7.4.16. Lower Richmond River

At the proposed bridge crossing Duck Creek (on the upstream project boundary), under existing conditions the predicted impact is about five millimetres in the 20 year ARI flood. Under climate change conditions, at the same location, the predicted impact is about 25 millimetres (see Figure 7-58).

There is a potential for climate change to reduce the design flood immunity of the project through increasing flood levels. The flood modelling carried out under climate change conditions indicates that the predicted peak 20 year ARI flood levels with the upgrade would be around 310 millimetres higher under climate change conditions (see Figure 7-58) at the bridge over Duck Creek. However, the project would still meet the design flood immunity objectives at this location under climate change conditions. The detailed design phase should consider the need for maintaining the 300 millimetres clearance under the bridge deck required for debris passage.

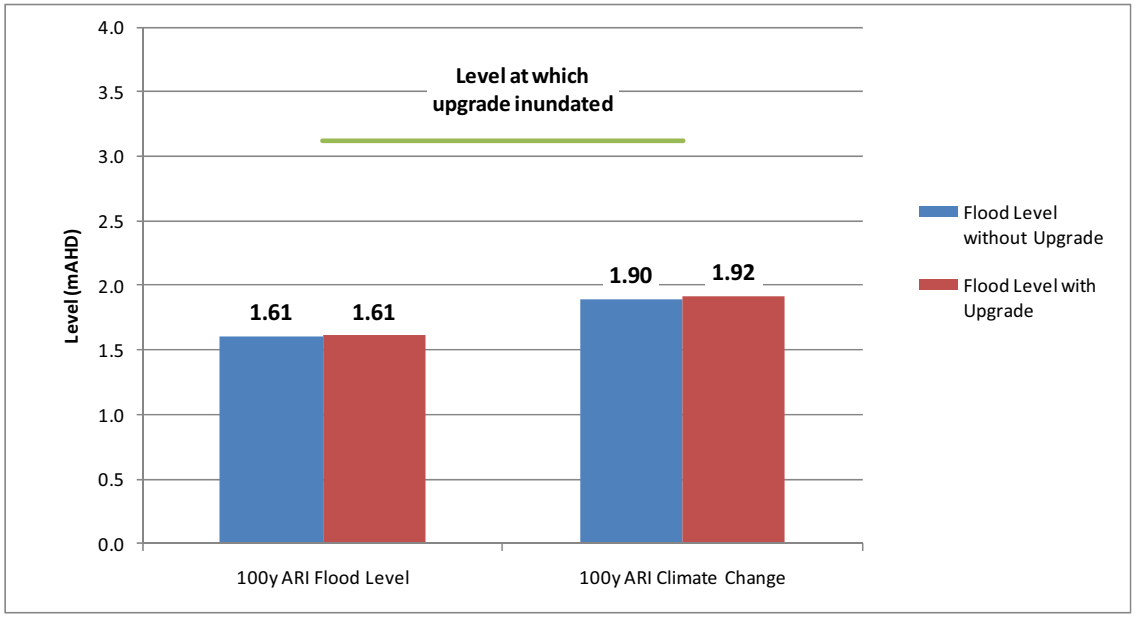


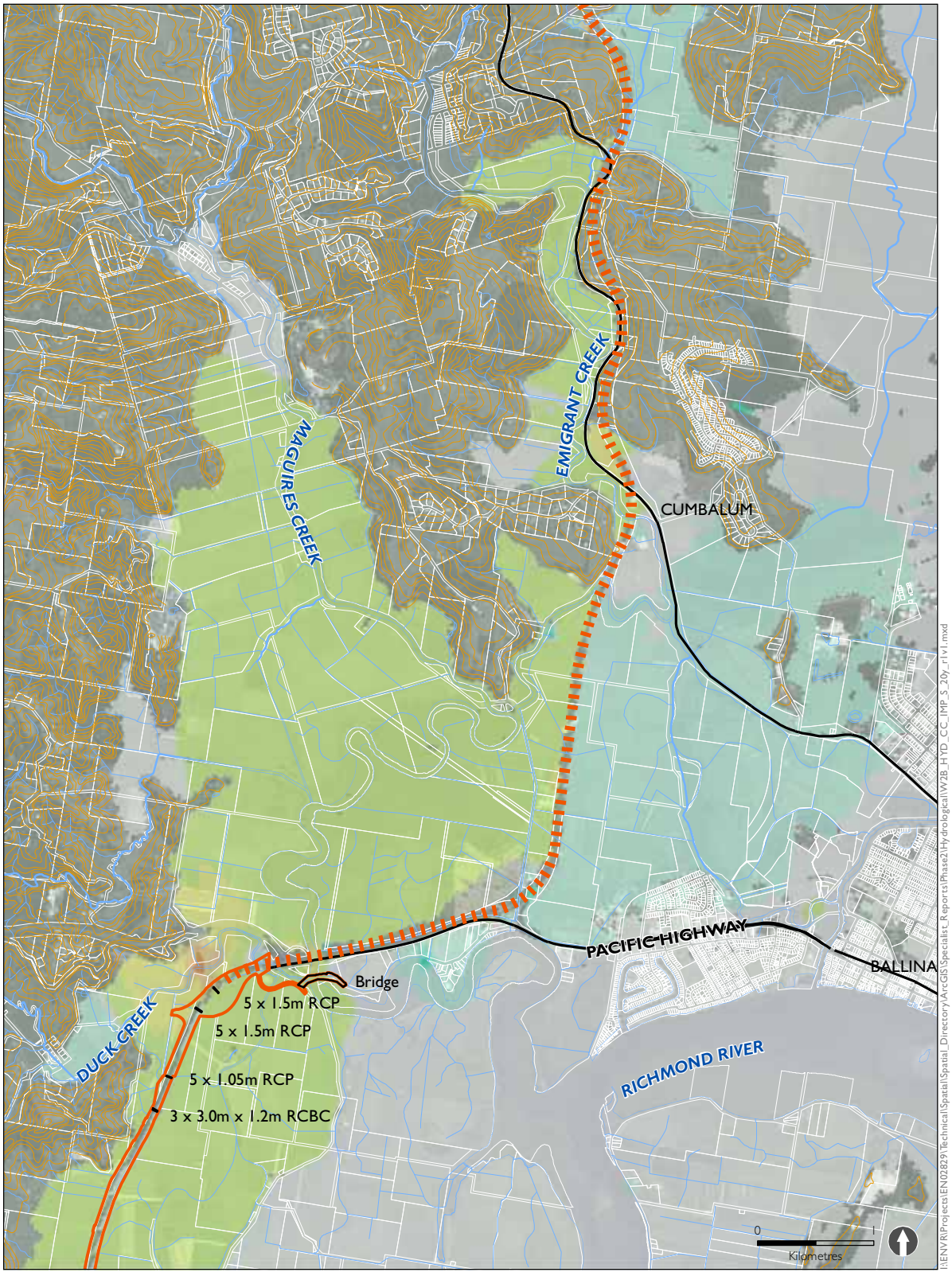
Figure 7-58 Flood impacts 20 year ARI event at bridge over Duck Creek at station 164.65 under existing and climate change scenarios

A map of the Lower Richmond River flood impacts under climate change conditions in the 100 year ARI event are presented in Figure 7-59.

Under climate change conditions, in the 100 year ARI, areas to the east of the project experience impacts of up to 30 millimetres. This is within flood level impact objectives.

In summary, the flood assessment under climate change conditions indicates that the structure capacity of the project is sufficient to meet the flood design objectives for both flood immunity and flood level impacts under these conditions.

Figure 7-59 Flood impacts under 20 year ARI climate change scenario: Lower Richmond River and Ballina



7.5. Achieving design flood immunity with climate change

7.5.1. Costs of additional earthworks

The additional embankment heights for the Clarence and Richmond River floodplains required to achieve an average flood immunity of 20 years ARI under predicted climate change conditions are not considerable. However, it would result in a substantial increase to the volume of fill material required due to the length of embankments across these two floodplains.

The estimated increase in imported fill for the project if it was to be constructed at these higher levels is:

- To accommodate predicted sea level rise (0.6 metres in 2070): about 140,000 cubic metres, at a cost in the order of $6 million
- To accommodate predicted sea level rise (0.6 metres in 2070) and rainfall intensity increases: about 300,000 cubic metres, at a cost in the order of $12 million.

The increase in embankment height would result in an increase in the total embankment area. However, it would not be necessary to change the project boundary to accommodate this increase in area.

7.5.2. Bridge costs

The large majority of flood conveyance through the project across the Clarence and Richmond River floodplains would be via bridges.

The project includes an allowance for each bridge obvert/soffit to have a 300 millimetre clearance above the 100 year ARI flood level for the passage of debris. Hence, any increase in 20 year ARI flood levels due to sea level rise would not result in bridge obverts/soffits being inundated. However, there would be an increase in the risk of failure of infrastructure, such as handrails, that fails when the road overtops.

Likewise, due to the requirement for the 300 millimetre clearance above the 100 year ARI flood levels, any minor increases in the 20 year ARI flood levels due to sea level rise would not result in the flood immunity at the bridges falling below the target of 20 years ARI.

7.5.3. Pavement rehabilitation

It needs to be noted that the road pavement would require rehabilitation every 30 to 40 years. If necessary this pavement rehabilitation could include raising the pavement by 0.2 metres without substantial changes to the road design. Hence, the road embankment could rise during the life of the project in order to maintain the desired flood immunity if sea levels rise as predicted.

7.6. Conclusions of climate change impacts on project

The following conclusions are drawn from this assessment of climate change and its potential impact on this project:

- The road embankment would be designed to withstand flood inundation. Hence, overtopping of the road embankment would not constitute a failure of the embankment, but rather a disruption to highway traffic
- A projected increase in rainfall intensity of 10 per cent would reduce the flood immunity from 100 year ARI to about 55 year ARI (for the sections not on the Clarence and Richmond River floodplains)
- Sea level rise projections would require increases in embankment height of between 0.09 metres and 0.22 metres across the Clarence and Richmond River floodplain sections to maintain average 20 year ARI flood immunity throughout the project life. Due to the length of the embankment, this is considered to be cost-prohibitive
- The costs of the additional fill required to meet the 20 year ARI flood immunity with the sea level rise projections is estimated to be $10 million. This is considered to be a high cost for the relatively low benefit of attaining 20 year ARI flood immunity
- The flood immunity of the bridges in the project would be much higher than the 20 year ARI flood immunity across the Clarence and Richmond River floodplains and also higher than the 100 year ARI flood immunity in the remainder of the project
- Periodic pavement rehabilitation could assist in raising the embankment levels to maintain the desired flood immunity of the project if sea levels rise as predicted
- The width of the project boundary has been widened, where required, across the Richmond and Clarence river floodplains to allow for any future raising of the embankments by up to 0.2 metres. In most places, the project boundary did not require adjustment as there was sufficient width to accommodate the wider embankment. In some places, the project boundary was widened by up to 1.6 metres to accommodate an increase in embankment height of up to 0.2 metres with a batter slope of one vertical to four horizontal on each side.

In summary of this issue:

- Predicted changes to rainfall intensity (in the order of 10 per cent) are well within the limits of accuracy (in the order of 20 per cent) of current rainfall intensity estimates

- The long-term variability of the frequency of large river flood events indicates that a 10 per cent increase in rainfall intensities would have only a minor impact on embankment flood immunity compared to the impact of natural variability in flood frequencies
- The consequences of under-estimating rainfall intensities for this project are not catastrophic. The road embankment would be designed to withstand flood inundation. Underestimating rainfall intensities would result in more frequent road overtopping than expected and higher outlet velocities and associated scour potential.