7. FUTURE FLOOD ENVIRONMENT

The following sections consider changes to the flood environment as a result of future conditions – namely, further development in the catchment, and climate change.

7.1. Changes due to development

The cumulative impact of future development has been assessed by filling all the flood affected area in the catchment to the Flood Planning Level (FPL). The FPL is derived from the concurrence of a 1% AEP catchment scenario with a 5% AEP ocean scenario plus 0.5 m of freeboard.

The impact of future development on peak flood levels is shown in Figure 29. The average increase is slightly above 0.4 m, although this can reach 1 m in Balgowlah and Brookvale. This is primarily a result of overland flow paths through private property being blocked by the fill. The scenario causes slight decreases (0.05 m) around the lagoon.

7.2. Changes due to climate variation

Whilst there is general consensus that the climate in the future will be different from current conditions, there is uncertainty in the magnitude, and even the direction, of that change. Climate change has the potential to impact flooding through changes in the frequency, intensity, spatial extent, duration and timing of extreme weather and climate events, and through sea level rise. However, quantifying the effects of climate change on these factors is a difficult task, and includes large uncertainties. As such, using an approach based on a sensitivity analysis of different scenarios, and focusing on the consequences (like that used in the Coastal Zone Management Plan for Collaroy-Narrabeen Beach & Fisherman's Beach, 2014) facilitates an assessment of the potential impacts of climate change despite this uncertainty.

The NSW Government issued a policy statement in 2009 which required Councils to consider a sea level increase of 0.4 m by 2050 and 0.9 m by 2100 (relative to 1990 levels), and a sensitivity analysis of increases in rainfall intensity of +10%, +20% and +30%. Whilst this policy has now been repealed and Councils are required to make their own assessments, the estimates are still widely used in NSW.

For sea level rise, current estimates vary between 0.13 m increases by 2050 for low emissions scenarios, to as high as 0.98 m for high emission scenarios in 2100. The *Floodplain Risk Management Guideline: Practical Consideration of Climate* Change (Reference 4) recommends undertaking a sensitivity analysis which includes 0.18 m, 0.55 m and 0.91 m increases in sea level rise, whilst information provided by CSIRO and Bureau of Meteorology (Climate Change in Australia website) suggests increases ranging from 0.22 m to 0.88 m by 2090 for Eastern Australia. Therefore, the commonly applied estimates of +0.4 m (2050) and +0.9 m (2100) remain reasonable factors to use in sensitivity analyses as they encompass a significant portion of the range in estimates.

Australian Rainfall and Runoff (ARR) recommends using the RCP 4.5 (low emissions) and RCP8.5 (high emissions) for impact assessment, and allowing for a 5% increase in rainfall for every one degree Celsius of increased temperature. Using the methodology prescribed in ARR and the outputs of the Climate Future web tool, the following estimates of rainfall increase for the Manly Lagoon catchment are generated.

Table 9: Climate change rainfall increases

Scenario	2025	2050	2090
RCP4.5	+2.5%	+2.5%	+12%
RCP8.5	+12%	+12%	+20%*

** assuming 3.5^{o}C increase based on the Climate Futures result of >3^{o}C*

Based on this, using the +10% and +20% rainfall increase would sufficiently cover the range of expected changes in rainfall.

As such, six climate change scenarios have been modelled as the basis of the impact assessment, all derived from the 1% AEP design event with a 5% ocean condition, being:

- +0.4 m sea level rise
- +0.9 m sea level rise
- +0.4 m sea level rise and +10% rainfall
- +0.9 m sea level rise and +10% rainfall
- +0.4 m sea level rise and +20% rainfall
- +0.9 m sea level rise and +20% rainfall

The consequences of climate change were assessed based on the impact on estimated flood damages, changes to above-floor property inundation and extent of hazardous (H4, H5) areas.

7.2.1. Impacts on Property Inundation and Flood Damages

The climate change scenarios increased the number of residential properties affected by 22 – 38%, and increased the estimated flood damages by 49 –91%. This is because not only were more properties affected, there was a significant increase in those which experienced above floor inundation (33% - 54%), and hence tangible damages were increased.

Table 10: Impact on Tangible Residential Damages and Above Floor Affectation, 1% AEP event

Scenario*	No. Properties Affected (change from existing)	No. Flooded Above Floor (change from existing)	Approximate Total Damages for Event (% change from existing)
Existing	381	289	$28.5m
+0.4 m sea level rise only	463 (+22%)	384 (+33%)	$42.5m (+49%)
+0.9 m sea level rise only	486 (+28%)	409 (+42%)	$48.2m (+69%)
+0.4 m sea level rise and +10% rainfall	489 (+28%)	404 (+40%)	$46.0m (+61%)
+0.9 m sea level rise and +10% rainfall	507 (+33%)	428 (+48%)	$51.4m (+80%)
+0.4 m sea level rise and +20% rainfall	510 (+34%)	422 (+46%)	$49.5m (+74%)
+0.9 m sea level rise and +20% rainfall	524 (+38%)	445 (+54%)	$54.5m (+91%)

* Scenarios are based on the 1% AEP catchment event with 5% AEP ocean conditions

7.2.2. Impact on Flood Hazard

A comparison of the “worst case” climate change scenario (+0.9 m sea level rise and +20% rainfall increases) with the current 1% AEP hazard classification is shown on Figure 30. This shows that whilst the areas of ‘high hazard’ (H5 & H6) increase, they are predominantly confined to the non-developed areas adjacent to the lagoon and creeks. The extent of residential properties affected by flooding does increase, particularly around Hotspot A on the south side of the lagoon. There is also some increase in affected properties in Hotspot C on the north side. These areas generally lie in hazard category H3 & H4.