Setting Flood Planning Levels under a Changing Climate on the Nepean River Floodplain in the Camden LGA

B.C. Phillips[1]*, S. Chakrabarty[1] and B. Kilaparty[2]

[1] *Cardno (NSW/ACT) Pty. Ltd, Level 9, 203 Pacific Highway, St Leonards NSW 2072, Australia*

[2] *The Hills Shire Council, Administration Centre, 3 Columbia Court Norwest NSW 2153, Australia*

**Corresponding author email: brett.phillips@cardno.com.au*

Highlights

- A 10% increase in rainfall causes 1% AEP flood levels to increase by between 0.6 m – 1.5 m.
- A 0.5 m freeboard could be exceeded within the planning horizon under a changing climate.
- It is unclear if 1% AEP flood levels are conservative or not which has impacts on the freeboard.

Introduction

Flooding in the Nepean River and its tributaries within the Camden LGA has been the subject of flood studies undertaken in 1986, 1990, 1995, 1997, 1998 and 2015. Camden, located 65km west of Sydney, covers an area of 215 km^2 and lies in the upper reaches of the wider Hawkesbury-Nepean catchment.

The 2015 Nepean River Flood Study (Worley Parsons, 2015) assessed the impact of a 10% and 20% increase in 1% AEP rainfall intensities on 1% AEP flood levels on the Nepean River floodplain. In the case of a 10% increase in the 1% AEP rainfall intensities, it has been assessed that 1% AEP flood levels would increase by between 0.6 m – 1.5 m depending on location. The concern that arises is that under a changing climate a flood planning level based on the 1% AEP flood level plus a standard 0.5 m freeboard could be exceeded by a changing 1% AEP flood level well within the planning horizon. This issue is explored in Tables 1 and 2.

The ARR Data Hub provides a table of temperature increases and percentage increase in rainfall for a set of forecast years and RCP 4.5, 6 and 8.5 emissions scenarios (CSIRO and BoM, 2015). ARR recommends the use of RCP 4.5 and 8.5 values. Table 1 lists the values for Sydney (within the East Coast South Cluster).

Table 1 Interim Climate Change Factors for NRM East Coast South (Design Rainfall Increase in %) (Source: ARR Datahub)

Year	RCP4.5	RCP8.5
2030	4.3%	4.9%
2040	5.3%	6.8%
2050	6.4%	9.0%
2060	7.5%	11.5%
2070	8.5%	14.2%
2080	9.2%	16.9%
2090	9.5%	19.7%

Table 2 Timeframes in which a 0.5 m Freeboard may reduce to 0.0 m under a Changing Climate

How long would floor levels be protected 0% CC allowance + 0.5 m freeboard?

	Zone A			Zone B		
Freeboard	0.5	0.5	0.5	0.5	0.5	0.5
FL Rise due to 0% increase	0	0	0	0	0	0
FPL	0.5	0.5	0.5	0.5	0.5	0.5
FL Rise due to 10% increase	0.25	0.50	0.75	0.75	1.00	1.50
Rainfall increase to exceed FPL	>20%	10%	6.9%	6.9%	4.6%	3.0%
Year when reached under RCP4.5	>>2100	2100	**2055**	**2055**	**2034**	***2022***
Year when reached under RCP8.5	2090	**2053**	**2040**	**2040**	***2028***	***2020***

How long would floor levels be protected with 10% CC allowance + 0.5 m freeboard?

	Zone A			Zone B		
Freeboard	0.5	0.5	0.5	0.5	0.5	0.5
FL Rise due to 10% increase	0.25	0.5	0.75	0.75	1.0	1.5
FPL	0.75	1.0	1.25	1.25	1.5	2.0
Rainfall increase to exceed FPL	>>20%	25%	21%	21%	17%	14%
Year when reached under RCP4.5	>>2100	*>>2100*	>>2100	>>2100	*>>2100*	*>2100*
Additional years protected			>45	>45	>66	>68
Year when reached under RCP8.5	>2100	2105	2092	2092	2080	2070
Additional years protected	>10	52	52	52	52	50

Methodology

The streamflow records at Station 212202 (Nepean River @ Wallacia Weir) reported in the 2015 Nepean River Flood Study (Worley Parsons, 2015) were re-analysed using the FFA procedure released by ARR2016.

Peak-Over-Threshold (POT) Gauged Series Analysis at Wallacia Weir (Station 212202)

A POT series consists of all floods with peak discharges above a selected threshold value regardless of the number of such floods occurring each year however there should not be more than 3 or 4 floods above the threshold each year (ARR, 2016). The POT series reported by (Worley Parsons, 2015) based on a threshold of 400 m^3/s was found to have no more than 3 flood events which occurred above the threshold in any one year. The POT series includes 57 events which exceeded the threshold over the period 1917 - 2012, at a ratio of 0.6 to 1. When fitting a Log Pearson III (LP III) distribution it is recommended that the ratio of floods to number of years of record be 1:1 (Jayasuriya and Mein, 1985). The POT series did not meet this criterion.

TUFLOW FLIKE analyses were undertaken of the following cases, using the LPIII probability model:

- Case 0: Period from 1860 to 2012 with a flow threshold of 400 m^3/s;
- Case 1: Period from 1917 to 2012 with a flow threshold of 400 m^3/s;
- Case 2: Case 1 plus 3 exceedances of 3,940 m^3/s in the preceding 58 years.

Results

The results of the FLIKE FFA analysis are given in **Table 3**. A comparison of the peak flows estimated at Wallacia Weir using RORB and the 1% AEP flows estimated by FFA are summarized in **Table 4**.

Table 3 2019 FFA for Nepean River at Wallacia Weir (Station 212202)

	AEP (1 in X)					
	2	**5**	**10**	**20**	**50**	**100**
Case 0	830	1,694	2,756	4,384	7,931	12,288
Case 1	779	1,440	2,175	3,213	5,273	7,588
Case 2	789	1,496	2,301	3,463	5,824	8,537

Table 4 Comparison of 1% AEP Nepean River Peak Flows estimated at Wallacia Weir (Station 212202)

Rainfall Losses		36 hour Temporal Pattern		Peak Flow (m3/s)	Difference to ARR1987
IL (mm)	**CL (mm/h)**	**Number**	**Source**	**Median**	
60	0.5	1	ARR1987	7,800	
60	0.5	10	ARR2016	6,807	-13%
45	3.9	10	ARR2016	5,324	-32%
FFA		**Period of Record**			
1995		1917-1993		6,400	-18%
2015		1860 – 2012		8,635	11%
		1917 – 2012		5,101	-35%
2019		1860 – 2012		12,288	58%
		1917 – 2012		7,588	-3%
		1917 – 2012		8,537	9%

Results and discussion

The impact of a 10% increase in the (ARR1987) 1% AEP rainfall intensity is a 15% increase in the 1% AEP peak flow at the upstream boundary of the study area (at Menangle). The impact of adopting the 10 ARR2016 storm burst areal temporal patterns and rainfall intensities in combination with the rainfall losses adopted in the 1995 and 2015 flood studies is to lower the 1% AEP (median) peak flow (at Wallacia Weir) by 13%. This equates to an 8.8% change in rainfall.

Flood Levels estimated using ARR1987 are conservative

If the reduction in 100 yr ARI peak flow due to ARR2019 data is accepted, then the ramification is that adopting the 100 yr ARI flood levels based on ARR1987 would provide a significant off-set against the impacts of a 10% increase in 100 yr ARI rainfall. Assuming that (i) the change in 100 yr ARI flood levels due to a change in peak flows from 6,807 m^3/s to 7,800 m^3/s at Wallacia is similar to the assessed impact of a peak flow increase from 8,313 m^3/s to 9,256 m^3/s at Menangle; and (ii) a linear response in raised flood levels to changes in rainfall intensity; then adopting a freeboard of 0.6 m in Zone A and 0.7 m in Zone B would give a planning horizon of beyond the year 2100 under RCP4.5 and between years 2070 and 2090 under RCP8.5.

Flood Levels estimated using ARR1987 are not conservative

While hydrological modelling using ARR2019 data estimates reduced peak flows, the analysis of the recorded data at Wallacia Weir using the ARR2019 procedure FLIKE found that the 100 yr ARI peak flows estimated for the period 1917-2012 is close to the 100 yr ARI peak flow estimated using ARR1987 data. If this is the case, then the current adopted 1% AEP flood levels do not include any allowance for climate change. The potential ramifications for the planning horizon when adopting a flood planning level with allowances of 0% and 10% increase in 100 yr ARI rainfall intensities is explored in Table 2.

To achieve a planning horizon of beyond the year 2100 under RCP4.5 and between years 2070 and 2090 under RCP8.5 would require the inclusion of a 10% rainfall increase in either the benchmark flood level (with a further 0.5 m freeboard) or a 10% rainfall increase in the freeboard ie. the freeboard above the current adopted 100 yr ARI flood level would vary from 1.1 m to 2.0 m depending on location.

Allowing for Climate Change Only

The third approach could be to adopt freeboards equal to the differences between the 2015 flood levels with 0% and 10% rainfall increase across the Nepean River floodplain. The FPL would then vary from 0.6 m – 1.5 m above the current adopted 100 yr ARI flood level depending on location. The planning horizon for these FPLs would be the year 2100 under RCP4.5 and the year 2055 under RCP8.5. The aim of this approach would be to monitor research on changes in rainfall intensities if appropriate to adjust the approach to setting FPLs in the next 10 years.

Conclusions and future work

It is concluded that depending on the approach adopted that the planning horizon will vary significantly depending on the adoption of RCP4.5 or RCP8.5 rainfall increases and whether the flood levels estimated using ARR1987 are conservative or not. Future research on changes in rainfall intensities over the next 10-20 years is needed to ascertain if changes are tracking closer to the RCP4.5 or to the RCP8.5 estimates.

References

CSIRO and Bureau of Meteorology (2015), “Climate Change in Australia, Projections for Australia's NRM Regions”. *Technical Report*, CSIRO and Bureau of Meteorology, Australia. Retrieved from www.climatechangeinaustralia.gov.au/en [http://www.climatechangeinaustralia.gov.au/en].

Jayasuriya, M.D.A. and Mein, R.G. (1985), Frequency analysis using the partial series. Hydrology and Water Resources Symposium 1985, Inst. Engrs Aust., Natl Conf. Publ. No. 85/2, pp: 81-85

Worley Parsons (2015) Nepean River Flood Study, prepared for Camden Council.