6.17. Lower Richmond River

6.17.1. Flood management objectives

Land use within the Lower Richmond River floodplain consists of residential, cane farm land, agricultural and forested areas. The flood management objectives of relevance to this catchment are:

- Less than 50 millimetres increase in flood heights at houses for any assessed flood event less than and equal to 100 year ARI event
- Less than 50 millimetres increase in flood heights on cane farm land for any assessed flood event less than and equal to 100 year ARI event
- On grazing, forested and other rural areas, generally less than 250 millimetres increase for any assessed flood event less than and equal to 100 year ARI event
- No more than five per cent increase in the flood duration where there are houses and cane land
- No more than ten per cent increase in the flood duration in recognition on grazing, forested and other rural lands
- Velocities to remain and below one metre per second on grazing, forested and other rural lands where currently below these figures. An increase of not more than 20 per cent where existing velocity is above these figures
- Velocity-depth products for houses, commercial premises and urban areas remain in low hazard category (for children)
- No change to the direction of watercourses or the direction of flood flows except for constriction into and expansion out of discrete openings (culverts and bridges) and constructed diversions.

These objectives are detailed in Section 2.1.

6.17.2. Design

Section 11 of the project traverses the western edge of the Richmond River floodplain. The embankment has an immunity of 20 year ARI and ties in with the Ballina Bypass and the Bruxner Highway in the area where it crosses Duck Creek and Emigrant Creek just upstream of their confluence.

The flood impact assessment for the project is a cumulative impact assessment of the project and the Ballina bypass, compared to conditions as existed in 1998 as discussed in Section 4.15.3.

A number of flood simulations were carried out and it was determined that to meet the stated flood management objectives, the waterway structures provided in Table 6-30 would be required for this project and the Ballina Bypass.

Table 6-30 Proposed structures on the Lower Richmond River

Station (km)	Proposed structures[1]
Continuous except for the structures listed below	Embankment: Dual carriageway raised above 20 year ARI flood levels following the alignment of the existing highway.
162.68	3 x 3 m x 1.2 m box culverts
163.00	Extension of 5 x 1.05 m diameter RCP under the duplicated carriageway
163.60	5 x 1.5 m concrete pipes
163.84	5 x 1.5 m concrete pipes
164.65	Additional bridge for local access road (Smith Drive) south of the existing highway near the junction of Duck Creek and Emigrant Creek

1. Subject to review during future stages of the project.

Differences in the concept design compared to the design of the previous development project incorporate the reconfiguration of the Bruxner Highway interchange and design refinement. Other structures have been redesigned to ensure the project meets the stated impact objectives for the 100 year ARI flood event.

6.17.3. Flood impacts

Impacts associated with the construction of the Ballina Bypass are discussed in the *Flood Impact Assessment for the Ballina Bypass Final Design Report* (BMT WBM, 2008a) except for the augmented culverts 900 metres east of Emigrant Creek which were increased in size after the final design report was produced.

Flood level impacts

The predicted impacts of the project for the 100 year ARI flood event are presented in Figure 6-52. The figure shows that impacts in all areas outside the project boundary are less than 50 millimetres increase during a 100 year event. Approximate flood impact levels are presented in Table 6-31.

Several houses within the Maguires Creek/Emigrants Creek floodplain are expected to experience increases of up to 40 millimetres in the 200 year ARI events, with smaller impacts during 20 and 100 year events. Flood levels were found to decrease in this area during a five year event, with no houses inundated in the existing or developed case.

The project is above the floodplain from Wardell to Whytes Lane so there is no impact on flooding for this section.

The raised road from Whytes Lane to Duck Creek is expected to cause some increase in peak flood levels associated with flows from the catchments to the west of the highway building up behind the project embankment. For events of 20, 100 and 200 year ARI, these impacts are less than 30 millimetres and meet the objectives set for this project.

The proposed culverts under Whytes Lane overpass on the western side of the highway serve to decrease flood levels upstream of Whytes Lane. A reduction in flood levels results in decreased flood storage in small floods. As such, flows in the drain channel downstream of Whytes Lane increase in the five year ARI flood event, causing impacts of up to 90 millimetres. This impact can be mitigated through detail design of the culverts to limit flow in small floods through bunding of culverts to a similar level as Whytes Lane, mimicking existing flow conditions, whilst not impairing flow in larger floods. This measure is further documented in Chapter 8.

Similarly, along the floodplain areas south-west of Duck Creek (station 162 to 164) there is the potential for the project to result in increased flood inundation for small flood events. This is due to the three waterway structures under the project along this section (at stations 162.68, 163.60 and 163.84) to potentially allow floodwaters from the western side of the project to pass through to the eastern side. Currently, the existing highway serves as a levee to protect the eastern side. This potential impact would be mitigated in the detailed design phase by inclusion of bunds around the western side of the culverts within the property boundary to the same level as the existing highway. These bunds would serve to stop flood passing in smaller floods but would not impede flood flows for larger, rarer flood which would have overtopped the existing highway. This measure is further documented in Chapter 8.

The proposed replacement bridges on Duck Creek and the Smith Street bridge have been designed with soffit/obvert levels above the 100 year ARI flood level. In addition, the proposed pier configuration will be more hydraulically efficient than the existing bridges. These measures are expected to reduce the losses associated with these bridges and should not adversely affect peak flood levels.

The additional Bruxner Highway bridges and local access road bridge will result in additional losses. These increased flood levels are somewhat offset by the decreases associated with the replacement of the existing Pacific Highway bridges to result in impacts of less than 50 millimetres during the 100 year ARI event.

Table 6-31 Flood level impacts in Lower Richmond River catchment

Location	5 year ARI event	20 year ARI event	100 year ARI event	200 year ARI event
Between Maguires and Emigrants Creeks	No flooding	15 mm	25 mm	40 mm

Flood impacts to property

The sum total of average annual flood damages is expected to increase around the town of Ballina by around 0.6 per cent as a result of project flood impacts. However, this assessment does not consider numerous properties in Ballina that would experience a reduction in average annual flood damages due to reduced flood levels as a result of the project.

The existing mean of average annual flood damages for impacted residences in and around Ballina is about $1,700 per property.

Histograms showing the distribution of increased average annual damages and increased flood levels as a result of the project in Ballina for impacted properties are presented in Figure 6-49 and Figure 6-50. There are no properties which experience greater than 50 millimetres increase in flood levels. Increases of less than 50 millimetres would meet the flood management objectives for the area.

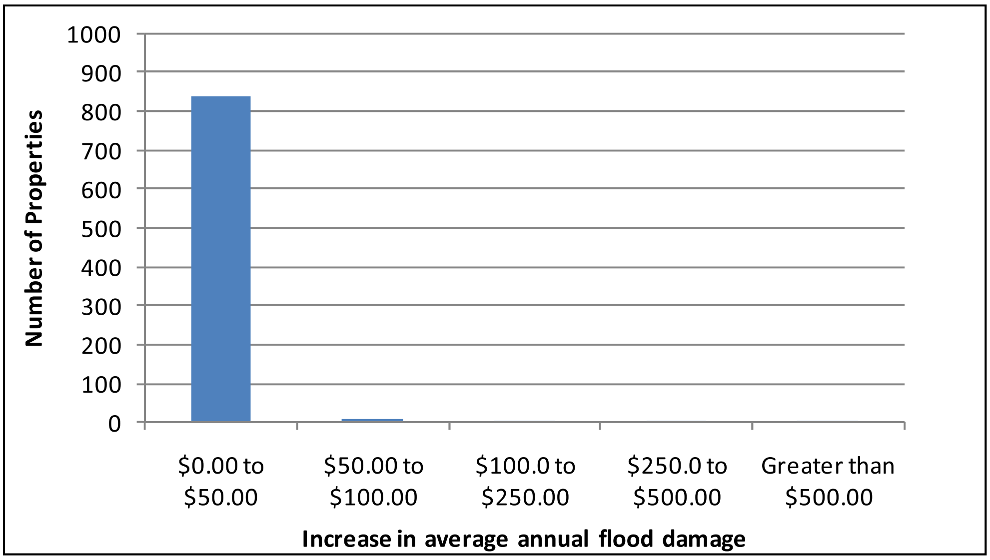


Figure 6-49 Distribution of increase in average annual flood damages in Ballina and surrounding areas

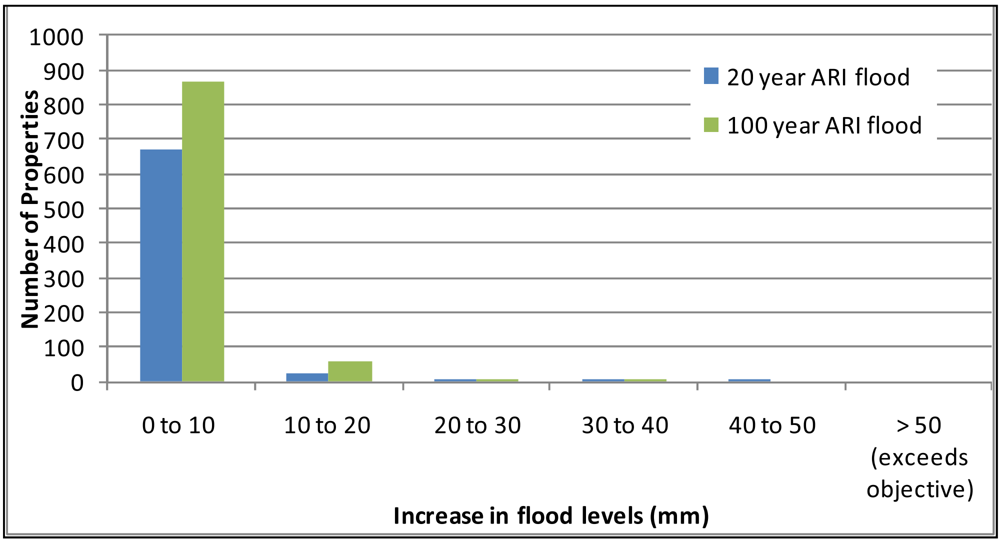


Figure 6-50 Distribution of impact to flood levels in Ballina and surrounding areas

Flood inundation duration impacts

The impacts of the project on the time of flood inundation are presented in Appendix G. These figures demonstrate that any change in inundation time as a result of the project is less than five per cent of the overall period of inundation, in line with the flood management objectives.

Flood velocity and direction impacts

Velocity impacts upstream and downstream of structures are considered representative of greatest velocity impacts that would be experienced outside the property boundary. Changes in velocities upstream and downstream of structures through this catchment are included in Appendix F.

Peak velocity impacts and changes in direction as a result of the project are presented in Figure 6-53 and Figure 6-54.

There is little appreciable change in the flow regime as a result of the project, so velocity and flow direction is not greatly impacted. Velocities are less than one metre per second upstream and downstream of all structures in the 100 year ARI event.

Rate of flood rise and warning time impacts

Based on the plots of flood level over time on the Lower Richmond River floodplain, the project would have a similar rate of rise as the existing case.

East of the project, around station 163.5, there would be a reduction in flood warning time of between five to 10 hours below 1.5 metres AHD. Around four kilometres along the Pacific Highway east heading into Ballina, there is also a reduction in flood warning time of up to five hours below 1.5 metres AHD. As the land use around these locations is agricultural, this is not expected to have any impact on flood warning time for residents.

Flood level plots and locations are provided in Appendix G.

Flood evacuation and flood access impacts

As this section of the project would be a duplication of the existing highway, no known evacuation routes would be severed by the project. Therefore, there is not expected to be any impact to the potential for evacuation in this area as a result of the project. The increased immunity of the highway would, in most cases, provide greater ability to evacuate during large flood events.

Flood hazard impacts

In regard to a broad consideration of flood hazard parameters (depth, velocity, velocity-depth product, duration of flooding, rate of rise, warning times, evacuation and flood access), it is considered that the overall level of flood hazard would not be increased by the project. Some land would experience a faster rise of flood level. However, this would not increase the level of flood hazard for people, stock or property. Therefore, it is considered that the overall level of flood hazard would not be increased by the project.

Bed and bank stability impacts

For the Duck Creek crossing at station 164.3, the project would expand the existing bridge and result in lower velocities to the existing case with risk of bank erosion unlikely.

Sensitivity to culvert and bridge blockage on floodplains

An analysis was carried out to determine the sensitivity of the flood impacts to assumptions of culvert and bridge blockage during the 100 year ARI flood event. The analysis was based on a 10 per cent blockage of bridges and culverts with diagonal span over six metres. Culverts with a diagonal span up to one metre were simulated with a 25 per cent blockage. For culverts with a diagonal span between one and six metres, linear interpolation was used to determine the fraction of blockage.

Increases in impact would be concentrated south of the existing Bruxner Highway and west of the project (the area surrounding Duck Creek). Here, an area of one square kilometre would experience 10 to 15 millimetres additional impact due to culvert blockage. The remainder of the floodplain is considered insensitive to the blockage, with impacts less of than five millimetres.

6.17.4. Flood impact summary

The flood regime in the Maguires Creek/Emigrant Creek floodplain is highly sensitive to waterway structures under the upgraded highway. These structures have been designed carefully to ensure the flood management objectives (particularly associated with flood level impact) are met.

West of Duck Creek, culverts have also been sized and located carefully to ensure impacts upstream and downstream meet objectives.

The project would meet all flood management objectives for this area.

Figure 6-51 Flood impacts 20 year ARI event: Lower Richmond River and Ballina

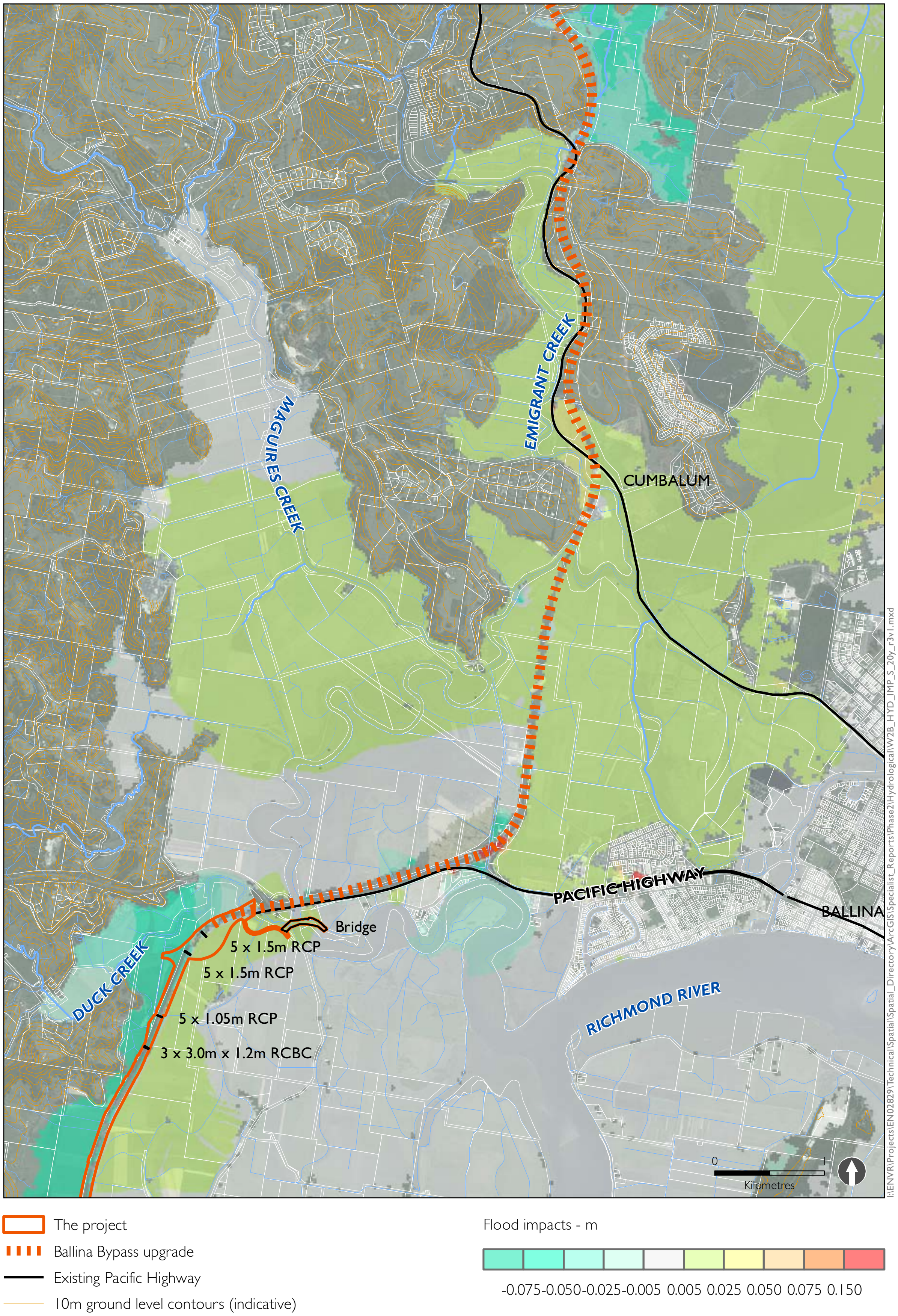


Figure 6-52 Flood impacts 100 year ARI event: Lower Richmond River and Ballina

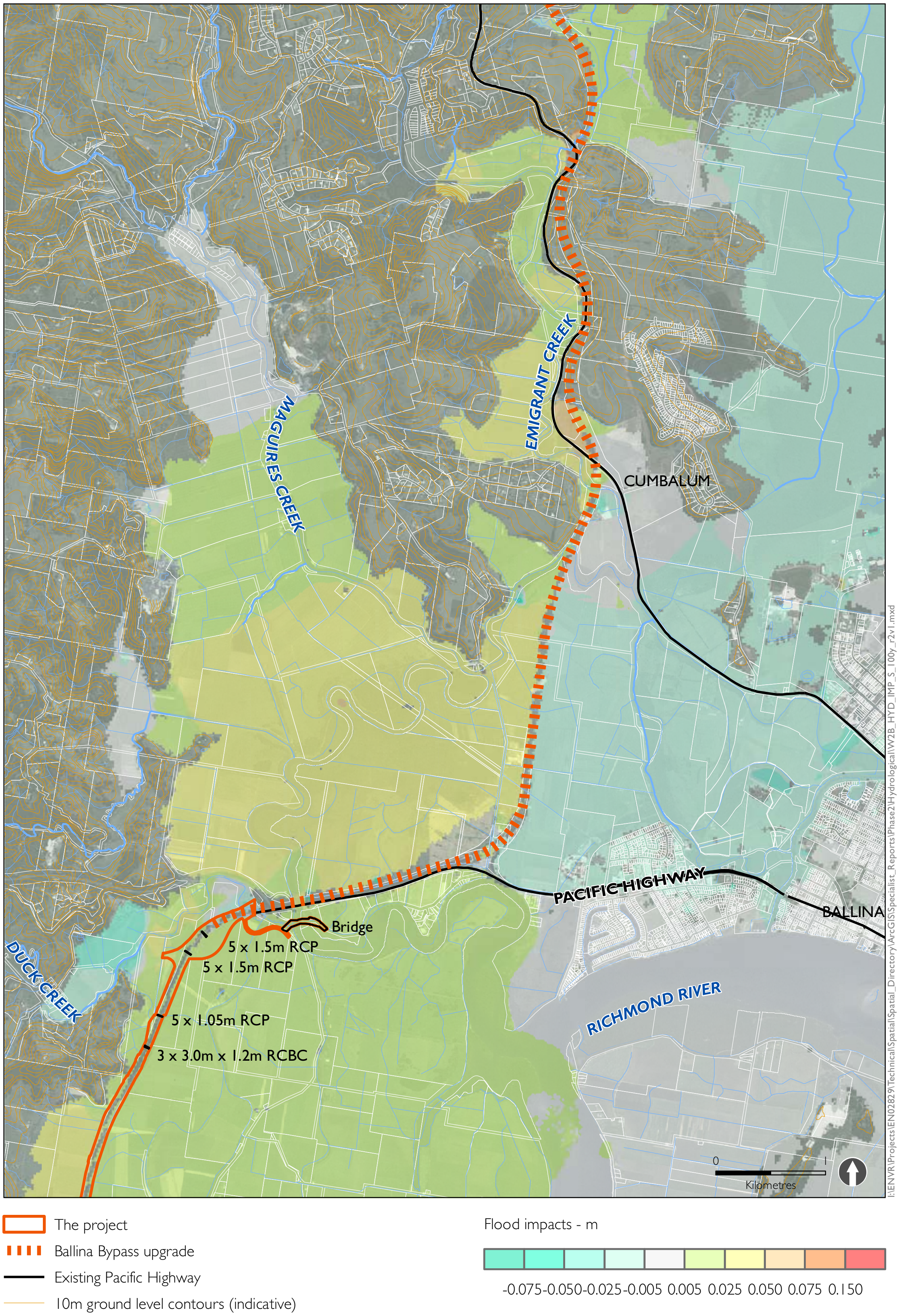
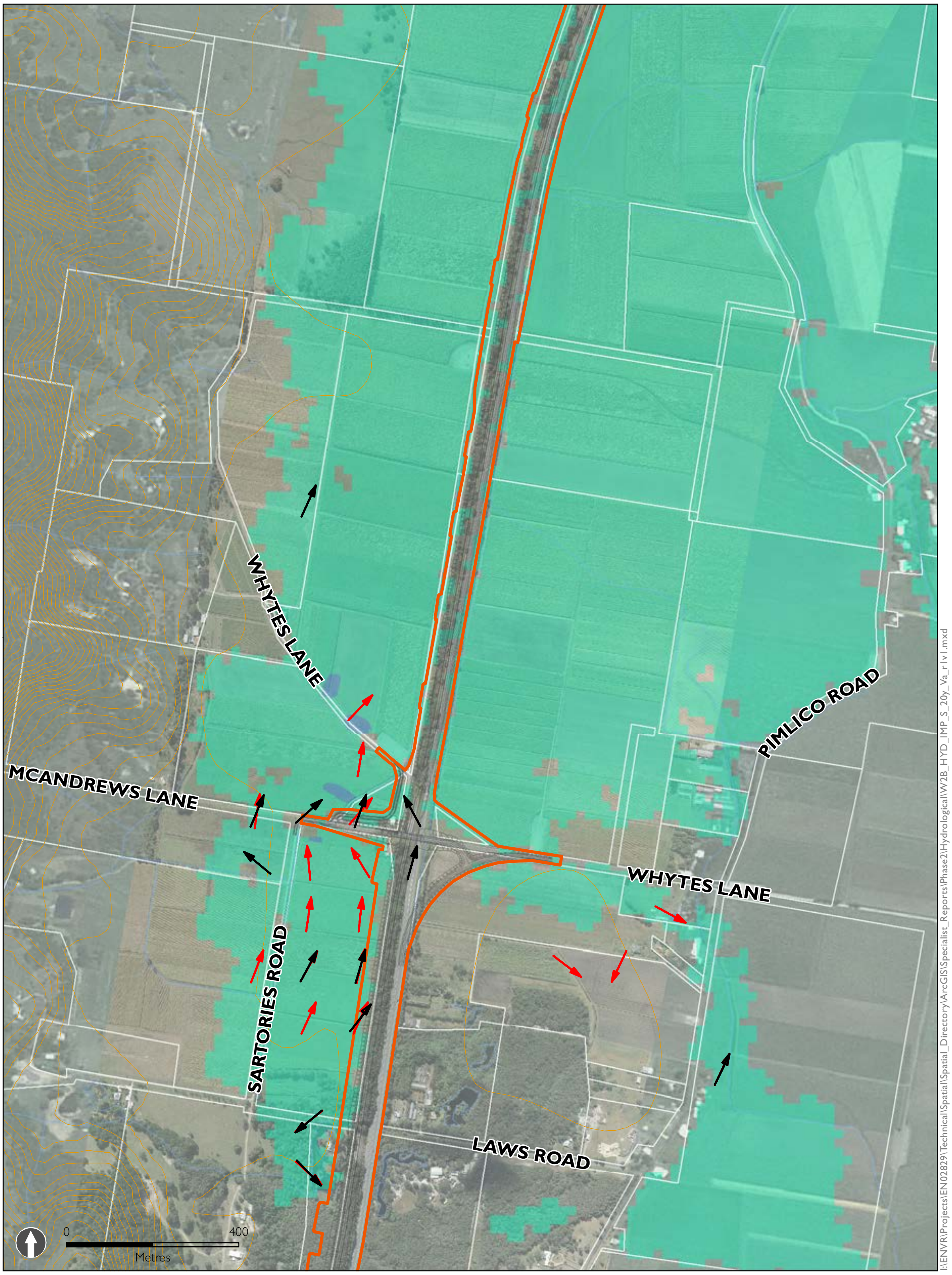
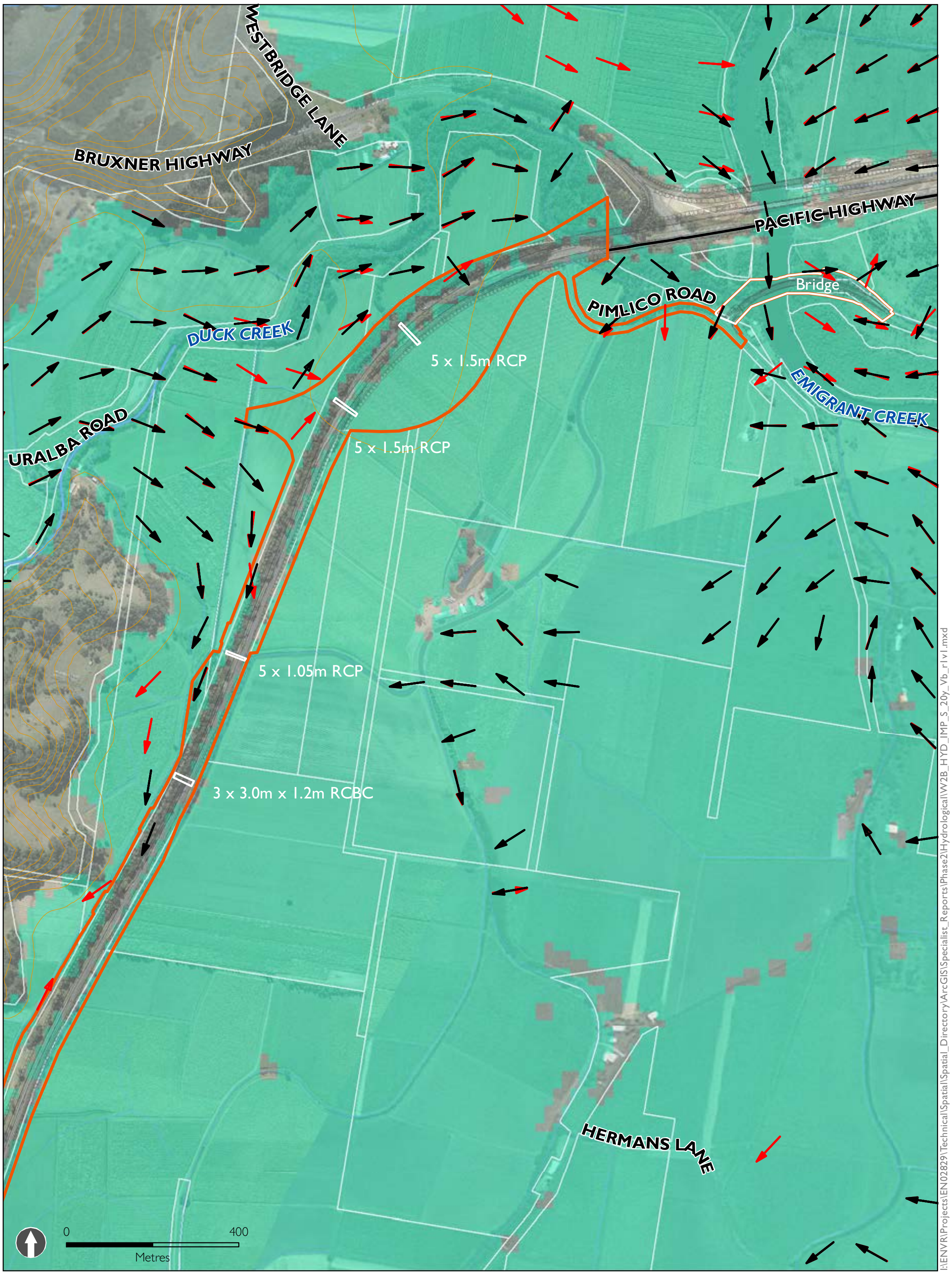


Figure 6-53 Velocity impacts 20 year ARI event: Lower Richmond River at Pimlico (South)



The project
Project concept design
Existing Pacific Highway
5m ground level contours (indicative)
Velocity direction with project
Existing velocity direction
Increase in flood velocity due to project - m/s
0.2 0.4 0.6 0.8 1.0 1.5 2.0

Figure 6-54 Velocity impacts 20 year ARI event: Lower Richmond River at Pimlico (North)



The project
Project concept design
Existing Pacific Highway
5m ground level contours (indicative)
Velocity direction with project
Existing velocity direction
Increase in flood velocity due to project - m/s
0.2 0.4 0.6 0.8 1.0 1.5 2.0

6.18. Impacts on hydrology of waterways

While most of the discussion in this assessment has focussed on major flood events, the impacts of the project on the overall hydrology of the crossed watercourses also require consideration. Small, frequent flood flows and more common wet-season flows are critical to maintaining the hydrological regime of the watercourses. As well, the ecology of many floodplain areas is dependent on the maintenance of seasonally wet conditions.

The project is unlikely to result in any measureable change in hydrological regime. The project would not result in any changes to the seasonality and frequency of flow. However, localised changes to the magnitude and timing of flows may result from modification to the proportion of pervious and impervious areas in catchments traversed by the project.

In general, the project would result in minor increases to the impervious fraction of catchments crossed due to the construction of the impervious road pavement surface. The change in impervious a fraction would generally be small in comparison to the overall catchment areas crossed.

Furthermore, a proportion of the runoff from these impervious road pavement surfaces would pass through water quality ponds prior to discharging into watercourses. These ponds would reduce peak flows from the impervious surfaces due to the ability of the ponds to detain runoff for a short period of time and then slowly discharge the stored volume. This retarded flow would mitigate the impact of the increased runoff rates from the impervious areas. Hence, the impact of the project on flow regimes would not be significant.

There are many creeks and watercourses crossed by the project where culverts (typically reinforced concrete box culverts) would be used. In some of these watercourses (such as Mororo Creek, Tabbimoble Creek and Oakey Creek) culverts are currently used to convey flows under the existing Pacific Highway. Hence, there would not be any additional changes to the hydrology of these creeks resulting from the project.

In other locations, the culvert crossings would require an assessment at the detailed design stage of the inlet and outlet velocities and the capacity of the watercourse to accommodate these velocities. These assessments are dependent on the final culvert size adopted in the design and a detailed understanding of the stream conditions of the watercourse.

Velocities of daily flows through culverted watercourses would require mitigation through detailed design to reduce velocity impacts to natural system velocities at the property boundary. These daily flows would need to be maintained or mimicked as closely as possible. In bridged watercourses, there would not be any change to the area of flow, hydraulic roughness or vegetation outside of flood events. As a result, velocities in daily flow conditions would not be affected.

The detailed design phase would include identification of treatments required to minimise erosion due to the project. These treatments would include larger culverts to reduce velocities and/or rock protection at the inlet and outlets of the culverts.

As well, the impacts to stream morphology of these culvert crossings would be minimised in the detailed design by maintaining the same inlet and outlet locations of the watercourse crossing. That is, shortened flowpaths with culverts perpendicular to the highway direction (aimed at minimising the culvert length) would be avoided and culverts would be designed to cross the project diagonally to result in the inlet and outlet locations being in the watercourse.

6.19. Impacts of hydrological changes on the ecology of waterways

Changes in hydrological and flooding conditions as a result of the project have the potential to impact aquatic ecosystems. The potential impacts identified with respect to changed hydrological response and/or flooding behaviour are generally related to the habitats and potential habitats of threatened fish species (Oxleyan Pygmy Perch and Purple-spotted Gudgeon) near the project. Waterways that are habitats or potential habitats of these threatened fish species include:

- Corindi River
- Cassons Creek
- Redbank Creek
- Chaffin Creek
- Tabbimoble Creek, tributaries and floodways
- Oakey Creek
- Agricultural drains north of Tuckombil Canal
- McDonalds Creek.

Potential impacts on aquatic ecology as a result of changes in hydrological response and/or flooding behaviour are discussed in the Biodiversity Working Paper. These are discusses below and further detail and mitigation of these issues is presented in the Biodiversity Working Paper.

6.19.1. Barriers to aquatic fauna movement

During flood events, the project may restrict the ability of threatened fish species (ie Oxleyan Pygmy Perch and Purple-spotted Gudgeon) to disperse across floodplains and colonise or re-colonise otherwise isolated bodies of water. During daily streamflow conditions, structures may also provide physical or behavioural barriers to fish if conditions are not suitable.

6.19.2. Increase of stream velocities through structures

The Oxleyan Pygmy Perch and Purple-spotted Gudgeon have a habitat preference for low velocity conditions and are sensitive to change. Increases of instream velocities have the potential to sweep fish downstream or disrupt natural reproductive cues.

Stream velocities may be increased in daily streamflow conditions through culverts but would generally not be affected by bridges which span the width of the channel. The design principles state that all Class 1[6] waterways (including all known sites of Oxleyan Pygmy Perch) should be bridges.

For the concept design, all but two of the Class 1 waterways are crossed by bridges. The remaining two Class 1 waterways (Redbank Creek region and the Unnamed Watercourse at station 134.7) will be addressed during detailed design.

6.19.3. Increase of flood velocities through structures

Velocities through floodplain culverts and bridges may be increased from natural conditions due to constriction of otherwise very slow moving floodwaters across the floodplain. The safe limits for passage of Oxleyan Pygmy Perch during flood times are not known. Hence, an assessment of the impacts to species movement due to increases in floodplain velocities is difficult.

Table 6-32 below lists the peak flood velocities for small flood events for structures across the known and potential habitats of the Oxleyan Pygmy Perch.

It is seen from Table 6-32 that, in some cases, existing velocities and velocities with the project are above the identified velocity parameters for Oxleyan Pygmy Perch habitat. However, velocities with the upgrade do not change from the existing scenario to a degree that is expected to impact upon the habitat of the Oxleyan Pygmy Perch. During detailed design, the design of these structures would be further considered to further assess velocity impacts to Oxleyan Pygmy Perch in consultation with relevant government agencies.

Table 6-32 Peak velocities in Oxleyan Pygmy Perch habitat in small flood events

Habitat area	Station (km)	Proposed Structures	Small flood event assessed	Existing peak velocity (m/s)	Peak velocity through structure with project (m/s)
Known habitat areas					
Tabbimoble Creek	101.54	100 m bridge over Tabbimoble Creek	2 year ARI	0.6	0.7
Unnamed watercourse at station 114.000	114.81	4 x 0.9 m concrete pipe (three existing pipes and one additional culvert)	2 year ARI	0.5	0.6
McDonalds Creek	136.67	10 m bridge	5 year ARI	0.1	0.1
Unnamed watercourse at station 134.700	134.60	1 x 1.8 m x 1.2 m box culvert	Minor waterway crossing; not assessed for small flood events – to be assessed in detailed design		
Swamps in Broadwater National Park	140.82	1 x 2.4 m x 2.7 m box culvert	5 year ARI	0.1	0.2

[6] Major permanently or intermittently flowing waterway, habitat of a threatened fish species (Fairfull and Witheridge, 2003). For more detail on waterway classes, refer to the Biodiversity Working Paper.

Habitat area	Station (km)	Proposed Structures	Small flood event assessed	Existing peak velocity (m/s)	Peak velocity through structure with project (m/s)
Potential habitat areas					
Redbank Creek	5.66	1 x 2.4 x 1.2 m box culvert 2 x 2.4 x 0.9 m box culvert	Not assessed – to be assessed in detailed design		
Casson Creek	4.69	56 m bridge over Cassons Creek floodway	2 year ARI	0.3	0.3
Coldstream River	42.54	120 m span bridge over western tributary	2 year ARI	0.8	0.8
	43.12	300 m span bridge over Coldstream River	2 year ARI	0.5	0.5
	43.91	160 m span bridge over unnamed creek to the east of the Coldstream River	2 year ARI	Not flooded	0.4
Pillar Valley and Black Snake Creek	46.07	80 m bridge over Pillar Valley Creek anaranch	2 year ARI	1.6	1.6
	46.34	90 m bridge over Pillar Valley Creek	2 year ARI	1.4	1.5
	46.67	50 m bridge over Black Snake Creek	2 year ARI	3.7	3.6
	47.02	4 x 3.0m x 1.5m box culverts for Pillar Valley Creek Tributary	2 year ARI	0.5	0.5
	47.66	60 m bridge over Pillar Valley Creek Tributary	2 year ARI	1.4	1.5
	47.81	40 m twin bridges for Pillar Valley Creek Tributary	2 year ARI	1.2	1.3
Oaky Creek	122.55	3 x 3 m x 2.4 m box culverts (replacing existing culverts)	2 year ARI	0.8	0.6
Nortons Gully	123.59	4 x 3 m x 2.4 m box culverts (replacing existing culverts)	2 year ARI	0.2	0.3
Tuckombil Canal	130.11	Additional 100 m span bridge over Tuckombil Canal	5 year ARI	1.3	1.3
Montis Gully	140.82	1 x 2.4 x 2.7 m box culvert	Not assessed as at upper end of gully – to be assessed in detailed design		
Eversons Creek	143.7	Diversion of 100 metres required as project batters on creek alignment	Not assessed – to be assessed in detailed design		
Richmond River	145.29	Additional 770 m span bridge over the Richmond River	5 year ARI	1.1	1.1

6.19.4. Changes in stream form and/or water quality as a result of erosion

Threatened fish species have preferences for specific stream conditions. These include dense aquatic vegetation and undercut and root-filled banks (Oxleyan Pygmy Perch) and weeds, rocks or large woody debris and low turbidity (Purple-spotted Gudgeon). Changes to instream velocities have the potential to change natural processes of erosion and sedimentation resulting in loss of aquatic habitat.

6.19.5. Alteration of water flow and/or damage to stream bank vegetation

Instream construction work or temporary connections have the potential to disturb daily flow conditions and/or damage aquatic habitat. Instream piers may result in localised changes to stream conditions, such as velocity and turbulence, which may create less-favourable conditions and/or barriers to fish movement.

6.20. Probable maximum flood considerations

6.20.1. General considerations

The probable maximum flood (PMF) is an estimate of the largest possible flood for a particular catchment. While there are procedures available for estimating these flows, it needs to be recognised that the estimates have a high degree of uncertainty due to the extrapolation of a relatively short period of recorded data.

For the larger Clarence and Richmond River catchments, the multiplier between the 100 year ARI peak flow and PMF peak flow is expected to be relatively low due to the very high improbability of high intensity rainfall over the whole catchment at one time. In the *Lower Clarence River Flood Study Review* (WBM, 2004), this multiplier was estimated to be in the order of 1.5. For the smaller Richmond River, the multiplier is estimated to be 2.6 (based on ratios of rainfall intensities for the 72 hour duration event).

Regardless of the magnitude of the flood event, the issue requiring consideration is the consequence of a flood event in which the peak flows exceed the capacity of the designed waterways and road embankment height.

6.20.2. Local catchments

For the local catchments, the likely consequences and impacts of the project on a PMF event would be higher flood levels with little or no likelihood for re-routing of flows into other catchments. This is largely due to the well-defined nature of the watercourses and floodplains.

The increases in levels resulting from the project crossing these catchments would have an upper limit. Once floodwaters overtop a significant section of the road embankment, the constriction to the flow becomes considerably less than that prior to overtopping. This is because the weir-like flow over the road is a more efficient form of floodwater conveyance than flows being constricted through the waterway opening. Therefore, while there would be increases in flood levels, it is possible that the magnitude of these increases would be less than that for a 100 year ARI flood event.

The other consideration for these flood events is that of road safety. It is likely that during events larger than the 100 year ARI event, the road would overtop and high velocity flows would cross the road. Where flooding occurs quickly, this could create dangerous conditions for driving, especially at night.

6.20.3. Clarence River and Richmond River floodplains

It is assumed in the considerations provided here that the crossing of the Clarence River and Richmond River floodplains would be constructed at or just above the 20 year ARI flood levels. In a PMF event (or any event significantly larger than the 20 year ARI flood), long sections or possibly the entire length of the floodplain section of road would be inundated.

6.21. Impacts on agricultural drainage networks

The potential for the project to impact on more frequent flood events is greater on the Clarence and Richmond River floodplains. These floodplains include networks of cane drains that play a critical role in the drainage of the land following flood events. Maintaining adequate drainage of agricultural lands is important for property owners.

The waterway structures listed in this working paper are derived from consideration of impacts during peak levels of large rare flood events. These drains play an important role in ensuring the runoff is able to drain to major watercourses such as the Clarence River. Operational crossings exceed the need for cane drainage except for along the Shark Creek floodplain because it experiences backwater flooding in large events. However, drainage requirements dictate lots of local drains.

As mentioned, culverts incorporated into the concept design accommodate all cane drains along the project length. In locations where several cane drains join under the road or cross the project in close proximity, drains are taken into one culvert. In some instances, new drainage routes may be constructed to simplify the current drainage route. Mitigation measures are discussed further in Section 8.3.1.

Subsequent stages of the project development would include further consideration of the required waterway structures on the Clarence River floodplain for local floodplain drainage such as those in the Chaselings Basin. It is expected that the requirement for major waterway structures on the floodplain can be coordinated with the need for minor drainage structures to provide adequate cross-drainage for both types of flood events.

6.22. Impacts on wetlands and waterbodies

6.22.1. Impacts on wetlands

The project will result in an increase in the quantity of runoff from the wetland catchments identified in Section 4.16. This is due to the increase in impervious area associated with the project. For all wetland catchments, the project area would be less than two per cent of the catchment area (see Table 6-33). Thus, it is not expected that the project would result in any discernible increase in the quantity of runoff flowing to the wetlands.

Table 6-33 Area of highway upgrade within wetland catchments

Wetland identification number	Wetland name (if applicable)	Catchment area (km^2)	Area of highway upgrade within catchment (km^2)	Area of highway upgrade as a per cent of catchment area
1		21	0.05	0.22%
2		150	0.18	0.12%
3	Cold Stream Wetlands	216	0.32	0.15%
4		62	0.11	0.18%
5		19	0.04	0.22%
6*	Upper Coldstream	629	0.99	0.16%
7	Shark Creeek Wetlands	162	0.18	0.11%
8	Yaegl Nature Reserve	8	0.04	0.53%
9		37	0.07	0.20%
10*	Bundjalung National Park	339	0.31	0.09%
11		8	0.08	1.09%
12		111	0.14	0.12%
13		7	0.04	0.63%
14		32	0.24	0.74%
15		24	0.10	0.41%
16		142	0.05	0.03%

6.22.2. Impacts on the Solitary Islands Marine Park

The project will result in an increase in the quantity of runoff from the Corindi River catchment, which drains into the Solitary Islands Marine Park. This is due to the increase in impervious area associated with the project. The project within the entire Corindi River catchment (about 150 square kilometres) consists of around 7.6 kilometres of road. This represents about 0.12 per cent of the total catchment area. Thus, it is not expected that the project would result in any discernible increase in the quantity of runoff flowing to the Solitary Islands Marine Park.

The Arrawarra gully catchment drains into the Arrawarra creek catchment, with both discharging into the Solitary Islands Marine Park. The project will result in an increase in the quantity of runoff from the Arrawarra Gully and Arrawarra Creek catchments, with approximately 2.6 kilometres of road being constructed in these catchments. The Arrawarra Gully catchment is about 11.23 square kilometres and the Arrawarra creek catchment is about 21.1 square kilometres. Hence, the project would represent 0.42 per cent and 0.22 per cent of the catchment areas, respectively. As such, it is not expected that the project would result in any discernible increase in the quantity of runoff flowing to the Solitary Islands Marine Park.

6.22.3. Impacts on farm dams

A farm dam impact assessment has been undertaken to identify farm dams currently located within the project boundary, or farm dams which are likely to be affected as a result of a reduction in catchment area. This reduction in catchment area is predominantly associated with sections of the project to be cut into elevated terrain which would subsequently drain stormwater away from its natural course.

Twenty-five dams were identified to either fall within the project boundary or have affected catchments. More than half (15) of these dams are located within, or partially within, the project boundary. These dams would be acquired and compensated by the project as part of the land acquisition process.

The remaining 10 dams are expected to experience some loss of catchment area, which would reduce the overall volume of rainfall-runoff captured by the dam. These dams are summarised in Table 6-34. A reduction in dam inflow may not be directly proportional to the loss of catchment area, however this is considered to be a good representation of the degree of impact.

Table 6-34 Affected farm dam catchments

Approximate station of affected farm dam	Catchment area (ha)	Predicted proportion of catchment affected (%)
10.2	16.2	5
40.3	11.8	19
45.2	9.0	50
51.8	1.3	68
52.3	4.3	93
54.6	9.1	77
66.4	7.3	88
127.5	9.5	51
125.8	5.6	20
152.9	1.3	56

6.23. Impacts to future development potential of land

6.23.1. Reduction in available land with future development potential

As discussed elsewhere in Section 6 for each floodplain crossed by the project, there would be small increases in the area of flood inundation in the 100 year ARI flood event. This will lead to a small reduction in the available land for future development (ie residential or commercial development). Alternatively, the impacts of the project would require higher fill levels to be used for future development areas immediately upstream of the highway.

This small decrease in future land use potential needs to be balanced against the increase in development potential accruing from the project for land adjacent to the project.

6.23.2. Future development potential of access affected land

Land with development potential in the vicinity of the project would generally require flood access in a 100 year ARI flood event. In order to identify land which currently has flood access in a 100 year ARI flood event that would be adversely affected by the project, an assessment of the flood impacts and access routes (i.e. public roads) was carried out. This assessment identified that there would not be any land that is currently accessible in a 100 year ARI flood event that would have this access reduced due to the project.

Land south on Wants Lane at the Coldstream River area would experience an increase in flood levels in the 100 year ARI flood event. However, access for this land is via Wants Lane and the bridge across the western tributary of the Coldstream River. In a 100 year ARI Coldstream River flood event, access across this bridge would not be possible. In a 20 year ARI Clarence River flood event, this bridge is also not trafficable. Hence, the development potential of this land is limited due to existing flood access issues and this potential would not be affected by the access across Wants Lane.

It should be noted that there are many locations where the project would result in significant improvements in flood access due to the increased flood immunity of the highway. The development potential of land in these locations would therefore be increased as a result of the project.

6.24. Cumulative assessment

There is the potential for residential filling to occur on the Clarence River floodplain at west Yamba. This is the only known filling or notable change proposed for the Clarence River floodplain. This filling was assessed in conjunction with the project to define the cumulative impacts. It was found that the flood impacts presented in this working paper are independent of those associated with the proposed filling at West Yamba. Hence, the impacts presented in this working paper are deemed to represent a cumulative impact scenario for the Clarence River floodplain.

There are not any known areas of filling or changes to the floodplain proposed for the Mid Richmond River floodplain area.

The Wardell to Ballina bypass section of the highway includes a cumulative assessment of the bypass and the Pacific Highway upgrade against conditions in 1998. This assessment is described in Section 6.17.

No other cumulative impacts of operation exist as flooding impacts of the project occur on discrete sections of the highway with no regional or overarching impacts.