

# 10. Hydrology and water management

## 10.1 Assessment approach

Flooding is the primary issue of concern to residents and farmers in the Macleay Valley, particularly communities located on the floodplains surrounding Kempsey, Frogmore and Frederickton, who are most susceptible to flooding risk.

Predicted changes in flood behaviour resulting from proposed upgrade bridges and embankments on the floodplains include changes in flood levels, flow velocities, periods of inundation and flow paths. These changes could result in impacts on land use, emergency procedures and flood risk.

Figure 10-1 shows the hydrological features of the proposed upgrade.

To assess the impact of the proposed upgrade on flood behaviour, a detailed study was undertaken between 2004 and 2006. The details of studies conducted for the Macleay River floodplain and other areas are outlined below.

### 10.1.1 Macleay River floodplain

The Macleay River floodplain flood modelling extended from west of Kempsey to east of Frederickton, covering the town of Kempsey, the East Kempsey wetland and the floodplain area of Frogmore, as shown in Figure 10-1. This study assessed the flooding characteristics for a range of flood events, including the March 2001 (approximate 13 year) average recurrence interval (ARI, see definition below); 20, 100, 200 and 500 year ARI; and probable maximum flood (PMF) events. Flood behaviour characteristics modelled included afflux (see definition overleaf), flow velocity and the area and period of inundation.

Flooding behaviour was also modelled for a range of flood events and bridging configurations. This modelling aimed to optimise the bridging configuration that minimise changes to the existing flood regime and current land uses, while also considering other performance criteria. This optimisation was done in consultation with the local community and considered issues such as property access across the corridor and maintenance of existing overland flow paths. Further details of community involvement regarding flooding issues are provided in Chapter 4 – *Community and stakeholder consultation* and Technical Report 1 – *Supplementary Flooding Report* in Volume 2 of this Environmental Assessment.

An outline of the bridging configurations, and performance criteria considered, is provided in Section 5.3.3. An optimum bridging configuration was selected and is described in detail in *Chapter 6 – Concept Design*.

The proposed crossing of the Macleay River floodplain would have three main waterway openings, comprising the Macleay River Bridge and two floodplain viaducts at locations corresponding with natural flow paths. The proposed upgrade would be on embankment through the remainder of this section.

The *Kempsey to Eungai Pacific Highway Upgrade – Flood Investigations Report* (NSW Roads and Traffic Authority 2006a) was published and displayed within the *Kempsey to Eungai Pacific Highway Upgrade Project Application Report (Supporting Information)* in August 2006.

In response to a request for additional information during a planning focus meeting with government agencies (August 2006) and a subsequent meeting with the Department of Natural Resources (December 2006), two larger flood events, the 200 year and 500 year ARI events were modelled. The assessment of potential impacts is documented in Technical

#### What is ARI?

ARI (average recurrence interval) is the long-term average number of years between the occurrence of a flood as big as or larger than the selected event. For example, floods with a discharge as great as or greater than the 20 year ARI flood event will occur on average once every 20 years.

ARI is another way of expressing the likelihood of occurrence of a flood event (Department of Natural Resources 2005).

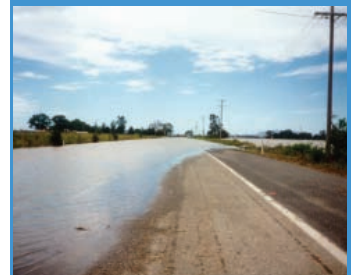
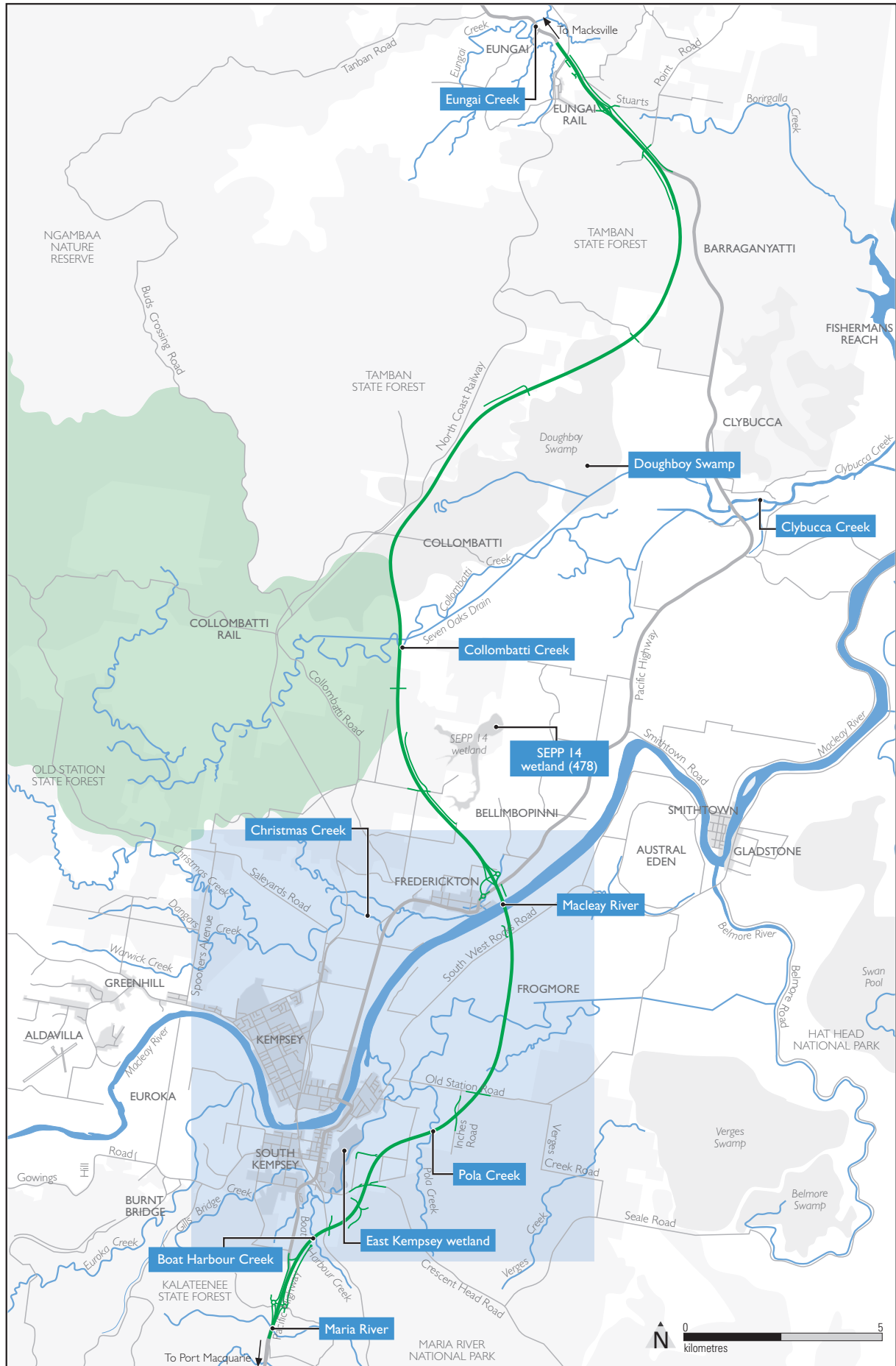


Photo: A road cut during March 2001 floods.

Figure 10-1 Hydrological features and extent of flood modelling



— The proposed upgrade    
  Collombatti Creek flood modelling extent    
  Macleay River flood modelling extent

Report 1 – *Supplementary Flooding Report* – Volume 2. The potential impacts of a flood event occurring during the construction of the embankments were also assessed. The outcomes of these assessments are included in this chapter.

### 10.1.2 Other areas

Modelling was also undertaken to determine potential hydrological changes at Pola Creek, Collombatti Creek and other waterway crossings. Figure 10-1 shows the location of key waterways crossed by or in close proximity to the proposed upgrade.

The Probabilistic Rational Method described in *Australian Rainfall and Runoff* (Engineers Australia 2001) was used to determine peak flows and design discharges for all other crossings for the 20 year and 100 year ARI design floods.

For the Pola and Collombatti Creeks, the hydraulic characteristics of the crossings were assessed in more detail using a quasi two-dimensional hydraulic model, MIKE10. Cross-sections for the model were extracted from survey data using a 12d Model (software that allows the development of designs in three dimensions). Three main flow paths were identified during detailed surveys of Collombatti Creek: the main Collombatti Creek channel, the Seven Oaks drainage canal and the breakout to the north of these channels.

At other waterway crossings, the one-dimensional hydraulic model, HEC-RAS, or basic culvert calculations, were used to determine hydraulic characteristics and provide details of minimum waterway crossing dimensions.

## 10.2 Flood behaviour

### 10.2.1 Changes to flood behaviour

#### Macleay River and floodplain

The Macleay River originates in the Great Dividing Range and flows across the New England Tablelands to the east through the Macleay Valley, before entering the Pacific Ocean at South West Rocks. The river is navigable and was used historically for shipping timber and other produce as far inland as Kempsey. Some recreational fishing occurs on the river.

The river emerges from rugged gorge country some 35 kilometres upstream of Kempsey. East of Kempsey, the river meanders through a wide expanse of low-lying floodplain with a network of channels and depressions, which act as flood storages.

#### Afflux

Table 10-1 shows the March 2001 (13 year), 20, 100, 200 and 500 year ARI events, and flood levels under existing conditions, and the predicted afflux that would be caused by the proposed upgrade at key locations across the floodplain. These locations are shown on Figure 10-2.

Changes to flood levels during the March 2001, 20 year ARI and 100 year ARI flood events are illustrated in Figure 10-3. Figures showing the predicted afflux during the 200 and 500 year ARI, and the PMF event are provided in Technical Report 1 - *Supplementary Flooding Report* in Volume 2.

The proposed upgrade crosses the Macleay River at the point the river breaks out of a confined valley into a broad floodplain. As a result, the narrowing of the floodplain by the elevated road embankment has caused an increase in the flood levels in the adjoining area.

Investigations indicated that the provision of adequate floodplain bridging to achieve minimal afflux would involve the bridging of virtually the full floodplain area. Given the fact that the

#### What is afflux?

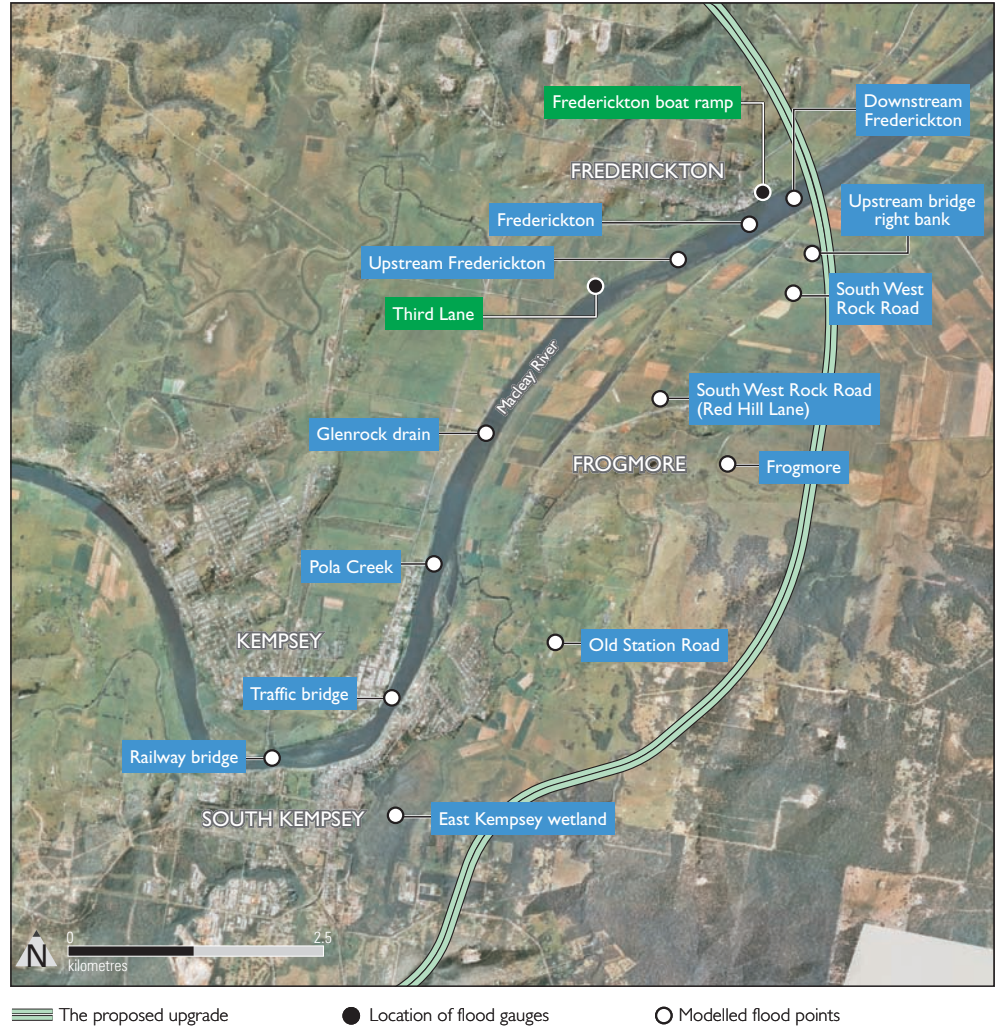
Afflux is an increase in water level resulting from additional obstacles in the flow path.

In this case, the proposed upgrade embankments would provide an obstacle to the flow path where it crosses the Macleay River floodplain.



Frogmore area is a sparsely populated floodplain area, it was considered more cost-effective to provide suitable compensatory measures in combination with afflux minimisation measures to restore the flood risk to an equivalent level similar to that of the existing conditions.

Figure 10-2 Location of modelled flood points



The Kempsey town centre and parts of Frederickton already have existing flooding problems. The floodplain crossing for the proposed upgrade has therefore been located sufficiently downstream of the town of Kempsey to avoid any increase in flood levels in the Kempsey CBD for flood events less than, or equivalent to a 100 year ARI flood event. It is also proposed to protect the village of Frederickton with a levee and provide a range of other flood management measures for the isolated properties in the Frogmore and East Kempsey wetland area. These measures would include house raising, stock mounds and selective flood protection of dairies and other critical agriculture infrastructure.

The crossing has been located sufficiently downstream of the town of Kempsey to avoid any afflux in the Kempsey town centre, which has a significant existing flood problem. It is proposed to protect the village of Frederickton with a levee and provide a range of flood management measures to the isolated properties in the Frogmore and East Kempsey wetland area.

These measures include house raising, stock mounds and selective flood protection of dairies and other critical agriculture infrastructure.

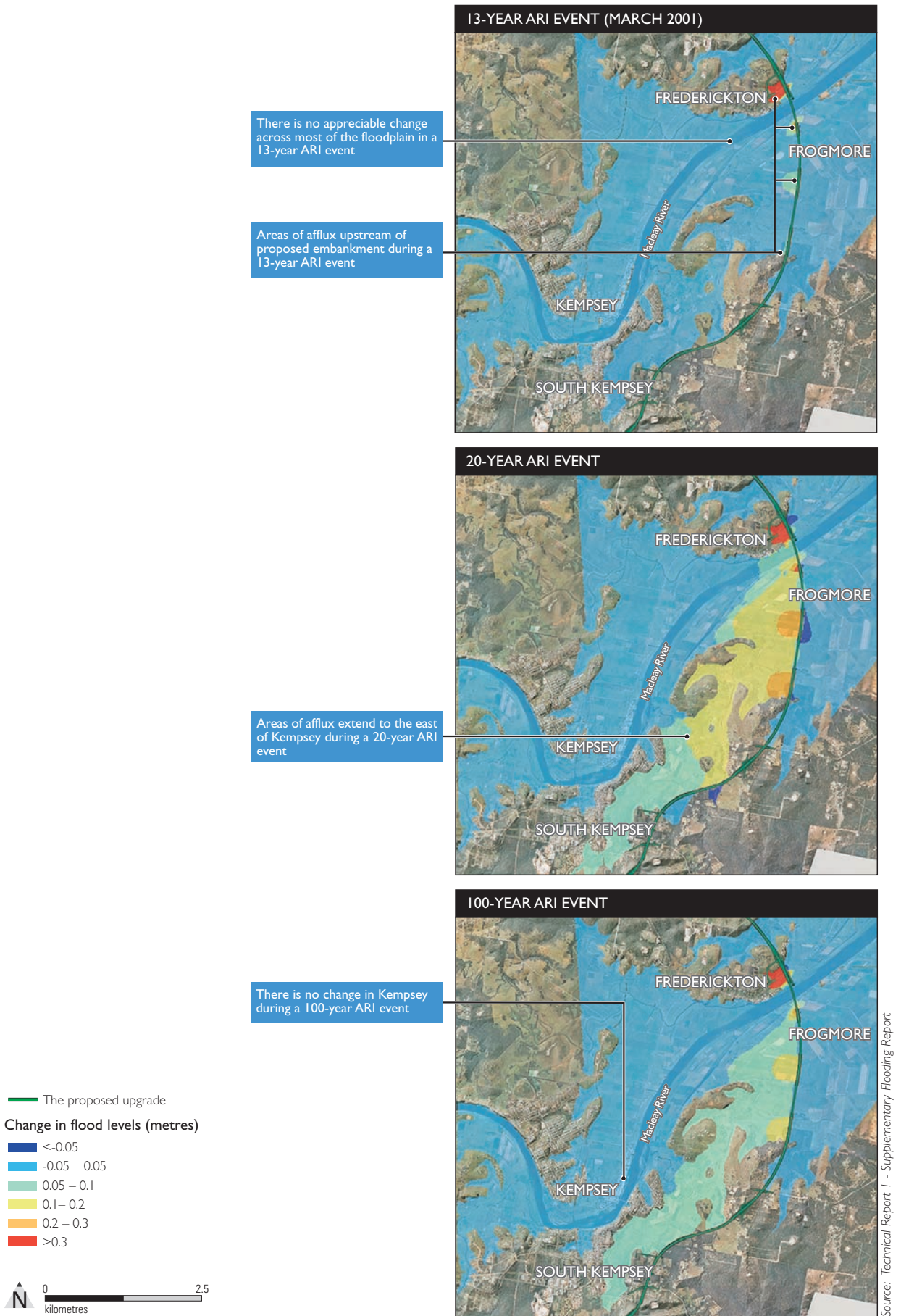
Table 10-1 Changes to afflux (Macleay River floodplain) under modelled flood conditions

| Location                   | Area       | March 2001 <sup>2</sup>      |                              |                 | 20-year ARI     |                 |                 | 100-year ARI    |                 |                 | 200-year ARI    |                 |                 | 500-year ARI    |                 |                 | PMF             |  |
|----------------------------|------------|------------------------------|------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|--|
|                            |            | Existing (mAHD) <sup>1</sup> | Change <sup>3</sup> (metres) | Existing (mAHD) | Change (metres) | Existing (mAHD) | Change (metres) | Existing (mAHD) | Change (metres) | Existing (mAHD) | Change (metres) | Existing (mAHD) | Change (metres) | Existing (mAHD) | Change (metres) | Existing (mAHD) | Change (metres) |  |
| Railway bridge             | River      | 8.17                         | No change                    | 8.79            | No change       | 10.15           | No change       | 10.98           | +0.01           | 10.71           | +0.01           | 16.29           | +0.03           |                 |                 |                 |                 |  |
| Traffic bridge             | River      | 7.48                         | No change                    | 7.81            | No change       | 8.70            | No change       | 9.56            | +0.02           | 10.20           | +0.03           | 14.63           | +0.05           |                 |                 |                 |                 |  |
| Pola Creek                 | River      | 6.98                         | No change                    | 7.28            | +0.01           | 8.11            | +0.01           | 8.81            | +0.03           | 9.34            | +0.04           | 13.18           | +0.09           |                 |                 |                 |                 |  |
| Glenrock drain             | River      | 6.75                         | No change                    | 7.07            | +0.01           | 7.86            | +0.02           | 8.49            | +0.04           | 8.99            | +0.05           | 12.66           | +0.11           |                 |                 |                 |                 |  |
| Upstream Frederickton      | River      | 6.22                         | +0.01                        | 6.43            | +0.02           | 6.96            | +0.04           | 7.47            | +0.08           | 7.86            | +0.11           | 10.38           | +0.20           |                 |                 |                 |                 |  |
| Frederickton               | River      | 6.04                         | +0.01                        | 6.23            | +0.02           | 6.65            | +0.05           | 7.02            | +0.10           | 7.35            | +0.14           | 10.86           | +0.26           |                 |                 |                 |                 |  |
| Downstream Frederickton    | River      | 5.86                         | +0.01                        | 6.00            | +0.02           | 6.32            | +0.06           | 6.60            | +0.11           | 6.87            | +0.14           | 10.53           | +0.27           |                 |                 |                 |                 |  |
| East Kempsey wetland       | Floodplain | 5.20                         | +0.03                        | 5.62            | +0.05           | 6.64            | +0.09           | 7.44            | +0.15           | 8.04            | +0.15           | 12.23           | +0.12           |                 |                 |                 |                 |  |
| Old Station Road           | Floodplain | 5.15                         | +0.04                        | 5.58            | +0.06           | 6.60            | +0.10           | 7.40            | +0.15           | 8.00            | +0.15           | 12.22           | +0.12           |                 |                 |                 |                 |  |
| Frogmore                   | Floodplain | 4.90                         | +0.05                        | 5.21            | +0.08           | 5.93            | +0.16           | 6.44            | +0.27           | 6.84            | +0.31           | 10.90           | +0.19           |                 |                 |                 |                 |  |
| South West Rocks Road      | Floodplain | 4.89                         | +0.04                        | 5.19            | +0.06           | 5.87            | +0.12           | 6.33            | +0.19           | 6.69            | +0.23           | 10.69           | +0.21           |                 |                 |                 |                 |  |
| Upstream bridge right bank | Floodplain | 4.98                         | +0.11                        | 5.27            | +0.12           | 5.88            | +0.16           | 6.32            | +0.24           | 6.66            | +0.30           | 10.61           | +0.47           |                 |                 |                 |                 |  |

Source: Technical Report 1 - Supplementary Flooding Report - Volume 2

1. mAHD = metres above Australian Height Datum
2. March 2001 flood data has been recalculated and therefore varies from values quoted in the Project Application – Supporting Information (NSW Roads and Traffic Authority, 2006a)
3. Change in water level with proposed upgrade  
These changes could alter as a result of refinements during detailed design.

Figure 10-3 Change in peak flood levels as a result of the proposed upgrade



The results indicate that there would be no change to flood levels at Kempsey (railway and traffic bridge locations) for the 20 year and 100 year ARI events or the March 2001 event, as a result of the proposed upgrade.

Near East Kempsey (East Kempsey wetland and Old Station Road) the estimated afflux is 100 millimetres for the 100 year ARI event. For the low-lying floodplain areas of Frogmore, adjacent to South West Rocks Road and the proposed upgrade, the estimated afflux is up to 160 millimetres for the 100 year ARI event, but less than 100 millimetres for the 20 year ARI and March 2001 events. Therefore changes to flood levels would most affect low lying areas around Frogmore, requiring the provision of mitigation measures to reduce flood impacts at this location.

For the 200 and 500 year ARI events, a comparable level of afflux is predicted at all locations, with the largest afflux at Frogmore. However, during a PMF event where flood levels are much higher, the predicted afflux varies considerably depending on location, with significant afflux downstream of Frederickton and upstream of the bridge's right bank (near the proposed Macleay River bridge).

Embankment heights on the floodplain may temporarily change during the settlement process as fill is added to the embankments. Should a major flood event (e.g. 100 year ARI or larger) occur during this time, there could be a slight increase in the afflux experienced across the floodplain. A full assessment of this risk and the level of sensitivity to changes in embankment height are provided in Technical Report 1 - *Supplementary flooding report* in Volume 2.

Measures to reduce the impacts of changes to flood levels (up to the 100 year ARI) are described in Section 10.5.

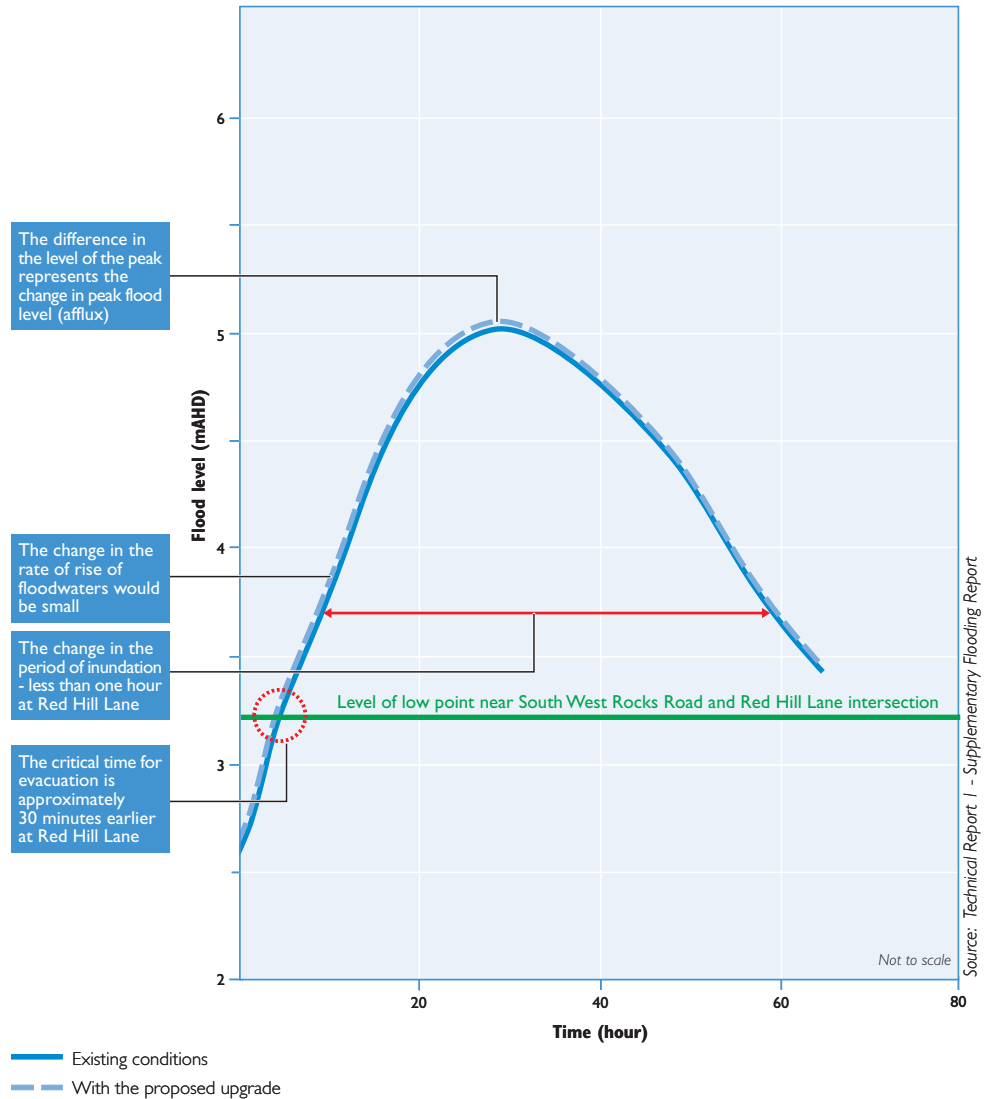
#### *Inundation*

The predicted period of inundation during times of flood is important because it can affect pasture survival and recovery rates and the ability to carry stock. It can also affect local landholders during and after the event, due to disruptions in access to their properties and potential loss of income.

The modelling of the 100 year ARI and March 2001 flood events for existing and proposed upgrade conditions determined that there would be little change to the duration of inundation of the floodplain. For areas like Frogmore and South West Rocks Road at Red Hill Lane (refer to Figure 10-2) the period of inundation predicted was approximately 34 hours in a 100 year ARI event and 48 hours in a March 2001 event. The change in the period of inundation that would result from the proposed upgrade would be less than 1 hour for both a 100 year ARI event and a March 2001 event, as shown on Figures 10-4a and 10-4b. In the context of existing inundation times, this predicted increase and the associated impacts are small.

For the 200 and 500 year ARI and PMF events, the change in the predicted period of inundation associated with the proposed upgrade is very small. Further, affected areas would already have been inundated for a considerable period of time under current conditions, resulting in damage to crops, pasture and other infrastructure regardless of whether the proposed upgrade is constructed or not.

Figure 10-4a Change in period of inundation and rate of rise – March 2001



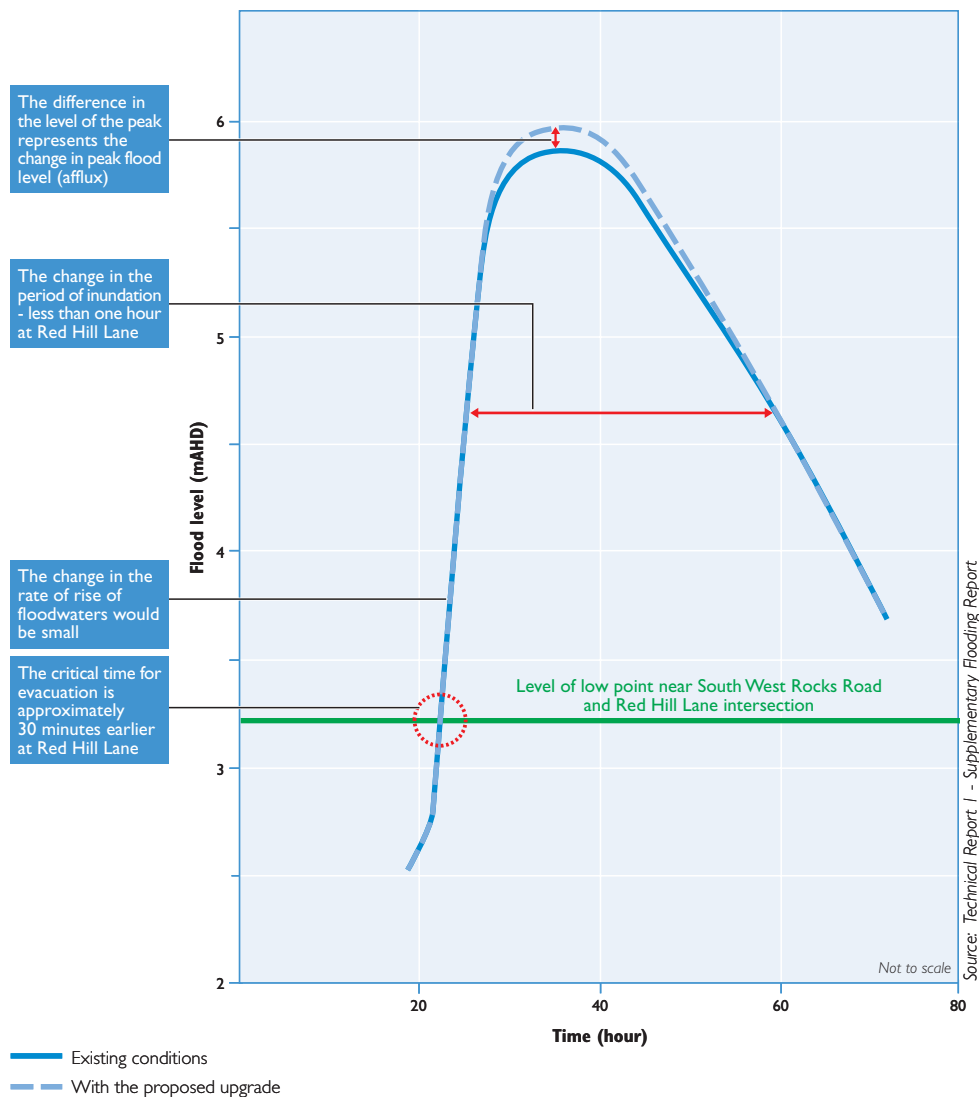
Source: Technical Report 1 - Supplementary Flooding Report

The area or extent of inundation is also an important characteristic of a flood. This characteristic is a function of the actual flood level in a particular area. Any increase in flood levels can therefore potentially cause an increase in the extent of inundation, which in turn can change the flood risk for the newly inundated land.

As indicated by the modelling, the areas where the afflux would be increased by the proposed upgrade for flood events up to and including the 100 year ARI event would occur across the southern part of the floodplain (particularly in the Old Station Road, South West Rocks Road, Frogmore and upstream bridge right bank locations as shown in Figure 10-2). For these locations, there is unlikely to be any significant increase in the current extent of inundation (see Figure 10-3), because the flood waters would generally be constrained by the road embankment in an existing low, flat floodplain area. Where these areas do adjoin the edges of the existing floodplain, the banks are relatively steep and there would be little increase in the area of inundation. As indicated previously, afflux is only predicted to occur in those areas adjoining the proposed upgrade, and therefore no increase in the extent of inundation is expected in areas further away from the alignment.



Figure 10-4b Change in period of inundation and rate of rise – 100-year ARI



### Rate of rise

The rate of rise of floodwaters affects the time available for emergency flood evacuation procedures to be implemented.

Modelling results show that at the early stages of a flood where the decision to evacuate is made, flood levels would not rise significantly faster as a result of the proposed upgrade. It was predicted that, for major flood events (i.e. flood events 20 year ARI and larger) floodwaters would rise up to and above South West Rocks Road 30 minutes sooner with the proposed upgrade, affecting the time of flood evacuation procedures. This is illustrated in Figure 10-4a (March 2001) and 10-4b (100-year ARI).

Current evacuation procedures would need to be reconsidered by residents, landholders and emergency services in the context of the afflux, rate of rise and period of inundation. This is discussed further in Section 10.2.2. Measures to reduce impacts of changes in the rate of rise are described in Section 10.5.

### *Flow velocity*

Flow velocity is described as the speed of flow of a volume of water. The construction of the proposed upgrade would result in some localised changes to flow behaviour within the floodplain, causing velocities to increase around waterway openings and decrease both upstream and downstream of the proposed embankments on the Macleay River floodplain, as illustrated in Figure 10-5. Changes in flood flow velocity are generally not critical unless they cause changes to the level of damage to infrastructure, such as fences, soil, crops and pasture.

Figure 10-5 presents the existing and predicted velocities across the floodplain for the 100 year ARI event. The largest increase in flow velocity is predicted in the vicinity of the middle bridge at South West Rocks Road. At this location, the predicted increase in velocity is from 0.7 metres per second (existing) to 0.9 metres per second for a 100 year ARI event. According to the RTA *Road Design Guide* (NSW Roads and Traffic Authority 2006c), velocities of 1.5 metres per second are an approximate maximum velocity, which is not likely to cause erosion of average uniform crop cover. This value would reduce to between 0.2 to 0.7 metres per second for bare soils.

With the exception of South West Rock Road, flow velocity during the 200 and 500 year ARI and PFM events would either not change or would decrease. The predicted increase at South West Rocks Road is very minor in the context of predicted flow velocities, which are mostly well over 1.5 metres per second. Further details on predicted flood velocities during these events are provided in Technical Report 1 - *Supplementary Flooding Report* in Volume 2.

For the majority of the floodplain, there would be no measurable change in flow velocities due to the proposed upgrade. Measures to reduce impacts of changes to flow velocity are described in Section 10.5.

### **Other areas**

#### *Pola Creek*

Pola Creek is a tributary of the Macleay River, and originates in the high ground to the south of East Kempsey. The creek flows north and meanders through the low-lying area of the East Kempsey wetland before discharging into the Macleay River (refer Figure 10-1). The proposed upgrade would cross Pola Creek, west of Inches Road.

The catchment area is small compared to the Macleay River catchment. The peak flood levels in this vicinity are dominated by backwater from the river. During a flood, floodwaters from the Macleay River back up and converge with water flowing from the Pola Creek catchment. Floodwaters backing up from the area to the east of Hampden Hall also flow into the East Kempsey wetland.

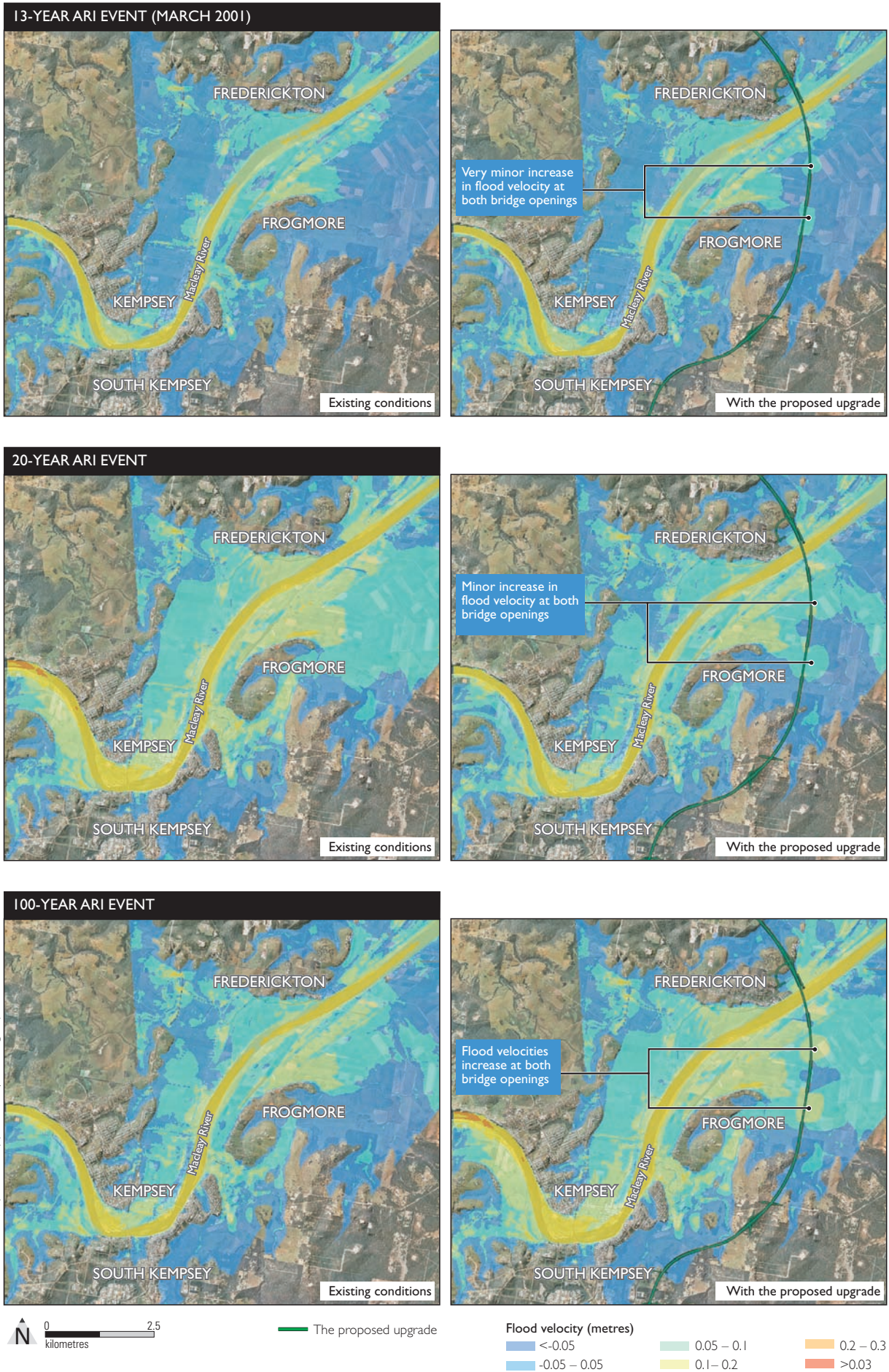
To account for these dynamics, peak flood levels at Pola Creek were determined based on the Macleay River hydraulic model. However, peak velocities would be generated by local run-off from the local catchment and are not related to the backwater effect from the Macleay River.

The proposed upgrade embankment would limit the progression of backwater from the Macleay River into the Pola Creek catchment. This would slightly reduce the peak flood level for major floods for the catchment upstream of the embankment, with negligible impact downstream. The waterway opening at Pola Creek would have a minimum opening of 30 square metres.

#### *Collombatti Creek*

Collombatti Creek is a meandering tributary on the northern side of the Macleay River running from south of Collombatti Rail through Doughboy Swamp, before joining the Macleay River at Bellimbopinni (refer Figure 10-1) between Frederickton and Smithtown.

Figure 10-5 Change in flow velocities as a result of the proposed upgrade



**What is a critical storm event?**

A critical storm event is the duration of a particular rainfall event which produces the highest flood level at a particular geographic location.

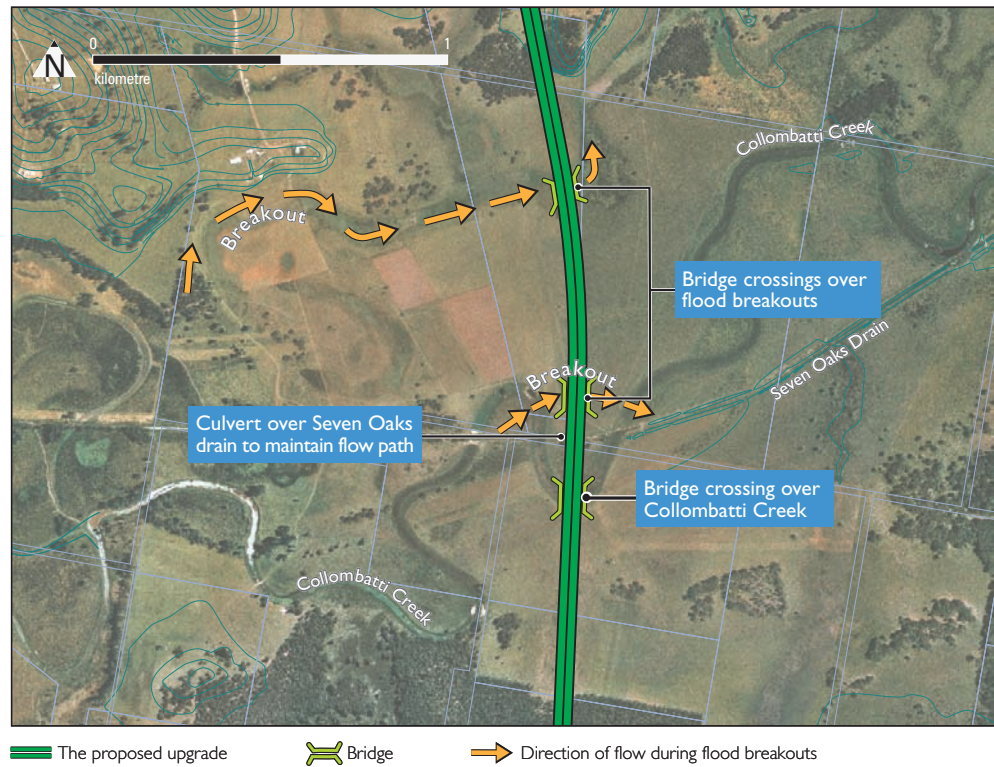
In the vicinity of the proposed upgrade and Collombatti Creek, three main flow paths were identified: the main Collombatti Creek, the Seven Oaks drain and a flood breakout flow path to the north of these. Flow paths at Collombatti Creek are illustrated in Figure 10-6.

Modelling of Collombatti Creek was undertaken for the 5 year, 10 year and 100 year ARI design events. The critical storm event in all instances was the 36-hour event.

The modelling predicted existing hydrological conditions and changes as a result of the proposed upgrade. A number of trials were run to assess the optimal locations for bridge and culvert crossings for the proposed upgrade.

A combination of bridges and culverts at low points across the floodplain was found to satisfy the performance criteria (refer Section 5.3.3). Three bridge locations were identified, one across Collombatti Creek and two in the breakout area to the north of the Seven Oaks drain.

**Figure 10-6 Collombatti Creek flow paths and proposed bridging**



Weirs have been placed in several locations in the Seven Oaks drain by the local drainage union and landholders to minimise drying of soils and oxidation of potential acid sulfate soils. To maintain the existing flow path, culverts would be included in the proposed upgrade over Seven Oaks drain. The locations and spans of the Collombatti Creek floodplain bridges and culverts are provided in Table 6-6. Figure 10-6 shows the location of bridges and the Seven Oaks drain culvert.

Changes in flood levels on Collombatti Creek floodplain resulting from the proposed upgrade are predicted to comprise an increase of up to 190 millimetres immediately upstream of the proposed upgrade, reducing to less than 100 millimetres approximately 600 metres upstream of the Collombatti Creek bridge. The impacts of changes to flood levels on residences and other infrastructure are outlined in Section 10.2.2.

## 10.2.2 Impacts of changed flood behaviour on the community

### Residences

The proposed upgrade would result in an increase in flood levels upstream of the alignment and would affect a number of residences, both in the town of Frederickton and in rural areas on the Macleay River floodplain.

Under existing conditions, 46 residences and commercial buildings would be inundated during a 100 year ARI flood event. Two additional residences not previously flood liable would be subject to flooding as a result of the proposed upgrade.

The proposed Frederickton flood levee would provide 100 year ARI flood protection for 24 residences and commercial buildings, mostly on Lawson Street, Frederickton. A total of 26 residences here would be protected that were previously flood liable.

Twenty-three (23) residences would remain flood liable after construction of the proposed upgrade with the proposed flood levee. This includes the following:

- 11 at Frederickton.
- 2 downstream of Frederickton.
- 8 near the East Kempsey wetland.
- 2 at Christmas Creek.

No other residences in catchment areas along the proposed upgrade would be affected by increased flood levels. Future residential development on the floodplain would need to comply with revised minimum height requirements stipulated in the local planning instruments.

A 200 or 500 year ARI event would significantly increase the number of dwellings affected by flooding. However, the proposed upgrade and Frederickton levee would still protect up to 26 residences during a 200 year ARI event.

Several strategies are available to mitigate impacts on affected properties. A more detailed description of proposed management measures is provided in Section 10.5.

### Agricultural land

Good drainage reduces the duration of inundation during high rainfall and flood events, allowing pasture to recover more quickly. Higher ground provides refuge for cattle during floods and gives farmers the opportunity to find unaffected pasture if their pasture is spoiled or remains inundated.

Extended periods of inundation during flood events can kill pastures and render the ground unusable for an extended period of time. The period of inundation during major flood events increases by typically less than 1 hour for a 100 year ARI, where the period of inundation is currently approximately 34 hours. However, the change in the period of inundation for pastoral lands during large flood events as a result of the proposed upgrade would not be noticeable as pasture is likely to be damaged regardless due to the length of the period it is inundated. During smaller events, which are more frequent, any increase in inundation would put areas of pasture at risk of damage on a more frequent basis at greater cost to the landholder.

The proposed upgrade is predicted to increase flood velocities in close proximity to the Macleay River Bridge. In some circumstances this velocity could result in some localised damage to topsoil and pasture. Measures to minimise impacts on topsoil and pasture are discussed in Section 10.5.

### Stock refuge

Cattle properties on the Macleay River floodplain and in the Collombatti area have evacuation plans to protect stock during major flood events. These rely on upstream flood level monitoring and reporting, local knowledge of drainage, flow paths and rates of rise.

The evacuation of stock from the Macleay River floodplain is carried out by either walking stock to high ground and/or trucking them out to high ground. For many properties, evacuation by truck is the only practical option. Truck access to the floodplain is constrained by the low point on South West Rocks Road near Red Hill Lane.

Increased flood levels may affect the safety of stock in the area immediately upstream of the proposed upgrade. Further consideration of stock evacuation and agricultural impacts is provided in Chapter 15 – *Land use and property*. Existing stock evacuation routes and proposed changes as a result of the proposed upgrade are illustrated in Figure 10-7.

While the Rural Lands Protection Board stock reserve on Old Station Road (shown in Figure 10-7) would be directly impacted by the proposed upgrade, it would remain available for temporary holding of stock prior to transportation.

### Emergency services access

The State Emergency Service (SES) attends major accidents on the Pacific Highway and provides emergency services during major flood events. Emergency services in Kempsey are isolated as flood levels rise, cutting off Frederickton and East Kempsey and, therefore, access to the existing Pacific Highway.

Spooners Avenue, which runs north-south through West Kempsey, is currently used as an alternative access route to the existing Pacific Highway at Frederickton. This access route is unavailable during flood events larger than the 10 year ARI flood, at which point the route is also cut off by flood waters.

The proposed upgrade would carry traffic clear of flood waters for all events up to and including the 20 year ARI event. Therefore, during flood events greater than a 10 year flood, the Kempsey SES would not be able to access the new highway to attend accidents.

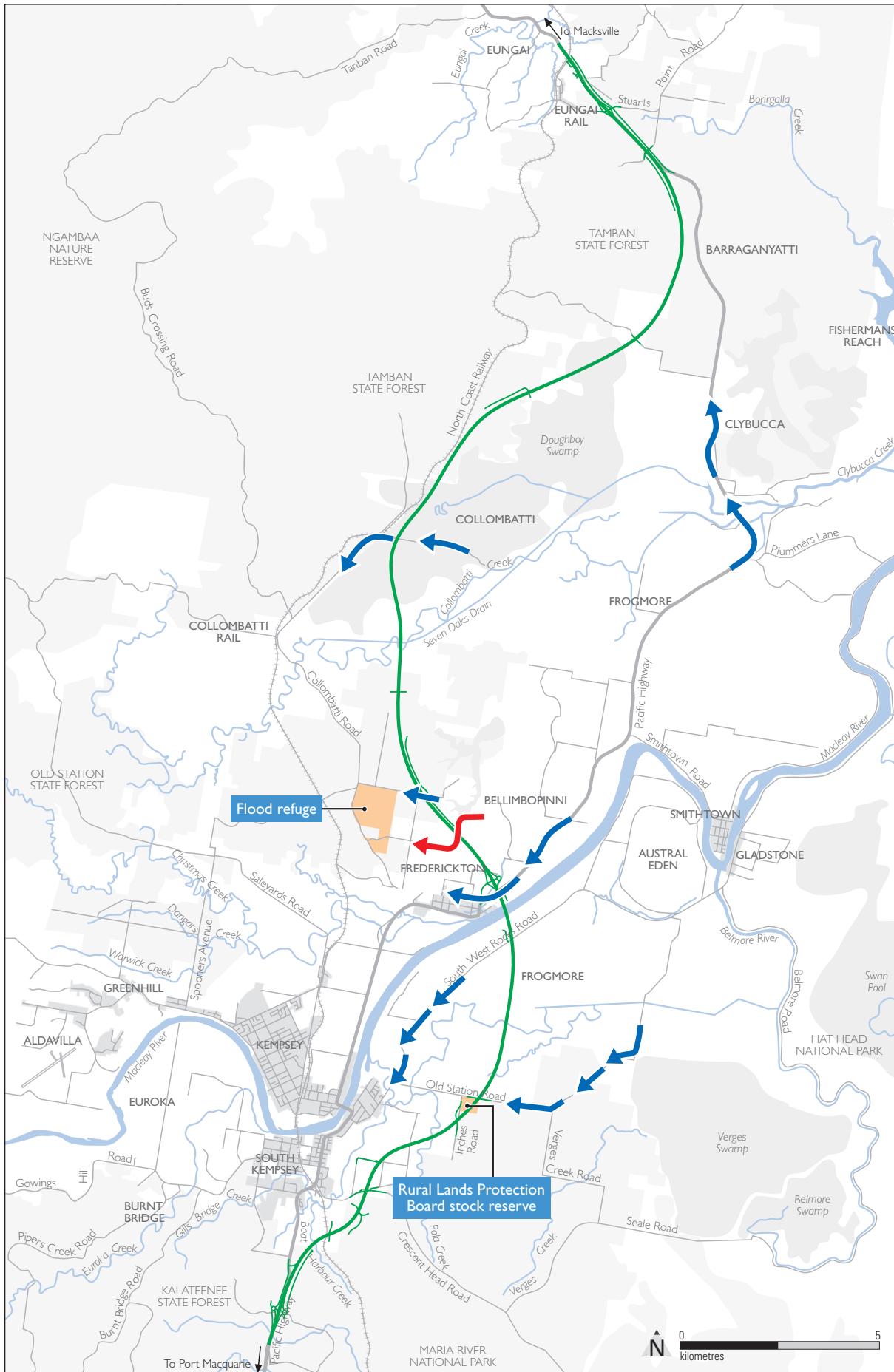
A risk assessment carried out after consultation with the Kempsey State Emergency Services to assess future SES access requirements on Spooners Avenue indicated that an upgrade of Spooners Avenue would not be cost-effective. It is expected that an upgraded highway would deliver a reduction in the incidence of crashes on the highway between Kempsey and Frederickton to such a level that there was little likelihood of an accident occurring which required the attendance of the SES on this section of the proposed upgrade during flood events greater than the 10 year ARI and less than the 20 year ARI. Further, the upgraded highway would most likely be accessible to other regional SES units in the event that an accident occurred at a time when floodwaters prevented access to the highway for the Kempsey SES.

## 10.3 Surface water flows

### 10.3.1 Changes to surface water flows

The design of the proposed upgrade would allow the natural flow regimes and existing flow paths to be maintained. Transverse culverts would be provided to convey run-off from upslope catchments beneath the proposed upgrade. Culverts have been designed with adequate capacity to convey the 100 year ARI peak flood flow with:

Figure 10-7 Location of refuge areas and emergency evacuation routes during floods



- The proposed upgrade
- Stock reserves
- ← Emergency evacuation routes
- ← Emergency evacuation routes to be closed

- No flow on at least one carriageway of the proposed upgrade.
- Minimal increase to water levels upstream of the structure.
- Minimal disruption to the natural hydrological regime through the diversion of flow onto adjoining catchments.

Culverts have been sized to ensure peak water levels upstream of the structure meet the road flood immunity requirements. Where culverts may increase the velocity of water exiting culverts, the design has been altered to prevent potential scouring and impacts on fish passage. Culvert design is detailed in Section 6.1.4.

Waterway diversions within the proposed upgrade corridor would only be constructed where there is a requirement to:

- Relocate a waterway clear of the road alignment where the waterway is flowing parallel to the proposed upgrade.
- Limit the skew on proposed culverts to minimise the length of the culvert as it passes underneath the proposed upgrade.
- Direct clean water around water quality basins (to minimise the size of basins).
- Combine minor flow paths in a single structure.

The need for waterway diversions would be assessed during the detailed design phase of the project considering these principles.

### 10.3.2 Impacts of changes to surface water flows

Local hydrological impacts could result from increases in run-off due to the greater impervious areas associated with the proposed upgrade, the concentration of flows and changes in flow regimes. Where possible and practicable, the concept design has incorporated measures such as culverts and diversion drains to limit the extent of change to these local drainage characteristics.

#### Waterways

Three wetland areas, Doughboy Swamp, the SEPP 14 wetland (No. 478) and the East Kempsey wetland (refer Figure 10-1), are located in close proximity to the proposed upgrade. Any significant reduction in surface water flows to wetlands and waterways could impact on flora and fauna within and in proximity to wetlands and other riparian areas, while also affecting soil erodibility and stability. The proposed upgrade incorporates sufficient transverse drainage infrastructure to maintain existing surface water flow regimes.

#### Local drainage

Disturbance to drainage paths would change local hydrological regimes and could potentially reduce the productivity of agricultural land. Detailed discussions were held with local landholders to ensure that all drainage paths were identified and their dimensions measured. The proposed upgrade would not change local drainage paths essential for the drainage of agricultural land.

Culverts would be appropriately sized and fitted with scour protection and energy dissipation devices, as required, to minimise impacts of any increase in flow velocity. Energy dissipation devices would result in very minor afflux near waterway openings.

#### Aquatic ecology

Potential impacts on aquatic ecology resulting from changes to surface water flows associated with the proposed upgrade are described in Section 10.3.8.



## 10.4 Groundwater

Groundwater was encountered at levels ranging from 0.5 to 35 metres below the surface along the proposed upgrade alignment. Data was sourced from peizometers installed during geotechnical investigations and registered bores maintained by the Department of Energy and Water (NSW Department of Natural Resources 2005). Shallow water levels, ranging from 0.5 to 4.5 metres below the surface, were found toward the centre of the study area, low in the Macleay River catchment and mostly within the floodplain alluvium.

### Changes to groundwater flows

Alluvial aquifers in the Macleay Valley provide a source of potable town water for the area and recharge regularly with good rainfall. In other areas, fractured rock aquifers provide water for stock and domestic supplies in rural areas (Department of Land and Water Conservation 1998a). A local farmer advised that several farm dams adjacent to the proposed upgrade in the Collombatti area may be spring-fed.

The horizontal and vertical alignment of the proposed upgrade has been designed to minimise changes to the local hydrology and access to groundwater. The proposed upgrade would not prevent groundwater recharge or sever groundwater flows feeding water resources like farm dams or groundwater-dependent ecosystems like wetlands. The proposed cross drainage would allow natural surface flows to recharge areas that are to be maintained.

The construction of pile foundations could involve dewatering in areas where groundwater is close to the surface. Both bored and driven piles would be used depending on ground conditions. In some circumstances, particularly with bored piles, this process could potentially induce salt water intrusion into the groundwater system, potentially affecting vegetation and the quality of potable water.

Depending on the preloading technique used for the embankment on the Macleay River floodplain, some surcharging could occur where groundwater is forced upwards saturating the ground surface. Techniques such as vacuum consolidation could be used to minimise surcharge whilst maximising the consolidation process. Any residual water would be extracted and treated on-site prior to release into local waterways.

The disturbance of acid sulfate soils during construction and lowering of the water table could potentially result in changes to groundwater chemistry, such as a lowered pH, increased metals in solution (e.g. aluminium and iron), and raised total dissolved solids. Although the water quality in areas containing acid sulfate soils is generally poorer, disturbance of these soils could potentially cause further degradation of groundwater quality and, in turn, surface water.

Impacts of the proposed upgrade on water quality and proposed mitigation measures are discussed further in Section 20.2.

## 10.5 Management of impacts

### 10.5.1 Building protection

The proposed Frederickton flood levee would provide 100 year ARI flood protection for 24 residences and commercial buildings, mostly on Lawson Street, Frederickton. A total of 26 residences would be protected that were previously flood liable.

As outlined in Section 10.2.2, 23 residences would remain flood liable after the construction of the proposed upgrade with the proposed flood levee at Frederickton. Approximately 17 flood affected houses would be raised so that the floor level is a minimum of 0.5 metres higher than the 100 year ARI peak flood level. Some of these properties would need to be assessed for their structural integrity prior to raising. Details of building raising requirements would be confirmed during the detailed design phase.

Six properties, including several commercial premises, cannot be raised due to the materials the buildings are made from. These would require alternative strategies to reduce damage during flooding. Strategies could include constructing a ring embankment around the building, or flood proofing lower levels of the properties to ensure damage is kept to a minimum. Flood proofing could involve elevating high value items and electrical power outlets, or installing flood proof doors, which can prevent the ingress of floodwaters up to a particular height.

Two properties upstream of the proposed viaducts and one downstream would be affected by localised increases in velocity. It is proposed to construct small levees around the houses and some sheds on the affected properties to protect them against the increased velocities.

Mitigation measures relating to buildings would be further assessed and negotiated with land owners prior to construction of the proposed upgrade.

### 10.5.2 Stock refuge

It is proposed to construct stock mounds and truck-loading facilities for affected landholders within affected areas to assist in the refuge and/or evacuation of stock during floods.

Raising South West Rocks Road was considered and would provide an improved exit route for residents and cattle. However, the construction of stock mounds provides a more cost-effective strategy with fewer potential impacts on local flood levels.

During minor (short duration) flood events, the mounds could be used as a temporary refuge for cattle until the floodwaters have receded. During major events they could provide a temporary safe area for livestock from the flood waters, prior to transport out of the flood-affected area.

Generally, the mounds would be located parallel to, but clear of the identified flow paths, where possible to reduce potential impacts on local flood levels. Mounds would also shadow each other in the principal direction of flow across South West Rocks Road, to minimise the amount of flow area obstructed. Additionally, mounds should be elongated in shape to allow suitable sizing in line with relevant stock rates while minimising any potential flood level impacts. Mound heights would be governed by the height of South West Rocks Road to allow access for loading stock into trucks for evacuation. It is anticipated that up to 20 mounds could be required to service affected properties on the floodplain. They would incorporate fencing and loading facilities to enable stock to be evacuated if necessary.

Requirements for the number, sizing and location of cattle mounds and truck-loading facilities would be assessed during the detailed design phase of the project. Farmers using stock mounds would be made aware that the mounds would only protect stock up to a particular flood event and how the stock mounds work in the context of a flooding event.

It is essential that the two affected dairy farms (on either side of South West Rocks Road near Red Hill Lane – refer Figure 10-1) have elevated land close to milking facilities to enable continuous milking during a flood event. One dairy operation already has elevated milking facilities near a cattle refuge area. It is proposed that for the other affected dairy operation, a combined stock mound and ring levee are constructed. This would provide cattle refuge and protect a residence, adjacent milking facilities and other farm infrastructure.

The need for earthworks and other mitigation measures on agricultural properties would be further assessed and negotiated with land owners prior to the construction of the proposed upgrade. Materials for stock mounds and other fill requirements could be sourced from material unsuitable for road construction.

### 10.5.3 Floodway control devices in Frederickton

Preliminary work carried out by the RTA has indicated that some form of flood control device to maintain the passage of run-off from the local town catchment through the levee during flood events would be viable. Further assessment of the options available would be carried out during detailed design. Consideration would be given to the following options during this further assessment.

- Potential for a controlled spillway with a low level flood-gated outlet structure.
- Design of a suitably sized flood-gated outlet structure to manage local run-off.
- The potential to divert run-off from part of the local town catchment directly to the river.

### 10.5.4 Flood gauges

The RTA has installed two flood gauges on behalf of Kempsey Shire Council to improve the early warning system and emergency procedures during major flood events. One flood gauge is located in close proximity to the Macleay River at Third Lane. The second flood gauge is located at the existing Frederickton boat ramp as shown in Figure 10-2.

### 10.5.5 Scour protection and energy dissipation

The RTA would work with local landholders to install scour protection and energy dissipation devices at locations where increased flood velocities result in localised soil erosion or pasture damage.

### 10.5.6 Summary of management measures

Standard and project-specific mitigation and management techniques for flooding and other hydrological impacts arising from construction and operation of the proposed upgrade are included in the draft Statement of Commitments for the proposed upgrade in Appendix D and are summarised below.

### Hydrology

- The need for earthworks and other mitigation measures (such as scour protection) would be further assessed and negotiated with affected land owners prior to construction of the proposed upgrade.
- Subject to landholder preferences and where possible, identified flood-affected houses would be raised so that the floor level is a minimum of 0.5 metres higher than the 100 year ARI peak flood level. Premises that cannot be raised would require alternative strategies to reduce damage during flooding. Strategies could include constructing a ring embankment around the building or flood proofing lower levels of the properties to ensure damage is kept to a minimum.
- Subject to landholder preferences, small levees would be constructed around houses and some sheds on properties that would be affected by localised increases in velocity.
- Stock mounds and truck-loading facilities would be provided for affected landholders along South West Rocks Road to assist in the refuge and/or evacuation of stock during floods.
- A levee wall will be constructed prior to commencement of construction on the Macleay River floodplain.