Hydrologic analysis
Tomaga and Moruya catchments

Report No. J047/R01 Draft B

October, 2002

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1 INTRODUCTION

This report outlines the hydrologic analysis undertaken to estimate streamflow characteristics for the tributaries of the Tomaga and Moruya River estuaries in southern New South Wales.

This hydrologic analysis forms a part of the estuarine process studies of the Tomaga and Moruya Rivers being undertaken by AMOG Consulting. Water Technology was commissioned to undertake the hydrologic analysis and carried out the analysis in accordance with instructions from AMOG Consulting.

The objectives of the hydrologic analysis were to estimate the following streamflow characteristics for tributaries of the Tomaga and Moruya estuaries:

- Design peak flood flows for the 1,5,20 and 50 year ARI events
- Dry weather and median daily flows

Figure 1.1 shows the tributaries of the Tomaga and Moruya estuaries for which the above streamflow characteristics were determined. For the Tomaga estuaries, three tributaries were analysed, while, four tributaries where analysed for the Moruya estuary. The numbering of the tributaries in Figure 1.1 corresponds to the numbering used in Sections 2 and 3 for the discussion of the analysis. Also shown in Figure 1.1 are the streamflow gauges used in the analysis and further discussion of the available streamflow data is provided in Sections 2 and 3.

The structure of this report is as follows:

- Section 2 – outlines the hydrological analysis employed to determine streamflow characteristics for tributaries of the Tomaga River Estuary
- Section 3- outlines the hydrological analysis employed to determine streamflow characteristics for tributaries of the Moruya River Estuary.

The methodology used in this analysis, as described in Sections 2 and 3, is considered appropriate given the scope and nature of the overall estuary process studies. The streamflow characteristics determined by this study should be solely used for input to the current estuary process studies. A more detailed analysis is recommended before using this study's streamflow characteristics for other investigations and/or purposes.

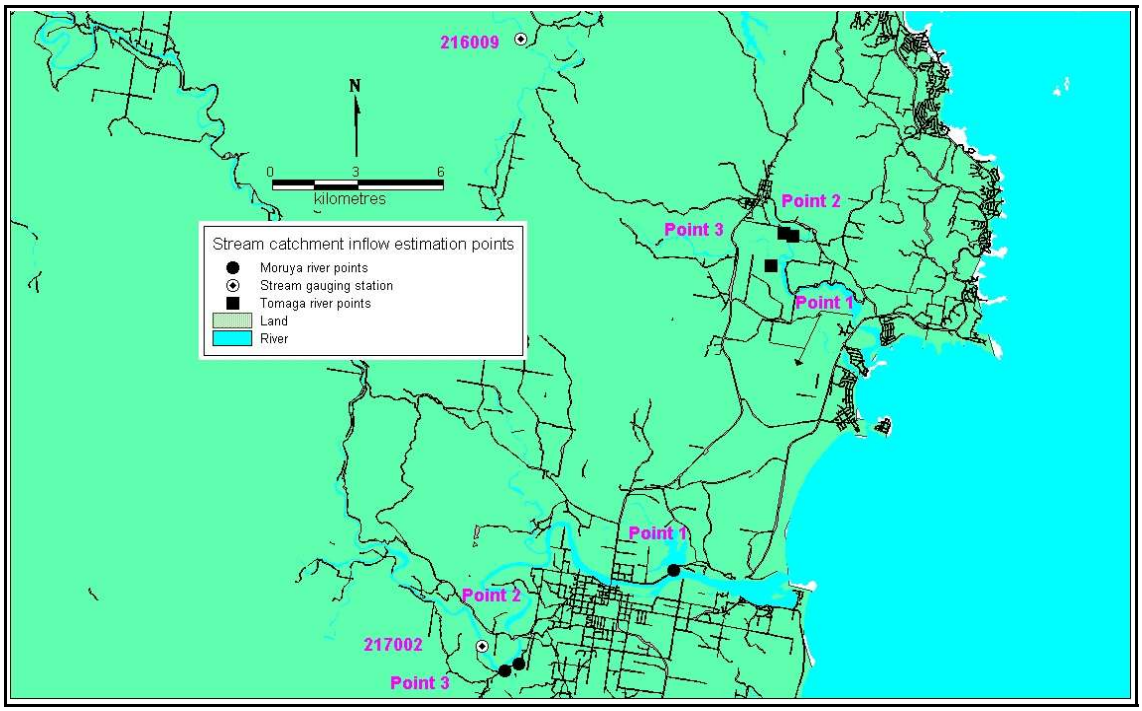

Figure 1.1 Locations of the Tomaga and Moruya estuary inflow points and streamflow gauging stations

2 TOMAGA CATCHMENT FLOWS

For the Tomaga estuary, streamflow characteristics were evaluated at three locations as shown in Figure 1.1. As no streamflow data is available within the Tomaga estuary catchment, the streamflow characteristics were evaluated using streamflow data from adjacent catchments and regional techniques. Details of the methodology and results are provided in Sections 2.1 and 2.2.

2.1 ESTIMATION OF DRY WEATHER AND MEDIAN DAILY FLOWS

In the absence streamflow measurements in the Tomaga catchment, the streamflow records of the Buckenbowra River at Buckenbowra No. 3 (gauging station 216009) were used to estimate mean daily flow in the Tomaga catchment. The Buckenbowra River is located to the north of the Tomaga River as shown in Figure 1.1. It is considered, due to the proximity of the Buckenbowra River to the Tomaga River, the streamflow characteristics of the two catchments are likely be to broadly similar. Given this likely similarity, it is considered reasonable to use streamflow data from the Buckenbowra River to estimate streamflow characteristics for the Tomaga estuary tributaries for the purposes of this study.

A flow duration analysis for the Buckenbowra River was performed using the mean daily flow data (23/12/1992 to 13/06/2002) at Buckenbowra No. 3 (gauging station 216009). The flow duration analysis ranked the daily flows in ascending order and determined the percentage of time a given flow is exceeded. The median, 80 and 90 percentile (percent time exceeded) daily flows were obtained from this analysis. Figure 2.1 shows the flow duration curve for the period from 23/12/1992 to 13/06/2002 at Buckenbowra No. 3 (gauging station 216009).

Dry weather flows were also obtained from the flow duration analysis undertaken on a seasonal basis. The mean daily flows (23/12/1992 to 13/06/2002) at Buckenbowra No. 3 (gauging station 216009) were grouped according to the season. A flow duration analyses were then performed on daily flow data for each season. The season adopted by this study were summer (Dec-Feb), autumn (Mar-May), winter (Jun-Aug) and spring (Sep-Nov). This process provides estimates of median, 80 and 90 percentile daily flow in each season. Figure 2.1 shows the entire period and seasonal flow duration curves at Buckenbowra No. 3 (gauging station 216009).

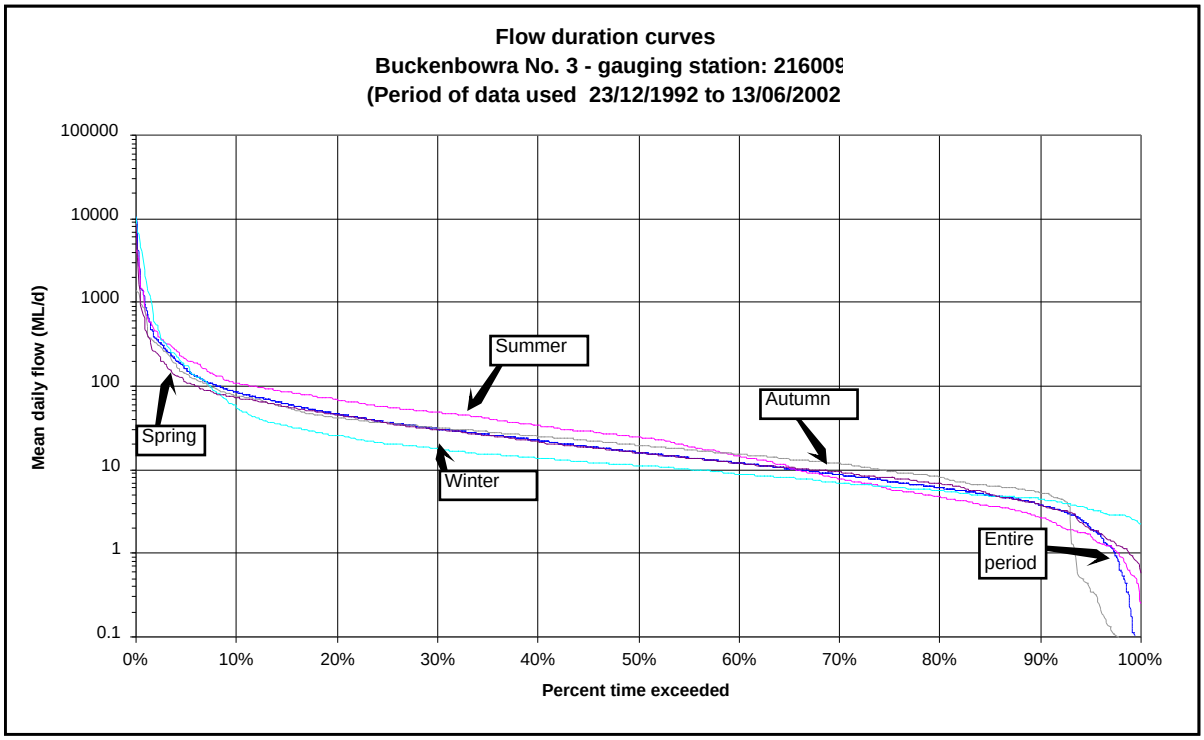

Figure 2.1 Flow duration curves for the Buckenbowra River at Buckenbowra No.3

The results showed in Figure 2.1 are for the Buckenbowra River at Buckenbowra No. 3 with a catchment area of 168 km2. These values were then translated to the tributaries of the Tomaga estuary as shown in Figure 1.1. This translation was based on a linear correction factor based on the relevant catchment area and the catchment area at Buckenbowra. Table 2.1 shows the estimated mean daily flow at the inflow points considered and the corresponding catchment areas.

Table 2.1 Dry weather and median Mean daily flows at the Tomaga catchment inflow points

Point 1: *Catchment* Area – 32.37 *km²*

Percent time exceeded	Mean Daily Fflow in (m^3³/s)				
	Summer	Autumn	Winter	Spring	All data
50%	0.055	0.044	0.025	0.035	0.036
80%	0.011	0.018	0.012	0.015	0.014
90%	0.006	0.012	0.010	0.008	0.008

Point 2: Drainage *Catchment* Area – 19.94 sq km*2*

Percent time exceeded	*Mean Daily Fflow in (m³^3/s)*				
	Summer	Autumn	Winter	Spring	All data
50%	0.034	0.027	0.016	0.022	0.022
80%	0.007	0.011	0.008	0.009	0.008
90%	0.004	0.007	0.006	0.005	0.005

Point 3: DrainageCatchment Area – 28.69 *km²*sq km

Percent time exceeded	Mean Daily fFlow in (m³^3/s)				
	Summer	Autumn	Winter	Spring	All data
50%	0.048	0.039	0.022	0.031	0.032
80%	0.009	0.016	0.011	0.014	0.012
90%	0.005	0.010	0.009	0.008	0.008

2.2 ESTIMATION OF DESIGN PEAK FLOOD FLOWS

In the absence of streamflow data, the Rational Method was used to determine the design peak flood flows for the tributaries as shown in Figure 1.1.

The rational method, as recommended for Eastern New South Wales (Institution of Engineers, Australia, 1987), was applied to the entire Tomaga River estuary catchment. The parameters adopted are provided in Table 2.2.

Table 2.2 Rational Method parameters for Tomaga River estuary catchment

Model parameter	Adopted value	Reference
Time of concentration t_c	4.2 hours	- IEAust (1987) $t_c = 0.76 *(\text{Catchment area})^{0.38}$
10 year ARI Runoff Co-efficient C_{10}	0.48	- Australian Rainfall Runoff (IEAust 1987) Volume 2
Average recurrence interval factor Fy	0.75 0.90 1.10 1.15	- IEAust (1987) – Table 5.1 (Below 500 m) 1 year ARI 5 year ARI 20 year ARI 50 year ARI

Design rainfall depths for the Tomaga River estuary were determined using the procedure outlined in Australian Rainfall Runoff (IEAust 1987).

Table 2.3 presents the calculated peak discharge for 1, 5, 20 and 50 year ARIs from the total area (90.54 km2) of the Tomaga catchment.

Table 2.3 Peak flow at the Tomaga catchment outlet

Average Recurrence IntervalARI (years)	Peak flow (m^3/s)
1 Year	89.990
5 Year	236
20	400
50	509

From these estimates, peak flow in each tributary as shown in Figure 1.1 can be determined according to the relevant catchment areas as given in Table 2.1.

3 MORUYA CATCHMENT FLOWS

For the Moruya estuary, catchment inflows were evaluated at five locations as shown in Figure 1.1. In Figure 1.1, Moruya inflow points 1 to 4 represent inflows from small tributaries located adjacent to the estuary, whereas, point 5 is the inflow from the Devu/Moruya River.

The catchment areas for the small tributaries (points 1 to 4) range from 18 to 74 km^2. No streamflow data is available for the small tributaries. For these small tributaries, the streamflow characteristics were evaluated using streamflow data from adjacent catchments and regional techniques.

The catchment area for the Devu/Moruya River to Point 5 is approximately 1200 km^2. Streamflow data for the Moruya River at Wamban (gauge number 217002) is available. Design peak flood flow estimates at Wamban were determined as part of a previous study by the Public works Department in 1992 (Public Works Department 1992). Inflow point 5 is located just downstream of Wamban with no significant additional catchment area contributing between the two locations. For this study, the streamflow characteristics for Point 5 were determined using the available streamflow data at Wamban and the design peak flood flow estimates from the previous study.

Details of the methodology and results for the Moruya estuary inflows are provided in Sections 3.1 and 3.2.

3.1 ESTIMATION OF DRY WEATHER AND MEDIAN DAILY FLOWS

3.1.1 Small tributaries inflows (Points 1 to 4)

The inflows from the small tributaries were estimated using the results obtained from the flow duration analysis on the Buckenbowra River, as discussed in Section 2.1. The median, 80 and 90 percentile flows at the inflow points 1 to 4 were determined by adjusting the flow for the Buckenbowra River according to the ratio of the relevant catchment areas. The results are given in Table 3.1.

Table 3.1 Dry weather and median daily at the Moruya catchment inflow points 1 to 4

Point 1: Catchment area – 27.18 km^2

Percent time exceeded	Flow (m^3/s)				
	Summer	Autumn	Winter	Spring	All
50%	0.046	0.037	0.021	0.030	0.030
80%	0.009	0.015	0.010	0.013	0.011
90%	0.005	0.010	0.008	0.007	0.007

Point 2: Catchment area – 41.83 km^2

Percent time exceeded	Flow (m^3/s)				
	Summer	Autumn	Winter	Spring	All
50%	0.071	0.057	0.033	0.046	0.046
80%	0.014	0.023	0.016	0.020	0.018
90%	0.008	0.015	0.013	0.011	0.011

Point 3: Catchment area – 75.55 km^2

Percent time exceeded	Flow (m^3/s)				
	Summer	Autumn	Winter	Spring	All
50%	0.124	0.100	0.057	0.081	0.082
80%	0.024	0.041	0.028	0.035	0.031
90%	0.014	0.027	0.023	0.019	0.019

Point 4: Catchment area – 718.68 km^2

Percent time exceeded	Flow (m^3/s)				
	Summer	Autumn	Winter	Spring	All
50%	0.032	0.025	0.015	0.020	0.021
80%	0.006	0.010	0.007	0.009	0.008
90%	0.003	0.0007	0.006	0.005	0.005

3.1.2 Moruya River inflow (Point 5)

A flow duration analysis was undertaken, to estimate the median and dry weather flows of the Moruya catchment, using the streamflow record for the Moruya River at Wamban (gauge 217002).

The available streamflow data for the Moruya at Wamban contains several periods of missing data. Streamflow data from the Tuross River at Eurobodalla (gauge 218008) was used to infill the periods of missing data in the streamflow record at Wamban. The Tuross River is located to the south of Moruya River as shown in Figure 1.1.

For the purpose of infilling missing data in the daily record at gauge 217002, a linear regression relationship was developed between the monthly totals of the mean daily flow at the two gauging stations. The relationship developed is shown in Figure 3.1.

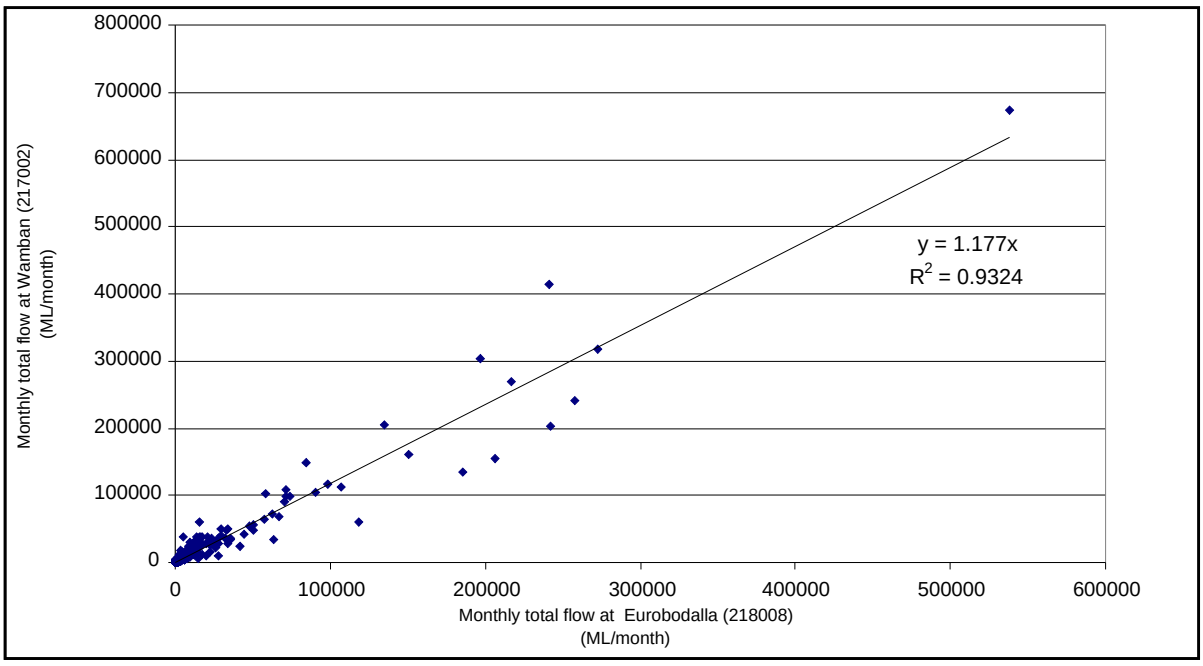

Figure 3.1 Regression relationship between monthly flows at Wamban and Eurobodalla

A flow duration analysis was performed using mean daily flows record (including infilled data) at gauge 217002. The median and dry weather flows were obtained corresponding to 50, 80 and 90 percentile values. As for the Tomaga (see Section 2.1), a seasonal flow duration analysis were undertaken using the daily flow at Wamban. The seasonal flow duration analysis for the Moruya was conducted using the same methodology as the Tomaga. The results from the flow duration analyses are given in Table 3.3. Figure 3.2 shows the entire period and seasonal flow duration curves.

Table 3.3 Dry weather and median flows at the Moruya catchment inflow point 5

Percent time exceeded	Flow (m^3/s)				
	Summer	Autumn	Winter	Spring	All
50%	1.464	2.070	1.960	1.808	1.811
80%	0.376	0.580	0.686	0.686	0.571
90%	0.163	0.279	0.421	0.244	0.278

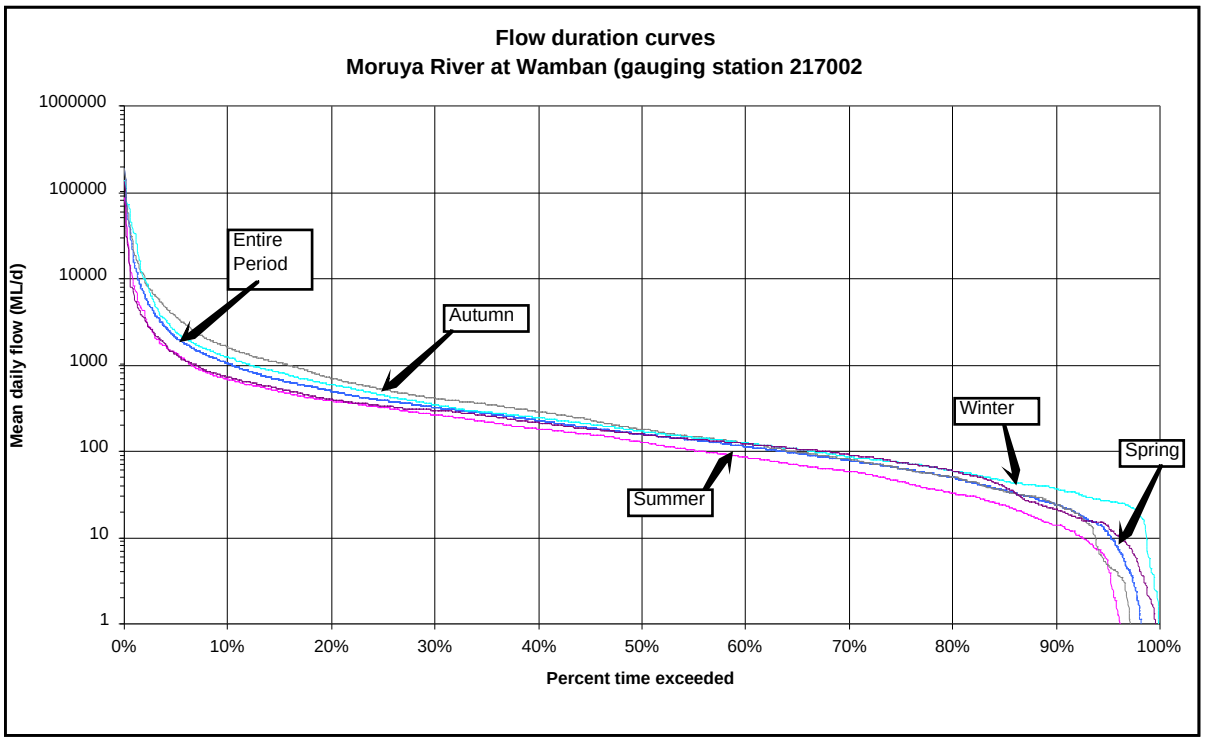

Figure 3.2 Flow duration curves for the Moruya River at Wamban

3.2 ESTIMATION OF DESIGN PEAK FLOOD FLOWS

3.2.1 Small tributaries inflows (Points 1 to 4)

The design peak flood flows for points 1 to 4 were calculated using the peak flow estimates of the Tomaga catchment and by correcting it according to the ratio of the relevant catchment area to the Tomaga catchment area. This approach was used as the catchment areas at the inflow points of the Moruya catchment are similar in size to the Tomaga catchment in comparison with that of the Moruya catchment area at Wamban.

Table 3.4 Peak flow at the Moruya catchment inflow points 1 to 4

Point 1: Catchment area – 27.18 km²

ARI (years)	Peak flow (m³/s)
1	27.6
5	72.5
20	122.9
50	156.5

Point 2: Catchment area.-.41.83 km²

ARI (years)	Peak flow (m³/s)
1	41.5
5	109.0
20	184.8
50	235.3

Point 3: Catchment area - 73.55 km²

ARI (years)	Peak flow (m³/s)
1	73.0
5	191.7
20	324.9
50	413.8

Point 4: Catchment area – 18.68 km²

ARI (years)	Peak flow (m³/s)
1	18.5
5	48.7
20	82.5
50	105.1

3.2.2 Moruya River inflow (Point 5)

A flood study for the Moruya River undertaken by the New South Wales Public Works Department in 1992 estimated design peak flows at Wamban for the 20, 50 and 100 year ARI events. This previous study adopted a comprehensive approach employing a calibrated hydrologic model with design rainfall estimates to evaluate the design peak flows. Given the use of a comprehensive approach, it is considered appropriate to adopt the design peak flow estimates for the 20 and 50 year ARIs from the previous study for use in this study.

The previous study did not consider the 1 and 5 year ARI flood events. As part of this study, a flood frequency analysis was performed using the stream flow records for the Moruya River at Wamban (gauge 217002). Based on the results, design peak flood flows corresponding to the 1 and 5 year ARI were obtained.

Table 3.4 displays the design peak flood flows for the 1, 5, 20 and 50 year ARI for inflows at Point 5.

Table 3.4 Design peak flood flows at the Moruya catchment point 5

Drainage Area 1207 sq km	
ARI (years)Average Recurrence Interval	Peak flow (m^3/s)flow (m^3/s)
11 Year	431
55 Year	1230
20	3250
50	4300

Table 3.5 Peak flow at the Moruya catchment inflow points

Point 1: Drainage Area 27.81 sq km

Average Recurrence Interval	Peak flow (m^3/s)
1 Year	27.6
5 Year	72.5
20 Year	122.9
50 Year	156.5

Point 2: Drainage Area 41.83 sq km

Average Recurrence Interval	Peak flow (m^3/s)
1 Year	41.5
5 Year	109.0
20 Year	184.8
50 Year	235.3

Point 3: Drainage Area 73.55 sq km

Average Recurrence Interval	Peak flow (m^3/s)
1 Year	73.0
5 Year	191.7
20 Year	324.9
50 Year	413.8

Point 4: Drainage Area 18.68 sq km

Average Recurrence Interval	Peak flow (m^3/s)
1 Year	18.5
5 Year	48.7
20 Year	82.5

4 REFERENCES

Institution of Engineers Australia (IEAust, 1987): *Australian Rainfall and Runoff*, Vols 1&2. (Ed: Pilgrim D.H.) Institution of Engineers, Australia

Public Works Department (1992): *Moruya River Flood Study*. New South Wales Public Works Department – Coast and Estuaries Branch. Report No. 92006 . ISBN 0730594327. December 1992