8 Assessment of key issues

8.1 Traffic and transport

This section presents an assessment of the potential direct and indirect impacts of the project on traffic and transport and identifies measures to avoid and minimise these impacts. It draws on information in the traffic and transport report prepared for this EIS (refer to *Appendix D, Technical Paper: Traffic and Transport*).

Table 8-1 lists the Director-General's environmental assessment requirements relevant to traffic and transport and where they are addressed in this section.

Table 8-1 Director-General's environmental assessment requirements relevant to traffic and transport

Director General's environmental assessment requirements	Where addressed in EIS
Details of how the following meet the traffic and transport objectives of the project, taking into account future growth areas and traffic (vehicular, cyclist and pedestrian) needs: - the preferred bridge alignment and design, - the proposed intersection of the Pacific Highway, Spring Street, and the southern approach road, - the proposed widening of the Gwydir Highway between the Pacific Highway and Bent Street, and intersection treatment at the intersection of the Gwydir Highway and Bent Street, and - associated bridge approaches and local road network treatments at Grafton and South Grafton;	Appendix D, Chapter 5 and Section 8.1.4
Operational traffic and transport impacts on the local and regional road network, with reference to access to adjoining residential, commercial and industrial land uses;	Section 8.1.4
Safety of navigation on the Clarence River for water based traffic	Section 5.2, Section 8.1.3 and Section 8.1.4
Construction traffic and transport impacts of the project (including ancillary facilities) and associated management measures, in particular: - impacts to the road network (including safety and level of service), - pedestrian and cyclist access, and - disruption to public transport services and access to properties, having reference to the cumulative construction impacts taking into account other infrastructure preparing for or commencing construction;	Section 8.1.3
Impacts of the project (construction and operational) on existing and future maritime and recreational use.	Section 8.1.3 and Section 8.1.4
Integration of the bridge with existing and future pedestrian and cycle network in the local, regional and metropolitan context	Section 5.2.5 and Section 8.1.4

Director General's environmental assessment requirements	Where addressed in EIS
Consideration of design, and safety measures for pedestrian and cycle access on the bridge	Section 5.2, Section 8.1.3, Section 8.1.4 and Section 8.8.4
Justification for the proposed width of the bridge based on shared use by pedestrians, cyclists and public transport	Section 5.2 and Section 12.1.2
Details of pedestrian and cyclist access (dedicated or shared-use), and public transport and emergency vehicle access	Section 5.2

8.1.1 Assessment methodology

The project objectives, and associated supporting objectives, relevant to traffic and transport are to:

- Enhance road safety for all road users over the length of the project
  - Reduce the potential for road crashes and injuries on the bridge and approaches, including any intersections and connecting roads
  - Provide safe facilities for pedestrians and cyclists.
- Improve traffic efficiency between and within Grafton and South Grafton
  - Provide efficient access for a second crossing of the Clarence River and for the State road network
  - Provide a traffic management network that reduces delays between Grafton and South Grafton in peak periods to an acceptable level of service for 30 years after opening
  - Provide adequate vertical clearance for heavy vehicles
  - Consider demand management strategies to minimise delays to local and through traffic.

Overall assessment methodology

The traffic and transport assessment involved:

- A review of transport and the transport environment in the project area, including:
  - The function of the State, regional and local road networks
  - Existing traffic demand and constraints
  - Heavy vehicle use
  - Road safety and recent crash history
  - Pedestrian and cycle network
  - River access and traffic
  - Public transport.
- An assessment of the impacts of project construction on traffic and transport, including:
  - Impacts on the road network
  - Impacts on pedestrian and cyclist access
  - Disruption to public transport services
  - Impacts on property access
  - Impacts on river access and navigation

- An assessment of the impacts of project operation on traffic and transport, taking into consideration:
    - Forecast changes in local and inter-regional traffic within the area
    - Operational improvements for traffic, including freight, sustainable transport modes and emergency services
    - Changes in accessibility at a local and regional level
    - Improvements in road safety
    - Impacts on river access and navigation.

Existing traffic demands

Traffic demands across the bridge and bridge capacity were based on a traffic counts survey conducted in August 2010. This data is considered suitable to determine whether the existing bridge is at capacity during peak periods because there have been no significant changes to the road network or land uses since these counts were carried out that would result in changes in travel patterns. This, along with expected growth in the Grafton area suggests that there would not be a reduction in demand for travel across the bridge since the counts were conducted.

Traffic forecasts

- Traffic forecasts were developed in consultation with Clarence Valley Council and Department of Planning and Environment. The forecasts were informed by the *Mid North Coast Regional Strategy 2006–31* (Department of Planning, 2009)
- In August 2013, Department of Planning and Environment released revised preliminary population projections, which are lower than the 2009 projection series. However, these were provided at local government area level only, not at a statistical local area level. As such, the 2013 information was not relied on in this assessment. If more detailed information becomes available during detailed design of the project, the traffic and transport assessment would be revised in light of such projections.

Transport modelling

The operational traffic impacts of the project were assessed using three transport modelling tools:

- Strategic transport model (developed using Cube-TRIPS)
- Micro-simulation model (developed using Paramics, primarily for the purpose of design development and analysis)
- Isolated intersection models (developed using Sidra Intersection).

Pedestrian and cyclist needs assessment

The assessment of proposed pedestrian and cycling facilities focussed on the level to which they would provide connection at both a local and wider network level, and how the design would provide safety for pedestrians and cyclists. The primary reference documents for the purposes of the assessment were Clarence Valley Council's *Bike Plan and Pedestrian Access and Mobility Plan* (2008) and *Clarenza Cycleway Options Study* (2012).

8.1.2 Existing environment

Road network

The road network in Grafton and South Grafton is presented in Figure 8-1 and described in the following sections.

State roads

State controlled roads in the Grafton area include:

- The Pacific Highway. This is the major coastal route between Sydney and Brisbane. The Pacific Highway enters the Grafton city area at South Grafton, connecting to various local streets and the Gwydir Highway
- The Gwydir Highway. This traverses the New England region from South Grafton to the inland areas of Glen Innes (connecting with the New England Highway), Inverell, Warialda, Moree and Walgett. It is the only east–west B-double truck route in the NSW northern region
- The Summerland Way. This road is where most highway related businesses in Grafton (on Fitzroy and Prince Street) and South Grafton (on Bent Street) are located, and provides the main access to Grafton Shopping World. The route is designated for 25/26 metre long B-double trucks, but the vertical clearance beneath the rail viaduct across Prince Street (four metres) is less than Roads and Maritime's minimum standard of 5.3 metres. At present, signs direct high vehicles along Villiers Street, which has a vertical clearance of five metres.

Regional roads

Regional roads that connect Grafton and South Grafton with other towns and villages include:

- Lawrence Road, which connects Grafton with Lawrence and Maclean (to the north-east)
- Armidale Road, which connects South Grafton with the villages of Coutts Crossing and Ebor (to the south) and the Northern Tablelands at Armidale.

Local roads

The key local roads in Grafton are:

- Villiers Street, which connects the Grafton centre and residential areas to the north-east, and accommodates high vehicles using the Summerland Way
- Pound Street, which provides access to Shopping World and a number of other small businesses, and provides secondary access to the existing bridge.

The key local roads in South Grafton are:

- Spring Street, which is a secondary route between Bent Street and the Pacific Highway, and provides access to a number of small businesses along its entire length.

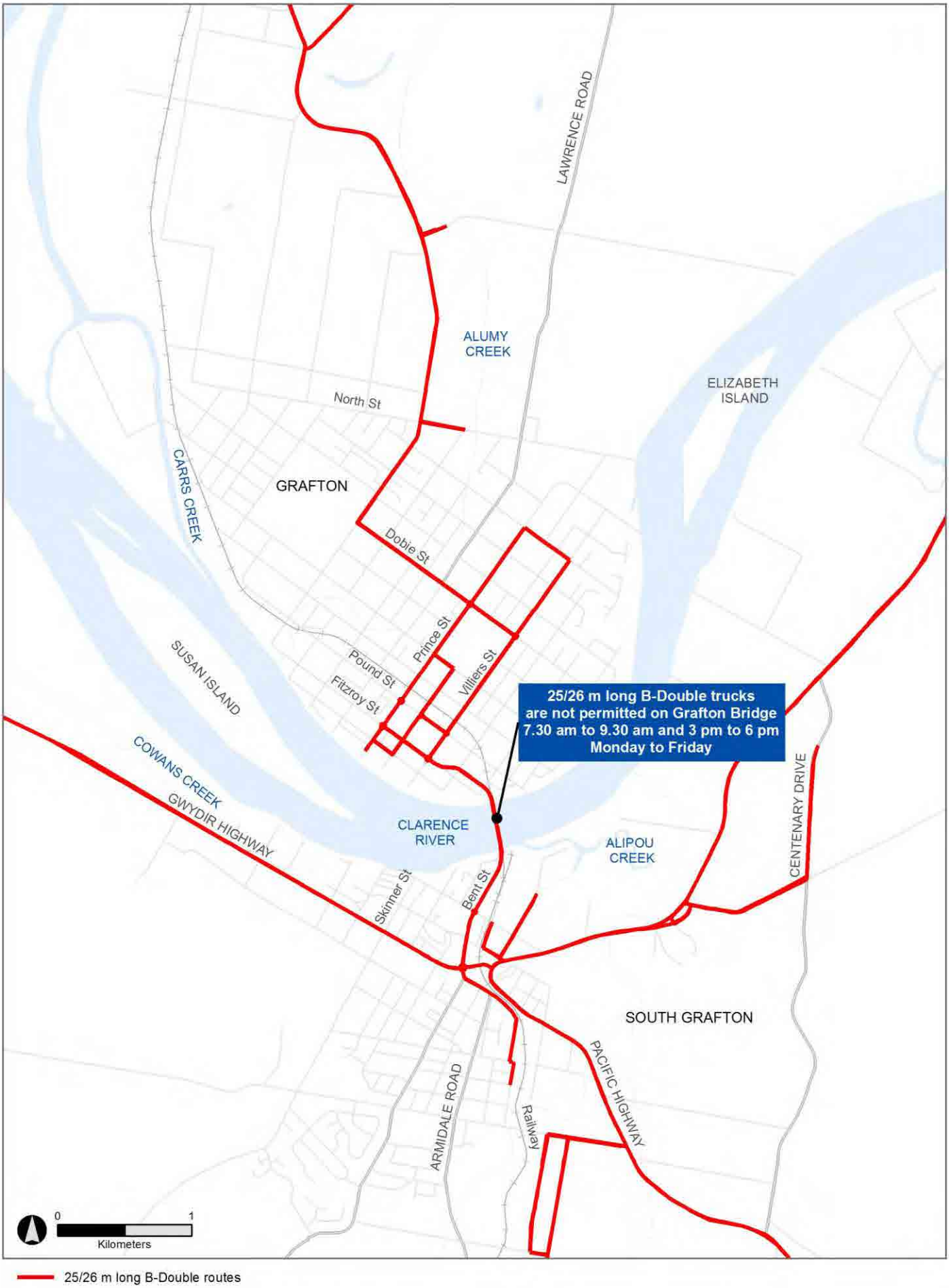


Figure 8-1 Key roads in the Grafton area

Car parking

- Along the project alignment, angled parking is in place on both sides of Pound Street between Villiers Street and Clarence Street and near the TAFE campus on Clarence Street. There is also unmarked on-street parking along Iolanthe Street, South Grafton
- There are few areas in the Grafton and South Grafton CBDs with parking restrictions of one or two hours which are limited to sections of Prince Street, Victoria Street and Fitzroy Street in Grafton and sections of Skinner Street in South Grafton. There is no user-pays street parking in Grafton or South Grafton.

Existing freight network

An existing freight network passes through the Grafton area using the existing State roads including Pacific Highway, Gwydir Highway and Summerland Way (which crosses the existing Grafton Bridge). The main freight routes in the Grafton area are the designated B-double routes shown on Figure 8-1. Freight operators use these routes to transport goods to and from the Grafton area, as well as through Grafton to access other major centres.

Existing traffic demand

Traffic across the existing bridge

Traffic counts were carried out in August 2010 to understand traffic use of the existing bridge. For this period, it was found that:

- An average of 27,578 vehicles per day crossed the bridge
- The majority of vehicles used the bridge during the day
- The highest daily traffic volumes across the bridge were on Friday, and the lowest traffic volumes were on Sunday
- In the morning peak period most traffic is northbound into Grafton while in the evening peak period the traffic flow is more even in both directions but the predominant traffic flow is southbound into South Grafton. The average weekday peak period traffic volumes are presented in Figure 8-2.

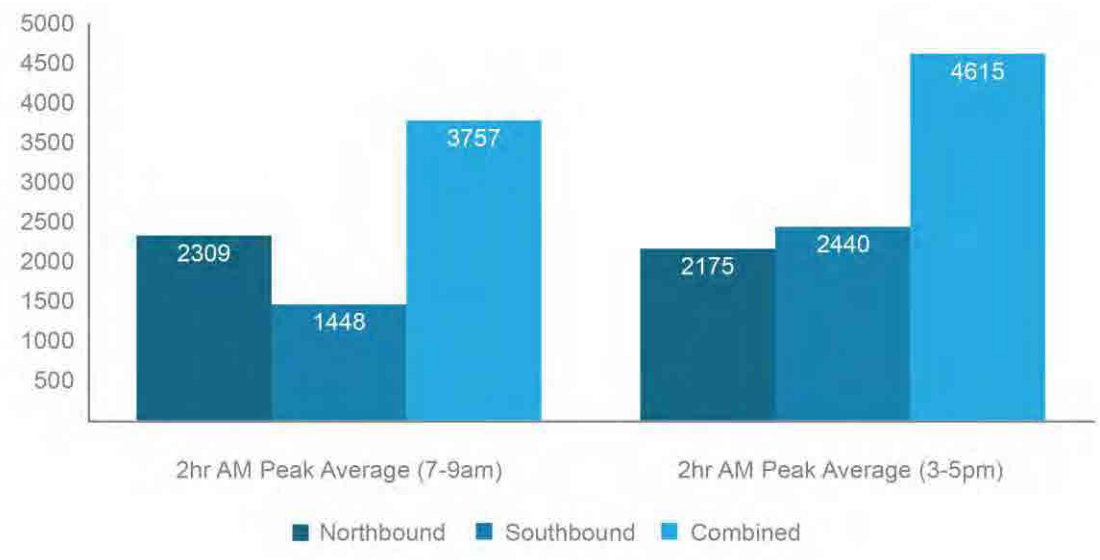


Figure 8-2 Average weekday peak period traffic volumes on Grafton Bridge, August 2010 (Source: *Heavy Vehicle Traffic Study* (Roads and Maritime, 2011))

The traffic counts indicate that the bridge carried an average of 1360 vehicles per hour in the northbound direction for the AM peak and 1330 vehicles per hour in the southbound direction for the PM peak. The *Guide to Traffic Management Part 3: Traffic Studies and Analysis* (Austroads, 2009) indicates that the theoretical capacity of the bridge could be considered to be in the range of 900 to 1400 vehicles per lane per hour. This indicates that the bridge is at capacity during peak periods.

For heavy vehicles, the survey found that, on average:

- On weekdays, 1408 heavy vehicles crossed the bridge
- During AM peak periods, 186 heavy vehicles (five per cent of total traffic) crossed the bridge
- During PM peak periods, 472 heavy vehicles (10 per cent of total traffic) crossed the bridge.

Heavy vehicle volumes during weekday peak periods are presented in Figure 8-3.

There are currently restrictions on 25/26 metre long B-double trucks using the bridge between 7.30am–9.30am and 3pm–6pm. These restrictions are a traffic management measure to alleviate congestion during peak periods.

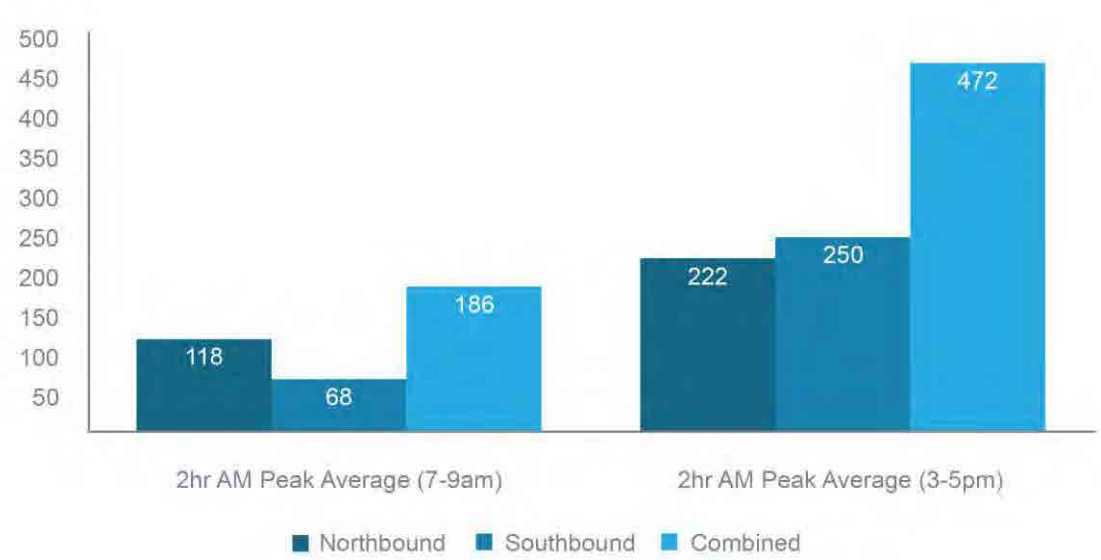


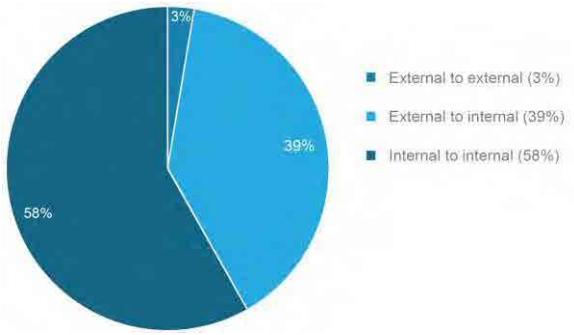
Figure 8-3 Heavy vehicle volumes during weekday peak periods on Grafton Bridge, August 2010 (Source: *Heavy Vehicle Traffic Study* (Roads and Maritime, 2011))

Origins and destinations of vehicles using the bridge

A survey was carried out in 2010 to identify the origins and destinations of vehicles using Grafton Bridge. The survey results are shown in Figure 8-4 and indicate that:

- Three per cent of trips made by all vehicles using the bridge were 'through trips' that originated and terminated outside Grafton and South Grafton
- Ninety-seven per cent of trips made by all vehicles using the bridge had an origin and/or destination in Grafton or South Grafton
- Twelve per cent of heavy vehicles were making 'through trips' that did not have an origin or destination within Grafton or South Grafton
- Eighty-eight per cent of heavy vehicles using the bridge had an origin and/or destination within Grafton or South Grafton.

All vehicles



Heavy vehicles (including buses)

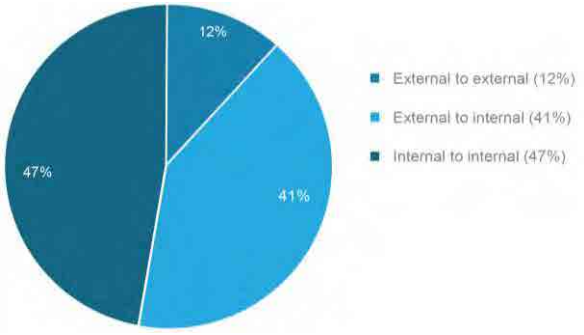


Figure 8-4 Vehicle trip types crossing Grafton Bridge on 19 August 2010 (5am–7pm) (Source: *Heavy Vehicle Traffic Study* (Roads and Maritime, 2011))

A travel time survey was conducted between the Bent Street/Gwydir Highway and Prince Street/Pound Street intersections (a route of about 2.6 kilometres) during the AM peak (7am–10am) and PM peak (between 4 pm and 7 pm) periods between 3 and 7 November 2008 and on 12 May 2009. The survey results are presented in Table 8-2 and show that travel times were higher travelling northbound (ie from South Grafton to Grafton) during the AM peak period. In the PM peak, travel times were more even in both directions. This is consistent with the findings of the traffic counts carried out in August 2010 (refer to Section 1.1.2.3).

Table 8-2 Average travel time and speed, southbound and northbound (Source: *Traffic Study Report* (Roads and Maritime, 2009))

Peak period	Time	Average travel time (minutes)		Average speed (km/h)	
		Southbound	Northbound	Southbound	Northbound
AM	7-8am	4.7	9.1	33.2	17.1
	8-9am	5.3	8.4	29.4	18.6
PM	3-4pm	4.9	5.3	31.8	29.4
	4-5pm	4.8	4.9	32.5	31.8

Existing road safety

Roads and Maritime's CrashLink database provided crash data for the Grafton area for the period 1 January 2008 to 30 June 2013. The data revealed crash clusters in various areas along the alignment of higher order roads. This is typical given that these roads carry larger traffic volumes. The crash clusters identified were:

- Pacific Highway near intersections with Spring Street and Gwydir Highway. This area is characterised by closely spaced priority-controlled intersections with poor geometry
- Bent Street near its intersections with the Gwydir Highway and Through Street. This area is characterised by roundabout intersections with a significant volume of daily traffic (most crossing the river)
- Grafton Bridge. Most crashes occurred near the kinks in the existing bridge alignment, which are difficult for larger vehicles to negotiate without encroaching on the opposite traffic lane, and are the direct cause of congestion on a daily basis during peak periods

- Fitzroy Street near its intersections with Villiers Street and Clarence Street. This area is characterised by intersections and merge points that can be congested, particularly on the southbound carriageway in the evening peak period.

Existing pedestrian and cycle network

The existing pedestrian and cycle network in Grafton and South Grafton is shown on Figure 5-8. Key features of the local network are described below.

Grafton

- There are generally no dedicated facilities for cyclists. Grafton's city cycle routes guide cyclists to use local streets to the west to access areas closer to the river, and Kent Street and Oliver Street to access areas to the north
- Footpaths are generally provided on at least one side of the road in central Grafton
- There is a footpath on the south-west side of Pound Street that serves as a link between the Grafton centre and residential areas to the south-east.

Existing bridge

- There is a dedicated pedestrian and cycle path on both sides of the bridge on the lower deck. The paths have safety railings, but are narrow (about 1.5 metres wide) and have little or no opportunities for casual surveillance.

South Grafton

- There is an off-road path that extends from the bridge to the Grafton Rail Station parking area, stopping at the southern end of Crisp Avenue
- The path starts again south of Spring Street at Derek Palmer Park. The path continues through the park near the rail line, crosses the Gwydir Highway (at an uncontrolled crossing), and continues through Silver Jubilee Park to Armidale Street. This route requires crossing of Spring Street, Gwydir Highway and Armidale Road, all of which are heavily trafficked
- There are no specific facilities in place at the end of the pedestrian and cycle path at Crisp Avenue eastbound to or across the Pacific Highway. The route uses unformed road verges or the existing road formation to get to the Pacific Highway. Student pedestrians and cyclists trying to access McAuley Catholic College to the north need to cross the Pacific Highway (which carries around 12,000 vehicles a day) to get to Hennessey Drive and the college
- At Iolanthe Street there is a short, disconnected footpath at the front of the Supercheap Auto site
- There are no other formal paths along the Pacific Highway, Gwydir Highway or Spring Street within the project boundary.

Regionally, the main cycle links connecting Grafton with surrounding areas include:

- An off-road pedestrian and cycle path within the Gwydir Highway corridor, connecting South Grafton with Waterview Heights
- An off-road pedestrian and cycle path to the north, near the Summerland Way, connecting Grafton with Junction Hill
- There are no formal links along the Pacific Highway. Cycle links between South Grafton and nearby towns along the highway are sparse and disconnected.

Access and use of the Clarence River

River access

The Clarence River at Grafton can be accessed through a number of boat ramps, wharfs and jetties on both sides of the river. These are shown in Figure 8-5.

River traffic

River traffic on the Clarence River at Grafton includes the following recreational craft:

- Sailing dinghies
- Sailing and motor yachts
- Power boats (including waterski and wakeboard tows)
- Small unpowered craft (including rowing boats, canoes and paddle boards).

As well as normal river traffic, a number of recurrent events on the river result in additional vessels transiting the proposed bridge alignment. These events include the Clarence River Rowathon, Grafton Rowing Club Regatta, Grafton Bridge to Bridge Waterski Race and sailing races.

The following commercial vessels also operate near the proposed bridge alignment:

- Commercial fishing vessels that operate between Susan Island downstream to the bridge, and from the bridge downstream to Elizabeth Island
- A 35 metre barge owned by Boral, which mainly operates upstream of the existing bridge. For repairs or other exceptional operations it may travel downstream past the proposed bridge alignment.

Flood evacuation routes

The main flood evacuation routes out of Grafton are shown in Section 8.2 and include two routes north, to Junction Hill; and a route across the existing bridge to South Grafton.

The Grafton levees can overtop during a large flood, resulting in ponding in the floodplain between Grafton and Junction Hill, cutting the evacuation routes to the north. When this occurs, the only flood-free route available for evacuation is across the bridge to South Grafton. As such, the efficiency of flood evacuation in Grafton is largely constrained by traffic movement across the bridge.

Travel to work patterns

The 2011 census (ABS, 2011) reported that, on the census day in the Grafton Urban Centre Locality about 84.7 per cent of people travelled to work by car (either as a driver or passenger), 0.1 per cent by train and 0.6 per cent by bus. In addition, 3.1 per cent of people walked and 7.5 per cent of people travelled by bicycle to work.

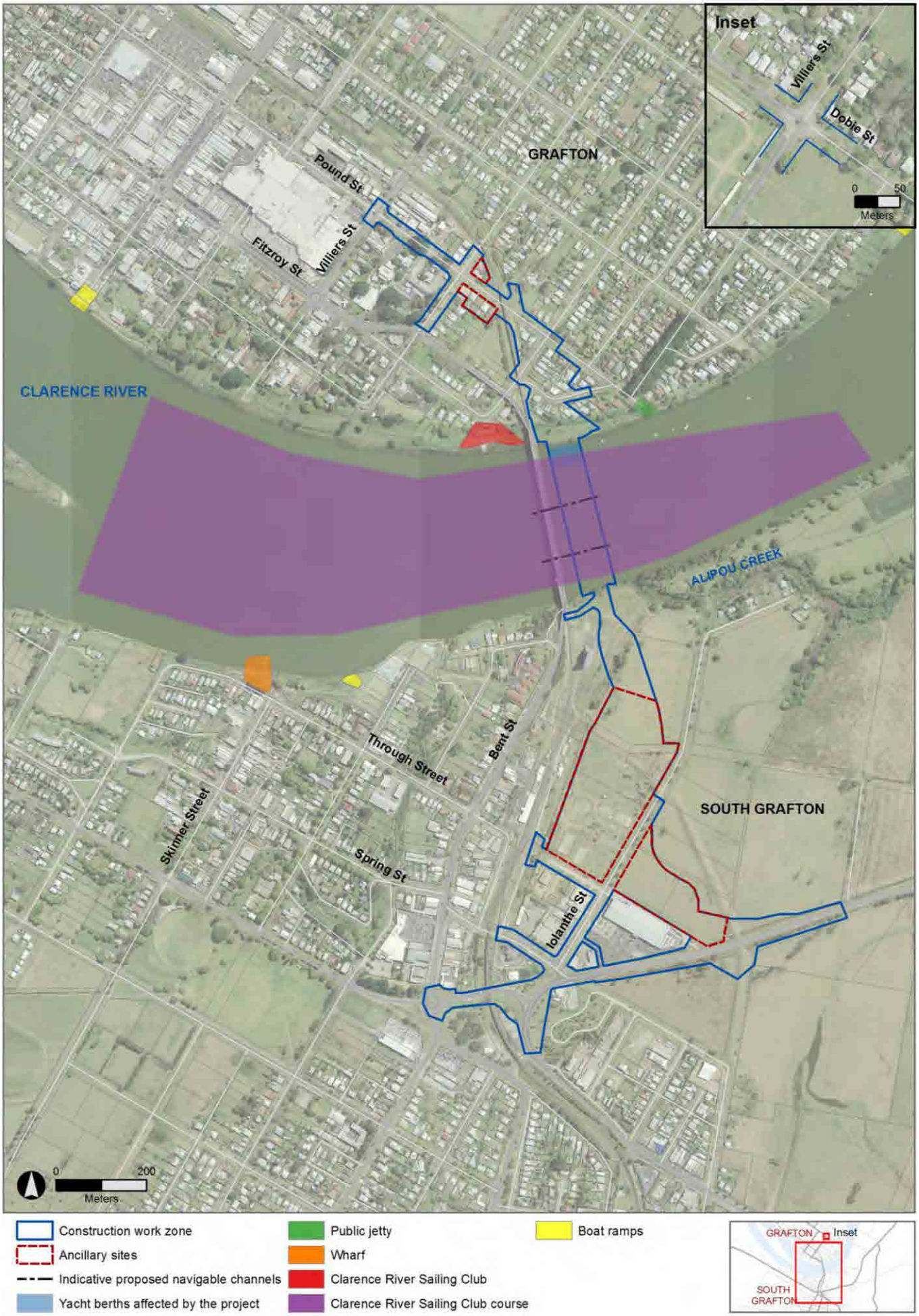


Figure 8-5 Existing maritime access and use of the Clarence River

Public transport services

Public transport in the project area mainly consists of bus services but there is also a regional and interstate train service.

Bus services

Busways is the main public bus operator in Grafton. It provides regular services to Grafton and South Grafton and the towns and villages of Ulmarra, Maclean, Yamba, Iluka, Copmanhurst and Jackadgery. Several routes converge at the Summerland Way corridor through the centre of Grafton and at the bridge crossing, deviating to Through and Spring streets in South Grafton.

A number of coach companies provide services to and from Grafton and towns and regional centres such as Lismore, Yamba, Maclean, Lawrence, Corindi Beach, Woolgoolga, Byron Bay, Moree, Copmanhurst, and Cangai, as well as long-distance services to Brisbane and Sydney.

Buses in Grafton and South Grafton typically operate 5.30am to 8.30pm Monday to Friday and 7.30am to 3.30pm on Saturdays. The bus fleet moves about 2500 students each morning and about 2000 general passengers per day.

Train services

Grafton is serviced by the North Coast Line, which stops at the Grafton City railway station (in South Grafton). The town forms a key stopping point for the Grafton, Casino and Brisbane XPT services that operate daily. Each of these north coast rail services terminate at, or depart from, Sydney. The North Coast Rail line crosses the Clarence River on the existing bridge.

8.1.3 Assessment of potential impacts - Construction

Impacts on the road network

Increased traffic

The likely routes to be used by construction vehicles are described in Chapter 6 and shown in Figure 6-5.

About 18,700 truck trips would be needed during the three year construction period (the average number of trips per day would be about 40 trips). These trips would be generated by the workforce, materials haulage, and deliveries to site (these are expected to involve around 20 trips per day). Construction deliveries would be timed to occur outside peak traffic periods when feasible and reasonable, to minimise impacts on the road network. (refer to Section 8.1.5 for traffic management measures to be implemented)

Temporary lane and road closures

Construction of the project (refer to Chapter 5) may require temporary lane closures or reductions in traffic capacity, on-street parking and pedestrian and cycle paths on the following streets:

- Clarence Street (Grafton) – between Fitzroy Street and Bacon Street
- Kent Street (Grafton) – between Fitzroy Street and Bacon Street
- Pound Street (Grafton) – between Villiers Street and Bromley Street
- Through Street (South Grafton) – between the rail corridor and Iolanthe Street
- Iolanthe Street (South Grafton) – along the whole road
- Spring Street (South Grafton) – east of the rail corridor
- Pacific Highway (South Grafton) – between the rail corridor and the start of the proposed Pacific Highway diversion

- Gwydir Highway (South Grafton) – between Bent Street and the Pacific Highway.

In addition, temporary road closures are expected to occur on:

- Greaves Street, Grafton, near the northern approach to the new bridge crossing. The closure would occur during construction of the approach and Greaves Street underpass. This section of the street currently carries very low traffic volumes. Road users to the north would be required to detour through Bacon Street. Those to the south of the closure would be required to detour through Fitzroy Street
- Pound Street, Grafton, between Kent and Clarence streets. This section would be closed during construction of the Pound Street viaduct. This street section carries an average of about 1500 vehicles per week day. Road users would detour using Bacon Street.

It is anticipated that the cumulative impact of the above changes may have some temporary impact on the level of service of the road network during peak periods. Mitigation measures are required to ensure the safety and efficiency of the road network is not compromised.

To address these issues, traffic analysis would be carried out to quantify the impact on level of service during critical construction periods once the haulage routes and construction sequence are confirmed by the construction contractor. Based on the analysis, traffic management measures would be included in the construction environmental management plan. These are developed to enable acceptable traffic operations and level of service on the road network during construction to be maintained.

Appropriate traffic control measures would be determined on a site-by-site basis and would include a combination of temporary lane closures, realignments, or detours, along with temporary fencing, visual barriers, traffic controllers and signage.

Impacts to freight services

Access across the existing Grafton Bridge would be maintained during construction, however surrounding road network upgrades as part of the project may cause delays which would have a minor impact on the freight services travelling through, to or from the Grafton area during construction.

Impacts on access to properties

Access to residential, commercial, TAFE and the Gummyaney Aboriginal preschool properties would be maintained during construction at all times.

Pedestrian and cycle access would be prohibited from foreshore areas within the construction work zone as well as some sections of the road reserve as described in Section 8.1.3.

Impacts on public transport

Bus services

The proposed construction work and traffic management measures are not expected to directly impact bus services as the proposed road closures would not occur on bus routes in the project area. Therefore, the level of disruption on bus services would be low, and would be similar to the disruption experienced by general traffic.

The one exception would be a school bus route that picks up and drops off students in Pound Street near Clarence Street. The bus operator would be contacted before construction starts to find an alternative pickup up and drop-off location.

Rail services

Construction of the project would have short-term impacts on the North Coast Line rail services, which would not be able to run during possession (closure of the rail line). The duration of the possession would be confirmed during detailed design but it

could potentially occur over a long weekend and in line with scheduled rail network outages. This is usually done in off-peak periods of the year in terms of patronage and freight movements, to minimise impact on rail operations.

During this period, alternative passenger transport services would be provided where possible. For regional trips to other communities in the area, coach services would be provided.

Freight trains would not be able to operate during the closure period. Roads and Maritime would consult with freight operators to minimise impact on freight.

Impacts on pedestrian and cyclist access

Construction of the project may have temporary impacts on access to pedestrian and cycle paths, as follows:

- In Grafton, work at the rail viaduct and road upgrades at Pound Street may require closure of the route from the existing bridge to residential areas in the north along Kent Street. Cyclists and pedestrians may need to detour through Villiers Street, or another temporary alternative route
- In South Grafton, work associated with the Gwydir Highway widening may impede crossing of the highway between Derek Palmer Place and Silver Jubilee Park. This may require cyclists to detour along Bent Street.

Impacts on access to and use of the Clarence River

Construction of the project would generate additional river traffic, which would likely be limited to piling barges and general work boats such as the vessels used for installing and decommissioning the sediment control devices. As noted in Chapter 6, a temporary jetty for barge launching is proposed off the South Grafton foreshore to facilitate these river-based construction activities.

Impacts on river traffic may potentially occur during installation of the new bridge piles and piers, wholly or partially restricting transit through the main navigable spans and presenting a physical safety hazard. Construction and support barges used during piling and pier construction would also obstruct vessels while in use.

Maritime access to the Clarence River would be maintained throughout construction, excluding the areas of construction as shown on Figure 8-5. For the majority of users it is expected that this would not restrict maritime access.

The main impact would be on the sailing course and mooring areas, which may need to be permanently relocated, as discussed in Section 8.1.4.

Impacts on flood evacuation routes

Construction of the project would not impact on evacuation routes or emergency services. Emergency services would be notified on traffic conditions changes (eg partial or total road closures) during the construction phase.

Cumulative impacts during construction

Potential cumulative construction impacts would occur from the aggregated effect of other developments preparing for or starting construction, including:

- Cumulative traffic disruptions to road users travelling to and from Grafton along the Pacific Highway
- Cumulative traffic disruptions to road users travelling between Grafton and South Grafton across the existing bridge.

Refer to Section 9.4 for developments likely to occur near the project and their cumulative impacts.

8.1.4 Assessment of potential impacts - Operation

Future traffic demand

Future traffic demand has been modelled with the project in operation. The overall growth rates for trips within the modelled network is set out in Table 8-3 for both morning and afternoon peak periods. For growth between 2011 and 2019, trips are distributed across the network so that the theoretical capacity of the existing bridge is not exceeded in the peak periods.

Table 8-3 Peak period traffic forecasts

Year	AM peak (7am to 9am)		PM peak (3pm to 5pm)	
	Total trips (vehicles)	Traffic growth rate per annum (%)	Total trips (vehicles)	Traffic growth rate per annum (%)
2011	12,456	-	14,641	-
2019	14,040	1.5	15,963	1.1
2029	18,130	2.6	20,554	2.6
2039	21,232	1.6	23,833	1.5

Impacts on traffic volumes across the bridge

Forecast traffic volumes at both the existing and proposed bridge for the AM peak are summarised in Table 8-4. Table 8-4 indicates that significant traffic demand between Grafton and South Grafton could be redistributed from the currently at-capacity bridge to the proposed bridge. About 65 per cent of peak period traffic is anticipated to use the proposed bridge in its first 20 years of operation.

Table 8-4 Forecast AM peak (7am to 9am) traffic demand at the two bridges (number of vehicles)

Year	Scenario	Existing bridge		Proposed bridge	
		Northbound	Southbound	Northbound	Southbound
2019	Minimal network improvements	2763	1884	-	-
	Project	1237	473	1526	1411
2029	Minimal network improvements	3760	2516	-	-
	Project	1676	529	2084	1987
2039	Minimal network improvements	4260	2852	-	-
	Project	1779	831	2481	2021

Impacts on the local road network

The proposed changes to the local road network are documented in Chapter 5. The main change in route choice would be within the trunk road network in Grafton and South Grafton; wider road network impacts would be relatively minor. The changes would see:

- Increased traffic along Pound Street in Grafton, with corresponding similar decreases along Fitzroy Street
- Increased traffic along Iolanthe Street and sections of the Gwydir Highway in South Grafton, with corresponding similar decreases along Bent Street
- Relatively minor impacts on the wider network, namely, Pacific Highway, Gwydir Highway (west of Skinner Street), and Summerland Way (north of central Grafton).

It is anticipated that the project would facilitate a reduction in traffic using Skinner Street, Spring Street and Through Street to the north of Gwydir Highway in South Grafton to access the bridge.

Impacts on road intersections

The proposed road intersection upgrades are documented in Chapter 5. The key driver for the intersection upgrades is to support forecast traffic demand on the proposed bridge and enable the project to safely and efficiently integrate with the existing road network. Analysis shows that the upgrades would meet the traffic and transport objectives for the project and the intersections would operate at an acceptable level of service.

For the purposes of this project, the minimum desirable performance for an intersection has been identified as a level of service E in 2039. The findings of the intersection analysis are presented in Table 8-5.

The level of service performance metric is based on the average delay per vehicle at each intersection. Level of service ranges from A (very good) to F (unsatisfactory) as described in detail in Table 10 of *Appendix D, Technical Paper: Traffic and Transport*.

Table 8-5 Performance of intersections directly impacted by the project (year 2039)

Intersection	Upgrade proposed	Level of service		Impact
		AM peak	PM peak	
Pound Street / Villiers Street	This intersection would be widened to a four-leg roundabout at the south-east Pound Street leg to accommodate increases in traffic from the proposed bridge.	B	C	The form of this intersection is not proposed to change significantly. The increased traffic along Pound Street attracted by the new bridge is anticipated to be accommodated by the proposed adjustments at the south eastern leg, as such impacts on performance and safety are anticipated to be minor.

Intersection	Upgrade proposed	Level of service		Impact
		AM peak	PM peak	
Pound Street / Clarence Street	Traffic lights would be installed, and Pound Street widened to four lanes to accommodate increased traffic from the bridge and safely accommodate pedestrians crossing Pound Street and/or accessing the TAFE.	B	B	The role of this intersection will change as a result of the project. It is currently used as the main access to the TAFE and as a rat-run to access the existing bridge. The analysis indicates the proposed intersection will perform at an acceptable level of service, while safety of the intersection will be maintained.
Iolanthe Street / Pacific Highway / Through Street	This intersection would be upgraded to a four-leg roundabout, and Pacific Highway realigned to provide additional capacity for traffic accessing the proposed bridge, and to improve traffic flow at the highway's intersection with Spring Street.	B	B	The role of this intersection will change as a result of the project. It is currently used to facilitate the small volume of traffic accessing local business and residences. Although traffic volumes are anticipated to increase, the analysis indicates the proposed intersection will perform at an acceptable level of service, while safety of the intersection should be upheld through the provision of a large roundabout with sufficiently spaced conflict zones.
Gwydir Highway / Pacific Highway	This intersection would be upgraded to a three-leg roundabout, and Gwydir Highway widened to four lanes to increase traffic capacity of the intersection.	A	A	Preliminary analysis of the existing intersection has demonstrated that without an upgrade, the right turn movement from the Gwydir Highway would perform at a level of service F by year of opening. At priority controlled intersections, this can lead to increased chances of aggressive / forceful driver behaviour. Provision of the roundabout upgrade will help ensure adequate intersection performance (level of service A in 2039) and safe operation.

Intersection	Upgrade proposed	Level of service		Impact
		AM peak	PM peak	
Gwydir Highway / Bent Street / Ryan Street	Retained as all movements, four-leg roundabout	A	C	The form of this intersection is not proposed to change significantly. The intersection analysis indicates that the intersection will perform with an acceptable level of service in 2039. As such, it is expected that there would be minimal, if any, change in safety.
Possible initial upgrades at year of opening in South Grafton (refer to Chapter 5)				
Gwydir Highway / Pacific Highway	As described above.	A	A	As described above
Iolanthe Street / Pacific Highway / Spring Street	The Pacific Highway would remain on its current alignment and connect with Iolanthe Street at a new roundabout at the Iolanthe Street/Spring Street intersection. A pedestrian crossing with traffic lights would be provided on the Pacific Highway about 100 m east of the Iolanthe Street intersection.	E	E	In the existing situation, this intersection configuration includes two closely-spaced priority controlled intersections, with recorded crashes in the last five years. It is anticipated that the proposed roundabout will improve the road geometry and hence safety and traffic operations in the area.
Iolanthe Street / Through Street / Butters Lane	This intersection would be upgraded by realigning Butters Lane, which would become the fourth leg of the roundabout, instead of the Pacific Highway.	A	A	As per the Iolanthe Street / Pacific Highway / Through Street upgrade discussed above, however performance of the intersection is anticipated to be even higher in light of the eastern approach servicing residents of Butters Lane only (instead of the realigned Pacific Highway).

Note: The intersection upgrades presented in the table above are subject to further refinement during detailed design.

Analysis indicates that the intersections directly impacted by the project would perform within acceptable limits of operation in the 2039 peak periods.

Table 8-5 also shows that with the possible initial upgrades at year of opening in South Grafton, the Iolanthe Street / Pacific Highway / Spring Street intersection would operate at a level of service E by 2039. After this, the remainder of the project elements proposed for South Grafton (ie the Pacific Highway realignment and converting the Spring Street intersection to a left-in and left-out only junction) would need to be built to maintain acceptable levels of service at this intersection.

Impacts on the regional road network

Transport modelling indicates that the project would have a minimal impact on the wider road network in terms of traffic movements (external to central Grafton and South Grafton). The State roads (Gwydir Highway and Summerland Way), and regional roads (Lawrence Road and Armidale Road) would continue to function as per their existing role, connecting communities to the west, north and south.

Impacts on road safety for bridge users

Roads and Maritime would carry out a project road safety audit during detailed design to identify and address potential safety issues associated with the operation of the project.

In addition, the project would deliver the following safety benefits:

- A pedestrian and cycle path separated from traffic
- Traffic lights for safe pedestrian crossing
- The proposed bridge would become the heavy vehicles route across the Clarence River at Grafton. 25/26 metre long B-doubles would be banned from using the existing bridge, which would improve safety at the kinks in the existing bridge alignment
- A reduction in the number of crashes along the existing Summerland Way route at intersections near the bridge approaches due to a reduction in traffic along the existing bridge and less congestion during peak hours
- A reduction in the number of crashes at Pacific Highway intersections with Gwydir Highway and Iolanthe Street due to the upgrading of these closely spaced intersections
- Provision of median-separation of the Iolanthe Street and Pound Street carriageways. This would limit the amount of right-turn movements across heavily trafficked roads
- Intersections and roads would be designed for the safe movement of vehicles, provide sufficient traffic capacity and reduce conflicts between vehicles and pedestrians.

Impacts on freight and heavy vehicles

The project is anticipated to provide travel time savings for both heavy and light vehicles and improve freight operations.

The proposed bridge would become the designated heavy vehicle route across the Clarence River at Grafton. Roads that would form part of the B-double route have been designed to accommodate the turning movements of such vehicles, while other main roads have been designed to accommodate 19-metre general access vehicles. Other roads to be upgraded have been designed to accommodate a 12.5 metre rigid truck. It is anticipated that these changes would:

- Improve the resilience of the existing bridge by reducing freight vehicle loadings
- Reduce the time it takes freight operators to cross the river
- Result in a change of route for large vehicles travelling through Grafton – trucks travelling through Grafton along Summerland Way would be diverted along Pound Street, the proposed bridge and Iolanthe Street. Trucks accessing local businesses in Grafton and South Grafton (eg Bunnings Warehouse on Iolanthe Street and other local industry) may also need to redirected.

In light of the above, heavy vehicle volumes along the existing Summerland Way alignment (Fitzroy Street to Bent Street) are anticipated to decrease. This would occur in tandem with increases along the new alignment including on Pound Street (as far as Villiers Street) and on Iolanthe Street.

Impacts on parking

The proposed changes to parking arrangements for the project are described in Chapter 5.

In Grafton, the project would formalise and maintain the current level of parking in the Pound Street and Clarence Street area, which services local businesses, the TAFE campus and nearby residences.

In South Grafton, no on-street parking would be permitted on Iolanthe Street and the Gwydir Highway section of the project to maintain the hierarchal function that these roads provide in terms of traffic movement. Future developments along Iolanthe Street would need to provide an adequate level of parking within their premises.

Impacts on pedestrian and cyclist access and connectivity

As shown on Figure 5-8, the project's proposed pedestrian and cyclist facilities would integrate with existing and future pedestrian and cycle network at the following strategic locations:

- Gwydir Highway, allowing access to areas in the west such as Waterview Heights
- Pacific Highway to the south, allowing access to South Grafton
- Pacific Highway to the north, allowing access to the north including the McAuley Catholic College and Clarenza.

The project would also integrate with the existing and future pedestrian and cycle network at:

- Grafton commercial precinct (Pound, Fitzroy and Prince streets)
- North Coast TAFE Campus
- Iolanthe Street commercial precinct, between Through Street and Spring Street.

However, the northern approach road to the proposed bridge would block the Coastline Cycleway route along Kent Street in Grafton. This would have a minor impact on cyclists given the viable route options available to them:

- Cyclists would continue to access the existing route along Kent Street (from either bridge) by rerouting via Greaves Street and Pound Street
- Alternatively, they could also travel on road along Clarence Street instead of Kent Street. This route would use the safe crossing of Pound Street and the proposed traffic signals at the Clarence Street / Pound Street intersection
- In South Grafton, Coastline Cycleway users would use the proposed Gwydir Highway crossing, which would have traffic lights to increase safety.

Impacts on public transport

Bus services

The project would have a positive effect on bus services:

- Existing bus routes would be retained
- The removal of a significant proportion of cross-river traffic from the existing bridge and approaches would result in less congestion and, as a consequence, faster travel times and more reliable services
- The proposed bridge could accommodate buses, should operators choose to use them, and the approach roads could accommodate bus stops.

Rail services

The project would not affect the functioning of the North Coast Line services operating out of the Grafton City railway station (in South Grafton).

Impacts on river access and traffic

The project would not affect access to points along the river from foreshore areas. Potential impacts on river access and traffic are discussed in Table 8-6.

Table 8-6 Impacts on river traffic

Traffic	Impacts from proposed bridge
Commercial vessels / barges	For the relatively larger commercial vessels the channel width has been reviewed against international design guidance *Approach Channels – A Guide for Design* (PIANC 1997) and *BS 6349-1-4:2013 Maritime Works. General* (2000), which proposes a channel width of 28 to 42 metres for one-way movements. Adopting the middle of the range channel width values is considered acceptable because there is additional horizontal clearance between the bridge piers outside of the proposed navigation channel. There are no anticipated restrictions on barge type vessels up to around 35 metres long assuming a height of about 7 metres.
Ferries	There are no anticipated restrictions on ferry type vessels up to around 25 metres long assuming a height of about 7 metres. Ferries are typically designed for a particular operational route and larger ferries could be accommodated with a low vertical clearance.
Powered recreational crafts	The proposed bridge provides for two deepwater navigation channels 35 metres wide through the two centre spans to allow larger vessels to pass under the bridge. For recreational traffic, various international guidance (including *AS 3962-2001 Guidelines for Design of Marinas* (2001) and *Standards for the use of Inland Waterways by Recreational Craft* (PIANC, 2002) show the proposed channel is wider than the minimum width required for safe navigation. There may be some height restrictions for larger powered recreational craft and vessels of unique design.
Unpowered (smaller) recreation craft	There would be no restrictions on small unpowered recreational marine craft such as canoes, small dinghies, row boats, etc.
Water sport activities	The proposed bridge alignment is not likely to affect rowing and powered water sports activities but could make it more difficult for Grafton River Sailing Club to run sailing races (see below).
Sailing yachts and sailing course	The project would be located within the Clarence River. Larger recreation sailing craft would be able to pass under the two bridges with their masts dropped. The additional bridge crossing would potentially restrict the use of some existing sailing courses (for larger dinghies and catamaran classes) due to the proximity of two bridges and associated piers.
Large dinghies	The proposed vertical height clearance should accommodate all but the largest sailing dinghies commonly used in in-shore club racing.
Mooring areas	Moorings closed during construction would be reopened after completion of the bridge, though some may be relocated away from the bridge.

The probability of vessels hitting the proposed bridge is considered to be relatively low given its height and width clearances. In addition, the bridge piers would be positioned to minimise risks to navigation and would be in line with the existing bridge

piers. The provision of permanent aids to navigation would be considered during detailed design (refer to Chapter 5).

Impact on adjoining land uses

The project has been designed in consultation with businesses and the community (refer to Chapter 7) and takes into account their need for access and parking. Potential impacts on adjoining land uses are presented in Table 8-7.

Table 8-7 Impacts on adjoining land uses

Land use	Impacts
Grafton	
Residences near the northern bridge approach and on Clarence Street	Current access would be retained at all properties. The level of on-street parking would be maintained.
Commercial land uses along Pound Street and educational establishments (TAFE campus and Gummyaney Aboriginal pre-school)	Existing parking levels and property access locations would be maintained. The proposed median separation of Pound Street carriageway would limit movements at local driveway crossovers to left-in and left-out movements. This has been incorporated into the design as a safety feature limiting the amount of traffic turning right across heavily trafficked roads. It is considered that the existing roundabout at the Villiers Street / Pound Street intersection would allow a majority of connectivity to the affected sites to be retained. For some properties, this may mean slightly longer trips to access these sites than currently occurs. Access to and from Pound Street west of the Gummyaney Aboriginal preschool would be restricted with trips diverted to access Pound Street via Kent and Bacon streets or Greaves and Fitzroy streets. This would result in longer trips in some cases.
South Grafton	
Commercial land uses along Iolanthe Street	Current access would be retained at all properties. The proposed median separation of Iolanthe Street carriageway would limit movements at local driveway crossovers to left-in and left-out movements. This has been incorporated into the design as a safety feature limiting the amount of traffic turning right across heavily trafficked roads. It is considered that the roundabouts proposed along the Iolanthe Street corridor would allow a majority of connectivity to the affected sites to be retained. For some properties, this may mean slightly longer trips to access these sites than currently occurs.
Proposed commercial development at north-west corner of the existing Spring Street / Iolanthe Street intersection	Access locations proposed as part of the approved development application for the site have been incorporated into the project design. Also, turning restrictions to be put in place once the proposed bridge is open to traffic have been incorporated into the development application design plans.

Land use	Impacts
Petrol station on the Pacific Highway, opposite the Iolanthe Street / Pacific Highway intersection	This property has two closely-spaced driveway crossovers with an internal one-way traffic flow arrangement. Because of the realignment of the highway at this location and the proximity of the proposed Pacific Highway / Iolanthe Street intersection, one of the driveway crossovers would be removed. It is not anticipated that this would cause significant issues for traffic movement within the site. Further design investigations and consultation with the property owner would be carried out during detailed design.

Impact on flood evacuation routes

The project would maintain current evacuation routes. The proposed bridge would significantly increase traffic capacity across the Clarence River, which would benefit Grafton should the need for flood evacuation arise. Similarly, it is considered that the proposed bridge would enhance access for emergency services due to the increased traffic capacity across the Clarence River.

How the project would meet traffic and transport objectives

The Director-General's environmental assessment requirements relevant to traffic and transport requires detail on how various project elements meet the traffic and transport objectives of the project. These are presented in Table 8-8.

Table 8-8 How the project would meet traffic and transport objectives

Objective	How the project meets the objective
Objective: Enhance road safety for all road users over the length of the project	
Reduce the potential for road crashes and injuries on the bridge and approaches, including any intersections and connecting roads	The project would meet this objective by: • Being designed to meet current design standards (refer to Chapter 5). Unlike the current bridge, it would be free of kinks • Diverting the existing heavy vehicle route for articulated trucks to the proposed bridge, which is likely to reduce road crashes and injuries across the Clarence River. This would also improve the operational safety at the kinks in the existing bridge alignment • Reducing the number of crashes on the Summerland Way route. This may result from reduced traffic volumes, congestion and speed differentials along the existing bridge, which may reduce the anticipated frequency of bumper-to-bumper incidents and aggressive driving behaviour • Reducing the number of crashes at Pacific Highway intersections with the Gwydir Highway and Spring Street. This may result from upgrading the existing set of closely spaced intersections • Providing median separation of the Iolanthe Street and Pound Street carriageways. This has been incorporated into the design as a safety feature to limit the amount of priority-controlled right-turn movements across heavily trafficked roads • Improving the design of intersections and roads. This would allow for the safer movement of vehicles, provide sufficient traffic capacity, and reduce conflicts between vehicles and pedestrians. Road safety audits would be carried out during detailed design, and where appropriate any issues raised would be addressed in the project design.

Objective	How the project meets the objective
Provide safe facilities for pedestrians and cyclists	Pedestrian and cyclist links would be provided as part of the project (refer to Chapter 5) on the western (upstream) side of the proposed road alignment. These would be segregated from the road, and traffic lights would be provided at key intersections.
Objective: Improve traffic efficiency between and within Grafton and South Grafton	
Provide efficient access for a second crossing of the Clarence River and for the State road network	The project would meet this objective by: • Widening the Pound Street / Villiers Street roundabout (south-east Pound Street leg), which would accommodate increases in traffic from the proposed bridge • Upgrading the intersection at Pound Street / Clarence Street would allow the efficient management of forecast traffic demands from the bridge • Providing left-in / left-out only at the proposed intersection of Pacific Highway / Spring Street to improve the geometry of this intersection and allow reasonable access to commercial development along Iolanthe Street • Providing approach roads with a vertical and horizontal road alignment unconstrained by kinks and to a standard suitable for a heavy vehicle route • Providing a bridge cross-section that complies with Roads and Maritime Supplement to Austroads Guide to Road Design Part 3: Geometric Design. The proposed cross-section is consistent with the required provision of minimum 5.5 metres trafficable width between kerbs / barriers to allow for the passing of broken-down vehicles. This is considered suitable to ensure efficient access across the bridge • Widening the Gwydir Highway to four lanes, realigning the Pacific Highway, and providing a 4-leg Iolanthe Street / Pacific Highway / Through Street roundabout and 3-leg Gwydir Highway / Pacific Highway roundabout. These changes would provide additional capacity for traffic accessing the proposed bridge and integrate it into the South Grafton road network • Providing efficient access to the proposed bridge and the Summerland Way.
Provide a traffic management network that reduces delays between Grafton and South Grafton in peak periods to an acceptable level of service for 30 years after opening	The project would provide an acceptable level of service for 20 years after date of opening. The preferred option alignment announced in April 2013 includes additional road network upgrades. If the elements proposed as part of this project approach capacity before 2049 (30 years after opening) then some or all of the additional road network upgrades identified in the preferred option could be implemented. Implementing these additional road network upgrades would provide an acceptable level of service for 30 years after opening.
Provide adequate vertical clearance for heavy vehicles	The project would provide minimum vertical clearance in accordance with Roads and Maritime standards.

Objective	How the project meets the objective
Consider demand management strategies to minimise delays to local and through traffic	As documented in Section 4.1.3, demand management strategies to reduce travel demand (specifically that of private motor vehicles) or to redistribute this demand in space or in time were considered. Demand management strategies are likely to have only a marginal effect on managing travel demand during peak periods. Hence, this alternative was not considered a viable alternative to meet the project objectives and was therefore discounted.

8.1.5 Environmental management measures

The route options development process and concept design investigation described in Chapter 4 and Chapter 5 have sought to minimise traffic and transport impacts as far as possible.

Project-specific management and mitigation measures have been developed with the aim of minimising or mitigating, as far as practical, the traffic and transport impacts during construction and operation as described in Table 8-9. The management and mitigation measures draw on best management practice, government standards and guidelines and specialist knowledge. Potential impacts for both construction and operation phases of the Grafton Bridge project are summarised in the table below and proposed management and mitigation measures outlined.

Table 8-9 Environmental management measures for traffic and transport impacts

Issue	Environmental management measure	Responsibility	Timing
Operational impacts on river navigation and access	The provision of permanent aids to navigation on the bridge will be investigated as part of detailed design.	Roads and Maritime	Detailed design
Road safety audit	Roads and Maritime will conduct a project road safety audit as part of detailed design to identify and address potential safety issues associated with the operation of the project	Roads and Maritime	Detailed design
Future traffic demand	If more detailed information regarding future demand becomes available during detailed design of the project, Roads and Maritime will assess the suitability of incorporating the revised projections.	Roads and Maritime	Pre-construction
Construction impacts on public transport	Access to bus stops will be maintained during construction in consultation with the bus operators where feasible and reasonable.	Roads and Maritime	Pre-construction

Issue	Environmental management measure	Responsibility	Timing
Construction traffic impacts	Construction traffic management measures will be developed and identified as part of the construction environmental management plan. The plan will: • Detail how the traffic associated with construction activities will be managed in accordance with the relevant standards, including *Traffic Control at Work Sites* (Roads and Maritime, 2010), AS1742 and Roads and Maritime Specification G10 • Confirm haulage routes between material source sites and ancillary site / flood levee stockpile access locations • Quantify the impacts on level of service during critical construction periods and demonstrate how the mitigation measures proposed will enable acceptable traffic operations and level of service on the road network during construction • Identify how the continuous, safe and efficient movement of traffic for both the public and construction workers will be maintained • Identify site-specific traffic control measures (including signage) to be provided to manage and regulate traffic movements at relevant locations during construction • Identify access arrangements at both construction sites and quarry sites, detailing vehicle ingress / egress movements • Include requirements and methods to consult and inform the local community of impacts on the local road network and traffic • Describe impacts on all transport modes, identifying appropriate mitigation measures in accordance with the relevant guidelines and in consultation with relevant parties (ie bus and rail operators). • Consider other developments and projects that may also be under construction to minimise traffic conflict and congestion that may occur due to the cumulative increase in construction vehicle traffic.	Construction contractor Roads and Maritime	Pre-construction Construction

Issue	Environmental management measure	Responsibility	Timing
Construction traffic impacts	Construction deliveries will be timed to occur outside peak traffic periods when feasible and reasonable, to minimise impacts on road network. Where feasible and reasonable, machinery and materials to be delivered over long distances will be transported to Grafton by rail and hauled to site by road transport. Consultation will be initiated with the appropriate rail operators / owners to explore this opportunity at the appropriate design stage. Emergency services will be notified in advance of changes to traffic conditions (eg partial or total road closures).	Construction contractor Roads and Maritime	Construction
Construction impacts on the road network	Local roads used for construction access will be repaired where required and maintained in serviceable condition.	Construction contractor Roads and Maritime	Construction
Construction impacts on public transport	Roads and Maritime will coordinate the placement of the new Pound Street bridge with ARTC to ensure the North Coast Line possession coincides with other works required along the line. In addition, North Coast Line users (passengers and freight operators) will be notified of impending changes to minimise impacts on them.	Construction contractor Roads and Maritime	Construction
Construction impacts on river navigation and access	Exclusion zones around critical areas of construction activities and floating construction plant will be clearly marked in accordance with Roads and Maritime advice and requirements.	Construction contractor	Construction
	Commercial fishing licence holders on the Clarence River at Grafton will be consulted during construction to minimise impacts and address any access issues in and around the construction site.	Construction contractor Roads and Maritime	Construction
	A proclaimed Marine Notice will be issued through Roads and Maritime alerting river users of ongoing construction activities.	Construction contractor Roads and Maritime	Construction
	Temporary aids to navigation will be provided where feasible and reasonable and in accordance with Roads and Maritime advice and requirements (such as lighted buoys to mark exclusion zones).	Construction contractor Roads and Maritime	Construction

Issue	Environmental management measure	Responsibility	Timing
	Early and ongoing liaison with local marine events organisers (including Grafton Rowing Club, Grafton River Sailing Club and the Grafton Bridge to Bridge Waterski Race organiser) will be carried out to ensure the viability of these annual events and general activities organised by the clubs.	Construction contractor Roads and Maritime	Construction
	A construction navigation management plan will be prepared and implemented to set out river procedures and impact reduction measures to be adopted during construction.	Construction contractor Roads and Maritime	Construction

8.2 Flooding and hydrology

This section presents an assessment of the potential impacts of the project relating to flooding and hydrology. The assessment draws on information in the flooding and hydrology assessment report prepared for this EIS by BMT WBM consultants (refer to *Appendix E, Technical Paper: Flooding and Hydrology Assessment*).

The assessment addresses the Director-General's environmental assessment requirements, which are provided in Table 8-10.

Table 8-10 Director-General's environmental assessment requirements relevant to flooding and hydrology

Director General's environmental assessment requirements	Where addressed in EIS
An assessment, in accordance with the Floodplain Development Manual (Department of Natural Resources, 2005), of:	
- changes to existing flood regimes (including riverine, overland, and internal levee ponding) in Grafton and South Grafton, with reference to modelling for a range of flood events (including the 1, 2 and 5 average recurrence interval events, and the probable maximum flood (Probable Maximum Flood)) and across a range of flood characteristics (including changes in depth, velocity, direction, hazard, frequency or duration of inundation)	Department of Planning and Environment has confirmed that reference to the 1, 2 and 5 average recurrence interval in the DGRs is actually the 1, 2 and 5 per cent annual exceedance probability events which corresponds to the 100-, 50- and 20-year average recurrence interval events respectively. Section 8.2.3 and Section 8.2.4
- consistency with relevant floodplain risk management plans	Section 8.2.4
- impacts to existing receivers and infrastructure, the future development potential of affected land (including areas outside the existing levee system) and planned infrastructure (including the project)	Section 8.2.3 and Section 8.2.4
- identifying the potential impacts on flow velocities and directions, and impacts on the bed and bank stability, as a result of construction of the new bridge	Section 8.2.4
- details of any proposed mitigation measures, including, where required, upgrade of the Grafton, South Grafton and other rural levee systems, evacuation routes, riverbank protection assets, and drainage asset	Section 8.2.5

Specific flooding and hydrology terms used in this section are defined in Table 8-11.

Table 8-11 Glossary of terms relevant to flooding and hydrology

Term	Definition
100-year flood event	A 100-year flood is the flood that will occur or be exceeded on average once every 100 years. It has 1% probability of occurring in any given year. The same principle applies to other flooding events, such as 10-year, 20-year and 50-year flood events).
Australian height datum (AHD)	This is the standard datum that most flood levels are measured from. Its value is equivalent to mean sea level.
Average recurrence interval (ARI)	The long-term average number of years between the occurrence of a flood larger than the selected event.
Probable maximum flood (PMF)	The largest flood that could conceivably occur (a worst-case flood event). It is typically estimated from probable maximum precipitation coupled with the worst flood-producing catchment conditions. The PMF extent defines the floodplain and incorporates all flood-prone land. The PMF is a very rare and improbable flood.

8.2.1 Assessment methodology

This assessment has been carried out in accordance with the *Floodplain Development Manual* (Department of Natural Resources, 2005) and with regard to the *Grafton and Lower Clarence Floodplain Risk Management Plan* (CVC, 2007). It has involved the following tasks:

- Reviewing information on project design and constructability, land use and property, significant planned infrastructure, digital terrain data, aerial imagery and other relevant information
- Defining the existing flood behaviour between Mountain View, upstream of Grafton, and the Clarence River entrance at Yamba/Iluka, using the lower Clarence River flood model developed for the *Lower Clarence River Flood Study Review* (WBM, 2004; and updated by BMT WBM, 2013)
- The updated lower Clarence River flood model was used to provide increased definition at Grafton, South Grafton and Maclean
- Identifying potential hydraulic impacts resulting from the project on peak flood levels, depths, velocities and inundation durations across a full range of design flood events based on the lower Clarence River flood model
- Identifying solutions to offset potential hydraulic impacts and quantifying any residual impacts that may remain after mitigation
- Identifying measures to manage residual impacts following the implementation of flood mitigation work.

This assessment was based on an updated flood model for the lower Clarence River flood model. The flood model was updated to provide a more detailed assessment of the potential flooding impacts of the project. Updates to the lower Clarence River flood model included:

- A more detailed model grid was used to define the existing topography in the flood plain. A combination of a 30 metre grid on the flood plain and a 10 metre grid in the vicinity of Grafton was used. This results in a more detailed representation of flooding in the Clarence River and less averaging of flood depths when compared with the flood model used during the route selection

stage of the project (which used a 60 metre grid to define the existing topography)

- More accurate survey data for the flood plain (updated lidar data. Lidar is a detection system which works on the principle of radar, but uses light from a laser) and the existing levee system was incorporated into the flood model
- The TUFLOW flood modelling software was updated.

These updates were made to improve the resolution of the flood model and to provide a more detailed assessment of flood impacts as a result of the project. As a result of the more detailed flood model and survey data, there are some minor differences in the flood extents and the change in peak flood levels (an additional two centimetres at the existing bridge in a 20-year flood event) as a result of the project, when compared with the flood model used during the route selection stage of the project. The assessment of potential impacts of the project is provided in Section 8.2.3 and in *Appendix E, Technical Paper: Flooding and Hydrology Assessment*.

8.2.2 Existing environment

Existing flood regime

The Clarence River is a major coastal river with lower floodplain areas subject to frequent and extensive flood inundation. The river catchment covers about 20,000 square kilometres upstream of Grafton. During times of major flooding, a floodplain of about 500 square kilometres downstream of Grafton may also become inundated.

The flooding behaviour of the lower Clarence River is dominated by runoff generated in the large catchment area upstream of Grafton. The upstream catchment typically contributes 80 to 90 per cent of the total volume of floodwater that enters the lower floodplains during main river flood events. Clarence River floods typically occur from low rainfall intensity events that last several days, or even weeks.

Minor tributaries within the lower floodplain of the Clarence River also have the potential to cause flooding issues.

Flood protection in Grafton and South Grafton

Grafton and South Grafton have a long history of flooding. The towns are protected by a ring levee system (refer to Figure 8-6). Flood protection is also provided by natural high ground and the embankments for the railway and Pacific Highway.

The existing levee system provides flood immunity for around a 20-year average recurrence interval event; that is, there is around five per cent chance that the levee may be overtopped in any given year. Overtopping begins when flood levels are at, or close to, eight metres on the Prince Street gauge (the location of this gauge is shown in (Figure 8-6)). After the levee overtops, large areas of Grafton and South Grafton are inundated by floodwater.

Because the levee system can withstand a 20-year flood, this is the lowest flood magnitude event considered in this assessment.

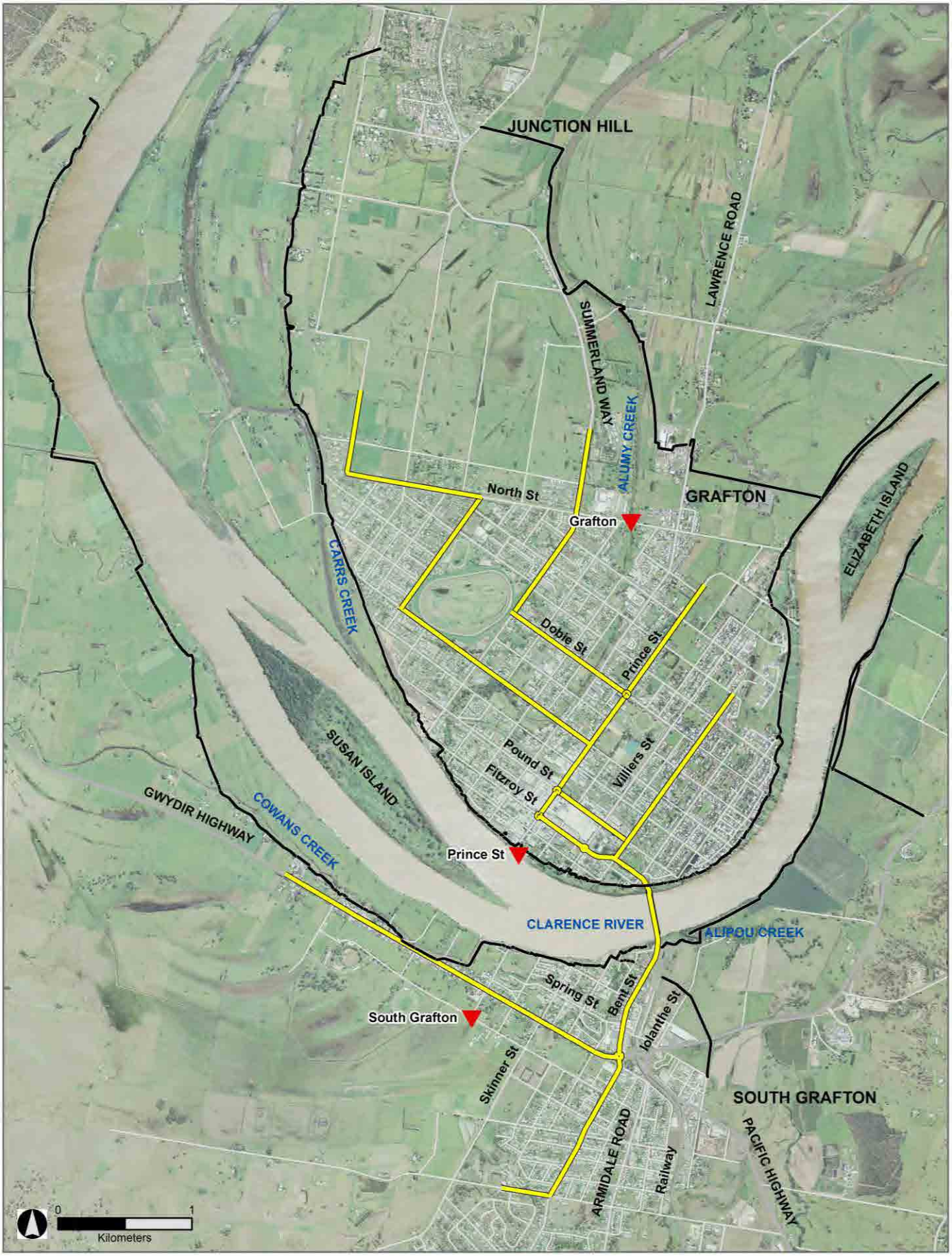


Figure 8-6 Existing levee system and flood evacuation routes

Peak flood levels and peak flood depths for the Clarence River at Grafton are presented in Table 8-12 and Table 8-13. The tables show that significant overtopping of the levee system occurs during floods above the 20-year average recurrence interval.

Table 8-12 Existing peak flood levels

Flood event	Peak flood level (m AHD)			
	Prince Street gauge	**Existing Grafton bridge**	**Grafton: Alumy Creek near North Street**	**South Grafton: intersection of Abbott Street and Vere Street**
20-year	7.95	7.60	No flooding	No flooding
50-year	8.27	7.90	6.40	3.83
100-year	8.35	7.96	7.05	5.86
Probable maximum flood	9.78	9.29	9.27	10.01

Table 8-13 Existing peak flood depths

Flood event	Grafton: Alumy Creek near North Street	South Grafton: intersection of Abbott Street and Vere Street
20-year	No flooding	No flooding
50-year	1.80 m	0.66 m
100-year	2.45 m	2.68 m
Probable maximum flood	4.66 m	6.63 m

Impact of flood events

Figure 8-7 shows the extent of inundation for the 20-, 50- and 100-year average recurrence interval flood events and for probable maximum floods in Grafton and South Grafton. The figure shows flooding is a significant issue as:

- Under a 100-year flood, most of the land inside the levee system would be inundated
- Under the probable maximum flood (that is, the worst-case scenario), the entire township of Grafton would be inundated (refer to Figure 8-6).

Due to these factors, flooding poses a significant risk to the residents in Grafton and lower lying areas in South Grafton. Inundation of individual properties could potentially result in damage to buildings and belongings. It would also have physical and mental health impacts on residents due to injury, sickness, emotional losses, and fear of future flooding. Local businesses would also be impacted due to a loss of trade and income, and damage to property and goods.

Emergency response and evacuation

The NSW State Emergency Services (SES) has developed a flood evacuation plan for Grafton, documented in the *Clarence Valley Council Local Flood Plan* (SES, 2012). The flood plan defines the following information:

- Evacuation sectors
- Evacuation trigger levels, defining sector-specific evacuation actions relating to a range of flood levels at the Prince Street gauge
- Vulnerable community groups requiring special consideration or help during an evacuation
- Evacuation routes
- Evacuation centres.

The plan defines three main evacuation routes out of Grafton (Figure 8-6):

- Two routes to the north, to Junction Hill
- One route across the existing Grafton bridge to South Grafton.

However, during a large flood, overtopping of the Grafton levee system results in ponding in the floodplain between Grafton and Junction Hill and cuts the evacuation routes to the north. When this occurs, the efficiency of flood evacuation within Grafton is constrained as the only flood-free route available for evacuation is via the existing Grafton bridge to South Grafton. Therefore, the efficiency of flood evacuation in Grafton is largely constrained by traffic movement across the existing bridge. Key factors that influence how the proposed bridge would impact evacuation operations include:

- Evacuation route contingency: As shown in Figure 8-6, evacuation routes currently converge within the business district of Grafton
- Evacuation route flood immunity: An evacuation route is compromised if it is inundated by flood water. It is best practice for evacuation routes to be flood-free up to and including the probable maximum flood. This can be impractical for Grafton, which is affected by flooding in flood events greater than the 20 year average recurrence interval event. Due to this local flood behaviour, where possible, the elevation of flood evacuation routes should be greater than surrounding land and avoid traversing drainage depressions which many prematurely compromise the evacuation route
- Provision of services: Flooding within the Lower Clarence Valley can last for prolonged periods (several days to weeks). Due to this flood behaviour, it is important that evacuated residents have access to services and shelter following evacuation from Grafton. South Grafton represents the primary place large enough to provide for these needs
- Vulnerable community groups: SES resourcing needs to accommodate for vulnerable community groups that may require special consideration and/or assistance during an evacuation.

Floodplain risk management plan

The *Grafton and Lower Clarence Floodplain Risk Management Plan* (CVC, 2007) recognises the flood risk to Grafton and South Grafton and identifies mitigation work that focuses on the maintenance and augmentation of the levee system. The plan notes that any work to increase the levee height has the potential to increase inundation to areas not protected by the levees.

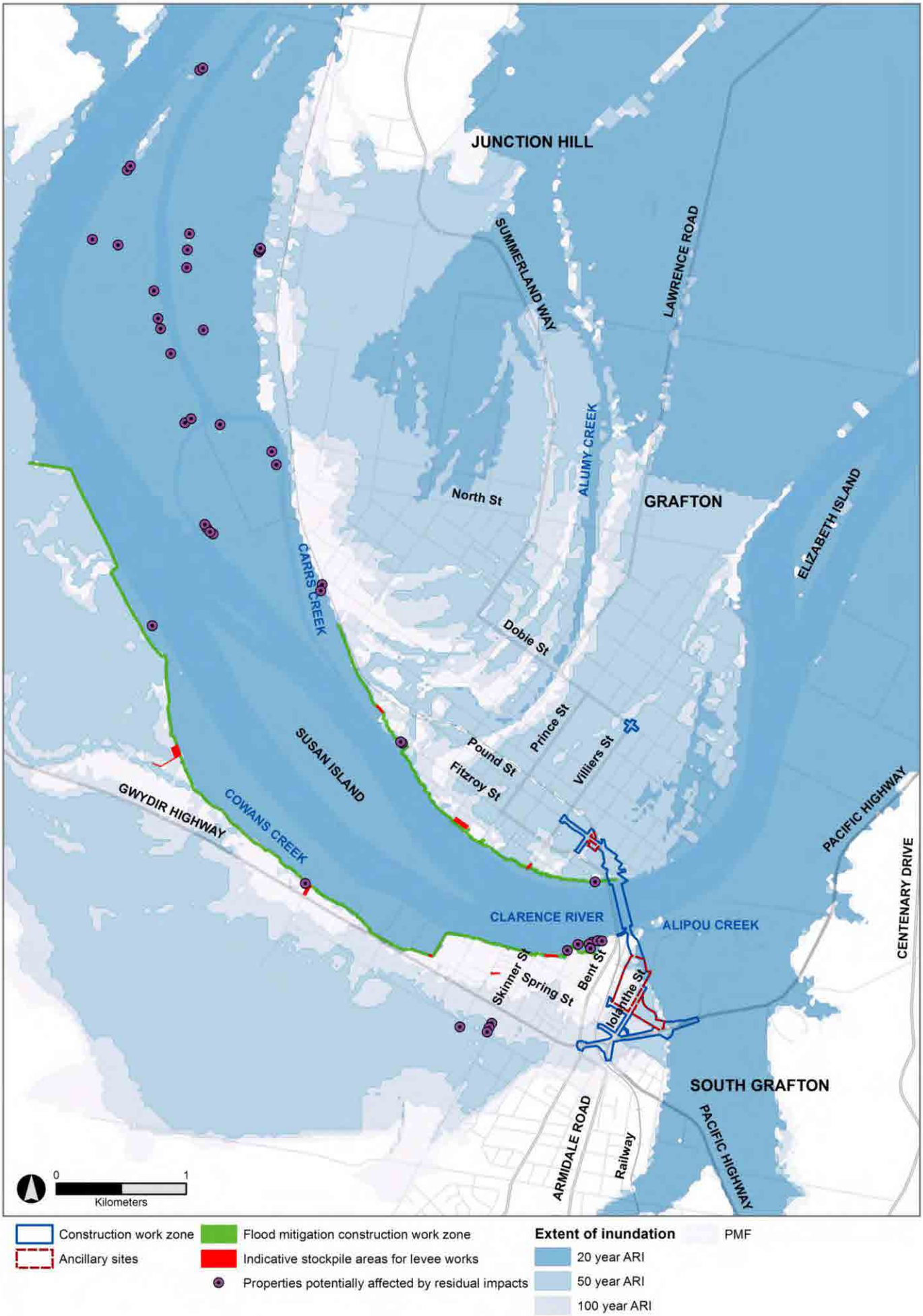


Figure 8-7 Approximate extent of inundation without the project

8.2.3 Assessment of potential impacts – construction

Potential impacts of flooding on the project

Flood events above the 20-year average recurrence interval flood event have the potential to impact construction ancillary sites and construction work zones and to disrupt construction activities. Flooding also has the potential to increase the risk of soil erosion and sedimentation.

With the exception of a small portion of the South Grafton ancillary site and construction work zone, all ancillary sites and construction work zones for the bridge and approaches would be protected by the existing levee system in a 20-year flood event.

In Grafton, there is potential for the construction work zone near the Pound Street rail viaduct to flood when there is a local rainfall event in Grafton and the Clarence River is in flood. There is an existing low point in this area which normally drains to the river during a local rainfall event. When the Clarence River is in flood the raised river level prevents local storm water from draining to the river and water can pond across Pound Street.

Measures to avoid, minimise and manage flooding impacts during construction are presented in Section 8.2.5. Environmental management measures to minimise potential erosion and water quality impacts during construction are presented in Section 8.10.

Potential impacts of project construction on the flood regime

During the construction of the project, construction activities within the levee system would have a negligible impact on the existing flood regime. Construction activities outside the levee system would also have negligible impact on the exiting flood regime. Activities outside the levee system would include project preliminaries and site establishment activities such as property acquisition and adjustments, detailed surveys, site establishment work, fencing and signage, and installation of environmental controls. These construction activities may occur before the implementation of the proposed flood mitigation work.

Due to the extensive length of the Grafton and South Grafton levees, slight changes in flood level within the Clarence River (even as little as one centimetre) have the potential to alter the volume of water overtopping the levee. The introduction of additional structures on the floodplain and river such as bridge piers, embankments and temporary construction structures (such as the proposed jetty for barge launching) would have a progressive and gradual impact on the existing flood regime upstream of the proposed bridge. However, flood modelling shows no impacts are predicted downstream of the proposed bridge as a result of the project.

The incremental change to the flood regime upstream of the proposed bridge would give the construction contractor flexibility to modify the indicative project construction timeline (refer Section 6.1.3) by staging flood mitigation works as the bridge work progresses. Under this alternative construction timeline scenario, additional flood modelling during detailed design would be carried out to ensure the existing flood regime is maintained.

Changes to emergency response and evacuation

Construction activities would not have a significant impact on existing evacuation routes. The NSW SES would be notified of any partial or total road closures during construction.

8.2.4 Assessment of potential impacts – operation

Without mitigation measures, the project would increase the peak flood levels upstream of the proposed bridge during flood events. There are no predicted impacts

downstream of the proposed bridge. The predicted flood impacts in Grafton and South Grafton resulting from the proposed bridge would be triggered by relatively minor increases in the Clarence River water level.

The predicted changes in peak flood level with the new bridge in place without mitigation measures are summarised in Table 8-14.

In view of these potential impacts, the project incorporates flood mitigation measures designed to maintain the current level of flood immunity. These proposed mitigation measures are described in the following section.

Table 8-14 Change in peak flood level with the new bridge in place without flood mitigation

Flood event	Change in peak flood level with the new bridge in place (metres)			
	Prince Street gauge	Existing Grafton bridge	Grafton: Alumy Creek near North Street	South Grafton: intersection of Abbott Street and Vere Street
20-year	0.07	0.07	0.00	0.00
50-year	0.04	0.06	0.08	0.67
100-year	0.04	0.06	0.01	0.43
Probable maximum flood	0.05	0.08	0.04	0.04

Proposed flood mitigation works

Flood mitigation measures can be classified into three general categories:

- Flood modification: The behaviour of floodwater can be modified by either reducing flood depths and/or velocities or by excluding floodwater from certain areas by using measures such as levees and floodways
- Response modification: A community's response to flooding can be changed or improved through better flood warnings and/or education
- Property modification: The resilience of existing property to flooding can be improved, and appropriate planning controls can be implemented to ensure new property is compatible with the level of flood risk.

Flood risk management typically consists of a suite of measures drawn from all three of these categories.

In Grafton and South Grafton, potential measures to mitigate flood impacts could include:

- Dredging the Clarence River to lower the flood level. This option is not considered sustainable and would have uncertain impacts, so has not been assessed further
- Implementing a floodway with associated inlet and outlet control structures to reduce downstream flood levels. No downstream flood impacts are predicted and the option would be prohibitively expensive, therefore this measure has not been assessed further
- Augmenting existing levees to contain the increased flood levels
- Creating or enhancing water storage in the floodplain to temporarily detain or slow floodwater and reduce the peak levels. Floodplain storage options around Grafton are likely to be very expensive and of very limited effect against such

significant flows, however, they do have potential when considered alongside other measures such as levees

- Raising houses above the predicted flood level (for the 20-year flood).

Defining flood mitigation for the project was an iterative process aimed at identifying the extent of levee upgrades needed to reduce the volume of water that would overtop the levee system to reduce potential impacts from major flood events. Four flood mitigation options were assessed. These options were developed using a combination of the appropriate potential measures listed above and considering the potential flood impacts identified in the flood models for the unmitigated case (used to guide length and height of levee upgrade). These options are outlined below:

- Option 1: Raise around 3.7 kilometres of levee on the northern bank of the Clarence River, and around 4.7 kilometres on the southern bank, by 20 centimetres. With this option, peak flood levels in Grafton are reduced. While the volume of water overtopping the raised levee into South Grafton is reduced, there remains significant overtopping into the floodplain to the north which then flows into South Grafton. Therefore this option was not considered further in the assessment
- Option 2 (preferred): Raise around 3.7 kilometres of levee on the northern bank of the Clarence River, and around seven kilometres on the southern bank, by up to 20 centimetres. This option significantly reduces the flooding impact resulting from the project. There are still some properties that are not protected by the existing levee and would be affected by increased flood levels within the river. As a result it may be necessary to raise any houses that fall within this area
- Option 3: Raise around 3.7 kilometres of levee on the northern bank of the Clarence River, and around 4.7 kilometres on the southern bank, by 20 centimetres; and raise the height on a 425-metre length of the Gwydir Highway to an elevation of 6.5 metres Australian Height Datum. In this option, the Gwydir Highway would act as a levee reducing the amount of water flowing into the floodplain south of the Gwydir Highway between Waterview Heights and South Grafton. With this option, peak flood levels in Grafton are reduced. While the peak flood levels in South Grafton are also reduced from the unmitigated case, they remain higher than the peak flood levels without the project. This increase affects existing property and is considered unacceptable
- Option 4: Raise around 3.7 kilometres of levee on the northern bank of the Clarence River, and around 4.7 kilometres on the southern bank, by up to 20 centimetres; and raise a 550-metre length of the Gwydir Highway to an elevation of seven metres Australian Height Datum. In this option, the Gwydir Highway would act as a levee reducing the amount of water flowing into the floodplain south of the Gwydir Highway between Waterview Heights and South Grafton. Raising the Gwydir Highway also creates additional storage in the floodplain upstream of Grafton. This option offers significant benefits to Grafton and South Grafton, over and above the mitigation of the impacts from the project. There are still some properties that are not protected by the existing levee and would be affected by increased flood levels within the river. As a result, it may be necessary to raise any houses that fall within this area.

The mitigation options considered are consistent with the *Grafton and Lower Clarence Floodplain Risk Management Plan* (CVC, 2007).

Options 2 and 4 were shown to mitigate the majority of the flood impact resulting from the project. In both options residual impacts remain to properties located outside the zone of protection afforded by the levees. Option 2 was chosen by Roads and Maritime as the preferred flood mitigation for the project because it would avoid reconstructing and raising part of the Gwydir Highway, which is the B-double route between the Pacific Highway and the New England Highway in northern NSW. Refer

to *Appendix E Technical Paper: Flooding and hydrology assessment* for detailed information on the hydraulic modelling carried out for the mitigation options.

The predicted changes to the existing flood regime after the implementation of Option 2 are discussed below.

Changes to the existing flood regime

Table 8-15 summarises the predicted changes in peak flood levels for locations in Grafton and South Grafton as a result of implementing the proposed flood mitigation compared to the existing peak flood levels (which are summarised in Table 8-12). The extent of the proposed flood mitigation works and extent of inundation for 20-, 50- and 100-year average recurrence interval flood events and the probable maximum flood are shown in Figure 8-8, Figure 8-9, Figure 8-10 and Figure 8-11, respectively.

Table 8-15, Figure 8-9 and Figure 8-10 show a net reduction in peak flood levels in Grafton for the 50- and 100-year average recurrence interval events as a result of the proposed flood mitigation works. Table 8-15 and Figure 8-10 also show a reduction in peak flood levels in South Grafton for the 100-year average recurrence interval event as a result of the proposed flood mitigation works. These reductions in peak flood levels are likely to benefit existing receivers and land uses protected by the levee system.

Table 8-15 Change in peak flood level with the proposed flood mitigation works

	Change in peak flood level (metres)			
Flood event	Prince Street gauge	Existing Grafton bridge	Grafton: Alumy Creek near North Street	South Grafton: intersection of Abbott Street and Vere Street
20-year	0.06	0.07	0.00	0.00
50-year	0.08	0.08	-0.27	0.05
100-year	0.09	0.09	-0.07	-0.11
Probable maximum flood	0.05	0.07	0.02	0.05

Note: Table should be read in conjunction with Figure 8-8, Figure 8-9, Figure 8-10 and Figure 8-11

Changes to velocity, bed and bank stability, flood hazard, flow direction, frequency or duration of inundation

With the implementation of the proposed flood mitigation, the flood model predicts:

- No changes to peak flood velocity and, therefore, no predicted hydraulic impacts on bed and bank stability
- Minor increases in flood hazard in areas where the depth would increase (flood hazard is flooding that has the potential to cause damage to the community); however, these impacts would be of limited spatial extent (refer to Figure 8-8 to Figure 8-11 for the predicted extent and depth of flood depth increase). The predicted flood depth would increase as a result of the proposed bridge which would trigger relatively minor increases in the Clarence River water level upstream of the proposed bridge

- No changes in flow direction following construction of the project. Changes in direction would be limited to minor increases in flood extent around the periphery of areas subject to existing flooding
- No increase in the frequency or duration of inundation, and a slight reduction in the predicted frequency of levee overtopping in Grafton.

Impacts on existing land uses and receivers

The proposed flood mitigation would decrease the overall level of flood risk in Grafton and South Grafton for the majority of flood events. However, there would still be impacts on properties outside the levee system and during floods greater than the 20-year average recurrence interval event. About 45 properties would be affected, as follows:

- Within the levee system: During the 50-year flood, there would be a minor water level increase of five centimetres for four residential properties on Skinner Street and the South Grafton Airport
- Outside the levee system: For all flood events, there would be minor increases of between five to 10 centimetres for 41 properties outside the levee system. Most of these are semi-rural and rural properties on Carrs Island, Grafton and residential properties on Riverside Drive, South Grafton. These properties are shown in Figure 8-8, Figure 8-9, Figure 8-10 and Figure 8-11.

It should be noted that:

- The above assessment is based on conservative assumptions on existing floor levels as no surveyed property floor level data was available. Floor levels surveys would be carried out during detailed design to establish the relative impact on each affected property. This would allow property-specific risks to be better understood and provide the basis for any discussion with property owners regarding further property mitigation measures
- Once flood mitigation is in place, it is unlikely the project would change any potential for development of these affected properties.

Impacts on future development

For the purposes of this assessment, the following future development has been identified:

- Pacific Highway Upgrade – Woolgoolga to Ballina: The highway upgrade would bypass South Grafton. The project application is being assessed by Department of Planning and Environment
- Proposed service station, fast food restaurant and café at the intersection of Spring Street and Iolanthe Street, South Grafton: Clarence Valley Council has approved the development application
- Proposed homemaker centre at the intersection of Through Street and Iolanthe Street, South Grafton: The approval by Clarence Valley Council for this development has lapsed and the development proposal may change.

The flood model identified that the project would not have impacts on these future developments. In particular:

- The proposed Pacific Highway upgrade is a significant distance from the crossing and no downstream impacts are predicted
- At the proposed service station and homemaker centre, lower flood levels are predicted, which would benefit future land uses.

Changes to emergency response and evacuation

The project would maintain current evacuation routes (Figure 8-6) and would also improve the overall efficiency of evacuation by providing an alternative route across the Clarence River, particularly during larger flood events.

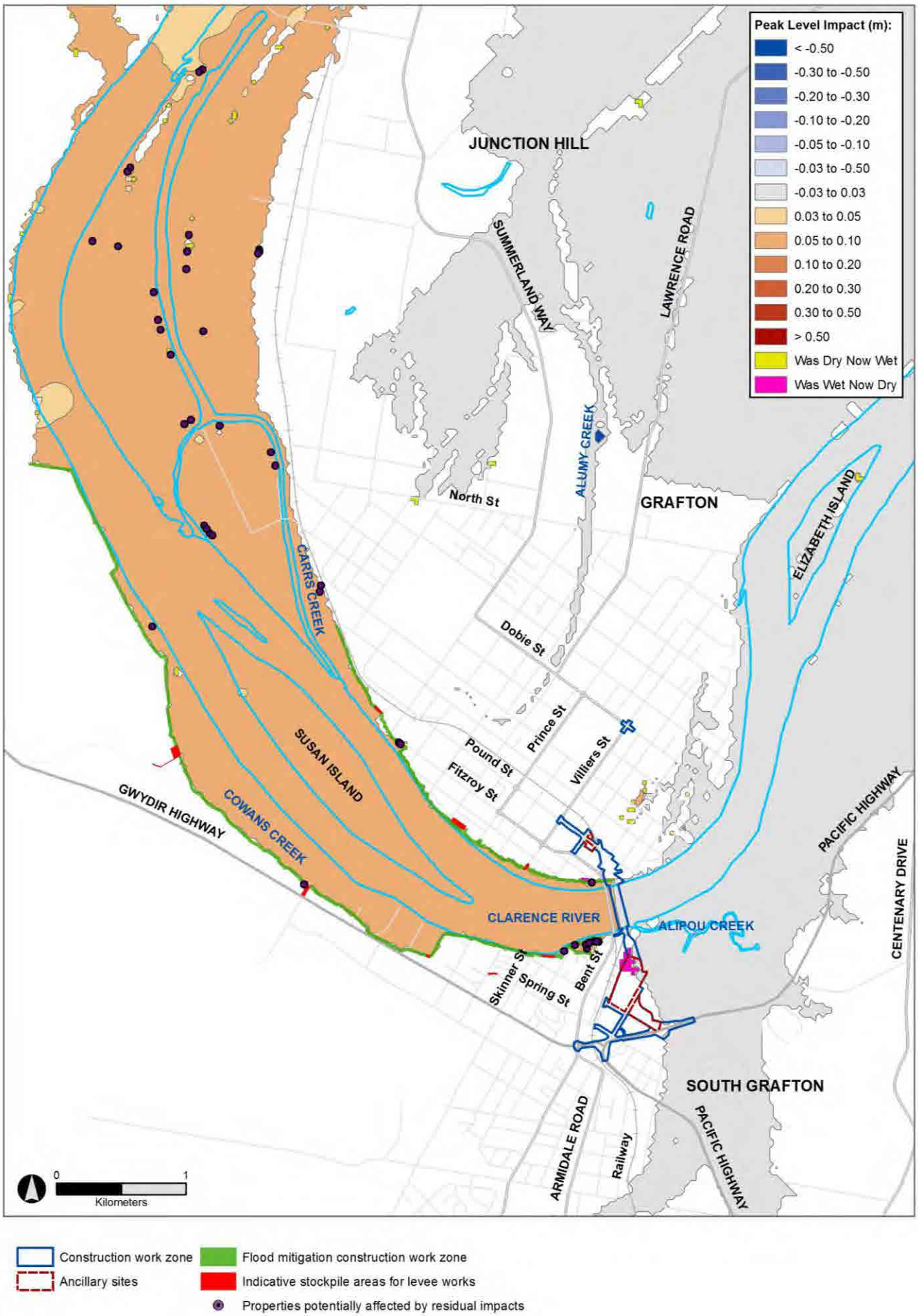


Figure 8-8 Extent of proposed flood mitigation works and extent of inundation for a 20-year flood event

Note: Subject to further refinement during the detailed design stage

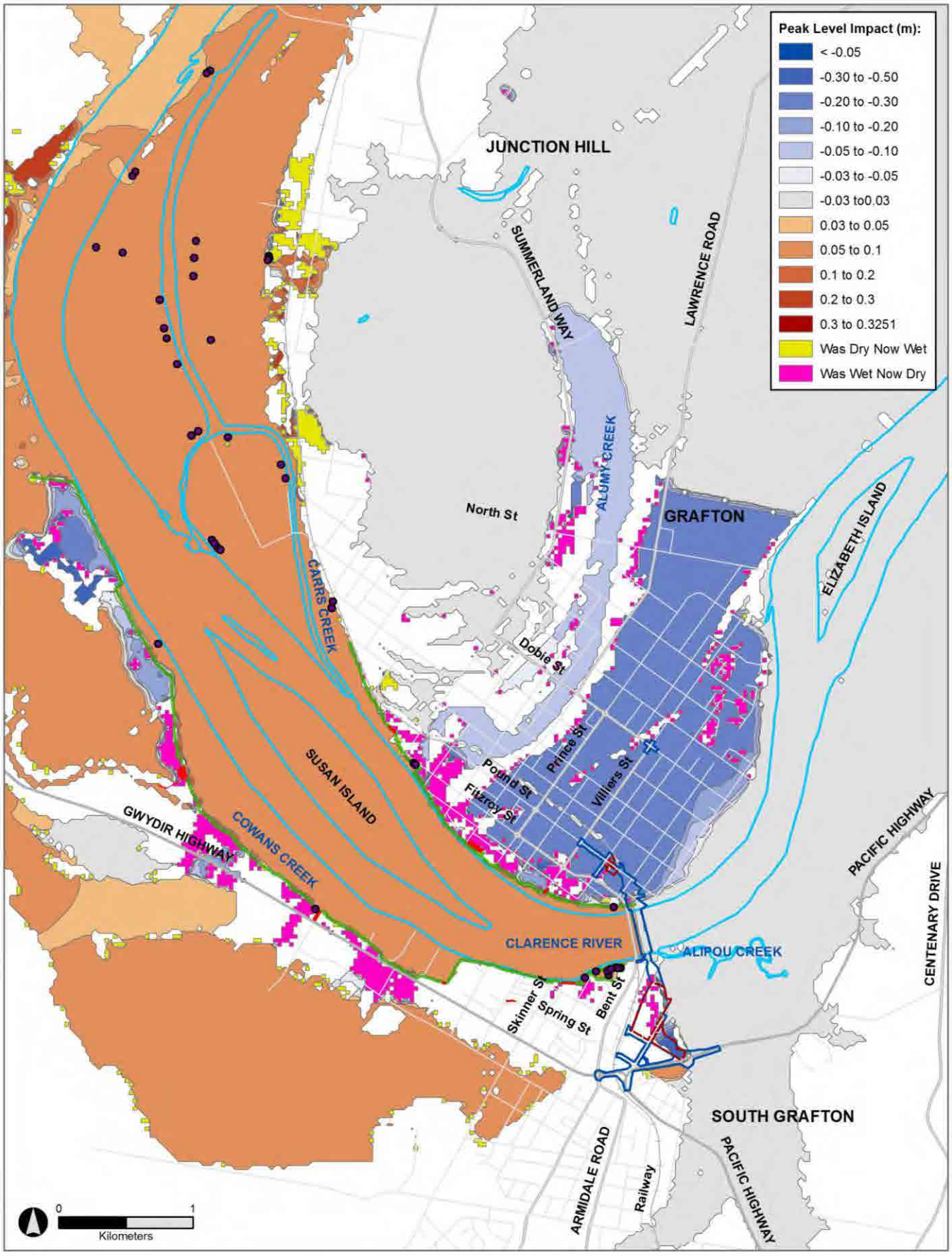


Figure 8-9 Extent of proposed flood mitigation works and extent of inundation for a 50-year flood event

Note: Subject to further refinement during the detailed design stage

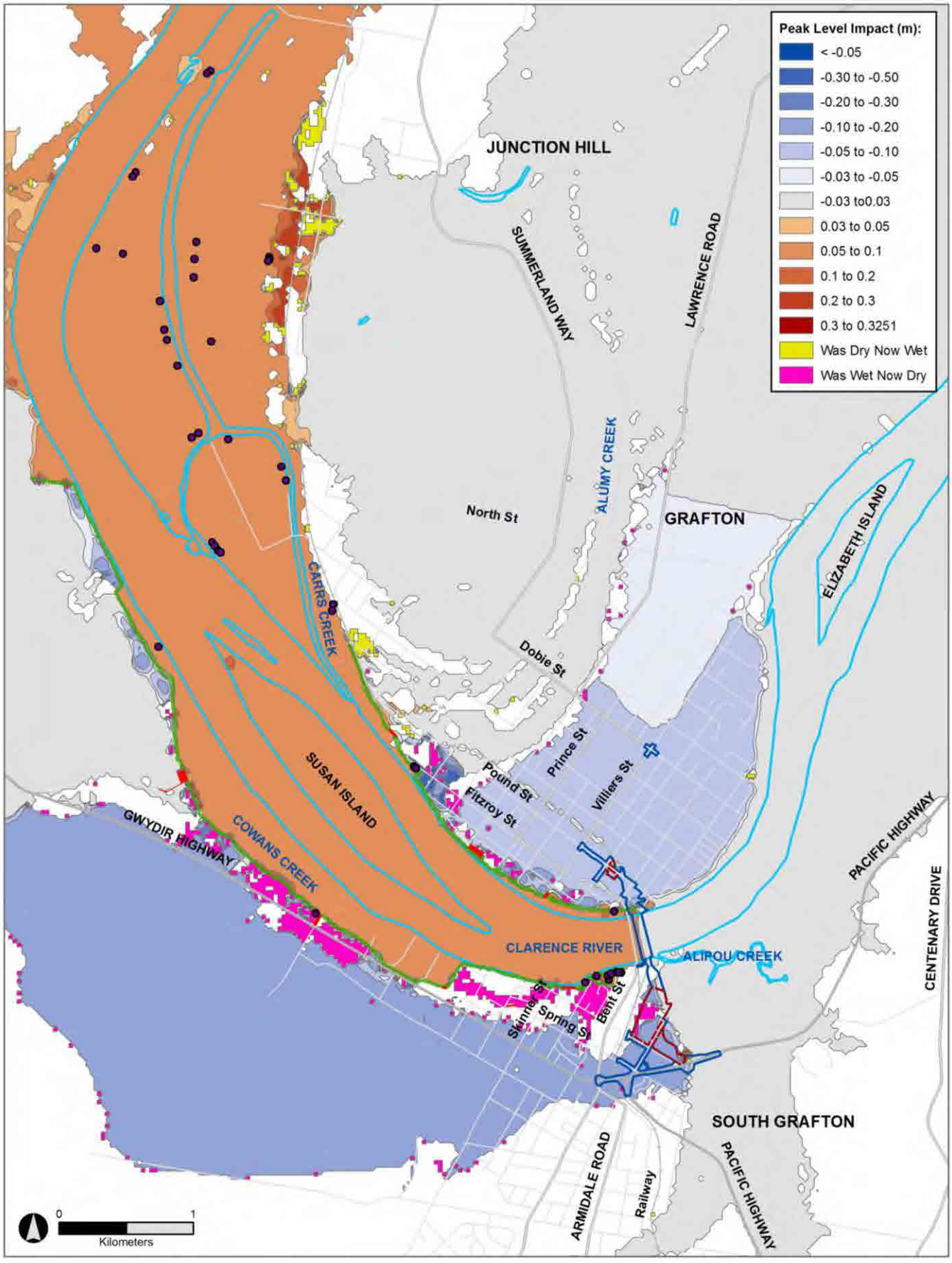


Figure 8-10 Extent of proposed flood mitigation works and extent of inundation for a 100-year flood event

Note: Subject to further refinement during the detailed design stage

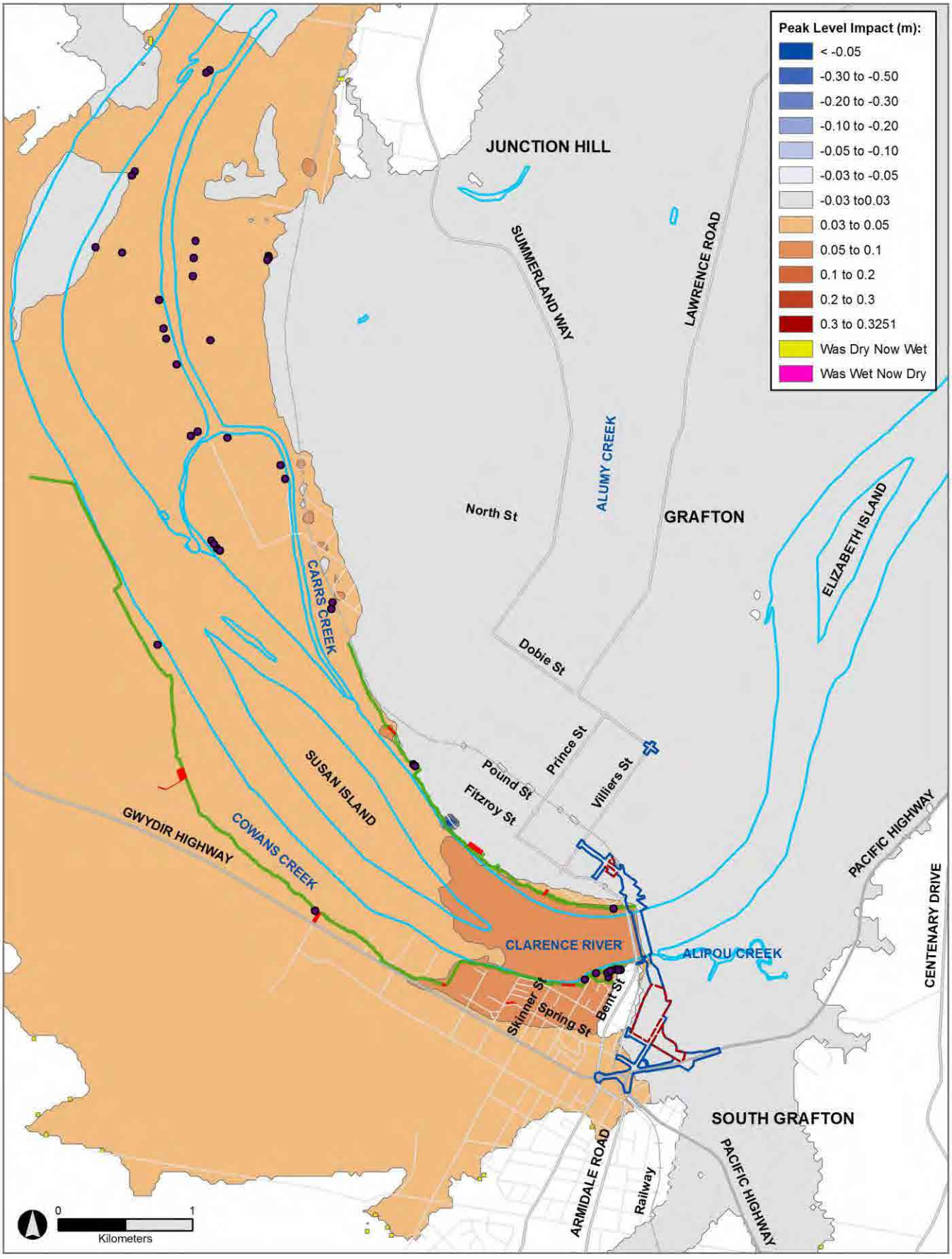


Figure 8-11 Extent of proposed flood mitigation works and extent of inundation for a probable maximum flood event

Note: Subject to further refinement during the detailed design stage

8.2.5 Environmental management measures

The project includes major flood mitigation works involving raising 3.7 kilometres of levee on the northern bank of the Clarence River and seven kilometres of levee on the southern bank upstream of the proposed bridge by up to 20 centimetres.

Additional mitigation measures to manage identified residual impacts from the project are listed in Table 8-16.

Environmental management measures to minimise potential erosion and water quality impacts during construction are presented in Section 8.10.

Table 8-16 Environmental management measures for flooding and hydrology impacts

Issue	Environmental management measure	Responsibility	Timing
Impacts of flooding on the project construction	Flood monitoring and response measures will be included as part of the construction environmental management plan. These measures will include protocols to monitor the forecast of large rainfall and flood events in the project area and protocols to minimise the risk of damage to infrastructure and equipment during a large flood or rainfall event and will include but not limited to: • Methods of monitoring rising water and where possible notification from upstream • A register of all materials stored in work areas within the banks of the Clarence River and within the levee system • Methods and responsibilities for removal of all materials safely from work areas during a flood event • Notification and consultation with relevant stakeholders.	Construction contractor	Pre-construction
Impacts of the project on flood evacuation routes	NSW State Emergency Services will be notified of any partial or total road closures during construction.	Construction contractor	Pre-construction
Consultation	Roads and Maritime will consult with affected landowners during detailed design and construction regarding flooding impacts on properties, residences and other structures.	Roads and Maritime	Pre-construction

Issue	Environmental management measure	Responsibility	Timing
Flood modelling	Detailed flood modelling will be carried out to further refine the levee raising mitigation measures proposed for the project and to further consider the need to raise any houses not protected by the existing levee which would be affected by increased flood levels within the river. As part of this modelling, floor level surveys will be carried out on properties identified as potentially affected by residual impact from the project.	Roads and Maritime	Pre-construction of bridge
Residual impacts on properties and infrastructure	Property-specific flood risk will be assessed for each property identified as being affected by residual impact from the project, based on the results of the floor level survey. Flood mitigation options will be developed and implemented in consultation with property owners and Clarence Valley Council.	Roads and Maritime	Pre-construction of bridge
Impacts of project construction on existing flood regimes	Flood mitigation works will be staged to ensure no worsening of the existing flood regimes during construction.	Construction contractor	Pre-construction of bridge

8.3 Climate change and sea level rise

This section assesses the potential effects of sea level rise on the project as a result of climate change, and the potential impacts of the project on flooding, when sea level rise is taken into account.

The assessment presented in this section draws on information from the report prepared by BMT WBM consultants for the EIS (refer to *Appendix E, Technical Paper: Flooding and hydrology*) and responds to the Director-General's environmental assessment requirements relevant to climate change and sea level rise (refer to Table 8-17).

Table 8-17 Director-General's environmental assessment requirements relevant to sea level rise

Director General's environmental assessment requirements	Where addressed in EIS
An assessment of the effects of sea level rise as a result of climate change on the project.	Appendix E and Section 8.3

8.3.1 Background

The climate of New South Wales is changing. Average temperatures have been steadily rising since the 1960s. The period from 2000–2010 was the State's hottest decade on record. The *NSW Climate Impact Profile* (DECCW, 2010) suggests that there is likely to be a substantial change in regional climate for the North Coast Region by 2050 including:

- Average annual temperatures could increase by up to three degrees Celsius and extreme temperatures could increase significantly
- Summer and autumn rainfall could increase, and winter rainfall could decrease
- The frequency and intensity of annual extreme rainfall events could increase by up to 20 per cent.

8.3.2 Policy setting

In 2011, the NSW Government released its policy document, *NSW 2021: A Plan to Make NSW Number One* (NSW Government, 2011). This document outlines priority actions to help local government, business and the community build resilience to future extreme events and hazards by helping them understand and prepare for the impacts of climate change. As part of this strategy, the NSW Government has begun to assess regional vulnerabilities to extreme weather events. This will help deliver locally based adaptation programs where required. To deliver on this target the NSW Government will:

- Complete fine-scale climate change projections for NSW, which will be made available to local councils and the public by late 2014
- Work with government agencies and universities to deliver improved climate projections for NSW and the ACT.

The NSW Government announced its Stage One Coastal Management Reforms on 8 September 2012. As part of these reforms, the NSW Government no longer recommends Statewide sea level rise benchmarks for use by local councils. Previously the NSW sea level rise planning benchmarks were an increase above 1990 mean sea levels of 0.4 metres by 2050 and 0.9 metres by 2100. The reforms allow councils to have the flexibility to consider local conditions when determining local future hazards.

Roads and Maritime has also developed a climate change plan (Roads and Maritime 2010) to respond to impacts posed by climate change, including reducing greenhouse gas emissions and planning for physical consequences. This includes actions to:

- Reduce Roads and Maritime's carbon footprint
- Help reduce the carbon footprint of NSW road transport
- Adapt the Roads and Maritime road transport system to the impacts of climate change
- Manage the Roads and Maritime transition to a low carbon economy.

8.3.3 Methodology

This climate change assessment involved:

- Preparing a sensitivity assessment focusing on potential impacts of the bridge under future climate scenarios in 2050 and 2100 (these climate scenarios allow for increases in sea level of 0.4 and 0.9 metres and increases in rainfall intensity of 10 and 20 per cent for the 2050 and 2100 climates, respectively)
- Adopting the baseline hydraulic model (pre-development of the project) by increasing the climate conditions to match the scenario parameters for each respective future climate scenario
- Comparing peak flood levels between the existing climate and future climate baseline models
- Adopting the developed case (with the project) hydraulic model by increasing the climate conditions to match the scenario parameters for each respective future climate scenario
- Assessing impacts of the project under a predicted future climate and comparing them to the impacts under the existing climate. This allowed for a comparison of how impacts of the project may change under future climates when compared with the impacts of the project under the existing climate
- A risk assessment to assess the residual risks to the project as a result of climate change. Adaptation measures were determined based on risk level to the project.

8.3.4 Climate change projections

IPCC Global projections

The Intergovernmental Panel on Climate Change (IPCC) assesses information relevant to understanding the scientific basis for the risk of anthropogenic climate change. The IPCC *5th Assessment Report* (IPCC, 2013) considers new evidence of climate change based on the most recent international scientific and technical assessments. One of the main findings highlighted in the report is that it is now extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century.

The IPCC *5th Assessment Report* adopted new terminology for climate model scenarios which are based on representative concentration pathways (RCPs). The pathways are four greenhouse gas concentration scenarios (RCP2.6, RCP4.5, RCP6, and RCP8.5 meaning +2.6, +4.5, +6.0, and +8.5 watts per square metre (W/m^2), respectively). These scenarios have been named after a possible range of radiative forcing values (the difference of sunlight received by the Earth and energy radiated back to space) for the year 2100.

According to the IPCC *5th Assessment Report*, the global mean sea level has risen by 0.19 metres over the period 1901–2010, based on tide gauge records and satellite

data since 1993. The report projects that the global mean sea level rise by 2100, relative to 2005 levels, will likely be in the ranges described in Table 8-18.

Table 8-18 IPCC *5th Assessment Report* global climate change projection of sea level rise

Climate scenarios	Corresponding sea level rise by 2100 (m)
RCP2.6	0.26–0.55
RCP4.5	0.32–0.63
RCP6.0	0.33–0.63
RCP8.5	0.45–0.82

Local projections

Future climate change can potentially affect flood behaviour through:

- Increased sea levels
- Increased severity of storms and other weather systems.

Due to its levees, Grafton and South Grafton are particularly sensitive to any factors that may result in changes to the baseline water levels within the Clarence River. Future sea level rise is one such factor that has the potential to increase the rate and frequency of inundation within the towns. Sea level rise has therefore been modelled as a sensitivity check on predicted flood levels. Both the 2050 and 2100 scenarios have been assessed with ocean boundary increases of 0.4 and 0.9 metres respectively.

Climate change also has the potential to affect rainfall. Evidence suggests that while mean annual rainfall over Australia is likely to decrease, the intensity of extreme daily rainfall could increase. The CSIRO predicts the effects of climate change to result in increases in rainfall intensity of up to 12 per cent by 2070 (CSIRO, February 2007).

As part of this study, a sensitivity assessment was carried out on the potential impact of increases in rainfall intensity of between 10 and 20 per cent combined with the sea level rise. In summary, two future climate scenarios have been modelled which are consistent with the NSW North Coast Region projections stated in the *NSW Climate Impact Profile* (DECCW, 2010):

- 2050 Climate: 0.4 metre rise in sea level and 10 per cent increase in rainfall intensity
- 2100 Climate: 0.9 metre rise in sea level and 20 per cent increase in rainfall intensity.

The 20-year and 100-year average recurrence interval (ARI) events were used as the basis of the sensitivity assessment with levels compared for a future baseline and developed case (with mitigation) scenarios.

8.3.5 Assessment of potential impacts

The 2050 climate scenario has been chosen to be the focus of the climate change impact assessment in the EIS. This scenario was chosen because it is consistent with other future year assessments carried out for the project which focus on potential impacts 10 to 20 years after opening. A 2050 climate scenario assessment considers the potential impacts of climate change about 30 years after opening, which is comparable to other future year assessments carried out for the project. Information for the 2100 climate scenario is presented in *Appendix E Technical Paper: Flooding and hydrology*.

Potential flooding impacts due to climate change (without the project)

Potential flooding impacts due to climate change were measured by comparing peak flood levels for the existing flood regime (without the project) with peak flood levels for the 2050 climate scenario (without the project). The differences in peak flood levels are presented in Table 8-19.

Under a 2050 climate scenario, baseline peak flood levels in the Clarence River at Grafton for a 20-year average recurrence interval flood event increase by between 0.2 and 0.3 metres compared with the existing flood regime (existing climate). During a 100-year average recurrence interval flood event, the change is less pronounced. However, the peak levels still increase by between 0.1 and 0.15 metres.

The increases would result in additional overtopping of the levees into Grafton and South Grafton leading to increased flooding within the towns. In Grafton, this is most notable for the 20-year average recurrence interval flood event. Under the existing climate floodwaters are largely excluded from urban areas by the levees but these would be overtopped under a 2050 climate scenario.

Under a 2050 climate scenario in South Grafton, no change is predicted for the 20-year average recurrence interval flood event. However, a large increase of 2.79 metres is predicted during a 100-year average recurrence interval flood event.

Table 8-19 Change in peak flood level due to climate change (2050 climate scenario)

Flood event scenario	Change in peak flood level (m) Future climate (without project) minus existing climate (without project)			
	Prince Street gauge	Existing Grafton Bridge	Alumy Creek adjacent to North Street, Grafton	Intersection of Abbott Street and Vere Street, South Grafton
20 year	0.27	0.25	0.45	0.00
100 year	0.10	0.08	0.36	2.79

Potential flooding impacts due to climate change (with the project)

The potential flood impacts from the project under a future climate would be similar to the potential flood impacts from the project under the existing climate. This was tested by comparing the change in peak flood levels as a result of the project for each climate scenario (existing climate and 2050 climate).

For both scenarios it was assumed that the project would include the flood mitigation measures outlined in Section 8.2, namely, raising the existing levee system upstream of the proposed bridge by up to 0.2 metres. Changes in peak flood levels were measured by comparing the peak flood level without the project, with the peak flood level with the new bridge in place. Changes in peak flood levels were determined for both the 20-year and 100-year average recurrence interval flood events. The results are presented in Table 8-20.

The results indicate:

- Climate change would have a minor effect on the flood impacts as a result of the project in areas of Grafton and South Grafton
- There would be a minor difference in the change in peak flood levels because of the project under a 2050 climate scenario when compared to the change in peak flood levels because of the project under existing climate. The impacts of the project on peak flood levels for each climate scenario are shown in Table 8-20. While the change in peak flood levels as a result of the project are similar, the actual flood levels would be governed by the climate scenario (eg the flood levels for the existing climate would be lower than the flood levels for the 2050 climate.

The differences in flood levels between the different climate scenarios are shown in Table 8-19).

Table 8-20 Change in peak flood level due to the project (including mitigation Option 2) under 2050 climate scenario

Scenario	Change in peak flood level (m) as a result of the project (developed case minus baseline case)							
	Prince Street gauge		Existing Grafton Bridge		Alumy Creek adjacent to North Street, Grafton		Intersection of Abbott Street and Vere Street, South Grafton	
Flood event scenario	**20 year**	**100 year**	**20 year**	**100 year**	**20 year**	**100 year**	**20 year**	**100 year**
Existing climate scenario (change in peak flood level)	0.06	0.09	0.07	0.09	0.00	-0.07	0.00	-0.11
2050 climate scenario (change in peak flood level)	0.07	0.10	0.08	0.09	-0.09	-0.04	0.00	-0.15

Climate change risk to the project

A qualitative risk assessment has been carried out to assess the residual risks to the project as a result of climate change, including sea level rise. The Australian Standard (AS 5334-2013) *Climate Change Adaptation* was used to determine risks to the project. Risk is defined as the combination of consequences and likelihood. For each worst-case scenario, the consequences and likelihood of occurrence were determined in accordance with Table 8-21 and Table 8-22.

Table 8-21 Qualitative description of consequence

Level	Descriptor	Consequence	Social	Financial
1	Insignificant	No change	No adverse human health effects or complaints.	Insignificant financial loss
2	Minor	Localised service disruption. No permanent damage. Some minor restoration work required. Lifespan reduced by 10–20%	Short-term disruption to employees, residents or businesses. Slight adverse human health effects or general amenity issues. Negative reports in local media.	Additional operational costs. Minor financial loss

Level	Descriptor	Consequence	Social	Financial
3	Moderate	Widespread damage and loss of service. Damage recoverable by maintenance and minor repair. Partial loss of local infrastructure. Lifespan reduced by 20–50%	Frequent disruptions to employees, residents or businesses. Adverse human health effects. Negative reports in State media.	Moderate financial loss
4	Major	Extensive damage requiring extensive repair. Lifespan reduced by >50%	Permanent physical injuries and fatalities may occur from an individual event. Negative reports in national media. Public debate about performance.	Major financial loss
5	Catastrophic	Permanent damage and/or loss of service Retreat and translocation of development	Severe adverse human health effects – leading to multiple events of total disability or fatalities. Emergency response. Negative reports in international media.	Significantly high financial loss

Table 8-22 Qualitative description of likelihood

Level	Descriptor	Description
A	Almost certain	The event is expected to occur in most circumstances
B	Likely	The event will probably occur in most circumstances
C	Moderate	The event should occur at some time
D	Unlikely	The event could occur at some time
E	Very unlikely	The event may occur only in exceptional circumstances

Table 8-23 Risk rating matrix

Likelihood		Consequence				
		1	2	3	4	5
		Insignificant	Minor	Moderate	Major	Catastrophic
A	Almost certain	L	M	H	E	E
B	Likely	L	M	M	H	E
C	Moderate	L	L	M	H	H
D	Unlikely	L	L	M	M	H
E	Very unlikely	L	L	L	M	M

E - Extreme risk, requiring immediate action.
H - High risk issue requiring detailed research and planning at senior management level.
M - Moderate risk issue requiring change to design standards and maintenance of assets.
L - Low risk issue requiring action through routine maintenance of assets.

The consequences and likelihoods have been considered for the project and associated flood mitigation measures outlined in Section 8.2. The risk rating was then determined in accordance with Table 8-23.

A summary of the potential risks to the proposed project are identified in Table 8-24 below.

Table 8-24 Potential risks to the project as a result of climate change

Potential risk	Likelihood	Consequence	Risk rating	Adaptation measure
Increased frequency and severity of extreme rainfall events leading to increased localised flooding or saturation of embankments and ground conditions	C	2	L	Project embankments would be investigated in detailed design to take into account sea level rise and severity of storms and flooding resulting from climate change. There would be regular inspections of project elements for early identification of potential issues relating to embankments and ground conditions.

Potential risk	Likelihood	Consequence	Risk rating	Adaptation measure
Increased frequency and severity of extreme rainfall events leading to more frequent malfunctioning of power supplies. Impacts on traffic signals and pump station.	D	2	L	The pump station would be equipped with redundant power supply capacity.
Increased frequency and severity of extreme storm, hail and wind events leading to debris, fallen trees and branches impacting infrastructure and road users	C	2	L	Operational procedures would be in place for the regular and timely removal of debris and falling trees and branches.
Increased frequency and severity of flood events changing the inundation levels on project infrastructure and levee	D	2	L	Adopted design flood levels would include an appropriate allowance for increased rainfall intensities due to climate change in accordance with the *NSW Floodplain Risk Management Guideline – Practical Considerations of Climate Change* (DECC, 2007). The proposed bridge would be designed to withstand flooding events up to and including the 2000-year average recurrent interval event as per Australian Standard 5100.2. Bridge approach roads would be designed to maintain serviceability during the 20-year average recurrent interval event.
Increased restrictions on maritime navigation due to reduced clearance beneath the bridge.	E	2	L	A reduction of the bridge clearance height above mean high water springs as a result of sea level rise is unlikely to restrict existing and likely future maritime access and traffic. Further discussion is provided in Section 8.1.

8.3.6 Environmental management measures

The following adaptation measures identified in Table 8-24 have been incorporated into the project design:

- The proposed bridge would be designed to withstand flooding events up to and including the 2000-year average recurrent interval event as per *Australian Standard 5100.2*
- Bridge approach roads would be designed to maintain serviceability during the 20-year average recurrent interval event.

In addition, the following mitigation measures are proposed to manage potential risks to the project as a result of climate change.

Table 8-25 Environmental management measures to manage climate change risks to the project

Issue	Environmental management measure	Responsibility	Timing
Managing climate change risks to the project	Bridge approach embankments will be investigated in detailed design to take into account sea level rise and severity of storms and flooding resulting from climate change. The proposed pump station in Grafton will be equipped with redundant power supply capacity. Adopted design flood levels will include an appropriate allowance for increased rainfall intensities due to climate change in accordance with the *NSW Floodplain Risk Management Guideline – Practical Considerations of Climate Change (DECC, 2007)*.	Roads and Maritime	Detailed design
	Regular inspections of project elements will be carried out for early identification of potential issues relating to embankments and ground conditions. Operational procedures will be in place for the regular and timely removal of debris and falling trees and branches.	Roads and Maritime	Operation

8.4 Noise and vibration

This section presents an assessment of the potential noise and vibration impacts of the project and identifies mitigation and management measures to minimise and reduce these impacts. The assessment draws on information in the noise and vibration report prepared for this EIS (refer to *Appendix F, Technical Paper: Noise and Vibration*).

Table 8-26 lists the Director-General's environmental assessment requirements relevant to noise and vibration and where they are addressed in this chapter.

Table 8-26 Director-General's environmental assessment requirements relevant to noise and vibration

Director General's environmental assessment requirements	Where addressed in EIS
An assessment of the noise impacts of the project during operation, consistent with the *Road Noise Policy* (Environment Protection Authority, 2011). The assessment must include specific consideration of impacts to receivers (dwellings, child care centres, educational establishments, hospitals, motels, nursing homes, or places of worship), as relevant and identify feasible and reasonable mitigation measures.	Section 8.4.4
An assessment of construction noise and vibration impacts, consistent with the *Interim Construction Noise Guideline* (Department of Environment, Climate Change and Water, 2009) and *Assessing Vibration: A Technical Guideline* (Department of Environment and Conservation, 2006).	Section 8.4.3

8.4.1 Assessment methodology and criteria

Noise surveys

Noise surveys were carried out in August 2010, September 2011 and November 2013 to gather baseline information on the existing noise environment. These involved:

- Noise monitoring at 26 locations throughout the study area, including locations near the existing bridge, locations in the wider Grafton area, and locations along the levee. The noise monitoring locations are shown in Figure 8-12 and Figure 8-13
- Unattended noise loggers to continuously measure noise at each location
- Attended noise monitoring at each location to record more detailed noise data.

Road traffic counts were carried out concurrent with noise logging throughout the noise monitoring period.

Noise modelling

Noise modelling was carried out to assess the project's potential road traffic noise impacts. Forecast traffic flow data for the 'no build' (also known as 'future existing') and the 'build' scenarios for the assumed year of opening (2019) and 10 years after opening (2029) were applied to the noise model to predict the road traffic noise levels for each scenario.

Construction noise criteria

The *Interim Construction Noise Guideline* (Department of Environment, Climate Change and Water, 2009) provides recommended noise levels for airborne construction noise at sensitive land uses and sets out noise management levels.

Noise management levels for airborne construction noise at residences are detailed in Table 8-27. These noise levels apply at the worst affected property boundary of a residence, 1.5 metres above ground level. If the property boundary is more than 30 metres from the residence, the noise levels apply at the most noise affected point within 30 metres of the residence.

Table 8-27 *NSW Interim Construction Noise Guideline* management levels for airborne construction noise at residences

Time of day	Management level, LA_{eq}(15min)
Recommended standard hours: Monday to Friday, 7am to 6pm Saturday, 8am to 1pm No work on Sundays or public holidays	Noise affected Rating background level (RBL) + 10 dB
	Highly noise affected 75 dB(A)
Outside recommended standard hours	Noise affected Rating background level (RBL) + 5 dB

Fourteen noise catchment areas were defined along the construction work zone (each catchment area represents a typical background noise environment). Construction noise criteria were set based on noise catchment areas relative to proposed construction work. The noise catchment areas defined for the assessment are shown in Figure 8-12 and Figure 8-13 while the screening criteria for residential receivers for each noise catchment area are presented in Table 4 of *Appendix F Technical Paper: Noise and Vibration.*

The *Interim Construction Noise Guideline* also recommends noise level limits for sensitive land uses other than residential receivers. These recommended noise limits are shown in Table 8-28.

Table 8-28 Recommended construction noise limits for non-residential sensitive receivers

Sensitive land use	Management level, LA (15min) (applies when properties are being used)
Classrooms at schools and other educational institutions	Internal noise level 45 dB(A)
Hospital wards and operating theatres	Internal noise level 45 dB(A)
Places of worship	Internal noise level 45 dB(A)
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dB(A)
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dB(A)
Community centres	Internal noise levels 45 dB(A) (based on the maximum internal noise level for reading areas in public libraries in AS2107)

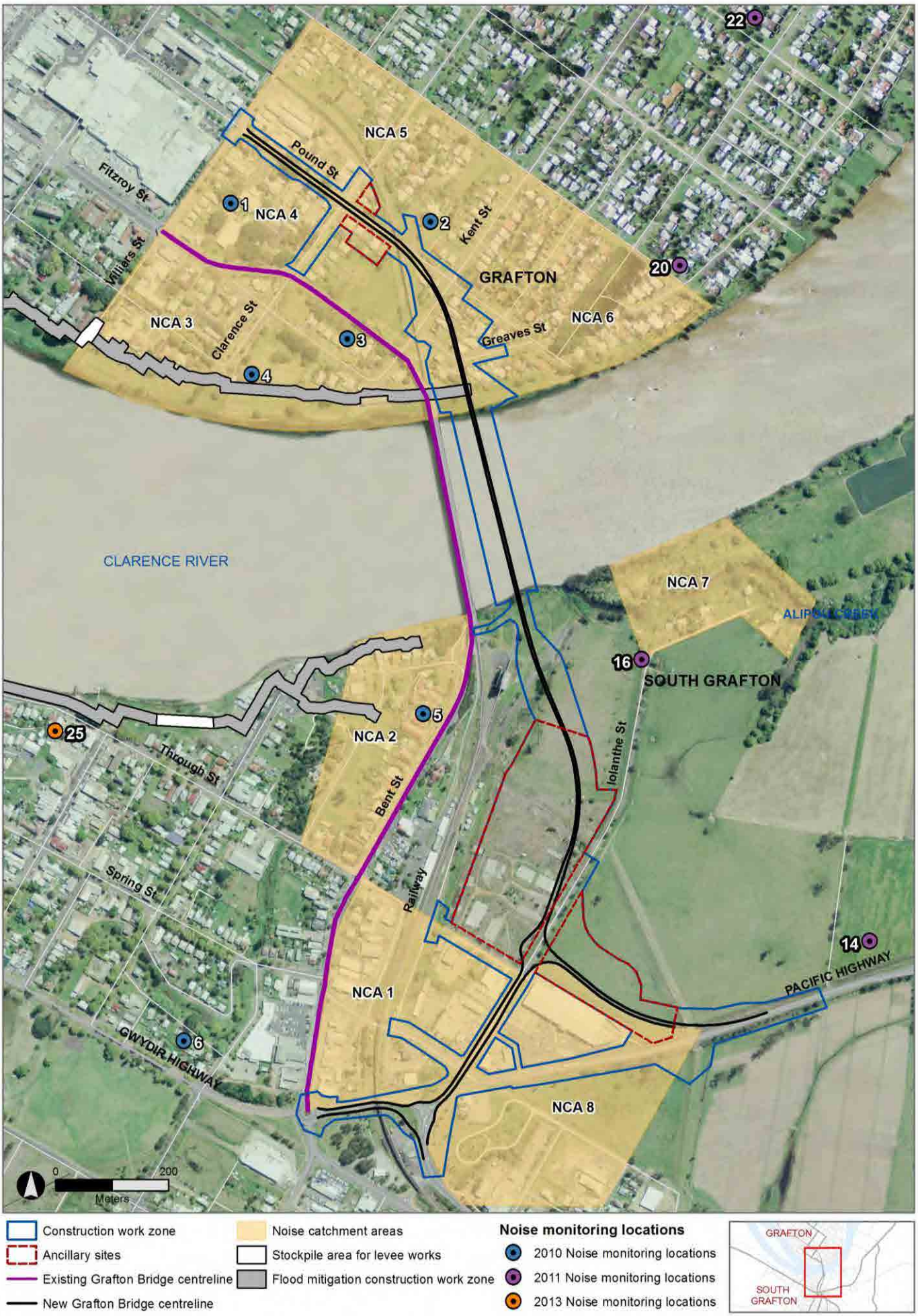


Figure 8-12 Noise catchment areas for Grafton and South Grafton

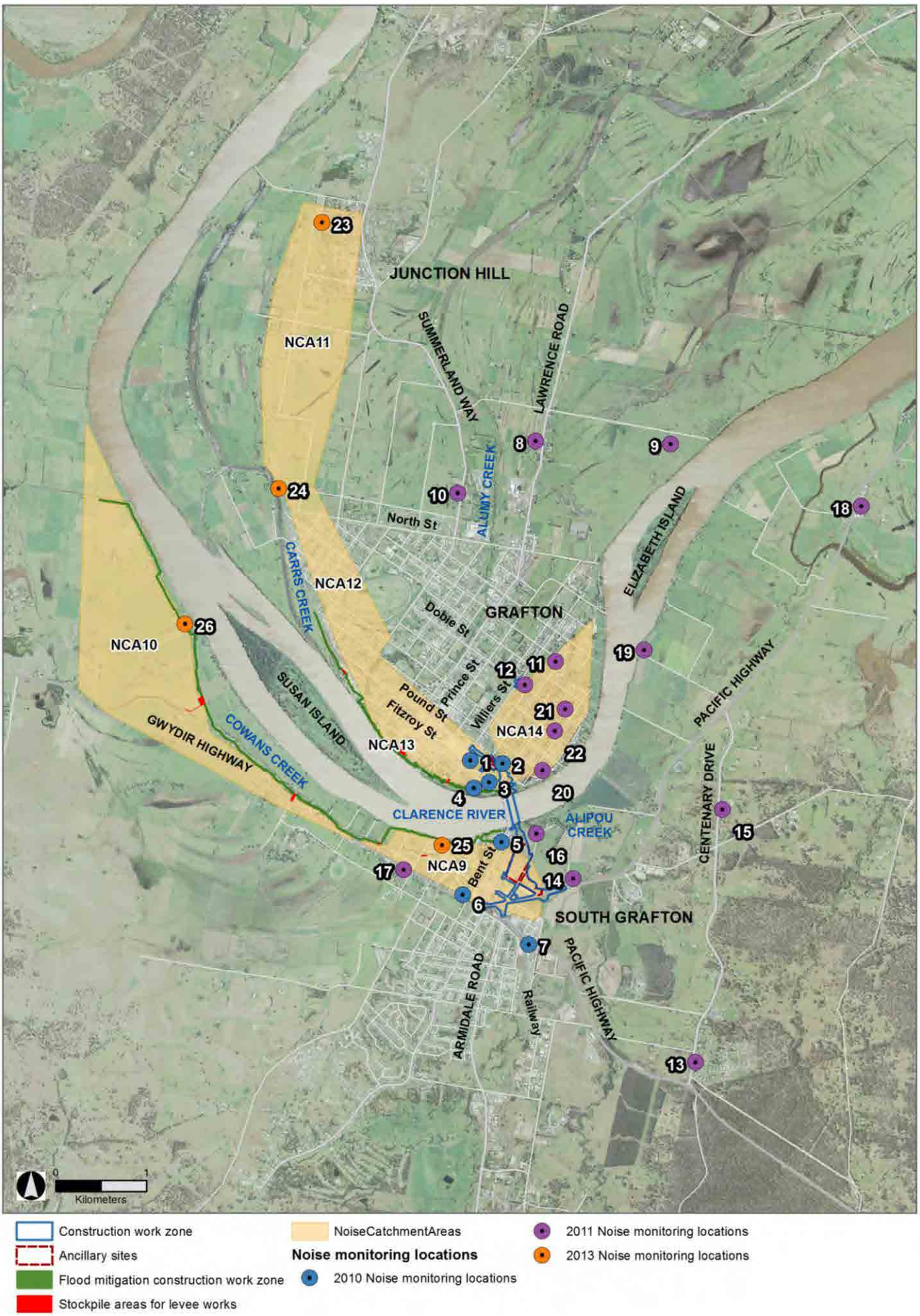


Figure 8-13 Noise catchment areas along proposed flood mitigation works

Construction vibration criteria

Human comfort criteria

The vibration impact assessment used vibration criteria in *Assessing Vibration Guideline* (Department of Environment and Conservation NSW, 2006) for maintaining human comfort within different spaces.

The recommended vibration limits for maintaining human comfort in residences and other relevant receiver types for continuous/impulsive and intermittent vibration are provided in Table 8-29 and Table 8-30.

Table 8-29 Preferred and maximum weighted root-mean-square (rms) values for continuous and impulsive vibration acceleration (m/s²) 1-80 Hz

Location	Assessment period	Preferred values		Maximum values	
		z axis	x and y axes	z axis	x and y axes
Continuous vibration					
Residences	Daytime 7am to 10pm	0.010	0.0071	0.020	0.014
	Nighttime 10pm to 7am	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day or nighttime	0.020	0.014	0.040	0.028
Impulsive vibration					
Residences	Daytime 7am to 10pm	0.30	0.21	0.60	0.42
	Nighttime 10pm to 7am	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day or nighttime	0.64	0.46	1.28	0.92

Table 8-30 Acceptable vibration dose values for intermittent vibration ($m/s^{1.75}$)

Location	Daytime 7am to 10pm		Nighttime 10pm to 7am	
	Preferred value	Maximum value	Preferred value	Maximum value
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80

Building damage criteria

In addition, the British standard *BS7385: Part 2: 1993* and German standard *DIN 4150:3 – Structural Vibration, Part 3: Effects of Vibration on Structures* were used to assess the potential for vibration to cause structural damage to buildings. The most stringent vibration velocity limit recommended in the German Standard is three millimetres per second. This criterion was used to assess potential damage to heritage listed items.

No detailed vibration survey was carried out for the project to determine baseline vibration levels as the existing vibration levels in Grafton and South Grafton are considered to be well below levels that are either perceptible to humans or could potentially cause damage to sensitive structures.

Operational noise criteria

Road traffic noise criteria

Noise levels were predicted at individual residential receivers and other sensitive land uses along the existing and proposed bridge and approach roads. The noise level predictions were made both for daytime (7am to 10pm) and night-time (10pm to 7am) for two future scenarios: without the project, and with the project.

The *NSW Road Noise Policy* (Environment Protection Authority, 2011) road traffic noise criteria, for both residential and other non-residential noise-sensitive receivers, were adopted for the assessment (refer to Table 8-31 and Table 8-32).

Table 8-31 Road traffic noise assessment criteria for residential land uses (from *NSW Road Noise Policy*)

Road category	Type of project/land use	Assessment criteria (dB)	
		Day 7am 10pm	Night 10pm 7am
Freeway / arterial / sub-arterial roads	1. Existing residences affected by noise from new freeway / arterial / sub-arterial road corridors	LAeq, 15 hour 55 (external)	LAeq, 9 hour 50 (external)
Freeway / arterial / sub-arterial roads	2. Existing residences affected by noise from redevelopment of existing freeway/arterial/sub-arterial roads	LAeq, 15 hour 60 (external)	LAeq, 9 hour 55 (external)
Relative increase criteria			
Freeway / arterial / sub-arterial roads	New road corridor / redevelopment of existing road / land use development with the potential to generate additional traffic on existing road	Existing traffic LAeq, 15 hour + 12 (external)	Existing traffic LAeq, 9 hour + 12 (external)

Table 8-32 Road traffic noise assessment criteria for non-residential land uses (from *NSW Road Noise Policy*)

Sensitive land use	Assessment criteria (dB)	
	Day 7am 10pm	Night 10pm 7am
1. School classrooms	LAeq, 1 hour 40 (internal)	-
2. Hospital wards	LAeq, 1 hour 35 (internal)	LAeq, 1 hour 35 (internal)
3. Places of worship	LAeq, 1 hour 40 (internal)	LAeq, 1 hour 40 (internal)
4. Open space (active use)	LAeq, 15 hour 60 (external) when in use	-
5. Open space (passive use)	LAeq, 15 hour 55 (external) when in Use	-
8. Childcare facilities	Sleeping rooms: LAeq, 1 hour 35 (internal) Indoor play areas: LAeq, 1 hour 40 (internal) Outdoor play areas: LAeq, 1 hour 55 (external)	-
9. Aged care facilities	Residential land use noise assessment criteria should be applied to these facilities.	

Practice Note IV of the Roads and Maritime *Environmental Noise Management Manual* (Roads and Maritime, 2001) guidance was used to:

- Investigate noise treatment options for road traffic noise based on the 'feasible and reasonable' guidance outlined in the manual
- Determine whether the relevant facade of a receiver has an existing road traffic noise exposure
- Identify noise-sensitive receivers that exceed the 'acute' noise levels. For the purposes of this assessment, residential receivers and other sensitive land uses that exceed the 'acute' noise levels, and have been subject to a traffic noise level increase due to the project have been specifically considered for mitigation. Receivers that are predicted to be above 'acute' noise levels and where the existing roads are the dominant noise source are not considered for mitigation
- Assess the potential for sleep disturbance due to maximum noise level events associated with road traffic as a result of the project.

Rail noise criteria (Pound Street viaduct)

The project includes the replacement of the viaduct above Pound Street with a bridge (refer to Chapter 5 for details on this work).

The *NSW Rail Noise Infrastructure Guideline* (2013) rail noise criteria for residential and other non-residential sensitive receivers were used to assess the impacts (for airborne and groundborne noise) of the operation of this rail bridge.

Pump station noise criteria

As noted in Chapter 5, a below ground pump station is proposed in Grafton as part of the project's operational stormwater management system. The *NSW Industrial Noise Policy* (2000) industrial noise criteria were used to determine the noise emission

criteria for the operation of the pump station. The criteria were derived from the most representative noise monitoring location and is presented in bold font in Table 8-33.

Table 8-33 *NSW Industrial Noise Policy* noise emission criteria for the proposed pump station

Time of the day	Intrusive criteria dBLAeq (15min)	Amenity criteria dBLAeq (Period)
Day (7am–6pm)	63	**56**
Evening (6pm–10pm)	**51**	56
Night (10pm–7am)	**36**	43

Note: Numbers highlighted in bold font represent the adopted criteria for this assessment.

8.4.2 Existing environment

Existing ambient noise and sensitive land uses

The main contributors to ambient noise in the Grafton area are:

- Road traffic noise, including heavy vehicles, along the main arterial roads in and around Grafton
- General road traffic in and around the city centre
- Passenger and freight rail along the Northern Railway Line
- Rural industry and machinery
- Local insect and animal noise.

Residential and non residential noise sensitive land uses relevant to the project are presented in Figure 8-14 and Figure 8-15. The majority of receivers relevant to the project are residential with a small number of non-residential open space and educational land uses (TAFE and Aboriginal pre-school) near the project area. Refer to *Appendix F, Technical Paper: Noise and Vibration* for information on existing noise levels at the noise monitoring locations shown in Figure 8-12 and Figure 8-13. Typical land use characteristics within each noise catchment area are presented in Table 8-34.

Table 8-34 Typical land use characteristics within each noise catchment area (NCA)

Noise catchment area	Typical land use characteristics within catchment
NCA 1	This area is predominantly commercial and industrial with a few residential single storey detached dwellings.
NCA 2	This is a residential area consisting predominantly of single storey and high-set detached dwellings and aged care facilities.
NCA 3	This area is a mixture of residential single storey and high-set detached dwellings and an area owned by the Catholic Church consisting of some two storey buildings used for a range of purposes such as education, places of worship and residential.
NCA 4	This area is largely made up of the TAFE and residential single storey and high-set detached dwellings.

Noise catchment area	Typical land use characteristics within catchment
NCA 5	This is a residential area consisting predominantly of single storey and high-set detached dwellings and the Gummyaney Pre-School.
NCA 6	This is a residential area consisting predominantly of single storey and high-set detached dwellings.
NCA 7	This area is predominantly rural with a few isolated residential dwellings.
NCA 8	This area is a mixture of rural land, commercial properties such as a petrol station and public open spaces.
NCA 9	This area is a mixture of residential single storey and high-set detached dwellings, the main South Grafton commercial precinct, other commercial and industrial areas and rural land.
NCA 10	This area is predominantly rural with a few isolated residential dwellings.
NCA 11	This area is predominantly rural with a few isolated residential dwellings. It also includes part of Junction Hill which is predominantly residential.
NCA 12	This area is a mixture of residential single storey and high-set detached dwellings, some industrial areas and the Grafton racecourse.
NCA 13	This area is a mixture of residential single storey and high-set detached dwellings, the main Grafton commercial precinct, the TAFE and an area owned by the Catholic Church consisting of two storey buildings used for a range of purposes such as education, places of worship and residential.
NCA 14	This is a residential area consisting predominantly of single storey and high-set detached dwellings.

Existing vibration

There are no significant existing sources of vibration affecting the Grafton area. Vibration levels from existing traffic are well below levels that are either perceptible to humans or could potentially cause damage to sensitive structures.

Figure 8-14 Sensitive land uses in Grafton and South Grafton

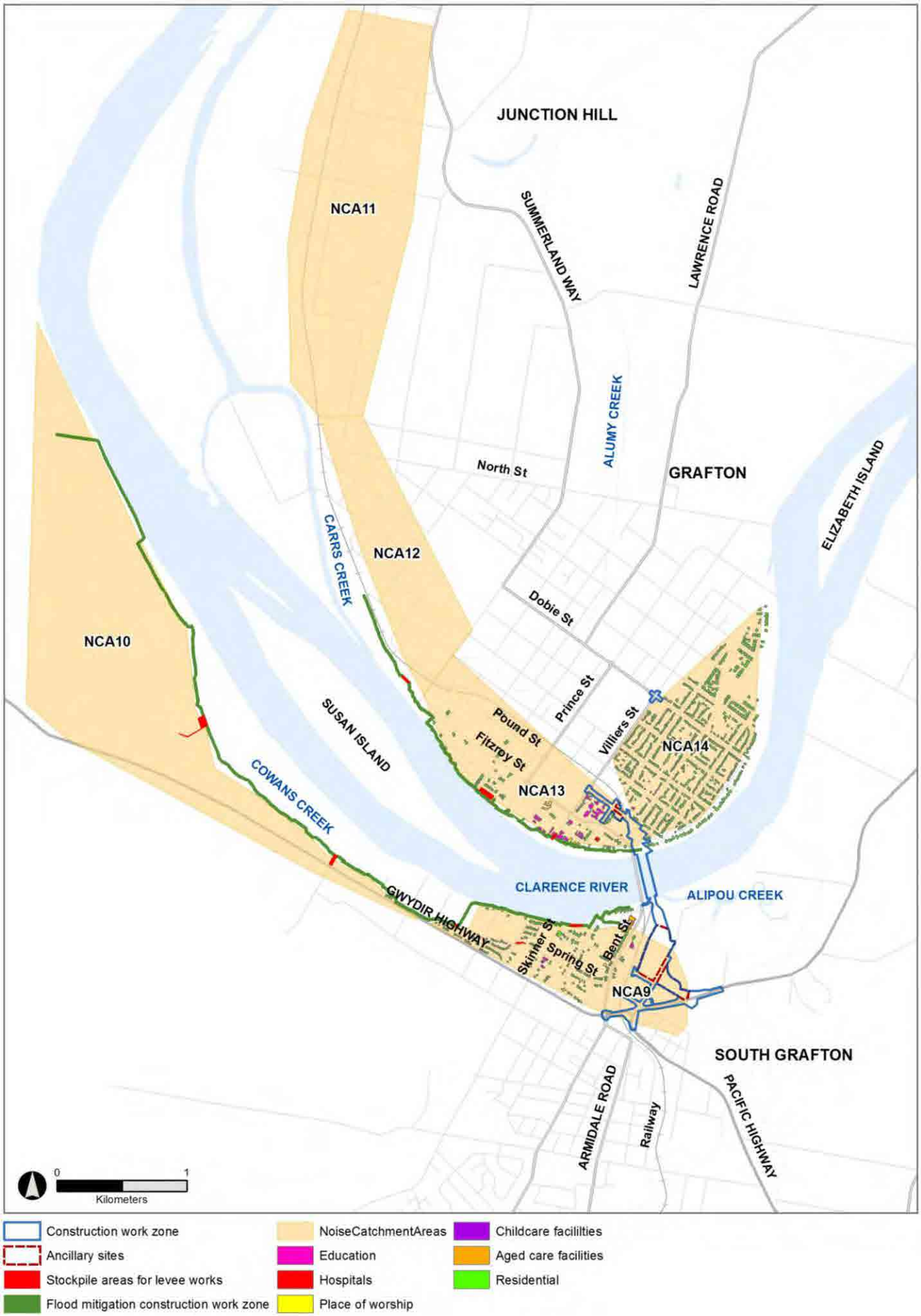


Figure 8-15 Sensitive land uses along proposed flood mitigation works

8.4.3 Assessment of potential impacts - construction

Noise from construction work zones, ancillary sites and stockpile areas

There is potential for construction noise criteria to be exceeded at times during construction where sensitive receivers are close to construction work. Typical construction noise levels are predicted to be around 70 to 75 dB_{LAmax} at a distance of 50 metres from construction work zones, and 45 to 55 dBL_{Amax} at a distance of 150 metres. This would apply equally to bulk earthwork, roadwork, road surfacing and flood mitigation activities. These noise levels are representative of the 'highly noise affected level' and 'noise affected level' respectively for noise catchments identified in Figure 8-12 and Figure 8-13.

The recommended construction noise limits are described in Table 8-27 and Table 8-28 in Section 8.4.1.

Noise associated with each of the two ancillary sites would likely be generated for the entire construction period and would mainly be from vehicle movements, although, the South Grafton ancillary site may also incorporate batching plant and equipment. Sensitive receivers within 100 to 150 metres of the ancillary sites may be subject to construction noise at levels exceeding the screening criteria for residential receivers for each noise catchment (refer to screening criteria in Table 4 of *Appendix F Technical Paper: Noise and Vibration*).

Noise associated with the proposed flood mitigation works stockpile areas would mainly be from earthmoving equipment and heavy haulage vehicles loading and unloading. Stockpile areas 2 and 7 would be located beside noise-sensitive receivers (a dwelling and the Sisters of Mercy Grafton Congregation, respectively). The other stockpile areas would be between 15 and 135 metres away from the nearest sensitive receiver.

Predicted noise impacts at the worst affected sensitive receiver in each noise catchment area are presented in Table 8-35 (for further details on predicted noise impacts during construction please refer to *Appendix F Technical Paper: Noise and Vibration*). Predicted noise impacts are subject to further refinement during the detailed design stage. Environmental management measures have been developed to manage these impacts (refer to Section 8.4.5).

Table 8-35 Noise predictions for worst affected receiver within each noise catchment

Noise Catchment Area	Noise Limits (dBA)				Predicted noise level for construction stage (dBA)													
	Time Period	Noise Affected Level	Highly Noise Affected Level	Sleep Disturbance (LAmax)	Project preliminaries and site establishment		Flood mitigation		Roadwork and road surfacing		Drainage		Bulk earthwork		Bridge work		Piling		Finishing work	
					LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}
1	Day[1]	55	75	-	62	67	-	-	61	67	66	67	62	67	61	67	51	80	58	67
	Day[2]	50	55	-																
	Evening	44	49	-																
	Night	37	42	47																
2	Day[1]	69	75	-	62	67	-	-	61	67	66	67	62	67	61	67	65	80	58	67
	Day[2]	64	69	-																
	Evening	51	56	-																
	Night	41	46	51																
3	Day[1]	63	75	-	73	77	-	-	72	77	76	77	72	77	72	77	71	90	68	77
	Day[2]	58	63	-																
	Evening	46	51	-																
	Night	36	41	46																
4	Day[1]	58	75	-	82	87	-	-	81	87	86	87	82	87	81	87	61	100	78	87
	Day[2]	53	58	-																

Noise Catchment Area	Noise Limits (dBA)				Predicted noise level for construction stage (dBA)															
	Time Period	Noise Affected Level	Highly Noise Affected Level	Sleep Disturbance (LAmax)	Project preliminaries and site establishment		Flood mitigation		Roadwork and road surfacing		Drainage		Bulk earthwork		Bridge work		Piling		Finishing work	
					LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}
	Evening	47	52	-																
	Night	40	45	50																
5	Day[1]	54	75	-	82	87	-	-	81	87	86	87	82	87	81	87	63	100	78	87
	Day[2]	49	54	-																
	Evening	44	49	-																
	Night	40	45	50																
6	Day[1]	54	75	-	82	87	-	-	81	87	86	87	82	87	81	87	75	100	78	87
	Day[2]	49	54	-																
	Evening	44	49	-																
	Night	40	45	50																
7	Day[1]	49	75	-	62	67	-	-	61	67	66	67	62	67	61	67	64	80	58	67
	Day[2]	44	49	-																
	Evening	47	52	-																
	Night	42	47	52																
8	Day[1]	59	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Noise Catchment Area	Noise Limits (dBA)				Predicted noise level for construction stage (dBA)													
	Time Period	Noise Affected Level	Highly Noise Affected Level	Sleep Disturbance (LAmax)	Project preliminaries and site establishment		Flood mitigation		Roadwork and road surfacing		Drainage		Bulk earthwork		Bridge work		Piling		Finishing work	
					LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}
	Day[2]	54	59	-														
	Evening	53	58	-														
	Night	46	51	56														
9	Day[1]	69	75	-														
	Day[2]	64	69	-	-	-	84	90	-	-	-	-	-	-	-	-	-	-	-	-
	Evening	51	56	-														
	Night	41	46	51														
10	Day[1]	40	75	-														
	Day[2]	35	40	-	-	-	84	90	-	-	-	-	-	-	-	-	-	-	-	-
	Evening	46	51	-														
	Night	42	47	52														
11	Day[1]	39	75	-														
	Day[2]	34	39	-	-	-	84	90	-	-	-	-	-	-	-	-	-	-	-	-
	Evening	41	46	-														
	Night	40	45	50														

Noise Catchment Area	Noise Limits (dBA)				Predicted noise level for construction stage (dBA)													
	Time Period	Noise Affected Level	Highly Noise Affected Level	Sleep Disturbance (LAmax)	Project preliminaries and site establishment		Flood mitigation		Roadwork and road surfacing		Drainage		Bulk earthwork		Bridge work		Piling		Finishing work	
					LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}	LA_{eq}	LA_{max}
12	Day[1]	39	75	-	-	-	84	90	-	-	-	-	-	-	-	-	-	-	-	-
	Day[2]	34	39	-																
	Evening	41	46	-																
	Night	40	45	50																
13	Day[1]	63	75	-	-	-	84	90	-	-	-	-	-	-	-	-	-	-	-	-
	Day[2]	58	63	-																
	Evening	46	51	-																
	Night	36	41	46																
14	Day[1]	54	75	-	-	-	84	90	-	-	-	-	-	-	-	-	-	-	-	-
	Day[2]	49	54	-																
	Evening	44	49	-																
	Night	40	45	50																

Note:
1. Day (standard working hours)
2. Day (outside standard working hours)

Noise from construction traffic

Indicative construction access routes to ancillary facilities are presented in Figure 6-5. Construction traffic would comprise:

- About 40 trips per working day by haulage trucks, that is, about 18,700 trips throughout project construction which is expected to take about 3 years (refer to Figure 6-1)
- About 20 trips per day by delivery vehicles.

The daily increase in road traffic due to the project's construction would be relatively low when compared with daily traffic demand on the existing road network (refer Section 2.2 of *Appendix D, Technical Paper: Traffic and Transport*). Hence, the associated change in road traffic noise during construction would be negligible. For example, in order to increase traffic noise levels by to 2 dBA (which is considered to be a small detectable change in noise) the traffic volume would need to roughly double.

Noise from piling

Construction of the proposed bridge would require piling for the installation of bridge foundations on the riverbed and banks. As noted in Figure 6-1 Depending on the piling method used, this activity has the potential to cause noise impacts.

Based on the sound power level of typical impact piling, noise from piling work could be up to 75 $dBLA_{eq}$(15min) at the closest affected receivers in Greaves Street (refer to Table 8-35). The piling noise is likely to remain higher than the noise-affected limit up to several hundred metres from the piling work, affecting sensitive receivers in Pound Street, Breimba Street, Bromley Street and Kent Street in Grafton, and Butters Lane, Bent Street and Riverside Drive in South Grafton.

Piling works would occur during standard approved work hours (refer to Section 6.4.1) and are likely to occur over a six to eight month period during the construction of the bridge over the Clarence River. Actual duration of piling works would depend on the piling method chosen and the construction contractor's program of works.

Vibration impacts

Construction vibration sources

The main potential sources of construction vibration would include:

- Piling in the riverbed and banks
- Excavation
- Demolition
- Grading of existing roadways
- Vibratory compacting of new road surfaces
- Soft soil treatment.

Impacts to human comfort

Any exceedances to the criteria outlined in Table 8-29 and Table 8-30 would depend on the separation distance between the human receiver and the piece of vibration intensive equipment. Some of the vibration intensive equipment that could be used duing construction is listed in Table 8-36.

Although the location of the project's construction work zone, ancillary sites and stockpile areas are known (refer to Figure 6-4), the exact location of vibration intensive equipment in relation to a given human receiver is unknown. Human comfort criteria are likely to be exceeded if a human receiver is located within or

closer to the distances outlined in Table 8-36. Table 8-36 would be used during construction to identify where a detailed assessment of impacts to human comfort would be required to confirm impacts and mitigation measures.

Table 8-36 Recommended safe working distances for vibration intensive plant (Source: TfNSW, 2013 (modified))

Plant item	Rating / description	Safe working distance human response
Vibratory roller	<50 kN (typically 1-2 t)	15-20 m
	<100 kN (typically 2-4 t)	20 m
	<200 kN (typically 4-6 t)	40 m
	<300 kN (typically 7-13 t)	100 m
	>300 kN (typically 13-18 t)	100 m
	>300 kN (>18 t)	100 m
Small hydraulic hammer	300 kg – 5-12 t excavator	7 m
Medium hydraulic hammer	900 kg – 12-18 t excavator	23 m
Large hydraulic hammer	1600 kg – 18-34 t excavator	73 m
Vibratory pile driver	Sheet piles	20 m
Jackhammer	Hand held	Avoid contact with structure

Impacts to buildings

Structures potentially most sensitive to vibration impacts would be heritage listed dwellings in Grafton close to bridge construction work and the construction work zones (refer to Section 8.5 for the locations of these heritage properties).

Construction vibration is predicted to be well below the most stringent vibration velocity limit recommended in the German standard *DIN 4150:3 – Structural Vibration, Part 3: Effects of Vibration on Structures* (three millimetres per second) and is therefore not expected to have an impact on these properties. Nonetheless, measures are proposed to manage vibration generated by the construction activities listed above (refer to Section 8.4.5).

8.4.4 Assessment of potential impacts - operation

Road traffic noise

Based on the concept design, the noise modelling found that up to 93 receivers would exceed the noise trigger levels in the NSW Road Noise Policy, or exceed the *Environmental Noise Management Manual* 'acute' noise levels when the project is operational. Of those affected receivers, architectural noise treatment may be required at 34 residential properties in Grafton, three residential properties in South Grafton, nine receivers within the TAFE campus and at the Gummyaney Aboriginal Preschool in Grafton. Maps showing indicative locations potentially considered for noise mitigation are shown in Appendix G of *Appendix F Technical Paper: Noise and Vibration*. Treatments may include one or a combination of the following:

- Upgraded windows

- Door and window seals
- Fresh air ventilation or air-conditioning (if windows need to be kept closed to block noise).

The reduction in noise level that would be achieved by these treatments would depend on the structure type and condition of the existing building, but the treatments could achieve an improvement of between 10 and 15 dBA indoors.

An analysis of 'feasible and reasonable' noise mitigation options, in accordance with Practice Note IV of the *Environmental Noise Management Manual*, indicates that a noise barrier may be required, in conjunction with architectural noise treatment, to mitigate noise impacts on the 34 noise-affected residences in Grafton. The noise barrier would be located on the eastern side (downstream) of the northern bridge and approach road and would be about three metres high (measured from the road surface) and 310 metres long.

Refer to Figure 8-16 and Figure 8-17 for the location of properties potentially considered for noise mitigation.

Rail noise

The replacement of the Pound Street viaduct with a bridge would have the potential to increase the overall noise level at the nearest residential receiver by about 1.8 dBA. This is a very small increase and would be within the maximum allowable increase stipulated in the *NSW Rail Noise Infrastructure Guideline*.

In addition, reradiated ground-borne noise and vibration from the redeveloped section of rail line is expected to remain the same or improve compared to existing levels.

Notwithstanding the above predictions, care would be taken during detailed design to ensure that the redeveloped section of rail is equal to or better than the existing construction and that no additional impact noise is introduced into the system via expansion joints or similar.

Pump station noise

A below ground pump station is proposed in Grafton as part of the operational stormwater management system. Given the nature of the pumping station equipment, and the fact that it would usually only run during flooding events or testing, significant noise impacts from its operation are not expected. Nevertheless, the pump station may require some noise mitigation to ensure that noise emissions during regular maintenance and testing comply with the *NSW Industrial Noise Policy*. This would likely include careful selection of the equipment and acoustic treatment if appropriate for the pump station generator and switchboard, which may be located above ground.

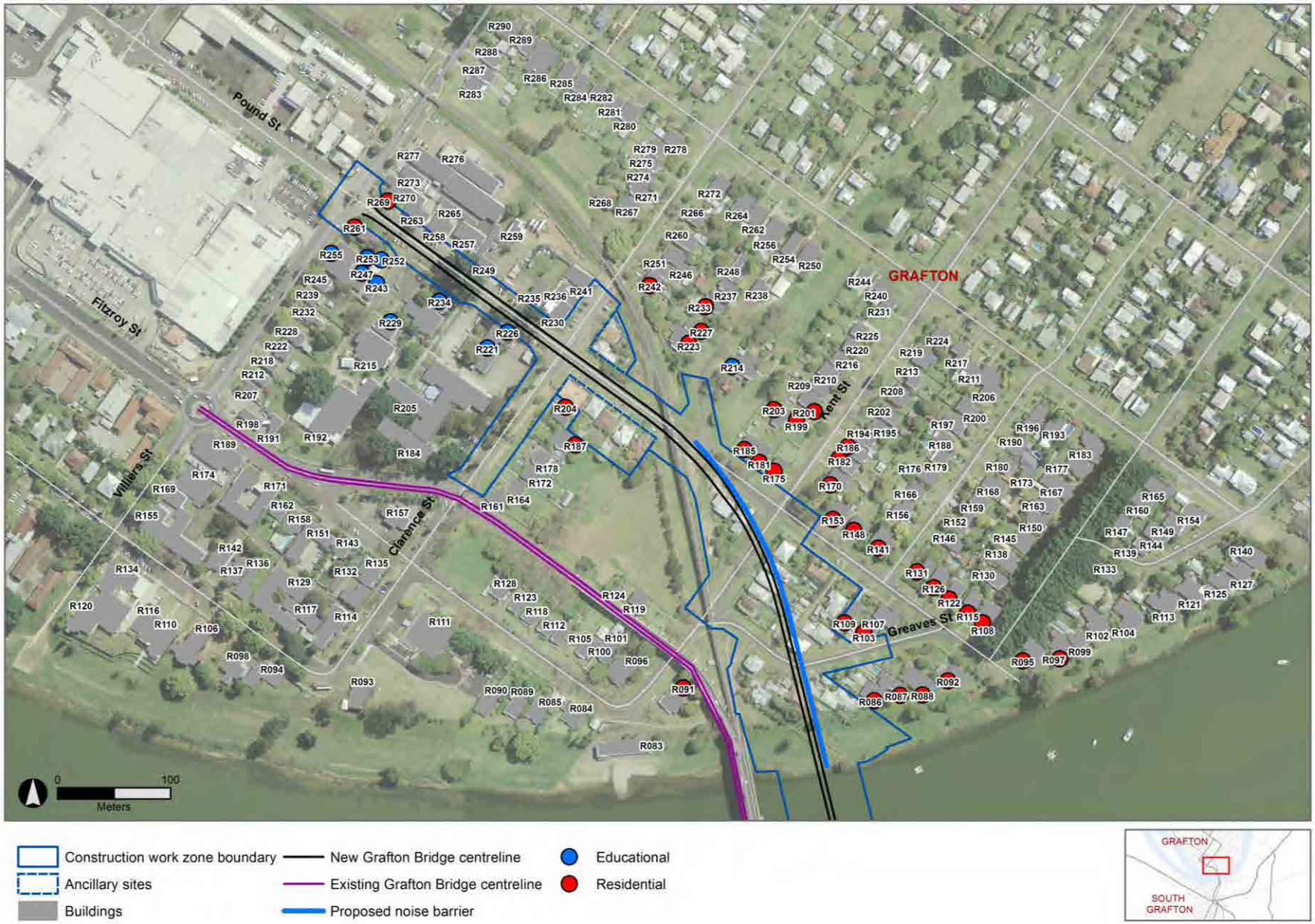


Figure 8-16 Properties potentially considered for noise mitigation – Grafton

Note: Subject to further refinement during the detailed design stage

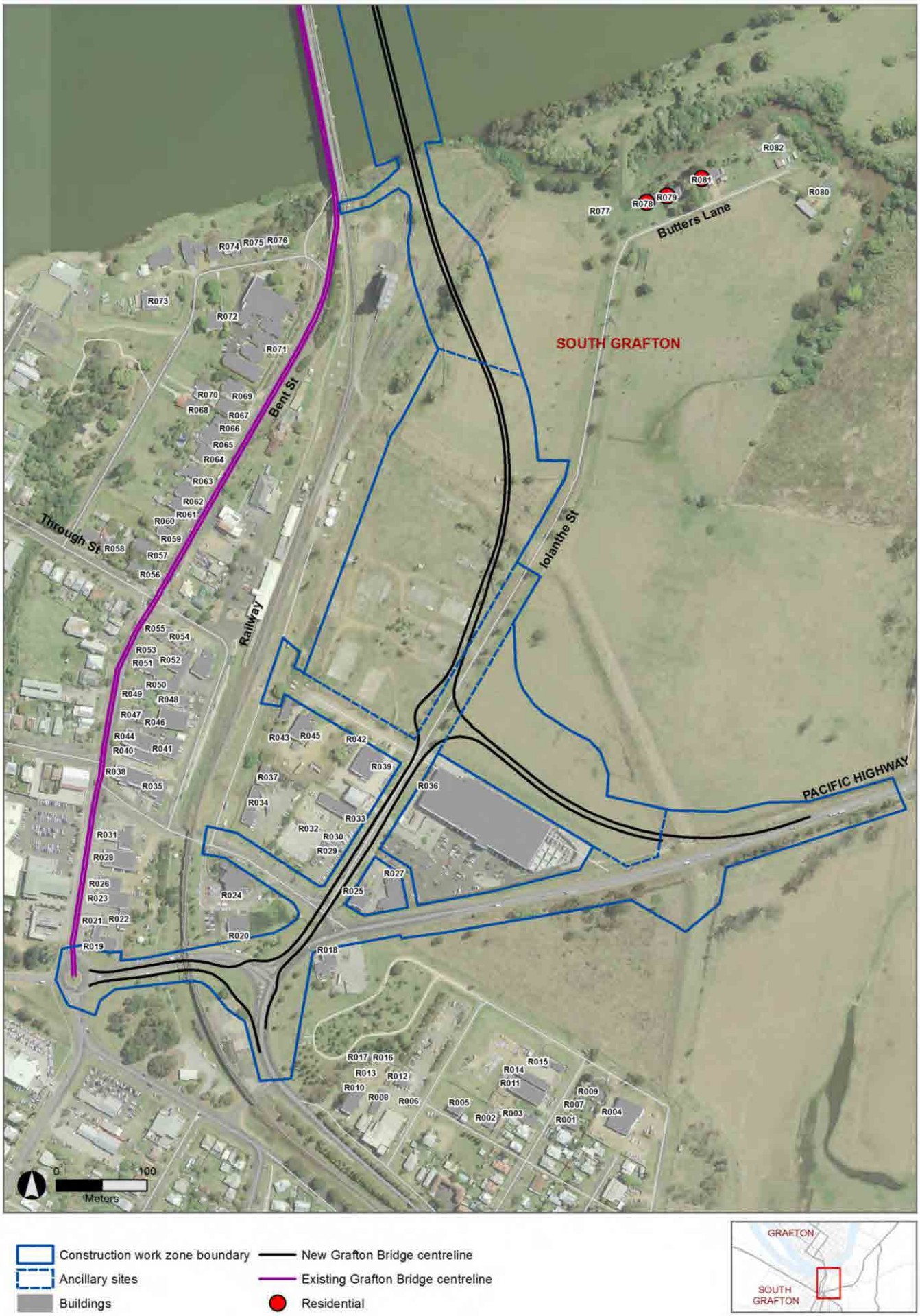


Figure 8-17 Properties potentially considered for noise mitigation – South Grafton

Note: Subject to further refinement during the detailed design stage

Operational vibration

Operational vibration from road traffic movements resulting from the project is considered to be negligible as vehicles are generally well isolated from the ground by pneumatic tyres and vehicle suspension systems. Operational vibration is therefore not expected to be above perceptible levels at any of the sensitive receivers nor have any effect on existing structures and buildings.

8.4.5 Environmental management measures

The project includes 'feasible and reasonable' noise mitigation measures that have been determined in accordance with Practice Note IV of the *Environmental Noise Management Manual*. Table 8-37 includes additional measures that are proposed to manage noise and vibration impacts during construction and operation.

Table 8-37 Environmental management measures for noise and vibration impacts

Issue	Environmental management measure	Responsibility	Timing
New railway bridge above Pound Street	The redeveloped section of rail should be equal to or better than the existing viaduct in terms of noise impact, with no additional noise impact introduced into the system via expansion joints or similar.	Roads and Maritime	Detailed design
Pump station, Grafton	The pump station and pump station building will be designed to achieve the industrial noise emission criteria outlined in this EIS (refer to Table 8-33).	Roads and Maritime	Detailed design
Noise wall design	Noise walls developed for the project would be designed in accordance with the *Noise wall design guideline* (Roads and Maritime, 2006).	Roads and Maritime	Detailed design
General	The appointed construction contractor will be required to prepare a detailed Construction Noise and Vibration Management Plan (CNVMP). This plan will include but not limited to the following: • Roles and responsibilities • Noise-sensitive receiver locations • Predicted impacts • Mitigation strategy • Monitoring methodology • Community engagement strategy.	Roads and Maritime Construction contractor	Construction
	Workers and contractors will be inducted and trained (such as through toolbox talks) in the use of equipment in ways that minimise noise.	Construction contractor	Construction
	Site managers will periodically check the site and nearby residences for noise problems so that solutions can be quickly applied, where required.	Construction contractor	Construction

Issue	Environmental management measure	Responsibility	Timing
Working hours	Construction work will be undertaken in accordance with the approved construction hours as outlined in Section 6.4 of the EIS.	Roads and Maritime Construction contractor	Construction
	Noise from construction work that might be carried out outside the recommended standard hours will follow Section 2.3 of the *Interim Construction Noise Guidelines* (DECC, 2009) where feasible and reasonable.	Construction contractor	Construction
Sensitive receivers	The location of stationary plant (such as air-compressors and generators) will be located as far away as feasible and reasonable from sensitive receivers.	Construction contractor	Construction
Noise screening – construction	Natural screening by topography and vegetation will be used wherever possible to reduce noise impacts.	Construction contractor	Construction
	Site sheds, other temporary structures or screens will be used to limit noise exposure where feasible and reasonable.	Construction contractor	Construction
Construction equipment	Low noise construction equipment and/or methods will be preferred, where feasible and reasonable.	Roads and Maritime Construction contractor	Construction
	Compliance with the Transport for New South Wales *Construction Noise Strategy* which summarises the maximum allowable noise levels for construction equipment to be applied to the project.	Roads and Maritime Construction contractor	Construction
Programming	Construction programming should aim to reduce noise impacts and minimise noisy activities occurring concurrently as far as feasible and reasonable.	Construction contractor	Construction

Issue	Environmental management measure	Responsibility	Timing
Community consultation	The Draft Community Consultation Strategy prepared for the project outlines methods for consultation with the community during construction which are to be followed, including, but not limited to: • Advance notification of planned activities and expected disruption/effects • Construction noise complaints handling procedure • Effective monitoring of noise levels in and around potentially affected dwellings.	Roads and Maritime Construction contractor	Construction
Piling	Alternative piling methodologies will be investigated to reduce potential impacts from these activities.	Construction contractor	Construction
Vibration	Limit construction vibration impacts on sensitive receivers.	Construction contractor	Construction
Noise screening – operation	Operational noise barriers will be installed as early as possible to provide ongoing screening from construction activities, where feasible and reasonable.	Roads and Maritime Construction contractor	Operation / construction
Noise architectural treatments	Noise architectural treatments at affected properties will be developed and implemented in consultation with property owners.	Roads and Maritime	Operation

Issue	Environmental management measure	Responsibility	Timing
Operational noise	No later than one year after commencement of operation of the project, Roads and Maritime will undertake operational noise monitoring to compare the actual noise performance of the project against predicted noise performance. The report will include, but not necessarily be limited to: • Noise monitoring to assess compliance with operational noise levels predicted • A review of the operational noise levels in terms of criteria and noise goals • Methodology, location and frequency of noise monitoring undertaken • Details of any complaints and enquiries received in relation to operational noise • Any required recalibrations of the noise model • An assessment of the performance and effectiveness of applied noise mitigation measures • Any additional feasible and reasonable measures required.	Roads and Maritime	Operation

8.5 Non-Aboriginal heritage

This section presents an assessment of the impacts of the project on non-Aboriginal heritage and identifies mitigation and management measures to minimise and reduce these impacts.

The assessment presented in this section draws on information from the non-Aboriginal heritage assessment report prepared by Biosis Research consultants for this EIS (refer to *Appendix G, Technical Paper: Non-Aboriginal Heritage*).

Table 8-38 lists the Director-General's environmental assessment requirements relevant to non-Aboriginal heritage and where they are addressed in this chapter.

Table 8-38 Director-General's environmental assessment requirements relevant to non-Aboriginal heritage

Director General's environmental assessment requirements	Where addressed in EIS
An assessment of impacts to State and local historic heritage (including heritage items, and maritime and terrestrial archaeology), in particular, impacts on the Grafton Bridge, should be assessed. Where impacts to State or locally significant historic heritage items are identified, the assessment shall:	Appendix G
- outline the proposed mitigation and management measures (including measures to avoid significant impacts and an evaluation of the effectiveness of the mitigation measures) generally consistent with the guidelines in the *NSW Heritage Manual* (Heritage Office and Department of Urban Affairs and Planning, 1996)	Section 8.5.4
- be undertaken by a suitably qualified heritage consultant(s) (note: where archaeological excavations and maritime surveys are proposed the relevant consultant must meet the NSW Heritage Council's Excavation Director criteria)	Section 8.5.1
- include a statement of heritage impact for all heritage items (including significance assessment)	Section 8.5.2 and Section 8.5.3
- consider impacts from vibration, demolition, archaeological disturbance, altered historical arrangements and access, landscape and vistas, and architectural noise treatment, and	Section 8.5.3
- develop an appropriate archaeological assessment methodology, including research design, in consultation with the Department and the Heritage Council of New South Wales, to guide physical archaeological test excavations (terrestrial and maritime) and include the results of these excavations	Section 8.5.1 and Section 8.5.2
An assessment of the visual and amenity impacts of the project on the existing State Heritage listed Grafton Bridge (SHR 01036) and local heritage items	Section 8.5.3 and Section 8.8

8.5.1 Assessment methodology

The assessment was carried out in accordance with heritage guidelines including *Assessing Heritage Significance* (NSW Heritage Office, 2001), *Assessing Significance for Historical Archaeological Sites and 'Relics'* (Heritage Branch, DP&E,

2009) and *Burra Charter* (Australia ICOMOS Inc., 1999). The assessment methodology is outlined below. More detail is provided in *Appendix G, Technical Paper: Non-Aboriginal Heritage.* The assessment involved:

- Investigations carried out before selection of the preferred option
- Historical research
- Terrestrial and maritime archaeology field work and assessment, which involved:
    - Preparation of a research design methodology
    - Consultation with government agencies on the research design methodology
    - Identification of potential archaeological resources and archaeological research potential
    - Terrestrial archaeology field work
    - Terrestrial archaeological test excavations
    - Maritime archaeological surveys.
- Assessment of impacts on built heritage and conservation areas based on available information and the fieldwork
- Statement of significance.

These activities are briefly described below.

Investigations before selection of the preferred option

The assessment carried out for this EIS built on the investigations and field work conducted by Biosis as part of the route option development and assessment phase of the project between 2010 and 2012 (refer to *Preliminary Route Options Report Technical Paper: Non-Aboriginal Heritage*, (Biosis, 2011); and *Route Options Development Report Technical Paper: Non-Aboriginal Heritage* (Biosis, 2012)).

The site investigations involved:

- Field surveys in June 2010 and August, 2010
- Field surveys of Grafton and South Grafton between 2011 and 2012
- Field assessment in February 2012
- Field visit in April 2012 focussing on ARTC land in South Grafton.

Historical research

Research was carried out to identify the land use history of the project area, identify key phases in its history and identify the location of any potential archaeological resources within the project area.

Terrestrial and maritime archaeology field work and assessment

Research design methodology

A research design methodology was prepared to guide the physical archaeological investigations. The research design was prepared in consultation with relevant Government authorities including the Department of Planning and Environment (formerly Department of Planning and Infrastructure) and Office of Environment and Heritage (Heritage Division). Table 8-39 identifies the government authorities consulted, the consultation activities carried out and the outcomes of the consultation.

Consultation with government agencies on the research design methodology

Table 8-39 Consultation carried out with government authorities on the non-Aboriginal heritage assessment

Government Authority	Consultation activity	Summary of outcomes
Office of Environment and Heritage (Heritage Division)	Draft research design emailed to Heritage Division on 7 November 2013 for feedback and comment	Feedback received on draft research design was incorporated into an amended research design. This included consideration of broader heritage listings within the project area, revision of the archaeological methodology to focus on larger trenches on the southern bank, with increased justification on the reasoning behind archaeological investigations to be completed. As a result of consultation, maritime research design methodology was separated from the terrestrial research design methodology.
Department of Planning and Environment, Office of Environment and Heritage	Presentation of proposed project, and draft research design for terrestrial archaeological investigations with Department of Planning and Environment and Office of Environment and Heritage (Heritage Division) on 20 November 2013.	
Office of Environment and Heritage (Heritage Division)	Teleconference between Roads and Maritime and the Office of Environment at Heritage (Heritage Division) on 3 December 2013 discussing the submission of proposed methodology for maritime heritage assessments.	Inclusion of ground penetrating radar at the same time as side scan sonar as part of the maritime field work to identify potential items buried in the river sediment. Desktop assessment to consider dredging history of channel, shipbuilding/timber yards, maritime infrastructure, refuse fields, reclamation activities and impact from potential river scouring on SS Induna.
Office of Environment and Heritage (Heritage Division)	Letter submitted on 05 March 2014 to Office of Environment at Heritage (Heritage Division) regarding the revised research design	No comments received.
Office of Environment and Heritage (Heritage Division)	Letter submitted on 13 March 2014 to Office of Environment at Heritage (Heritage Division) requesting confirmation of the consultation procedure with Department of Planning and Environment, Office of Environment and Heritage (Heritage Division) and Heritage Council of NSW. A response was received on 26 March 2014.	The letter confirmed consultation to date and requested confirmation from Roads and Maritime on how further consultation was to be carried out, either by formal letter, briefing or meeting.

Government Authority	Consultation activity	Summary of outcomes
Office of Environment and Heritage (Heritage Division)	Letter submitted on 19 June 2014 to Office of Environment at Heritage (Heritage Division) offering to meet and discuss project matters.	No response received.

Potential archaeological resources and archaeological research potential

Potential archaeological resources within the project area were identified. This involved:

- Identifying areas where archaeological resources may be found and, if found, the research potential of that resource
- Ranking the archaeological potential of areas using the categories in Table 8-40
- Ranking the archaeological research potential, that is, the ability of archaeological evidence to provide information about a site that could not be derived from any other source and which contributes to the archaeological significance of that site, as either high, moderate, low or negligible based on the existing condition of a site and the level of existing documentation.

Table 8-40 Categories for potential archaeological resources used in this assessment

Category	Potential archaeological resources
High potential	Areas with known archaeological remains established by surface evidence or the results of sub-surface testing
Moderate potential	Areas that may have archaeological remains based on other lines of evidence such as maps or documents
Low potential	Areas that are likely to have minimal archaeological remains based on analysis of known or likely disturbance
No potential	Areas where it is known that archaeological remains will not occur

Terrestrial archaeology field work

A preliminary archaeological survey was conducted on 8 and 9 October 2013 along the Clarence River bank and streetscapes within Grafton and South Grafton.

A second survey was completed on 27 and 28 February 2014. It comprised a visual inspection of the project area to consolidate the results from previous surveys and help in the understanding of the character and condition of existing heritage items.

Terrestrial archaeology field work surveys were directed by Alexander Beben, a suitably qualified archaeologist from Biosis Research consultants.

Terrestrial archaeological test excavations

Archaeological test excavations were completed on 27 February 2014 to investigate the area in South Grafton used to construct the Grafton Road and Rail Bridge, which is a heritage item of State significance (the Grafton Road and Rail Bridge are coded CZB36 for the purpose of this assessment)

The terrestrial archaeological test excavations were directed by Dr Iain Stuart from JCIS Consultants, Dr Stuart meets the NSW Heritage Council's Excavation Director Criteria.

Maritime archaeological surveys

A remote sensing survey of the Clarence River was completed between 17 and 19 December 2013 in an area of about 22 hectares extending from 100 metres upstream (west) of the *SS Induna* shipwreck (coded as FMW29 in this assessment) to about 400 metres downstream of Alipou Creek.

Key anomalies identified by the remote sensing survey were subject to a visual inspection by divers on 29 January 2014.

Maritime archaeological surveys were directed by David Nutley, a suitable qualified archaeologist from Comber Consultants.

Assessment of impacts on built heritage and conservation areas

Items listed in statutory and non-statutory heritage registers and contributory items (buildings not listed as heritage items but within conservation areas) were identified within or adjacent to the project area and characterised based on the information available and the field work carried out for the project. Items included elements within a heritage conservation area usually a building, but also trees and other items which contribute to the significance and character of that area.

Items were categorised according to their level of significance, as defined in Table 8-41.

Table 8-41 Definition of significance levels for non-Aboriginal heritage

Level of significance	Potential archaeological resources
Local significance	Local heritage items are those of significance to the local government area. They contribute to the individuality and streetscape, townscape, landscape or natural character of an area and are important parts of its environmental heritage.
State significance	State heritage items, places, buildings, works, relics, movable objects or precincts of State heritage significance include those items of special interest in the State context. They form an important part of the environmental heritage of New South Wales and must have some connection or association with the State in its widest sense.

Statement of significance

Previously known heritage items have been assessed in the past and are registered on the State Heritage Register and in the *Clarence Valley Local Environmental Plan* with detailed statements of significance. This assessment did not reveal any historical or archaeological information which alters the significance of these items. Therefore the statements of significance presented in Table 8-44 and documented in *Appendix G, Technical Paper: Non-Aboriginal Heritage* are as they appear on the State Heritage Register and in the community based heritage study.

Statement of significance were prepared using the NSW Heritage Office assessment criteria outlined in Table 8-42 for items that are not listed in any heritage register but were found to have heritage values. The criteria are based on the Australia ICOMOS *Burra Charter*.

Table 8-42 NSW heritage assessment criteria

Criterion	Description
A	An item is important in the course, or pattern, of NSW's cultural or natural history (or the cultural or natural history of the local area).

Criterion	Description
B	An item has strong or special association with the life or works of a person, or group of persons, of importance in NSW's cultural or natural history (or the cultural or natural history of the local area).
C	An item is important in demonstrating the aesthetic characteristics and/or a high degree of creative or technical achievement in NSW (or the local area).
D	An item has strong or special association with a particular community or cultural group in NSW (or the local area) for social, cultural or spiritual reasons.
E	An item has potential to yield information that will contribute to an understanding of NSW's cultural or natural history (or the cultural or natural history of the local area).
F	An item possesses uncommon, rare or endangered aspects of NSW's cultural or natural history (or the cultural or natural history of the local area).
G	An item is important in demonstrating the principal characteristics of a class of NSW's cultural or natural places; or cultural or natural environments; or a class of the local area's cultural or natural places; or cultural or natural environments.

Statement of heritage impacts

A statement of heritage impacts was prepared to identify the level of impact of the project on each item, and the steps taken to avoid, reduce or manage such impact.

The statement of heritage impacts was prepared in accordance with the *NSW Heritage Manual – Statements of Heritage Impact* (Heritage Office & DUAP, 2002).

8.5.2 Existing environment

Historical context

Eight local historic themes were identified for the Grafton area. These are summarised in Table 8-43.

Table 8-43 Historic themes for the Grafton area

Dates	Theme
Pre 1835	Aboriginal past No known events relevant to the assessment are documented during this period.
1835–1840	The cedar getters Timber-getters, graziers and shipbuilders move into the Grafton area in increasing numbers in the late 1830s. First surveys conducted of the Grafton area.
1840–1860	Squatters, settlers and the town plan Development of early infrastructure and early commercial endeavours. Grafton and South Grafton are surveyed into a grid layout town plan (adopted in 1849). Town allotments begin selling in Grafton and South Grafton. Grafton and South Grafton incorporated as the Municipality of Grafton (1858).

Dates	Theme
1860–1890	Grafton boom and bust: the golden years Land becomes available for purchase as freehold, encouraging further development of agriculture along the river and attendant commercial and residential purchases in Grafton and South Grafton. Various listed heritage items of local significance are built during this period including: Fishers Park (corner of Villiers and Dobie streets) (CZB08); 30–32 Villiers Street, Grafton (CZB09), built by the Henson Family; Ravensford (CZB10), built by the Henson family; and Grafton Court House (FMW15). An official program for the planting and protection of trees in streets and parks begins.
1890–1910	The big river A period of residential expansion starts, with construction of many Federation style dwellings. These include Dunvegan (CZB11) at 47 Pound Street, 18 Kent Street (CZB25), 14 Kent Street (CZB27), and Clarendon (CZB30) at 13 Pound Street. These items are listed in the *Clarence Valley Local Environmental Plan 2011*. Arcola (State heritage item SHR 1546), at 150 Victoria Street, is built by the Strauss brothers (FMW24). Fishers Park becomes the Grafton showground, and the complex is opened (CZB08). Construction and opening of the Grafton to Casino railway.
1910–1932	Bridging the gap *SS Induna*, a modified steamship, starts operation as a rail ferry across the Clarence River. Interwar period residences are built, including 16 Kent Street (CZB26) and 12 Kent Street (CZB28). Dwellings currently listed in the *Clarence Valley Local Environmental Plan 2011* are built. These included 31 Pound Street (CZB18), 7 Greaves Street (CZB31), 5 Greaves Street (CZB32), 1 Greaves Street (CZB33), and 1 Pound Street (CZB34). Glyndon Private hospital (CZB35) is opened. The railway from South Grafton south to Glenreagh is completed. This includes part of the Grafton City Railway Station Group (State Heritage item SHR No.1154). Grafton Rail and Road Bridge over the Clarence River is built (State heritage item SHR No.1036). The bridge opens in 1932.
1932–1957	United city of two towns Jacaranda trees are planted on Pound Street between Clarence Street and the river to commemorate the Silver Jubilee of King George V. An avenue of Cassia trees is planted in Clarence Street between Bacon and Pound Streets to commemorate the coronation of Queen Elizabeth II. Grafton and South Grafton reincorporated to form the City of Grafton in 1957.
1957–present	Modernism No events relevant to the assessment are documented during this period.

Terrestrial and maritime archaeology field work results and archaeological potential

Archaeological resources and archaeological research potential

Properties within and beside the project area identified as containing archaeological resources or research potential are presented in Figure 8-18.

Terrestrial archaeological test excavations results

None of the artefacts (made of steel, iron, wood, ceramic, aluminium or composite material) or features (comprising of post holes and metal and terracotta pipes) found in the two trenches excavated at the construction site of the existing bridge in South Grafton are related to the actual construction of the bridge. Artefacts and features are not considered relics within the meaning of the *Heritage Act 1977* and are related to buildings dating from the 1950s to 1994.

Archaeologically significant remains from the existing bridge construction workshops are unlikely to be present along the south bank of the Clarence River. The archaeological potential for the Grafton Road and Rail Bridge (CZB36) construction workshops is considered to be moderate and its archaeological research potential is considered to be low.

Maritime archaeological survey results

The maritime surveys and visual inspection found submerged cultural material next to the southern bank of the Clarence River within the project construction work zone. The cultural material consisted of wharf remains and early 20th century tools and fastenings. These remains are commonly found in other New South Wales railway and wharf contexts and have very limited potential to yield information of archaeological significance. These items are not considered relics within the meaning of the *Heritage Act 1977*.

With the exception of the *SS Induna* (FMW29), none of the features identified through remote sensing and visual inspection are relics or heritage items. The *SS Induna* shipwreck remains are located beside the southern bank of the Clarence River, about 140 metres upstream from the existing bridge and some 250 metres upstream from the proposed bridge construction work zone, and adjacent to the proposed flood mitigation works construction work zone.

Conservation areas and built heritage

Conservation areas and built heritage relevant to the project are presented in Figure 8-19, Figure 8-20 and Figure 8-21.

Grafton and South Grafton conservation areas

The Grafton conservation area (C3) and South Grafton conservation area (C7) are listed on the following registers and schedules:

- *Clarence Valley Local Environmental Plan 2011* – Schedule 5
- *North Coast Regional Environmental Plan 2008* – Schedule 2
- National Trust of Australia Register (non-statutory)
- Register of the National Estate (non-statutory).

Statement of Significance: The Grafton and South Grafton conservation areas are examples of a subtropical mid 19th century river port city and pastoral seat. It contains a group of civic and ecclesiastical buildings and many spacious timber houses which display both craftsmanship in detail and the ubiquitous verandah of northern Australia. The magnificent canopies of Ficus (fig), Jacaranda and Camphor laurel trees provide shade and colour while serving to link the natural and man-made features of the city.

Grafton and South Grafton conservation areas have local heritage significance.

The Grafton Rail and Road Bridge

The Grafton Rail and Road Bridge (CZB36) is listed on the following registers and schedules:

- State Heritage Register
- Section 170 Heritage and Conservation Register
- *Clarence Valley Local Environmental Plan 2011* heritage schedule number 5
- *North Coast Regional Environmental Plan 2008* schedule number 2
- National Trust of Australia Register (non-statutory).

Statement of Significance: This bridge is a double-deck road and rail structure, the only one of its type in NSW. There is a lift span to allow river traffic to pass under, however this is no longer in use. Opening of the bridge in 1932 completed the North Coast standard gauge line between Sydney and Brisbane, avoiding the winding route through Tenterfield.

The approach viaduct in addition to the wharf remains are important relics of the development of the North Coast railway. The viaduct is representative of similar structures constructed at a range of locations, many of which have been replaced.

Grafton Rail and Road Bridge is an item of State heritage significance.

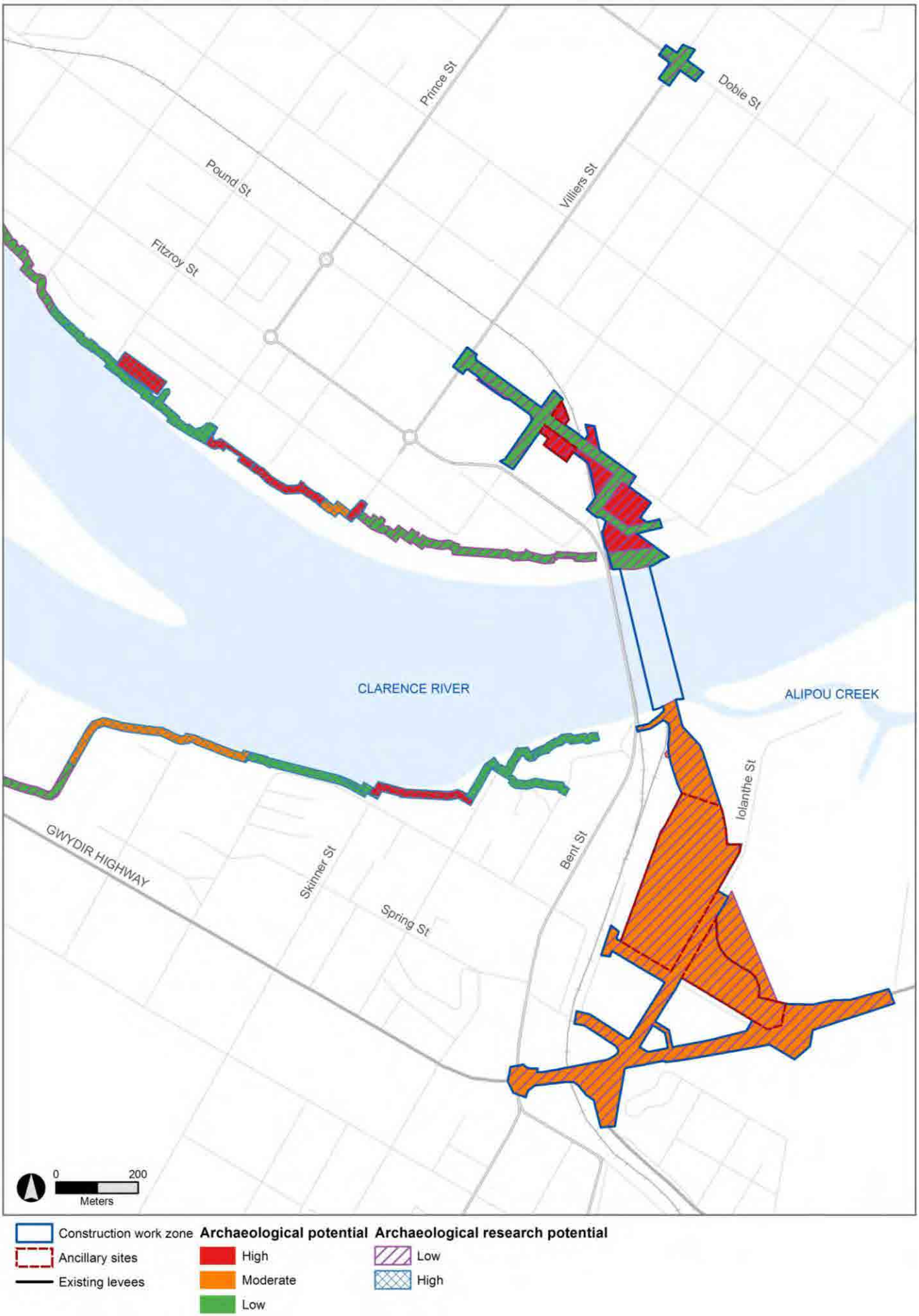


Figure 8-18 Archaeological potential within and next to the project area

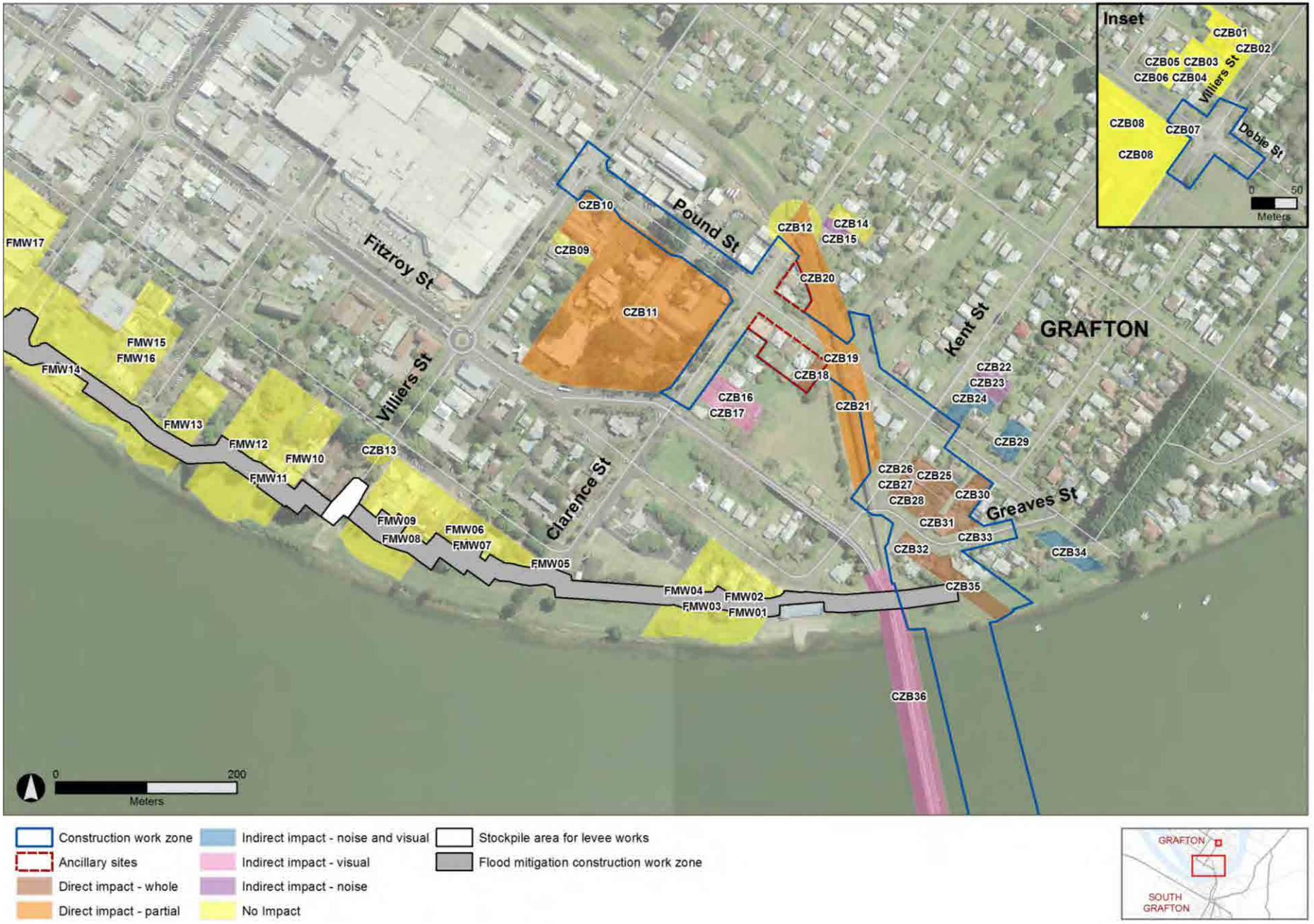


Figure 8-19 Built heritage impacted by the project (including the flood mitigation works) showing details within Grafton

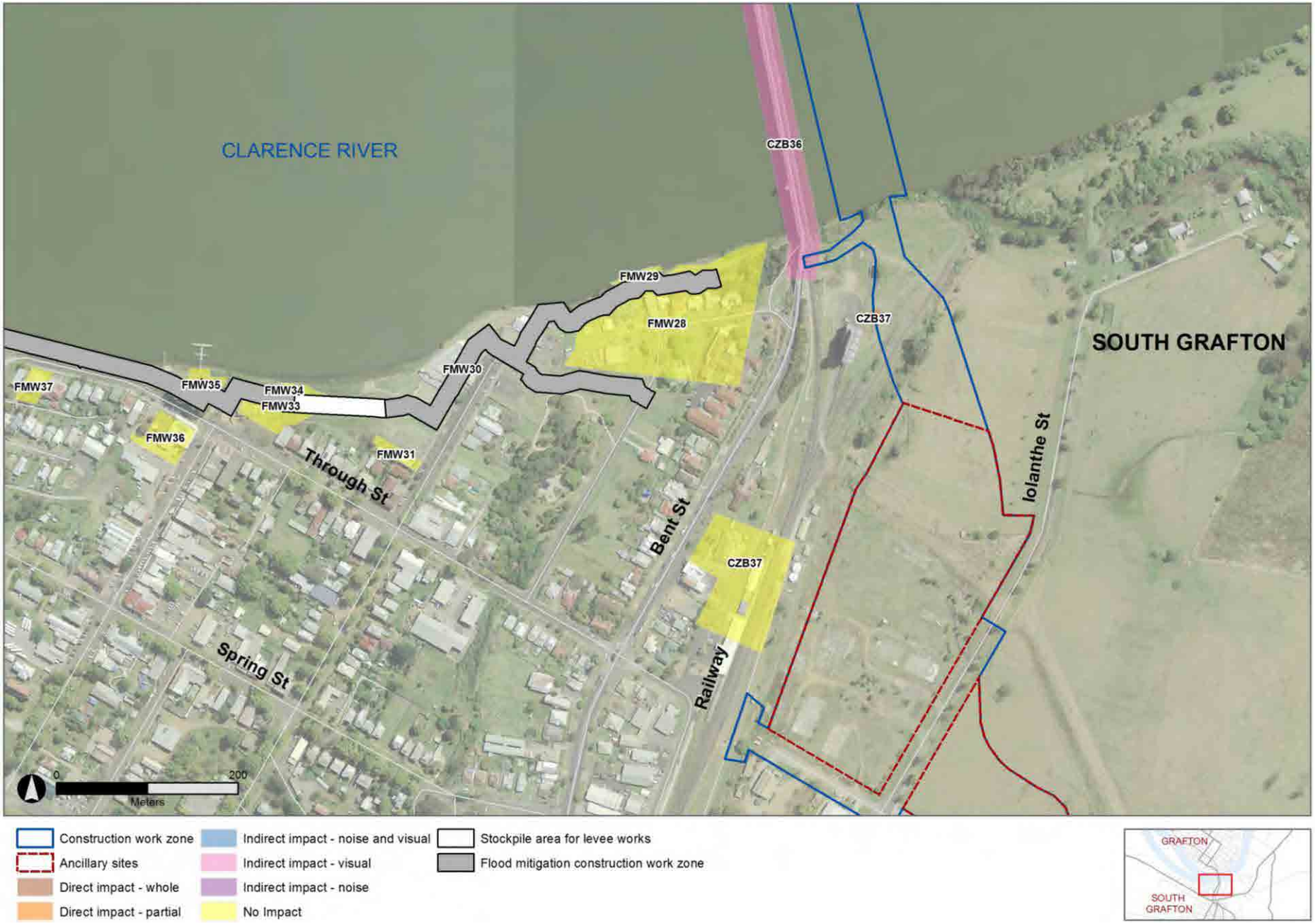


Figure 8-20 Built heritage impacted by the project (including the flood mitigation works) showing details within South Grafton

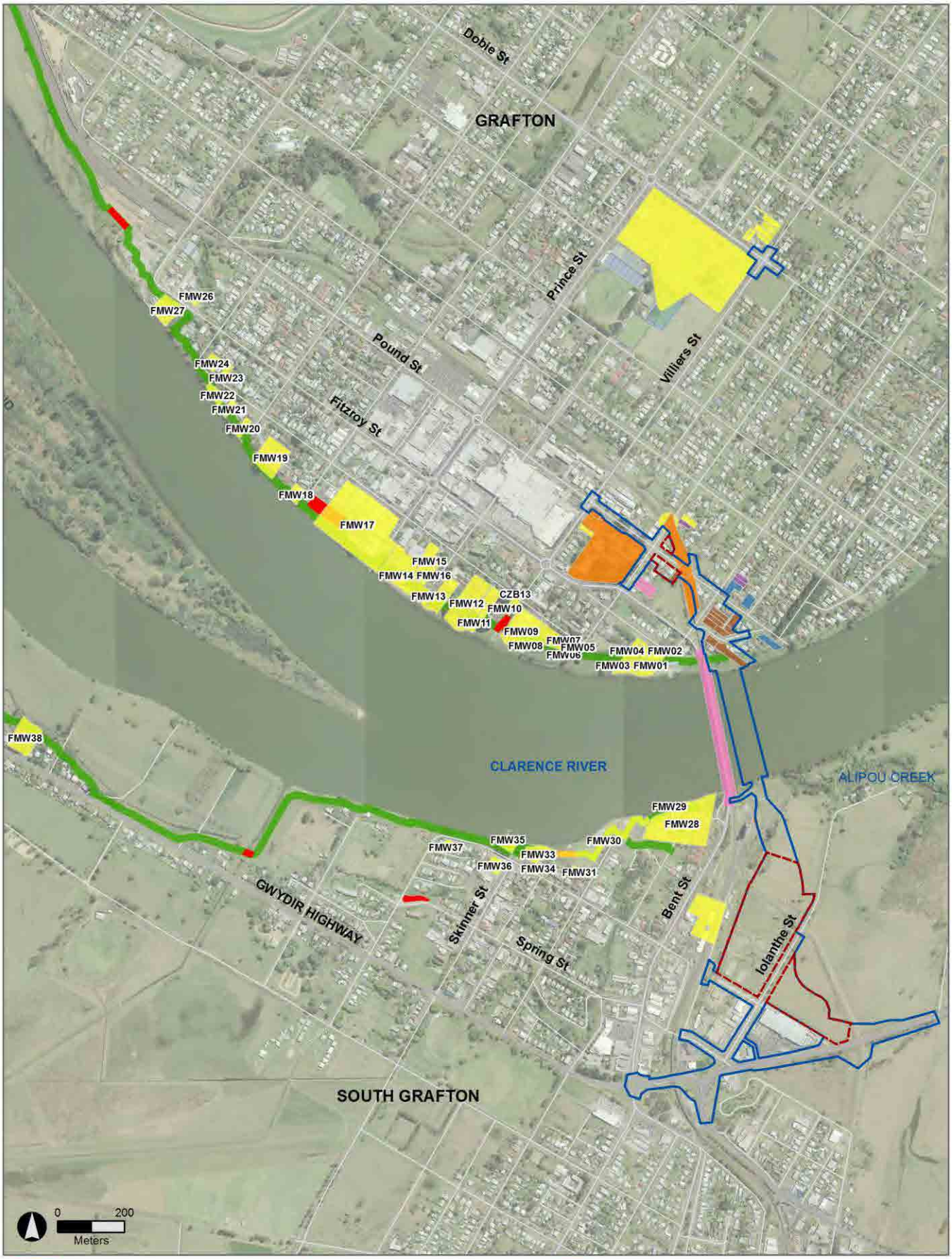


Figure 8-21 Built heritage impacted by the project (including flood mitigation works)

Other built heritage

Other heritage listings under statutory and non-statutory registers, relevant to the project and their significance are provided in Table 8-44. The level and description of impact is addressed in Table 8-45.

Statutory registers include:

- SHR: State Heritage Register under the *Heritage Act 1977*
- S. 170: Section 170 *Heritage Act 1977* Heritage and Conservation Registers
- CVLEP: *Clarence Valley Local Environmental Plan 2011*

Non-statutory registers include:

- NT: National Trust of Australia.

Table 8-44 Other heritage listings within project area

No	Name and listing	Heritage significance	Statement of heritage
Grafton			
CZB10	Ravensford 36 Villiers Street, Grafton (CVLEP, NT)	Local	This attractive two-storey residence has remarkably intact external details and is set within a garden of mature trees on an important corner site. It is significant historically for its association with Captain Greenway (c 1860) and later the Henson family who owned a cordial factory next door. It is representative of the quality two-storey residences built in the period 1890–1910 and can be compared with Lormont (16 Victoria Street). The site is likely to have archaeological potential.
CZB11	Dunvegan, 47 Pound Street, Grafton (CVLEP, NT)	Local	Dunvegan is an imposing two-storey timber-clad residence, unusually large in scale and in largely original condition, demonstrating the local use of timber. Built for the Powell family in 1905 and extended in 1926 it presents a variety of Victorian and Federation elements including iron lace balustrading and valances and carved bargeboards with fretted work at the apex. It is now in public ownership and forms part of the Grafton TAFE complex. Buildings of this quality and size are becoming increasingly rare in Grafton. It is likely to be significant to the State.
CZB13	Jacaranda, Brachychiton and Ficus trees over 3 metres on-road reserve (CVLEP)	Local	Tree planting was introduced as early as 1881 to beautify the town and provide much needed shade. Street plantings have also been carried out to commemorate particular historic events. Street trees have become synonymous with Grafton and make a significant contribution in depicting the history and aesthetics of the town. As commemorative monuments they have a specific relationship to people and historic events in Grafton and are important to the Grafton community as a whole.

No	Name and listing	Heritage significance	Statement of heritage
CZB15	26 Clarence Street, Grafton (CVLEP)	Local	This is a modest Federation weatherboard-clad cottage with several original elements, which contributes to the domestic scale of Clarence Street. It is located within the Grafton urban conservation area and is historically significant as it shows the continuing development of Grafton city.
CZB16	12 Clarence Street, Grafton (CVLEP)	Local	This c1900 or earlier weatherboard-clad dwelling has original joinery and contributes to the Clarence Street streetscape. Set back on the block on the same alignment as 10 Clarence Street, it tells of the growth of Grafton. Both dwellings have a pleasing backdrop of mature trees.
CZB17	10 Clarence Street, Grafton (CVLEP)	Local	This c1900 single-storey weatherboard-clad bungalow, is set back on a large block with a backdrop of mature trees. It may be a pair with 12 Clarence Street. It is historically significant as it demonstrates growth in Grafton and contributes to the city's social history.
CZB18	31 Pound Street, Grafton (CVLEP)	Local	It is rare to find Spanish Mission style cottages in Grafton, particularly those with barley curl columns supporting the front porch. This cottage is representative of its type and contributes to the historic fabric of Grafton. It can be compared with 4 Pound Street.
CZB19	King George V Plaque and street trees, Pound Street, Grafton (CVLEP)	Local	This plaque, dating from 1935, and the associated street trees, are historically significant as they show the warmth of feelings for the English, particularly King George V. The trees also demonstrate the continuing desire of Council to beautify the town through street plantings, a commitment begun in 1874 when Council adopted a by-law for the planting of street trees.
CZB20 & CZB21	Grafton Railway Viaducts, Grafton (CVLEP, S.170)	Local	The railway viaducts are architecturally significant as the first use of precast reinforced concrete beams and of concrete Art-Deco arches over seven roads in Grafton. They have historic significance as part of the final link in the North Coast railway linking Brisbane and Sydney and for their social and commercial benefit to passenger and freight transport by rail.

No	Name and listing	Heritage significance	Statement of heritage
CZB24	22 Kent Street, Grafton (CVLEP)	Local	While raised above flood levels, this is a representative example of an inter-war bungalow with much decorative timberwork. It is one of a group of three similar residences in Kent Street and complements the streetscape. It is also significant for its association with Mr B. C. Eggins who was Mayor of Grafton from 1932–35.
CZB25	18 Kent Street, Grafton (CVLEP)	Local	This is a typical example of a late Victorian residence (c1890) with vertical weatherboards cladding the exterior. Along with houses at 12–18 Kent Street, it makes a significant contribution to the streetscape and to the historic fabric of Grafton.
CZB26	16 Kent Street, Grafton (CVLEP)	Local	This is a representative example of a Californian bungalow. Along with houses at 14 and 18 Kent Street, it contributes to the domestic scale of this section of Kent Street.
CZB27	14 Kent Street, Grafton (CVLEP)	Local	This cottage is representative of the late Victorian to Federation style with a steeply pitched roof and use of traditional elements and materials. The projecting gable is likely to have been a later addition. Along with cottages at 16 and 18 Kent Street, it contributes to the streetscape.
CZB28	12 Kent Street, Grafton (CVLEP)	Local	While modified with the addition of a brick verandah, this Californian bungalow contributes to the form and scale of Kent Street. It is one of a group of dwellings extending from 12–18 Kent Street that demonstrates residential development in Grafton from the 1890s to the 1930s.
CZB29	14 Pound Street, Grafton (CVLEP)	Local	This residence is aesthetically pleasing and makes use of its corner location. Built c1950 in liver coloured brick it is an unusual addition to the architecture of Grafton, which at that time saw the construction of mainly weatherboard or fibro-cement-clad buildings. It features elements of the Spanish Mission style with its use of triple arches over the porches and a terracotta tiled roof. It is set on a large block with a mature garden.
CZB30	Clarendon,13 Pound Street, Grafton (CVLEP)	Local	This substantial single-storey weatherboard bungalow, with a hipped iron roof extending over deep front and side verandahs and brick chimneys with corbelled tops, contributes to the historic fabric of Grafton. While the bungalow is partially obscured from the street by an attractive garden, the exterior, with its tall chimneys, makes an aesthetic contribution to Pound Street. It is worthy of further historical research.

No	Name and listing	Heritage significance	Statement of heritage
CZB31	7 Greaves Street (New heritage item)	Local	This building contributes to the significance of the urban conservation area. On its own, it does not meet the thresholds for local heritage significance.
CZB32	5 Greaves Street (New heritage item)	Local	This building contributes to the significance of the urban conservation area. On its own, it does not meet the thresholds for local heritage significance.
CZB33	1 Greaves Street (New heritage item)	Local	This building contributes to the significance of the urban conservation area. On its own, it does not meet the thresholds for local heritage significance.
CZB34	1 Pound Street, Grafton (CVLEP)	Local	Located on the riverbank, this substantial inter-war Californian bungalow characterises properties in the Dovedale precinct. Its gardens and lawns extend to the road verge and the property boundary is defined only by a low fence. With its red tiled roof, intact chimney, wide verandah and casement windows, it appears to be in almost original condition and is representative of its type.
CZB35	Former Glyndon Private Hospital, 4 Greaves Street, Grafton (CVLEP)	Local	This Californian bungalow is of historic importance as a second-generation home on the original Dovedale property. It is associated with Mrs Loxton (daughter of W. A. B. Greaves) and later Matron Blackwell of the Glyndon Private Hospital. The hospital was well known in the Grafton district and is likely to be socially significant to the community who spent time there.
CZB07	Fisher's Drain: Corner of Villiers and Dobie streets (CVLEP)	Local	Fisher's Drain demonstrates early public works in Grafton and illustrates the need to drain low land near Fisher Park, an area subsequently subdivided into Fisher Park and the Grafton Showground. It is a significant archaeological relic and plans of the drain (GCC No 1 civil/drainage works plan) are also a significant moveable heritage item. It has the ability to be interpreted and to provide information on the development of Fisher Park and public works. This item would not be impacted by the project but an exclusion zone is proposed during construction as a precautionary measure (refer to Section 8.5.4).

No	Name and listing	Heritage significance	Statement of heritage
South Grafton			
CZB37	Grafton City Railway Precinct (SHR, ARTC s.170 Register, CVLEP)	State	Grafton City Railway Precinct is of State historic significance as a former major railway administrative centre for the North Coast. The extant refreshment room is a unique structure on the NSW rail system built for the movement of troops during World War II and remains an important reminder of the site's role in the Australian war effort and the role played by rail in moving troops around the country. The extant barracks building is representative of a series of similar barracks buildings constructed throughout the NSW railway system for train crews to rest between shifts. The office block demonstrates the former administrative role of the site. Overall, the significance of the railway precinct has been compromised by modern buildings, the demolition of the extensive locomotive servicing depot and all other original buildings.
FMW34	Water Trough, Lane Park, Through Street, South Grafton (CVLEP)	Local	The Bills horse trough in Lane Park is significant as one of only 700 troughs manufactured and distributed by the George Bills Trust in Australia. This item would not be impacted by the project but an exclusion zone is proposed during construction as a precautionary measure (refer to Section 8.5.4).

8.5.3 Assessment of potential impacts

Impacts on terrestrial and maritime archaeology

Impacts on terrestrial archaeology

The archaeological excavations carried out for this EIS concluded that it is unlikely that archaeologically significant remains from the Clarence Rail and Road Bridge construction workshops are present within the south bank of the Clarence River.

In terms of archaeological potential, the project would impact a number of parcels assessed as having high archaeological potential in Grafton. The majority of these parcels correspond to heritage listed houses of local significance (seven listed houses in total) that would be demolished as a result of the project. In South Grafton, the proposed construction work zone includes land assessed as having moderate archaeological potential (refer to *Appendix G, Technical Paper: Non-Aboriginal Heritage* for further information on archaelogical potential).

No land has been assessed as having high or moderate research potential within the Grafton and South Grafton construction work zones.

Within the flood mitigation construction work zone in Grafton and South Grafton, a number of parcels of land have been assessed as having moderate and high archaeological potential and moderate and high research potential associated with early settlement. Work along these areas would involve raising the levee up to 20 centimetres. It is unlikely that this work would require extensive below ground disturbance but, if it is required (for example, if geotechnical investigation results recommend complete replacement of a section of the levee) within areas of

moderate to high archaeological potential, a program of archaeological monitoring would be implemented (refer to Section 8.5.4).

Impacts on maritime archaeology

None of the features identified during investigations for the EIS on the Clarence River are considered relics or heritage items. The only maritime archaeological feature found corresponds to the shipwreck remains directly associated with the *SS Induna* (FMW29) but these remains are outside the project construction work zone. As a precautionary measure, a 'no go' area will be implemented around the *SS Induna* during construction to protect the heritage values associated with the shipwreck remains (refer to Section 8.5.4).

Impacts on Grafton and South Grafton urban conservation areas

Impacts on Grafton conservation area (C3)

The project would have a direct partial impact on a portion of the Grafton conservation area, which would result in:

- Removal of six heritage items, 11 contributory items and the Ficus and Jacaranda trees on Pound Street between Villiers and Kent Street
- Impact on the visual aspects and relationship between Ravensford (CZB10) and Dunvegan (CZB12)
- Alteration of street alignments from the grid established in the mid 19th century.

While the project would result in significant impacts on the aesthetic values of some parts of Grafton, it would have the potential, through the implementation of an interpretation plan (refer to Section 8.5.4), to emphasise and enhance other heritage values such as the Grafton Road and Rail Bridge (CZB36). The interpretation plan would provide opportunities to enhance understanding and appreciation of the heritage items, values and themes associated with Grafton and could include incorporating formalised heritage walks and tree-planting programs into the landscaping and planning of the project.

The section of the levee to be raised would traverse 27 heritage items of local significance in the Grafton conservation area. Impacts on these items are likely to be direct partial and consist of removal of gardens and cultural plantings associated with heritage items to enable the works and moderate to minor visual impacts on existing views to and from the setting of the heritage item. There is potential for excavation to impact archaeological resources beneath the levee, specifically those relating to early settlement in Grafton. Refer to *Appendix G, Technical Paper: Non-Aboriginal Heritage* for more information on the heritage times crossed by the proposed levee raising works.

Impacts on South Grafton conservation area (C7)

The flood mitigation construction work zone would traverse the coastal elements of the South Grafton conservation area and 11 heritage items. Impacts on these items are likely to be direct – partial. If sections of the levee located in areas of high archaeological potential were required to be completely replaced, there is potential for below ground excavation to impact archaeological resources, specifically those relating to early settlement in Grafton.

The levee raising works within the Grafton and South Grafton conservation areas would be completed in a sympathetic manner that, as far as practical, would not diminish the aesthetic values of the conservation areas. Refer to *Appendix G, Technical Paper: Non-Aboriginal Heritage* for more information on the heritage times crossed by the proposed levee raising works.

Impacts on the Grafton Rail and Road Bridge

The Grafton Rail and Road Bridge (CZB36) State heritage listed item would not be directly altered or impacted by the project. The project would have a positive effect on the heritage value of the existing bridge through reducing wear and tear on the bridge's fabric by reducing traffic volumes. The location of the new bridge would provide a new vantage point from which to view the Grafton Rail and Road Bridge. The concept design and design parameters for the new bridge require that it respects and responds to the presence and form of the Grafton Rail and Road Bridge in a complementary manner. In particular:

- The superstructure would be concrete (or similar material), to enable a simple, clean, contemporary character that allows the steel truss of the existing bridge to take visual precedence
- The bridge would be a low profile over the Clarence River to allow the existing bridge to take visual precedence and minimise the loss of views
- The bridge would be as parallel as possible to the existing bridge and have a straight horizontal alignment to echo the alignment of the existing bridge
- The longitudinal grades would be as 'flat' as possible to complement the flat alignment of the existing bridge while also meeting drainage requirements
- The piers would be positioned to align as closely as possible with the piers of the existing bridge, especially those in the river.

The proposed bridge would have indirect visual impacts on the existing bridge. In particular, the proposed bridge would permanently change views to the existing bridge from downstream viewpoints within public open space on the riverbank and on the Clarence River; views of portions of the existing bridge from these locations would be also blocked by the proposed bridge.

A detailed assessment of the magnitude and sensitivity of the impacts on views from and to the existing bridge is presented in Section 8.8 and *Appendix J, Technical Paper: Urban design and landscape concept report (Including landscape character and visual impact assessment)*. Archival recording would be prepared before the construction of the proposed bridge to document the visual relationships between the Grafton Rail and Road Bridge heritage item and its surrounds (refer to Section 8.5.4).

Impacts on other built heritage

The project would also have impacts on other heritage items. These impacts are categorised as follows:

- Direct impact – total: The project would result in demolition of 10 heritage items of local significance, but no items of State significance would be demolished
- Direct impact – partial: The project would result in acquisition of a small portion of lots occupied by one item of State significance and four items of local significance
- Indirect impact: The project would have impacts from architectural noise treatments at some properties, and from visual impacts from vegetation removal or when existing views to and from a heritage item are affected. Five items of local significance and one item of State significance would be impacted in this way. (Indirect visual impacts on the Grafton Rail and Road Bridge State heritage item are discussed in the section above)
- Impact on listed trees: The project would have impacts on trees listed under the *Clarence Valley Local Environmental Plan 2011*, namely, Brachychiton, Ficus or Jacaranda trees over three metres high, located in road reserves.

Table 8-45 documents the impacts of the project on these heritage items, shown in Figure 8-19, Figure 8-20 and Figure 8-21.

Table 8-45 Potential impacts on heritage items and conservation areas

No	Name and listing	Heritage significance	Impact
Grafton			
CZB10	Ravensford, 36 Villiers Street, Grafton (CVLEP, NT)	Local	Direct impact – partial The project would require a minor property acquisition, which would have an impact on its heritage value by reducing its setting. Note the road design on Pound Street, Grafton, was refined by Roads and Maritime to avoid demolition of this heritage item. Indirect impact – trees The project would remove mature trees on the road reserve fronting this property, which would have an impact on views towards it. The property may require architectural noise treatment. The heritage values of the property would be diminished by the project, but this is unlikely to affect its significance.
CZB11	Dunvegan, 47 Pound Street, Grafton (CVLEP, NT)	Local	Direct impact – partial The project would require a minor property acquisition, which would have an impact on its heritage value by reducing its setting. Indirect impact – trees The project would remove mature fig trees on the road reserve fronting this property, which would have an impact on views towards it. The property may require architectural noise treatment. The heritage values of the property would be diminished by the project, but this is unlikely to affect its significance.

No	Name and listing	Heritage significance	Impact
CZB13	Jacaranda, Brachychiton and Ficus trees over 3 metres on-road reserve (CVLEP)	Local	Impact on listed trees The project would remove 34 Jacaranda and four Ficus heritage listed trees within Grafton conservation area. This would affect the aesthetic setting of heritage items in this area. The removal of large, mature fig trees at the junction of Pound and Villiers streets would have the greatest impact as they occupy a prominent position within Grafton and provide an aesthetic backdrop to the Ravenswood (CZB10) and Dunvegan (CZB11) heritage items. Cultural plantings along Victoria Street, Grafton may be affected by the proposed flood mitigation work. The levee raising within this area would be carefully managed to mitigate, where feasible and reasonable, any potential impact on these cultural plantings.
CZB15	26 Clarence Street, Grafton (CVLEP)	Local	Indirect impact – noise The property may require architectural noise treatment. The impact is not expected to be significant as the noise treatment would be applied in a way that is sympathetic to the heritage values of the item.
CZB16	12 Clarence Street, Grafton (CVLEP)	Local	Indirect impact – visual The construction zone boundary would be beside this heritage item and street trees at the front of this property would be removed. This would result in a minor visual impact through alterations to the street alignment which may affect views to and from the item in a south-westerly direction.
CZB17	10 Clarence Street, Grafton (CVLEP)	Local	Indirect impact – visual The construction zone boundary would be beside this heritage item and street trees at the front of this property would be removed. This would result in a minor visual impact through alterations to the street alignment, which may affect views to and from the item in a south-westerly direction.
CZB18	31 Pound Street, Grafton (CVLEP)	Local	Direct impact – total The proposal would demolish this heritage item. There is a high potential for archaeological remains to be encountered, but the research potential is low given the date of these remains. The removal of the property would have an impact on the aesthetic appreciation of Pound Street and a cumulative impact on the Grafton conservation area (C3).

No	Name and listing	Heritage significance	Impact
CZB19	King George V Plaque, Pound Street, Grafton (CVLEP)	Local	Direct impact – partial The plaque is located on the section of viaduct to be replaced (It would not be viable to retain the viaduct). The removal of the plaque would have an impact on the historical appreciation of Pound Street. It is proposed the plaque be reinstated on the new section of viaduct after construction finishes (refer to Section 8.5.4).
CZB20 & CZB21	Grafton Railway Viaduct, Grafton (CVLEP, S.170)	Local	Direct impact – partial The section of the viaduct above Pound Street would be removed and replaced with a truss steel bridge. (It would not be viable to retain the viaduct). The removal of this portion of the viaduct would have a significant impact on the aesthetic appreciation of Pound Street within the Grafton urban conservation area.
CZB22	26 Kent Street, Grafton (Kent Street Residential Group 2 CVLEP I627)	Local	Indirect impact- noise The property may require architectural noise treatment. The impact is not expected to be significant, as the noise treatment would be applied in a way that is sympathetic to the heritage values of the item.
CZB23	24 Kent Street, Grafton (Kent Street Residential Group 2; CVLEP I626)	Local	Indirect impact- noise The property may require architectural noise treatment. The impact is not expected to be significant, as the noise treatment would be applied in a way that is sympathetic to the heritage values of the item.
CZB24	22 Kent Street, Grafton (CVLEP)	Local	Indirect impact – visual and noise The demolition of heritage items in Pound Street and alterations to the street alignment would change the views to and from the item. The property may also require architectural noise treatment. The impact is not expected to be significant, as the noise treatment would be applied in a way that is sympathetic to the heritage values of the item.

No	Name and listing	Heritage significance	Impact
CZB25	18 Kent Street, Grafton (CVLEP)	Local	Direct impact – total The proposal would demolish this heritage item. There is a high potential for archaeological remains to be encountered, but the research potential is low given the date of these remains. The removal of the property would have an impact on the aesthetic appreciation of Kent Street and a cumulative impact on the Grafton conservation area (C3).
CZB26	16 Kent Street, Grafton (CVLEP)	Local	Direct impact – total The proposal would demolish this heritage item. There is a high potential for archaeological remains to be encountered, but the research potential is low given the date of these remains. The removal of the property would have an impact on the aesthetic appreciation of Kent Street and a cumulative impact on the Grafton conservation area (C3).
CZB27	14 Kent Street, Grafton (CVLEP)	Local	Direct impact – total The proposal would demolish this heritage item. There is a high potential for archaeological remains to be encountered, but the research potential is low given the date of these remains. The removal of the property would have an impact on the aesthetic appreciation of Kent Street and a cumulative impact on the Grafton conservation area (C3).
CZB28	12 Kent Street, Grafton (CVLEP)	Local	Direct impact – total The proposal would demolish this heritage item. There is a high potential for archaeological remains to be encountered, but the research potential is low given the date of these remains. The removal of the property would have an impact on the aesthetic appreciation of Kent Street and a cumulative impact on the Grafton conservation area (C3).
CZB29	14 Pound Street, Grafton (CVLEP)	Local	Indirect impact – visual and noise The demolition of heritage items in Pound Street and alterations to the street alignment would change the views to and from this item. The property may require architectural noise treatment. The impact is not expected to be significant, as the noise treatment would be applied in a way that is sympathetic to the heritage values of the item.

No	Name and listing	Heritage significance	Impact
CZB30	Clarendon, 13 Pound Street, Grafton (CVLEP)	Local	Direct impact – total The proposal would demolish this heritage item. There is a high potential for archaeological remains to be encountered, but the research potential is low given the date of these remains. The removal of the property would have an impact on the aesthetic appreciation of Pound Street and a cumulative impact on the Grafton conservation area (C3).
CZB31	7 Greaves Street (New Heritage Item)	Local	Direct impact – total The proposal would demolish this heritage item. There is a high potential for archaeological remains to be encountered, but the research potential is low given the date of these remains. The removal of the property would have an impact on the aesthetic appreciation of Greaves Street and a cumulative impact on the Grafton conservation area (C3).
CZB32	5 Greaves Street (New Heritage Item)	Local	Direct impact – total The proposal would demolish this heritage item. There is a high potential for archaeological remains to be encountered, but the research potential is low given the date of these remains. The removal of the property would have an impact on the aesthetic appreciation of Greaves Street and a cumulative impact on the Grafton conservation area (C3).
CZB33	1 Greaves Street (New Heritage Item)	Local	Direct impact – total The proposal would demolish this heritage item. There is a high potential for archaeological remains to be encountered, but the research potential is low given the date of these remains. The removal of the property would have an impact on the aesthetic appreciation of Greaves Street and a cumulative impact on the Grafton conservation area (C3).
CZB34	1 Pound Street, Grafton (CVLEP)	Local	Indirect impact – visual and noise The project would change the views between this heritage item and the Road and Rail Bridge State heritage item (CZB36). The property may require architectural noise treatment. The impact is not expected to be significant, as the noise treatment would be applied in a way that is sympathetic to the heritage values of the item.

No	Name and listing	Heritage significance	Impact
CZB35	Former Glyndon Private Hospital, 4 Greaves Street, Grafton (CVLEP)	Local	Direct impact – total The proposal would demolish this heritage item. There is a high potential for archaeological remains to be encountered, but the research potential is low given the date of these remains. The removal of the property would have an impact on the aesthetic appreciation of Greaves Street and a cumulative impact on the Grafton conservation area (C3).
South Grafton			
CZB37	Grafton City Railway Precinct (SHR, ARTC s.170 Register, CVLEP)	State	Direct impact – partial Indirect impact – visual This item is located outside the project's construction zone boundary, and its built heritage aspects would not be impacted by the project. However, there would be a direct impact on the disused rail turntable, which would be removed by the project. There are archaeological remains associated with the locomotive depot, south of the sugar silo, which would be impacted by the project; these remains have a moderate archaeological potential but low research potential. Views from the railway station platform towards the east would change as a result of the proposed South Grafton approach embankment, pedestrian and cycle path, landscape planting and the vehicles travelling on the proposed approach road which are likely to be visible from the platform. An assessment of the visual impacts of the project on the railway station platform users, looking east, is presented in Section 8.8 and *Appendix J, Technical Paper: Urban design and landscape concept report (Including landscape character and visual impact assessment).*

Heritage items not impacted by the project

The heritage items listed in Table 8-46 (shown in Figure 8-19, Figure 8-20 and Figure 8-21) were also assessed however no impacts were found.

Table 8-46 Assessment of heritage items- no impact

No	Name and listing	Heritage significance	Impact
Grafton			
CZB01	129 Villiers Street, Grafton (Villiers Street Residential Group 2; CVLEP I848)	Local	No impact The construction works zone boundary is located adjacent to the heritage item. This may result in a minor visual impact through alterations to the street alignment. This is unlikely to affect the significance of the item.

No	Name and listing	Heritage significance	Impact
CZB02	127 Villiers Street, Grafton (Villiers Street Residential Group 2; I847)	Local	No impact The construction works zone boundary is located adjacent to the heritage item. This may result in a minor visual impact through alterations to the street alignment. This is unlikely to affect the significance of the item.
CZB03	125 Villiers Street, Grafton (Villiers Street Residential Group 2;I846)	Local	No impact The construction works zone boundary is located adjacent to the heritage item. This may result in a minor visual impact through alterations to the street alignment. This is unlikely to affect the significance of the item.
CZB04	123 Villiers Street, Grafton (CVLEP: Villiers Street Residential Group 2; I845).	Local	No impact The construction works zone boundary is located adjacent to the heritage item. This may result in a minor visual impact through alterations to the street alignment. This is unlikely to affect the significance of the item.
CZB05	106 Dobie Street, Grafton (CVLEP I537)	Local	No impact The construction works zone boundary is located adjacent to the heritage item. This may result in a minor visual impact through alterations to the street alignment. This is unlikely to affect the significance of the item.
CZB06	108 Dobie Street, Grafton (CVLEP I538)	Local	No impact The construction works zone boundary is located adjacent to the heritage item. This may result in a minor visual impact through alterations to the street alignment. This is unlikely to affect the significance of the item.
CZB07	Fisher's Drain: Corner of Villiers and Dobie Streets (CVLEP I535)	Local	No impact Fisher's Drain is located within the construction works zone boundary but outside of the areas of proposed impact. Any archaeological potential associated with Fisher's Drain is unlikely to be impacted by the proposed works. The heritage significance of this item is unlikely to be affected. A no-go area is proposed to be established around this item during construction as a precautionary measure (refer to Section 8.5.4).

No	Name and listing	Heritage significance	Impact
CZB08	Showground Complex: Corner of Villiers and Dobie Streets, Grafton (CVLEP; I116 & I533)	Local	No impact The construction works zone boundary is located adjacent to the heritage item. This may result in a minor visual impact through alterations to the street alignment. This is unlikely to affect the significance of the item.
CZB09	30-32 Villiers Street, Grafton (Villiers Street Residential Group 1; CVLEP I132; NT R2624)	Local	No impact The construction works zone boundary is located adjacent to the heritage item. The property is located sufficiently far outside the construction works zone boundary as to not be affected. There are no measurable impacts to this heritage item.
CZB12	Coronation Plaque, Clarence Street, Grafton (CVLEP I516)	Local	No impact The construction works zone boundary is located adjacent to the heritage item. The property is located sufficiently far outside the construction works zone boundary as to not be affected. There are no measurable impacts to this heritage item.
CZB14	28 Clarence Street (Clarence Street Residential Group 1; CVLEP I522)	Local	No impact The construction works zone boundary is located adjacent to the heritage item. The property is located sufficiently far outside the construction works zone boundary as to not be affected. There are no measurable impacts to this heritage item.
FMW34	Water trough, Lane Park	Local	No impact The construction works zone boundary is located adjacent to the heritage item. The property is located sufficiently far outside the construction works zone boundary as to not be affected. There are no measurable impacts to this heritage item. A no-go area is proposed to be established around this item during construction as a precautionary measure (refer to Section 8.5.4).

8.5.4 Environmental management measures

Avoidance by design

The project has been scoped and designed to avoid or minimise impacts on the heritage values of Grafton and South Grafton. In particular:

- The proposed bridge has been designed to minimise impact on the Grafton Rail and Road Bridge State heritage values

- The road design on Pound Street, Grafton, has been refined to avoid demolition of Ravensford, 36 Villiers Street, Grafton (CZB10).

Environmental management measures

The proposed environmental management measures presented in Table 8-47 are based upon the findings of a comprehensive investigation of documentary sources, built fabric, terrestrial and maritime archaeological sites. These investigations have informed the assessment of significance and impacts for all identified heritage items within the vicinity of the project area.

The proposed environmental management measures have been formulated based upon these assessments and the principles outlined in the *NSW Heritage Manual* (Heritage Office and Department of Urban Affairs and Planning, 1996) (and subsequent guidelines) and the Australia ICOMOS *Burra Charter*. The proposed environmental management measures detail methods to preserve and enhance heritage items where possible. Where impacts are unavoidable, processes for minimising the losses to archaeological knowledge have been outlined.

The proposed environmental management measures respond to the heritage significance of the project area. They have been developed under the guidance of the *NSW Heritage Manual* (Heritage Office and Department of Urban Affairs and Planning, 1996) and associated guidelines and the Australia ICOMOS *Burra Charter.* Given this, the proposed environmental management measures are considered to be effective in doing as much as necessary to care for the place and make it useable while reducing actions that would reduce cultural significance.

Table 8-47 Environmental management measures for non-Aboriginal heritage impacts

Issue	Environmental management measure	Responsibility	Timing
Prepare an interpretation plan for the project	A heritage interpretation plan will be prepared to provide opportunities to enhance understanding and appreciation of the heritage items, values and themes associated with Grafton. In particular, the interpretation plan will identify heritage items that are to be removed and provide opportunities for compensating for these losses. This may include incorporating formalised heritage walks and tree-planting programs into the landscaping and planning of the project.	Roads and Maritime	Detailed design
Consideration of heritage in urban design principles	Heritage considerations will be incorporated into the urban design and landscape objectives developed for the project. These features will be refined further during detailed design development for the project.	Roads and Maritime	Detailed design
Noise mitigation treatment on heritage items	If required, architectural noise treatments on heritage items will be applied in a sympathetic manner to minimise impact on the significance of the heritage item.	Roads and Maritime	Detailed design Construction

Issue	Environmental management measure	Responsibility	Timing
Construction impacts	A construction heritage management plan (CHMP) will be prepared as part of the construction environmental management plan for the project. The CHMP will detail how construction impacts on Aboriginal and non-Aboriginal heritage will be minimised and managed. The CHMP will include: • Details of Aboriginal and non-Aboriginal cultural heritage sites within and adjacent to the Project • Details of management measures for the project • Procedures for dealing with previously unidentified finds • Heritage training and induction processes for construction personnel • Procedures for ongoing Aboriginal consultation and involvement for the duration of the project.	Construction contractor	Pre-construction
Heritage values to be considered during flood mitigation works	Any construction and vegetation clearance within or near the curtilage of heritage items will be sympathetic to minimise the removal of, or impact on, associated heritage values.	Roads and Maritime	Pre-construction

Issue	Environmental management measure	Responsibility	Timing
Prepare an archival record before impact occurs and at the completion of the project	Archival recording will be prepared for the following heritage items: CZB10, CZB11, CZB13, CZB16, CZB17, CZB18, CZB19, CZB20 & CZB21, CZB24, CZB25, CZB26, CZB27, CZB28, CZB29, CZB30, CZB31, CZB32, CZB33, CZB34, CZB35, CZB36 and CZB37. Archival recording will also be carried out for portions of Pound Street within the Grafton Conservation Area (C3). The archival records will record the process of development and alterations to heritage values. A program of archival recording will be completed before impacts occur and at the completion of the project. All archival recording will be completed in accordance with the Heritage Branch guidelines *How to Prepare Archival Records for Heritage Items* and *Photographic Recording of Heritage Items Using Film or Digital Capture* (Heritage Office 2001, revised 2004, 2006).	Roads and Maritime	Pre-construction
Relocation of King George V Plaque	Following archival recording, the King George V Plaque (CZB19) will be relocated to a safe location and later reinstated on the new section of viaduct at Pound Street.	Construction contractor	Pre-construction Construction

Issue	Environmental management measure	Responsibility	Timing
No-go areas and temporary fencing	No-go areas will be established around three heritage items: • CZB07 (Fisher's Drain) • FMW29 (*SS Induna* shipwreck) • FMW34 (Water Trough, Lane Park). For CZB07 and FMW34, no-go areas will be established at an appropriate distance to protect the heritage values of the heritage items but allow construction to proceed unhindered. For FMW29, *SS Induna*, both terrestrial and maritime temporary exclusion areas will be established during construction to exclude the entry of vehicles or equipment associated with construction. The 'no-go' area perimeter will be placed on the existing property boundary to the south of the *SS Induna.* A maritime exclusion area (to be in accordance with Maritime and navigational requirements) will be placed 15 metres from the shipwreck to remind workboats to not enter this area. No-go areas will be marked on all construction plans and pointed out in induction talks with contractors undertaking work in vicinity to the items.	Construction contractor	Pre-construction Construction

Issue	Environmental management measure	Responsibility	Timing
Archaeological monitoring (if required)	The EIS has determined that the proposed flood mitigation works traverse areas of moderate and high potential for the survival of archaeological resources of local significance. Depending on the level of impact and the form of the proposed works, monitoring of these moderate and high archaeologically sensitive areas may be required. No monitoring is required for sites with low archaeological significance. Monitoring is proposed as it is not appropriate to carry out archaeological testing and salvage within or next to the existing flood levee. This is due to the risks associated with compromising the flood protection measures around Grafton. An archaeological excavation program will expose properties within Grafton to an unacceptable level of risk and therefore is not appropriate in this instance. An archaeological monitoring program will be developed as part of the heritage management sub-plan developed for the project. The monitoring program will provide the following details: • Description of the proposed works, including level of disturbance and consideration of previous levee construction activities and how this relates to the impacts from the work • Details of involvement of a suitably qualified archaeologist for all initial ground disturbance works which may impact upon archaeological deposits • Process to be followed should any heritage items be identified during the monitoring period.	Construction contractor Roads and Maritime	Pre-construction Construction
Discovery of unexpected non-Aboriginal objects and/or human remains	If unexpected non-Aboriginal heritage items or skeletal remains are encountered, the *Roads and Maritime Services Standard Management Procedure for Unexpected Archaeological Finds* (2012) will be implemented.	Construction contractor	Construction

8.6 Aboriginal heritage

This chapter describes the existing Aboriginal cultural heritage values and known Aboriginal sites in the study area; assesses the potential direct and indirect impacts on these values and sites as a result of the project; and outlines measures to manage potential impacts.

The assessment presented in this section is derived from the Aboriginal cultural heritage assessment prepared by Biosis Research (Biosis) (refer to *Appendix H, Technical Paper: Aboriginal Cultural Heritage Assessment* (Biosis, 2014)).

Table 8-48 Director-General's environmental assessment requirements related to Aboriginal heritage

Director General's environmental assessment requirements	Where addressed in EIS
An assessment of impacts to Aboriginal heritage (including cultural and archaeological significance), in particular impacts to Aboriginal objects and potential archaeological deposits (PAD), should be assessed. Where impacts are identified, the assessment shall:	
- outline the proposed mitigation and management measures (including measures to avoid significant impacts and an evaluation of the effectiveness of the measures) generally consistent with the *Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* (Department of Environment and Conservation, 2005),	Section 8.6.4
- be undertaken by a suitably qualified heritage consultant(s),	Section 8.6.1
- demonstrate effective consultation with Aboriginal communities in determining and assessing impacts and developing and selecting options and mitigation measures (including the final proposed measures),	Section 7.4 and Section 8.6.1
- assess and document the archaeological and cultural significance of cultural heritage values of affected sites, and	Section 8.6.2 and Section 8.6.3
- develop an appropriate assessment methodology, including research design, in consultation with the Department and the Office of Environment and Heritage, to guide physical archaeological test excavations of the sites and areas of PAD identified in a manner that establishes the full spatial extent and significance of any archaeological evidence across each site/area of PAD, and include the results of these excavations.	Section 8.6.1 and Section 8.6.2

8.6.1 Assessment methodology

Legislation, planning instruments and procedures

The legislation and planning instruments that have informed this assessment include:

- *State Environmental Planning Policy (State and Regional Development) 2011*
- *Environmental Planning and Assessment Regulation 2000*
- *National Parks and Wildlife Act 1974 (NSW)*
- *National Parks and Wildlife Amendment Act 2010 (NSW)*
- *Clarence Valley Local Environmental Plan 2011 (NSW).*

The assessment was carried out by suitably qualified heritage consultants from Biosis in accordance with:

- *The Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* ('the Code') (DECCW, 2010b)
- *The Aboriginal Cultural Heritage Consultation Requirements for Proponents* (DECCW 2010)
- *The Roads and Maritime Services Procedure for Aboriginal Cultural Heritage Consultation and Investigation* (PACHCI) (Roads and Maritime, 2011).

Refer to *Appendix H, Technical Paper: Aboriginal Cultural Heritage Assessment* (Biosis, 2014) for full list of relevant planning instruments and the relevant qualifications of the Biosis project team.

Aboriginal community consultation

Consultation framework

Roads and Maritime has consulted with the Aboriginal community throughout the development of the project to identify cultural heritage values and the potential impacts of the project. Consultation has been in accordance with:

- Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation (Department of Environment and Conservation, 2005)
- *RTA Procedure for Aboriginal Cultural Heritage Consultation and Investigation* (RTA, 2008); the procedure was updated in November 2011, and consultation subsequently followed the updated process
- Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010 (DECCW, 2010).

Consultation methodology

Aboriginal community consultation involved:

- Notifying, identifying and registering stakeholders
- Consulting during the preliminary route options phase
- Consulting during the shortlisted options and selection of the preferred option phase
- Consulting on the EIS Aboriginal heritage assessment methodology information pack
- Carrying out Aboriginal archaeological survey and subsurface test excavations with the Aboriginal site officers nominated by the Grafton Ngerrie Local Aboriginal Land Council (LALC)
- Providing the Grafton Ngerrie LALC (the only registered Aboriginal party for the project) with a draft Cultural Heritage Assessment Report (forming part of *Appendix H, Technical Paper: Aboriginal Heritage Assessment Report*) for comment
- Incorporating comments received from the Grafton Ngerrie LALC on the draft Cultural Heritage Assessment Report into the final report.

Consultation activities with the Aboriginal community are further detailed in Section 7.4 and a summary of consultation activities is provided in Table 8-49.

Table 8-49 Summary of consultation activities with the Aboriginal community

Timeline	Activity
Preliminary Route Options Report	Aboriginal focus group meeting with Grafton Ngerrie LALC (May, June and July 2011) LALC provided feedback on the Draft Preliminary Route Options Report: Technical Paper: Aboriginal Heritage (Biosis, 2011)
Route Options Development Report	Aboriginal focus group meeting with Grafton Ngerrie LALC (November, 2011)
Environmental Impact Statement	Aboriginal focus group meeting with LALC (January, April, July and September 2013 and February 2014) LALC provided feedback on the project methodology (September 2013) Phone discussion with Grafton Ngerrie LALC (March 2014) A draft of the Aboriginal Cultural Heritage Assessment Report was provided to the Grafton Ngerrie LALC on 22 May 2014 for review and comment. Feedback received from the LALC as follows: • The council is keen to see some interpretive signage opportunities around the bridge and noted opportunities for this are already included in *Appendix H, Technical Paper: Aboriginal Cultural Heritage Assessment* • The council is keen to ensure a pedestrian proof fence is provided during construction to protect the Alipou Creek area and noted this mitigation measure is already included in *Appendix H Technical Paper: Aboriginal Cultural Heritage Assessment* • The council wishes to include in *Appendix H Technical Paper: Aboriginal Cultural Heritage Assessment* opportunities for council site officers being used on site during construction to assist in identifying items of Aboriginal cultural heritage significance. Roads and Maritime acknowledges this request but considers council site officers would not be required during construction as the project area is considered to have low potential for Aboriginal archaeological sites. Nonetheless, in the event that unexpected Aboriginal cultural material or skeletal remains are encountered, Roads and Maritime would implement the *Standard Management Procedure for Unexpected Archaeological Finds* (Roads and Maritime, 2012). This procedure outlines the involvement of Aboriginal registered parties during construction where required (refer to Section 8.6).

Study area

This report refers to the study area and the project area. The study area covers all areas of Grafton and South Grafton in the Clarence Valley Council, local government area, that have been considered for all project options for this and previous heritage reports for the project. The project area encompasses the project boundary including all works during operation and construction.

Cultural heritage assessment methodology

The procedure and the steps followed for the Aboriginal cultural heritage assessment in this EIS was guided by the *Procedure for Aboriginal Cultural Heritage Consultation and Investigation* (Roads and Maritime, 2011). The procedure involves four stages of

consultation and investigation to assess known or potential impacts on Aboriginal cultural heritage:

- Stage 1: Initial assessment requiring Roads and Maritime to determine whether the project is likely to harm Aboriginal cultural heritage or not, and whether further assessment or investigation is required
- Stage 2: Further assessment and site survey with specific Aboriginal stakeholders and an archaeologist to assess a project's potential to harm Aboriginal cultural heritage, and to determine whether formal Aboriginal community consultation and a cultural heritage assessment report is required
- Stage 3: Formal consultation and preparation of a cultural heritage assessment report on potential harm to Aboriginal objects or places that would occur or is likely to occur. The registered Aboriginal parties (in this case, the Grafton Ngerrie LALC) are to be involved in the preparation of the report. This stage may also involve archaeological testing
- Stage 4: Implementation of project mitigation measures, which may include salvage excavation in accordance with an Aboriginal Heritage Impact Permit (AHIP) and/or a project approval or determination under *the Environmental Planning and Assessment Act 1979*.

The significance of Aboriginal heritage evidence was assessed using the four values of the *Burra Charter* (Australian ICOMOS, 1999), namely:

- Historical significance (evolution and association)
- Aesthetic significance (scenic/architectural qualities, creative accomplishment)
- Social significance (contemporary community esteem)
- Scientific significance (archaeological, industrial, educational, research potential and scientific significance values).

The cultural and archaeological significance of Aboriginal and historic sites and places was assessed on the basis of the significance values outlined above. As well as the *Burra Charter* significance values guidelines, various government agencies have developed formal criteria and guidelines that have application when assessing the significance of heritage places within NSW. Of primary interest are the following guidelines prepared by the NSW Office of Environment and Heritage:

- *Draft Guidelines for Aboriginal Cultural Impact Assessment and Community Consultation* (DEC, 2005)
- *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (OEH, 2010)
- *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (OEH, 2011).

The assessment for the project involved different forms of consultation with knowledge holders as identified by the registered Aboriginal party (Grafton Ngerrie LALC) (refer to Section 7.4 for details of consultation activities). The information provided has contributed to an understanding of the cultural value of the broader landscape surrounding the project. Knowledge holders have provided information about the traditional presence of Aboriginal people in the landscape, ceremonial sites and the impact of European land management practices on their traditional land and their culture. The cultural assessment identified locations of Aboriginal cultural value within the study area.

Archaeological assessment methodology and research design

The methodology of the archaeological assessment for the EIS involved ongoing consultation and revision throughout the stages outlined below.

Research design

Biosis developed an Aboriginal heritage methodology information pack to inform the survey, subsurface excavations and assessment process.

The methodology information pack was forwarded to the NSW Office of Environment and Heritage for comment on 9 October 2013. The following feedback was received from Office of Environment and Heritage on 11 October 2013:

- Office of Environment and Heritage encourages the continuation of the Aboriginal consultation process carried out to date
- Office of Environment and Heritage is satisfied with the methodology provided as long as the investigations are carried out in accordance with the Director-General's environmental assessment requirements.

The project's registered Aboriginal party, the Grafton Ngerrie LALC, was also consulted with regards to the Aboriginal heritage methodology information pack.

Sampling strategy

The survey effort targeted those portions of the project that were identified during previous reports and investigations as having high or moderate potential for Aboriginal cultural material. In addition the road verges of Iolanthe Street were also surveyed.

The survey focussed on the alluvial floodplain south of the Clarence River. Areas of low potential for Aboriginal cultural material were previously surveyed in 2010 and 2012 with the Grafton Ngerrie LALC representatives. The survey effort was considered adequate for this assessment. Some additional survey in the area surrounding the project was carried out after the discovery of the Aboriginal archaeological site, Alipou Creek AS 1.

Survey methods

The archaeological survey was conducted on foot, on 14 October 2013, with a field team of two members. Recordings taken during the survey followed the archaeological survey requirements of the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW, 2010) and industry best practice methodology. Information recorded during the survey included:

- Aboriginal objects or sites present
- Survey coverage
- Any resources that may potentially have been exploited by Aboriginal people
- Landform
- Photographs of the site indicating landform
- Evidence of disturbance
- Areas of potential archaeological deposits
- Aboriginal artefacts, culturally modified trees or any other Aboriginal sites.

A total of eight transects were walked across the floodplains landform, with the two surveyors walking two metres apart. They identified natural soil deposits within the project area and recorded soil information for each survey unit where possible. Representative photographs were taken of survey units, landform, vegetation coverage and ground surface visibility. Any potential Aboriginal objects observed during the survey were documented and photographed. The location of Aboriginal cultural heritage and points marking the boundary of the landform elements were recorded using a hand-held global positioning system (GPS) and the Map Grid of Australia (94) coordinate system.

Subsurface test excavation

Following the results of the field survey, a test excavation program was carried out between 14 and 16 October 2013. The excavation was accompanied by three representatives from the Grafton Ngerrie LALC.

Three test pits (one metre by two metres) were excavated within the project area on the floodplain south of the Clarence River to investigate areas of moderate and high potential for Aboriginal cultural material.

8.6.2 Existing environment

Aboriginal occupation in Grafton and South Grafton

At the time of non-Aboriginal arrival in Grafton, the area to the north of the Clarence River was within Bundjalung lands. The Yaegl tribe occupied lands on the coast. The Clarence River and Grafton are within the area previously inhabited by the Gumbainggir people. These people also inhabited the steep terrain of the escarpment zone located south of Grafton, where other sites and evidence of occupation have been found (Witter, 2000).

Non-Aboriginal settlement

The first interaction between the Aboriginal inhabitants of the Grafton region and the incoming European settlers was in 1825 when they encountered an escaped convict, Richard Craig, who later informed the colonial government of the Clarence River and drove the first sheep into the area (McKay, 1938).

Conflict between the Aboriginal population and the incoming settlers followed soon after initial non-Aboriginal settlement.

The land within and surrounding the Grafton and South Grafton area has undergone extensive modification. From the beginning of non-Aboriginal settlement in the 1830s, vegetation was cleared rapidly, followed by pastoral activity and the steady growth of the urban environment.

The northern side of the Clarence River comprises mostly urban streets, residential and commercial development and some parkland. To the south, there are developed urban areas to the west of the existing bridge; open farmland with associated houses and roads dominate the landscape to the east. The alluvial nature of the floodplain soils to the south and the impact of agriculture and urban development have reduced the likelihood of some types of evidence of Aboriginal occupation remaining intact.

Existing native title

A community of Aboriginal people remains in Grafton to this day, many with strong spiritual links to the original inhabitants and important knowledge of their past ways of life.

A search on the National Native Title Tribunal *TitleVision* online tool was conducted on 18 April 2014. No native title claims were identified within the study area.

Aboriginal cultural places

Representatives of the Grafton Ngerrie LALC identified the Golden Eel site (AHIMS site number 12-6-0326) as a place of important cultural value to the local Aboriginal community.

The Golden Eel site is a creation story associated with the Clarence River and Alipou Creek. The confluence of the Alipou Creek and the Clarence River in South Grafton has been identified as a specific landscape feature with an important relationship to the Golden Eel story. This landscape feature is located outside the project area, but the Grafton Ngerrie LALC has indicated that changing this landscape feature would impact the cultural values of the Golden Eel site.

The specific detail related to the Golden Eel story is culturally restricted information. Access to the Golden Eel site card is also restricted.

Aboriginal cultural significance

The Golden Eel dreamtime story holds important cultural values with the local Aboriginal community associated with Aboriginal cosmology, spirituality and connection to place. While no tangible Aboriginal cultural material associated with the Golden Eel dreamtime story is located in the project area, the physical setting and integrity of the Clarence River and Alipou Creek are intrinsically linked to the Golden Eel dreamtime story, particularly the mouth of Alipou Creek downstream from the project site in South Grafton.

Although the landscape of the Grafton area has been heavily modified by urban and industrial land uses and infrastructure, the context of the Clarence River and Alipou Creek and their relationships within the Golden Eel dreamtime story are readily interpretable by contemporary Aboriginal observers. As such, intangible cultural landscape values are associated with the physical landscape to provide a strong sense of place and identity to the local Aboriginal community.

Overall, Grafton and South Grafton are important cultural landscapes that have high cultural values with important visual components (aesthetic values) to the local Aboriginal community. In terms of Aboriginal heritage, while the study area contains low historic and scientific values, due to the high cultural values it is of overall high heritage significance.

Known Aboriginal sites

The results of the surveys and the searches in the Aboriginal Heritage Information Management System (AHIMS) found no Aboriginal sites within the project area.

The nearest sites to the project area are presented in Table 8-50. These sites are more than 200 metres from the project area. There are more known Aboriginal sites in the Grafton and South Grafton area but due to the culturally sensitive and tangible nature of some of these sites and the public nature of this EIS, only the nearest sites have been documented.

No potential archaeological deposits were found within or close to the project area.

Table 8-50 Closest AHIMS sites to the project area (within 200 metres of the project area)

AHIMS number	Site name	Site type	Remarks
12-3-0338	Carr's Creek Campsite	Open campsite	 The campsite is about 40 metres away from the proposed flood mitigation works construction zone boundary in South Grafton. It consists of a giant fig tree (shown in the picture above) situated between Carr's Creek to the east and a railway easement to the west. Carr's Creek Camp consisted of small, low-level occupation immediately beneath the fig tree. The site is of high social significance to the Grafton Ngerrie community. It is important in demonstrating the social connections that still exist between present-day communities and former places of habitation.
12-6-0326	Clarence River Golden Eel	Aboriginal Ceremony and Dreamtime	 The site is located about 60 metres from the bridge construction zone boundary. The site has a general restriction as it is within railway land. Access to the site card requires permission. The Grafton Ngerrie LALC considered the project area to have a high level of cultural significance due to the presence of the Golden Eel dreaming and ceremonial site.

AHIMS number	Site name	Site type	Remarks
12-6-0402	Alipou SCT 2	Modified tree	 This scarred tree is situated on the South Grafton open floodplain, about 900 metres south of the Clarence River, and about 50 metres away from the bridge construction zone boundary. The tree is dead. It is a *Eucalyptus tereticornis* (river red gum) with a 3.15-metre girth. The tree contains one scar facing east (shown in the picture above).
14-10-13	Alipou Creek AS 1	Grinding stones	The Aboriginal archaeological survey on 14 October 2013 identified a new Aboriginal site named 'Alipou Creek AS 1' in South Grafton, located about 50 metres south of Alipou Creek and 150 metres east (downstream) of the project construction work zone.  Alipou Creek AS 1 consists of two Aboriginal sandstone artefacts. The artefacts are sandstone river cobbles. Alipou Creek AS 1 is considered a low-density artefact scatter that contains a limited range of artefact types. It also lacks stratified deposits and is a common site type within the local region. The site has some potential, albeit limited, to provide new information about the exploitation of raw stone material and plant processing in the region. The archaeological significance of this site is considered to be low.

Subsurface test excavations findings, October 2013

The excavations carried out between 14 and 16 October 2013 found no subsurface Aboriginal cultural material in areas within the project area in South Grafton identified by the *Route Options Development Report Technical Paper: Aboriginal Heritage* (Biosis, 2012) as having moderate to high archaeological potential.

This indicates there is a lower potential for Aboriginal archaeological sites in tested portions of the project area than previously assessed during the archaeological surveys. As such, portions of the project area in South Grafton previously assessed as having high and moderate potential for Aboriginal archaeological sites are reassessed as having low potential.

8.6.3 Assessment of potential impacts

Impacts on Aboriginal cultural places

The cultural importance of the Golden Eel site has been continually highlighted during consultation with the Grafton Ngerrie LALC. The LALC has indicated that direct impacts on Alipou Creek through landscaping and construction would significantly impact the cultural values of the Golden Eel site and such impacts must be avoided.

Accordingly, the project has been designed to avoid direct impacts on this Aboriginal cultural place, as documented below.

Impact avoidance on the Golden Eel site

Meetings with Grafton Ngerrie LALC on the 1 July 2011, 10 November 2011 and 30 April 2013 discussed options for avoiding impact on the Golden Eel site by the preferred option for the project.

The land council requested that:

- The bridge alignment be shifted to avoid impacting Alipou Creek. Roads and Maritime responded by investigating a bridge route between the existing bridge and Alipou Creek that would avoid direct impacts on Alipou Creek
- The bridge be placed as far west as possible within the preferred project area (former Option C alignment) to minimise any potential visual impacts on Alipou Creek. Roads and Maritime has designed the project to satisfy this request
- Temporary fencing be erected between the construction area and the creek during construction. A pedestrian-proof fence was subsequently erected by Roads and Maritime to separate the project area and Alipou Creek to avoid potential impacts from the field investigations carried out for the EIS. The pedestrian-proof fence would be re-instated during construction to prevent access to the Golden Eel site (refer to Section 8.6.4)
- A public interpretation strategy be developed to promote community recognition of, and respect for, the cultural importance of the area to the local Aboriginal community. The LALC suggested that signage containing culturally appropriate information for the area and, potentially, a seating area be considered. These requests will be examined by Roads and Maritime during detailed design of the project (refer to mitigation measures in Section 8.6.4).

Impact on known Aboriginal sites

The assessment of impact found that there would be no harm or loss of heritage value on known Aboriginal sites provided the management measures listed in Section 8.6.4 were implemented. In particular:

- There would be no impact on the closest known Aboriginal sites to the project area, namely: Clarence River Golden Eel site, Alipou SCT 2 site, Alipou Creek AS 1 site, and Carr's Creek Campsite

- Test excavations on land within the project area did not reveal any Aboriginal cultural material
- There are no identified Aboriginal archaeological values located within the study area.

These findings are summarised in Table 8-51.

Table 8-51 Potential archaeological impact

Site	Cultural significance	Type of harm	Degree of harm	Consequence of harm
Clarence River Golden Eel (AHIMS site number 12-6-0326)	High	None	None	No loss of value
Alipou Creek AS 1 site	Low	None	None	No loss of value

8.6.4 Environmental management measures

Measures to manage and address the potential impacts of the project on Aboriginal heritage have been developed in consultation with the Grafton Ngerrie LALC. The measures are generally consistent with the *Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* (DEC, 2005) and comply with the requirements of the *National Parks and Wildlife Act 1974* and the *Environmental Planning and Assessment Act 1979*.

Table 8-52 Environmental management measures for Aboriginal heritage impacts

Impact	Environmental management measure	Responsibility	Timing
Golden Eel dreaming site	Detailed design and construction stages will avoid further encroachment towards the Golden Eel dreaming site.	Roads and Maritime	Detailed design Construction
Consultation with Aboriginal community	The Aboriginal community will continue to be consulted as an identified group within the overall community consultation strategy for the project.	Roads and Maritime	Detailed design Construction
Interpretive strategy for tangible and intangible Aboriginal heritage	An interpretive strategy will be formulated in conjunction with the local Aboriginal community. This will highlight salient sites and features within the landscape in a manner that respectfully enhances and protects these values. The interpretative strategy will be integrated with the non-Aboriginal heritage interpretation plan for the project.	Roads and Maritime	Detailed design Construction

Impact	Environmental management measure	Responsibility	Timing
Construction impacts	A construction heritage management plan (CHMP) will be prepared as part of the construction environmental management plan for the project. The CHMP will detail how construction impacts on Aboriginal and non-Aboriginal heritage will be minimised and managed. The CHMP will include: • Details of Aboriginal and non-Aboriginal cultural heritage sites within and adjacent to the project • Details of management measures for the project • Procedures for dealing with previously unidentified finds • Heritage training and induction processes for construction personnel • Procedures for ongoing Aboriginal consultation and involvement for the duration of the project.	Construction contractor	Pre-construction
Aboriginal cultural heritage induction	The project site induction will incorporate Aboriginal culture awareness training for all relevant staff and contractors. This induction will include information about the Aboriginal culture and history of the locality, the location of sites and items that require protection, heritage management measures and protocols, and legal obligations. This training will be developed in consultation with the Grafton Ngerrie LALC and provided to relevant staff before commencing work on-site.	Construction contractor	Construction
Known Aboriginal objects and places	Aboriginal sites located in close proximity to the project construction work zone will be designated 'no-go' areas and will be clearly identified and appropriately fenced to prevent access or damage during construction.	Construction contractor	Construction
Discovery of unexpected Aboriginal cultural material and human remains	In the event that unexpected Aboriginal cultural material or skeletal remains are encountered, the *Standard Management Procedure for Unexpected Archaeological Finds* (Roads and Maritime, 2012) will be implemented.	Construction contractor	Construction

8.7 Socio-economic, property and land use

This section assesses the project's socio-economic impacts on local communities. The full assessment is presented in *Appendix I, Technical Paper: Socio-economic, property and land use*.

Table 8-53 lists the Director-General's environmental assessment requirements relevant to socio-economic impacts and where they are addressed in this chapter.

Table 8-53 Director-General's environmental assessment requirements relevant to socio-economic, property and land use

Director General's environmental assessment requirements	Where addressed in EIS
A detailed description of the project, including: - land use changes, including resumption of residential and rural lands and vegetation clearing.	Section 8.7.3 and Section 8.7.4 vegetation clearing is addressed in Section 8.9
An assessment of social and economic impacts on the local community and community facilities directly impacted by the project.	Section 8.7.3 and Section 8.7.4
An assessment of impacts on: - access and use of the Clarence River and its banks, including fisheries, tourism, and recreational use, - regionally significant farmland, and - Crown land.	 Section 8.1.3, Section 8.1.4, Section 8.7.3 and Section 8.7.4 Section 8.7.3 Section 8.7.3

8.7.1 Assessment methodology

The first step in the assessment was to consider the range of potential socio-economic impacts of the project. These potential impacts were gathered from:

- Social and economic assessments carried out during the route selection process
- Site visits to the study area including a visual survey of land uses near the existing bridge and its approaches, and near the project
- The issues raised during community and stakeholder consultation for the project (Chapter 7 provides an overview of issues raised during consultation).

The next step was to identify existing land uses, properties and the socio-economic environment in the Grafton and South Grafton area.

The project's potential benefits and impacts were then considered. This included an assessment of the project's effect on:

- Property
- Local amenity
- Local and regional access and connectivity
- Local business
- Tourist and recreational
- Social infrastructure, such as community services and facilities.

The final step was to identify environmental management measures to enhance project benefits and avoid or reduce potential adverse impacts.

8.7.2 Existing environment

This section provides an overview of the existing socio-economic environment. More detailed information is provided in *Appendix I, Technical Paper: Socio-economic, property and land use* (BBC Consulting Planners, 2014).

Population, housing and car use

Data relevant to the project was taken from the 2011 *Australian Bureau of Statistics Census of Population and Housing*. In 2011:

- The Grafton Urban Centre (including Grafton and South Grafton) had a population of 16,598 people (Grafton and Junction Hill had a population of 12,208 and South Grafton had a population of 6193)
- The Grafton Urban Centre had 6404 occupied private dwellings
- On the census day in the Grafton Urban Centre Locality about 84.7 per cent of people travelled to work by car (either as a driver or passenger), 0.1 per cent by train and 0.6 per cent by bus. In addition, 3.1 per cent of people walked and 7.5 per cent of people travelled by bicycle to work.

Land use

Land uses in Grafton, along the Clarence River and foreshore, and in South Grafton are described below.

Land uses in Grafton

Grafton is located on the northern side of the Clarence River. It is a major regional centre providing a focus for services to the Clarence Valley community. Grafton is the sub-region's major employment centre, and a focus of local government administration. Its higher order services include retail and administrative services, a base hospital, Grafton TAFE campus, a community health centre and high schools.

A large number of Grafton's community and recreation facilities are located near and along the Clarence River or the Summerland Way.

Grafton's main retail and commercial business area is a compact area centred on Prince and Fitzroy streets. Grafton's major shopping centre, Grafton Shopping World, is accessed off Fitzroy and Duke streets. The north-eastern side of Pound Street, between Clarence and Villiers streets, contains a number of light industrial and service businesses. Near the retail and commercial area is a church and school precinct. Local government and administration activities are located in nearby Victoria Street and have more recently spread to areas around nearby King Street.

The residential area is located outside the main retail and commercial business area. Most residences are detached dwellings.

Land uses on the Clarence River and foreshore

The Clarence River supports a range of commercial and recreational uses including:

- Gravel and sand extraction on the southern channel of the river immediately adjoining the southern edge of Susan Island. The largest vessel working on the river near Grafton is a Boral barge associated with this extractive industry (the barge transits the river downstream from Susan Island four times per day, six days a week)
- Prawn trawling and fishing in the Clarence River estuary near Yamba, downstream of Grafton. The fishery generally operates October to May, and is confined to specific times and areas
- Ferries, which operate downstream of Grafton

- Major water events such as:
  - The Rowathon between Iluka and Grafton
  - The Head of the River Regatta and the Grafton Rowing Club Regatta
  - The Bridge to Bridge Water Ski Race
  - The Monster Energy Pro Wakeboard Show
  - Yacht and sailing club races
  - Cruising yachts, particularly for the annual Jacaranda Festival in November.
- Regattas held by the Clarence River Sailing Club (located in Salty Seller Reserve, off Fitzroy Street, Grafton). These generally use the reach of the river directly in front of their clubhouse/boat shed. About 28 races are held per year between September and April
- Rowing events managed by the Grafton Rowing Club. The rowing course extends from the clubhouse (located within Memorial Park, off Prince Street, Grafton) for two kilometres upstream, towards the opposite end of Susan Island
- Moorings – there are a number of moorings near the proposed bridge near Girl Guides Park. These are accessed from the Pound Street Jetty.

Riverfront open space near the project includes the Salty Seller Reserve near the sailing club, passive open space either side of the existing bridge, Girl Guides Park and the Pound Street Jetty.

Land uses in South Grafton

South Grafton is located on the southern side of the Clarence River. Its commercial area is focussed on Skinner Street with another shopping centre on Bent Street (the Summerland Way). South Grafton also contains business zones and industrial areas, the airport, railway station and the Clarence River Visitor Information Centre.

Bent Street, from the southern end of the existing bridge to the roundabout at the Gwydir Highway, contains a range of retail businesses, a shopping centre, service industries and light industrial land. Bent Street also has a motel and a bed-and-breakfast and a number of houses. Very few of these businesses, with the exception of the accommodation facilities and service stations, would depend on passing trade.

Land on the eastern side of the railway line, near Spring and Iolanthe streets, is emerging as a location for large bulky goods premises that are not suited to town centres because of the large floor space requirements or the need for direct vehicle access to load or unload goods.

Local businesses along the project alignment are presented in Figure 8-22.

Land on the western side of Bent Street is predominately residential. Most residences are detached dwellings.

Substantial future growth is planned for South Grafton, including new employment and residential development at South Grafton Heights and Clarenza.

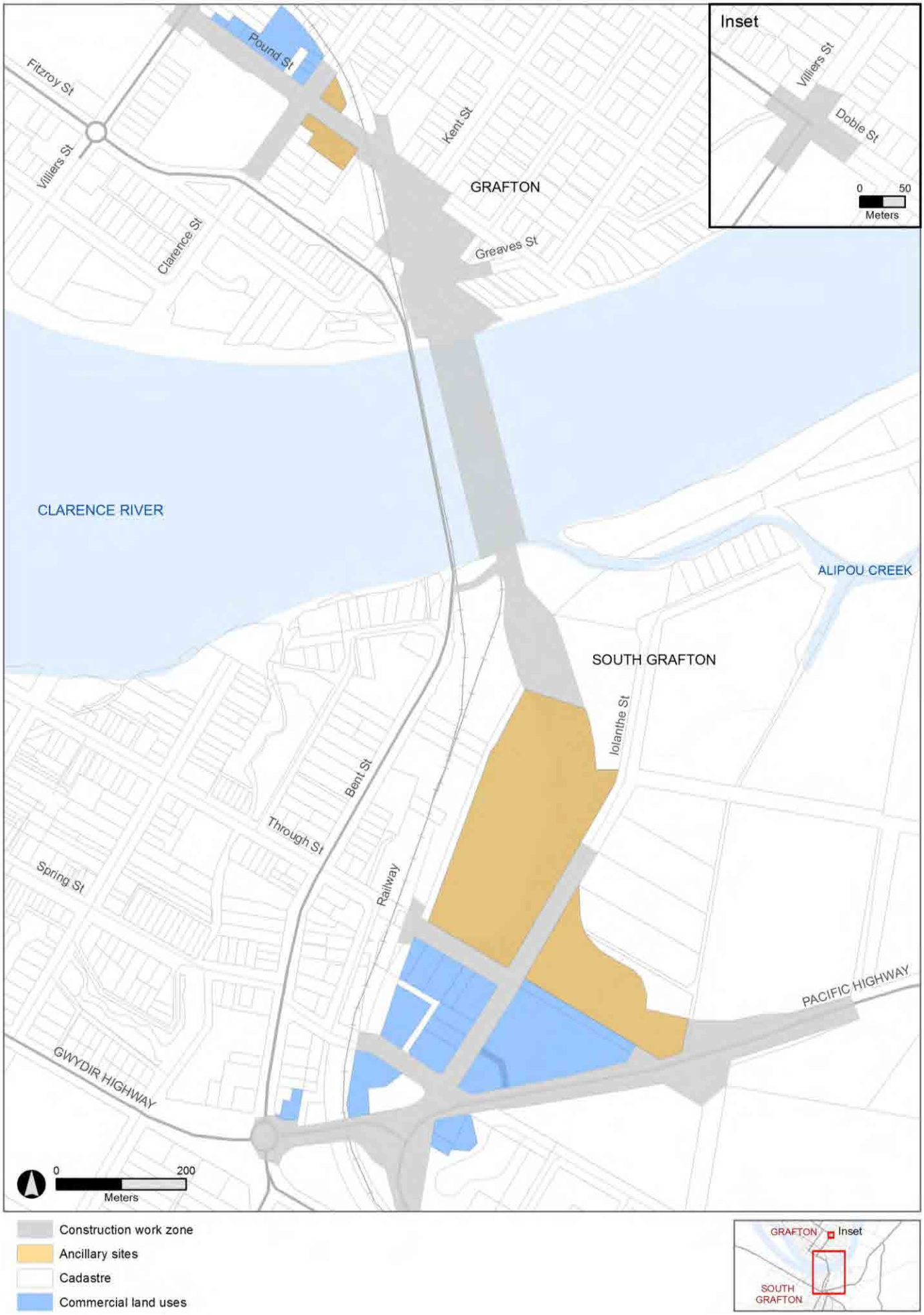


Figure 8-22 Local businesses along the project's route alignment

Land uses near the levee (proposed flood mitigation works)

The levee is located mostly on private property that is used for a range of purposes including farming, residential dwellings, recreation facilities, a church and associated primary school property, and commercial and industrial uses.

Crown Land

Crown land near the project includes the Grafton Showground, the Clarence River bed and foreshore, and Crown road reserves. Other parcels of Crown land may be crossed by the levee, which would be upgraded as part of the proposal.

Regionally significant farmland

Regionally significant farmland refers to land designated as 'regionally significant' by the NSW Department of Planning's *Farmland Mapping Project* (2009). It is defined as "land capable of sustained use for agricultural production with a reasonable level of inputs and which has the potential to contribute substantially to the ongoing productivity and prosperity of a region" (Department of Planning, 2009).

Regionally significant farmland in the Grafton area as identified in the *Mid North Coast Farmland Mapping Project* (Department of Planning, 2009) is shown in Figure 8-23.

Business and industry

The gross regional product for Clarence Valley was $2 billion in the 2011–12 financial year. The largest contribution was made by electricity, gas, water and waste services, while the fastest growing sectors were agriculture, forestry and fishing.

Tourism

Most visits to Grafton are for holiday purposes or visiting friends and relatives (92 per cent) and 90 per cent of visits are by private car. There is a network of tourist routes that focus on Grafton.

Festivals are an important contributor to the Grafton economy. For example, it has been estimated that the Bridge to Bridge Water Ski Race and Australian Wakeboarding Championship (held over the same weekend in 2011) were worth about $1 million to the Grafton City economy. The annual Jacaranda Festival held in late October to early November is also an important event for the Grafton economy.

Fitzroy Street is the gateway to Grafton and has a number of motels and other tourist accommodation.

Clarence River Visitor Information Centre on the Pacific Highway in South Grafton and nearby fast food businesses are important to the tourism industry. Research suggests that 20 per cent of visitors have no plans until they arrive at their destination, and 50 per cent are flexible. In addition, 30 per cent have not booked accommodation, and 50 per cent book tours after their arrival. On average, 20 per cent of all tourism visitors visit a tourist information centre during their trip.

Fishing industry

The commercial fishing industry, based at Yamba and Iluka, with fishing in the estuary of the Clarence River, is an important primary industry and has diversified into processing and retail. The commercial fishing industry supports 199 fishers and in 2006 returned a catch value of $19.9 million (CVC, 2009).

A number of commercial fishing vessels operate between Susan Island and downstream of the existing bridge to Elizabeth Island. The vessels mostly target mullet and Bull Sharks, but there are also eel fishers.

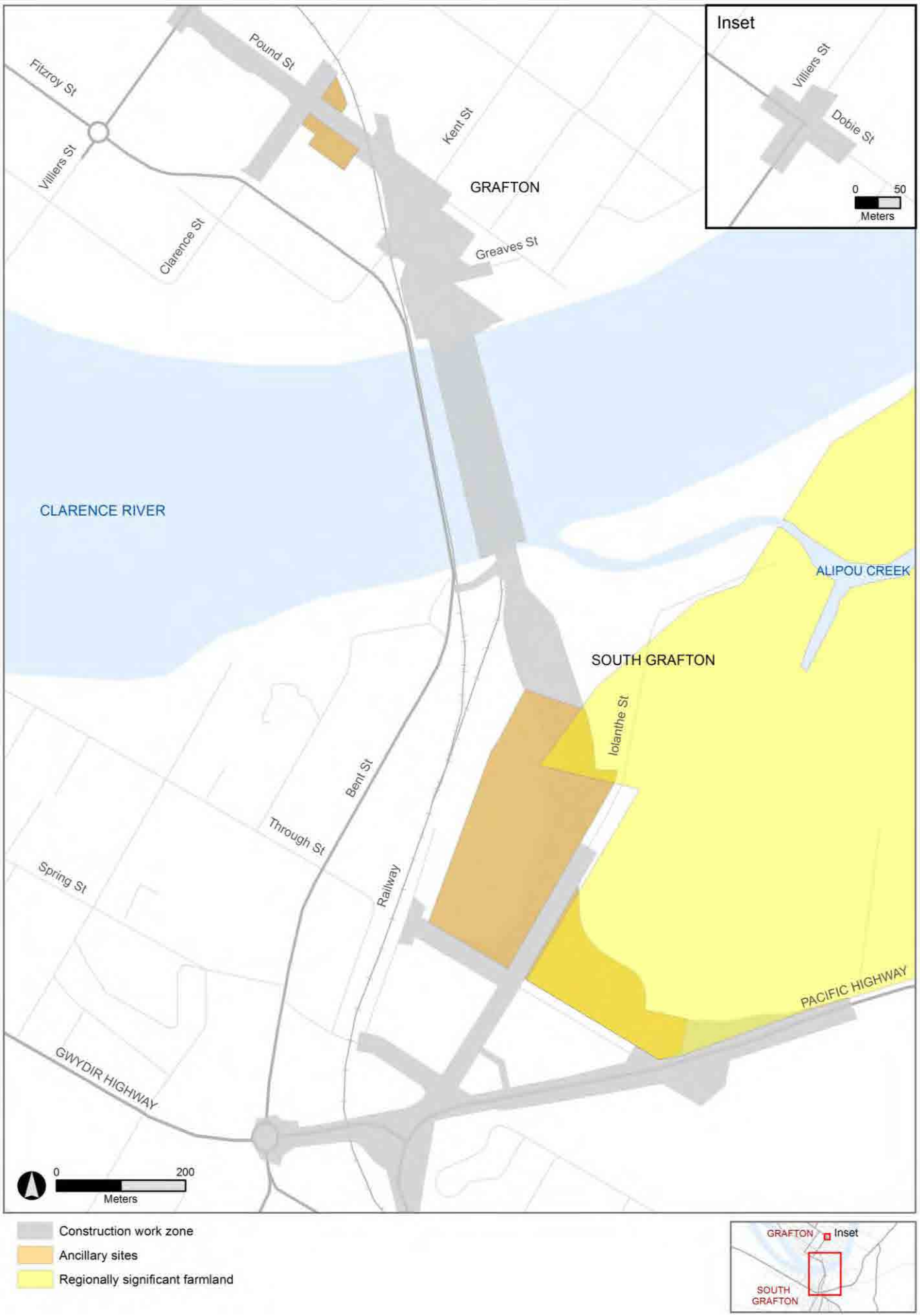


Figure 8-23 Regionally significant farmland

Community and recreation facilities

A large number of Grafton City's community and recreation facilities are located near and along the Clarence River or the Summerland Way, as shown in Figure 8-24. Facilities relevant to the project include:

- Gummyaney Aboriginal Pre-school (30 Pound St, Grafton)
- Grafton TAFE campus (1 Clarence Street, Grafton)
- Basmar Hall (21 Pound Street, Grafton). This is a private facility rented to community groups
- Grafton Showground and Fisher Park (Prince St, Grafton), which includes a key regional sportsground catering to a variety of sports
- Salty Seller Reserve (Fitzroy Street, Grafton), which is a foreshore park incorporating Clarence River Sailing Club
- Bridge Park (2 McClymont Place, Grafton), which is a natural foreshore reserve on the eastern side of the existing bridge from Salty Seller Reserve
- Girl Guide Park (Pound Street, Grafton), which provides access to a small jetty used to access moorings in the river
- Silver Jubilee Park (Charles Street, South Grafton). This is a passive park with a bus interchange at its southern end that is linked to the pedestrian and cycle path that extends north through Derek Palmer Reserve and onto the existing bridge and Grafton
- Derek Palmer Park (between Spring Street and Charles Street on the western side of the railway line, South Grafton), which is a passive park with picnic facilities
- Truck driver's memorial park (fronting the Pacific Highway, South Grafton), which is a passive park containing a memorial wall to truck drivers.

Access and connectivity

Land-based access

Grafton is well served by a range of transport services including road, rail, bus and air. Nearly 90 per cent of work trips by Grafton residents are by car either as a driver or passenger (ABS, 2011). The railway station and Grafton Regional Airport are located south of the river and a number of bus services run between South Grafton and Grafton (refer to Section 8.1 for more information on roads and bus services).

Currently, the bridge is the only crossing of the Clarence River in the Grafton area. The bridge also forms part of the alternative regional north–south road link when the Pacific Highway is closed due to traffic accidents or flooding. The bridge provides dedicated pedestrian and cycle paths on either side of the bridge at the railway line level (that is, on the lower deck).

River-based access

Maritime access to the Clarence River at Grafton is via a number of line moorings located along the foreshore, the yacht club located downstream of the bridge and the Grafton rowing club and sailing club located upstream of the bridge. Boat-launching facilities provide access for recreational boats launched from trailers. The stretch of the river between the rowing club and the bridge is generally used due to its width and ease of public access to the foreshore (refer to Section 8.1 for more information on existing river access and traffic).

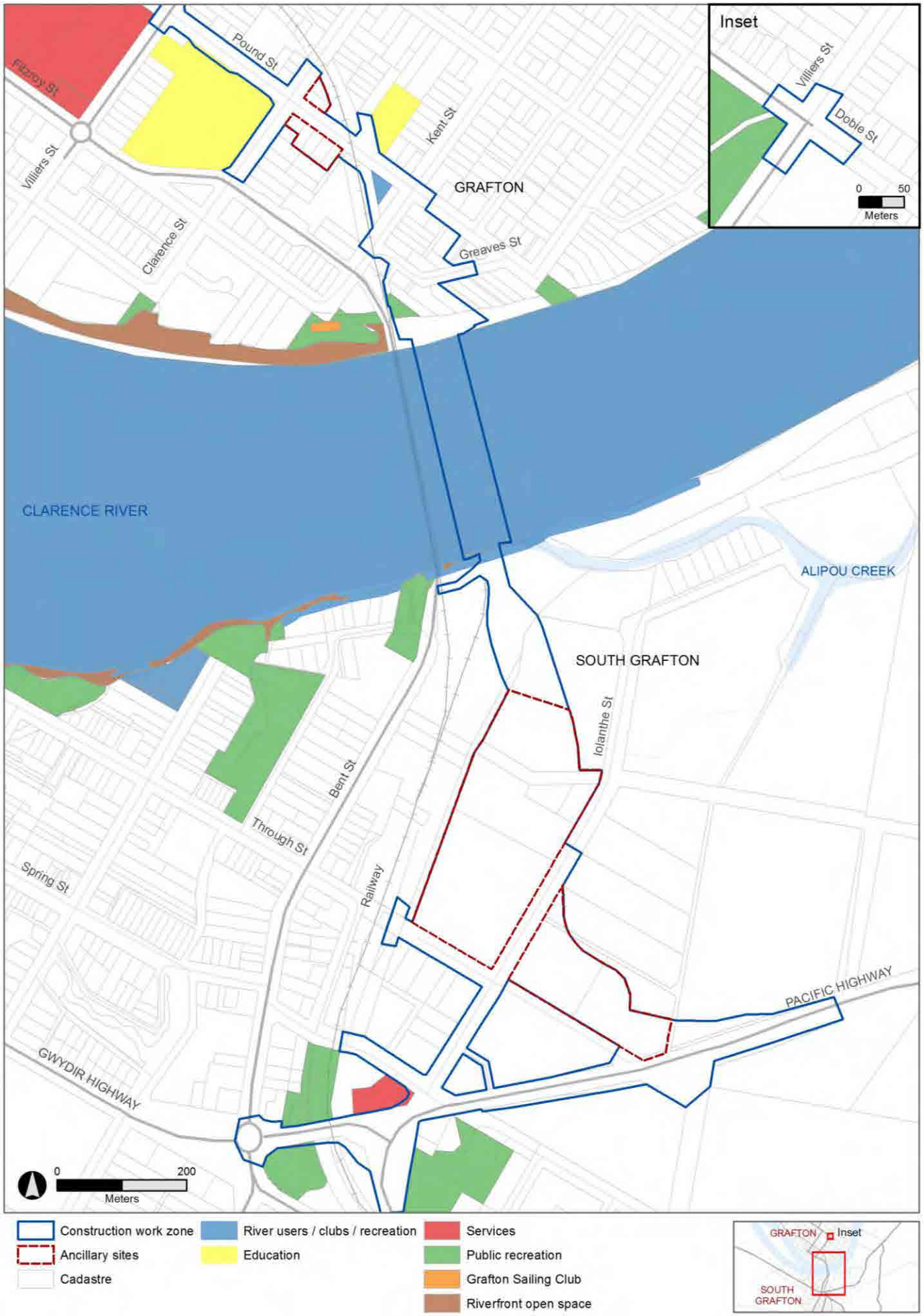


Figure 8-24 Community and recreation land uses

8.7.3 Assessment of potential impacts - construction

Construction of the project would have a number of property, land use and socio-economic impacts. These are presented below.

Directly affected properties

Directly affected properties are those that would be totally or partially acquired for the project. They are listed in Table 8-54 and shown on Figure 8-25. As shown in Table 8-54, the project would require the acquisition of 48 lots (including partial and total acquisition). No property would need to be acquired for the proposed flood mitigation works given the existing levee sits within an easement.

Table 8-54 Directly affected properties

Land use	No. of land parcels affected	Extent of impact
Residential	23	Total
Vacant	5	Total
Basmar Hall	1	Total
Park/reserve	1	Total
Subtotal	**30 properties totally affected**	
Residential	1	Partial
Grafton TAFE campus	1	Partial
ARTC (railway) land	4	Partial
Rural	5	Partial
Vacant	3	Partial
Clarence River Visitor Information Centre	1	Partial
Park/reserve	1	Partial
Disused petrol station	2	Partial
Subtotal	**18 properties partially affected**	
Total	**48 properties totally or partially affected**	

Note: The extent of impact is based on the current project design and subject to further refinement during the detailed design stage.

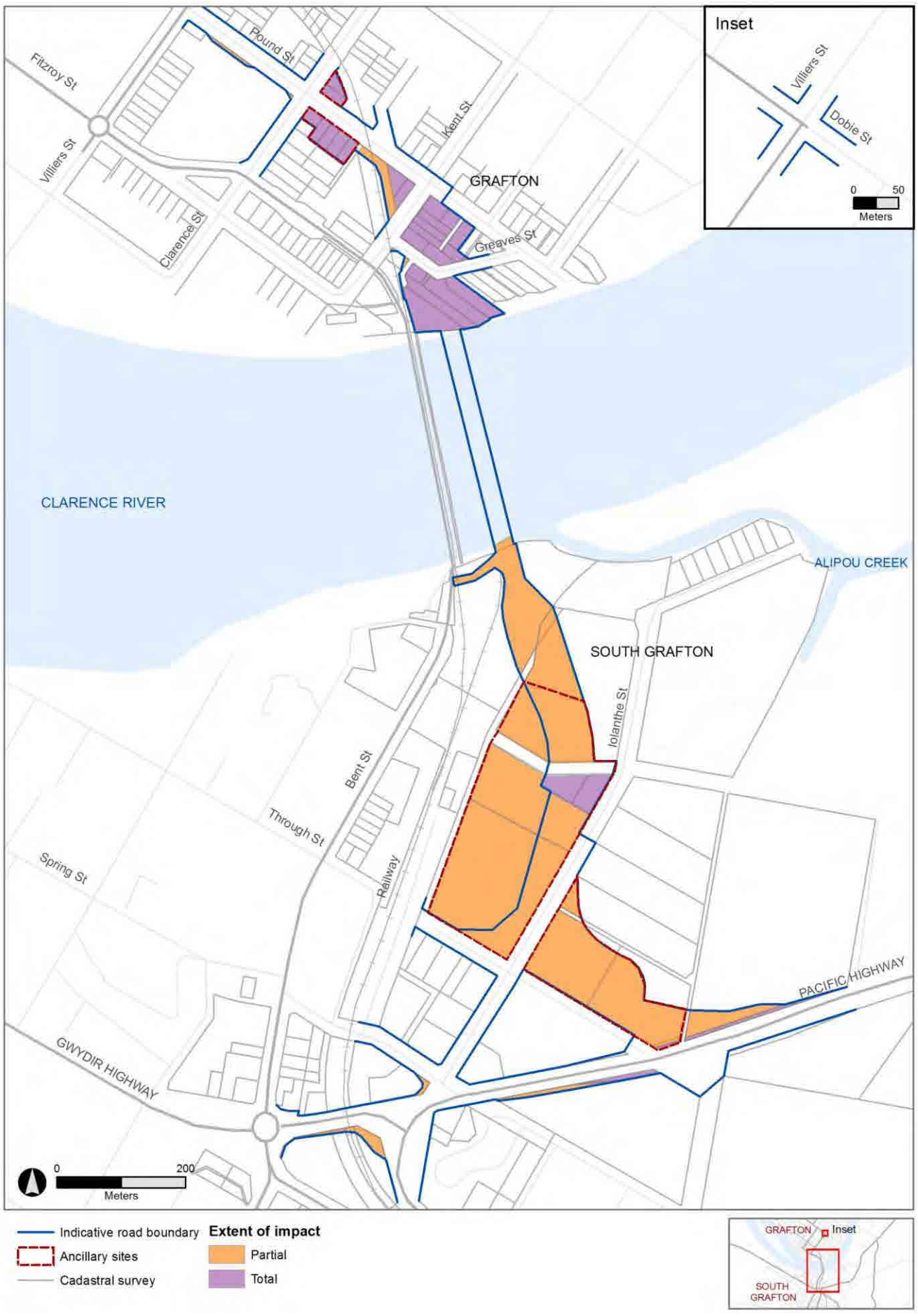


Figure 8-25 Directly affected properties

Note: The extent of impact is based on the current project design and subject to further refinement during the detailed design stage.

The land occupied by the stockpile areas along the levee and some of the land to be used for the ancillary site in South Grafton could be leased for the construction period and then returned to the owners following construction. This would be subject to consultation with land owners.

Of the lots to be totally or partially acquired:

- Thirty-seven are privately owned (some owners own more than one lot)
- Six are owned by Clarence Valley Council
- One is owned by TAFE NSW
- Four lots are owned by ARTC.

The properties to be totally acquired include:

- Twenty dwellings in the Dovedale area, Grafton and a dual occupancy development on the corner of Pound Street and Clarence Street, Grafton (one dwelling)
- Basmar Hall, a commercial property in the Dovedale area used for community uses
- One open space reserve on McClymont Place, Grafton owned by Clarence Valley Council
- Three vacant lots next to the Pacific Highway owned by Council
- Two vacant lots in the business development zone on Iolanthe Street, South Grafton.

The properties to be partially acquired include:

- A residence on the corner of Pound Street and Villiers Street
- The Grafton TAFE campus on the southern side of Pound Street
- Four vacant lots owned by ARTC in South Grafton
- Two lots on Charles Street, South Grafton, which are currently vacant but were used as a petrol station
- The Clarence River Visitor Information Centre on Spring Street, South Grafton
- One open space reserve on Charles Street, South Grafton, owned by Council
- Five rural lots in South Grafton
- A vacant lot on Spring Street, South Grafton
- Two vacant lots in the business development zone on Through Street, South Grafton.

Impacts on Crown land

The project would affect the following parcels of Crown land:

- TAFE land in Grafton (affected by partial land acquisition)
- Clarence Valley Council road reserve foreshore land in Grafton and South Grafton, and the Clarence River Visitor Information Centre in South Grafton (affected by partial land acquisition)
- Clarence Valley Council public reserve located on McClymont Place, Grafton (affected by total land acquisition)
- Roads and Maritime (Maritime) riverbed areas, which would be affected by the bridge foundations
- ARTC land in South Grafton (affected by partial land acquisition).

Impacts on regionally significant farmland

Two rural properties in South Grafton identified as containing regionally significant farmland would be partially affected. The regionally significant farmland affected (about 6.8 hectares) adjoins the South Grafton urban area and represents a small overall percentage of regionally significant farmland.

An excess land strategy would be developed during detailed design and would investigate opportunities to return available regionally significant farmland after the project is completed. This land is close to the urban area and is protected by the existing levee system. There is a broad range of other significant farmland available nearby in this section of the Clarence River valley.

Impacts on local amenity

The main types of amenity impacts that may result from the construction of the project would relate to traffic, noise, visual amenity and air quality, as discussed in Section 8.1.3, Section 8.4.3, Section 8.8.5 and Section 8.12.3, respectively.

Impacts on the local community

As discussed in Chapter 6, the project would take about three years to construct. Over that time, the expected workforce would be about 55 people. As is typical of other road projects, the construction contractor is likely to bring in key workers for the duration of the construction phase.

The existing labour force in the Grafton area would have some of the skills needed for the project. There may be direct employment opportunities during the construction phase and this would depend on the skills needed by the construction contractor.

There would also be additional demand for temporary hotel and motel accommodation and, possibly, dwellings leased on a short-term basis. Additional employment associated with the construction of the project could decrease the availability or increase the price of short term accommodation or on labour prices.

Impacts on recreational use of Clarence River

The proposed bridge would pass close to the boat moorings immediately downstream of the existing Grafton Bridge. These moorings would need to be relocated during construction. Roads and Maritime would consult with the owners of the moorings during detailed design and before construction. Moorings would be reopened after completion of the bridge, though some may be relocated away from the proposed bridge.

Construction would also require some restrictions on navigation around the work areas, which would include the placement of barges and sediment control structures, thus restricting speed and navigation similar to roadworks zones. These would potentially affect the use of the river for:

- Rowing, sailing and special events
- The Boral barge, which uses the river for transporting sand and gravel. The bridge has been designed with sufficient draft and separation between supports to enable the barge to continue operating during construction.

Roads and Maritime would consult with these river users to mitigate impacts by providing alternative arrangements as required.

Impacts on community facilities

Community facilities that would be directly affected by the project are listed in Table 8-55 and facilities that would be indirectly affected are listed in Table 8-56. For this assessment, a facility is regarded as potentially directly affected if either total or partial acquisition of the property is required or the project would otherwise cross within its boundary as in the case of river-based activities.

Table 8-55 Direct impacts on community facilities during construction

Community facility	Impact
Grafton	
Basmar Hall	The project would acquire the land on which the building is located, which is a privately owned hall hired out for a range of purposes. Therefore, tenants would need to find alternative facilities.
Grafton TAFE campus	The project would acquire a narrow strip of property to widen Pound Street between Clarence and Villiers streets. There would be an increase in construction noise from construction works next to facility (on Pound Street).
Bridge Park	The project would acquire land zoned for open space that connects under the existing bridge to Salty Seller Reserve and the sailing club. This reserve would also be partially affected by the proposed overhead bridge with portals spaced to allow access under the proposed bridge.
South Grafton	
Clarence River Visitor Information Centre	The project would acquire a small parcel of land.
South Grafton railway infrastructure	The project would acquire a portion of land, but there would be no significant impact on access to the station, or railway operations.

Table 8-56 Indirect impacts on community facilities during construction

Community facility	Impact
Grafton	
Informal open space areas near viaduct at Greaves Street	The railway reserve land next to the park would be partially impacted by construction activity and roadwork on Greaves Street.

Economic impacts

The project is expected to cost about $200 million. There is potential that the project would have multiplier effects for industries supplying goods and services to the project. The follow sections outline the economic impacts on local businesses, and the tourism and fishing industries.

Impacts on local businesses

Basmar Hall in Grafton is hired on a commercial basis, and would be directly affected by property acquisition. South of the river, no business would be directly affected.

On Iolanthe Street in South Grafton, about 4.5 hectares of vacant employment land would be needed for the project. Of this, about 1.2 hectares would be acquired. The remaining 3.3 hectares could be leased by Roads and Maritime for use as an ancillary site, and returned to land owners and made available for development

following completion of the project. Any future development over these lands would be subject to the relevant development approvals.

Impacts on on-street car parking

Road network upgrades in Grafton and South Grafton would require the temporary use of some of the existing on-street car parking for construction of the project. These impacts are considered minor temporary impacts to businesses given there is alternative parking available in the immediate surrounding area.

Appropriate methods to consult and inform the local community and businesses of on-street car parking disruptions would be implemented during construction (refer to Section 8.1.5 and *Appendix C: Draft Community Consultation Strategy*).

Impacts on tourism

There is potential for some impact on the tourism industry during construction in South Grafton due to impacts on the Pacific Highway, Spring Street and Charles Street. There may be negative impacts on businesses from the effects of reduced access, increased traffic disruptions and a loss in the quality of operating environment.

For example, access route to the Clarence River Visitor Information Centre and to Bent Street would change. However, the prominence of these localities suggests they would continue to be a destination of choice for highway and non-highway related needs.

These impacts would be managed through the implementation of construction traffic management plans including appropriate directional signage.

Impacts on the fishing industry

There is potential for some impact on the fishing industry during construction due to the disruption of access downstream of the existing bridge. Roads and Maritime would consult with commercial fishing licence holders on the Clarence River at Grafton to minimise impacts and address any access issues in and around the work site.

8.7.4 Assessment of potential impacts - operation

Impacts on property values

The project would add capacity in the transport network and reduce congestion. These benefits would potentially improve property values by improving local amenity in areas near the existing bridge approaches and improving access and connectivity. These improvements in access and connectivity would potentially lead to increased economic activity, including land development, which would also have a positive impact on property values.

Impacts on local amenity

The main types of amenity impacts that may result from the operation of the project would relate to access, traffic noise, visual amenity and air quality. These impacts are assessed in Section 8.1.4, Section 8.4.4, Section 8.8.6 and Section 8.12.4 respectively.

Impacts on the local community

The acquisition of about 23 dwellings would result in a potential relocation of up to 60 residents in the Dovedale area of Grafton. This represents a small proportion of the study area and is not likely to impact on the population and demography of Grafton as a whole. However, it may impact on population and demography at a local community level. Some residents would stay in the area while others may relocate.

The project would also benefit the health and safety of the Grafton community by providing a pedestrian and cycle path. A safety barrier on the proposed bridge would physically separate the path from traffic. It is possible that pedestrians may feel safer using the proposed path due to the presence of casual surveillance (passing traffic).

Impacts on recreational use and access to the Clarence River

Feedback from the Clarence River Sailing Club indicated that the proposed bridge would impact regattas held by the Clarence River Sailing Club as there would be additional bridge supports restricting manoeuvrability under the bridges. Regattas could still be held on the present course and there is also potential to redesign or relocate the course to alternative locations.

The operation of the proposed bridge may also impact the Iluka to Grafton Rowing Race course. The course begins at the end of Victoria Street near Susan Island.

During operation of the project, an opportunity exists for Clarence Valley Council to provide linkages along the riverfront, including an open space connection between Salty Seller Reserve and Girl Guide Park and the Pound Street Jetty. This would enhance the accessibility of the Dovedale area to the foreshore and to the open space system upstream of the bridges.

Impacts to local amenity

The project is likely to affect the amenity of both residents along the route and the wider community, including residents of Grafton and users of either the existing bridge or the new bridge.

Impacts on community facilities

Community facilities that would be directly affected by the project are listed in Table 8-57 and facilities that would be indirectly affected are listed in Table 8-58. For this assessment, a facility is regarded as potentially directly affected if either total or partial acquisition of the property is required or the project would otherwise cross within its boundary as in the case of river-based activities.

Table 8-57 Direct impacts on community facilities during operation

Community facility	Impact
Grafton	
Grafton TAFE campus	In addition, roadwork on Pound and Clarence streets would change access to the Grafton TAFE campus. The access on Pound Street would become left-in left-out and there would be some restrictions to turning movements on the Pound Street and Clarence Street intersection. A signalised pedestrian crossing would also be installed at Pound and Clarence streets. There would be a potential increase in noise levels from increased traffic next to the facility (on Pound Street). There would be a potential reduction in noise levels from reduced traffic on Fitzroy Street.
Clarence River Sailing Club Course	The project would be located within the sailing course, which would impact on manoeuvrability under the bridges. Bridge supports would be designed to align with existing bridge supports to minimise impacts.
Bridge Park	Post-construction, this park would continue to function as a passive riverside park.

Community facility	Impact
South Grafton	
Clarence River Visitor Information Centre	Access to the Clarence River Visitor Information Centre from Spring Street would remain unchanged, but Spring Street would be limited to left-in and left-out only at Iolanthe Street. This means that traffic from the north would need to turn around using the proposed roundabout at the Gwydir Highway to access Spring Street. This impact can be mitigated with directional signage. Traffic travelling into Grafton from the north would not pass by the centre. These impacts would not occur if only the possible initial road network upgrades in South Grafton were constructed (refer to Chapter 5). The possible initial upgrades would maintain visibility of the centre, and Spring Street would retain full access to Iolanthe Street via a roundabout at the junction of the two streets.
South Grafton railway infrastructure	The project would acquire a portion of land, but there would be no significant impact on access to the station, or railway operations.

Table 8-58 Indirect impacts on community facilities during operation

Community facility	Impact
Grafton	
Gummyaney Aboriginal Pre-school	The project would result in a potential increase in noise levels from higher traffic flows near the preschool (on Pound Street). Access to and from Pound Street west of the preschool would be restricted with trips diverted to access Pound Street via Kent and Bacon streets or Greaves and Fitzroy streets. This would result in longer trips in some cases.
Salty Seller Reserve	A potential opportunity exists for Clarence Valley Council to provide a link between Salty Seller Reserve and Girl Guide Park and the Pound Street Jetty.
Facilities on the foreshore near the levee	The levee raising work would result in a potential minor impact on riverside parks, schools on Victoria Street, bowling and recreational clubs, and boat launching facilities.
South Grafton	
Derek Palmer Place	The project would result in a minor impact, but there would also be a possible reduction in traffic volumes, which would improve amenity.
Silver Jubilee Park	The project would result in a minor reduction in the size of the park.

Economic impacts

Impacts on local businesses

The businesses on the main approaches to the proposed bridge and the existing bridge would experience changes in traffic volumes and accessibility for customers, staff and suppliers. There would be improved access and exposure to properties on Iolanthe Street including currently undeveloped sites next to the project. The character of Pound Street from the proposed bridge to Villiers Street would change because of the widening of the street and provision of additional formalised on-street parking. A gradual change in the nature of businesses is anticipated in this area, potentially associated with property redevelopment.

There would be a reduction in traffic volumes on Bent Street south of the existing bridge and Fitzroy Street north of the existing bridge. It is considered that businesses on Bent Street would benefit from a reduction in congestion and an improvement in accessibility. Very few of these businesses rely on passing trade; they are primarily businesses serving Grafton and surrounds and relying on good access to the main road network for ease of customer access. Some businesses such as accommodation and service stations would be impacted slightly due to a reduction in passing traffic.

Fitzroy Street has traditionally been the main entry to Grafton and accommodates a number of motels and other businesses that serve passing traffic or visitors to Grafton. These businesses may be adversely affected by the reduction in traffic along sections of Fitzroy Street. However, they would also benefit from a reduction in congestion and traffic with a consequential increase in ease of movement and amenity and a reduction in noise.

Impacts on tourism

The project would improve accessibility into and around Grafton, which would benefit tourism through shortened and less congested trips. This would also improve the ability of the city to host major tourist events.

The project would also help Grafton to develop as a regional tourism hub by improving access to and around the city.

Access route to the Clarence River Visitor Information Centre and to Bent Street would change. However, the prominence of these localities suggests they would continue to be a destination of choice for highway and non-highway related needs.

Impacts on the fishing industry

The proposed bridge design provides for two deepwater navigation channels 35 metres wide, between the two centre spans, to allow larger vessels to pass under the bridge. Nevertheless, the proposed bridge would have potential impacts on vessels, including commercial fishing vessels, navigating the Clarence River. These impacts would include:

- Restriction of vessels with a beam larger than can safely navigate through the bridge spans
- Restriction of vessels with a vertical clearance larger than can be permitted by the clearance height beneath the proposed bridge
- The physical presence of the proposed bridge, which would present a new impact hazard.

Despite these impacts, no impacts on the fishing industry are expected. Other impacts on river access and traffic are discussed in Section 8.1.

Impacts on transport and connectivity

High levels of connectivity to existing and future land uses and development can provide economic benefits to businesses served by these connections, and social

benefits to their employees (through reduced travel time). Better connectivity can also contribute to the economic development of the Clarence Valley. The project would provide these connections by:

- Facilitating the efficient movement of people and goods between existing land uses and future development and growth sites. Good connections are important as they can help encourage residents or businesses to locate to these areas
- Improving access from employment or industrial centres to the wider road network beyond Grafton
- Improving traffic flows across the Clarence River, providing a better level of connectivity to all land uses located on opposite sides of the river
- Improving connectivity between strategic land uses such as employment and residential areas, and growth areas.

In addition, the proposed South Grafton road network upgrades would improve access to the traffic-generating developments on Spring Street, such as take-away food outlets. The provision of roundabouts at either end of that section of Iolanthe Street and directional signage would facilitate access to these developments.

Impacts on community access and connectivity

The project would provide the following benefits for community access and connectivity:

- The communities of Grafton and South Grafton would be better integrated, economically and socially
- The northern and southern commercial centres would be strengthened, in turn building stronger communities and improving access to community facilities. A reduction in congestion on Fitzroy Street and an increase in exposure to commercial properties along Pound Street would likely to benefit business along both streets
- The time restriction on access from Clarence Street to Craig Street could be removed, benefiting access from the Grafton TAFE Campus
- A reduction in congestion along Bent Street would provide potential for additional business related development, enhance accessibility across the street and facilitate further development in this area
- The pedestrian and cycle path would improve connections across Iolanthe Street and the Pacific Highway (Charles Street) to connect to Clarenza
- Public transport services would benefit from the reduction in congestion on the existing bridge.

The project also has the potential to impact access and connectivity to community activities by imposing barriers that make established patterns of travel more difficult. These barriers can affect community cohesion. The project is likely to have the following adverse impacts on community access and connectivity:

- Local movement patterns in the southern part of the Dovedale area would be restricted through the closure of Pound Street east of the existing rail viaduct and Kent Street south of Pound Street. This would require residents of the eastern end of Pound Street, Greaves Street, Bromley Street and Breimba Street to use an alternative route to Pound Street and the Grafton business district, including Greaves and Fitzroy streets and Bacon Street
- Access to residential properties on Clarence Street between Fitzroy and Pound would generally be left-in and left-out only. Instead of turning right-in and right-out of the access driveways, residents would be required to do U-turns at each end of the median parking

- The central median on Pound Street would generally restrict access to properties to left-in and left-out only, south of Villiers Street
- Access to properties on Iolanthe Street would be limited to left-in and left-out only
- If the possible initial upgrades are constructed, Spring Street would be restricted to one-way westbound beneath the railway viaduct.

8.7.5 Environmental management measures

Recommended strategies to minimise socio-economic impacts during the construction and operation of the project are detailed in Table 8-59.

Table 8-59 Environmental management measures for socio-economic impacts

Impact	Environmental management measure	Responsibility	Timing
Excess land	Roads and Maritime will prepare an excess land strategy during detailed design and would investigate opportunities to return available regionally significant farmland, following completion of the project.	Roads and Maritime	Detailed design
Social infrastructure – Basmar Hall	Roads and Maritime will communicate in a timely way with the tenants of Basmar Hall regarding its closure, to maximise the opportunity for tenants to find alternative space.	Roads and Maritime	Detailed design Pre-construction
Impacted moorings	Roads and Maritime will consult with the owners of the moorings during the detailed design stage and before construction.	Roads and Maritime	Detailed design Pre-construction
Affected residents	Roads and Maritime will: • Continue ongoing timely communication with affected residents on project timing and acquisition processes • Deal in an efficient and empathetic manner with residents who seek acquisition on hardship grounds • Provide compensation in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991* and Roads and Maritime policies.	Roads and Maritime	Detailed design Pre-construction Construction

Impact	Environmental management measure	Responsibility	Timing
Local amenity – vegetation	Roads and Maritime and the construction contractor will minimise impacts, where feasible and reasonable, on existing character trees, including figs and jacarandas. Visual impacts and mitigation measures are outlined in Section 8.8 of this EIS.	Roads and Maritime Construction contractor	Detailed design Construction
Community engagement	Roads and Maritime will prepare and implement a community consultation strategy to fully inform the community of works during the construction process. The Strategy will be implemented by the construction contractor. A draft of this strategy is presented in Appendix C. The mitigation measures below will be incorporated into the strategy.	Roads and Maritime Construction contractor	Pre-construction Construction
Social infrastructure – Grafton TAFE Campus and Gummyaney Aboriginal pre-school	Roads and Maritime and the construction contractor will continue to liaise with Grafton TAFE Campus and the Gummyaney Aboriginal pre-school to minimise impacts on access and operations.	Roads and Maritime Construction contractor	Pre-construction Construction
Social infrastructure – Clarence River Sailing Club and other Clarence River event organisers	Roads and Maritime will consult with Clarence River Sailing Club and other Clarence River event organisers regarding the need to make alternative access arrangements during construction.	Roads and Maritime	Pre-construction Construction
Local amenity – residents and business	Roads and Maritime and the construction contractor will maintain ongoing and timely communication with nearby residents regarding construction work. This will include notice on timing and duration of activities and potential localised impacts. The community and business will be notified of any construction activities outside standard construction working hours. Management measures to reduce construction noise impacts would be required and would be implemented as identified in Section 8.4 of this EIS.	Roads and Maritime Construction contractor	Pre-construction Construction

Impact	Environmental management measure	Responsibility	Timing
Local business and tourism	Roads and Maritime and the construction contractor will maintain ongoing timely communication with affected businesses on project timing, changes to traffic conditions and access arrangements.	Roads and Maritime Construction contractor	Pre-construction Construction
Social infrastructure – general	The construction contractor will: • Maintain access to existing bridge pedestrian links • Maintain access for river users, including the Clarence River Sailing Club, and provide appropriate safety and maritime directional and safety signage on structures in the river • Maintain communications with police and emergency services in relation to changed access arrangements and traffic management plans.	Construction contractor	Construction
Local business and tourism	The construction contractor will maintain access to affected businesses at South Grafton and Grafton and provide directional signage.	Construction contractor	Construction
Local amenity – construction traffic	Roads and Maritime will develop construction traffic management measures as part of the construction environmental management plan. The measures will detail access arrangements for residents close to the ancillary sites and construction work zones including residents along Greaves Street and Bridge Street. Mitigation measures are outlined in Section 8.1 of this EIS to enable acceptable traffic operations and level of service on the road network during construction.	Roads and Maritime	Construction
Social infrastructure – Clarence River Visitor Information Centre and other businesses	Roads and Maritime will maintain access to the Clarence River Visitor Information Centre and other businesses along Spring and Charles streets in South Grafton by providing directional signage in accordance with relevant Roads and Maritime and Government guidelines.	Roads and Maritime	Construction Operation

8.8 Visual amenity, built form and urban design

This section assesses the project's landscape and visual impacts in Grafton and surrounds and overshadowing impacts on the public domain, open space, foreshore and residential areas. It addresses the proposed urban and landscape design concept and in particular, how the form and design characteristics of the proposed bridge relates to the existing bridge.

The assessment draws on information in the urban design and landscape concept report prepared for this EIS (refer *Appendix J, Technical Paper: Urban Design and Landscape Concept Report (including landscape character and visual impact assessment)*). Landscape and visual impacts resulting from the proposed levee raising works to the Clarence River levees were separately assessed by Arup's landscape and urban design specialists and are documented in *Appendix K, Technical Paper: Levee works landscape and visual appraisal*.

Table 8-60 lists the Director-General's environmental assessment requirements relevant to visual amenity, built form and urban design and where they are addressed in this chapter.

Table 8-60 Director-General's environmental assessment requirements relevant to visual amenity, built form and urban design

Director General's environmental assessment requirements	Where addressed in EIS
An assessment of the visual and amenity impacts of the project (height, scale and lighting) on the local and regional area, particularly on:	Appendix J, Section 8.8.5 and Section 8.8.6
- The existing State heritage listed Grafton Bridge (SHR 01036) and local heritage items	Section 8.5.3 and Section 8.8.6
- any adjoining land owners and land owners along the foreshore of the Clarence River,	Section 8.4.3, Section 8.4.4, Section 8.7.3, Section 8.7.4, Section 8.8.5 and Section 8.8.6
- existing and future residential properties in Grafton and South Grafton,	Section 8.1.3, Section 8.1.4, Section 8.4.3, Section 8.4.4, Section 8.7.3, Section 8.7.4, Section 8.8.5 and Section 8.8.6
- the southern 'town entry',	Section 8.8.4
- use of the Clarence River, and	Section 8.1.3, Section 8.1.4, Section 8.7.3, Section 8.7.4, Section 8.8.5, Section 8.8.6 and Section 8.8.7
- significant vantage points in the public domain	Section 8.8.6
Overshadowing impacts of the bridge structure, embankments and ramps on existing and proposed public domain, open space, foreshore areas and residential uses	Appendix J and Section 8.8.7
Development of urban design objectives for the new bridge, approaches and local road network treatments;	Appendix J and Section 8.8.3

Director General's environmental assessment requirements	Where addressed in EIS
Rationale for the overall design (length, height, width and appearance) and an assessment of the built form (materials and finishes) and urban design (bulk and scale) of the bridge, including:	Appendix J, Chapter 5, and Section 8.8.4
- Design relationship to the existing Grafton and South Grafton built forms and streetscapes, including the existing State Heritage listed Grafton Bridge	Section 8.5.3, Section 8.8.4 and 8.8.6
- Views to and from the bridge	Section 8.8.2 and Section 8.8.6

8.8.1 Assessment methodology

The assessment builds on studies and investigations during previous project stages, which are documented in the following reports:

- *Main Road 83 Summerland Way – Additional Crossing of the Clarence River at Grafton: Preliminary Route Options Report. Technical Paper: Landscape and Urban Character* (SMM, 2011)
- *Main Road 83 Summerland Way – Additional Crossing of the Clarence River at Grafton: Route Options Development Report. Technical Paper: Landscape and Urban Character* (SMM, 2012).

The urban design concept development and the assessment of landscape, visual and overshadowing impacts were carried out with reference to the following guidelines and documents:

- *Beyond the Pavement* (Roads and Maritime, 2014)
- *Bridge Aesthetics Design Guidelines* (Roads and Maritime, 2012)
- *Environmental Impact Assessment Guidance Note, Guidelines for Landscape Character and Visual Impact Assessment* (Roads and Maritime, 2013).

The assessment involved the following tasks:

- Conducting site visits and field investigations
- Reviewing relevant reports and literature, and analysing aerial photographs and topographic maps to understand the study area
- Reviewing the project details, engineering concept design and technical papers prepared for this EIS to gain an appreciation of the project
- Preparing urban design and landscape objectives and principles taking into account the desired future landscape and urban design character of the Grafton area as set out in Clarence Valley Council documents, including the *Clarence River Way Masterplan, Urban Tree Management Strategy, Grafton City Open Space Plan* and the *Grafton Waterfront Precinct Masterplan*
- Defining urban and landscape character through a contextual analysis
- Identifying and describing landscape character zones and evaluating the project's impact on them
- Identifying the visual catchment of the bridge and approaches and selecting viewpoints within the visual catchment representing a range of different land uses
- Identifying viewpoints for the proposed levee raising works representing a range of different land uses

- Assessing the project's visual impact by combining the sensitivity of viewpoints and the magnitude of the impact of the project on them
- Assessing overshadowing from the proposed bridge and approach embankments using shadow diagrams for June and December, which are the months when overshadowing would potentially have the most dramatic impact on the surrounding landscape
- Identifying urban design and landscape strategies to mitigate adverse impacts
- Developing the urban design, bridge and landscape concept for the project
- Developing recommendations and management measures to be considered further during detailed design.

Landscape character assessment criteria

A qualitative assessment was carried out for each landscape character zone that would be potentially impacted by the project. The assessment used 'sensitivity', 'magnitude' and 'impact' parameters, which were scored on a qualitative basis using a scale from 'negligible' to 'high'. These terms are defined as follows:

- Sensitivity refers to how sensitive the character of the setting is to the proposed change. A judgement was made on the quality of the landscape, its cultural and historical importance to the community, scenic quality, and overall composition of the place and its inhabitants. Places with high social, recreational and historical significance to local residents have higher sensitivity. Generally, water and natural environments are more highly valued than modified areas, though views over rolling farmland are still highly valued. Areas of unique scenic quality have higher sensitivity. A pristine environment would have greater sensitivity with less ability to absorb new elements in the landscape than modified landscapes or those areas with contrast and a variety of landscape types. The number and frequency of viewers also affects sensitivity, with retail, residential and open space viewers generally more sensitive than workers and motorists
- Magnitude refers to the type of proposal and its compatibility with the existing landscape character. All elements of the project, including the bridge, alignment, road infrastructure, pedestrian and cycle paths, planting, lighting, etc, were considered in the assessment. The scale of the elements (height, length) and their location or setting (eg on the floodplain or near the town) have a bearing on the magnitude of the physical presence of each element. A high magnitude would result if the proposal were a major development or piece of road infrastructure that would contrast highly with the surrounding landscape, or if it would heavily modify the landscape. A moderate magnitude rating would result if the proposal would be moderately integrated into the landscape. A low magnitude rating would result if the project is small scale and would integrate well into the landscape
- Impact is the combination of the magnitude and sensitivity rating in accordance with the impact assessment grading matrix shown in Figure 8-26.

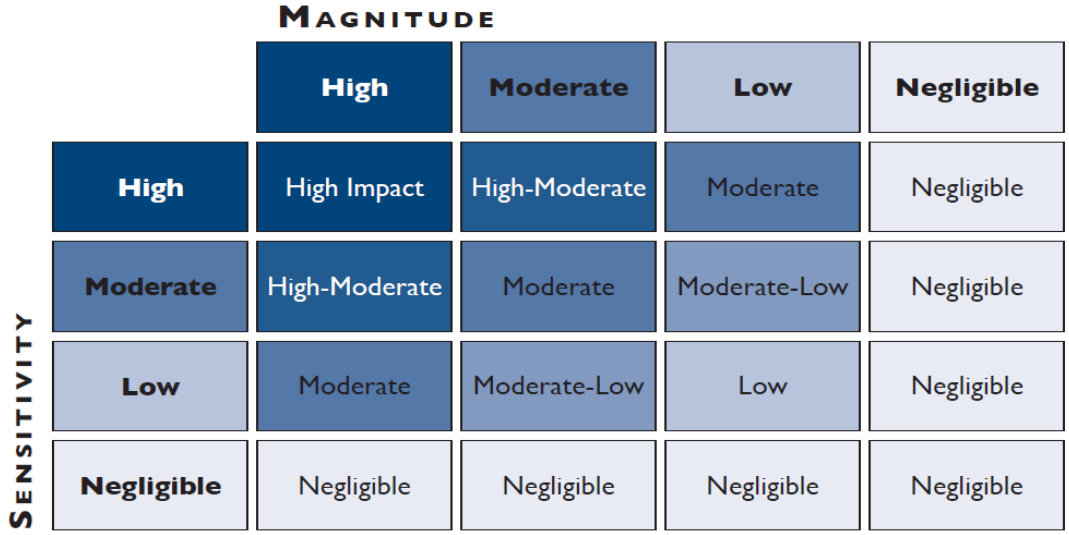


Figure 8-26 Impact assessment grading matrix

Visual impact assessment criteria

A visual impact assessment was carried out to determine the areas from where the project would be visible and key viewpoints to and from the project. The assessment was based on the 'magnitude' of change to existing views and the 'sensitivity' of the viewer. These terms are defined as follows:

- Magnitude of change to existing views refers to the nature and scale of the proposal, and the extent and proximity of the view to it. Magnitude represents the contrast in scale, form and type of proposal to the location and context to which it is to be placed. It also considers landscape and urban design treatments and improvements that are included in the concept design. A high magnitude would result if the proposal were of a major scale and would be out of scale or uncharacteristic of the existing visual character, or if it would considerably modify the landscape. A moderate magnitude would result if the proposal would be prominent, but not substantially uncharacteristic of the existing visual character. A low magnitude would result if the proposal would cause a minimal change to the existing view and would be of a scale and nature consistent with the existing visual character
- Sensitivity is the measure of the visual importance of the nominated view and is dependent on the distance between the viewer and the project, the location of the viewer (for example, residence, workplace, shops, open space), the project elements that are visible, and the importance of the view for locals and visitors to the area. Visual sensitivity includes the consideration of the perceived cultural and historical values of the visual environment and the elements within it. Generally, viewers with a higher sensitivity include residents who enjoy attractive views that would be affected by the proposal, users of public open space whose attention is generally focused on the landscape, or communities that place high cultural and historical significance on the visual landscape. Viewers with a lower sensitivity are most likely to be employees or motorists whose attention is focused elsewhere
- Impact is the combination of the magnitude and sensitivity rating in accordance with the impact assessment grading matrix shown in Figure 8-26.

Visual catchment and viewpoints

The area from where the proposal is likely to be visible and the location of viewpoints used for the visual impact assessment are presented in Figure 8-27, and the representative viewpoints to the proposed levee raising works are presented in

Figure 8-28. Table 8-61 lists the selected viewpoints and the representative views that would be experienced by visual receivers.

Visual impacts on future residential development areas are negligible as they are located away from the project footprint.

Table 8-61 Viewpoints and visual receivers

No	Representative view	Visual receiver
Views to the proposed bridge and road upgrades		
1, 2, 3	Foreground view of Pound Street and Clarence Street, Grafton	Pedestrians, cyclists, motorists, TAFE users, adjoining commercial tenants and landowners on Pound Street, Grafton
4	Foreground view of Pound Street, Grafton	Residents, cyclists and tourists (to the Jacaranda Festival) on Pound Street; and motorists on Kent Street, Grafton
5	Foreground view of the existing bridge and the Clarence River	Grafton Sailing Club users, and users of public open space along the Grafton foreshore
6	Foreground view of the existing bridge and the Clarence River	Residents on Greaves Street whose houses overlook the river; and users of Girl Guide Park on the Grafton foreshore
7	Foreground downstream views from the existing bridge	Pedestrians, cyclists, motorists and train passengers on the bridge
8	Foreground view of the existing bridge	Clarence river users who are rowing, sailing, boating or fishing
9	Foreground view of South Grafton industrial area and rural hinterland	Residents on Butters Lane, South Grafton
10	Foreground and mid distance view of South Grafton industrial area and rural hinterland	Railway station employees and customers, South Grafton
11	Foreground view of South Grafton industrial and commercial area	Visitors to the Truck Driver's Memorial, and park users, South Grafton
12	Long-distance view of the rural hinterland and the Clarence River	Motorists on Centenary Drive and the small group of Centenary Drive residents, South Grafton
Views to the proposed levee raising works		
1	Foreground and mid distance view of existing levee and the Clarence River	Residents on Riverstone Drive whose houses overlook the levee and river, South Grafton
2	Foreground and mid distance view of the levee and the Clarence River	Users of Grafton Memorial Park and Grafton Rowing Club, Grafton
3	Foreground and mid distance view of the levee and the Clarence River	Pedestrians, cyclists and motorists on Through Street, South Grafton

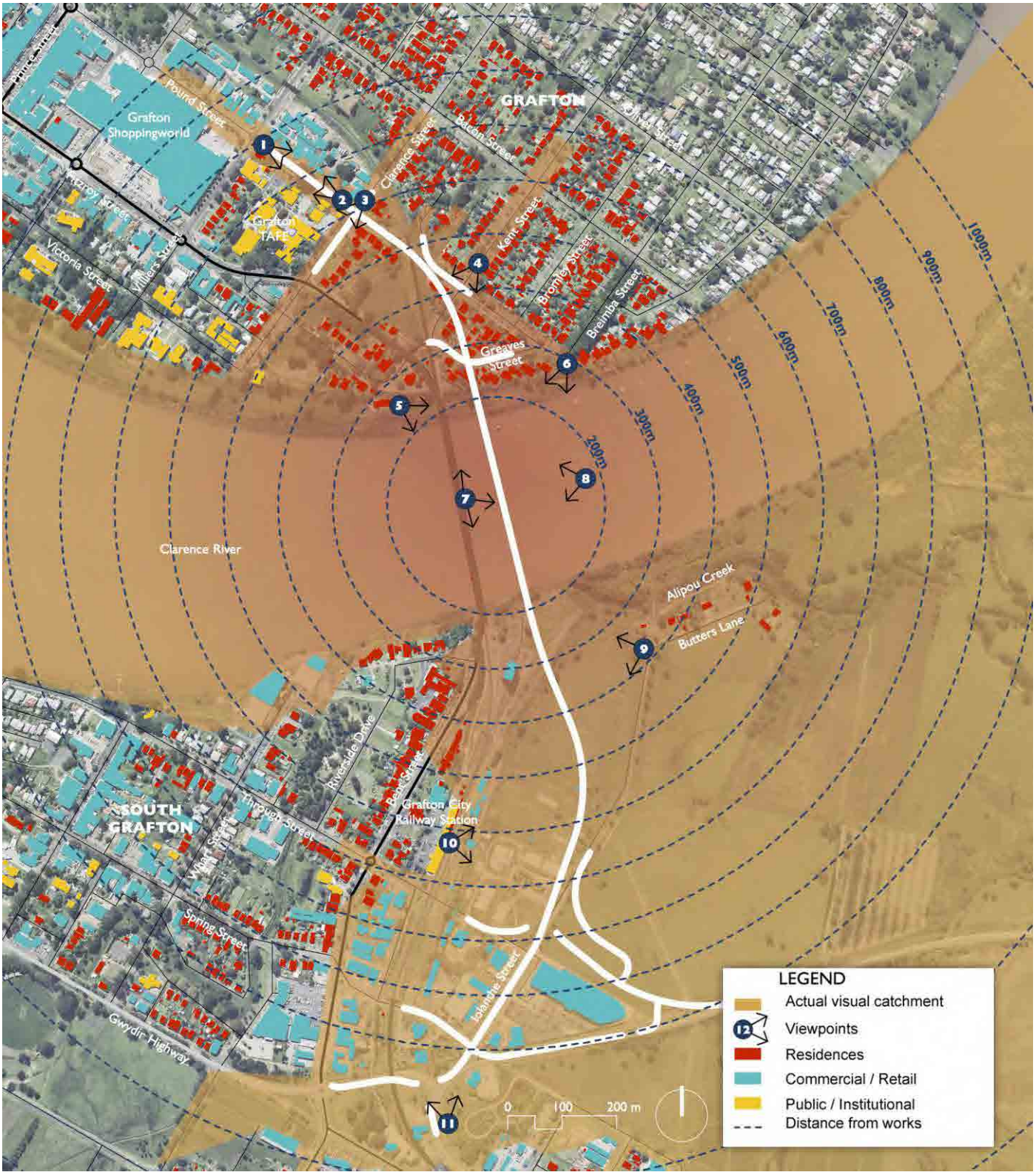


Figure 8-27 Selected viewpoints to the proposed bridge and road upgrades

Figure 8-28 Selected viewpoints to the proposed levee raising works

8.8.2 Existing environment

Existing landscape character

The landscape character of the area that would be traversed by the project is relatively flat and dominated by the Clarence River and its floodplain. Either side of the river are the town centres of Grafton and South Grafton which consist of wide gracious streets laid out on a square grid. Outside of the town centres, there are established and newly developing residential areas, and industrial areas, generally concentrated around the regional road and rail corridors. These urban areas are surrounded by the agricultural areas that comprise the city's rural hinterland.

The landscape character zones (LCZ) relevant to the project are shown in Figure 8-29. They are:

- Grafton and South Grafton town centres and established residential (LCZ1): This zone is generally a transitional area between the residential areas and the urban core
- Grafton and South Grafton established residential (LCZ2): This zone is strongly defined by the street grid pattern, wide streets and single-storey dwellings
- Clarence River and foreshore (LCZ3): In this zone, the bridge is the dominant visual feature on the river and strongly defines the landscape character of the zone
- Rural hinterland (LCZ4): This zone comprises rail lines, vacant industrial land and flat, open agricultural fields in the floodplain
- South Grafton industrial and commercial (LCZ5): This zone is distinguished by a range of medium and large industrial and commercial buildings.

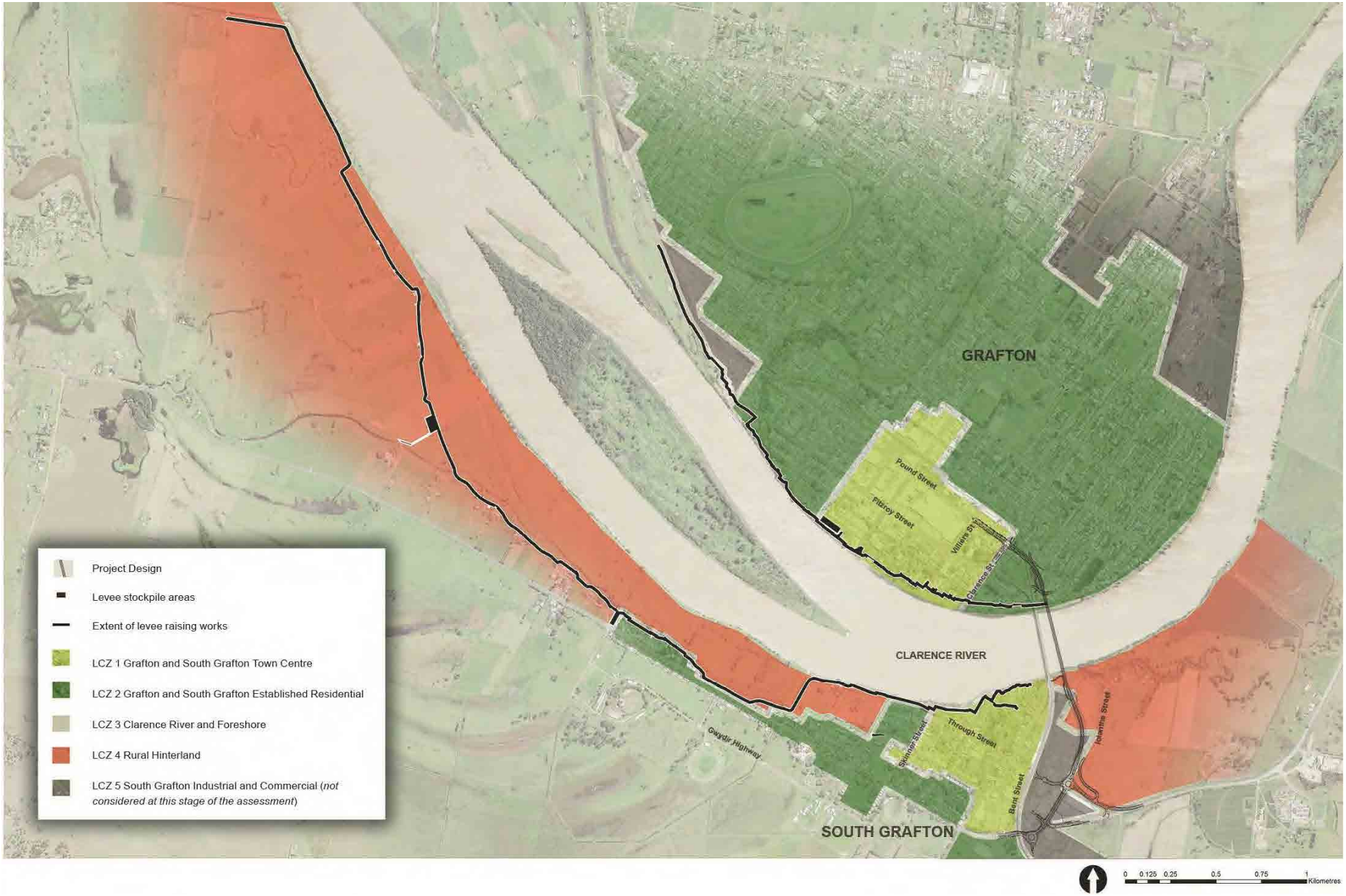


Figure 8-29 Landscape character zones relevant to the project

Existing views

The existing bridge is a key urban landmark that contributes significantly to the identity of Grafton and South Grafton. There are two primary types of views to the bridge: proximate views from the riverfront public spaces at Grafton and South Grafton, and long-range views from elevated vantage points throughout the district, primarily south of the Clarence River. The existing key viewpoints of the existing bridge in the context of the project are presented in Figure 8-30.

The views of the town from the existing bridge are also an important component of the urban experience, and provide a strong visual sense of the relationship between the town and the Clarence River. The best views from the bridge of the river and the adjoining foreshores are from the two pedestrian and cycle paths, located at the rail deck level on either side of the bridge. The views from the train are partially screened by the bridge's steel trusses, and motorists' views from the road deck are partially obscured by the bridge parapet.

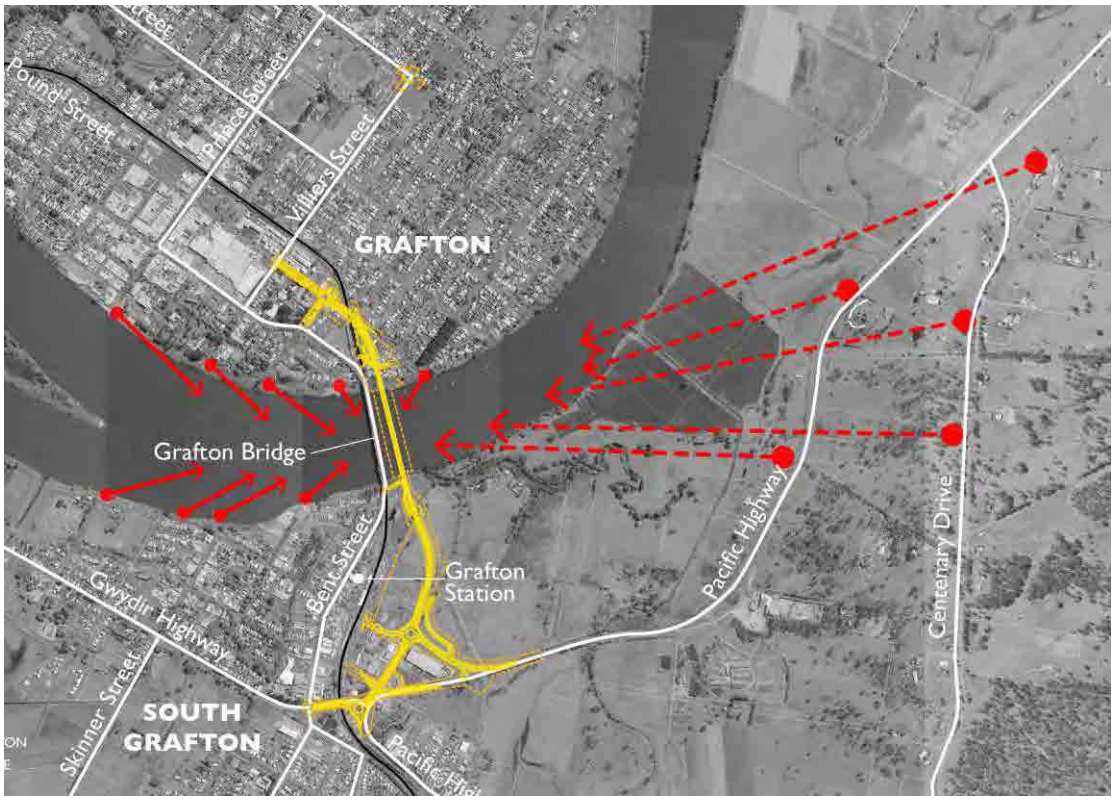


Figure 8-30 Key viewpoints from Grafton and South Grafton of the existing bridge in the context of the proposed project

8.8.3 Urban design principles and objectives

Eight urban design objectives were defined to guide the concept design and ensure the project is physically, visually and operationally integrated with the surrounding environment. These objectives are to:

- Achieve a project that fits sensitively with the existing qualities and characteristics of Grafton, South Grafton and its Clarence River setting
- Maintain the integrity of the existing urban character, particularly the physical and visual experience of the streetscape and street grid
- Protect the integrity of the heritage and cultural values of the Grafton area
- Protect the integrity of the existing State Heritage-listed Bridge as the pre-eminent structure in its setting

- Achieve an integrated road design form and character that blends with the adjoining areas
- Contribute to the accessibility and connectivity into and through Grafton and surrounding areas
- Create a project that facilitates future urban development and revitalisation along and surrounding the project area
- Enhance the quality and value of the public domain along and surrounding the project area.

The objectives underpin a series of principles that provide a high-level urban design response for each of the objectives. The urban design principles can be found in *Appendix J, Technical Paper: Urban Design and Landscape Concept Report (including landscape character and visual impact assessment)*.

8.8.4 Urban design and landscape concept

The project design process included understanding the built, natural and community character of Grafton and characteristics of the existing historic Grafton Bridge, analysing the impacts that a new crossing of the Clarence River in this location and associated road upgrades can make and identifying opportunities for mitigation and public space improvements, and articulating urban design principles and objectives.

The project design is the result of an integrated design approach in which a team of engineering, environmental, heritage and urban design specialists worked collaboratively to achieve a better integration of the project with Grafton and South Grafton and produce:

- An integrated design that best fits in with its context, complements the existing historic Grafton Bridge, minimises the impacts and mitigates the impacts that are unavoidable
- A proposed bridge design that is elegant and well considered in the whole, parts and detailed elements
- A new pedestrian and cycle path crossing of the river well connected into the pedestrian and cycle network of the town.

The urban design and landscape concept for the project are supported by an indicative planting schedule that provides the framework for detailed species selection and planting design during detailed design (refer to *Appendix J Technical Paper: Urban design and Landscape Concept Report*). The proposed planting would enhance the southern arrival to town, integrate the project into the landscape setting and further define and reinforce the landscape character zones. The final selection of plant species would be carried out in consultation with Clarence Valley Council, the local community and key stakeholders.

The key urban design and landscape components of the concept design are presented in Figure 8-31 and Figure 8-32 and summarised in the following sections.

Figure 8-31 Proposed urban design and landscape concept plan – Grafton

Note: Subject to further refinement during the detailed design stage

Figure 8-32 Proposed urban design and landscape concept plan – South Grafton

Note: Subject to further refinement during the detailed design stage

Grafton

On Pound Street and Clarence Street, a combination of tree planting (including semi-mature trees), formal garden beds, shrubs, groundcovers and turfed verges are proposed to provide a visual entry to Pound Street, provide shade to parking areas and screening (in the case of the proposed off-street car park). Tree plantings would also reduce the visual scale of the proposed road upgrades including the removal of a number of existing mature trees. Visually contrasting pavement material, such as permeable pavers, would be considered in the designated parking areas (subject to acceptance by Clarence Valley Council) to visually break up the large expanse of road pavement with a different texture and tone.

On the northern bridge approach road, the eastern embankment would be planted with native shrubs and groundcovers to soften the base of the road infrastructure and provide some screening of the road while still allowing views of the landscape for motorists. On the western side of the approach road, a fenced water detention basin would be installed and planted with native grasses to integrate it into the landscape.

The land between Greaves Street and the river foreshore would be grassed and planted with native trees to retain the existing character of the river foreshore.

Proposed bridge

The urban design concept for the proposed bridge has been developed in accordance with the *Bridge Aesthetics Design Guidelines* (Roads and Maritime, 2012), and in response to the requirements for road design, structural design, drainage design and lighting design.

Relationship to the existing bridge

The horizontal position of the proposed bridge is governed by the need to tie in with the alignment of Pound Street in Grafton and to minimise impacts on Alipou Creek and the existing sugar-loading facility in South Grafton. Within these constraints, the proposed bridge has been designed to be as parallel as possible to the existing bridge.

The proposed bridge piers have been designed to align as closely as possible with the piers of the existing bridge, especially those in the river.

The proposed bridge structure has been kept as low as possible over the river to allow the existing bridge to take visual precedence and to minimise the loss of views to the existing bridge. The height of the proposed bridge is also governed by:

- A need to allow for two navigation channels, 9.1 metres high at mean high water spring
- The span lengths between the piers have been determined by the positions of the piers on the existing bridge.

Given these parameters, the road level at the centre of the proposed bridge would be about 15.4 metres above the river at mean high water spring. This is roughly halfway between the levels of the road deck and the railway deck on the existing bridge.

Overall form

The proposed bridge would have a straight horizontal alignment that would reference the straight alignment of the existing bridge. The vertical alignment would be a continuous curve with a crest in the centre to facilitate stormwater drainage. The longitudinal grades have been kept as ‘flat’ as possible to complement the flat alignment of the existing bridge while also meeting the necessary drainage requirements.

Key urban design elements

The elements of the proposed bridge include:

- Girders: Spans 3 to 9 (refer to Figure 5-3) would have a single haunched box girder to reflect the long spans over the Clarence River; spans 1, 2 and 10 (refer to Figure 5-3) would have super-T girders about 1.2 metres deep to minimise the structural depth of the bridge over the existing ground in Grafton and South Grafton
- Bridge deck: The concrete bridge deck would be about 17 metres wide and would accommodate two vehicle lanes, shoulders, a median, a pedestrian and cycle path and barriers. The cantilevers would cast a shadow on the vertical face of the girder, helping it to visually recede and minimise its visual bulk
- Parapets: There would be simple, unarticulated, precast concrete parapets on both sides of the bridge. The parapets are designed to appear as crisp, uninterrupted, linear elements that extend the full length of the bridge to beyond the abutments, helping to emphasise the horizontal and to anchor both sides of the bridge beyond the shores of the river
- Piers: Three types of piers are required in response to the two different types of girder – simple concrete blade columns, twin concrete blade columns and single blade columns with a headstock over one half of the column (refer to Figure 5-4, Figure 5-5 and Figure 5-6, respectively)
- Pile caps: River pile caps would have a precast concrete skirt with rounded ends that reference the shape of the pile caps on the existing bridge. Land pile caps would be buried below the finished ground surface
- Bridge abutments: Abutments would be simple, robust and unadorned concrete structures in keeping with the character of the abutments of the existing bridges in Grafton
- Vehicle barriers: The barriers would be on the shoulders of both carriageways. They would be about 1.3 metres high. The barriers would be concrete under twin rail steel to enable views out to the river from the roadway. On the southbound (downstream) side of the bridge, the barrier would be integrated with the parapet and consistent with the traffic barrier on the opposing side
- Balustrades: Balustrades at the edge of the pedestrian and cycle path would provide safety for pedestrians and cyclists. They would be 1.4 metres high and integrated with the bridge parapets
- Lighting: Lighting on the bridge would meet the relevant standards. Lighting for navigational purposes may also be required on the piers.

South Grafton

On the southern bridge approach road, the eastern embankment would be planted with scattered stands of native trees to allow expansive views over the grazing land. On the western embankment, a native tree avenue would provide shade for pedestrians and cyclists and a visual identity for the bridge approach road. The eastern side of the embankment would be planted with pasture grasses to maintain the surrounding rural character.

On the proposed Pacific Highway diversion, pasture grasses would be planted on the verges and fill embankments to maintain the existing character of the highway. On the southern side of the highway, native trees would be planted to supplement existing plants; on the northern side, small stands would be planted to allow views over the grazing land.

The verges along the Gwydir Highway would be grassed and planted with Jacarandas, denoting the major entry point into South Grafton from the Pacific

Highway. New planting would supplement existing plants around the 'Grafton – A Tidy Town' sign.

On the eastern side of Iolanthe Street, native street trees would be planted where space permits. The verges of Through Street and Spring Street would be grassed and planted with native and exotic trees.

Proposed improvements to the southern town entry

Two new roundabouts, one at the Through Street and Iolanthe Street intersection and another at the Pacific Highway (south), Gwydir Highway and Iolanthe Street intersection would be the major entries to Grafton via the new bridge, and South Grafton from the Pacific Highway. The verges outside the roundabouts would be planted with feature trees (Jacarandas, Flame trees and Fire Wheel trees). Three Fig trees and low shrubs and groundcovers would be planted in the centre of the roundabouts to highlight their importance and to reduce the scale of the road infrastructure.

Directional signage would be provided to guide drivers to the Clarence River Visitor Information Centre and to Grafton.

8.8.5 Landscape character and visual assessment of potential impacts – construction

Landscape character impacts

Bridgework

During construction, there would be moderate to high adverse impacts on the following landscape character zones:

- Grafton and South Grafton town centres
- Established residential areas
- Clarence River and foreshore.

These impacts would be due to the demolition of houses, removal of trees and general construction work at the Pound Street ancillary site and construction work zones. The construction work over the Clarence River would impact the scenic character of the river setting and river traffic.

There would also be moderate to low adverse impacts on the following landscape character zones:

- South Grafton industrial and commercial
- Rural hinterland.

These impacts would be due to the construction of the South Grafton ancillary site for the construction work zone.

Levee raising works

During the levee raising works construction, there would be moderate to high adverse impacts at almost all landscape zones as the raising of the levee might involve the temporary closure and/or diversion of existing footpaths, removal of vegetation and presence of construction machinery, which would disturb the tranquility of the riverside setting. The exception would be the rural hinterland landscape zone where the temporary impacts would be low to moderate adverse. The landscape character impacts of this work would be subject to detailed design to determine the extent of vegetation removal and the contribution this vegetation has to the character of the area.

Visual impacts

Bridgework

During construction, there would be moderate to high adverse visual impacts. Ancillary sites and construction work zones would be visible to nearby receivers and motorists, pedestrians and cyclists travelling near the project. Bridge work would also be visible to the Clarence River and foreshore users as well as people travelling across the existing bridge.

Levee raising works

During the levee raising works construction, there would be low visual impacts for motorists, pedestrians and cyclists travelling on roads where the levee is visible; moderate impacts for residents whose houses overlook the levee; and moderate to high impacts for people using parks and public open spaces along the foreshore, the Sailing Club and Ex-Servicemen's Club and other recreational receptors. The visual impact would result from the presence of construction plant and equipment, stockpiles and in some cases from vegetation removal. The visual impact from the levee raising works would be subject to a detailed design to determine the extent of vegetation removal and the contribution this vegetation has to the character of the area.

8.8.6 Landscape character and visual assessment of potential impacts – operation

Landscape character impacts

Bridgework

A qualitative assessment of the magnitude, sensitivity and resulting impact on the landscape character zones is presented in Table 8-62.

The overall fabric of the historic town centres and streetscapes of Grafton and South Grafton would be kept largely intact. However, there are unavoidable high landscape impacts concentrated at Pound Street, Clarence Street and the residential area associated with proposed northern bridge approach road, to a zone of the Clarence River and foreshore where the project would seat. There would be:

- High impacts in the following landscape character zones: Grafton town centre and established residential, established residential, and Clarence River and foreshore. Foreshore areas required for the implementation of Council's waterfront master plan and related strategies are left untouched
- Moderate to low impacts in the following landscape character zones: South Grafton industrial, rural hinterland, and South Grafton industrial and commercial.

Levee raising works

The proposed levee raising works would have negligible to minor impacts on landscape character. Confirmation of the assessment would be subject to detailed design to determine potential design solutions and extent of change of the existing levee.

Visual impacts

Bridgework

A qualitative assessment of the magnitude, sensitivity and resulting visual impact for each of the viewpoints is presented in Table 8-63. The assessment found:

- Views to the existing bridge would be kept completely open from the important upstream viewpoints (refer to Figure 8-30). While visually blocked from the downstream side of the Clarence River and foreshores, due to the location of the proposed bridge, the obstructed views to the existing bridge are limited to a

single key viewpoint site and a series of distant ones. The design of the proposed bridge keeps it visually subservient to the existing historic Grafton Bridge

- High and high to moderate impacts in the town centre, residential areas, heritage areas, educational precincts, open space areas and the river setting, where the sensitivity to change is the highest and the magnitude of the work would be greatest
- Moderate and low visual impacts in areas that would be more distant from the work and in areas of lower sensitivity, such as South Grafton industrial area.

Photomontages illustrating how the project would fit in the existing setting and how the description of the magnitude and sensitivity are determined in the viewpoint assessment are presented in Figure 8-33, Figure 8-34, Figure 8-35 and Figure 8-36. Mitigation measures and strategies to help reduce the impact of the project are presented in Section 8.8.8).

Levee raising works

A qualitative assessment of the magnitude, sensitivity and resulting visual impact for each of the viewpoints to the proposed levee raising works is presented in Table 8-63. Key assessment findings as follows:

- Negligible impacts in viewpoints representing the views likely to be experienced by residents, cyclists and motorists as the assessment has assumed that the levee raising works near these receivers would be carefully designed to respond to the contours of the landscape. In the case of existing levee wall structures, the assessment has assumed the finish of the levee wall would be similar to the existing levee, with the potential to improve the appearance with the addition of a capping stone
- High to moderate impacts on Grafton Memorial Park and Rowing Club users as these viewers have a prolonged interest in the surrounding environment and focus on views across and along the Clarence River.

Confirmation of the potential impacts arising from the proposed levee work would be subject to a detailed understanding of the design solutions and extent of change of existing levee. Through the application of sensitive landscape design treatments and careful design consideration, the proposed work has the potential to be sympathetic and compatible with the existing landscape and visual amenity.

Table 8-62 Landscape character impact assessment

Zone	Magnitude (and rationale)	Sensitivity (and rationale)	Impact
LCZ1: Grafton town centre and established residential	High The project would increase the scale of road infrastructure in Pound and Clarence streets and require the removal of buildings and trees.	High This is a local community place with social, cultural, heritage and recreational values that is used by a high number of people.	High
LCZ2: Grafton established residential	High The project would increase the scale of road infrastructure in a limited area in this residential zone. Although impacts are localised, the demolition of houses (some of them heritage listed) and removal of trees would contribute to the high magnitude impact.	High This part of Grafton has strong heritage, social and cultural significance for local residents, cyclists, visitors and tourists.	High
LCZ3: Clarence River and foreshore	Moderate (upstream) High (downstream) The project would increase the scale of infrastructure on the river setting, which would be particularly visible from the downstream side.	High (upstream and downstream) This zone features the highly scenic river setting, the heritage listed bridge, Alipou Creek Aboriginal cultural values.	High to moderate
LCZ4: South Grafton industrial and rural hinterland	Moderate The proposed embankment would increase the scale of road infrastructure. However, its proximity to the existing road and rail embankment, the low scenic value of the nearby post-industrial land and proposed tree plantings would reduce the magnitude rating to moderate.	Low The project elements would be located in the transition zone between the rural and urban landscape of South Grafton.	Moderate to low
LCZ5: South Grafton industrial and commercial	Moderate The project would increase the scale of road infrastructure within this industrial/commercial zone. The proposed feature tree plantings in and around the roundabouts would help to reduce the visual scale of the work.	Moderate This zone attracts a relatively high number of viewers as it includes the Clarence River Visitors Information Centre, retail establishments and parks, and is at the intersection of two highways.	Moderate

Table 8-63 Visual impact assessment

Viewpoint	Magnitude (and rationale)	Sensitivity (and rationale)	Impact
Impact on views to the proposed bridge and road upgrades			
1	High This view would be impacted by the clearing of vegetation at the roundabout, increased road pavement on Pound Street and removal of trees in the middle ground and background. Proposed tree planting would mitigate the magnitude of the impact as they mature over time, however the works would greatly alter the existing views causing a high magnitude rating.	High Pedestrians, TAFE staff and students, residents and vehicle passengers would be affected by the changes to the view.	High
2	High The existing intersection would be replaced by a signalised intersection with two lanes provided in each direction with angle parking increasing the extent of road infrastructure. The majority of trees in this view, including some located on the TAFE campus, would be removed. New tree planting would mitigate the magnitude of the impact as they mature over time, although they would open the view to Grafton Shopping World in the short to medium term, but the magnitude rating would remain high.	High Pedestrians, TAFE staff and students, residents and vehicle passengers would be affected by the changes to the view, particularly local residents who would see the view often and because of the perceived cultural and heritage importance of the TAFE campus and the Fig and Jacaranda trees that would be removed.	High
3	High A number of changes to this view would result in a high magnitude impact. The existing intersection would be replaced by a signalised intersection. There would be a traffic island in the centre of the Clarence Street to provide 90º parking, which would dominate the centre of the street. The grass swales would be replaced with parallel and angled parking with formalised kerb and gutter. All existing street trees would be removed, and the house to the left of the viewpoint would be demolished, opening the view down the street. Mitigation would include new tree planting on the western side of Clarence Street and feature planting at the intersection, but the magnitude rating would remain high.	High Changes to the view would affect TAFE staff and students, residents, pedestrians, cyclists and passengers in cars. Motorists waiting at traffic lights at this intersection would also be affected and sensitive to the change.	High

Viewpoint	Magnitude (and rationale)	Sensitivity (and rationale)	Impact
4	Moderate The long view along Kent Street would be obstructed by the proposed planted embankment, traffic barriers and noise wall for the new approach road. The project would require the removal of all houses south-east of Pound Street and six heritage listed Jacaranda trees south-west of Pound Street. However, existing vegetation on Kent Street, to the left, would obscure much of the work.	High Local residents, cyclists and tourists (particularly those visiting during the Jacaranda Festival) would be affected by the project, which would alter the attractive view along the Jacaranda-lined street with grassed shoulders and verges, by revealing the new approach road embankment and infrastructure.	High to moderate
5	Moderate The view of the proposed bridge superstructure and barriers would be partially obscured by the existing bridge from this location. The elements of the bridge that would be visible include the piers and pile caps, and part of the abutment on the southern foreshore. Vehicles, particularly trucks, would be visible through the existing bridge as they cross over the proposed bridge.	High Changes to this view would affect sailing club users and pedestrians whose attention is generally focussed on the river and its surrounds for reasonably long periods of time in the direction of the existing and proposed bridges.	High to moderate
6	High From this location, the proposed bridge would be in front of the existing (historic) bridge and would be highly visible. All components of the bridge would be visible and would block the view to a large portion of the existing bridge.	High Changes to this view would affect pedestrians and tourists who visit this public park to enjoy the panoramic views over the river and towards the existing bridge. This view has high cultural and historical significance for these viewers.	High
7	High All elements of the proposed bridge would be highly visible from this location. On the northern side, three houses and a number of native trees would be removed to build the bridge and pump station. On the southern side, a number of mature trees including the Jacarandas and She-Oak on the foreshore and the large Fig trees beyond, would be removed. The proposed bridge would also obscure the downstream views of the river and rural hinterland beyond. Mitigation measures would include new native tree planting along the existing levee and beside the approach roads, but the magnitude rating would remain high.	High Changes to this view would affect pedestrians crossing the bridge and train passengers who currently enjoy attractive views along the river and foreshore. The relatively long time that pedestrians have to focus on these views contributes to the high sensitivity rating.	High

Viewpoint	Magnitude (and rationale)	Sensitivity (and rationale)	Impact
8	High The proposed bridge would be built in front of the existing bridge and would be highly visible from this location. All components of the bridge would be visible and would block the view to a large portion of the existing bridge. The foreshore areas would also be visually impacted where the bridge approaches the abutments, requiring the removal of houses and trees.	High Changes to this view would affect people enjoying recreational activities on the river who currently enjoy attractive views of the existing bridge, which has high cultural and historical significance. The relatively long time they have to focus on these altered views contributes to the high sensitivity rating.	High
9	Moderate The embankment for the proposed bridge approach road would be highly visible from this location. Vehicles travelling on the approach road would be clearly visible and trucks would potentially break through the skyline in some locations.	Moderate Changes to this view would affect residents in Butters Lane travelling to and from their properties. The sensitivity is moderate due to their distance from the project and the existing view, which comprises rural landscape in the foreground, and industrial infrastructure (including a sugar loading facility and communications tower) in the background.	Moderate
10	Low Although the foreground trees would partially obscure the view, the approach road would be visible across the full width of this view. Vehicles travelling on the proposed approach road would also be visible from the platform. The embankment would be seeded with native grasses and planted with native trees. During construction, land in the foreground would be used as a concrete casting area for the new bridge.	Moderate Changes to this view would affect locals and tourists at Grafton Railway Station, which is a State listed heritage site and a key arrival point. The relatively long time that viewers have to focus on these views contributes to the moderate sensitivity rating.	Moderate to low
11	Moderate The proposed large two-lane roundabouts and approach roads would be the dominant project element visible from this location and would almost double the extent of visible road pavement. The ability to include feature trees around the outside of the intersection as well as a Fig tree and ground cover planting in the centre of the roundabout would result in a moderate rating.	Moderate Changes to this view would affect people viewing the memorial. The sensitivity would generally be moderate as their attention would be more focussed on the memorial and because a smaller intersection already exists in this location.	Moderate

Viewpoint	Magnitude (and rationale)	Sensitivity (and rationale)	Impact
12	Low The proposed bridge would be the main project element visible from this location. It would obscure the lower section of the existing bridge, and the removal of vegetation on both foreshores would potentially be noticeable. However, this vegetation would be replaced by similar species.	Low Changes to this view would have a minor effect on residents and motorists due to their distance from the project elements.	Low
Impact on views to the proposed levee raising works*			
1	Negligible It is assumed that the levee raising works near the properties would be carefully designed to respond to the contours of the landscape. Once the embankment seeding has established, it is assumed there would be a negligible change to the existing view.	High Changes to this view would affect residents, who are considered to have an inherent level of visual sensitivity due to their prolonged interest in the surrounding environment, particularly in rooms normally occupied in waking hours or daylight hours.	Negligible*
2	Moderate The magnitude of the change to the existing levee would be moderate provided the raised levee retains the mature vegetation and limits alterations to the Grafton Memorial Park and Rowing Club pillars (by for example, realigning the levee to the southern edge of the existing footpath).	High Changes to this view would affect people enjoying recreational activities, who are considered to have an inherent level of visual sensitivity due to their prolonged interest in the surrounding environment and focus on particular views – in this instance, views across and along the Clarence River.	High to Moderate*
3	Negligible It is assumed that the finish of the levee wall would be similar to the existing levee, with the potential to improve the appearance with the addition of a capping stone.	Moderate Changes to this view would affect cyclists and motorists, who are considered to have a reduced sensitivity to change largely due to the transient views that they are likely to experience. Street users would generally have moderate sensitivity as their attention would be more focussed on the road and the Clarence River in the background rather than the levee.	Negligible*

* Note: Confirmation of the potential impacts arising from the proposed levee raising works would be subject to a detailed understanding of the design solutions and extent of change of existing levee. Through the application of sensitive landscape design treatments and careful design consideration, the proposed work has the potential to be sympathetic and compatible with the existing landscape and visual amenity.

Existing view

Photomontage at the year of opening

Figure 8-33 Viewpoint 2: Foreground view of Pound Street and Clarence Street, Grafton

Note: Photomontage is for indicative purposes only and provides an indication of the bulk and scale of the project. The project is subject to further refinement during the detailed design stage.

Existing view

Photomontage at the year of opening

Figure 8-34 Viewpoint 4: Foreground view of the existing bridge, Grafton

Note: Photomontage is for indicative purposes only and provides an indication of the bulk and scale of the project. The project is subject to further refinement during the detailed design stage.

Existing view

Photomontage at the year of opening

Figure 8-35 Viewpoint 6: Foreground view of the existing bridge and the Clarence River

Note: Photomontage is for indicative purposes only and provides an indication of the bulk and scale of the project. The project is subject to further refinement during the detailed design stage.

Existing view

Photomontage at the year of opening

Figure 8-36 Viewpoint 7: Foreground downstream views from the existing bridge

Note: Photomontage is for indicative purposes only and provides an indication of the bulk and scale of the project. The project is subject to further refinement during the detailed design stage.

8.8.7 Assessment of potential impacts – overshadowing

The proposed bridge would overshadow areas that are currently not in shadow. The greatest overshadowing impacts would most likely be on the Clarence River due to the height, width and length of the proposed bridge deck over the river. The overshadowing of the river is unlikely to impact any river users or activities occurring on the water. However, overshadowing impacts of the proposed new bridge on the river and foreshore areas would be limited and transient. No overshadowing impacts would occur on residences.

The overshadowing impact would decrease on the northern and southern foreshores due to the reduced height of the bridge above the land in these locations. In addition, the impact would likely be relatively temporary as people would be mostly moving through the area. However, there is potential for the southern foreshore to have increased pedestrian and cycle activity which would be subjected to the increased overshadowing during the morning in winter.

For more information, refer to the overshadowing diagrams in *Appendix J, Technical Paper: Urban design and landscape concept report* (including Landscape Character and Visual Impact Assessment).

8.8.8 Environmental management measures

Management measures incorporated into the project design

Mitigation measures are incorporated into the concept design of the project to protect and enhance the visual character of the Grafton area, and the Clarence River and floodplain, where possible. Mitigation measures also create new landscaped open spaces, distinctive town entry points, plantings, landscaped parking arrangements and pedestrian and cyclist connections.

These measures include:

- Plantings to provide visual landmarks and to enhance visual identity
- Plantings to compensate for tree loss and to help reduce the visual scale and dominance of project elements
- Providing site specific finishings on the proposed retaining wall to relate to the character of the surrounding landscape
- Revegetating the foreshores to help integrate the scour protection work on the foreshore
- Designing the proposed bridge to ensure the existing bridge retains its visual precedence and has a complementary relationship with the proposed bridge. This would be achieved by:
    - Keeping the proposed bridge as low as possible while still allowing for the required navigation clearances
    - Allowing the existing bridge truss structure to be visible both above and below the proposed bridge
    - Designing the proposed bridge with a simple, streamlined and contemporary appearance that respects and retains the visual integrity of the existing bridge
    - Adopting a haunched superstructure to minimise the visual bulk of the proposed bridge
    - Aligning the piers on the proposed bridge with the piers on the existing bridge as much as possible
    - Keeping the exposed pile caps on the piers of the proposed bridge similar to the pile cap detailing on the existing bridge.

- Improving pedestrian access by providing new paths and upgrading existing paths (including pedestrian and cycle paths)
- Reducing visual dominance by investigating alternative types and colours of paved surfaces.

Environmental management measures

Further work would be carried out during detailed design to further refine the design of the project to produce enhanced urban design outcomes. The project's urban design objectives and principles – together with the urban design, landscape and bridge design concept – would be used to further guide the detailed design of key project elements of the proposed bridge, approach roads and public domain areas.

Key mitigation and management measures that would be considered during detailed design of the project are presented in Table 8-64.

Table 8-64 Environmental management measures for visual amenity, built form and urban design impacts

Impact	Environmental management measure	Responsibility	Timing
Impacts in Grafton	Detailed design will investigate opportunities to: • Refine car parking arrangements on the southern side of Pound Street • Adjust the kerbline along Pound Street between Clarence Street and Villiers Street. This would enable extra tree planting on both sides of the street and the removal of proposed parallel parking on the southern side. This would improve the visual and pedestrian amenity, reduce the scale of the street and reduce the encroachment of works in TAFE land • Reduce the batter steepness around the water detention basin to avoid the need for fencing • Reduce the construction boundary to reduce impacts on Pound Street and Greaves Street • Refine the drainage detention basin design in Grafton to minimise its visual impact.	Roads and Maritime	Detailed design

Impact	Environmental management measure	Responsibility	Timing
Proposed bridge	During detailed design, the pier designs will be developed to further reinforce the complementary relationship between the proposed bridge piers and the piers on the existing bridge. In particular, the option of tapering the piers at their long elevation will be considered. In addition, opportunities will be considered to further streamline the appearance of the bridge, including: • Aligning the edges of the piers with the outside faces of the girders • Investigating monolithic construction as an alternative to the current pier design • Ensure the proposed bridge soffit appears as a series of continuous curves with a segmented appearance to be avoided.	Roads and Maritime	Detailed design
Impacts in South Grafton	Detailed design will consider: • Flattening the fill embankments to the bridge approach road to better integrate it with the surrounding flat rural landscape • Opportunities to enhance the location's role as the southern arrival point to South Grafton and Grafton • Incorporating safe and efficient bicycle access on the Iolanthe Street / Pacific Highway / Through Street roundabout and the Gwydir Highway / Pacific Highway roundabout to allow a connection to the regional Coastline Cycleway route on the Pacific Highway.	Roads and Maritime	Detailed design

Impact	Environmental management measure	Responsibility	Timing
Flood mitigation impacts	Consideration should be given to undertaking an arborist assessment to inform the design development and optimum levee alignment. Where the levee has existing structures (eg a building) a specific levee raising design will be required. Where feasible and reasonable, the design will: • Investigate opportunities to avoid changes to the existing structure (eg minor realignment of the levee crest) • Keep changes to the existing structure to a minimum • Identify a construction method that will keep the structure operational while construction work is being carried out (subject to safety considerations). Roads and Maritime will consult with the infrastructure owners during detailed design. For heritage listed items, the design will seek to avoid or minimise the need to modify the structure and investigate non-intrusive options to achieve the required levee level. Levee raising materials and finishes will be sympathetic to minimise impact on the significance of the heritage item.	Roads and Maritime	Detailed design

Impact	Environmental management measure	Responsibility	Timing
Construction impacts	Detailed design and documentation drawings will define the extent of all construction activity, including temporary work, to protect the area during construction. Construction facilities will be contained within the construction work zone and occupy the minimum area practicable for the intended use. Suitable barriers will be erected to screen views from nearby areas. Work sites will be returned to at least their pre-construction state once work is complete, or progressively reinstated throughout the construction process, where possible. Pollution and dust emissions will be minimised and monitored throughout the construction period (refer to Section 8.12). Footpaths affected by construction activities will be diverted or re-routed. Trees to be retained within construction facilities areas will be identified, protected and maintained. Temporary lighting will be screened or diverted to reduce unnecessary light spill. Material used for temporary land reclamation will be removed once construction is complete.	Construction contractor	Pre-construction Construction

8.9 Biodiversity

This section presents an assessment of the potential direct and indirect impacts of the project on biodiversity and identifies mitigation and management measures to minimise and reduce these impacts.

The assessment presented in this section draws on information in the biodiversity report prepared for this EIS (refer to *Appendix L, Technical Paper: Flora and Fauna Assessment* (Biosis, 2014)).

Table 8-65 lists the Director-General's environmental assessment requirements relevant to biodiversity and where they are addressed in this chapter.

Table 8-65 Director-General's environmental assessment requirements relevant to biodiversity

Director General's environmental assessment requirements	Where addressed in EIS
An assessment of the potential (direct and indirect) ecological impacts of the project, with specific reference to vegetation and habitat clearing, connectivity, edge effects, riparian and aquatic habitat impacts and soil and water quality impacts. The assessment of these impacts must:	
- detail the existing environment, including discussion of flora and fauna characteristics to be affected by the proposal,	Section 8.9.2
- make specific reference to impacts on threatened species, populations and endangered ecological communities, and any Rare or Threatened Australian Plant species,	Section 8.9.2
- consider impacts to the receiving environment, including adjoining waterways, riparian vegetation and aquatic habitats. This must include consideration of water quality, marine vegetation, fish passage, soil types (including salinity), erosion and sedimentation, weed management and ongoing water management,	Section 8.9.3 and Section 8.9.4 Soil types (including salinity), erosion and sedimentation are addressed in Section 8.10
- identify appropriate avoidance, mitigation and management measures, including details of alternative options considered, and proposed arrangements for long-term management,	Section 8.9.5
- take into account the draft Guidelines for *Threatened Species Assessment* (Department of Environment and Conservation/Department of Primary Industries 2005), *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (Department of Environment and Conservation 2004), and the *Guidelines for Aquatic Habitat Management and Fish Conservation* (Department of Primary Industries 1999), and	Section 8.9.1 Note the *Guidelines for Aquatic Habitat Management and Fish Conservation* (update 2013) have been taken into account for this assessment
- include details of any offset of ecological impacts and native vegetation clearing, taking into account the *Principles for the use of biodiversity offsets in NSW* (Department of Environment, Climate Change and Water 2008).	Section 8.9.3

Director General's environmental assessment requirements	Where addressed in EIS
A detailed description of the project, including vegetation clearing	Vegetation clearing: Section 8.9.3. Project description: Chapter 5 and Chapter 6.

8.9.1 Assessment methodology

The project has been assessed in relation to key biodiversity legislation and policy including:

- *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- *NSW Threatened Species Conservation Act 1995* (TSC Act)
- *NSW Fisheries Management Act 1994* (FM Act)
- *NSW Noxious Weeds Act 1993* (NW Act)
- *NSW Native Vegetation Act 2003* (NV Act)
- *NSW Environmental Planning and Assessment Act 1979* (EP&A Act), including:
  - *State Environmental Planning Policy No. 44 – Koala Habitat Protection*
  - *State Environmental Planning Policy No. 14 – Coastal Wetlands*
  - *Clarence Valley Local Environmental Plan, 2011*.

The assessment has also been carried out in accordance with the *Draft Guidelines for Threatened Species Assessment* (DEC & DPI, 2005). The *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI, 2013) have been used instead of the *Guidelines for Aquatic Habitat Management and Fish Conservation* (Department of Primary Industries 1999).

Biodiversity study area

Information about flora and fauna within about 10 kilometres of the project area was obtained from relevant public databases to provide a context for the study area.

Aquatic fauna record searches were conducted for the Northern Rivers basin/catchment.

Other sources of biodiversity information, investigations, listings and reports were also reviewed including:

- *Main Road 83 Summerland Way Additional Crossing of the Clarence River at Grafton: Preliminary Route Options Report. Technical Paper: Ecology* (Biosis, 2011)
- *Main Road 83 Summerland Way – Additional Crossing of the Clarence River at Grafton: Route Options Development Report. Technical Paper: Ecology* (Biosis, 2012).

Field survey methods employed for the assessment comply with the *Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities – Working Draft* (DEC, 2004) and the biodiversity assessment guidelines in *Environmental Impact Assessment Practice Note* (Roads and Maritime, 2013).

Terrestrial and aquatic flora and fauna surveys were designed to identify the extent and quality of native vegetation, fauna habitats and species diversity. Threatened biodiversity with a moderate to high likelihood of occurrence were targeted during field surveys. Detailed information on the field survey effort and methodology is presented in *Appendix L Technical Paper: Flora and Fauna Assessment*.

Assessments to determine the significance of impacts for a range of TSC Act, FM Act and EPBC Act listed threatened ecological communities, threatened flora and fauna species and migratory fauna are presented in *Appendix L Technical Paper: Flora and Fauna Assessment*.

Mitigation measures were identified to manage impacts in accordance with the *Biodiversity Guidelines:* P*rotecting and Managing Biodiversity on RTA Projects* (Roads and Maritime, 2011).

8.9.2 Existing environment

Terrestrial flora

Vegetation communities and threatened ecological communities

The vegetation communities in the project area can be broadly categorised into four types:

- Freshwater Wetlands on Coastal Floodplains (listed in the TSC Act as endangered): This community was recorded within the project area mostly as narrow linear patches along the banks of the Clarence River and up and down stream in disjointed patches. It was also recorded within a number of the floodgate channels along the length of the levee and within some wet depressions adjoining the Clarence River. However, these were located outside the project area. This community was found to be in poor condition with heavy infestation of exotic species due to surrounding land uses
- Subtropical Coastal Floodplain Forest (listed in the TSC Act as endangered): This community is limited to isolated degraded patches of remnant vegetation. The largest patch in the project area is about 1500 metres upstream of the existing bridge, on the northern bank of the river. This community was found to be in poor condition due to a history of disturbance, including residential and urban development, grazing and construction of the existing levee
- Native and exotic plantings: This vegetation community comprises a high level of exotic canopy species and native species that are not endemic to the locality. It typically encompasses roadside verges and nature strips where planted jacarandas (*Jacaranda mimosifolia)* and Moreton Bay fig (*Ficus macrophylla)* are thriving
- Weeds and exotics: This vegetation community occurs throughout the project area among the native and exotic plantings community. The species composition varies according to land use, with exotic grasses dominant within mown areas and annuals and shrubs dominant through the riparian sections adjoining the Clarence River.

The distribution of these communities in relation to the project area is shown in Figure 8-37 and Figure 8-38.

Threatened flora species

The habitat assessment carried out for the project indicated that one threatened flora species, Hairy-joint Grass, *Arthraxon hispidus*, is considered to have a moderate to high likelihood of occurrence. The Freshwater Wetlands on Coastal Floodplains community was identified as providing marginal potential habitat for this species. Field surveys carried out for the project have not found evidence of this species within the project boundary.

It should be noted that Frogbit, *Hydrocharis dubia*, was previously listed as vulnerable under the EPBC Act and was the subject of targeted surveys as part of the project's fieldwork. This species was delisted as of 3 December 2013 (Commonwealth of Australia, 2013). Potential marginal habitat for Frogbit was identified within the project area; however, following removal of the species from the vulnerable list, potential impact on the species has not been considered further.

No rare or threatened flora species were recorded in the study area (within 10 kilometres of the project area).

Noxious weeds

Thirteen flora species recorded across the study area (within 10 kilometres of the project area) are listed as noxious weeds in the Clarence Valley local government area. These weeds are generally located along the banks of the Clarence River and within the paddocks traversed by the levee.

One of the weed species listed as noxious, Crack Willow, *Salix fragilis,* is a notifiable weed under Part 3 of the *Noxious Weeds Act 1993*.

Endangered populations

A desktop review for endangered flora populations (listed under the TSC Act) was carried out. No listed endangered flora populations were recorded or are predicted to occur within 10 kilometres of the project area.

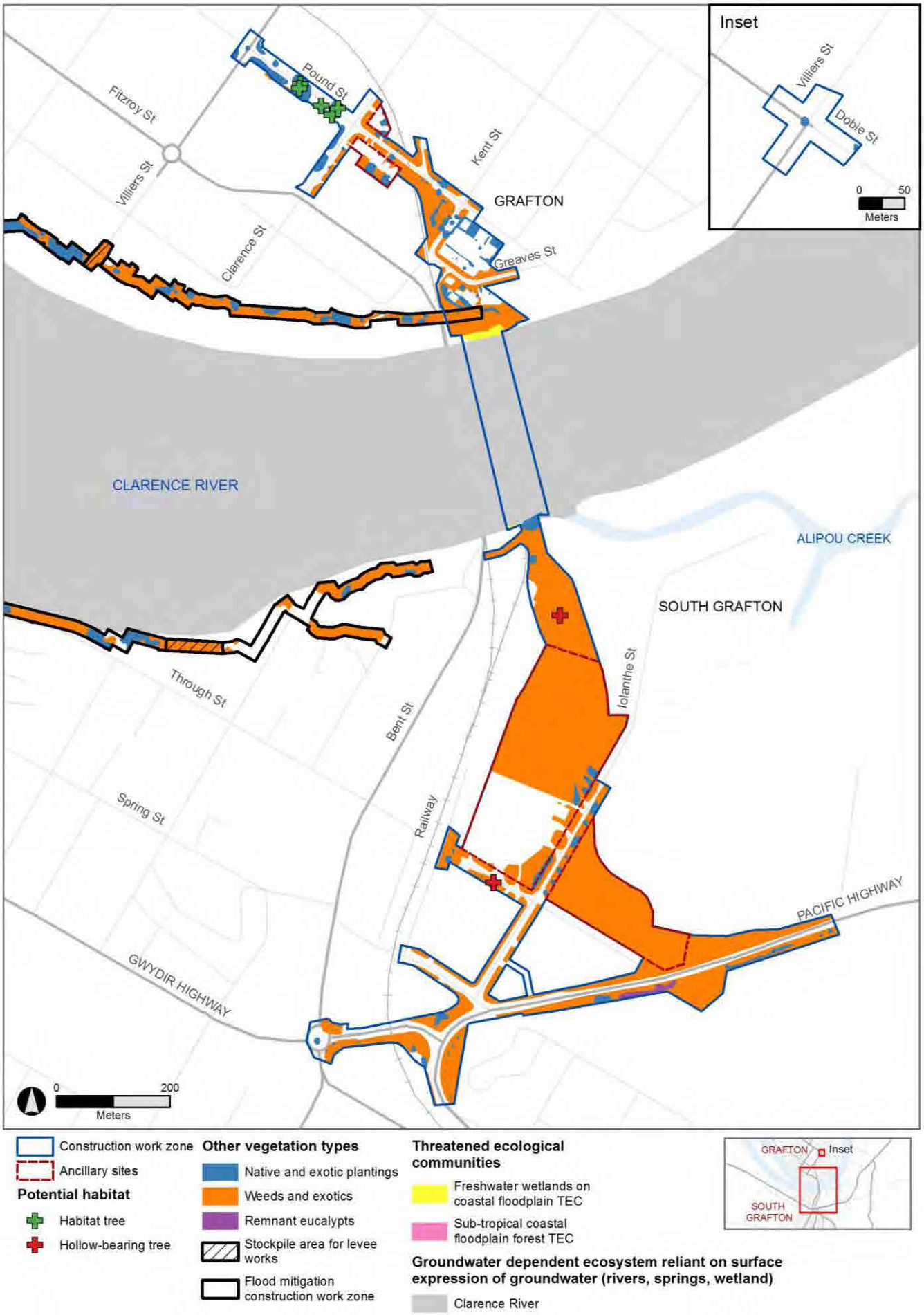


Figure 8-37 Vegetation communities and values in the project area (including the flood mitigation works) showing details within Grafton and South Grafton

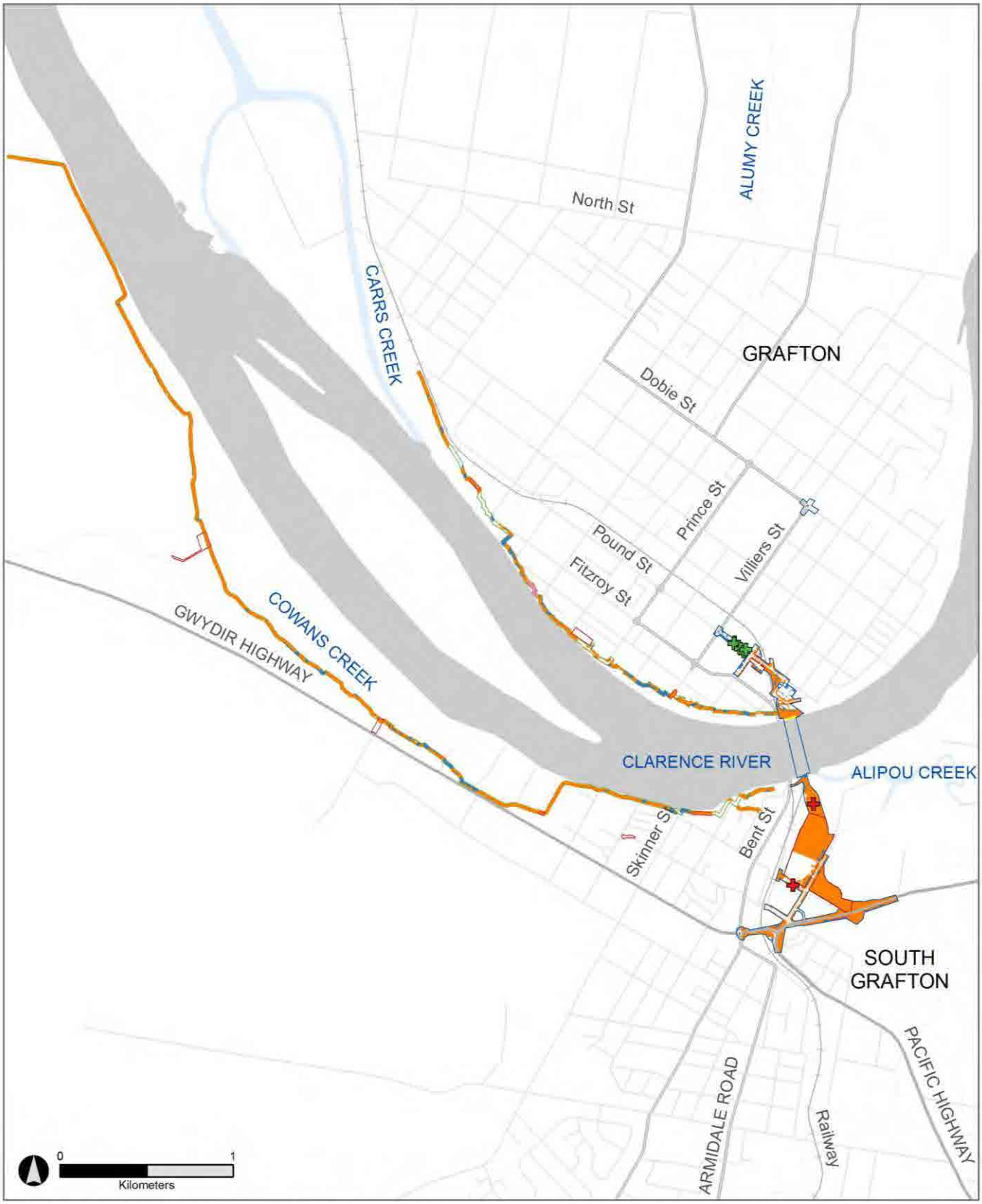


Figure 8-38 Vegetation communities and values in the project area (including the flood mitigation works)

Terrestrial fauna

Threatened fauna

Nineteen threatened fauna species are known to occur or are considered to have the potential to occur in the study area based on regional records, literature reviews and the presence of suitable habitat. These species are documented in *Appendix L: Technical Paper: Flora and Fauna Assessment*. Of these 19 species, nine threatened fauna species were recorded during field surveys:

- Masked Owl, *Tyto novaehollandiae*
- Hoary Wattled Bat, *Chalinolobus nigrogriseus*
- Little Bent-wing Bat, *Miniopterus australis*
- Eastern Bent-wing Bat, *Miniopterus schreibersii oceanensis*
- Eastern Freetail-bat, *Mormopterus norfolkensis*
- Southern Myotis, *Myotis macropus*
- Grey-headed Flying-fox, *Pteropus poliocephalus*
- Greater Broad-nosed Bat, *Scoteanax rupelli*
- Eastern Cave Bat, *Vespadelus troughtoni*.

Migratory fauna

Six migratory species are considered to have a high potential to use habitats within the study area based on the availability of suitable habitat in the locality:

- Cattle Egret, *Ardea ibis*
- Clamorous Reed-warbler, *Acrocephalus stentoreus*
- Common Tern, *Sterna hirundo*
- White-bellied Sea-eagle, *Haliaeetus leucogaster.*
- Rainbow Bee-eater, *Merops ornatus*
- Glossy Ibis, *Plegadis falcinellus*

State Environmental Planning Policy 44 – Koala habitat protection

Existing Forest Red Gum *Eucalyptus tereticornis* within the study area are not considered to be suitable habitat to support breeding or foraging activities of a population of Koalas.

Fauna movement corridors

The project area is not near any areas classified as regional 'significant vegetated corridors' or 'stepping stone corridors and priority restoration areas' as identified in the *Clarence Valley Council Biodiversity Management Strategy* (Wright, 2010).

The Clarence River represents a corridor for diadromous fish species (fish that migrate from freshwater to saltwater or vice versa, to complete life cycles). Locally occurring freshwater fish are likely to use the Clarence River to migrate to and from spawning sites and exploit resources throughout the system.

Endangered populations

The desktop review of endangered populations listed under the TSC Act identified one endangered fauna population associated with the study area, the Emu population *Dromaius novaehollandia* in the NSW North Coast Bioregion and Port Stephens local government area. Four records of this endangered population occur within 10 kilometres of the project area, with the closest record within one kilometre. However, there are no records of Emu sightings within the project boundary, and they are unlikely to come so far west of their normal range.

Aquatic ecology

Two threatened fish species listed under the FM Act are considered to have a moderate likelihood of occurrence within the study area based on previous records and correspondence with Department of Primary Industries (Fisheries) (NSW DPI, 2013, Butler pers. comm.):

- Purple-spotted Gudgeon, *Mogurnda adspersa*
- Silver Perch, *Bidyanus bidyanus* (this species is also listed as critically endangered under the EPBC Act).

No aquatic vegetation or seagrasses (*Posidonia* sp.) are considered likely to be present in the Clarence River where the proposed bridge would be located (Roads and Maritime received this advice during consultation with the Seagrass Working Group on 8 November 2014).

State Environmental Planning Policy 14 – Coastal Wetlands

The closest wetland listed under this policy is wetland number 292 located eight kilometres to the east of the project area. It is part of the Upper Coldstream Wetlands, associated with Coldstream River and Pillar Valley Creek.

Groundwater-dependent ecosystems

In the project area, there are two vegetation communities and habitats that have the potential to be affected by impacts on groundwater (Figure 8-37 and Figure 8-38):

- Freshwater Wetlands on Coastal Floodplains
- Subtropical Coastal Floodplain Forest.

The Atlas of *Groundwater Dependent Ecosystems* (Bureau of Meteorology, 2014) identifies the following groundwater-dependent ecosystems within the study area:

- The Clarence River, as a groundwater-dependent ecosystem reliant on surface expression of groundwater (rivers, springs, wetland)
- Vegetation, as a groundwater-dependent ecosystem reliant on subsurface groundwater, which is identified as having a high, moderate and low potential for groundwater interaction.

8.9.3 Assessment of potential impacts - construction

Impacts on flora

Impacts on threatened ecological communities and riparian vegetation

Project construction would require the clearing of 0.41 hectares of threatened ecological communities, comprising:

- About 0.31 hectares (3100 square metres) of Subcoastal Floodplain Forest
- About 0.1 hectares (1000 square metres) of Freshwater Wetlands on Coastal Floodplains.

Freshwater Wetlands on Coastal Floodplains and Subtropical Coastal Floodplain Forest comprises the riparian vegetation that would be impacted by the project.

Assessments to determine the significance of impacts for Subcoastal Floodplain Forest and Freshwater Wetlands on Coastal Floodplains found that the impacted areas are considered to be of relatively low regional and local importance based on the small patch size, degraded nature of the examples within the project area and their location within a peri-urban area (peri-urban areas are the non-urban areas close to cities and towns).

Biodiversity offsets have been considered taking into account the *Principles for the use of biodiversity offsets in NSW* (Department of Environment, Climate Change and

Water 2008). Offsets would not be required given that the amount of threatened ecological communities to be cleared is minimal in nature and that the project would not clear native vegetation or threatened species and/or threatened species habitat of very high conservation value. Also, the existing communities are already highly disturbed and in a degraded condition, and thus of low value.

Impacts on threatened flora species

No threatened flora species were recorded within the study area, so it is not anticipated that the project would have any significant impacts on threatened flora species or their habitat.

The TSC Act assessment of significance carried out for Hairy-joint Grass concluded that the project would have a minimal impact on this species or its potential habitat in the locality, and that neither a species impact statement nor a referral under the provisions of the EPBC Act are recommended.

Potential spread of noxious weeds

Vegetation removal, construction vehicles, plant and equipment have the potential to spread or introduce noxious weeds to the project area. Management measures to minimise the potential spread of noxious weeds are presented in Section 8.9.5.

Impacts on fauna

Impacts on threatened and migratory fauna

Project construction has the potential to impact on threatened species by causing any of the following:

- Death or injury of individuals
- Loss or disturbance of limiting foraging and breeding resources
- Removal of two hollow-bearing trees and five habitat trees (the location of these trees is shown in Figure 8-37).

Based on the precautionary principle construction of the project would include staged clearing of the two hollow-bearing and five habitat trees, to reduce the risk of fauna mortality associated with their removal.

Seven-part tests under the TSC Act were carried out for threatened fauna species recorded during field surveys and fauna species considered to have a moderate to high likelihood of occurrence in the project area. These concluded that the construction of the project is unlikely to have a significant effect on any of these species.

Similarly, the EPBC Act significant impact criteria assessments were carried out for Grey-headed Flying-fox, Three-toed Snake-tooth Skink and listed migratory species. These concluded that the project is unlikely to have a significant impact on any of these species.

There are various permanent Cattle Egret breeding colonies around Grafton (with the closest one to the project area on the corner of Kitchner and Price Street), but the project would not have any direct, or significant indirect, impact on this species.

The project would not directly impact on breeding colonies or any migratory species recorded within the project area.

It is unlikely there would be a significant impact on the endangered Emu population recordered within 10 kilometres of the project area as is it is unlikely the population would come so far west of their normal range.

Impacts on Koala habitat

A habitat assessment was carried out for the study area in accordance with the Interim Koala Referral Advice for Proponents (DSEWPaC, 2012) and State

Environmental Planning Policy 44 criteria. The results of the habitat assessment indicated the presence of one preferred feed tree species for the Koala within the study area – Forest Red Gum.

The habitat assessment indicated it is unlikely that the project area supports (or could support) a population of Koalas, and the species is considered to have a low likelihood of occurrence in areas flagged as potential Koala habitat within the project area. Furthermore, no individual Forest Red Gum trees are proposed to be removed, so the potential direct impact of the project on Koalas would be negligible.

Impacts on wildlife connectivity and habitat fragmentation

The project area is largely isolated from those optimal habitats and regional corridors occurring within the Clarence Valley local government area. The landscape surrounding the project area has been substantially modified and is now an urban landscape of mainly residential developments, farming lands and associated road infrastructure where habitat is fragmented.

Therefore, the construction of the project would not result in impacts on regional fauna corridors or habitat fragmentation.

Impacts from construction noise, vibration and light

Construction noise, vibration and lighting from ancillary sites and construction zones have the potential to impact native fauna species. However, given the existing levels of noise, vibration and light from Grafton and South Grafton, the increase above existing levels is unlikely to be substantial enough to result in any significant impacts on native fauna species.

Impacts on aquatic ecology

Impacts on aquatic habitat and species

The construction of the project is unlikely to have a significant impact on aquatic habitat and species. This is because:

- Potential construction impacts on aquatic habitat would be temporary and confined to areas occupied by the bridge foundations and abutments
- Erosion and sediment control measures (refer to Section 8.10) would minimise potential impacts on water quality, which would otherwise have the potential to affect aquatic species and their habitat
- The proposed river-based construction activities or structures are not considered to be barriers to the fish passage along the Clarence River
- FM Act assessments of significance were completed for Purple-spotted Gudgeon and Silver Perch. The assessments concluded that the project would have a minimal impact on these species and their potential habitat and determined that a species impact statement is not necessary for these fish species. An EPBC Act assessment for Silver Perch also concluded that the project is unlikely to have a significant impact on this species, and a referral to the Federal Environment Minister is not considered necessary.

Impacts on listed coastal wetlands

The project is unlikely to impact any listed *State Environmental Planning Policy 14 – Coastal Wetlands* given the distance between the nearest wetland and the project area and the erosion and sediment control measures proposed during construction (refer to Section 8.10).

Impacts on groundwater-dependent ecosystems

Given the likely high dependence of vegetation communities in the study area on groundwater, and the proximity of construction to the Clarence River, the proposal

has some potential to impact groundwater-dependent ecosystems. However, the risk of impact during construction is considered to be low because:

- There would be only a minor amount of cutting, and sections of cutting would be less than two metres deep
- Construction piling would be confined to the areas occupied by the bridge foundations and piers
- Vegetation communities and habitats that have the potential to be affected by impacts on groundwater are located away from cuttings and piling operations
- No dewatering is proposed
- The groundwater flow is likely to be towards the river, so the project would be unlikely to decrease groundwater levels at nearby groundwater-dependent ecosystems.

8.9.4 Assessment of potential impacts - operation

During operation of the project, potential impacts could be caused by:

- Stormwater runoff and fuel or chemical spills from accidents or maintenance work. The need for operational water quality management measures would be assessed during detailed design. Refer to Section 8.10 for an assessment of project impacts on the water quality
- Fauna injury or mortality from traffic. Revegetation and plantings as part of the project's landscape plan would help provide refuge and reduce incidents of fauna injury and mortality. Refer to Section 8.8 and *Appendix J Technical Paper: Urban design and landscape concept report (including landscape character and visual impact assessment)* for details on the proposed landscape plan.

8.9.5 Environmental management measures

Avoidance by design

The project has been scoped and designed to avoid or minimise impact. In particular:

- The ecological values identified during fieldwork and investigations during 2010, 2011 and 2012 were considered during the route option development and route selection stage to avoid and minimise impacts on these values
- Recommendations regarding the setback of bridge piers to minimise impacts on riparian vegetation were considered in the project design
- The locations of construction ancillary facilities were informed by identified flora and fauna constraints and site analysis
- Key environmental values such as terrestrial and aquatic ecology were included in the planning process.

Environmental management measures

The mitigation measures to be implemented for the project are listed in Table 8-66. These measures have been prepared in accordance with the *Biodiversity Guidelines: Protecting and Managing Biodiversity on RTA Projects* (Roads and Maritime, 2011).

Table 8-66 Environmental management measures for biodiversity impacts

Issue	Environmental safeguards	Responsibility	Timing
Impact on hollow-bearing trees and foraging resources	Disturbance and clearing of native vegetation will be minimised, particularly avoiding and minimising vegetation removal wherever possible through the detailed design process. Detailed design will investigate opportunities to retain the two hollow bearing and five habitat trees identified within the project area. A revegetation management sub-plan will be developed as part of the flora and fauna management plan to revegetate with species suitable for the creation of hollows and foraging resources. Strategies to compensate for the loss of hollow bearing/habitat trees will focus on revegetation and rehabilitation activities along riparian and adjoining areas.	Roads and Maritime	Detailed design
Revegetation management and landscaping	As part of the flora and fauna management plan, a revegetation management sub-plan will be developed to provide specific details for the re-establishment of native vegetation on areas disturbed by the project construction. This plan will be developed in accordance with *Roads and Maritime Biodiversity Guidelines* (RTA, 2011) and the design principles identified in *Appendix L, Technical Paper: Flora and Fauna Assessment*. It will also include details for the regeneration and rehabilitation of areas with a focus on riparian areas within the project area with reference to Guide 3, Guide 6 and Guide 10 of the *Roads and Maritime Biodiversity Guidelines*. The plan will include objectives to incorporate local native species across all revegetation and landscaping efforts along the Clarence River and in the adjoining project area. This will include species consistent with freshwater wetlands on coastal floodplain and sub-tropical coastal floodplain forest threatened ecological communities species composition, which could potentially provide foraging resources and roosting to threatened fauna species, and increase corridors and connectivity throughout the landscape.	Roads and Maritime	Detailed design

Issue	Environmental safeguards	Responsibility	Timing
Protection of fish habitat	During detailed design, the project design team will comply with the *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI, 2013) in relation to requirements for maintaining fish passage via the design and construction of instream structures.	Roads and Maritime	Detailed design
Flora and fauna management	A flora and fauna management plan (FFMP) will be prepared as part of the construction environmental management plan before construction in accordance with *Biodiversity Guidelines – Protecting and Managing Biodiversity on RTA Projects* (Roads and Maritime, 2011). The FFMP will detail how impacts on biodiversity will be minimised and managed during construction and operation and will incorporate specific management measures identified in the EIS. Measures outlined in this table will be addressed within the flora and fauna management plan, including timeframes for implementation and monitoring to be developed post-EIS and project approval.	Construction contractor Roads and Maritime	Pre-construction

Issue	Environmental safeguards	Responsibility	Timing
Vegetation clearing	To minimise the impacts of vegetation clearing and habitat loss the following specific measures will be implemented: • Clearing of vegetation will be carried out in accordance with *Guide 1 Pre-clearing Process of Biodiversity Guidelines* (RTA, 2011). These guidelines cover the felling of both non-habitat and habitat trees and the rescue and relocation of fauna • The pre-clearing process will be consistent with *Guide 2 Exclusion zones of Biodiversity Guidelines* (RTA, 2011) and include: pre-clearing surveys by an experienced/qualified ecologist and mapping and delineating the boundaries of threatened flora and/or fauna species, threatened ecological communities and/or suitable habitat (hollow bearing/habitat trees) • Pre-clearance surveys to include surveys for Hairy-joint Grass during flowering period (between summer and autumn) within final impact areas • Pre-clearing surveys to be carried out for the Three-toed Snake-tooth Skink, in suitable areas, not yet surveyed (ancillary sites, especially in North Grafton where houses are to be demolished) before demolition and construction works during late spring and early summer in accordance with the relevant guidelines (DSEWPaC,2011; DEC, 2004 and TSSC, 2008) • Construction traffic will be restricted to defined access tracks and construction works zone areas • The location of exclusion zones will be identified, with temporary fencing or flagging tape to indicate the limits of clearing (in accordance with the Roads and Maritime Biodiversity Guidelines (RTA, 2011)) • All relevant staff will be inducted and informed of the limits of vegetation clearing and the areas of vegetation to be retained.	Construction contractor	Pre-construction

Issue	Environmental safeguards	Responsibility	Timing
Weed management	• Weeds will be controlled in accordance with RTA (2011a) – *Biodiversity Guidelines Guide 6: Weed Management* • Declared noxious weeds will be managed in accordance with the requirements of the Noxious Weeds Act 1993 • Weed infested topsoil will be appropriately stockpiled with sediment fencing and as soon as practical, disposed of or treated appropriately to limit potential impacts on nearby areas of native vegetation.	Construction contractor	Pre-construction
Pests and pathogens	The FFMP will outline a strategy for the implementation of site hygiene protocols and management measures according to Biodiversity *Guide 7 – Pathogen Management from Roads and Maritime* (2011) to reduce the risk of localised or regional introduction of Myrtle Rust, *Phytophthora cinnamomi* and the amphibian chytrid fungus as a result of the project. Measures for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi will be implemented, as detailed in RTA (2011a) – *Biodiversity Guidelines Guide 7: Pathogen management*.	Construction contractor	Pre-construction

Issue	Environmental safeguards	Responsibility	Timing
Impact on fauna	Where practical, vegetation removal (especially of the two hollow-bearing and five habitat trees identified) will occur outside the main fauna breeding season (August to February) to avoid potential breeding disturbance to fauna, particularly avifauna (birds and bats). Pruning or lopping tree limbs will be conducted in preference to tree removal wherever possible. An appropriate tree removal procedure will be adopted. It will require the presence of a qualified ecologist or wildlife expert experienced in the rescue of fauna as detailed in *RMS Biodiversity Guidelines -Guide 4: Clearing of vegetation and removal of bush rock including the staged removal* process (2011). Woody debris and habitat trees removed for the project will be managed in accordance with *RMS Biodiversity Guidelines - Guide 5: Re-use of woody debris and bush rock* (2011). Fauna handling during vegetation removal will be carried out by a licensed fauna ecologist or wildlife carer, as detailed in *RMS Biodiversity Guidelines Guide 9: Fauna handling (2011).*	Construction contractor	Pre-construction
Threatened flora and fauna	Threatened species guidelines will be developed for threatened flora and fauna likely to occur directly within the project area and which may be impacted during construction, in order to show and educate construction workers of its appearance and outline what should be done if the species is found during construction. Relevant species will include: • Hairy-joint grass • Three-toed Snake-tooth Skink • Grey-headed Flying-fox • Microbats.	Construction contractor	Pre-construction

Issue	Environmental safeguards	Responsibility	Timing
Unexpected finds	If unexpected threatened fauna or flora species are discovered, works will stop immediately and the *Unexpected Threatened Species Find Procedure* RTA (2011a) as well as the *Biodiversity Guidelines Guide 1: Pre-clearing process* (Roads and Maritime, 2011) will be followed. This procedure will be included in the FFMP developed for the project.	Construction contractor	Pre-construction
Nest box and microbat management	Nest boxes and bat roost structures will be installed in accordance with the principles outlined in the *Roads and Maritime Guide 8 Nest Boxes* (2011). Details of the number and type of nest boxes will be included in the FFMP prepared for the project, and will include the following details: • The number and type of nest boxes required based on the number, quality and size of the hollows that will be removed • Specifications for nest box dimensions, installation requirements, locations of nest boxes and ongoing monitoring and maintenance • Installation timeframes, including the installation of 70% of nest boxes before the removal of any vegetation • Staged habitat removal, including removal of secondary or less preferential roosting habitat before removal of primary habitat, such as hollow-bearing trees and houses. • Pre-demolition inspection and exclusion measures to prevent continued use of roosts. These will be prepared to address the subject species, specific habitat, roosting habits at each location, and capture and handling procedures (if required).	Construction contractor	Pre-construction
Impact on aquatic fauna	Direct disturbance of aquatic fauna and riparian zones will be minimised in accordance with *Roads and Maritime Biodiversity Guidelines – Guide 10 Aquatic habitat and riparian zones* (2011).	Construction contractor	Construction

Issue	Environmental safeguards	Responsibility	Timing
Bank stability, sedimentation and erosion	Erosion and sediment control measures will be implemented and maintained to: • Prevent sediment moving off-site and sediment laden water entering any water course, drainage lines, or drain inlets • Reduce water velocity and capture sediment on-site • Minimise the amount of material transported from site to surrounding road surfaces • Divert clean water around the site in accordance with *Managing Urban Stormwater: Soils and Construction Guidelines* (Landcom, 2004). Erosion and sedimentation controls will be checked and maintained on a regular basis (including clearing of sediment from behind barriers) and records kept and provided on request. Erosion and sediment control measures will not be removed until the works are complete and areas are stabilised. Work areas will be stabilised progressively during the works. A progressive erosion and sediment control plan is to be prepared for the works. The *Guidelines for in stream works on waterfront land* (NSW DPI 2012) will be implemented when constructing and installing piers, bridge footings and undertaking river front landscape works.	Construction contractor	Construction
Impact on aquatic habitat	Where feasible and reasonable any large woody debris that may be encountered during construction will be relocated.	Construction contractor	Construction

8.10 Soils, sediments, water and contaminated land

This section assesses the impacts of the project on soils, surface water, groundwater and potentially contaminated land, and identifies measures that Roads and Maritime proposes to implement to manage these impacts.

Table 8-67 lists the Director-General's environmental assessment requirements relevant to soils, surface water, groundwater and contaminated land and where they are addressed in this chapter.

Table 8-67 Director-General's environmental assessment requirements relevant to soils, water and contaminated land

Director General's environmental assessment requirements	Where addressed in EIS
An assessment of construction and operation erosion and sediment and water quality impacts on the Clarence River and Alipou Creek, including details of:	Section 8.10.3 and Section 8.10.4
- existing surface and groundwater quality,	Section 8.10.2, Section 8.10.3 and Section 8.10.4
- impacts to water quality, considering potential changes to hydrologic flow regimes; dispersal of water pollutants; and erosion, siltation, destruction of riparian vegetation or reduction in the stability of river bank or watercourses; taking into account the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand 2000),	Section 8.10.3 and Section 8.10.4
- impacts to (quality or quantity of) groundwater sources, including details of whether the project would intercept groundwater, and impacts on groundwater dependent ecosystems, adjacent licensed water users and basic landholder rights	Section 8.9.3, Section 8.10.3 and Section 8.10.4
- mitigation measures to prevent and manage impacts to water quality, including proposed erosion and sediment controls (eg locations of sediment basins); storm water management system and management measures for the containment of pollutants; management of and disposal strategies for acid sulfate soils, in accordance with the Acid Sulfate Soils Manual (Acid Sulfate Soils Management Advisory Committee); and waste and chemical handling and transport	Section 5.2.8 and Section 8.10.5
Impacts from construction activities on contaminated land, including a description of proposals for site remediation with reference to the contaminated land planning guidelines.	Section 8.10.3, Section 8.10.4 and Section 8.10.5

8.10.1 Assessment methodology

Soils

The general information on soils presented in this section was sourced from work carried out by Arup for the route development phase of the project, and geotechnical investigations carried out in November 2013. Details of the route development phase investigations are provided in the *Technical Paper: Geotechnical Assessment for the Route Options* in the *Route Options Development Report* (Roads and Maritime, 2012). This report includes a desktop geotechnical assessment and details of a

supplementary geotechnical investigation carried out for the project by Arup in March 2012.

The desktop assessment included a review of:

- Historical geotechnical investigation reports in the area
- Historical aerial photos taken from 1964 to 1979
- Published data on regional geology (McEvilly et al, 2004; and Troedson and Hashimoto, 2008)
- Grafton 1:250,000 Scale Geological Sheet 56-6 (Brunker and Chesnut, 1976)
- Grafton Area 1:25,000 Coastal Quaternary Geology Map (NSW Department of Primary Industries, 2008)
- Australian Dryland Salinity Risk for 2000, 2020 and 2050 (NLWRA, 2000)
- 1:25,000 scale Grafton Acid Sulfate Risk Soil Map (OEH, 1997).

The desktop assessment also:

- Identified construction activities with potential to generate soil erosion or disturb acid sulfate soils
- Identified potential impacts on soil conditions, focusing on erosion and sediment impacts and the likelihood of disturbance of acid sulfate soils
- Developed a design criteria framework for erosion and sediment control for land-based and river-based construction activities. The framework includes guidelines for the location and sizing of the proposed temporary sedimentation basin at the South Grafton compound site.

Proposed measures to protect water quality during construction and operation were identified in accordance with relevant legislation, codes of practice, specifications and guidelines including *Managing Urban Stormwater: Soils and Construction* (Landcom, 2004), *Acid Sulfate Soils Manual* (Acid Sulfate Soils Management Advisory Committee, 1998) and *Guidelines for Instream Works on Waterfront Land* (NSW Office of Water, 2012).

Surface water quality

The assessment of surface water quality involved:

- Identifying catchments and waterways within and near the project, and clarifying which waterways have the potential to be impacted by the project
- Identifying sensitive receiver environments with the potential to be impacted by construction and operation of the project. This assessment was based on existing GIS data, the flora and fauna information gathered for the project (refer to *Appendix L Technical Paper: Flora and Fauna Assessment*) and desktop research
- Reviewing the status of the water-sharing plan for the lower Clarence River catchment area, which includes rules for protecting the environment, extractions, managing licence holders' water accounts, and water trading in the plan area (Office of Water, 2003)
- Reviewing human uses of the waterways relevant to the project
- Reviewing the types of basic landholder rights in the project area as defined by the *Water Management Act 2000*
- Analysing water quality samples collected on the Clarence River at Grafton by Roads and Maritime between January and May 2014 at the following locations (these locations are shown in Figure 8-39):
    - Grafton Sailing Club, Grafton, upstream of the existing and proposed bridges

    - Corcoran Park, Grafton, downstream of the existing and proposed bridges
    - Boat ramp at the end of Carrs Peninsula Road, Junction Hill, upstream of the existing and proposed bridges
    - End of Wharf Street, South Grafton, upstream of the existing and proposed bridges.
- Comparing available water quality data with the guideline values for protection of aquatic ecosystems set out in the *Australian and New Zealand Guidelines for Fresh and Marine Water quality* (ANZECC and ARMCANZ, 2000). The specific ANZECC and ARMCANZ guidelines used were the default trigger values for chemical and physical stressors for the protection of aquatic ecosystems in slightly disturbed estuarine and lowland river systems of south-eastern Australia
- Reviewing the August 2010 water quality information for the Clarence River at Grafton from the *Beachwatch Partnership Program* (OEH, 2014) at the following locations (these locations are shown in Figure 8-39):
    - Prince Street, upstream of the existing and proposed bridges
    - Grafton Sailing Club, Grafton, upstream of the existing and proposed bridges
    - Corcoran Park, Grafton, downstream of the existing and proposed bridges.
- Assessing the potential impacts of construction and operation of the project on the quality of surface and groundwater
- Identifying impact mitigation measures for construction and operation of the project based on the principles and guidelines set out in DECC (2008), Landcom (2004) and Roads and Maritime and Austroads guidelines (2003), including an assessment of the need, location and preliminary sizing of any water quality treatment devices during construction and operation.

Groundwater

The assessment of impacts on groundwater involved:

- Reviewing the Commonwealth Bureau of Meteorology *Groundwater Dependent Ecosystems Atlas* and fieldwork investigations to identify hydrogeology in the project area and groundwater-dependent ecosystems
- Reviewing groundwater levels obtained from groundwater bores excavated as part of the project's geotechnical investigations in December 2013 and previous geotechnical studies
- Reviewing groundwater quality samples collected by Roads and Maritime between January and April 2014 at:
    - Borehole BH1305, located in ARTC land within the proposed bridge southern approach, South Grafton
    - Borehole BH1308, located between the existing and proposed bridge approach road on the corner of Kent Street and Greaves Street, Grafton.
- Reviewing information on registered groundwater bores and groundwater usage in the project area (from the NSW Natural Resource Atlas online mapping)
- Qualitatively assessing the likelihood of the project intercepting groundwater, based on the information reviewed and the project constructability and design presented in Chapter 5 and Chapter 6
- Qualitatively assessing the impacts of the project on the quality and quantity of groundwater sources, nearby licensed water users, and basic landholder rights.

Contaminated land

A preliminary soil contamination assessment was carried out for the EIS to identify past and present potentially contaminating activities and land uses along the proposed bridge alignment and to identify potential contamination types for further

investigation. The assessment was carried out in relation to key contamination guidelines including:

- *Contaminated Sites Guidelines for Consultants Reporting on Contaminated Sites* (NSW Office of Environment and Heritage, 2011)
- *Managing Land Contamination: Planning Guidelines: SEPP55 – Remediation of Land* (Department of Urban Affairs and Planning and NSW Environmental Protection Authority, 1998)
- Australian and New Zealand *Guidelines for the Assessment and Management of Contaminated Sites* (ANZECC, NHMRC, 1992)
- *National Environment Protection (Assessment of Site Contamination) Measure Schedule B (2)* (National Environment Protection Council, 1999)
- *Contaminated Land Management Guideline* (Roads and Maritime, 2005).

The assessment of contaminated land involved:

- Reviewing site condition and the surrounding environment including topography, geology and hydrology
- Reviewing the land use history of the route alignment
- Searching the following databases:
    - NSW Environmental Protection Authority records for notices under Section 58 of *Contaminated Land Management Act*
    - *Protection of the Environment Operations Act 1997* Public Register
    - The cattle dip database
    - The groundwater bore database (from the NSW Natural Resource Atlas)
    - The Clarence Valley Council (former Grafton City Council) contaminated lands database.
- Reviewing selected sites for Section 149 Certificates
- Reviewing available condition reports for the existing bridge
- Reviewing Clarence Valley Council's planning documentation
- Reviewing selected site investigations on or next to the project
- Identifying parcels of land where contamination is known to occur or has the potential to occur
- Qualitatively assessing impacts, focusing on soil disturbance during construction activities
- Identifying management measures and further assessment to be implemented before construction begins.

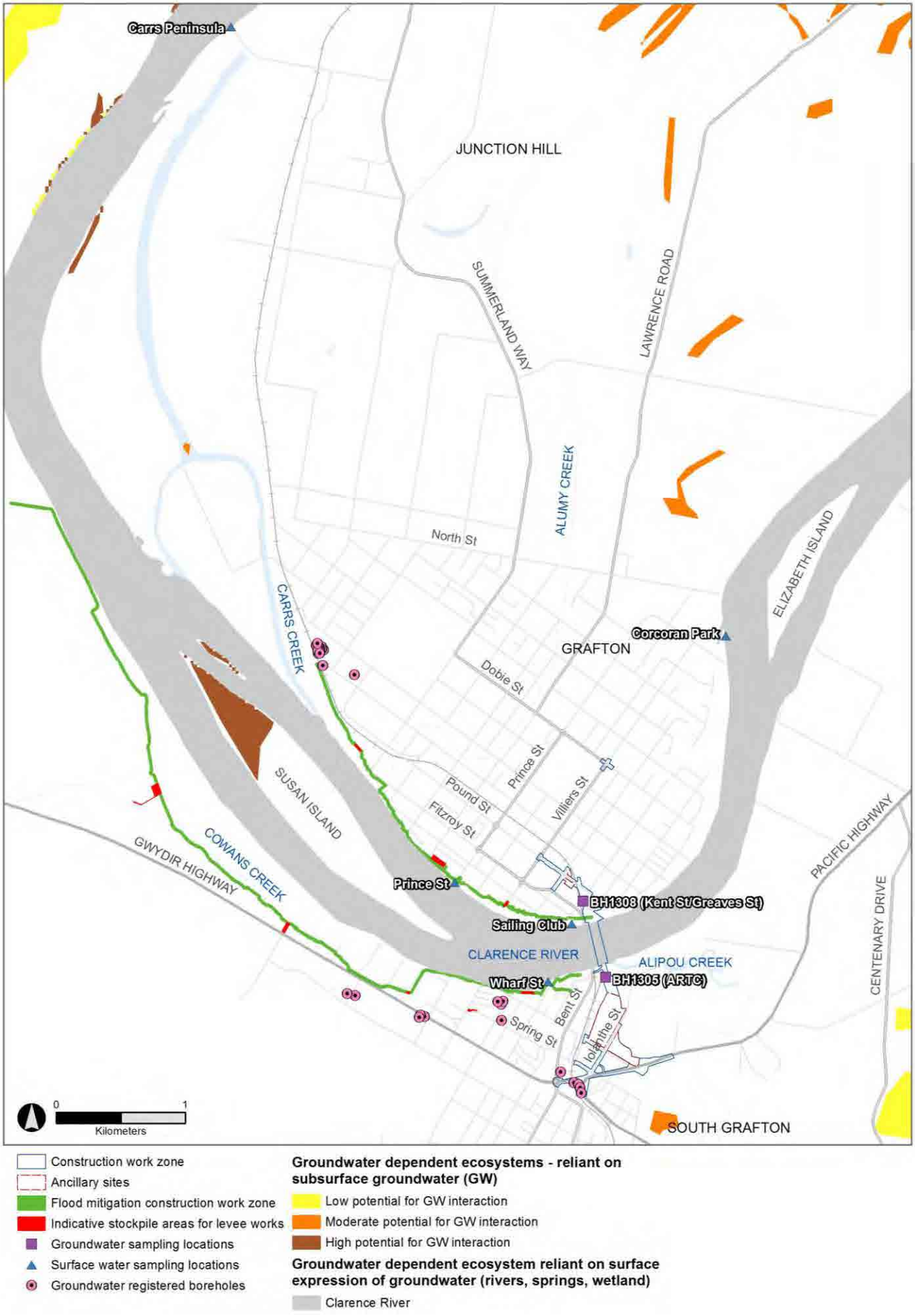


Figure 8-39 Water quality sampling sites and groundwater registered boreholes

8.10.2 Existing environment

The existing soil conditions and characteristics relevant to the project are described below.

Geology

The *Grafton 1:250 000 Scale Geological Sheet 56-6* (Brunker and Chesnut, 1976) indicates that the bedrock underlying Grafton and South Grafton is the Jurassic to Cretaceous period, Grafton Formation, comprising sandstone, siltstone, claystone and minor coal. The geological map indicates that Quaternary Alluvium overlies the Grafton Formation at the project site. The Alluvium is described as stream alluvial deposits that are sandy to silty with minor gravels. Packham (1969) also states that boulder beds are present in the Clarence River near Grafton.

Topography

The topography of the area gently rises on the southern side of the Clarence River to the east, south and west to an elevation of about 70 metres Australian Height Datum. The northern side of the river is mostly flat.

Salinity

The *Australian Dryland Salinity Risk* for 2000, 2020 and 2050 (NLWRA, 2000) does not indicate a high hazard or risk of dryland salinity in and around the project area.

Acid sulfate soils

The *1:25,000 Scale Grafton Acid Sulfate Risk Soil Map* (1997) indicates that the project area in Grafton where the road network upgrades would be carried out is located in an area of low probability of acid sulfate soil risk. In South Grafton, the map indicates the proposed road network upgrades are mostly in an area of low probability but does encroach into an area of high probability where the diversion of the existing Pacific Highway would be located and also along the proposed flood mitigation area. The river channel where the bridge would be constructed is also considered to have a high probability of acid sulfate soils as the soils are likely to contain estuarine bottom sediments within the river channel. Areas of high probability of acid sulfate soil risk are shown in Figure 8-40.

Soil landscape

Grafton soils consist of deep layered alluvium occurring right across the Clarence River floodplain. These silty soils vary in texture with well drained, brownish black sandy loams overlaying acidic dark brown sands at the riverbank, which extend out to more low plasticity, poorly drained clays with some fine sand overlaying heavy plastic clays. Erosion susceptibility within the project area is considered to be relatively low due to the alluvial soil landscape.

Soil characteristics

The ground conditions to the north of the Clarence River comprise Holocene channel levee deposits (fluvial sand, silt and clay) which overlie Holocene in channel bar deposits (fluvial sand, silts, gravels and clay). The Clarence River channel comprises fluvial sand, gravel, silt and clay.

To the south of the Clarence River, Holocene levee deposits are anticipated to overlie Holocene in-channel bar deposits beyond which Holocene floodplain deposits (fluvial sand, silt and clay) overlie Pleistocene deposits (clay, silt, fluvial sand and marine sand).

Geotechnical investigations carried out for the project in 2013 and previous desktop studies found the soil layers described in Table 8-68 are likely to be encountered in the project area.

Table 8-68 Materials that are likely to be encountered in the project area

Section	Material type	Typical thickness (m)
Grafton[1]	Topsoil	0.2 – 0.5
	Fill	1.0 – 3.1
	Holocene alluvium – Soft clay and silt	0.5 – 2.0
	Holocene alluvium – Loose sand	1.0 – 3.5
	Pleistocene alluvium – Loose to medium dense sand	4.0 – 9.0
	Pleistocene alluvium – Gravel	6.0 – 12.0
	Grafton Formation – Bedrock	>6.0
South Grafton[1]	Topsoil	0.05 – 0.5
	Fill	0.45 – 3.8
	Holocene alluvium – Soft clay and silt	0.7 – 3.0
	Holocene alluvium – Loose sand	1.0 – 3.3
	Pleistocene alluvium – Stiff clay	5.0 – 14.8
	Pleistocene alluvium – Loose to medium dense sand	1.0 – 1.3
	Residual soil – Clay	1.0 – 3.0
	Residual soil – Gravel	0 – 1.0
	Grafton Formation – Bedrock	>6.0
Clarence River[2]	Loose sand and gravel	2.0 – 5.5
	Grafton Formation – Bedrock	>6.0

Source:
1 Geotechnical Site Investigation Interpretive Report (Arup, 2014).
2 Desktop studies documented in the *Route Options Development Report* (Roads and Maritime, 2012).

As noted in Chapter 6, sections of the project are known to have soft soils with soft to stiff consistency, high compressibility and are prone to settlement. Soft soils treatment is proposed as part of the construction method.

Surface water quality

Catchments and waterways

The project is located within the Lower Clarence catchment area. The main watercourses within or near the project are the Clarence River, Alipou Creek, Swan Creek and Carrs Creek (refer to Figure 8-6 in Section 8.2).

The project would cross the Clarence River and be located immediately upstream of Alipou Creek. Hence, these two waterways are the focus of the surface water quality assessment.

Sensitive receiving environments

A sensitive receiving environment is defined as one that has a high conservation or community value or supports ecosystems or human uses of water that are particularly sensitive to pollution or degradation of water quality. Sensitive receiving environments relevant to the project are presented in Table 8-69.

Table 8-69 Sensitive receiving environments relevant to the project

Sensitive receiving environment	Commentary
Nationally Important Wetlands and State Environmental Planning Policy No 14 Wetlands	There are no listed wetlands within or near the project area. The Clarence River Estuary is the closest Nationally Important Wetland. It is located in Yamba, about 63 kilometres downstream from the project. Wetland number 292, listed under the *State Environmental Planning Policy No 14 Coastal Wetlands*, is located eight kilometres east of the study area and is part of the Upper Coldstream Wetlands, associated with Coldstream River and Pillar Valley Creek.
National parks, marine parks, nature reserves and State conservation areas	The NSW Office of Environment and Heritage website (OEH, 2014) indicates the nearest sensitive area is the Susan Island Natural Reserve located on the northernmost section of Susan Island on the Clarence River. It is located downstream from a section of the levee that Roads and Maritime proposes to upgrade as part of the project, but some 2.5 kilometres upstream from the proposed bridge. The reserve is a known grey-headed flying-fox colony. There are no national parks, marine parks or nature reserves within or in close proximity to the project. The nearest national park is the Fortis Creek National Park located about 30 kilometres north-west of Grafton while the nearest marine park is Solitary Islands Marine Park located off Corindi Beach.
Threatened ecological communities associated with aquatic ecosystems	There are two threatened ecological communities in the project area: • Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions (0.10 hectares). This is located on the northern and southern Clarence River bank immediately east of the project. The community is in poor condition with a high level of exotic species • Subcoastal Floodplain Forest of the NSW North Coast bioregion (0.31 hectares). This is limited to isolated patches of remnant vegetation. The canopy is mainly native with some exotic species, including garden escapees and noxious weeds in the mid storey and shrub strata. Refer to Figure 8-37 and Figure 8-38 for the location of these communities and Section 8.9 and *Appendix L Technical Paper: Flora and Fauna Assessment* for a detailed assessment of impacts on these communities.
Known and potential habitats for threatened fish	Silver perch and purple-spotted gudgeon are threatened fish species determined to have a moderate likelihood of occurrence on the Clarence River at Grafton. Refer to Section 8.9 and *Appendix L Technical Paper: Flora and Fauna Assessment* for an assessment of impacts on these species.

Sensitive receiving environment	Commentary
Key fish habitats as identified by the NSW Department of Primary Industry	Under the *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI, 2013), the Clarence River and nearby tributaries are classified as CLASS 1 waterways within and next to the project area. These waterways contain TYPE 2 moderately sensitive key fish habitat as they provide riverine brackish wetland habitats, and have a stable vegetated substrate.
Recreational swimming areas	The *NSW State of the Beaches 2010–2011: Far North Coast Region* report states that the Clarence River at Grafton has reported elevated enterococci levels during both dry and wet weather conditions, and its beach suitability is ranked as 'poor' and 'very poor'. Hence the Clarence River and Alipou Creek at Grafton are not considered suitable recreational swimming areas. The Clarence River surface water quality is further discussed in the section below.
Areas that contribute to drinking water catchments	According to the Clarence Valley Council website, there are no areas that contribute to drinking water catchments within or near the project. The closest water supply scheme is the Clarence Valley regional scheme which sources water from the Nymboida River catchment area, about 50 kilometres upstream from Grafton.
Areas that are available or used for aquaculture and commercial fishing	There are no areas available or used for aquaculture and commercial fishing within or near the project. NSW Fisheries has reported two commercial fishing licences near Susan Island, about three kilometres upstream from the proposed bridge. The majority of commercial fishing licences operate in the Yamba, Maclean and Iluka areas. The closest aquaculture farm is at Palmers Island, about 50 kilometres downstream from Grafton.

Water sharing plans

At the time this EIS was written, the NSW Office of Water was in the process of preparing a water sharing plan for the Clarence Alluvial Water Sources. Draft copies of the plan for review were not available for this EIS.

Water uses and basic landholder water rights

Recreational water uses mostly occur in the Clarence River and include boating, sailing, rowing and fishing. Various water events and water sport competitions are held in Grafton throughout the year (refer to Section 8.7.2).

The NSW Office of Water website (NOW, 2014) identifies three types of basic landholder rights in NSW under the *Water Management Act 2000*:

- Domestic and stock rights: Owners or occupiers of land which is overlaying an aquifer or river, estuary or lake frontage can take water without a licence for domestic (household) purposes or to water stock. Agricultural and livestock uses may occur on lands adjoining the Clarence River and Alipou Creek
- Native title rights: Anyone who holds native title with respect to water, as determined under the Commonwealth *Native Title Act 1993*, can take and use water for a range of personal, domestic and non-commercial purposes. A search on the National Native Title Tribunal TitleVision online tool on 18 April 2014 found no native titles in Grafton or South Grafton

- Harvestable rights – dams: Harvestable rights – dams allows landholders in most rural areas to collect a proportion of the runoff on their property and store it in one or more farm dams up to a certain size. Farm dams do not occur within the project area or Grafton and South Grafton urban areas but occur on rural land adjoining the Clarence River and Alipou Creek.

Surface water quality

Roads and Maritime collected water quality samples of the Clarence River between January and April 2014. The water quality sampling results are shown in Table 8-70 and the sampling sites are shown in Figure 8-39.

Table 8-70 Water quality sampling results

Location/Site	Date	Conductivity (µS/cm)	Dissolved oxygen (%saturation)	pH	Turbidity (ntu)
BH 1305 (ARTC)	14/03/14	1509	9	6.9	541
	28/03/14	2358	18	7.0	600
	15/04/14	3974	6	6.8	600
	23/05/14	2974	15	7.0	600
BH 1308 (Kent/Greaves)	14/03/14	8000	7	6.8	4
	28/03/14	1211	58	9.1	60
	15/04/14	8000	6	6.5	21
	23/05/14	8000	13	6.9	74
River (Sailing Club)	30/01/14	945	75	7.3	24
	14/03/14	6152	99	7.6	52
	28/03/14	7029	79	7.6	14
	15/04/14	171	78	7.1	59
	23/05/14	167	116	8.5	66
River (Corcoran Park)	30/01/14	2961	73	7.5	17
	14/03/14	8000	99	7.3	10
	28/03/14	8000	77	7.4	9
	15/04/14	181	75	7.2	59
	23/05/14	185	112	8.3	24
River (Carrs Peninsula)	30/01/14	205	79	8.2	27
	14/03/14	2046	97	7.4	20
	28/03/14	2852	74	7.5	17

Location/Site	Date	Conductivity (µS/cm)	Dissolved oxygen (%saturation)	pH	Turbidity (ntu)
	15/04/14	114	82	7.0	87
	23/05/14	145	114	8.5	16
River (Wharf St)	30/01/14	1550	67	7.6	2
	14/03/14	7472	106	7.4	40
	28/03/14	8000	77	7.3	6
	15/04/14	172	74	7.0	54
	23/05/14	155	110	8.5	15

These water quality samples were compared to ANZECC/ ARMCANZ guideline values for protection of aquatic ecosystems. Relevant water quality parameters available for comparison included conductivity, dissolved oxygen, pH and turbidity. The results for pH, turbidity and conductivity were above the guidelines and the results for dissolved oxygen were below the guideline values.

The Beachwatch Partnership Program (OEH, 2013) monitored the water quality of the Clarence River at the sites shown in Figure 8-39. The results indicated elevated enterococci levels at all three sites during both dry and wet weather conditions. The water quality monitoring results were compared to the *National Health and Medical Research Council's Guidelines for Managing Risks in Recreational Water* (NHMRC, 2008) and it was found that:

- The Prince Street location scored a beach suitability grade of 'poor' which indicates this location is susceptible to faecal pollution and microbial water quality and is not always suitable for swimming. During dry weather conditions, swimming should be avoided if swimming locations have signs of pollution, such as discoloured water, odour or debris in the water. Swimming should be avoided at all times during and for up to three days following rainfall
- The Grafton Sailing Club and Corcoran Park sites scored a beach suitability grade of 'very poor' which indicates these locations are very susceptible to faecal pollution and microbial water quality and may often be unsuitable for swimming. It is generally recommended to avoid swimming at these sites.

The poor water quality at Prince Street, Grafton Sailing Club and Corcoran Park was investigated by Office of Environment and Heritage and Clarence Valley Council, with inspection and testing of the sewerage system and faecal sterol analysis of the river water to identify the source of contamination; however, the results were inconclusive. The *NSW State of the Beaches 2010–2011: Far North Coast Region* report states that Council plans to carry out further investigations, including a review of the performance of North Grafton Sewage Treatment Plant (next to Corcoran Park) and a review of sewer and stormwater issues in the Grafton Sailing Club and Prince Street catchments.

Groundwater

Hydrogeology

The Bureau of Meteorology *Groundwater Dependent Ecosystem Atlas* online tool (BOM, 2014) showed the project rests over the Clarence-Morton groundwater province. DECCW (2010) describes this province as a porous rock aquifer system generally saline and therefore with limited potential uses. The coverage area of the

Clarence-Morton catchment is reported to be about 45,800 square kilometres (FrogTech, 2013).

Groundwater flow systems of the Clarence-Morton groundwater province are classified as 'intermediate' which indicates that groundwater may flow over distances ranging from five to 50 kilometres.

FrogTech (2013) estimates the Clarence-Morton basin has a groundwater sustainable yield of 834 gigalitres per year and a groundwater abstraction of 22 gigalitres per year.

Groundwater levels

Groundwater levels were measured as part of the investigations for the project between December 2013 and May 2014 at the locations shown in Figure 1. It was found that borehole BH1305 (within ARTC land, South Grafton) had groundwater levels between 0.2 and 0.7 metres Australian Height Datum, and borehole BH1308 (on the corner of Kent Street and Greaves Street, Grafton) had groundwater levels fluctuating between 0.1 and 0.3 metres Australian Height Datum.

Groundwater quality

Groundwater in the project area is saline. The *Clarence River Fact Sheet* (Oceanwatch, 2014) states the tidal limit reaches over 100 kilometres inland up to Copmanhurst, and this influences the groundwater resources at Grafton.

Borehole BH1305 in South Grafton recorded conductivity values of up to 3974 microsiemens per centimetre (refer to Table 8-70). These levels are not recommended for human consumption or irrigation but are acceptable for certain types of livestock. Groundwater from this borehole was also found to be turbid (above 540 nephelometric turbidity units) and with a very strong odour.

Borehole BH1308 in Grafton recorded conductivity values of up to 8000 microsiemens per centimetre (refer to Table 8-70). These levels are not suitable for human consumption but are suitable for irrigation and livestock. Water from this borehole was observed to be clear (below 75 nephelometric turbidity units).

Groundwater dependent ecosystems

Groundwater dependent ecosystems are ecosystems that have their species composition and natural ecological processes determined by groundwater (DLWC, 2002).

A search of the Bureau of Meteorology *Groundwater Dependent Ecosystem Atlas* online tool on 17 April 2014 identified the following groundwater-dependent ecosystems within the study area (refer to Figure 8-39):

- The Clarence River
- Surrounding vegetation as a groundwater-dependent ecosystem reliant on subsurface groundwater.

As outlined in Section 8.9 and *Appendix L Technical Paper: Flora and Fauna Assessment,* there are two threatened ecological communities with the potential to be affected by impacts on groundwater:

- Freshwater Wetlands on Coastal Floodplain (0.10 hectares)
- Subtropical Coastal Floodplain Forest Freshwater Wetlands on coastal floodplain (0.31 hectares).

Groundwater use

Groundwater resources surrounding the project are currently not subject to any groundwater sharing plan (refer to water sharing plans discussion in the surface water quality section).

A search in the *NSW Natural Resources Atlas* online tool (NSW Natural Resource Atlas, 2014) was conducted on 20 April 2014. The search found no registered groundwater boreholes within the project area. The closest registered boreholes are shown in Figure 8-39 and listed in Table 8-71. The majority of registered boreholes are used for monitoring purposes.

Table 8-71 Groundwater bores close to the project area

Borehole number	Ownership	Depth (metres)	Purpose	Yield (metres per second)
Grafton				
GW307339, GW307343, GW307340, GW307341, GW307342, GW307344, GW307345	Private	5.7 to 7.2	Monitoring	Not recorded
GW302258	Private	6.6	Domestic	Not recorded
GW304887	Public	10 to 11	Monitoring	Not recorded
GW302879, GW302880, GW302881, GW302882, GW302883, GW302884, GW302885, GW302886, GW302888, GW302887, GW302889, GW302890, GW302891, GW304886	Private	9.5 to 11	Monitoring	Not recorded
GW304885	Private	10	Monitoring	Not recorded
South Grafton				
GW305106, GW305827, GW305826, GW305829	Private	5.1 to 6.1	Monitoring	Not recorded
GW300861	Public	11.5	Domestic	0.01
GW307223, GW307222, GW307221	Private	6.5 to 9	Monitoring	Not recorded
GW307115, GW307116, GW307114	Private	5.8 to 9.8	Monitoring	Not recorded
GW068657	Private	8.5	Domestic stock	Not recorded
GW301785	Not recorded	7.5	Monitoring	Not recorded
GW305828	Private	5.1	Monitoring	Not recorded

Source: NSW Natural Resource Atlas, 2014

Contaminated land

A search of NSW Environmental Protection Agency (EPA) records for notices under Section 58 of the *Contaminated Land Management Act* has been carried out. No records were found for sites with a record of a written notice from the EPA for contamination within or in close proximity to the project.

A search of the *Protection of the Environment Operations Act 1997* (NSW) Public Register for notices, penalties and licences under that Act has been completed. The State Rail Authority of NSW (Grafton Locomotive Depot) at 29 Bent Street, South Grafton surrendered its POEO Licence in 2003. No other records were found within or in close proximity to the project.

Parcels of land that have the potential to be contaminated within or next to the project area are listed in Table 8-72 and shown in Figure 8-40. In Grafton, there is potential for contamination on land occupied by the project where there is, or has been, land uses such as automotive uses and agriculture. Residential areas within the proposed corridor in Grafton are not identified as high risk of contamination, although there is potential for localised contamination such as heavy metals, asbestos fragments and disused storage tanks. Due to the age of most dwellings in Grafton, there is a risk of asbestos being present and fibres being released during any demolition.

On the Clarence River, the preliminary investigation did not identify any existing or former uses, or potentially contaminating events that suggest contamination of the riverbed. Hence, there is a low risk of encountering contaminants on the section occupied by the below-water bridge foundations.

In South Grafton, potential for contamination on land occupied by the project relates to existing and former industrial, automotive and agricultural land uses. In particular, the ARTC land occupied by the former locomotive depot is known to be contaminated (Coffey, 2004). The site was used as a locomotive depot between the 1920s and late 1960s, and facilities such as railway lines and sidings, a turntable, a diesel refuelling facility, coal store, offices, workshops and garages were built during this time. Many of the facilities were removed in the 1970s and the site ceased being used as a refuelling facility in the late 1980s. The site was leased to Manildra Sugars for sugar loading operations in 1989 and has been used for this purpose since then.

Within the existing Grafton and South Grafton levees the fill material is likely to comprise virgin excavated natural material as well as fill material of unknown quality. There is a minor risk of encountering contaminated fill during the levee raising work.

While no known cattle dip sites occur along the project alignment, there is a possibility of encountering previously unknown cattle dips and associated contaminated soils.

There is no known groundwater contamination in the project area.

Table 8-72 Areas of potential contamination and acid sulfate soil risk within or next to the project area

Description	Ownership	Issue	Contaminants of concern
Grafton (within the project area)			
Lot 100 DP 851143	Grafton TAFE campus	Contaminated soils Combustible and flammable liquids stored on-site	TPH, benzene, toluene, ethyl benzene, xylenes
Grafton (next to the project area)			
Lot 5 DP 1068698	Private	Agricultural land uses	Heavy metals, organic contaminants
Lot 1 DP 1160909	Grafton Showground	Agricultural land uses	Heavy metals, organic contaminants

Description	Ownership	Issue	Contaminants of concern
Lot 7007 DP 92967	Grafton Showground	Agricultural land uses	Heavy metals, organic contaminants
South Grafton (within the project area)			
Not available	ARTC	Known contaminated soils	Confirmed presence of arsenic, cadmium, copper, lead, zinc and mercury, TPH c10-c36 exceeding the soil investigation level (sil), total Polycyclic Aromatic Hydrocarbons (PAHs), benzo(a)pyrene and asbestos (from one test pit 1.5 m deep).
Lot 2 and Lot 3 DP 1101889	Private	Contaminated soils Truck diesel distribution area	Asbestos, heavy metals, TPH, benzene, toluene, ethyl benzene, xylenes
Lots 384/ 385 DP 751385	Private	Agricultural land uses Acid sulfate soil risk area	Asbestos, heavy metals, TPH, organic contaminants High risk of acid sulfate soil
Lot 379 and Lot 380 DP 751385	Private	Acid sulfate soil risk area	Asbestos, heavy metals, TPH High risk of acid sulfate soil
Lot 457 DP 823651	Private	Agricultural land uses	Heavy metals, organic contaminants
Lot 12 DP 858248	Public	Agricultural land uses	Heavy metals, organic contaminants
Lot 17 DP 858248	Private	Agricultural land uses	Heavy metals, organic contaminants
Lot 3 DP 586649	Private	Disused diesel/petrol tanks	TPH, benzene, toluene, ethyl benzene, xylenes
Pacific Highway on approach to South Grafton	Various	Acid sulfate soil risk area	High risk of acid sulfate soil
South Grafton (next to the project area)			
Lot 1 DP 859759	Private	Contaminated soils Disused diesel/petrol tanks	TPH, benzene, toluene, ethyl benzene, xylenes
Lot 346 and 347 DP 751385	Private	Contaminated soils Disused diesel/petrol tanks	TPH, benzene, toluene, ethyl benzene, xylenes

Description	Ownership	Issue	Contaminants of concern
Lots 381/ 382/ 383 DP 751385	Private	Agricultural land uses Acid sulfate soil risk area	Asbestos, heavy metals, TPH, organic contaminants High risk of acid sulfate soil

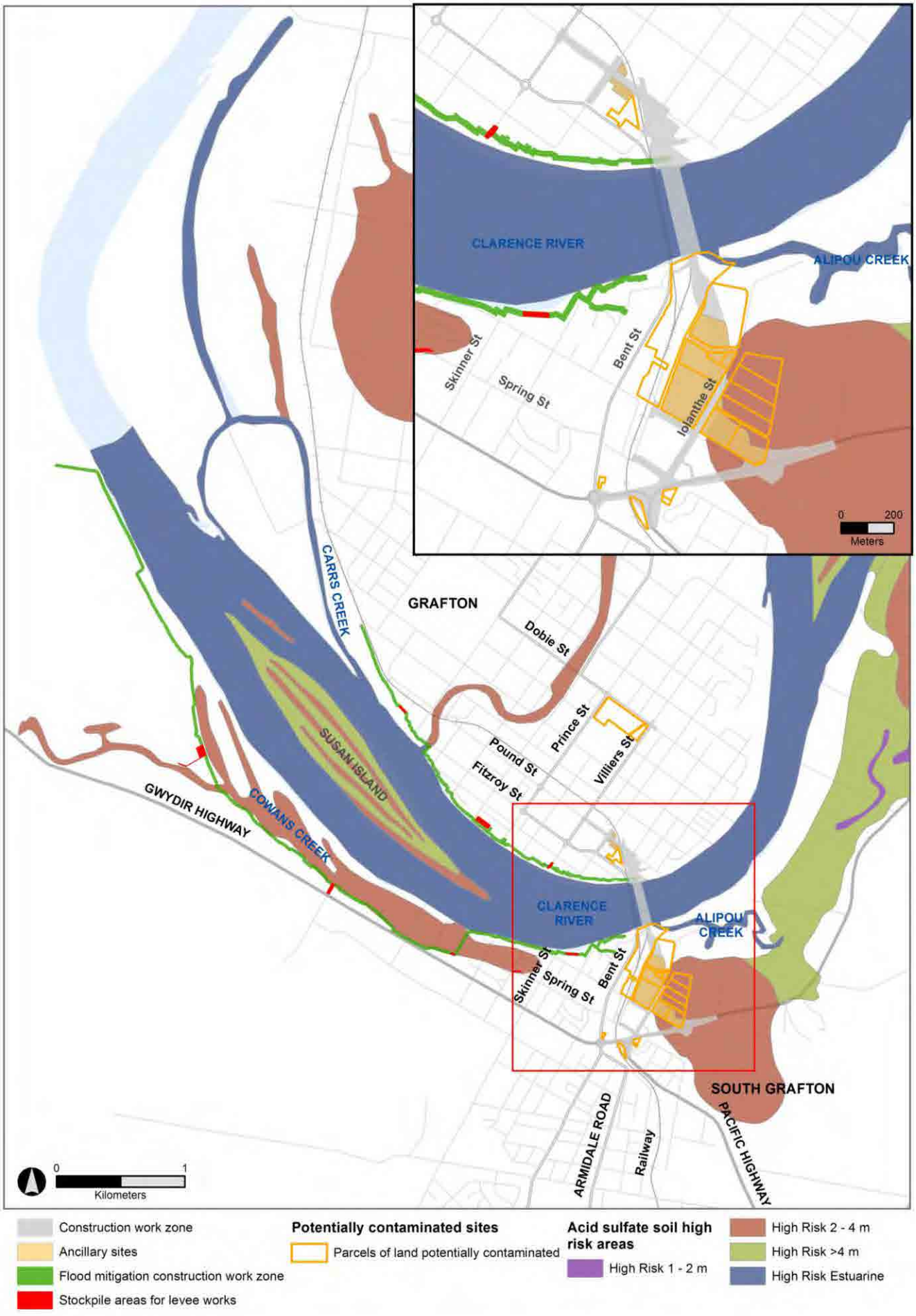


Figure 8-40 Potential contaminated land and acid sulfate soil high risk areas

8.10.3 Assessment of potential impacts - construction

Soils

Soil erosion and sedimentation generating activities

The construction activities outlined in Table 8-73 would result in exposure of soils and subsoils, creating an elevated risk of soil erosion and sedimentation. (For a detailed description of project construction activities, refer to Chapter 6)

Soil and sediment control measures would need to be in place during construction to manage erosion and sediment impacts.

Table 8-73 Construction activities with potential to cause soil erosion and disturb acid sulfate soils

Component	Activity
Project preliminaries and site establishment	• General site clearing • Construction of temporary access roads/access points • Construction of diversion and catch drains along the formation and sedimentation control basins or swales (where required) • Clearing of vegetation and processing of materials • Temporary upgrade work on existing local roads and intersections.
Levee raising work	• Stripping of topsoil • Placement and compaction of earthwork.
Roadwork and road surfacing	• Stripping of topsoil • Placement and compaction of earthwork • Road widening • Diversion of utilities • Installation of traffic signals, roadside furniture and lighting • Construction of any retaining walls and subsurface drainage • Construction of pedestrian and cycle path • Progressive landscaping and tree planting.
Drainage	• Construction of drainage, including culvert structures, grass-lined open channels, and kerbs and gutters • Construction of temporary sedimentation basins.
Bulk earthwork	• Stripping of topsoil and stockpiling for later reuse in landscaping • Materials haulage • Soft soils treatment • Embankment foundation treatment • Construction of fill embankments • Stockpiling.

Component	Activity
Bridge work	• Removal of viaduct structures below ground during the replacement of ARTC rail viaduct at Pound Street • Installation of scour protection along the bridge piers and abutments.

Acid sulfate soils disturbance

The following construction activities have the greatest risk of disturbing acid sulfate soils:

- Site establishment
- Levee raising
- Drainage construction
- Bulk earthwork construction
- River-based construction
- Construction of bridge foundations.

These activities could disturb and expose acid sulfate soils to oxygen. Pollutants could be readily released into the surrounding environment, polluting surface water and groundwater.

The risks associated with disturbing acid sulfate soils and potential acid sulfate soils can be adequately managed and mitigated by implementing the relevant measures and procedures in the *Acid Sulfate Soils Manual* (Acid Sulfate Soils Management Advisory Committee, 1998), and Roads and Maritime *Guidelines for Managing Acid Sulfate Materials 2005*.

The potential engineering consequences of building bridge approaches and new road infrastructure on acid sulfate soils have been taken into account during the concept design and would be further considered during detailed design of the project. Mitigation measures for managing acid sulfate soils are discussed in Section 8.10.5.

Soft soils settlement treatment

Soft soil areas would be treated to achieve adequate levels of soil settlement and consolidation before construction can begin. Possible treatment methods are provided in Section 6.2.4 and could include, but are not limited to:

- Pre-loading
- Dynamic replacement
- Deep soil mixing
- Stone columns.

The preferred method would depend upon construction scheduling requirements, thickness of the soft soil layers, soil consolidation properties, and height of the proposed embankment structures.

Surface water quality

Impact on sensitive receiving environments

If unmanaged, construction activities could increase levels of turbidity and sediment deposition, decrease dissolved oxygen, and change pH levels in downstream waters. These changes could have an adverse impact on the health of aquatic environments, particularly in sensitive receiving environments.

The following sensitive receiving environments (threatened ecological communities) and threatened fish species have the potential to be impacted by construction of the project:

- Threatened ecological communities:
  - Freshwater wetlands on coastal floodplains of the NSW North Coast
  - Subcoastal Floodplain Forest of the NSW North Coast bioregion
- Threatened fish species:
  - Silver perch
  - Purple-spotted gudgeon.

The flora and fauna assessment carried out for the project (refer to *Appendix L Technical Paper: Flora and Fauna Assessment*) found the impacts of the project on the threatened ecological communities and threatened fish species would not be significant provided that measures to substantially reduce the amounts of sediments entering the Clarence River are implemented. This would be achieved through standard erosion and sediment control measures (refer to Section 8.10.5).

Impact on water users and basic landholder rights

Project construction is unlikely to change the existing water quality of the Clarence River and other waterways provided that standard erosion and sediment control measures are implemented.

Construction activities would not change the ability of landholders to take and use water from Alipou Creek, the Clarence River or any other watercourse.

Impacts of ancillary sites on water quality

The following activities at ancillary sites have the potential to impact on water quality (Section 6.3 contains a description of ancillary sites):

- Storage of chemicals and other hazardous materials
- Earthworks, which could disturb acid sulfate soils high risk areas in South Grafton (refer to Figure 8-40)
- Concrete batching
- Handling of construction materials
- Vehicle washdown and refuelling
- Vehicle, plant and equipment movements
- Stockpiling operations.

If unmanaged, construction activities at ancillary sites could result in sediments and particles being washed off-site into drainage lines and waterways, and increasing levels of turbidity.

Surface water quality risk factors and impacts

The risk factors and impacts on surface water quality as a result of the construction stage of the project are presented in Table 8-74.

Table 8-74 Surface water quality risk factors and impacts

Risk factor	Impact
River-based construction activities (refer to Section 6.2.7) could result in changes to the Clarence River hydrologic flow regimes.	Temporary river-based construction structures such as barges, and activities such as piling work, would be confined to the areas occupied by the bridge foundations. The footprint of these areas is modest in relation to the river width. It is unlikely that river-based construction activities would result in changes to the flow or river levels.
River-based construction activities (refer to Section 6.2.7) such as installation of bridge foundations, bridge superstructure and piers. These may disturb riverbed sediments.	If unmanaged, disturbed sediment may increase river turbidity.
Dispersal of sediments and water pollutants from land-based construction activities. Construction activities outlined in Table 8-73may result in soil erosion, siltation and off-site movement of eroded sediments by wind and/or stormwater to receiving waterways.	If unmanaged, the dispersal of sediments and water pollutants could result in turbidity, increased nutrients, metals and other pollutants in the waterways.
Removal of riparian vegetation to enable bridge launching, construction of abutments and scour protection.	If unmanaged, the removal of riparian vegetation could reduce the stability of the Clarence River bank, and result in soil and streambank erosion and increased sediment loads into the Clarence River and Alipou Creek. The location and extent of riparian vegetation to be removed for the project is identified and assessed in Section 8.9.
Exposure of acid sulfate soils as a result of earthwork.	If untreated, the exposure of acid sulfate soils may result in generation of sulfuric acid and subsequent acidification of waterways and groundwater sources and mobilisation of heavy metals in the environment.
Disturbance of contaminated land.	If unmanaged, disturbed contaminated land may result in contamination of downstream waters, which could impact on aquatic and vegetation community habitats.

Risk factor	Impact
Accidental fuel and chemical spills, and contaminated runoff infiltration to groundwater.	If uncontained, accidental leaks or spills may pollute waterways and groundwater. The process of runoff infiltration is generally effective in filtering polluting particles and sediment. Hence, the risk of contamination to groundwater from any pollutants bound in particulate form in surface water, such as heavy metals, is generally low. Similarly, low-density pollutants such as oils, tars and petroleum products would be preferentially retained in the soil profile and would not penetrate to the groundwater table. However, soluble pollutants, such as acids and alkalis, salts and nitrates, and soluble hydrocarbons, would be able to infiltrate through soils into the groundwater and would pose a risk to that groundwater source. Under certain pH conditions, metals may also become soluble and infiltrate groundwater. In these areas, chemical treatments may be necessary to help remediate spills.

Risk management approach

Roads and Maritime would manage identified risks by implementing standard construction soil erosion and sediment controls and other construction site management procedures for both land- and river-based activities. Erosion and sediment controls would be designed and constructed in accordance with *Managing Urban Stormwater: Soils and Construction* (Landcom, 2004; DECC, 2008). The controls would be established before the start of construction and maintained in effective working order for the duration of the construction period until the site is stabilised.

Management and disposal of acid sulfate soils would be in accordance with the *Acid Sulfate Soils Manual* (Acid Sulfate Soils Management Advisory Committee, 1998) and contaminated soils would be disposed off-site in accordance with the *NSW Waste Classification Guidelines* (DECCW, 2008).

Groundwater

Impacts on groundwater levels

The project would have two sections of shallow cutting. One cutting would be on Greaves Street beneath the proposed bridge northern approach; it would be about 1.2 metres below existing ground level. The other cutting would be on Pound Street beneath the existing railway viaduct; it would be about 0.2 metres below existing ground level. Additional shallow cuttings may be identified during detailed design.

The final profile of cutting sections would be shallow and have a low risk for intercepting groundwater levels or changing exiting groundwater flows.

The construction of embankments has the potential to preferentially direct surface runoff and concentrate recharge to groundwater. These impacts are likely to be confined along the bridge approaches where the largest embankments are proposed.

As noted in Chapter 6, areas of soft soil are known to occur within the project footprint and would be treated as part of construction. Soft soil treatment compaction could restrict near-surface groundwater flows, resulting in discharge and waterlogging.

Impacts on groundwater quality

The main risks to groundwater during construction of the project would be from groundwater contamination, which may occur if construction activities are not adequately managed (refer to Table 8-75).

Impact on groundwater dependent ecosystems

An assessment of impacts on groundwater dependent ecosystems is provided in Section 8.9 and *Appendix L Technical Paper: Flora and Fauna Assessment.* The groundwater dependent ecosystems are:

- Freshwater Wetlands on Coastal Floodplains
- Subtropical Coastal Floodplain Forest.

These ecosystems are partly supported by shallow groundwater systems that effectively arrest the infiltration of surface waters. Potential impacts on groundwater recharge rates from general road construction are generally greatest in areas where significant cuttings are required as they have the potential to intersect the water table and affect groundwater levels downstream.

Given the limited extent of cutting proposed for the project, the risk of blocking or diverting groundwater flows that support these ecosystems is considered low.

Impact on licensed water users and basic landholder rights

The project construction is unlikely to impact the access, use or yield of registered groundwater boreholes or to change the level of access to underlying aquifers beneath lands with domestic and stock rights.

Contamination

The disturbance of potentially contaminated land identified in Figure 8-40 and Table 8-72 would have the following impacts:

- Mobilisation of surface and subsurface contaminants, which have the potential to impact surface water, groundwater and soils
- Migration of contaminants into the surrounding area, which have the potential to impact surface water, groundwater and soils via leaching, overland flow and/or subsurface flow
- Mobilisation of groundwater and/or surface water contamination
- Exposure of contaminants to ecological receivers, which would impact flora and fauna
- Exposure of contaminated soils and/or groundwater to people.

Any existing contamination present within the soils or groundwater underlying the project area and associated ancillary facilities has the potential to be exposed or disturbed by construction activities. The highest risk activities would be:

- Bulk earthwork
- Demolition of dwellings, old railway tracks and other structures (due to the potential presence of asbestos).

The project is unlikely to increase the risks associated with any site contamination and the placement of virgin excavated natural material fill would also act as a barrier to future exposure and disturbance of contamination. For example, the South Grafton and Pound Street ancillary facilities would generally be established by placing a temporary layer of aggregate or similar material over the ground surface. This overlying aggregate layer would reduce any risks of exposure to, and disturbance of, contamination.

Environmental management measures are discussed in Section 8.10.5.

8.10.4 Assessment of potential impacts - operation

Soils

Once the completed project is operating, it may impact soils due to potential contamination from a fuel or chemical spill following vehicle crashes on the proposed bridge and associated infrastructure.

These potential impacts would be avoided through the implementation of appropriate management and mitigation measures (refer to Section 8.10.5).

Riverbank erosion

Permanent scour protection would be installed around the piers and river banks to protect them from riverbank instability, riverbank erosion and riverbed erosion during flood or high-flow events.

Flood velocities at the bridge abutments are predicted to be less than 0.2 metres per second (0.72 kilometres per hour) for 2000-year flood event and below. Hence scour protection at the bridge abutments would not be required.

Surface water quality

Impacts on sensitive receiving environments

The project includes an operational stormwater management system that will incorporate water quality treatment processes to minimise the likelihood of impacts on water quality. These could include vegetated swales and temporary sedimentation basins. Therefore, operation of the project would be unlikely to have an adverse impact on sensitive receiving environments.

Impacts on water sharing plans

The operation of the project would not impact on the ability of NSW Office of Water to set up and implement rules for how water is allocated among users (including environmental flows) on the Clarence River or any other waterway. Hence, it would not impact any future water sharing plan for the Clarence Alluvial Water Sources.

Impacts on water uses and basic landholder water rights

The operation of the project would not change landholders' ability to exercise their basic water rights.

Impacts on surface water quality

The main potential impact on water quality during operation would be associated with runoff from stormwater. Direct deposition of airborne particles onto the road surface would be picked up by stormwater, potentially causing contamination of water quality in downstream waterways that receive discharged stormwater during rainfall events.

Pollutants from stormwater runoff include sediments, hydrocarbons, metals, and microbials. These deposits build up on-road surfaces and pavements during dry weather and get washed off and transported to downstream waterways when it rains.

Water quality treatment processes would be incorporated into the project design to minimise the impact of stormwater pollution on the waterways. These could include vegetated swales and sedimentation basins.

Groundwater

Impacts on groundwater levels

The permanent cuttings for the project would be shallower than the observed groundwater levels in Grafton and South Grafton. Therefore, changes to groundwater levels are unlikely.

Impact on groundwater quality

If unmanaged, pollutants from stormwater runoff have the potential to infiltrate into the soil and reach groundwater resources. The process of infiltration is generally effective in removing insoluble substances and contaminants that are readily bound to sediment particles, including heavy metals and hydrocarbons like oils, tars and petroleum. Therefore, runoff or spills of these substances have a relatively low risk of causing groundwater contamination.

In contrast, soluble pollutants, such as acids, alkalis, salts and nitrates are less readily removed by the infiltration process and have a greater chance of reaching groundwater.

Potential impacts on groundwater quality would be avoided through the implementation of appropriate engineering, management and mitigation measures (refer to Section 8.10.5).

Impact on licensed water users and basic landholder rights

The project would not impact the access, use or yield of registered groundwater boreholes nor would it change the level of access to underlying aquifers beneath lands with domestic and stock rights.

Contaminated land

It is unlikely that areas identified as contaminated or potentially contaminated land would be disturbed once the project is operational.

8.10.5 Environmental management measures

Protection of water quality during construction

During construction, temporary sediment control measures would be installed to protect water quality. The location, design and maintenance of these controls are outlined below and would be subject to confirmation and refinement during detailed design and upon appointment of the construction contractor(s) for the project. Controls and management measures outlined in this section are consistent with *Managing Urban Stormwater: Soils and Construction* (Landcom, 2004).

Design criteria for construction erosion and sediment control

Land-based construction activities

A significant part of construction involves extending and upgrading existing roads and raising existing levees. This work would not require large amounts of clearing, and standard practices for the control of erosion and sedimentation would be adopted to manage any sediment runoff. Erosion and sediment control measures are to be implemented (in accordance with the Landcom/Department of Housing *Managing Urban Stormwater, Soils and Construction Guidelines* (the Blue Book)) and maintained to:

- Prevent sediment moving off-site and sediment laden water entering any water course, drainage lines, or drain inlets
- Reduce water velocity and capture sediment on-site
- Minimise the amount of material transported from site to surrounding pavement surfaces
- Divert clean water around the site.

The location and extent of these temporary control treatments would be addressed during construction.

A review of the project catchments using 12d modelling software indicates that sedimentation basins for construction would not be required in Grafton as the

estimated average annual soil losses from most of the local catchments would not exceed the threshold of 150 cubic metres as specified in *Managing Urban Stormwater: Soils and Construction Vol. 1* (Landcom, 2004). This is largely attributed to the relatively flat topography of the project site.

Construction sedimentation basin

The preliminary earthwork modelling for the project catchments indicates that a construction sedimentation basin could be required at the South Grafton ancillary site to intercept sediment-laden runoff and retain the sediment and attached pollutants from the ancillary site.

The indicative location of the construction sedimentation basin is shown in Figure 6-4 and would be refined during detailed design. It would be sized to contain the five-day 85th percentile rainfall value, and its design, location and sizing would be subject to the construction contractor's construction staging plans.

For the other project catchments in Grafton and South Grafton, implementation of localised erosion and sediment control measures would be the main tools to minimise the volume of sediment transported from disturbed areas. These control measures would be located within the project area and confirmed during detailed design.

River-based construction activities

Any river-based construction activities would be carried out in accordance with the principles of the Blue Book as detailed above and would include:

- Measures to ensure no release of dirty water into drainage lines and/or waterways
- Visual monitoring of local water quality (ie turbidity, hydrocarbon spills/slicks) is to be carried out on a regular basis to identify any potential spills or deficient controls
- Water quality control measures are to be used to prevent any materials (eg concrete, grout, sediment etc) entering waterways.

Subject to the construction methodology chosen and the construction contractor program or works, a temporary working platform may also be constructed. This temporary working platform would extend from the existing banks into the river to enable stable and safe access to construction barges, and piling areas as required.

Any temporary working platforms would be designed in accordance with the principles outlined in Section 6.6.1.

Protection of water quality during operation

The proposed operational stormwater management system for the project is documented in Section 5.2.5 and presented in Figure 5-8.

In South Grafton, the proposed drainage strategy would direct stormwater runoff through a series of grass-lined open channels and culverts, eventually discharging through a culvert in the flood levee with a flap valve. The stormwater runoff from the road would receive some water quality treatment in the grass-lined channels. From here the water would disperse over the floodplain and ultimately discharge into Alipou Creek.

Over the bridge deck, the drainage network would extend along the bridge approaches, with stormwater runoff discharged into the existing drainage network. The need to provide measures to manage emergency spills would be evaluated during detailed design.

In Grafton, the drainage strategy would be to use or modify the existing drainage network where possible. Where this is not possible, existing drainage would be removed and replaced with pits that direct the stormwater runoff into grass-lined

open channels where possible, which would provide some water quality treatment. Where this is not possible, a pit-and-pipe network would be built. The proposed stormwater drainage would ultimately drain into the Clarence River, which is what currently occurs.

The water quality mitigation measures proposed during operation of the proposed project are comparable or better than the existing systems in Grafton and South Grafton.

Environmental management measures

Table 8-75 outlines proposed environmental management measures to manage impacts. The measures have been prepared in accordance with relevant legislation, codes of practice, specifications and guidelines.

Table 8-75 Environmental management measures for soils, sediments, water and contaminated land impacts

Impact	Environmental management measure	Responsibility	Timing
Soils, sediments and water quality			
Acid sulfate soils disturbance	Acid-resistant construction materials will be used where possible in areas known to contain acid sulfate soils.	Roads and Maritime	Detailed design
Protection of water quality during operation	Operational water quality management and protection measures, such as swales, to protect nearby waterways from pollutants from the bridge and approaches will be further refined and investigated in consultation with Clarence Valley Council.	Roads and Maritime	Detailed design

Impact	Environmental management measure	Responsibility	Timing
Construction soils and water management plan	As part of the construction environmental management plan, a soil and water management plan will be prepared in line with current Roads and Maritime specifications. The plan will include (but not limited to): • Details of erosion and sediment controls to be implemented, including erosion and sediment control plans developed for the project • Details of inspection frequency for control measures • Monitoring and maintenance of environmental control measures • Environmental work method statements for high risk activities such as dewatering and works within waterways • Procedures to manage stockpiles generated during construction • Tannin leachate management measures • Acid sulfate management measures • Detailed consideration of measures to prevent (where possible) or minimise any water quality impacts • Measures to manage known and unexpected contamination during the construction stage • Consideration of water dissipation due to wick drains.	Construction contractor	Pre-construction
Soil erosion and sediment control	Erosion and sediment control measures will be implemented in accordance with the Landcom/Department of Housing *Managing Urban Stormwater, Soils and Construction Guidelines* (the Blue Book) and maintained to: • Prevent sediment moving off-site and sediment laden water entering any water course, drainage lines, or drain inlets • Reduce water velocity and capture sediment on-site • Minimise the amount of material transported from site to surrounding pavement surfaces • Divert clean water around the site.	Construction contractor	Construction

Impact	Environmental management measure	Responsibility	Timing
	Erosion and sedimentation controls will be checked and maintained on a regular basis (including clearing of sediment from behind barriers) and records kept and provided on request.	Construction contractor	Construction
	Erosion and sediment control measures will not be removed until the works are complete and areas are stabilised.	Construction contractor	Construction
	Work areas will be stabilised progressively during the works.	Construction contractor	Construction
	Water from site will be used for construction purposes, such as dust suppression, where feasible and reasonable.	Construction contractor	Construction
Acid sulfate soils disturbance	Where excavation is to be carried out in areas anticipated to contain acid sulfate soils, work will proceed according to the soils and water management plan (acid sulfate soils section). Specific controls to be implemented will include: • Capping exposed surfaces with clean fill to prevent oxidation • Placing excavated acid sulfate soils separately in a lined, bunded and covered area • Neutralising acid sulfate soils for reuse (where appropriate) by using additives such as lime • Disposing of acid sulfate soils where necessary in accordance with the relevant guidelines set out in the *Acid Sulfate Soils Assessment Guidelines* (Ahern et al, 1998).	Construction contractor	Construction
	If acid sulfate soils are disturbed, any acid produced will be neutralised and acid waste prevented from leaving the site in accordance with the applicable guidelines.	Construction contractor	Construction

Impact	Environmental management measure	Responsibility	Timing
Protection of water quality during construction	Construction water quality management measures to protect nearby waterways from construction activities will be included in the soil and water management plan developed for the project. This plan will include (but not limited to) the following measures: • Appropriate controls to minimise risk of release of dirty water into drainage lines and/or waterways • Visual monitoring of local water quality (ie turbidity, hydrocarbon spills/slicks) is to be carried out on a regular basis to identify any potential spills or deficient erosion and sediment controls • Water quality control measures to prevent any materials (eg concrete, grout, sediment etc) entering waterways.	Construction contractor	Construction
Temporary working platforms	Before commencement of works within the river, a workshop will be held with relevant government agencies including representatives from EPA, NSW Office of Water, Department of Primary Industries Fisheries, Roads and Maritime and the construction contractor to discuss potential options for temporary working platforms. Any temporary working platforms will be managed in accordance with the principals detailed in Section 6.6.1 of the EIS.	Construction contractor	Construction
Exposed areas	Exposed areas will be progressively rehabilitated. Methods will include permanent revegetation, or temporary protection with spray mulching or cover crops.	Construction contractor	Construction
Stockpile site management	Topsoil, earthworks and other excess spoil material will be stockpiled in accordance with the principles outlined in *Stockpile Management Guidelines* (Roads and Maritime, 2011).	Construction contractor	Construction

Impact	Environmental management measure	Responsibility	Timing
	Stockpiles will be placed within a designated ancillary site or stockpile area in accordance with the following principles: • Not require removal of areas of native vegetation (where feasible and reasonable) • Not be located under the 'dripline' of trees • Be located outside known areas of weed infestation • Be located such that waterways and drainage lines are not directly impacted.	Construction contractor	Construction
	Where practicable, stockpiles will be located away from areas subject to concentrated overland flow. Stockpiles located on a floodplain will be managed so as to minimise loss of material in flood or rainfall events.	Construction contractor	Construction
	All construction stockpiles will comply with the requirements of the *Protection of the Environment Operations Act 1997* and *Waste Avoidance and Resource Recovery Strategy 2007* for any waste activities that involve the generation, storage and/or disposal of waste. The NSW Resource Recovery Exemptions will also be applied to the storage and management of stockpiled material.	Construction contractor	Construction
	Stockpiles containing potential acid sulfate soils will be managed in accordance with the *Acid Sulfate Soils Manual* (Acid Sulfate Soils Management Advisory Committee, 1998).	Construction contractor	Construction
Emergency spill response during construction	Emergency spill response measures will be developed and incorporated into the soils and water management plan as part of the construction environmental management plan. This plan will detail measures for the prevention, containment and clean-up of accidental spills of fuels and chemicals.	Construction contractor	Construction
Chemical use and storage	The storage, handling and use of the chemicals and fuels will be in accordance with the *Work Health and Safety Act 2000* and *Workcover's Storage and Handling of Dangerous Goods Code of Practice* (WorkCover, 2005).	Construction contractor	Construction

Impact	Environmental management measure	Responsibility	Timing
	Physical controls to address the potential risks associated with the use and storage of chemicals on-site will include: • Bunded storage facilities for chemicals and fuels • Bunded areas for refuelling and washdown • Effective spill kits at all construction sites.	Construction contractor	Construction
Disturbance of contaminated soils			
Detailed site investigation	A detailed site investigation will be prepared for the areas of potential contamination identified in this EIS in accordance with *Guidelines for Consultants Reporting on Contaminated Sites* (OEH, 2011). The site investigation will provide detailed information on the type, extent and level of contamination and assess: • Contaminant dispersal in air, surface water, groundwater, soil and dust • The potential effects of contaminants on public health, the environment and the project structures • Off-site impacts on soil, sediment and biota (where applicable) • The adequacy and completeness of all information available to be used in making decisions on remediation.	Roads and Maritime	Detailed design
Site remedial action plan	If the results of the detailed site investigation indicate a remedial action plan needs to be prepared and implemented, this plan will be prepared in consultation with Department of Planning and Environment and Office of Environment and Heritage. The plan will be prepared in accordance with *Guidelines for Consultants Reporting on Contaminated Sites* (OEH, 2011).	Construction contractor	Pre-construction
Asbestos on demolished structures	An asbestos survey will be conducted for structures to be demolished as part of the project. An asbestos certified disposal service will be engaged for properties identified as having asbestos materials.	Construction contractor	Construction

8.11 Mineral resources

This section provides an assessment of the impacts of the project on significant mineral resources including an assessment of the potential for the project to sterilise known significant resources or access to land for mineral exploration.

Table 8-76 lists the Director-General's environmental assessment requirements relevant to mineral resources and where they are addressed in this section.

Table 8-76 Director-General's environmental assessment requirements relevant to mineral resources

Director General's environmental assessment requirements	Where addressed in EIS
An assessment of impacts on significant mineral resources, including consideration of:	
Operating mines, extractive industries or known mineral or petroleum resources (including, where relevant, the quality and quantity of local fluvial sand and gravel resources proposed for use in construction of the project).	Section 8.11.3 Resources proposed for use in construction of the project is addressed in Section 6.5
Current exploration activities (and maintenance of access for future exploration) in the vicinity of the project.	Section 8.11.2 and Section 8.11.3

8.11.1 Assessment methodology

An assessment of impacts on significant mineral resources has been carried out through a desktop review of publicly available information relating to mineral deposits and an assessment of the potential of the project to impact on current and future mineral resources.

A range of online data has been accessed through the NSW Trade and Investment Geoscience Information Services. The key data sources used in this assessment are the NSW *Title View service* which provides up-to-date NSW mineral, coal and petroleum titles maps and related information, and the *MinView service* which provides current and historical exploration titles information, state-wide geology, mineral deposits and occurrences. Information for the assessment, including locations of quarries and other minerals resources, was sourced from the *Mineral Resources Audit for the Clarence Valley LGA* (NSW Industry and Investment, May 2011).

Quarry resources would be required to construct the project. Refer to Section 6.5.1 for locations of existing quarries where mineral resources needed for the project could be extracted. The cumulative demand on mineral resources resulting from other projects in the area is discussed in Section 9.4.

8.11.2 Existing environment

The geology, soils, surface water and groundwater conditions of Grafton, South Grafton and the broader Clarence Valley are documented in Section 8.10. Key minerals within the Clarence Valley local government area include fluvial gravels and sediments, of which there are large deposits within the Clarence River and areas beneath the floodplain. It is identified in the *Mineral Resources Audit* that the Grafton area is close to deposits of fluvial sand and gravel.

The *Minerals Resource Audit* for the Clarence Valley local government area states that:

- Construction materials are by far the most important mineral resource commodities being produced in the Clarence Valley local government area. The outlook for construction materials is for increasing demand to service ongoing maintenance and service needs, new development arising from population growth, upgrading of the Pacific Highway and possibly an increasing requirement to fill in low-lying areas to combat sea level rise
- Clay/shale production is an important source of red-firing and white-firing clays used as feedstock in brickmaking at South Grafton
- Chrysotile asbestos, gold, rutile and zircon were important in the recent past, but these industries are no longer active in the region
- Other mineral commodities produced include copper, silver, molybdenum, antimony, and mercury
- Metalliferous mineral exploration is currently active, particularly in the western part of the local government area
- Petroleum exploration titles cover most of Clarence Valley local government area including large tracts west of the Clarence-Moreton Basin.

Mineral tenures and titles, current mineral applications and leases within or in close proximity to the project area are described in Table 8-77. Information outlined in this table was obtained from searches of *NSW Titles Viewer* (accessed on 29 January 2014), *MinView* (accessed on 29 January 2014) and the *Minerals Resource Audit Clarence Valley local government area* (2011).

Refer to Section 6.5.1 and Figure 6-6 for quarries within the Clarence Valley that could be used for the project construction.

Table 8-77 Mineral resource information for the Clarence Valley local government area

Nearby mineral extraction sites				
No	**Quarry name**	**Location**	**Main commodity**	**Comment**
1	Tuckers Quarry	About 12 km north of the project. Near Orchard Road, Grafton.	Ironstone quarry, developing as sandstone quarry.	Recent production of 50,000 tonnes per annum.
2	Grafton Quarry (Boral)	Immediately west of the project, and stretching 10 km to the north of the project. Bounded by the Clarence River.	Construction sand and gravel.	Five sites located to the west and north of the project, within the bed and banks of the Clarence River. Life of resource is effectively unlimited (with replacement).
3	Jackys Creek (McLennan)	About 10 km west of the project. Old Glen Innes Road, Grafton.	Prepared road base.	Next to Jackys Creek Potential Resource Area.

Mineral tenure				Comment
Current mineral applications				None are located within the project alignment.
Current mineral titles				None are located within the project alignment.
Current petroleum titles				
No	**Company**	**Minerals**	**Title area**	**Comment**
PEL 426	Metgasco	Petroleum	38 Blocks	Title is located within the project area. Grant date 21 April 1998. Renewal date 08 April 2010.
Coal tenure				**Comments**
Coal applications				None located within or adjacent to the project area
Coal titles				None located within or adjacent to the project area
Gas sites				None located within or adjacent to the project area

The approval authority for quarries in the Clarence Valley is the Clarence Valley Council and Department of Planning and Environment, dependent on the quarry site and the amount of material required.

NSW Trade and Investment produced the *Mineral Resource Audit for the Clarence Valley LGA* but does not have a formal, statutory role in mineral extraction, apart from its statutory responsibilities under the *Mine Health and Safety Act 2004*. NSW Trade and Investment has a long-established and accepted role among state and local government agencies of assessing extractive resources and providing advice relevant to their management.

8.11.3 Assessment of potential impacts

This section assesses the impacts of the project on significant mineral resources identified in Table 8-77 and on access to future exploration activities.

Impacts on significant mineral resources

The assessment finds that the project is unlikely to impact significant mineral resources within the locality. This is because:

- The project occurs within the area of the existing petroleum title PEL 426. No recent petroleum investigation sites are recorded on *MinView* as being located in the vicinity of the proposed project and the title area covers much of the Clarence Valley. Given the small footprint of the project relative to the size of the area covered by the petroleum title, and the unlikelihood of future petroleum extraction in an urban environment, the potential impacts on existing or proposed mineral or petroleum tenures are assessed to be negligible
- The closest mineral extraction to the project area is of fluvial sand and gravel resources, located immediately to the west and north of the existing bridge within the Clarence River bed. These resources would not be sterilised from future

extraction by below-water structures of the proposed bridge, as all potential impacts from the project on the river bed would occur to the east of the existing bridge and the mapped resource. Any sand and gravel resources that may exist within the river bed areas occupied by the proposed bridge foundations would be sterilised, but such an impact is expected to be insignificant considering the relatively small area required for bridge foundations within the total size of the resource area

- Mineral resources in other areas of the Clarence Valley would not be sterilised by the project which is limited in its extent to the Grafton and South Grafton areas
- The total amount of construction materials required (refer Section 6.5) are expected to be met by a combination of quarries and sites as described in the *Clarence Valley LGA Mineral Resource Audit* May 2011 and Section 6.5.1 of this EIS. In the case of fill for the project this could also potentially be sourced from concurrent projects in the area such as the Woolgoolga to Ballina Pacific Highway Upgrade which is likely to generate more than 1 million cubic metres of surplus material (Roads and Maritime, 2012).
- Quarries are available in the local area of a scale that can provide material to the project. It is unlikely the project would trigger the need to increase approved extraction volumes for existing quarries The selection of resource sites for the project would occur before construction in consultation with Roads and Maritime and the construction contractor
- The project would not sterilise any access to potential fluvial sand or gravel resources as mapped in the *Mineral Resources Audit*. In addition, the proposed bridge site is assessed to be in an unsuitable location for any long-term operation of fluvial sand and gravel removal due to potential impacts on river users and potential visual and amenity impacts on residents in Grafton.

Impacts on access to future exploration

The proposed project would not prevent or limit access to any current or future exploration activity. This is because:

- Access to potential fluvial sand and gravel resources would be maintained by providing adequate horizontal and vertical clearance for any gravel barges to pass beneath the proposed bridge
- Access to the surrounding stretches of the river from the existing road network would not be restricted as a result of the proposed project. Details on the traffic and access impacts of the project are found in Section 8.1.

8.11.4 Environmental management measures

No significant impact on nearby mineral resources is likely as a result of the construction or operation of the project.

The opportunity to reduce the extraction of new material will be investigated as part of detailed design as proposed in Section 9.3. This opportunity includes the potential reuse of materials from the Woolgoolga to Ballina Pacific Highway upgrade to the project.

Management measures regarding construction impacts such as transport and material haulage (Section 8.1) soil and water impacts (Section 8.10), noise and vibration (Section 8.4), resource and waste management (Section 9.3) and cumulative impacts (Section 9.4) are discussed elsewhere in this EIS.

8.12 Air quality

This section provides an assessment of the project's potential impacts on air quality, both locally and regionally, during construction and operation. Table 8-78 outlines the Director-General's environmental assessment requirements relevant to air quality that are addressed in this chapter.

Table 8-78 Director-General's environmental assessment requirements related to air quality

Director General's environmental assessment requirements	Where addressed in EIS
An assessment of the potential for impacts on local and regional air quality.	Section 8.12.3 and Section 8.12.4
Details of the proposed mitigation measures to prevent the generation and emission of dust.	Section 8.12.5

8.12.1 Assessment methodology

Construction stage

A qualitative assessment of potential impacts on air quality during construction was carried out. It involved:

- Identifying the location, type and intensity of major construction activities (including the potential concrete batching plant)
- Identifying the location of the nearest sensitive receivers to construction activities
- Characterising the existing air quality environment and assessing the prevailing meteorological conditions
- Describing the potential local and regional air quality impacts during construction based on the information provided in Chapter 6 and outlining how these impacts would be managed and mitigated.

Operational stage

A quantitative assessment of local and regional air quality impacts from operation of the project was carried out using air dispersion modelling. The assessment was based on the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005). Model results were compared to Environmental Protection Authority (EPA) air quality assessment criteria (see below) and conservative estimates of existing background pollutant levels.

The air quality modelling software, AUSROADS V1.0 (developed by the Environment Protection Authority of Victoria), was used to predict concentrations of pollutants near the proposed roads and bridge. AUSROADS is a line source Gaussian plume dispersion model, based on the US CALINE model that can be used to predict concentrations of pollutant in the vicinity of roads. The *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* states that where stated air quality models are not appropriate for use, the *Guideline on Air Quality Models* (USEPA, 1999) may be referred to for a more appropriate air quality model. Appendix A of the USEPA document states that a CALINE3 Gaussian plume model is appropriate for use on highway (line) sources. AUSROAD V1.0, based on CALINE4 (the most recent version), has therefore been selected as the most appropriate air quality model in this study.

The air quality assessment was carried out for the key pollutants from motor vehicles: nitrogen dioxide (NO_2), carbon monoxide (CO) and fine particular matter less than 10

microns (PM_{10}). The air dispersion model was based on the following information sources:

- Traffic modelling for 2011, 2019 (assumed year of opening) and 2029 (10 years after opening). These years are representative of existing and future traffic conditions and consistent with other modelling carried out as part of this project (eg traffic and noise modelling)
- The project design (as described in Chapter 5)
- Existing and forecast hourly traffic volumes (daytime and night-time peaks, and 15-hourly daytime), including the percentage of heavy vehicles
- Meteorological conditions (local cloud cover, wind speed and direction and solar radiation) based on 2011 data from Grafton airport weather station, which is located about 11 kilometres from the Grafton Bridge. Although the Grafton Olympic Pool weather station is closer to the project area the full range of data required for the assessment was not available from historic Bureau of Meteorology data. In addition, data for Grafton airport station is considered to be representative of the conditions at Grafton. The meteorological data was reviewed and processed for use in the AUSROADS model
- Vehicle pollutant emission factors derived from EPA Victoria AusVEH estimates (January 2010) for 2011. The same emission factors were used for 2019 and 2029.

Twelve representative sensitive receivers were chosen that are close to or alongside major roads or the existing and future bridge (see location of receivers in Figure 8-41).

A conservative approach was taken for the air dispersion model and air quality assessment. In particular:

- The background concentrations assumed for the model (refer to Table 8-80) are based on background data from the Pacific Highway, which has higher traffic volumes and therefore higher emission levels than the traffic volumes in Grafton
- The model assumes there will be no improvement in vehicle emissions in the future. However, this is unlikely; it is more likely that there will continue to be incremental reductions in vehicle emissions due to improvements in technology
- The model assumes a NO_x:NO_2 conversion factor of 35 per cent based on the *Air Quality Modelling and Assessment Unit, The Environment Agency Conversion ratios for NO_x and NO_2* (UK Department for Environment, Food and Rural Affairs, 2006). This factor is considered in the UK as a worst-case factor for assessing short-term concentrations.

Sensitive receivers

Sensitive receivers are locations where potential air quality impacts are measured to determine whether any potential adverse health impacts may occur from increased traffic volumes. For this study, twelve sensitive receivers were selected as indicative locations within the project area to understand the change in air quality as a result of the project. These sensitive receivers were selected for the assessment based on where people are likely to reside close to existing and proposed roads. Sensitive receivers are generally selected on the basis that they are within 50 metres of the edge of existing or proposed roads, and are evenly distributed across the project area. Selected sensitive receivers for this project are shown in Figure 8-41.

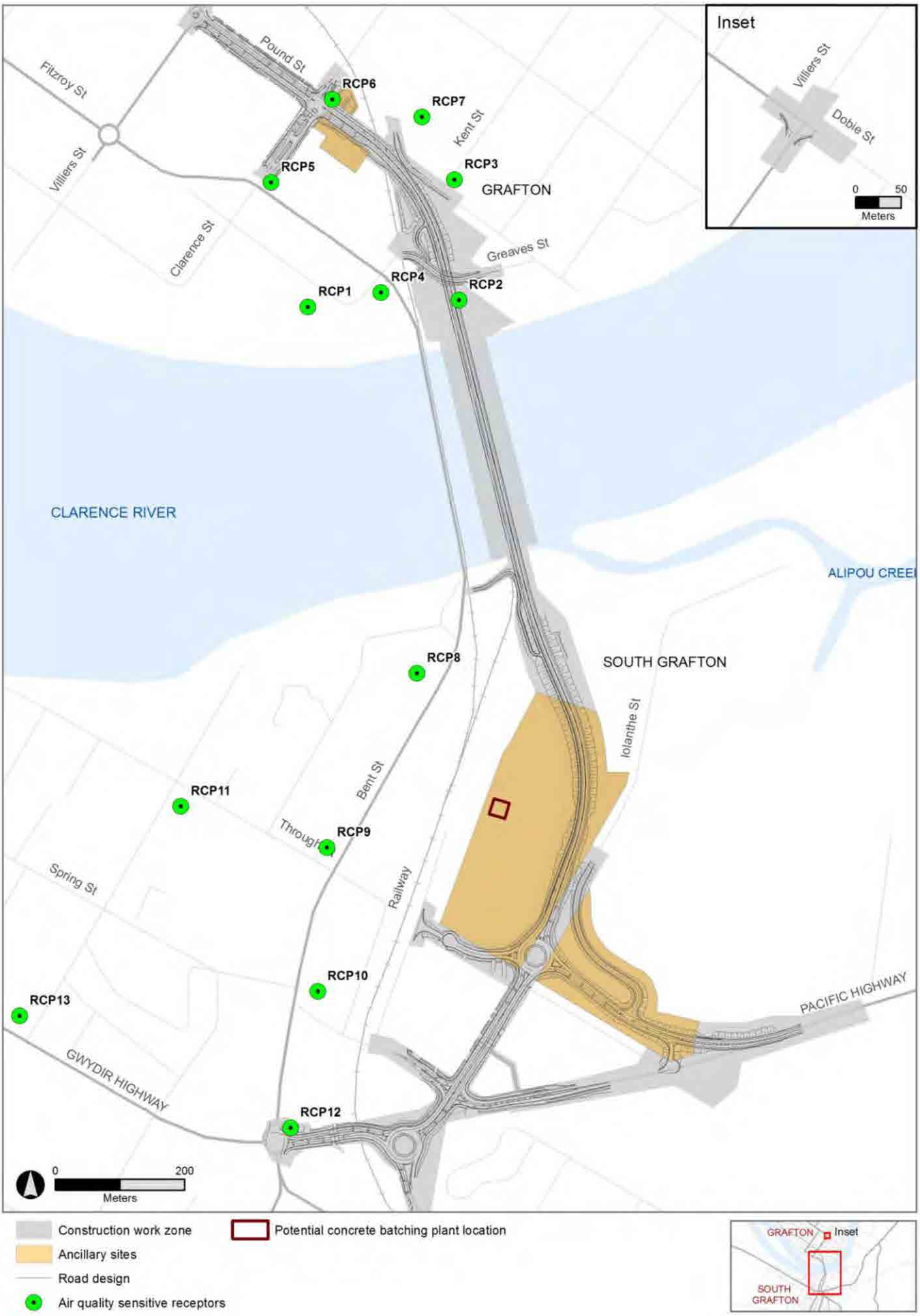


Figure 8-41 Sensitive receivers within the project area for the air quality assessment

Air quality criteria

The air quality criteria used in the assessment of operational impacts are listed in Table 8-79.

Table 8-79 Operational air quality criteria

Air pollutant	National Environment Protection Measure (NEPM) air quality criteria
Nitrogen dioxide (NO_2)	246 micrograms per cubic metre (1-hour averaging period)
Carbon monoxide (CO)	30 milligrams per cubic metre (1-hour averaging period)
Fine particles (PM_{10})	50 micrograms per cubic metre (24-hour averaging period)

The assessment did not include sulphur dioxide because sulphur dioxide emissions from road traffic exhaust are primarily controlled by the regulation of the sulphur content in diesel fuels, which has been systematically reduced since 2001 under the *Fuel Standard (Automotive Diesel) Determination 2001* (DEWHA, 2001). Under this determination, sulphur content in diesel fuel is now regulated to 10 parts per million (ppm), from 500ppm in 2002 and 50ppm in 2006.

The air pollutants used in the assessment, and their potential impacts, are as follows:

- Nitrogen dioxide (NO_2) results from combustion processes, such as internal combustion in vehicle engines. These are formed from the oxidation of nitrogen in the fuel or from the reaction of nitrogen and oxygen at high temperatures. The health effects of exposure to nitrogen dioxide at levels above normal ambient concentrations include irritation of the lungs. The symptoms are felt more greatly by people with existing lung conditions, such as asthma, and those with heart conditions
- Carbon monoxide (CO) is generated by partial oxidisation of carbon in fuel. Carbon monoxide can be harmful to human health as it more readily binds to haemoglobin than oxygen (this significantly limits the amount of oxygen that can circulate around the body). In high levels of exposure, this can lead to nausea and headaches
- Fine particles less than 10 micrometres (PM_{10}) are emitted by vehicles through incomplete fuel combustion, fuel additives and worn parts (from moving engine parts, brakes and tyres). Fine particles are considered a pollutant because they are easily inhaled by people into their lungs and airways, potentially causing damage.

Regarding air quality impacts during construction, the major air emission expected from construction activities is dust. Construction activities such as demolition works, civil engineering works and earthwork activities would generate dust or particulate emissions that can impact nearby surroundings. A qualitative assessment on air quality impacts from construction has been completed, and potential impacts will be managed through dust control measures during construction as outlined in Section 8.12.5.

8.12.2 Existing environment

Wind conditions

Local meteorology and wind conditions affect air quality and the dispersion of any air pollutants. Local meteorological conditions have been considered to assess potential air quality impacts.

Figure 8-42 provides a wind rose for Grafton (Grafton Airport weather station), which indicates the frequency of wind directions and corresponding wind speeds. The

predominant wind directions are from the south (21 per cent southerly, and 20 per cent south-south-westerly).

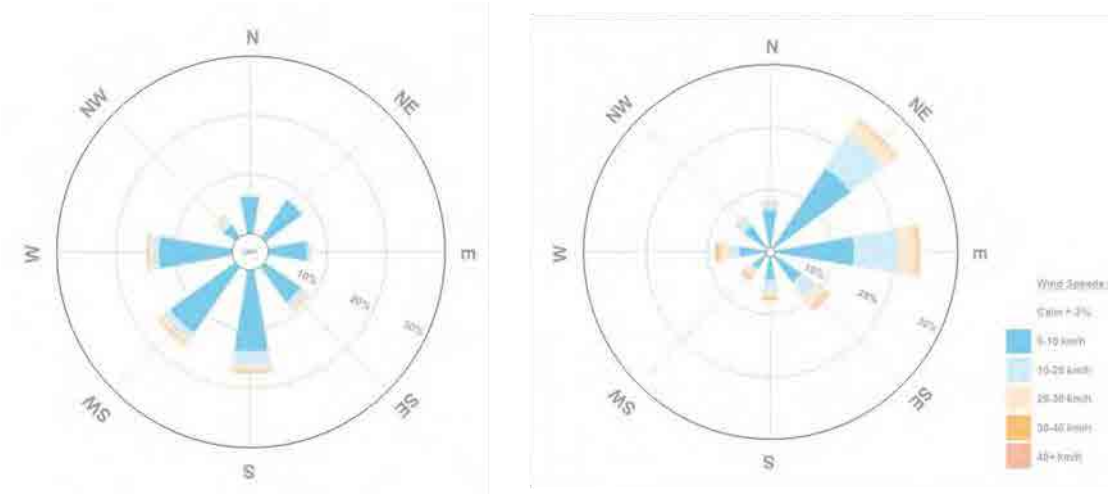


Figure 8-42 Wind rose at Grafton airport weather station in 2011 (left wind rose 9am, right wind rose 3pm)

The majority of wind speeds are below 4.5 metres per second (43 per cent are below eight kilometres per hour, and 41 per cent are below 16 kilometres per hour). The wind rose is based on 2011 data from the Bureau of Meteorology. It should be noted that wind patterns vary over time.

On average, across three years of data (2010–2013), the Grafton Airport weather station experiences annual average wind speeds between 2.1 and 2.4 metres per second (that is, 7.6 and 8.6 kilometres per hour), which are considered to be moderate.

Existing air quality information

There is limited information on existing air quality at Grafton as regional areas generally do not have access to local air quality monitoring stations (generally, pollutants do not occur in high enough concentrations to cause adverse health impacts, so air quality monitoring is not required).

Air quality monitoring has not been carried out specifically for this project. However, Roads and Maritime has previously monitored air quality at a site beside the Pacific Highway at Korora between Korora Public School and the Korora Rural Fire Brigade, north of Coffs Harbour (refer to Table 8-80). This is one of the most trafficked sections of the highway. The site is located about 65 kilometres from Grafton Bridge.

Average daily traffic on the Pacific Highway was around 19,700 vehicles, which is above the maximum daily traffic of 17,000 vehicles at Grafton Bridge. Therefore, the use of this data provides a conservative or worst-case indication of existing air quality in Grafton.

Table 8-80 Existing air quality (based on air quality monitoring data at Korora, October 2005 to January 2006)

Nitrogen dioxide (NO_2)	Carbon monoxide (CO)	Fine particles (PM_{10})
74 micrograms per cubic metre (maximum 1-hour average)	1.2 milligrams per cubic metre (maximum 1-hour average)	38 micrograms per cubic metre (maximum 24-hour average)

The assumed existing air quality at Grafton should consider the predominant wind speeds and directions in the area.

8.12.3 Assessment of potential impacts - construction

During construction, a range of activities may impact air quality. The main potential issues would relate to dust and construction vehicle emissions.

Earthworks, road construction activities and the concrete batching plant would generate dust or particulate emissions, which can impact nearby sensitive receivers. In this case, sensitive receivers would include residential homes, local educational facilities, retail or public areas, or pedestrians who are close to construction activities associated with the new bridge and roads.

Dust and particulates pose a potential health risk, particularly for children, the elderly or people with respiratory issues. Dust and particulates can also affect local amenity and cause a nuisance for nearby receivers. The extent of these impacts would depend on the size and nature of the construction activities and the wind direction.

Due to the age of most dwellings in Grafton, there is a risk of asbestos being present and fibres being released during any demolition. However, demolition of structures containing asbestos would be disposed of and managed in accordance with the mitigation measures outlined in Table 8-75.

Emissions from construction vehicles and machinery would be predominantly from diesel engines. These engines would emit particulate matter (in the form of soot), and other gaseous emissions such as carbon monoxide, sulphur oxides and nitrogen oxides.

However, these temporary air quality impacts from vehicle emissions are likely to be lower than the impacts from vehicle emissions during operation of the bridge. This is because construction traffic volumes would be significantly lower than the traffic volumes forecast for the new bridge. Forecast construction and operational traffic volumes are outlined in Section 8.1.

The potential location of a concrete batching plant is on the western side of the South Grafton construction work zone (refer to Figure 8-41) and has the potential to affect local ambient air quality and the nearest sensitive receivers.

If required, the plant would be expected to operate at a capacity of around 840 tonnes per day (peak demand). Batching plant operation would be between 7am to 6pm Monday to Friday and 7am to 1pm on Saturdays. No work would take place outside these hours or on public holidays without prior discussion with and/or notification of local residents and the Office of Environment and Heritage. Typically, concrete batching plants operate at maximum capacity only during the morning hours. Later in the day many of the processes have usually ceased.

Emissions from concrete batching plants are predominantly particulate matter emissions in the form of total suspended particulates (TSP) and particles with an aerodynamic diameter less than 10 microns (PM_{10}). Relatively small quantities of combustion pollutants (carbon monoxide, oxides of nitrogen, oxides of sulphur and hydrocarbons) can also be emitted. Mitigation measures would be implemented while the batching plant is operating, to reduce emissions arising from the concrete batching plant and minimise potential air quality impacts. Table 8-81 summarises the types of construction activities and the potential air quality impact that may result from these activities.

Table 8-81 Construction activity air quality impacts

Construction activity	Intensity of activity	Aspect	Impact description
Construction machinery use	Sporadically over three years	Vegetation and land clearing	Generation of dust or particulates
		Soil excavation	Generation of dust or particulates
		Bridge construction	Generation of dust or particulates
Stockpiling	Two years during construction phase	Uncovered stockpiles, or non-managed stockpiles particularly for solid wastes, debris or other materials	Generation of dust
Construction machinery and vehicle movements	Sporadically over two years	Uncovered vehicle loads during transportation of soil and fill	Generation of dust and particulates
	Daily over two years	Vehicle exhaust emissions	Diesel exhaust emissions from vehicle movements to and from construction site. These emissions are considered insignificant compared to existing traffic volumes.
Concrete batching plant	Two years during construction phase	Cement dust emissions	Cement dust generated from the batching process.

The air quality impacts identified in Table 8-81 would be managed though the measures outlined in Section 8.12.5.

8.12.4 Assessment of potential impacts - operation

As outlined in Section 8.12.1, the air quality assessment considered the potential for air quality impacts once the project is operational. The quantitative assessment was based on a dispersion software model that predicts pollutant concentrations likely to occur at sensitive receivers near the new bridge and new roads.

Table 8-82 provides the modelled levels of air pollution across the 12 sensitive receivers, all of which are below the NEPM air quality criteria. The dispersion modelling results show that during the operation of the project, the air quality levels at the 12 sensitive receivers would be below the NEPM criteria for the key pollutants (NO_2, CO and PM_{10}) for all modelled years (2011, 2019 and 2029). In years 2019 and 2029, there would be a slight increase in air pollutant levels compared to the background air pollution concentrations assumed due to higher traffic volumes in future years.

The modelling results show that in the 2029, without the project, there are two sensitive receivers (RCP5 and RCP8) where the NO_2 NEPM criteria would be exceeded.

For nitrogen dioxide (NO_2), once the project is operating, the results indicate that:

- In 2019 and 2029, the air quality concentrations would be, on average, 54 per cent and 57 per cent of the NEPM criteria, respectively
- In 2019, nine of the 12 receivers would have reduced NO_2 levels. The other three receivers would have increased levels, ranging from 10 to 36 per cent
- In 2029, 10 receivers would have reduced NO_2 levels. Two receivers (RCP5 and RCP 8) would exceed the NEPM criteria under a 'without project' scenario in 2029; but with the project in place, both receivers would be below the NEPM criteria. This is likely to be because of a shift in traffic from the existing route to the new route, resulting in a reduction in traffic adjacent to these receivers.

For carbon monoxide (CO), once the project is operating, the results indicate that:

- In 2019 and 2029, the air quality concentrations would be, on average, six per cent of the NEPM criteria
- In 2019, nine of the 12 receivers would have reduced CO levels. The other three receivers would have increased levels, ranging from eight to 28 per cent
- In 2029, all twelve sensitive receivers modelled would have reduced CO levels during the operation of the project.

For fine particles (PM_{10}), once the project is operating, the results indicate that:

- In 2019 and 2029, the air quality concentrations would be, on average, 79 per cent of the NEPM criteria
- In 2019, 10 of the 12 receivers would have reduced PM_{10} levels. One receptor would have a level five per cent higher, and another would have no change in levels
- In 2029, 10 receivers modelled would have reduced PM_{10} levels, with the other two receivers having increased PM_{10} levels of between two and seven per cent.

In summary, the results of the air quality modelling show that:

- There would be no air quality criteria exceedances due to the operation of the project
- In some cases, the project would generally improve air quality when compared to a 'without project' scenario
- The general decrease of the three key pollutant levels indicates that the operation of a new bridge would disperse the intensity of air pollutants at most receivers.

Table 8-82 Predicted operational air quality with and without the proposed project

Receptor No.	Without the project									With the project in operation					
	2011			2019			2029			2019			2029		
	NO_2 µm/m^3	CO µm/m^3	PM10 µm/m^3	NO_2 µm/m^3	CO µm/m^3	PM10 µm/m^3	NO_2 µm/m^3	CO µm/m^3	PM10 µm/m^3	NO_2 µm/m^3	CO µm/m^3	PM10 µm/m^3	NO_2 µm/m^3	CO µm/m^3	PM10 µm/m^3
NEPM Criteria	246 µg/m^3	30 mg/m^3	50 µg/m^3	246 µg/m^3	30 mg/m^3	50 µg/m^3	246 µg/m^3	30 mg/m^3	50 µg/m^3	246 µg/m^3	30 mg/m^3	50 µg/m^3	246 µg/m^3	30 mg/m^3	50 µg/m^3
RCP1	109	1.6	40	114	1.6	40	225	2.2	40	103	1.5	39	109	1.6	40
RCP2	172	2.3	42	187	2.4	43	216	2.7	44	153	2.1	39	175	2.3	39
RCP3	122	1.7	39	128	1.8	39	142	2.0	39	108	1.6	39	116	1.7	39
RCP4	106	1.5	39	109	1.6	39	115	2.3	39	131	1.8	41	144	2.0	41
RCP5	222	2.8	41	244	3.0	41	**282**	3.5	42	167	2.2	40	188	2.4	40
RCP6	128	1.8	39	138	1.9	39	153	3.1	40	187	2.4	40	215	2.7	41
RCP7	158	2.1	40	169	2.2	40	189	2.4	40	118	1.7	39	115	1.6	39
RCP8	218	2.7	41	244	3.0	41	**294**	3.6	42	136	1.9	39	121	1.7	39
RCP9	124	1.7	40	132	1.8	40	149	2.0	41	106	1.5	39	100	1.5	39
RCP10	102	1.5	39	106	1.5	39	115	1.6	39	98	1.5	39	100	1.5	38
RCP11	150	2.0	41	162	2.1	42	185	2.4	43	179	2.3	41	180	2.3	40
RCP12	107	1.6	39	115	1.6	39	133	1.8	39	111	1.6	39	117	1.7	39

Note: when the National Environment Protection Measure (NEPM) air quality criteria are exceeded, the number appears in bold font.

8.12.5 Environmental management measures

During construction, air quality impacts would need to be managed to minimise impacts on the Grafton community. Proposed management measures are listed in Table 8-83.

As vehicle emission impacts during operation are predicted to be within National Environment Protection Measure air quality criteria, no specific mitigation measures are proposed once the project is operating.

Table 8-83 Environmental management measures for air quality impacts

Impact	Environmental management measure	Responsibility	Timing
Dust generation during construction	An air quality management plan will be developed as part of the construction environmental management plan to manage any increased dust impacts from construction activities. The plan will consider and describe construction activity processes such as: handling of spoil, management of stockpiles, operation of machinery, and traffic management. The plan will have regard to the measures outlined in the *Local Government Air Quality Toolkit, Module 3: Guidance note – Construction sites* (NSW EPA 2007) and include the following: • A plan showing the locations of all potentially affected properties and residences on a map • Details of potential sources and impacts of dust • Air and dust management objectives consistent with EPA guidelines • Details of air quality control measures to be implemented during construction • A monitoring program to assess compliance with the identified objectives • Details of mitigation measures to be implemented during weather conditions where high dust episodes are likely (such as strong winds in dry weather) • A progressive stabilisation/rehabilitation strategy for disturbed surfaces with the aim of minimising exposed surfaces • Contingency plans to be implemented in the event of non-compliances and/or complaints about dust • Procedures for regularly reviewing the effectiveness of the air quality/dust management plan.	Construction contractor	Pre-construction / construction

Impact	Environmental management measure	Responsibility	Timing
Concrete batching plant	If a concrete batching plant is required, dust control measures would be incorporated into the design of the concrete batching plant. These could include the following: • A partially enclosed load hopper (on three sides) when truck loading/delivery is in progress • Continual wetting operations to reduce emissions during all materials handling • Bulk cement would be stored in silos with filter components on the vents • A dry batch dust collector to extract dust during the transfer of the concrete product to the trucks and any emissions from the loading of the weigh hoppers (this system has a dust extraction efficiency of 99.9% for all particulates greater than 5 microns) • A fully enclosed conveyor • Surface wetting along all exposed surfaces and stockpiles during unfavourable meteorological conditions (i.e. windy and dry conditions) • Use of water carts along haul roads and access points as required to minimise generation of dust.	Construction contractor	Construction

8.13 Wind and wind-wash effects

This section provides an assessment of wind and wind-wash effects on the bridge and users of the bridge.

The Director-General's environmental assessment requirements relevant to wind and wind-wash effects, and where they are addressed in this chapter, are listed in Table 8-84.

Table 8-84 Director-General's environmental assessment requirements relevant to wind and wind-wash effects

Director General's environmental assessment requirements	Where addressed in EIS
Visual amenity, built form and urban design — including but not limited to wind and wind-wash effects on the bridge and bridge users	Section 8.13.3

8.13.1 Assessment methodology

The assessment of the wind and wind-wash effects on the bridge and bridge users involved the following tasks:

- Collation and review of topography and wind information relevant to the project. Information on prevailing winds in the study area was sourced from the nearest Bureau of Meteorology weather station, at Grafton Olympic pool (on Turf Street, Grafton) and from the Grafton airport weather station (on Aerodrome Rd, Glenugie). Conditions recorded at these stations are considered an appropriate proxy of the wind conditions likely to be experienced by the bridge and bridge users
- For the purposes of this assessment, bridge users refer to pedestrians, cyclists, motorists and more indirectly, river users
- Identification of wind speed criteria
- For the purposes of this assessment, wind-wash refers to the blow created by wind on and around the proposed bridge and the bridge users
- Qualitative assessment of impacts on the bridge based on the bridge design average return interval and the prevailing wind conditions in the study area
- Qualitative assessment of impacts on bridge users based on the wind assessment criteria and the prevailing wind conditions in the study area
- Identification of mitigation measures to manage the identified impacts.

For the purposes of this assessment, the maximum wind speed exceeded five per cent of the time set by the University of Bristol: Department of Aerospace Engineering criteria – *Determination of the wind environment of a Building Complex Before Construction* (Lawson, 1990) was used as a proxy of the level of comfort that would be experience by the bridge pedestrian and cycle path users and motorists (Table 8-85).

Table 8-85 Wind criteria for pedestrian comfort and distress (Source: Lawson, 1990)

Maximum wind speed exceeded 5% of the time (km/h)	Comfort levels
<7	Acceptable for outdoor dining
7–14	Acceptable for sitting (considered to be of long duration)

Maximum wind speed exceeded 5% of the time (km/h)	Comfort levels
14–22	Acceptable for standing (or sitting for a short time)
22–29	Acceptable for general pedestrians
29–36	Acceptable for 'business walking' (purpose-related walking 'from A to B') and cycling
>36	Uncomfortable for most activities involving pedestrians
Maximum wind speed exceeded 0.022% of the time, twice per annum (m/s)	**Comfort levels**
<54	Acceptable in general access areas
54–72	Acceptable only where able-bodied people would be expected; no frail people or cyclists expected
>72	Unacceptable for most activities involving pedestrians

8.13.2 Existing environment

The wind rose at the Bureau of Meteorology Grafton airport weather station is presented in Figure 8-42 in Section 8.12. The figure shows that most of the time the wind blows to the south and south-southwest direction.

Wind data gathered at the airport weather station from January 2010 to February 2014 revealed that:

- No wind conditions are experienced 21.8 per cent of the time
- Wind speeds greater than 0 kilometres per hour and up to 36 kilometres per hour are experienced 78.1 per cent of the time
- Wind speeds greater than 36 kilometres per hour and up to 72 kilometres per hour are experienced 0.1 per cent of the time. These winds come from both on north and south directions
- Wind speeds greater than 72 kilometres per hour were not registered at the weather station.

8.13.3 Assessment of potential impacts

Wind and wind-wash effects on the proposed bridge

The wind and wind-wash effects over the proposed bridge are predicted to be nil to negligible as the design wind speeds for the proposed bridge would withstand wind speeds recorded at the nearby weather stations. Design wind speeds for the proposed bridge have been calculated in accordance with AS1170.2 (as referenced in AS5100.2) as follows:

- Wind average return interval of 20 years: 151 kilometres per hour
- Wind average return interval of 2000 years: 252 kilometres per hour.

Wind and wind-wash effects on the bridge users

Wind and wind-wash have the potential to affect pedestrian, cyclists, motorists and more indirectly, river users.

The proposed bridge would have some minor features that could potentially change the wind-flow pattern, including piers on the water and balustrades on the upstream and downstream edges and between the pedestrian and cycle path and the traffic lanes. However, the relatively streamlined nature of the piers and bridge deck would limit the amount of interference of the structure on the wind-flow pattern. Wind flow beneath and around the bridge is not considered to significantly change the wind-flow pattern, or create localised high wind speeds.

Further, the relatively flat topography and open wind environment surrounding the bridge would generate relatively constant windy locations with a turbulence level that would not change rapidly with distance, which is particularly important for cyclists and sailing boats (for whom strong and sudden gusts can be potentially hazardous).

When comparing the wind speed information against the comfort and distress criteria outlined in Table 8-85, it is likely bridge pedestrian, cyclists and motorists using the bridge would experience an acceptable level of comfort most of the time.

Based on the above, it is concluded that wind and wind wash would not be an issue for pedestrian, cyclists, motorists or river users.

8.13.4 Environmental management measures

No specific mitigation measures are required to manage wind or wind-wash impacts from the proposal beyond the bridge design described in Chapter 5.