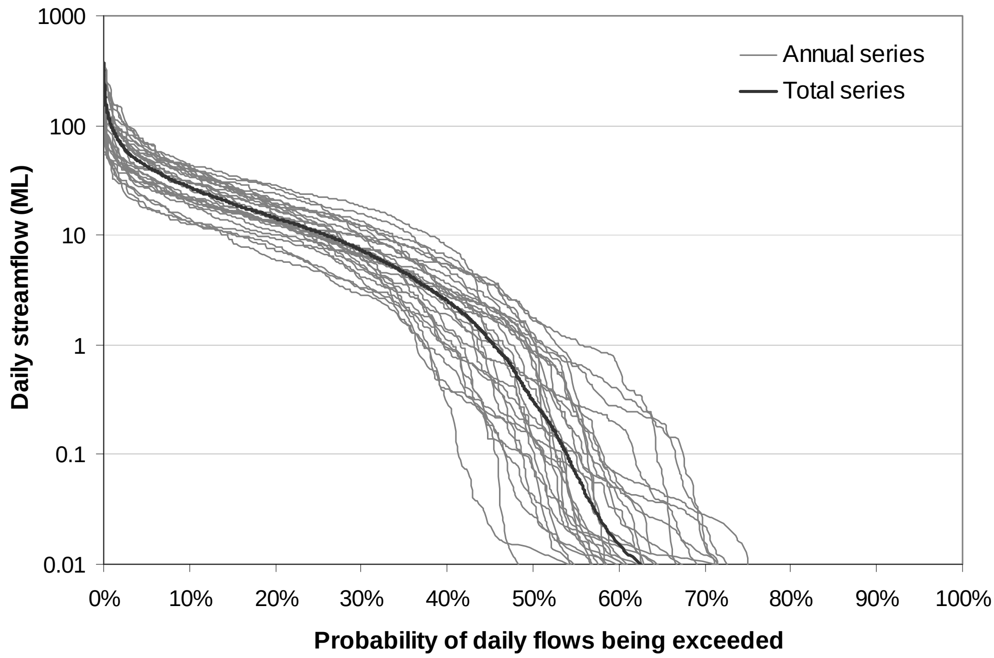

Figure 14 Yearly flow-duration curves at Gracetown – 610029

Flow-duration curves for 610029 were also calculated for each month using data from the period 1975–2003 (Figure 15). During the months from July to September the brook was always flowing at or above 1 ML/d. This is illustrated in Figure 15, where the value of streamflow exceeded 100 per cent of the time was greater than 1 ML, i.e. there was never zero flow in these months. From the graph, the months can be grouped into four clusters:

- July to September, where flows greater than 1 ML/d are experienced 100 per cent of the time and flows greater than or equal to 10 ML/d are experienced at least 67 per cent of the time.
- June, October and November, where flows greater than or equal to 0.01 ML/d are experienced at least 94 per cent of the time
- January to April, where flows greater than or equal to 0.01 ML/d are only exceeded 14 per cent of the time or less
- May and December, whose curves lie between the previous two clusters and where median daily flows range from 0.01 to 0.06 ML/d.

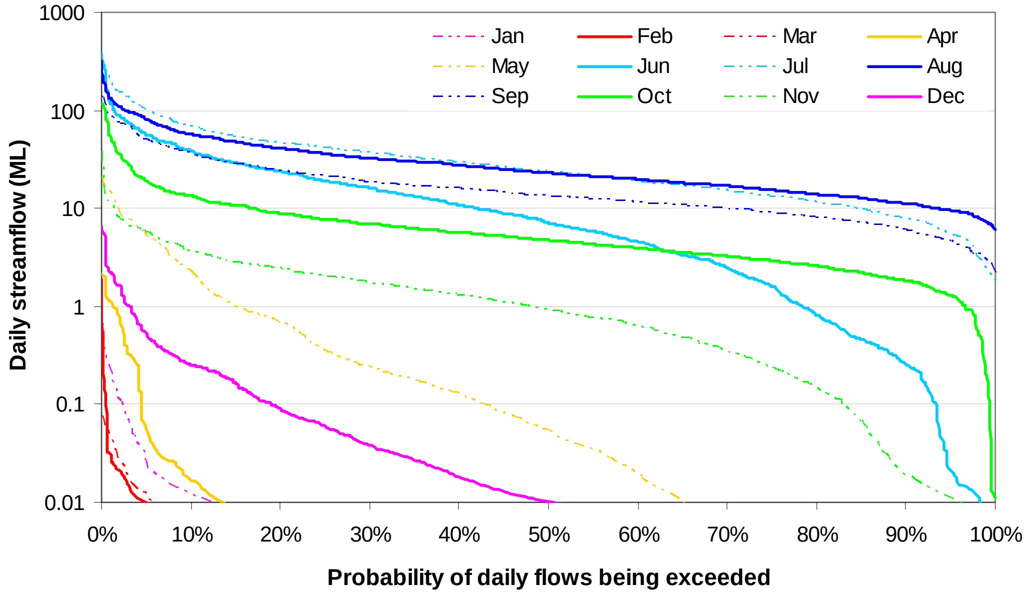

Figure 15 Monthly flow-duration curves at Gracetown – 610029

4.4 Flood frequency

A flood-frequency analysis for the Gracetown gauge was performed on the basis of the results of the flood-frequency analysis at the Woodlands gauge. The Woodlands analysis fitted a Log Pearson III distribution to 31 annual peaks recorded at the gauge. Based on the method described by Grayson et al. (1996) for estimating high flows in ungauged catchments, a set of flood-frequency values was calculated for the Gracetown gauge using the following equation:

$$Q_G = Q_W \left(\frac{A_G}{A_W}\right)^{0.7}$$

Where: Q_G = flow at Gracetown A_G = area of Gracetown catchment

Q_W = flow at Woodlands A_W = area of Woodlands catchment

The results of the analysis for significant average recurrence intervals are listed in Table 2.

Table 2 Results of FLIKE flood-frequency analysis for Gracetown – 610029

Average Recurrence Interval (1:year)	Annual Exceedance Probability (%)	Peak annual flow (m^3/s)	50% AEP Growth Factor
1.1	90.9	3.46	–
2	50	8.43	–
5	25	14.3	1.70
10	10	18.8	2.23
20	5	23.3	2.77
50	2	29.7	3.52
100	1	34.7	4.12

4.5 Baseflow

Finally, the daily streamflow series was run though the baseflow partitioning program in the Continuous Simulation System in order to obtain a baseflow series. The modelled baseflow sequence can be seen annually in Figure 16 and daily, for an example year (2005), in Figure 17. The partitioning used an average baseflow index of 0.450, or 45 per cent, with annual values ranging from 41 per cent to 52 per cent. Baseflow is a significant contribution to the total streamflow.

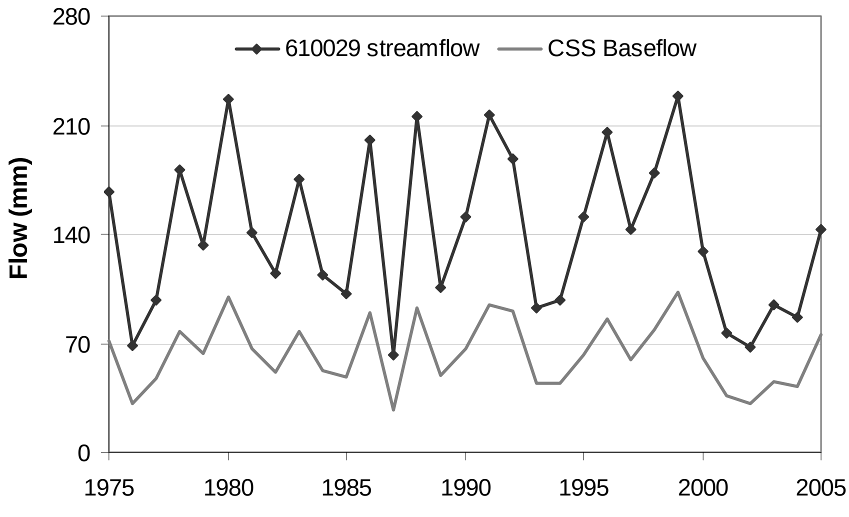

Figure 16 Annual observed streamflow and modelled baseflow series for Gracetown – 610029

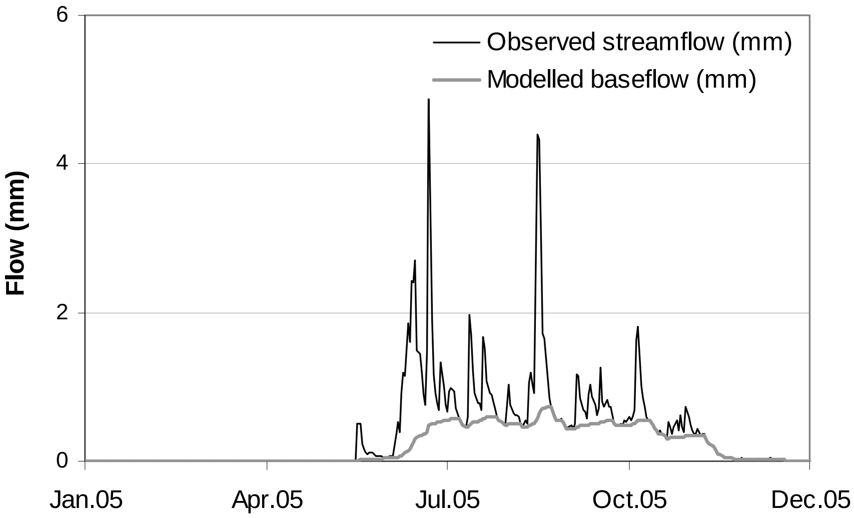

Figure 17 Daily observed streamflow and modelled baseflow for Gracetown – 610029

A monthly analysis of the data revealed that, on average, from September to December baseflow accounted for between 62 and 75 per cent of the total streamflow. This is shown in Figure 18, where the pattern of baseflow contribution is offset from that of streamflow, due to the lag that occurs between the filling of groundwater stores and groundwater expression at the beginning of each winter period. The timing and volume of this baseflow contribution may play an important role in sustaining ecological processes in and along the brook.

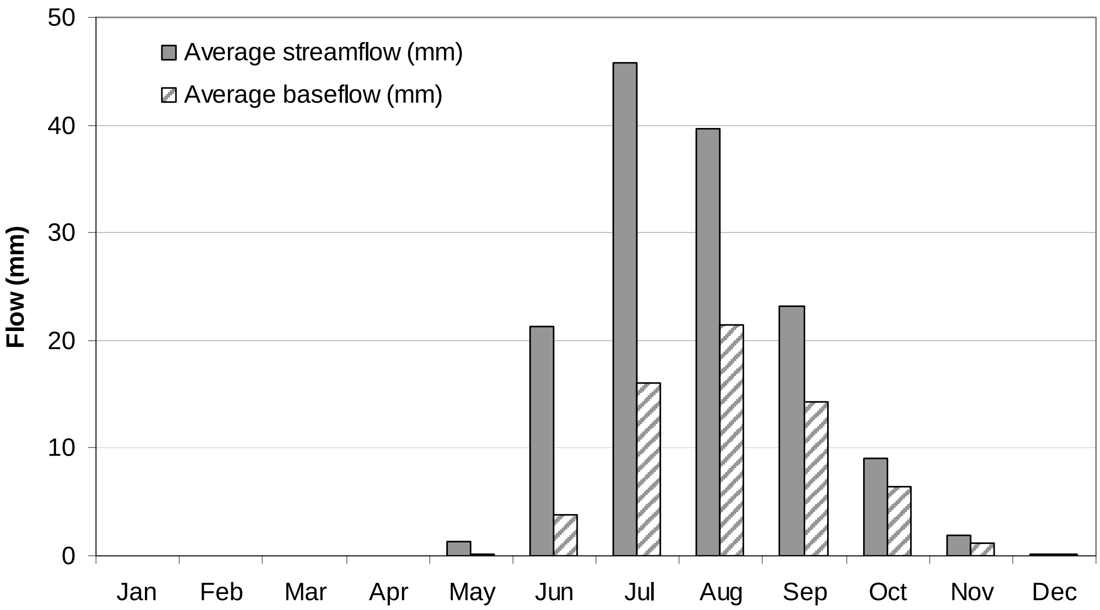

Figure 18 Monthly observed streamflow and modelled baseflow for Gracetown – 610029

5 Conclusion

Cowaramup Brook is located in the south-west corner of Western Australia in the Cape to Cape region. The catchment area is 23.5 km^2, of which 58 per cent is cleared, and viticulture is the dominant land use. As no gauges record rainfall in the catchment, surrounding stations were used to develop a catchment rainfall series. Based on this series, it was determined that 78 per cent of the average annual rainfall occurred in the five-month period from May to September. Analysis of one of the long-term stations revealed that rainfall for the period 1975–2003 was 12 per cent lower than the average for the previous 46 years.

Cowaramup Brook at Gracetown (610029), located near the outlet of the catchment, has been operating since the end of November 2004. A correlation with nearby station 610006 – Woodlands (on Wilyabrup Brook) – was completed to generate a daily streamflow series back to 1975. Based on the results of this, the average flow for Cowaramup Brook at 610029 was calculated to be 3.35 GL/y, with 98 per cent of the average annual streamflow occurring in the five-month period from June to October. The annual runoff coefficient calculated for the catchment was 14.2 per cent and the modelled baseflow index was 45 per cent. The seasonality of the baseflow contribution may play an important role in sustaining ecological processes in and along the brook.

The critical outcome of this hydrology analysis has been to produce daily streamflow series for 610029 for the period 1975–2003. This series will be used in the future to determine the ecological water requirements of Cowaramup Brook.

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