

Table 4-1 Recommended Flood Mitigation Measures

ID	Recommendation and Description	Constraints / Limitations / Challenges	Benefits
Property Modification Measures			
P1 Update Development Controls			
	<p>The imposition of development controls can be an effective means of managing flood risks associated with future development (including redevelopment). The <i>Ballina Development Control Plan, 2012, Chapter 26 – Floodplain Management</i> was adopted by Council on 2 December 2012. While these controls will manage future flood risk, a more flexible approach to managing future flood risk could be considered.</p> <p>A draft DCP has been developed by Bewsher Consulting in close collaboration with Council's planners during the Ballina Floodplain Risk Management Study. In addition, the draft Wardell and Cabbage Tree Island Floodplain Risk Management Plans provide specific advice as follows:</p> <ul style="list-style-type: none"> Council develop policy to limit residential dwellings on Cabbage Tree Island to maintenance or replacement of existing premises. It is recommended that community related buildings be allowed, provided they are constructed with flood compatible materials and meet other general requirements for development on flood prone land (Worley Parsons, 2009b). Provisions are made in Council's DCP that give suitable consideration to flood risk, flood hazard, flood warning and evacuation for proposed development and the impact on these facets to neighbouring development. More detail is provided in the draft Wardell Floodplain Risk Management Plan (Worley Parsons, 2009a). <p>The intent of the recommendations provided in the Cabbage Tree Island and Wardell Floodplain Risk Management Plans are captured in the draft DCP.</p>	<ul style="list-style-type: none"> Compliance in the development controls imposed on developers and planners. Mitigation is employed over time - does not mitigate the immediate flood problem. 	<ul style="list-style-type: none"> Flood mitigation can be targeted; i.e. flood risk areas and future development (such as sports fields) placed in higher flood risk areas. Flood mitigation is adaptable – controls can be updated as flood intelligence improves. Mitigates future flood risk by considering potential implications of climate change. Relatively low cost to implement.
P2	<p>Develop Agricultural Levees Guidance</p> <p>Levees are used by farmers in the study area to protect arable land from flooding. Particularly flooding associated with high tides where sea intrusion may degrade the quality of the soil. Currently there are no formal controls on this form of development. In some areas these levees impact on flood levels to neighbouring properties. Thus, it is recommended that some limitations are developed. This issue is common to the Richmond River County Council (RRCC). Thus, it is recommended that this is done in collaboration with RRCC.</p>	<ul style="list-style-type: none"> Removal/lowering of levees may increase flood risk in some areas. Enforcement of the levee limitations may be difficult. 	<ul style="list-style-type: none"> Reduction of flood risk in some areas.
P3	<p>Develop Voluntary House Raising Scheme</p> <p>House raising typically involves the raising of dwellings to above Council's flood planning level. Houses can be raised vertically on piers; reconstructed at a higher level on fill or piers; or relocated within the property.</p> <p>In the BFRMS 49 properties within the 20 year ARI flood event were selected for consideration in a voluntary house raising scheme. Also, consideration should be given to voluntary house raising for existing dwellings at East Wardell (upstream from the Pacific Highway Bridge) that are expected to experience over floor flooding during the 100 year ARI flood, and existing dwellings at Wardell Village (near the intersection of Richmond and Wilson Streets) that are affected by over floor flooding during the 20 year ARI event</p> <p>It is recommended that a voluntary house raising scheme is investigated. Floor levels should be limited to 3.5m above ground level due to practicality and as well as the fact that the scheme is targeted at properties at risk of flooding. It is recommended that the voluntary house raising grant is capped at \$40,000, and increased each year to account for market trends. The grant will be provided following completion of the works and Council inspection.</p>	<ul style="list-style-type: none"> The occupation of areas beneath a raised house may offset reduction in damage potential. People living in raised houses may be less likely to evacuate, increasing the threat to life in the rare event that a flood reaches the floor level; Risk to emergency services if rescue required. House isolated at times of flood; some intangible costs remain; Risk to emergency services; rescue required due to medical emergency. Building may prove to be incapable of withstanding force of floodwater and debris loading, resulting in structural collapse. (Note that the Floodplain Development Manual regards VHR as a suitable management measure only for low hazard areas of the floodplain). Steps to gain access to the house may not be suitable for older people or those with disabilities. Aesthetic and town planning constraints may apply; e.g. isolated raising of individual properties in a street may be less desirable than schemes that include a group of properties in a street. 	<ul style="list-style-type: none"> Reduced risk to personal safety and intangible costs such as anxiety, stress and post-flood trauma. Reduced tangible flood damage. Provision of under-house space for a garage, laundry or storage. Enhanced resale value of property.

RECOMMENDED FLOOD MITIGATION MEASURES

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		<ul style="list-style-type: none"> Raise some houses, such as slab on ground, may be economically unfeasible or impractical. Voluntary house raising can take a considerable time to implement in full. 	
<p>Response Modification Measures</p>			
<p>R1</p>	<p>Finalise Selection of Evacuation Centres</p> <p>A key aspect of the evacuation process is to have adequate facilities at the evacuation centres that house the evacuees. At the inception of the BFRMS there was no formal plan on where evacuation centres would be located and what the limitations at those centres may be. The BFRMS identified a number of potential evacuation centres. Council attempted to contact the NSW Department of Community Services (DoCS) to discuss the proposed evacuation centres further, but were unsuccessful in getting a response from DoCS at the time.</p> <p>It is recommended that DoCS are engaged to discuss the feasibility of using the proposed evacuation centres. If inadequacies are identified it may be necessary to seek alternative evacuation centres.</p>	<ul style="list-style-type: none"> Evacuation centres need to be located outside the floodplain with good access to the evacuation routes. There needs to be adequate space and facilities for the evacuees. 	<ul style="list-style-type: none"> Provides a safe location for the community to shelter during a flood. Assists the SES with formulating and implementing an evacuation plan. Reduces the residual flood risk through a more effective response to flooding.
<p>R2</p>	<p>Update Evacuation Planning</p> <p>Evacuation planning in the Shire in specific high risk areas (such as Cabbage Tree Island and Toven Valley), have been thought-out and documented in the existing Local Flood Plan. Additional evacuation procedures have been proposed in the draft Cabbage Tree Island and Warrall Floodplain Risk Management Plans (Worley Parsons, 2009a, 2009b). It is recommended that these proposed plans are appended to the Local Flood Plan</p> <p>There is little structure to the evacuation procedure within the BFRMS area. Preliminary evacuation routes and zones have been proposed in the BFRMS. It is recommended that these are included in the Local Flood Plan along with the proposed evacuation centres following completion of recommentation R1.</p> <p>Once the Local Flood Plan has been updated, it is recommended that a street signage strategy is devised and implemented.</p>	<ul style="list-style-type: none"> If the evacuation plan is complex or poorly documented it may not be interpreted correctly or may cause confusion. A rigid procedure may not be flexible enough to cope with unforeseen circumstances. 	<ul style="list-style-type: none"> Assists the SES with formulating and implementing an evacuation plan. Expedite evacuation during a flood emergency Provides material for knowledge sharing within the SES and community. Reduces the residual flood risk – reduced risk to life and welfare of the community and SES.
<p>R3</p>	<p>Develop Community Engagement Strategy</p> <p>The community needs to know how to react when receiving a flood warning or evacuation order. It is recommended that an ongoing flood education programme is implemented, as the community is dynamic and may constantly change. It is recommended that a community engagement strategy is developed. For example:</p> <ul style="list-style-type: none"> Lismore City Council runs a successful programme through one of its committees. Richmond Valley Council is currently developing a flood information website in collaboration with the SES and OEH. 	<ul style="list-style-type: none"> Disseminating the flood awareness message to a varied and changing audience. Retaining the awareness during long periods without flooding. 	<ul style="list-style-type: none"> Reduces the residual flood risk through a more effective response to flooding. Expedite evacuation during a flood emergency Reduced risk to life and welfare of the community and SES.
<p>R4</p>	<p>Extend Gauge Network</p> <p>Rain and stream gauges provide essential flood intelligence during a flood event. It is recommended that a minimum of three additional rain gauges (Newyear Swamp, Brookler and Cumberlun Ridge) and two river gauges (Enigrant Creek and Merin Creek) are installed. More appropriate locations may be determined during discussions with Council, the SES and OEH.</p>	<ul style="list-style-type: none"> Gauges are relatively expensive to install and require ongoing maintenance. Gauges can be susceptible to vandalism. 	<ul style="list-style-type: none"> Improved flood intelligence may assist with flood warning, and therefore reduce flood risk to people.

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RECOMMENDED FLOOD MITIGATION MEASURES

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R5	<p>Develop Flood Intelligence Cards</p> <p>The use of reliable flood intelligence to base decisions upon can improve the human response to a flood emergency. The quicker the potential implications of a flood can be understood, the more time is available to act on the appropriate response. One method used by the SES for managing flood intelligence is the use of flood intelligence cards.</p> <p>It is recommended that SES flood intelligence cards are developed for each of the gauges surrounding the catchment (including gauges proposed under measure R4). Whereby, the implications on flooding in Ballina for prescribed gauge recordings are defined. It is recommended that this measure is supported by additional flood modelling covering a wider range of potential flooding scenarios.</p>	<ul style="list-style-type: none"> Rainfall patterns and tidal conditions causing a flood may differ from what has been pre-assessed during establishment of the flood intelligence cards. 	<ul style="list-style-type: none"> Flood intelligence cards may expedite evacuation decisions and therefore reduce flood risk to people.
R6	<p>Assess Alternative Evacuation Order Methods</p> <p>The traditional method used by the SES for issuing evacuation orders is door knocking. Significant time-savings could be made by opting for a fast dissemination method such as broadcast radio and television, mass telephone dialling, SMS or sirens warning. Increasing use of social media by society may also provide an opportunity for enhancing flood warning and dissemination of evacuation orders. Use of a website such as Twitter may provide a fast means of sharing flood information between emergency services and the public.</p> <p>It is understood that the SES has already begun looking at alternative dissemination methods. It is recommended that several dissemination methods are used simultaneously to improve the time of response.</p>	<ul style="list-style-type: none"> If a purpose built website is used for dissemination of flood information, the website should be designed such that it is capable of handling high web traffic during a flood event. Utilising high-tech methods may not be appropriate for the high proportion of elderly people in Ballina. Improved evacuation capability may be limited by the road capacity, a very short warning time can lead to traffic congestion. 	<ul style="list-style-type: none"> Expedite evacuation during a flood emergency. Reduced risk to life and welfare of the community and SES.
R7	<p>Investigate Flood Warning and Prediction System Options</p> <p>It is recommended that Council investigate the potential for installing a dedicated flood warning system. The flood warning system would automatically monitor gauges around the catchment and disseminate the information through emergencySMS to selected personnel who are located in the area. Such a system already exists in the Taven Valley. Since the Richmond River catchment is serviced over by a number of local councils, and a flood could affect several of these council areas, it is recommended that such a system would be set up at a catchment scale.</p> <p>The BoM provide a national flood forecasting service. They use rainfall-runoff models to forecast flood flows, and in some instances they also use pre-existing flood model results to assist with predicting flood levels. The BoM currently provides flood forecasting to major towns along the Richmond River up to the downstream end of Woodburn. However, they don't currently have a formal flood forecasting system that covers Ballina Shire. For the Ballina area, the BoM has a weather system model that they use to issue a flood watch. Gauges in the Richmond River catchment are then monitored by the SES, who has ultimate responsibility for deciding whether to evacuate.</p> <p>It is recommended that the BoM are engaged to extend their flood forecasting to Ballina.</p> <p>It is recommended that the feasibility of developing flood predictive tools is investigated in more detail. Consideration should be given to doing this at a catchment scale, encompassing other local councils in the Richmond River catchment.</p>	<ul style="list-style-type: none"> Improved evacuation capability may be limited by the road capacity, a very short warning time can lead to traffic congestion. Some areas are susceptible to flash flooding, which occurs rapidly and is difficult to predict with adequate lead time. Cross collaboration across Councils may present some administrative and funding challenges. Flood predictions may be overestimated at times, causing the community to become complacent in regards to responding to the predictions. Cross collaboration across Councils may present some administrative and funding challenges. 	<ul style="list-style-type: none"> Improved warning methods would expedite the dissemination of a flood warning, thus reducing the response to a flood and reducing risk to people. Reduced demand on SES resources. Flood prediction would lead to earlier warning, thus expediting the response to a flood and reducing risk to people.
R8	<p>Raise Low Points on Evacuation Routes</p> <p>Various evacuation routes have been identified in the study area in the BFRMS. An assessment of the closure of these routes was undertaken. It was found that the route closure can be delayed through raising the low points along some routes. It is recommended that the potential to delay evacuation route closure by raising low points on Moon Street, Kerr Street and River Drive (see Figures D-1 and D-6 in Appendix D in the BFRMS) is investigated further. In addition, consideration should be given to raising sections of Tamarind Drive and River Street.</p>	<ul style="list-style-type: none"> The BFRMS assessment was undertaken using a Digital Elevation Model, which has some inate inaccuracy in ground levels. Therefore, the levels of the low points should be surveyed to confirm their existence and nature. Road raising may adversely impact the road behaviour. Therefore, the potential flood impacts should be considered. 	<ul style="list-style-type: none"> Increase the time available for evacuation, thus reducing the risk to life and welfare of the community and SES.

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RECOMMENDED FLOOD MITIGATION MEASURES		Benefits	
ID	Recommendation and Description	Constraints / Limitations / Challenges	Benefits
Flood Modification Measures			
F1	<p>Implement Gallians Road Cycleway Floodway</p> <p>Lying to the south of the Cumbalum Ridge between the Emigrant Creek and North Creek floodplains is the Gallians Road Cycleway. The cycleway has been constructed on an embankment containing water and sewer rising mains which service Ballina Heights. An improved service in the cycleway has been provided to allow flow between Emigrant Creek and North Creek. The proposed flood modification includes removal of the southern 100m of the embankment and incorporates clearing of drains and Robbers Creek. A cost-benefit analysis undertaken in the BFRMS indicated that the scheme has a cost-benefit ratio of 2.6 (or 3.6 when accounting for intangible damage).</p> <p>It is recommended that a preliminary design, which includes a more detailed feasibility assessment and environmental impact assessment, is undertaken.</p>	<ul style="list-style-type: none"> High initial cost outlay – estimated \$400k. Small increase in flood levels in the North Creek valley – impacts on a few properties. Requires diversion of water mains housed in the embankment. Only provides a small reduction in flood levels along Emigrant Creek Valley; no notable improvement to risk to people lives / welfare. 	<ul style="list-style-type: none"> Reduces damage caused by flooding – estimated flood damage saving of \$1.1million (at present value) over the next 50 years. Potential to improve environmental values of watercourses through Ballina Nature reserve.
F2	<p>Consider Removal or Lowering of Deadmans Creek Road</p> <p>Deadmans Creek Road, which services development on the Cumbalum Ridge, is located along an embankment across the Emigrant Creek floodplain in Cumbalum. This embankment acts like a weir, raising upstream flood levels. A new road (Ballina Heights Drive) providing a similar service is located approximately 1km north of Deadmans Creek Road. Therefore, there may be an opportunity to remove or lower Deadmans Creek Road.</p>	<ul style="list-style-type: none"> Before implementation it will need to be demonstrated that the new road provides immunity and as a flood evacuation route. This measure will increase the route length for local residents travelling to Ballina. 	<ul style="list-style-type: none"> Reduces flood levels upstream of Deadmans Creek valley, by as much as 20mm to 30mm for moderate size flood events (20 year ARI).
F3	<p>Implement Cabbage Tree Island Low Level Deflector Levee (from Cabbage Tree Island Floodplain Risk Management Plan - Worley Parsons, 2009a)</p> <p>Construction of a low level deflector levee with a nominal crest elevation of 2.6 mAHD (10 year ARI flood level plus a freeboard of 300mm) extending south from the upstream end of Cabbage Tree Island. The levee would be elevated up to 2 metres above the island. It would deflect flood flows around the southern end of Cabbage Tree Island and prevent floodwaters from discharging in a northerly direction across the habited areas during floods up to and including the 10 year ARI flood. The levee would also serve to slow the progression of floodwaters during larger floods. Flood modelling for the levee has shown that the 100 year ARI flood level would be decreased by 100mm at the island and flow velocities are expected to decrease by up to 0.4 m/s behind the levee.</p>	<ul style="list-style-type: none"> Floodwaters continue to inundate the island by backing up around the downstream end of the proposed deflector levee. Will require ongoing maintenance. For large floods there may be considerable erosive forces acting on the levee. Thus, erosion protection on the levee may be a design challenge. 	<ul style="list-style-type: none"> Reduces flood hazard on the island, i.e. through reduced flow velocities.
F4	<p>Implement Structural Measures Assessed Separately From BFRMS:</p> <p>West Ballina Flood Relief</p>	<ul style="list-style-type: none"> Apportionment of responsibility and cost for implementation is complicated, particularly when many stakeholders are concerned. 	<ul style="list-style-type: none"> Reduce existing flood levels / mitigate impacts on flooding caused by proposed development.
F5	Waste Transfer Floodway		
F6	Development specific flood mitigation measures		
F7	Consider recommendations from the Newybar Swamp Flood and Drainage Assessment		



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