5 Methodology for the comparative assessment of the route options

This chapter describes the methodology used to undertake the comparative assessment of the route options against the project objectives and supporting objectives. It describes the indicators (qualitative and quantitative measures) used for the comparative assessment, and the technical and environmental investigations undertaken.

The indicators have been updated from the *Preliminary Route Options Report - Final* (RMS, January 2012) based on the investigations undertaken as part of the route options assessment.

5.1 Indicators used for comparative assessment

Key indicators for each supporting objective were developed by the project team in consultation with technical specialists to measure the impact or effectiveness of each option in achieving the supporting objectives, and hence the project objectives.

The indicators were developed to be as simple, meaningful and manageable as possible and to support the overall intent of this assessment. The indicators used for the comparative assessment of the route options for each of the project objectives and the respective supporting objectives are presented in Table 14, Table 15, Table 16, Table 17, Table 18 and Table 19.

Table 14: Indicators for project objective: Enhance road safety for all road users over the length of the project

Project objective	**Enhance road safety for all road users over the length of the project.**
Supporting objective: Reduce the potential for road crashes and injuries on the bridge and approaches including any intersections and connecting roads	
Indicator	**Description**
Issues identified by the road safety audit (No.)	This indicator compares the safety issues of the route options. An independent feasibility stage road safety audit of each option has been conducted in accordance with the *Technical Direction TD 2003/RS03 Ver 2* (RTA, August 2005) and the *Accident Reduction Guide Part 2 Road Safety Audits* (RTA, 2005) to identify potential 'safety issues'. The road safety audit has checked the route options in terms of their accident potential and likely safety performance in order to identify potential 'safety issues'. These are potential safety problems for all road users (including pedestrians, cyclists and heavy vehicles) that could not be fully addressed without substantial changes to the design. Any safety issues easily resolved by minor design changes are not included in the assessment. The audit has identified the number of high priority, medium priority and low priority safety issues for each option. Comparatively, the lower the number of safety issues identified, the safer the option is considered to be. Refer to the road safety audit in Appendix 3.

Project objective	Enhance road safety for all road users over the length of the project.
Supporting objective: Provide safe facilities for pedestrians and cyclists	
Indicator	**Description**
Issues related to pedestrians and cyclists identified by the road safety audit (No.)	This indicator compares the safety issues related to pedestrians and cyclists of the route options. An independent feasibility stage road safety audit of each option has been conducted in accordance with the *Technical Direction TD 2003/RS03 Ver 2* (RTA, August 2005) *and the Accident Reduction Guide Part 2 Road Safety Audits* (RTA, 2005) to identify potential 'safety issues'. 'Safety issues' are defined for this indicator as potential safety problems for pedestrians and cyclists that could not be fully addressed without substantial changes to the design of the new bridge and approach roads. Any safety issues easily resolved by minor design changes are not included in the assessment. The audit has identified the number of safety issues for pedestrians and cyclists for each option. Comparatively, the lower the number of safety issues identified, the safer the option is considered to be. Refer to the road safety audit in Appendix 3.

Table 15: Indicators for project objective: Improve traffic efficiency between and within Grafton and South Grafton

Project objective	Improve traffic efficiency between and within Grafton and South Grafton.
Supporting objective: Provide efficient access for a second crossing of the Clarence River and for the State road network	
Indicator	**Description**
Total time travelled by all vehicles across the modelled road network at the year of opening (2019) and at 20 years after opening (2039) (million hours per year)	This indicator compares the total time travelled by all vehicles across the modelled road network for each of the route options. It is the time spent travelling by all vehicles measured in vehicle hours travelled (VHT). The VHT is a measure of the estimated total number of hours spent travelling by all vehicles within the modelled network of Grafton and South Grafton. It includes all classes of light, medium and heavy vehicles. The time spent travelling (VHT) for this indicator has been derived from the microsimulation traffic model for the years 2019 and 2039, representing the assumed year of opening and 20 years after opening. The time spent travelling is the annual travel time for 2019 and 2039 across the modelled network. Comparatively, options with a lower time travelled (VHT) indicate less time spent travelling on average and a more efficient road network. Benefits of a lower VHT include less congestion and commuting time, and improved accessibility to work and services.
Total distance travelled by all vehicles across the modelled road network at the year of opening (2019) and at 20 years after opening (2039) (million km per year)	This indicator compares the total distance travelled by all vehicles across the modelled road network for each of the route options. It is the distance travelled by all vehicles measured in vehicle kilometres travelled (VKT). The VKT is a measure of the estimated total number of kilometres travelled by all vehicles within the modelled network of Grafton and South Grafton. It includes all classes of light, medium and heavy vehicles. The distance travelled is derived from the microsimulation traffic model for the years 2019 and 2039, representing the assumed year of opening and 20 years after opening. The distances travelled are annual distances travelled for 2019 and 2039 across the modelled network. Comparatively, options with a lower distance travelled (VKT) indicate less distance travelled on average and a more efficient road network.
Total time travelled by heavy vehicles across the modelled road network at the year of opening (2019) and at 20 years after opening (2039) (million hours per year)	This indicator compares the total time travelled by heavy vehicles across the modelled road network for each of the route options. It is the time spent travelling by heavy vehicles measured in vehicle hours travelled (VHT). The VHT is a measure of the estimated total number of hours spent travelling by heavy vehicles within the modelled network of Grafton and South Grafton. It includes all buses, trucks, articulated vehicles and B-doubles but excludes light commercial vehicles. The time spent travelling (VHT) for this indicator has been derived from the microsimulation traffic model for the years 2019 and 2039, representing the assumed year of opening and 20 years after opening. The time spent travelling is the annual travel time for 2019 and 2039 across the modelled network. Comparatively, options with a lower time travelled (VHT) indicate less time spent travelling on average and a more efficient road network for heavy vehicles. Benefits of a lower VHT would include less congestion, which would be expected to result in lower transport costs and improved accessibility for deliveries.

Project objective	**Improve traffic efficiency between and within Grafton and South Grafton.**
Supporting objective: Provide efficient access for a second crossing of the Clarence River and for the State road network	
Indicator	**Description**
Total distance travelled by heavy vehicles across the modelled road network at the year of opening (2019) and at 20 years after opening (2039) (million km per year)	This indicator compares the total distance travelled by heavy vehicles across the modelled road network for each of the route options. It is the distance travelled by heavy vehicles measured in vehicle kilometres travelled (VKT). The VKT is a measure of the estimated total number of kilometres travelled by heavy vehicles within the modelled network of Grafton and South Grafton. It includes all buses, trucks, articulated vehicles and B-doubles but excludes light commercial vehicles. The distance travelled is derived from the microsimulation traffic model for the years 2019 and 2039, representing the assumed year of opening and 20 years after opening. The distances travelled are annual distances travelled for 2019 and 2039 across the modelled network. Comparatively, options with a lower distance travelled (VKT) indicate less distance travelled on average by heavy vehicles resulting in a more efficient road network and lower transport costs.
Supporting objective: Provide a traffic management network which reduces delays between Grafton and South Grafton in peak periods to an acceptable level of service for 30 years after opening	
Indicator	**Description**
Average travel time between Grafton and South Grafton using the existing bridge, 30 years after opening (2049) (minutes)	This indicator compares the average travel time between Grafton and South Grafton using the existing bridge for each of the route options. The average travel time between Grafton and South Grafton using the existing Grafton Bridge has been estimated for each option in the year 2049 as an indicator of the reduction in delays for vehicles using the existing bridge. The travel times are measured between the intersection of Bent Street and Gywdir Highway, South Grafton, and the intersection of Prince Street and Pound Street (clock tower), Grafton, using the existing bridge. The times have been derived from the microsimulation traffic model for the morning (AM) peak period (8-9am) in the northbound direction and the afternoon (PM) peak period (4-5pm) in the southbound direction in 2049. The average travel time is reported in minutes. Comparatively, the higher the travel time, the greater the congestion experienced on the existing bridge, for that option. Refer to Figure 31 at the end of Chapter 5.1 for travel time start and end points.
Supporting objective: Provide adequate vertical clearance for heavy vehicles	
There is no indicator in this assessment for this supporting objective as all route options would provide adequate vertical clearance for heavy vehicles. Therefore this supporting objective does not provide any differentiation between options. Where lowering of roads is required in order to achieve heavy vehicle clearance it is shown on the engineering drawings in Chapter 4.12 and an allowance has been made in the route option strategic costs.	
Supporting objective: Consider demand management strategies to minimise delays to local and through traffic	
There is no indicator in this assessment for this supporting objective as this is part of an overall strategy for improving the road network and is likely to be required for any of the options.	

Table 16: Indicators for project objective: Support regional and local economic development

Project objective	**Support regional and local economic development.**
Supporting objective: Provide transport solutions that complement existing and future land uses and support development opportunities	
Indicator	**Description**
Level of connectivity to existing and future land uses and development	This indicator compares the level of connectivity to existing and future land uses and development for each of the route options. It is a qualitative assessment of how well the options connect: • Existing and future residential areas with the Grafton and South Grafton CBDs • Existing and future residential areas with existing and future employment areas • Grafton and South Grafton CBDs Comparatively, the better the connections, the better the support to land uses and development opportunities.
Supporting objective: Provide improved opportunities for economic and tourist development for Grafton	
Indicator	**Description**
Potential to contribute to tourism	This indicator compares the potential to contribute to tourism for each of the route options. It is a qualitative assessment of how the options would contribute (positively or negatively) to tourism. This includes assessment of any potential direct impacts on existing major festivals or events.
Supporting objective: Provide for commercial transport including B-doubles where required	
Indicator	**Description**
Travel distance between the Pacific Highway and the Summerland Way using the new bridge (km)	This indicator compares the travel distance for heavy vehicles between the Pacific Highway and the Summerland Way for each of the route options. The travel distances are between the intersection of the Pacific Highway and Tyson Street, South Grafton, and the intersection of the Summerland Way and Butterfactory Lane, Grafton using the new bridge. The travel distance is reported in kilometres. Comparatively, the greater the travel distance the less efficient the route option is considered to be for heavy vehicles travelling through Grafton. Refer to Figure 31 at the end of Chapter 5.1 for travel distance start and end points.
Average travel time between the Pacific Highway and the Summerland Way using the new bridge, 30 years after opening (2049) (minutes)	This indicator compares the average travel time for heavy vehicles between the Pacific Highway and the Summerland Way for each of the route options. The travel times are between the intersection of the Pacific Highway and Tyson Street, South Grafton, and the intersection of the Summerland Way and Butterfactory Lane, Grafton using the new bridge in 2049. The times have been derived from the microsimulation traffic model for the morning (AM) peak period (8-9am) in the northbound direction and the afternoon (PM) peak period (4-5pm) in the southbound direction in 2049. The average travel time is reported in minutes. Comparatively, the higher the travel times the less efficient the route option is considered to be for heavy vehicles travelling through Grafton. Refer to Figure 31 at the end of Chapter 5.1 for travel time start and end points.
Supporting objective: Provide flood immunity for the bridge for a 1 in 100 Year flood event, and for the approach roads for a 1 in 20 year flood event, where economically justified	
All route options have been designed to have flood immunity for the bridge for a 100-year ARI flood event and for the approach roads for a 1 in 20 year flood event. Therefore this supporting objective does not provide any differentiation between options.	
Supporting objective: Provide navigational clearance from the additional crossing for river users	
All route options would provide the designated navigational clearance as identified by NSW Maritime (now part of RMS) in Chapter 4. Therefore this supporting objective does not provide any differentiation between options.	

Table 17: Indicators for project objective: Involve all stakeholders and consider their interests

Project objective	**Involve all stakeholders and consider their interests.**
The project objective „Involve all stakeholders and consider their interests" relates to the consultation and communication processes that are being undertaken throughout the project. As this objective relates to the consultation process undertaken, it does not provide indicators for the assessment of each of the route options. The following discusses how each of the three supporting objectives for this project objective are being incorporated into the project and communication processes.	
Supporting objective: Develop solutions that consider community expectations for the project	
A revised approach to engage more effectively with the community and stakeholders to identify a preferred route for an additional crossing was announced in December 2010. The revised approach was developed in response to sections of the community asking the Minister for Roads and RMS to reconsider options for a second bridge as well as raising concerns about the basis and justification for identifying the four preliminary route options announced in February 2010. Clarence Valley Council wrote to the Minister for Roads in September 2010 to ask that RMS survey the people of Grafton and surrounds about the location of a second crossing. In December 2010, RMS made a commitment to undertake a process that would be transparent, involve all residents and stakeholders and make information available at the appropriate times, and not afterwards. The December 2010 community update also identified 13 preliminary options, including the additional nine options suggested by the community since the announcement of the four preliminary route options in February 2010. RMS undertook three community surveys to gauge the views of residents and businesses regarding the additional crossing of the Clarence River at Grafton. The responses to the surveys helped the project team to identify the key community issues for the project and the values held by the community. The responses also identified an additional 28 community suggestions for the location of the crossing, bringing the total number of suggestions to 41. At community forums in March 2011, RMS advised that the 41 suggested locations would be assessed for their feasibility, to identify those options that would be further considered and investigated. In June 2011, RMS issued a community update and the *Feasibility Assessment Report* which identified 25 preliminary route options within five strategic corridors to go forward for further engineering and environmental investigations. Following consideration of community input, including the outcomes of a stakeholder evaluation workshop attended by members of the community, six short-listed options to go forward for further investigation were identified in January 2012. Four of the six short-listed options are based on suggestions received from the community. The process to identify an additional crossing, which facilitated community input, was discussed at community meetings between December 2010 and January 2012. A process flowchart was developed to assist in communicating the process, current status and next steps. The flowchart is updated regularly and published in community updates and on the project website. Community feedback and issues have been considered at each stage of the project process. In response to community feedback, the project team undertook a review of the project purpose and objectives. Supporting objectives were developed to assist the project team and community members to gauge how effective the route options are in achieving the project purpose and objectives. The project purpose, objectives and supporting objectives were discussed at community meetings between March and August 2011 and wider community comment was invited via a community update issued in June 2011. Letters, emails and phone calls received by the project team that raise issues and questions relevant to an additional crossing of the Clarence River are considered by the project team and responded to individually. This consultation is captured in the project"s consultation database. Community feedback received has and will continue to assist the project team in gaining an understanding of the community"s views and issues regarding the preferred location for an additional river crossing.	
Supporting objective: Satisfy the technical and procedural requirements of RMS with respect to the planning and design of the project	
The project team work within the guidelines of RMS technical and procedural requirements for all aspects of the project, including community and stakeholder consultation, environmental investigations, Aboriginal stakeholder guidelines and planning and design guidelines. This includes thorough internal review and approval processes.	

Project objective	Involve all stakeholders and consider their interests.

Supporting objective: Integrate input from the community into the development of the project through the implementation of a comprehensive program of community consultation and participation

In response to concerns raised by the community, RMS adopted a revised approach to the development of the project in December 2010 to communicate more effectively and transparently with the community. As part of this revised approach, RMS undertook a comprehensive program of community consultation and participation activities.

In response to community feedback, the project team updated the Community Liaison Plan (CLP). The CLP describes how the project team will engage with the community to assist with the identification of an additional crossing of the Clarence River and includes a program of consultation activities.

The consultation program includes an extensive range of community consultation and participation activities including:

- Community Liaison Plan (CLP) updated at key stages
- Dedicated phone line
- Dedicated project website updated regularly
- Community and business surveys
- Community forums, information sessions and staffed displays
- Information releases including reports and community updates
- Letters to residents and key stakeholders, including responses to written and verbal inquiries
- Advertising and media releases
- Emails to the community members registered on the community consultation database

Table 18: Indicators for project objective: Provide value for money

Project objective	**Provide value for money.**
Supporting objective: Achieve a justifiable benefit-cost ratio at an affordable cost	
Indicator	**Description**
Route option strategic cost estimate ($m)	This indicator compares the strategic costs for each of the route options. Strategic cost estimates have been prepared to allow a comparison of likely relative costs of the route options. Costs are given in million 2012 dollars and include an allowance for concept development, detailed design and documentation, property acquisition, utility adjustment, infrastructure construction and handover costs. A contingency allowance was added to each cost item for each option in accordance with normal RMS procedures. Major potential future upgrades to the Summerland Way or the existing Pacific Highway have not been allowed for at this stage.
Benefit-cost ratio over 30 years from 2019 based on strategic cost estimates (ratio)	This indicator compares the benefit-cost ratio (BCR) for each of the route options. The BCR is an indicator produced by cost-benefit analysis (CBA). The BCR is the ratio of the present value of total project benefits over the present value of total project costs. The present values are calculated by discounting and summing the forecast annual benefits and costs over a 30-year evaluation period. The annual benefits and costs of a project are measured against a base case and are therefore additional and directly attributable to the project. The benefits in a road user cost benefit analysis (RUCBA) are measured as reductions in travel time costs, vehicle operating costs, crash costs and environmental costs. The costs relate to project capital and recurrent costs such as maintenance. A BCR that is greater than 1.0 suggests that the road user benefits exceed the costs. The BCR can be used to compare the economic performance of the route options where the investment is undertaken in a constrained budget environment.
Net present value over 30 years from 2019 based on strategic cost estimates ($m)	This is an indicator comparing net present value (NPV). NPV is also a key indicator produced by CBA. The NPV is calculated as the difference between the present value of total project benefits and the present value of total project costs. The present values are calculated by discounting and summing the forecast annual benefits and costs over a 30-year evaluation period. The annual benefits and costs of a project are measured against a base case and are therefore additional and directly attributable to the project. The benefits in a road user cost benefit analysis (RUCBA) are measured as reductions in travel time costs, vehicle operating costs, crash costs and environmental costs. The costs relate to project capital and recurrent costs such as maintenance. A positive NPV suggests that the road user benefits exceed the costs. The NPV can be used to compare the economic performance of the route options where the investment is undertaken in an unconstrained budget environment.
Supporting objective: Develop a strategy to integrate future upgrades into the project	
All route options would include a strategy to integrate future upgrades into the project. Therefore this supporting objective does not provide any differentiation between options.	

Table 19: Indicators for project objective: Minimise impact on the environment

Project objective	**Minimise impact on the environment.**
Supporting objective: Minimise the impact on the social and economic environment, including property impacts	
Indicator	**Description**
Number of residential properties potentially directly affected (No.)	This is an indicator of the comparative impacts on residential properties. For the purposes of this assessment, an existing residential property is regarded as potentially directly affected if a route option is likely to require full or partial acquisition of the property. It excludes properties located in land zoned as rural as these are considered in a separate indicator. Comparatively, the greater the number, the greater the potential impact.
Number of community facilities potentially directly affected (No.)	This is an indicator of the comparative impacts on community facilities including: clubs and recreation, education, river uses, places of worship (eg churches), government, services, health and emergency, parks and reserves and major infrastructure. This includes community facilities that are currently in operation and potentially directly affected by the route option. For the purposes of this assessment, a community facility is regarded as potentially directly affected if an option is likely to require full or partial acquisition of the property or would otherwise cross within its boundary (in the case of river-based activities). Commercial properties are excluded except for Grafton Shopping World. Comparatively, the greater the number, the greater the potential impact.
Number of businesses with potential impacts on business viability (No.)	This is an indicator of the comparative potential impacts on businesses. This count includes businesses that are currently in operation and potentially directly affected. For the purposes of this assessment, potentially directly affected businesses are those where full or partial acquisition of the property is required and the acquisition would be likely to impact the viability of the business. Comparatively, the greater the number, the greater the potential impact.
Number of businesses with potential minor impacts (No.)	This is an indicator of the comparative potential minor impacts on businesses. This count includes businesses that are currently in operation and potentially directly affected by the route option. For the purposes of this assessment, potentially directly affected businesses are those where partial acquisition of the property is required. The route option is considered to have a minor impact on the business where acquisition would not be likely to impact the viability of the business. Comparatively, the greater the number, the greater the potential impact.
Number and area of rural properties with potential direct impacts (No. and ha)	This is an indicator of the comparative potential direct impacts on rural properties. This count measures the number and area of rural properties that are potentially directly affected. For the purposes of this assessment, potentially directly affected rural properties are those where full or partial acquisition of the property is required.
Area of regionally significant farmland potentially directly affected (ha)	This is an indicator of the comparative impacts on areas of regionally significant farmland potentially directly affected by a route option. For the purposes of this assessment, regionally significant farmland is regarded as potentially directly affected if an option may require full or partial acquisition of such land. Regionally significant farmland in the Grafton area is identified in the *Mid North Coast Farmland Mapping Project* (DP&I, 2008). Note: The majority of regionally significant farmland potentially directly affected is also zoned as primary production land in the *Clarence Valley Local Environmental Plan 2011* (CVLEP 2011).
Changes to access and disruption to community activities or plans	This is an indicator of the comparative impacts on changes to access and disruption to community activities or plans. The indicator considers the ease with which people are able to move between and through areas at neighbourhood and wider scales, on foot as well as by vehicles; it also considers the ease of access to community facilities. Works that reduce the number of connections from an area, or impose barriers that make established patterns of travel more difficult, present a potential negative impact on access and community activities and plans.

Project objective	**Minimise impact on the environment.**
Supporting objective: Minimise the impact on residential amenity, including noise, vibration and air quality etc	
Indicator	**Description**
Number of residential properties where noise levels exceed 55 dB(A) during the day or 50 dB(A) during the night, at 10 years after opening (2029) (No.)	This is an indicator of the comparative impacts on residential properties adjacent to existing or new arterial roads. It also includes aged care facilities which are assessed using the same noise criteria as residential properties. This indicator is calculated using the noise model that was developed for the project. For each option the number of residential properties that in 2029 would exceed the *NSW Road Noise Policy* (NSW OEH, 2011) criterion for new arterial/sub-arterial road corridors, 55 dB(A) during the day or 50 dB(A) during the night is identified. The number of residential properties where noise levels exceed these levels in the „no build" (ie if a new bridge were not to be built) for 2029 is also shown. The noise levels have been set approximately at the point at which 10% of residents are highly annoyed by the noise. Comparatively, the greater the number, the greater the potential impact. Note: • No mitigation measures have been included in the assessment. • The noise model takes into account the influence of the number and speed of heavy vehicles (on traffic noise levels). • Some of the residences counted in this indicator would also experience an increase of at least 12 dBA, and would also be counted in the following indicator.
Number of residential properties where noise levels increase by 12 dB or more, at 10 years after opening (2029) (No.)	This is an indicator of the comparative impacts on residential properties adjacent to existing or new arterial roads. It also includes aged care facilities which are assessed using the same noise criteria as residential properties. This indicator is calculated using the noise model that was developed for the project. For each option the number of residential properties that in 2029 would exceed the *NSW Road Noise Policy* (NSW OEH, 2011) criterion for new road corridor/redevelopment, an increase of 12 dB or more is identified. A relative increase of 12 dB represents slightly more than an approximate doubling of perceived loudness (AS2659.1-1988) and is likely to trigger community reaction, particularly in environments where there is a low existing level of traffic noise (*NSW Road Noise Policy* (NSW OEH, 2011)). Comparatively, the greater the number, the greater the potential impact. Note: • No mitigation measures have been included in the assessment. • The noise model takes into account the influence of the number and speed of heavy vehicles (on traffic noise levels). • Some of the residences counted in this indicator would also experience noise levels that are above the 55 dB(A) or 50 dB(A) criteria in the *NSW Road Noise Policy* (NSW OEH, 2011) and would also be counted in the above indicator.
Number of other sensitive land uses where noise levels exceed the criteria in the *NSW Road Noise Policy* (NSW OEH, 2011), at 10 years after opening (2029) (No.)	This is an indicator of the comparative impacts on sensitive land uses other than residential and aged care facilities adjacent to existing or new arterial roads. These include schools, hospitals, places of worship (eg churches), open spaces (when occupied eg parks) and childcare facilities. This indicator is calculated using the noise model that was developed for the project. For each option the numbers of facilities that in 2029 exceed the *NSW Road Noise Policy* (NSW OEH, 2011) criterion have been estimated. Comparatively, the greater the number, the greater the potential impact. Note: • No mitigation measures have been included in the assessment. • The noise model takes into account the influence of the number and speed of heavy vehicles (on traffic noise levels).

Project objective	**Minimise impact on the environment.**
Supporting objective: Minimise the impact on residential amenity, including noise, vibration and air quality etc	
Indicator	**Description**
Estimated fuel consumption in urban areas during peak hours at 10 years after opening (2029) (L)	This is an indicator of the comparative impacts on the air quality in Grafton and South Grafton urban areas. Fuel consumption during peak hours has been estimated as an indicator of the comparative impact of each option on the air quality of Grafton and South Grafton urban areas. The indicator focuses on sections of the road that are urbanised (ie developed) only, as these are the areas where air quality sensitive receivers are located (eg houses, schools, hospitals, child care centres, aged care centres, etc). The traffic modelling results have been used to estimate the fuel consumption for different types of vehicles (ie cars, light commercial vehicles and heavy vehicles including buses) for each of the route options. The traffic modelling results provide the average speed in urban areas achieved by each of the route options during the morning (AM) peak hour (8-9am) and afternoon (PM) peak hour (4-5pm) in year 2029, and these speeds together with the distances travelled by the different classes of vehicles in the peak hours have then been used to estimate the total fuel usage in litres for each option. Fuel consumption is calculated in accordance with the methodology identified in the *Guide to Project Evaluation Part 4: Project Evaluation Data* (Austroads, 2008). The amount of fuel consumed per option is proportional to the amount of contaminants emitted by vehicles to the atmosphere and therefore is considered a good indicator for air quality impacts. Comparatively, the greater the amount of fuel consumed, the greater the air quality impact of the route option on urban areas.
Supporting objective: Minimise the impact on heritage	
Indicator	**Description**
Impact on known Aboriginal cultural heritage	This is an indicator of the comparative impacts on Aboriginal cultural heritage. A qualitative assessment of the physical, visual and spiritual impacts on known Aboriginal cultural sites. The comparative assessment is informed by the Aboriginal consultation undertaken for the project.
Length through areas of high Aboriginal archaeological potential (m)	This is an indicator of the comparative impacts on Aboriginal archaeological potential. While some areas have been identified as containing 'known' Aboriginal archaeological sites/items (per the indicator above), other areas may have the 'potential' to contain Aboriginal archaeological sites/items. Areas around Grafton have been ranked as having high, medium or low potential to contain Aboriginal archaeological sites/items. This indicator measures the length of each option that crosses through areas of high Aboriginal archaeological potential. Areas considered as having a high archaeological potential include major creek lines, raised flat landforms such as ridges and hills, or where there has been minimal disturbance to the specific area. Artefacts that remain within these areas are likely to be high in density and large in size. For the purposes of this assessment, the length through areas of high archaeological potential has been measured along the widest part of the area of high potential where it falls within each route option. Comparatively the greater the length, the greater the potential impact.
Number of non-Aboriginal heritage items and archaeological sites that would potentially be directly impacted (No.)	This is an indicator of the comparative potential direct impacts on non-Aboriginal heritage items and archaeological sites. It identifies the number of potentially directly affected heritage and contributory items within the route option indicative road boundary. Trees are not included in this indicator. For the purposes of this assessment, an item is regarded to be potentially directly affected if a route option is likely to require full or partial acquisition of the item. For the purposes of this assessment, items were split into two categories: 'State significant' items (as listed on the NSW State Heritage register) and other items (ie listed heritage items or items with potential to be listed, that do not have State significance). Comparatively, the greater the number, the greater the potential impact.

Project objective	**Minimise impact on the environment.**
Supporting objective: Minimise the impact on heritage	
Indicator	**Description**
Contribution of trees as heritage items as well as their collective effect on streetscape and setting (No.)	This is an indicator of the comparative potential impacts on plantings of cultural significance. It identifies the number of cultural plantings that are part of a listing, such as the camphor laurel (*Cinnamomum camphora*) specifically listed in certain areas as well as blanket heritage listed species ie *Brachychiton*, *Ficus*, or Jacaranda trees over 5 m in height that are potentially impacted by the route options. This also includes plantings considered to have some cultural significance but not listed as heritage items. If part of the tree canopy is inside the option footprint, then the tree is considered to be impacted and therefore included. Comparatively, the greater the number the greater the potential impact of the option on cultural plantings, except in instances where the trees in question are mature or belong to a memorial avenue.
Potential impact on (non-Aboriginal) heritage conservation area (m)	This is an indicator of the comparative impacts on the Grafton and South Grafton Heritage Conservation Areas. It provides a comparative assessment on how the option potentially impacts areas of distinctive character of heritage significance which are desirable to conserve. These areas are defined by Heritage Manual "Heritage Terms and Abbreviations" (DUAP 1996). It measures the length of each option through the urban conservation area as defined in the *Clarence Valley Local Environmental Plan 2011* (CVLEP 2011). For the purposes of this assessment, the length has been measured along the centreline of the new road alignment and all associated road upgrades. Comparatively, the greater the length, the greater the potential impact.
Supporting objective: Minimise impact on the natural environment	
Indicator	**Description**
Potential direct impact on known threatened flora species	This is an indicator of the comparative potential direct impacts on known threatened flora species. It identifies whether the option potentially impacts known threatened flora species listed in the NSW Threatened Species Conservation Act 1995 or the Environment Protection and Biodiversity Conservation Act 1999. A route option affecting known threatened flora species is considered to have a comparatively greater impact on the natural environment.
Potential direct impact on identified endangered ecological communities (EEC) (m^2)	This is an indicator of the comparative potential direct impacts on EEC. It measures the area of each option through ecological communities considered endangered by the NSW Threatened Species Conservation Act 1995 or the Environment Protection and Biodiversity Conservation Act 1999. For the purposes of this assessment, the area has been measured within the indicative road boundary. Endangered ecological communities in the Grafton area include sub-tropical coastal floodplain (riparian forest and remnant eucalyptus), lowland rainforest on floodplains and freshwater wetlands on coastal floodplains (reedlands and drainage soaks). It also describes the condition of such vegetation (eg poor/degraded, fair, etc) Comparatively, the greater the area, the greater the potential impact.
Potential direct impact on other vegetation and habitat (m^2)	This is an indicator of the comparative potential direct impacts on other vegetation and habitat. It measures the area of each option through potential threatened flora and fauna habitat and other plant community (ie not EEC) and flora and fauna habitat. For the purposes of this assessment, the area has been measured within the indicative road boundary. Comparatively, the greater the area of native plant community, the greater the potential impact.
Potential direct impact on known habitat for threatened fauna species	This is an indicator of the comparative potential direct impacts on known habitat for threatened fauna species. It identifies whether the option affects areas with known nesting, roosting and/or foraging habitat for threatened fauna species listed in the NSW Threatened Species Conservation Act 1995 or the Environment Protection and Biodiversity Conservation Act 1999. A route option affecting an area with known habitat for threatened fauna species is considered to have a comparatively greater impact on the natural environment.

Project objective	**Minimise impact on the environment.**
Supporting objective: Provide a project that fits sensitively into the built, natural and community context	
Indicator	**Description**
Visual integrity of the existing bridge in its setting	This indicator compares the extent to which the new bridge maintains the visual integrity of the existing bridge in its setting: • Ability to maintain important and recognisable views from and to the existing and new bridges of Grafton and South Grafton. • Ability of the new bridge to have a complementary scale and form, particularly related to aligning the new bridge deck with the lower (railway) deck of the existing bridge, that still allows the existing bridge to take visual precedence. • Ability of the new bridge to have an independent visual expression (form and scale) from the existing bridge and the potential to become a landmark in its own right.
Integrity of existing landscape and street pattern	This indicator compares the extent to which the new bridge maintains the integrity of the existing urban and rural landscapes, particularly the physical and visual experience of the historical street grid. It examines: • Ability to minimise the street scale and form of the new bridge approach roads. • Ability to retain the existing landscape character of the area, including minimising the removal of trees. • Ability to minimise the size of intersections between the approach roads and the existing local roads. • Ability to generally maintain existing urban patterns and integrate the geometry of any new approach roads within the existing road reserves.
Urban context and connections	This indicator compares the extent to which the new bridge assists in maintaining the integrity of the existing patterns of urban settlement, facilitates continued future urban development, and improves accessible connections between Grafton and South Grafton. It examines: • Ability to minimise the effects of fragmentation on neighbourhoods or precinct areas. • Ability to provide more direct connections for local trips and destinations beyond Grafton and South Grafton town centres. • Ability to improve connectivity and connection opportunities for pedestrian and cycle networks. • Ability to improve connectivity to existing and proposed riverfront public recreation spaces. • Ability to be integrated with or support future development and revitalisation of existing areas (retail, commercial, industrial, recreation, education, etc). • Ability to minimise the creation of new main street environments and strip development that does not support or connect to the town centres of Grafton and South Grafton.
Supporting objective: Minimise flooding impact caused by the project	
Indicator	**Description**
Maximum Clarence River afflux upstream of option in a 20-year ARI flood event with levee upgrades in place (m)	This indicator compares the maximum expected change in the peak flood level in the Clarence River immediately upstream of the new (or proposed) bridge as a result of the route option, as measured in the project flood model. This is the peak flood level assuming that the levees have been upgraded. The level reported is for the 20-year average recurrence interval (ARI) design flood event. The 20-year ARI design flood event is the flood that can be expected to occur, based on long-term averages, once every 20 years.
Length of levees upstream that would need to be upgraded for a 20-year ARI flood event (km)	This indicator compares the length of existing levees that must be upgraded to maintain the current level of flood immunity in a 20-year ARI design flood event (see point above for definition).

Project objective	**Minimise impact on the environment.**
Supporting objective: Minimise flooding impact caused by the project	
Indicator	**Description**
Flooding emergency response considerations	This indicator provides a qualitative comparison of the route options which considers the following key factors of evacuation operations: • Availability of alternative evacuation routes – Existing evacuation routes are defined in the *Grafton Evacuation Strategy* (SES 2008) and currently converge within the business district of Grafton. Options which are not located adjacent to the existing bridge provide some contingency for an evacuation scenario in which roads within the business district of Grafton are compromised (inundated by flooding or impacted by a serious traffic crash). Furthermore, options which are distanced away from the existing Grafton Bridge will require new evacuation routes in addition to the existing ones. The additional evacuation routes will reduce traffic congestion within the Grafton business district. • The flood immunity of the evacuation routes – 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. However, this criterion is impractical for Grafton, which is affected by flooding in design flood events greater than a 20-year ARI flood event. • Access to evacuation services and shelter – 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 location of sufficient size to provide these needs. • Impact on evacuation of vulnerable community groups – State of Emergency Services resourcing needs to accommodate for vulnerable community groups which may require special consideration/assistance during an evacuation.

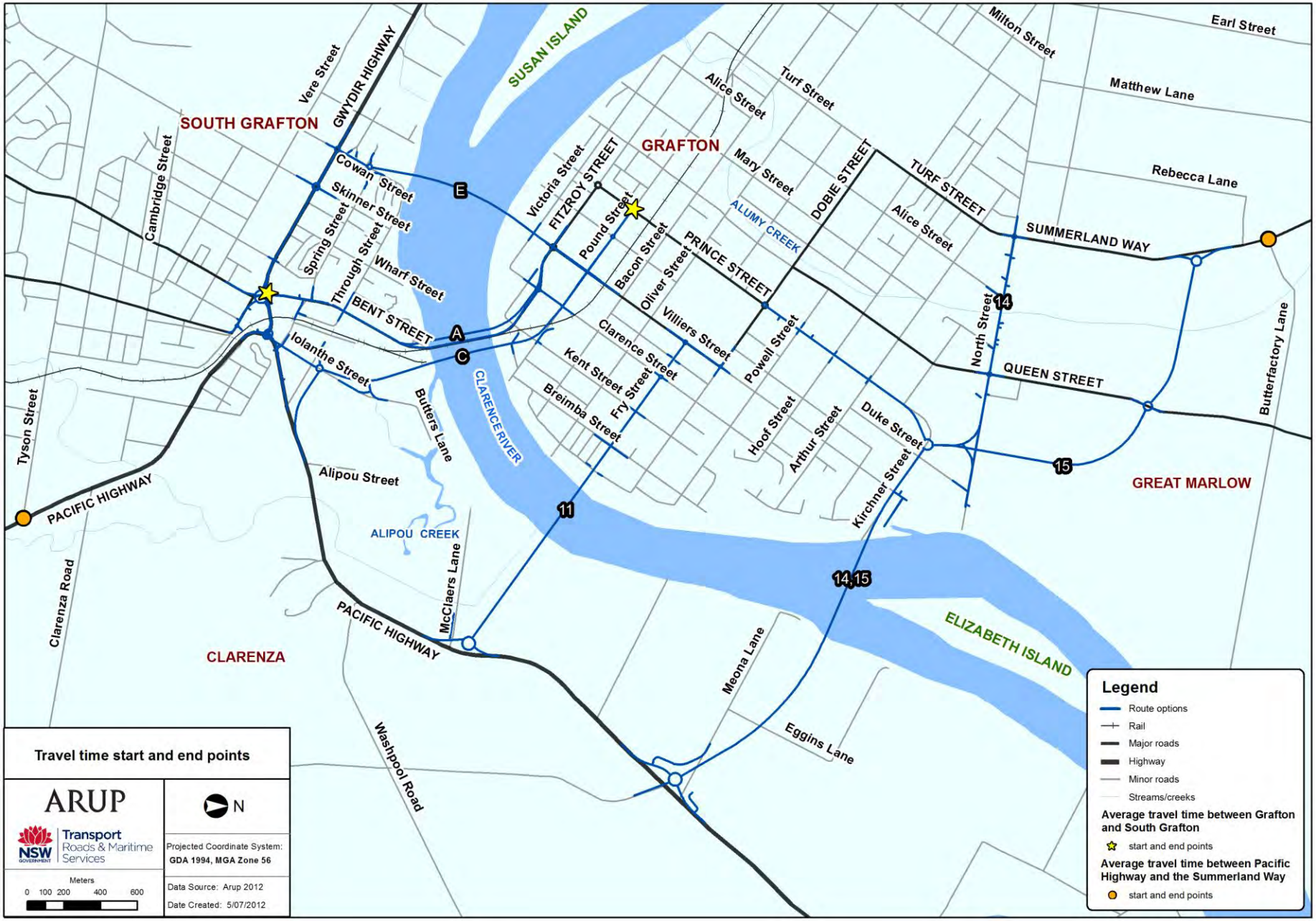

Figure 31: Travel time start and end points

5.2 Investigations undertaken on the route options

Following the traffic modelling, geotechnical investigations and design development of the route options further technical and environmental investigations of each route option were undertaken to inform the comparative assessment of the options based on the indicators previously described in Table 14, Table 15, Table 16, Table 17, Table 18 and Table 19.

These investigations build upon the project work undertaken in the last 10 years, including the recent investigations documented in the *Preliminary Route Options Report – Final* (RMS, January 2012). Investigations for the route options assessment are described in the following chapters.

5.2.1 Strategic cost estimates

Strategic cost estimates for the design, construction and commissioning for each route option were investigated. The strategic cost estimates include allowances for:

- Concept development (based on the engineering drawings presented in Chapter 4.12)
- Detailed design and documentation
- Geotechnical conditions including depth to rock and soft soil treatments
- Property acquisition costs (acquisition was identified via Geographic Information System (GIS) and estimated via historical property sales within the immediate area)
- Utility adjustment costs (cost allowances were estimated based on adjustments that may be required for major utilities potentially impacted by each of the route options)
- Infrastructure construction costs
- Handover costs.

The strategic cost estimates are documented in the *Technical Paper: Strategic Cost Estimates* in Volume 2. Cost estimates were used as an indicator for the assessment of the route options as shown in Table 18 in Chapter 5.1.

5.2.2 Economic evaluation

The economic evaluation included:

- Strategic cost estimates as described in Chapter 5.2.1
- Investigation into recurrent costs (ie operation and maintenance costs) for the options
- Determination of road user vehicle operating costs and benefits based on the vehicle kilometres travelled, as calculated by the microsimulation model (refer to Chapter 4.4.1)
- Identification of road user travel time costs and benefits based on the vehicle hours travelled calculated by the microsimulation model (refer to Chapter 4.4.1)
- The estimated cost of environmental effects from vehicle use based on vehicle kilometres travelled, as calculated by the microsimulation model (refer to Chapter 4.4.1)
- Calculation of net present value (NPV) and benefit-cost ratio (BCR).

The benefit-cost analysis findings are documented in the *Technical Paper: Economic Evaluation* in Volume 2. Net present value and benefit-cost ratio are used as indicators for the assessment of the route options as shown in Table 18 in Chapter 5.1.

5.2.3 Socio-economic investigations

The following social and economic investigations were undertaken:

- Site visits during February 2012
- Identification of community and infrastructure facilities and businesses within or close to the route options (based on GIS mapping and field verification)
- Identification of residential properties and community facilities directly affected (based on GIS mapping and field verification)
- Existing land use and land use zones along the route options
- Future known land uses in Grafton and surrounds
- Consultation with Council and key social services providers
- Survey of businesses in the vicinity of the route options to allow an understanding of their characteristics and potential impacts
- Identification of rural properties and farmland potentially directly affected (based on GIS mapping)
- Analysis of distributional equity of impacts, effects on housing affordability, severance, and disruption to community activities or plans for each option.

Social and economic investigations are documented in the *Technical Paper: Social and Economic Issues* in Volume 2. The investigations were used to assess the route options against the social and economic indicators listed in Table 19 in Chapter 5.1.

5.2.4 Noise investigations

The following noise investigations were undertaken:

- Noise surveys of Grafton and South Grafton conducted between 9 and 19 August 2010 and between 13 and 22 September 2011, to benchmark the existing acoustic environment in the Grafton area.
- Identification and GIS mapping of residential and non-residential noise-sensitive receivers and land uses.
- Construction of the traffic noise computer model for the project using noise modelling and prediction software called SoundPLAN. The model was constructed using:
  - Noise survey measurements undertaken in 2010 and 2011
  - Weather data for the periods when noise surveys were carried out
  - Traffic counts undertaken in concurrence with the noise surveys at noise logging locations aligning existing road corridors
  - Annual average traffic flow predictions as calculated by the microsimulation traffic model for years 2019 and 2029 (refer to Chapter 4.4.1)

- Determination of noise criteria for residential and other sensitive receivers and land uses
- Assessment of the traffic noise for each route option in general accordance with the *NSW Road Noise Policy* (NSW OEH, 2011) and the *Environmental Noise Management Manual* (RTA, 2001).

Noise investigation findings are documented in the *Technical Paper: Noise Assessment* in Volume 2.

The results of the modelling were used to calculate the number of properties above the criteria for each indicator adopted for the assessment of the noise impact of the route options (refer to Table 19 in Chapter 5.1).

The assessment of traffic noise impact has been undertaken with no mitigation measures in place. Noise mitigation requirements would be assessed in accordance with the *NSW Road Noise Policy* (NSW OEH, 2011) for the preferred route. Where feasible and reasonable, noise exceedances would be addressed through noise mitigation measures. Some of the mitigation measures that could potentially be implemented are described below.

At road mitigation:

- Noise barriers
- Reducing the speed limit
- Use of low-noise pavement.

At dwelling mitigation:

- Architectural treatments of individual properties using measures such as enhanced glazing, increased sound insulation and/or installation of mechanical ventilation systems.

Given the built-up nature of the majority of route options, noise barriers are unlikely to be a practical mitigation measure due to access requirements (ie driveways).

5.2.5 Air quality investigations

The amount of fuel that would be consumed by motor vehicles in the Grafton and South Grafton urban areas in peak hours in the year 2029 was estimated for each route option. Fuel consumption was calculated using the results of the traffic modelling (refer to Chapter 4.4.1) in accordance with the methodology set out in the *Guide to Project Evaluation Part 4: Project Evaluation Data* (Austroads, 2008).

As explained in Table 19 in Chapter 5.1, the amount of contaminants emitted by vehicles to the atmosphere is proportional to the amount of fuel consumed per option and therefore fuel consumed is considered a good proxy for air quality impacts.

5.2.6 Aboriginal heritage investigations

The following Aboriginal heritage investigations were undertaken:

- Consultation with the Grafton-Ngerrie Local Aboriginal Land Council (refer to Chapter 3.2.3).
- Targeted field surveys conducted in February and April 2012. The surveys were conducted by technical specialists accompanied by Grafton-Ngerrie Local Aboriginal Land Council representatives.

- Identification of areas/items of Aboriginal cultural heritage and archaeological significance.
- GIS mapping of known areas of Aboriginal cultural heritage and archaeological significance in the vicinity of the route options.
- Assessment of the impact of the route options on the Aboriginal cultural and Aboriginal archaeological significance in the Grafton area.

The findings of the Aboriginal heritage investigations are documented in the *Technical Paper: Aboriginal Heritage* in Volume 2. The investigations were used to assess the route options against the Aboriginal heritage indicators listed in Table 19 in Chapter 5.1.

5.2.7 Non-Aboriginal heritage investigations

The following non-Aboriginal heritage investigations were undertaken:

- Heritage register searches to identify any recorded cultural heritage sites or items
- Historical desktop research for the Grafton and South Grafton area
- Site inspections along the route options, in February and April 2012
- Consultation with Council heritage staff and the Clarence River Historical Society
- GIS mapping of identified heritage items (or potential listed items), conservation areas and cultural plantings within or in the vicinity of the route options
- GIS mapping of archaeological sites and potential archaeological sites on or adjacent to the route options
- Assessment of the impact of the route options on items, conservation areas, archaeological sites and potential archaeological sites.

The findings of the non-Aboriginal heritage investigations are documented in the *Technical Paper: Non-Aboriginal Heritage* in Volume 2. The investigations were used to assess the route options against the non-Aboriginal heritage indicators listed in Table 19 in Chapter 5.1.

5.2.8 Ecology investigations

Ecology investigations included:

- Desktop research on existing information regarding the flora and fauna of the Grafton and South Grafton area from a range of sources including: databases; aerial photographs and maps; previous studies carried out in the vicinity of the proposal; and consultation with local experts and government agencies.
- Review of previous ecology studies undertaken for the project, including the recent study undertaken for the assessment of the preliminary route options which is documented in the *Preliminary Route Options Report – Final* (RMS, January 2012).
- Terrestrial flora surveys of the route options undertaken in February and April 2012. The fieldwork included targeted searches for threatened plant species, plot-based (quadrants) surveys and assessment of the condition of the vegetation.
- Terrestrial „habitat-based assessment" fauna surveys undertaken in February and April 2012. The work included diurnal bird surveys, active searching for herpetofauna (eg turning surface debris or rubbish and fallen timber), active searching and listening for birds and frogs, recording

and observing tree hollows, inspecting trees for scratch marks, observing the dusk flight path of flying-foxes from Susan Island, opportunistic spotlighting of flying-foxes, potential roost site searches and ultrasonic call recording.

- Identification of ecological constraints along the route options.
- GIS mapping of vegetation (including Endangered Ecological Communities), hollow-bearing trees and migratory fauna recorded.
- GIS mapping of areas of biodiversity value.
- Assessment of the impact of the route options on the ecology of the Grafton and South Grafton area.

The findings of the ecology investigations are documented in the *Technical Paper: Ecology* in Volume 3. The investigations were used to assess the route options against the ecology indicators listed in Table 19 in Chapter 5.1.

5.2.9 Landscape and urban character investigations

Landscape and urban character investigations included:

- Review of Grafton"s and South Grafton"s urban form, town centres and regional, historical and heritage context
- Site visit to the Grafton area in January 2012
- Identification of landscape and urban design values and issues for the Grafton area
- Identification of landscape and urban design goals for the additional river crossing
- Analysis of landscape and urban design strengths, weaknesses, opportunities and challenges for the route options
- A landscape and urban design assessment of the route options.

The findings of the landscape and urban character investigations are documented in the *Technical Paper: Landscape and Urban* Character in Volume 3. The investigations were used to assess the route options against the landscape and urban character indicators listed in Table 19 in Chapter 5.1.

5.2.10 Flooding investigations

The flooding investigations aimed to:

- Estimate the likely flood impacts associated with the route options
- Identify necessary mitigation measures required to maintain the current level of flood immunity within Grafton and South Grafton following construction, for each route option
- Identify the qualitative flood evacuation considerations for each route option.

The options assessment was completed using the Lower Clarence River flood model, originally developed and calibrated as part of the *Lower Clarence River Flood Study Review* (WBM 2004). This model defines the regional flood behaviour between Mountain View (upstream of Grafton), and the Clarence River entrance at Yamba/Iluka. The model was used to define baseline data for the flooding assessment and represent the existing flood behaviour within the Grafton area.

The potential changes to the existing flood behaviour, resulting from the development of the bridge were identified for each route option following an update of the Lower Clarence River flood model. This update took into consideration the following design features:

- Bridge losses accounting for bridge type, soffit level, span width, pier width, pier configuration and pile cap allowances
- Road upgrades and embankments associated with the bridge approaches
- Mitigation measures required to maintain the existing level of flood immunity within Grafton and South Grafton following the construction of the bridge.

Flood impacts were estimated by comparing the peak flood level results associated with the developed case scenario and the existing case scenario.

For the purpose of comparing the route options, the flood impact assessment considered the 20- and 100-year ARI design flood events. These two design flood events were identified for assessment due to their respective flood levels relative to the Grafton and South Grafton levees.

The flooding investigations also assessed the qualitative impact of each route option on flood evacuation considerations based on:

- The catchment flood behaviour relative to the location and design of the route option, defined using the Lower Clarence River flood model
- Local emergency response experience as described by Clarence Valley Council and local State Emergency Service staff.

The flooding investigations are documented in the *Technical Paper: Flooding* in Volume 3. The investigations were used to assess the route options against the flooding indicators listed in Table 19 in Chapter 5.1. The flooding investigation was reviewed by Paterson Consultants. Comments received and RMS responses are included in the *Technical Paper: Flooding.*

5.2.11 Road safety assessment

Review of crash data

Road safety investigations included a review of RMS' CrashLink database of crash data for the Grafton area between 4 October 2006 and 3 October 2011. Within the area covered by the microsimulation traffic model (refer Chapter 4.4.1), a total of 350 crashes were reported to police during this five year period. Of these crashes, two resulted in fatalities and 175 resulted in injuries.

Considering the volume of traffic using the existing bridge each day, the number of reported crashes on the bridge and viaduct approaches was not high. Of the 11 reported accidents in the five year period, six resulted in injuries.

The number of crashes in the Grafton and South Grafton area is also relatively low at around 60 reported crashes per 100 million vehicle kilometres. It is a little less than the average reported crash rate for urban roads in NSW of 69.45 crashes per 100 million vehicle kilometres (Table B.1 of the *Road Safety Engineering Risk Assessment Part 7: Crash Rates Database* (Austroads, 2010)).

Road safety audits of route options

An independent feasibility stage road safety audit for each route option (including traffic lanes, shared path and approach roads) was carried out in accordance with the *Technical Direction TD*

2003/RS03 Ver 2 (RTA, August 2005*) and the Accident Reduction Guide Part 2 Road Safety Audits* (RTA, 2005).

The purpose of the road safety audit was to identify potential safety issues with each option and allow a comparative assessment of their likely safety during operation. A secondary purpose of the audit is so that, following selection of the preferred option, any issues can be carried forward for further consideration during the design and assessment of the preferred option.

The audit methodology and findings are documented in Appendix 3. The investigations were used to assess the route options against the safety indicators listed in Table 14 in Chapter 5.1.

The audits were carried out by a team of road safety auditors independent of the project team. The audit is based on a subjective review of issues and hazards that might contribute to the potential or severity of crashes. Using audit guidelines, but necessarily requiring a level of professional judgement, issues identified are assigned a priority based on the assessed likelihood and severity of a crash occurring as a result of the identified issue.

The road safety audit was based on the engineering drawings shown in Chapter 4.12 which represent the proposed road layout for each option in 2049, thirty years after the assumed opening year of 2019. In assigning a priority to each identified issue, consideration was given to the expected growth in traffic volumes from 2019 to 2049 as shown in Table 29.

It is normal for any audit to identify a number of safety risks associated with perceived road safety deficiencies. Design adjustments to partially or fully address any issues would normally be subject to a review of the cost and complexity of addressing the issue, and the extent of any resulting environmental, urban design or heritage issues that might be introduced. Note also that even if all identified issues could be addressed it would not eliminate safety risks.

6 Assessment of the route options

This chapter presents the assessment of the route options. The assessment was undertaken against the project objectives and supporting objectives and using the indicators defined in Chapter 5.1. The assessment was informed by the traffic modelling and the technical and environmental investigations described in Chapter 5.2. The assessments are discussed in detail in the technical papers in Volumes 2 and 3.

The assessment of the route options is presented for each project objective and split into each supporting objective in Chapters 6.2 to 6.7.

6.1 Results of the traffic modelling

The results of the traffic modelling discussed in Chapter 4.4.1 show that by the time of the assumed year of opening (2019), all six route options perform similarly, and would result in significant network improvements. However, as traffic demands increase in the later years (2039 and 2049), the options that are in close proximity to the existing bridge (Options E, A and C) perform better than those further downstream (Options 11, 14 and 15), in terms of average speed, travel times and total distance travelled.

The results also indicate:

- The „do minimum" results show that if the assumptions of growth are realised by 2029 the demands across the river would significantly reduce the performance of the network, potentially causing grid lock during the peak periods.
- All options with a new bridge in close proximity to the existing bridge (ie Options E, A and C) attract much more traffic away from the existing bridge when compared to those downstream (Options 11, 14 and 15).
- The network performance in Options 14 and 15 deteriorates in future years with average speeds in the AM peak up to 40 per cent less than the other options by 2049. This is a result of the majority of motorists still wanting to use the existing bridge with those options.
- From 2029 and beyond, point-to-point travel times indicate that Options E and C provide the shortest travel times between South Grafton and Grafton; and that Options 14 and 15 provide the shortest travel times between Butterfactory Lane and the Pacific Highway to the south via the new bridge.
- In 2049 Options E and C provide the best overall travel speeds in the AM and PM peaks. Options A and 11 perform well in the AM peak but average travel speeds drop off in later years during the PM peak, particularly for Option A.

In summary, the modelling presented in this report indicates that each of the options provide improved operation of the network, with the options close to the existing bridge (Options E, A and C) performing better than the options further downstream.

Further details of the network performance of the base year in 2011 and each of the route options in the AM and PM peaks in 2019, 2029, 2039 and 2049 are summarised in the following tables. These tables summarise the network performance for all trips during the period and year indicated using the statistics detailed in the list below. Using Table 20 below as an example, in 2011 there were around 7700 recorded individual trips within the modelled network in the one hour peak between 8-9am:

- Average kilometres per vehicle (kilometres per vehicle) – this is the average length of each trip in the recorded period, in this case about 3.0 kilometres
- Average travel time per vehicle (minutes per vehicle) – this is the average travel time for each trip in the recorded period, in this case about 4.2 minutes
- Average speed (kilometres per hour) – this is the average speed for each trip in the recorded period, in this case about 42.2 kilometres per hour
- Vehicle kilometres travelled (VKT) – this is the total distance travelled after summing the length of all trips in the recorded period, in this case about 23,200 kilometres
- Vehicle hours travelled (VHT) – this is the total travel time after summing the travel times of all trips in the recorded period, in this case about 550 hours.

A shorter average kilometres per vehicle and fewer vehicle kilometres travelled means trips are more direct and the network is more efficient. A shorter average travel time and lower vehicle hours travelled means vehicles reach their destination quicker and also suggests a more efficient network. Lower average speeds imply higher levels of congestion and less travel efficiency.

Table 20: Network performance in 2011 base year model

Statistic	**2011 Base year model**	
	AM peak (8-9am)	**PM peak (4-5pm)**
Average kilometres per vehicle (km/veh)	3.0	3.0
Average travel time per vehicle (min/veh)	4.2	4.3
Average speed (km/hr)	42.2	41.5
Vehicle kilometres travelled (VKT)	23,199	22,984
Vehicle hours travelled (VHT)	550	554

Table 21: Network performance in 2019 (AM peak: 8-9am)

Statistic	**'Do minimum'**	**Option**					
		E	**A**	**C**	**11**	**14**	**15**
Average kilometres per vehicle (km/veh)	3.1	3.0	3.1	3.1	3.1	3.1	3.1
Average travel time per vehicle (min/veh)	4.7	3.6	3.6	3.6	3.5	3.6	3.5
Average speed (km/hr)	38.4	51.2	50.9	51.8	53.3	51.7	52.3
Vehicle kilometres travelled (VKT)	26,390	24,840	24,914	25,143	24,929	25,272	25,307
Vehicle hours travelled (VHT)	686	485	489	486	468	489	484

Table 22: Network performance in 2019 (PM peak: 4-5pm)

Statistic	**'Do minimum'**	**Option**					
		E	**A**	**C**	**11**	**14**	**15**
Average kilometres per vehicle (km/veh)	2.9	2.8	2.8	2.8	2.8	2.9	2.9
Average travel time per vehicle (min/veh)	5.5	3.5	3.5	3.5	3.4	3.4	3.4
Average speed (km/hr)	27.5	48.6	48.1	49.2	50.3	49.9	49.9
Vehicle kilometres travelled (VKT)	22,837	22,930	23,034	22,969	23,187	23,220	23,351
Vehicle hours travelled (VHT)	829	471	479	467	461	466	468

Table 23: Network performance in 2029 (AM peak: 8-9am)

Statistic	Option					
	E	A	C	11	14	15
Average kilometres per vehicle (km/veh)	3.2	3.3	3.3	3.3	3.3	3.3
Average travel time per vehicle (min/veh)	3.9	4.0	3.9	3.7	4.4	4.4
Average speed (km/hr)	49.8	49.5	50.7	49.9	43.7	42.9
Vehicle kilometres travelled (VKT)	33,507	33,817	33,764	34,052	33,886	33,415
Vehicle hours travelled (VHT)	673	683	666	683	776	779

Table 24: Network performance in 2029 (PM peak: 4-5pm)

Statistic	Option					
	E	A	C	11	14	15
Average kilometres per vehicle (km/veh)	3.0	3.0	3.0	3.1	3.1	3.2
Average travel time per vehicle (min/veh)	3.8	3.8	3.7	4.6	5.9	6.2
Average speed (km/hr)	47.6	47.2	48.5	39.5	30.7	29.7
Vehicle kilometres travelled (VKT)	31,780	31,760	32,087	32,425	33,651	33,911
Vehicle hours travelled (VHT)	668	673	661	821	1095	1141

Table 25: Network performance in 2039 (AM peak: 8-9am)

Statistic	Option					
	E	A	C	11	14	15
Average kilometres per vehicle (km/veh)	3.3	3.3	3.3	3.4	3.3	3.3
Average travel time per vehicle (min/veh)	4.0	4.1	4.1	4.2	4.6	4.7
Average speed (km/hr)	48.7	47.9	47.6	47.5	38.1	38.6
Vehicle kilometres travelled (VKT)	39,365	40,336	40,180	40,614	39,349	39,050
Vehicle hours travelled (VHT)	814	842	844	855	1033	1011

Table 26: Network performance in 2039 (PM peak: 4-5pm)

Statistic	Option					
	E	A	C	11	14	15
Average kilometres per vehicle (km/veh)	3.0	3.1	3.1	3.2	3.3	3.3
Average travel time per vehicle (min/veh)	3.9	4.1	3.9	5.4	6.8	6.5
Average speed (km/hr)	46.3	44.7	48.0	34.4	26.8	29.0
Vehicle kilometres travelled (VKT)	37,090	37,430	37,708	38,666	39,168	39,937
Vehicle hours travelled (VHT)	801	838	786	1125	1460	1377

Table 27: Network performance in 2049 (AM peak: 8-9am)

Statistic	Option					
	E	A	C	11	14	15
Average kilometres per vehicle (km/veh)	3.3	3.4	3.4	3.4	3.4	3.4
Average travel time per vehicle (min/veh)	4.5	4.5	4.8	4.6	5.6	5.5
Average speed (km/hr)	43.7	45.3	42.5	43.8	31.8	29.4
Vehicle kilometres travelled (VKT)	43,685	44,909	44,732	44,543	42,422	41,174
Vehicle hours travelled (VHT)	1000	992	1053	1017	1335	1401

Table 28: Network performance in 2049 (PM peak: 4-5pm)

Statistic	Option					
	E	A	C	11	14	15
Average kilometres per vehicle (km/veh)	3.1	3.2	3.2	3.3	3.4	3.5
Average travel time per vehicle (min/veh)	4.2	5.1	4.0	5.7	7.5	6.9
Average speed (km/hr)	44.5	37.2	47.6	33.6	25.7	28.8
Vehicle kilometres travelled (VKT)	41,366	42,111	41,692	42,648	43,979	45,011
Vehicle hours travelled (VHT)	929	1133	875	1271	1711	1564

The microsimulation model also provides the likely distribution of cross-river traffic between the existing bridge and the additional crossing. The modelling shows that, during peak periods, a relatively high proportion of traffic (around 70 per cent) would use the new bridge with Options E, A and C. This proportion is relatively constant over time.

However, for the route options that are further downstream (Options 11, 14 and 15) a much lower proportion of traffic would use the new bridge. The proportion varies from 20 to 30 per cent in 2019 to 35 to 45 per cent in 2049. The reasons for lower utilisation of the new bridge with the downstream options is most likely a function of the trip origins and destinations with fewer motorists choosing to use the new bridge because of the longer travel distances. In later years, as congestion and delays on the existing bridge increase with the downstream options, more motorists then choose to use the new bridge.

Details of the forecast traffic volumes on the existing and new bridges in the AM and PM peaks in each assessment year are summarised in Table 29.

Table 29: Microsimulation modelling results for bridge crossing volumes

Year	Option	2 hour AM peak (7-9am)		2 hour PM peak (3-5pm)	
		Existing bridge total	New bridge total	Existing bridge total	New bridge total
2011	Base model 2011	3617	N/A	4581	N/A
2019	Do minimum	3939	N/A	5086	N/A
	E	1384	2697	2243	3240
	A*	915	3188	1835	3603
	C	1356	2808	2483	2972
	11	2796	1296	4331	1049
	14	3212	936	4570	869
	15	3241	921	4696	835

Year	Option	2 hour AM peak (7-9am)		2 hour PM peak (3-5pm)	
		Existing bridge total	New bridge total	Existing bridge total	New bridge total
2029	E	1849	4048	2769	4807
	A*	1492	4402	2705	4919
	C	1798	4123	3250	4343
	11	3827	2079	5437	2004
	14	4186	1545	5519	1775
	15	4273	1468	5531	1906
2039	E	2421	4640	3214	5432
	A*	1725	5340	2810	5849
	C	2113	4889	3802	4875
	11	3902	3061	5563	2883
	14	4669	2090	5588	2491
	15	4718	2023	5556	2743
2049	E	2764	5231	3480	6106
	A*	2137	5919	3155	6303
	C	2539	5431	3996	5551
	11	4379	3515	5574	3629
	14	4864	2673	5582	3279
	15	4902	2578	5585	3484

* For Option A the new bridge would be two lanes northbound and one lane southbound, and the existing bridge would become one lane southbound only. For the other five options, the new bridge would be one lane northbound and one lane southbound, and the existing bridge would remain as one lane northbound and one lane southbound.

6.2 Enhance road safety for all road users over the length of the project

This chapter presents the assessment of the route options against the supporting objectives for the project objective: Enhance road safety for all road users over the length of the project.

6.2.1 Reduce the potential for road crashes and injuries on the bridge and approaches including any intersections and connecting roads

The comparative assessment of the route options against the road crash and injury indicators is presented in Table 30. This chapter should be read in conjunction with the road safety audit in Appendix 3 and the *Technical Paper: Traffic Assessment* in Volume 2.

Table 30: Comparative assessment of road safety

Supporting objective: Reduce the potential for road crashes and injuries on the bridge and approaches including any intersections and connecting roads							
Indicator		**Option**					
		E	**A**	**C**	**11**	**14**	**15**
Issues identified by the road safety audit	High priority (No.)	2	3	1	3	2	2
	Medium priority (No.)	9	13	10	8	7	7
	Low priority (No.)	7	7	4	4	5	5

Issues identified by the road safety audit

The identified road safety audit issues for each option have been given a priority or risk rating from high (higher relative likelihood and severity of crashes) to low (lower relative likelihood and severity of crashes) and the number of issues with each priority have then been summed for each option.

The options with the highest number of safety issues are Options A and E, respectively. Generally this is because these two options direct traffic through the centre of Grafton, and are more constrained by existing developments and infrastructure, providing less flexibility to adjust the design to address road safety issues. Conversely, Options C, 11, 14 and 15 remove some traffic from central Grafton, are less constrained by existing developments and infrastructure, and overall would be expected to result in fewer and/or less severe crashes. According to the road safety audit findings, Options 14 and 15 have a lower potential for compromising road safety than Options 11 and C. Option A has the highest potential for compromising road safety, followed by Option E.

6.2.2 Provide safe facilities for pedestrians and cyclists

The comparative assessment of the route options against the safe facilities for pedestrians and cyclists is presented in Table 31. This chapter should be read in conjunction with the road safety audit in Appendix 3.

Table 31: Comparative assessment of pedestrian and cyclist safety

Supporting objective: Provide safe facilities for pedestrians and cyclists						
Indicator	**Option**					
	E	**A**	**C**	**11**	**14**	**15**
Issues related to pedestrians and cyclists identified by the road safety audit (No.)	3	8	4	4	3	3

Issues related to pedestrians and cyclists

The issues identified by the road safety audit include potential safety problems that could be faced by pedestrians and cyclists in negotiating specific aspects of each route option. These generally include negotiating roundabouts and intersection left-turn slip lanes and other road layouts that create difficulties for the flow of pedestrians and cyclists. Left-turn slip lanes in particular can create difficulties as drivers tend to focus on gaps from the traffic on the right, increasing the potential for conflict between pedestrians and cyclists with vehicles.

Consideration of the likely change in level of exposure of pedestrians and cyclists to through traffic and heavy vehicles was also a part of the road safety audit, in terms of the potential of each option to deviate the primary highway route from the core streets that form the key connections in the existing pedestrian and cycle networks, as defined in the *Bike Plan and Pedestrian Access and Mobility Plan* (Clarence Valley Council, August 2008).

Due to their closer proximity to the existing river crossing, Options E, A and C retain the primary highway route through streets that form the existing core pedestrian and cycle networks; thereby retaining exposure to through traffic and heavy vehicles. Since Options 14 and 15 are located further from the existing river crossing, they reduce the exposure of the existing core pedestrian and cycle networks to through traffic and heavy vehicles. While Option 11 is also located further away from the existing crossing, it still follows the highway route through the northern part of Grafton which forms a general access route for pedestrians and cyclists.

The road safety audit also considered the material changes to intersections, particularly the addition of new roundabouts, introduced within each option in terms of their potential to increase conflict between pedestrians and cyclists and vehicles.

All options introduce new roundabouts of various sizes and some with left-turn slip lanes; thereby increasing the potential for conflict between pedestrians and cyclists and vehicles to some degree.

In general terms, according to the road safety audit findings, Option A has the most potential to compromise road safety for pedestrians and cyclists; while Options E, 14 and 15 would be slightly better than Options C and 11.

6.3 Improve traffic efficiency between and within Grafton and South Grafton

This chapter presents the assessment of route options against the supporting objectives for the project objective: Improve traffic efficiency between and within Grafton and South Grafton. Traffic data for this objective has been taken from the *Technical Paper: Traffic Assessment* in Volume 2.

6.3.1 Provide efficient access for a second crossing of the Clarence River and for the State road network

The comparative assessment of the route options against the access efficiency indicators is presented in Table 32. This chapter should be read in conjunction with the *Technical Paper: Traffic Assessment* in Volume 2.

Table 32: Comparative assessment of traffic efficiency

Supporting objective: Provide efficient access for a second crossing of the Clarence River and for the State road network								
Indicator			**Option**					
			E	**A**	**C**	**11**	**14**	**15**
Total time travelled by all vehicles across the modelled road network	At the year of opening (2019) (million hours per year)	„Do minimum" 2.37	1.91	1.97	1.89	1.85	1.89	1.88
	20 years after opening (2039) (million hours per year)		2.99	3.12	2.96	3.07	3.32	3.27
Total distance travelled by all vehicles across the modelled road network	At the year of opening (2019) (million km per year)	„Do minimum" 95.56	94.63	95.75	95.14	95.14	96.18	95.95
	20 years after opening (2039) (million km per year)		145.85	148.32	146.88	147.56	148.91	148.89
Total time travelled by heavy vehicles across the modelled road network	At the year of opening (2019) (million hours per year)	„Do minimum" 0.041	0.035	0.034	0.033	0.032	0.035	0.033
	20 years after opening (2039) (million hours per year)		0.053	0.052	0.050	0.049	0.055	0.053
Total distance travelled by heavy vehicles across the modelled road network	At the year of opening (2019) (million km per year)	„Do minimum" 1.86	1.83	1.79	1.77	1.73	1.92	1.82
	20 years after opening (2039) (million km per year)		2.73	2.71	2.62	2.61	2.87	2.75

Time travelled by all vehicles

All options create additional road network capacity substantially reducing peak period delay in the network at 2019.

Total annual hours of travel for Options E, C, 11, 14 and 15 are within three per cent of each other in 2019. Option 11 has the lowest total travel time with the next best performing being Option 15. Option A has the highest total travel time, as all cross-river traffic travels within the Bent Street/Craig Street/Fitzroy Street corridor. The extra traffic in this corridor creates additional delays

and therefore higher total travel time. Option 11 performs best as the option provides a convenient route to Grafton for traffic from Clarenza and the north, while attracting enough traffic away from the Bent Street corridor to improve the overall network performance.

Traffic demands from the major new development areas of Clarenza and Waterview Heights become more pronounced on the network at 2039 and the relative performance of each option alters compared to 2019.

At 2039 Option C is the best performing option followed by Option E. Both Options E and C perform better than Option A at reducing traffic in the Bent Street/Craig Street/Fitzroy Street corridor, reducing delays and total travel times. One reason is that Options E and C provide the most direct routes for traffic from Waterview Heights and Clarenza respectively to the central area of Grafton, attracting traffic away from the existing bridge. By 2039 Option 11 is no longer the best performing option. Traffic demand on the existing bridge corridor is higher for Option 11 than for Option C or Option E, resulting in poorer overall network performance.

Options 14 and 15 have the highest total travel times and do not perform as well. The options do not attract enough traffic to the new bridge during either the peak hours or off peak hours and are less effective at reducing delay in the Bent Street/Craig Street/Fitzroy Street corridor. The result is higher overall travel times.

Distance travelled by all vehicles

Option E performs the best as it offers the shortest route between South Grafton and Grafton in both 2019 and 2039.

Options C and 11 are the next best options in 2019 with total distance travelled being equal. By 2039, Option C is performing slightly better than Option 11. Option C has better road network capacity on the Grafton side, particularly along the Pound Street corridor, whereas traffic in Option 11 must use less direct routes to access the central area of Grafton. Option 11 does not reduce traffic on the existing bridge to the same extent as Option C. The delay associated with the Bent Street/Craig Street/Fitzroy Street corridor is higher for Option 11 which encourages some drivers to choose to travel further, using the new bridge, to avoid this delay.

Option 14 has the highest total distance travelled in 2019 and in 2039, marginally more than Option 15. These options are least effective in reducing traffic on the existing bridge and at reducing delay in the Bent Street/Craig Street/Fitzroy Street corridor. The delay associated with the existing bridge and the 100 kilometres per hour posted speed limit on the Pacific Highway encourages some traffic to make the longer journey over the new bridge. As a result total travel distance is higher for Options 14 and 15 than for the other options.

Time travelled by heavy vehicles

The addition of a second river crossing creates additional road network capacity substantially reducing peak period delay for heavy vehicles in the network at 2019. However the performance of the options for heavy vehicles differs to that of all vehicles because the larger heavy vehicles are obliged to use the new bridge.

In 2019 the total annual hours of heavy vehicle travel would be lowest for Option 11 which provides good overall access for heavy vehicles at this time. Options A, C and 15 are the next best performing in 2019, with Options E and 14 the worst performing.

By 2039 the relativities change as traffic grows. Option 11 is still the best performing option but is closely followed by Option C. Options E, A and 15 are a little worse, with Option 14 having the highest heavy vehicle travel time. For Option 14, increasing congestion around the central areas of Grafton and South Grafton is increasing the travel time for heavy vehicles accessing these areas.

Distance travelled by heavy vehicles

In terms of distance travelled by heavy vehicles, rather than distance travelled by all vehicles, Option E is no longer the most efficient network. Option 11 provides the most efficient network in 2019, followed by Options C and A. Options E and 15 are the next best with Option 14 having appreciably greater heavy vehicle travel distances. By 2039, Option 11 still has the lowest heavy vehicle travel distances, closely followed by Option C. Options A, E and 15 are the next best, with Option 14 again having the highest heavy vehicle travel distance.

6.3.2 Provide a traffic management network which reduces delays between Grafton and South Grafton in peak periods to an acceptable level of service for 30 years after opening

The comparative assessment of the route options against the travel times indicator is presented in Table 33. This chapter should be read in conjunction with the *Technical Paper: Traffic Assessment* in Volume 2.

Table 33: Comparative assessment of travel times between Grafton and South Grafton

Supporting objective: Provide a traffic management network which reduces delays between Grafton and South Grafton in peak periods to an acceptable level of service for 30 years after opening							
Indicator		**Option**					
		E	**A**	**C**	**11**	**14**	**15**
Average travel time between Grafton and South Grafton using the existing bridge, 30 years after opening (2049)	Morning (AM) peak period, northbound (minutes)	7	8	7	8	14	14
	Afternoon (PM) peak period, southbound (minutes)	7	9	6	10	12	12

Average travel time

Options E and C would result in the shortest travel times in 2049 during the morning 8-9am (northbound) and afternoon 4-5pm (southbound) peaks between the intersection of Bent Street and Gwydir Highway, South Grafton and the intersection of Prince Street and Pound Street (clock tower), Grafton. They are the best performing options as they provide convenient alternative routes between South Grafton and Grafton. They attract more traffic away from the existing bridge and allow higher travel speeds in the Bent Street/Craig Street/Fitzroy Street corridor. Option C performs a little better than Option E in the afternoon peak because it separates traffic at both the southern and northern ends of the bridge reducing the conflicts between various movements and reducing the overall delay, particularly at the Fitzroy Street/Villiers Street intersection.

Options 14 and 15 perform in a similar manner and are least successful in reducing delay in the Bent Street/Craig Street/Fitzroy Street corridor as the options attract less traffic away from the existing bridge.

6.3.3 Provide adequate vertical clearance for heavy vehicles

All route options would provide adequate vertical clearance for heavy vehicles. Therefore this supporting objective does not provide any differentiation between options.

6.3.4 Consider demand management strategies to minimise delays to local and through traffic

This is likely to be required for all options and would be addressed as part of an overall strategy for improving the road network.

6.4 Support regional and local economic development

This chapter presents the assessment of the route options against the supporting objectives for the project objective: Support regional and local economic development.

6.4.1 Provide transport solutions that complement existing and future land uses and support development opportunities

The comparative assessment of the route options against the existing land use and development indicators is presented in Table 34. This chapter should be read in conjunction with the *Technical Paper: Social and Economic Issues* in Volume 2.

Table 34: Comparative assessment of level of connectivity to existing and future land uses

Supporting objective: Provide transport solutions that complement existing and future land uses and support development opportunities							
Indicator		**Option**					
		E	**A**	**C**	**11**	**14**	**15**
Level of connectivity to existing and future land uses and development	Existing and future residential areas with the Grafton and South Grafton CBDs	Strong	Strong	Moderate	Low to moderate	Low	Low
	Existing and future residential areas with existing and future employment areas	Moderate (existing residential and employment areas)	Moderate (existing residential and employment areas)	Moderate (existing residential and employment areas)	Moderate (existing residential and future growth areas)	Moderate (future growth areas)	Moderate (future growth areas)
	Grafton and South Grafton CBDs	Strong potential	Moderate potential	Moderate potential	Low potential	Low potential	Low potential

Level of connectivity

All options would provide some improvement in the level of connectivity between Grafton and South Grafton by virtue of the fact that an additional crossing would result in reduced congestion across the overall road network.

Options E, A and C provide improved connectivity between existing residential areas and the Grafton and South Grafton CBDs. Options E and A provide the highest level of connectivity. Option 11 may provide marginally improved connectivity between Clarenza and the Grafton CBD. Comparatively, Options 14 and 15 are unlikely to improve connectivity between residential areas and the Grafton and South Grafton CBDs due to their distance from the two centres.

All options would provide some improvement to the level of connectivity to employment areas. Options E, A and C provide improved connectivity to the existing industrial areas in South Grafton. Option 11 provides improved connectivity to the Clarenza residential growth area. Options 14 and 15 provide improved connectivity between the two separate growth and employment areas of Junction Hill and Clarenza.

Options that are closest to the existing crossing (Options E, A and C) would provide a better level of connectivity between the two CBDs than those located further away from the existing bridge (Options 11, 14 and 15). Option E provides a relatively more direct link between the two CBDs and provides the strongest improvement to connectivity in this area.

6.4.2 Provide improved opportunities for economic and tourist development for Grafton

The comparative assessment of the route options against the economic and tourist development indicator is presented in Table 35. This chapter should be read in conjunction with the *Technical Paper: Social and Economic Issues* in Volume 2.

Table 35: Comparative assessment of tourism opportunities

Supporting objective: Provide improved opportunities for economic and tourist development for Grafton						
Indicator	**Option**					
	E	**A**	**C**	**11**	**14**	**15**
Potential to contribute to tourism	Strong potential to integrate with several local strategies and provides stronger link with waterfront	Moderate potential as option enters Grafton near CBD	Moderate potential as option enters Grafton near CBD	Low potential as option enters Grafton at some distance from the CBD	Low potential as option enters Grafton at some distance from the CBD	Low potential as option enters Grafton at some distance from the CBD

Contribution to tourism

All options offer the potential for some contribution to tourism by integrating with the *Clarence River Way Masterplan* (Clarence Valley Council, 2009). Option E offers the strongest potential for integration, which may complement several of the plan"s strategies and the opportunity to provide a stronger link between Grafton and its waterfront. Options A and C have a stronger potential to contribute to tourism development than Options 11, 14 and 15. Options 11, 14 and 15 are located significantly downstream and would enter Grafton at some distance from the CBD. They are therefore unlikely to satisfactorily provide the „gateway experience" outlined in the masterplan.

6.4.3 Provide for commercial transport including B-doubles where required

The comparative assessment of the route options against the commercial transport indicator is presented in Table 36. This chapter should be read in conjunction with the *Technical Paper: Traffic Assessment* in Volume 2.

Table 36: Comparative assessment of travel distances and times for commercial transport

Supporting objective: Provide for commercial transport including B-doubles where required							
Indicator		**Option**					
		E	**A**	**C**	**11**	**14**	**15**
Travel distance between the Pacific Highway and the Summerland Way using the new bridge (km)		9.1	8.7	8.4	10.0	10.5	10.3
Average travel time between the Pacific Highway and the Summerland Way using the new bridge, 30 years after opening (2049)	Morning (AM) peak period, northbound (minutes)	15	14	13	11	10	10
	Afternoon (PM) peak period, southbound (minutes)	12	16	10	10	10	10

Note: Both indicators are taken between the intersection of the Pacific Highway and Tyson Street, South Grafton and the intersection of the Summerland Way and Butterfactory Lane, Grafton.

Travel distance

Option C would provide the shortest travel distance for through vehicles travelling between the Summerland Way and the Pacific Highway to the south. Travel via Option A would be marginally longer followed by Option E. Options 11, 14 and 15 require additional travel along the Pacific Highway and as a result would require a slightly longer travel distance.

Travel time

Options 14 and 15 would result in the shortest travel times in 2049 during the morning 8-9am (northbound) and afternoon 4-5pm (southbound) peaks between the intersection of the Pacific Highway and Tyson Street, South Grafton and the intersection of the Summerland Way and Butterfactory Lane, Grafton. The lower traffic levels and higher speed limits on the Pacific Highway assist in reducing the travel times for Options 14 and 15. Option E has the highest travel time in the AM peak and Option A in the PM peak. Both options require through traffic to travel through key central area intersections where the delays are higher and add to the time required to complete the trip.

6.4.4 Provide flood immunity for the bridge for a one in 100-year flood event, and for the approach roads for a one in 20-year flood event, where economically justified

All route options would have flood immunity for the bridge for a one in 100-year flood event and the approach roads for a one in 20-year flood event. Therefore, this supporting objective does not provide any differentiation between options.

6.4.5 Provide a navigational clearance from the additional crossing for river users

All route options would provide the designated navigational clearance as identified by NSW Maritime (now part of RMS). Therefore this supporting objective does not provide any differentiation between options.

6.5 Involve all stakeholders and consider their interests

The project objective: Involve all stakeholders and consider their interests, relates to the consultation and communication processes that are being undertaken throughout the project. As

this objective relates to the consultation process, it does not provide indicators for the assessment of each of the route options. See Table 17 in Chapter 5 for more details.

6.6 Provide value for money

This chapter presents the assessment of the route options against the supporting objectives for the project objective: Provide value for money.

6.6.1 Achieve a justifiable benefit-cost ratio at an affordable cost

The comparative assessment of the route options against the benefit-cost ratio indicators is presented in Table 37. This chapter should be read in conjunction with the *Technical Paper: Strategic Cost Estimates* and the *Technical Paper: Economic Evaluation* in Volume 2.

Table 37: Comparative assessment of benefit-cost ratio

Supporting objective: Achieve a justifiable benefit-cost ratio at an affordable cost						
Indicator	**Option**					
	E	**A**	**C**	**11**	**14**	**15**
Route option strategic cost estimate ($m)	215	231	231	210	304	340
Benefit-cost ratio over 30 years from 2019 based on strategic cost estimates	1.6	1.3	1.6	1.7	1.0	0.9
Net present value over 30 years from 2019 based on strategic cost estimates ($m)	75.3	41.2	72.4	80.0	-5.5	-22.2

Strategic cost estimates

Estimated costs generally increase as the options move downstream. Options 14 and 15 are appreciably more costly than the other options due primarily to the longer bridge and viaduct lengths required.

Options E and 11 are the least costly options. While the total bridge and viaduct costs are slightly more expensive than for Options A and C, property acquisition costs are appreciably less.

Options A and C costs are similar, approximately $20 million more than Options E and 11, but still appreciably less than Options 14 and 15. Property acquisition costs and public utility adjustments are higher for Options A and C. Option C also has higher drainage costs because of the additional drainage infrastructure required where it passes under the rail viaduct at Pound Street.

Benefit-cost ratio and net present value

The comparative BCR and NPV results indicate that for Options E, A, C and 11, the road user benefits would appreciably exceed the capital cost, but for Options 14 and 15 the benefits would be marginally lower than the cost.

With a BCR of 1.7 and the highest NPV, Option 11 performs the best overall. While the road user benefits with Option 11 are marginally lower than with Option C, Option 11 performs better due to a lower capital cost compared with Option C.

The performance of the next best Options E and C are similar and only marginally behind Option 11. Option C generates higher road user benefits than Option E but this is offset by a higher capital cost.

Option A does not perform as well as Options E, C and 11 because the road user benefits are lower with Option A and it has a comparatively high capital cost.

Options 14 and 15 are the worst performing options since they generate the lowest road user benefits while their capital costs are highest.

Comparison to *Preliminary Route Options Report – Final* (RMS, January 2012)

All route option estimates have been completely reviewed and revised since the *Preliminary Route Options Report – Final* (RMS, January 2012) *(PROR)* to reflect the design development of both the roadworks and structures that has been carried out for the *Route Options Development Report (RODR)*. The developed designs have also allowed a more detailed assessment of likely property acquisition costs. As a result there have been changes to the strategic costs estimates as noted in Table 38 below.

The major factor in the change in cost estimates for the upstream options (Options E, A and C) is that the microsimulation traffic modelling for the upstream options identified significant additional roadworks. These are mainly works on key feeder roads to the additional crossing in both Grafton and South Grafton that would be necessary to meet 2049 traffic demands. Because of limited road reservation widths the additional roadworks also increase property acquisition costs for those options.

For the downstream Options 14 and 15, the main change is that, based on recent construction contracts, the structure costs have been reduced. The length of the viaduct on the South Grafton side has reduced by about 150 metres as a result of the more detailed flood modelling carried out as part of this report. The other change is that development of more detailed bridge and viaduct span configurations and cross-sections, and a much more detailed approach to pricing of the structures has resulted in lower structure rates generally for the longer structures.

Further details of the key changes are provided in the comparison table below.

Table 38: Comparison of *PROR* and *RODR* strategic cost estimates

Option	*PROR* ($m)	RODR ($m)	Difference ($m)	Comments
E	163	215	51	Traffic modelling identified significant additional roadworks in Grafton and South Grafton necessary to meet 2049 traffic demands, including upgrades of sections of the Gwydir Hwy, Pacific Hwy, Bent St, Pound St and Clarence St. The additional roadworks added about $29m, with additional acquisition costs arising largely from the additional roadworks adding a further $17m approximately. The allowance for bridge structure cost was increased by about $3m.
A	192	231	39	Traffic modelling identified significant additional roadworks in Grafton and South Grafton necessary to meet 2049 traffic demands, including upgrades of sections of the Gwydir Hwy, Pacific Hwy, Spring St, Villiers St, Pound St and Clarence St. The additional works added about $28m, with additional acquisition costs arising largely from the additional roadworks adding a further $21m. These increases were partially offset by a reduction in bridge and viaduct costs of about $11m.
C	177	231	55	Traffic modelling identified significant additional roadworks in Grafton and South Grafton necessary to meet 2049 traffic demands, including upgrades of sections of the Gwydir Hwy, Iolanthe St north, Ryan St, Villiers St and Clarence St. Including in addition the realignment of a section of the Pacific Hwy, an extension of works on Pound St through to Prince St, and drainage works on Pound St near the rail viaduct added to an increase of about $42m in roadworks costs. Additional acquisition costs arising largely from the additional roadworks added a further $12m approximately. These increases were partially offset by a reduction in bridge and viaduct costs of about $4m.

Option	*PROR* ($m)	RODR ($m)	Difference ($m)	Comments
11	205	210	6	Traffic modelling identified additional roadworks to the Pacific Hwy and the Gwydir Hwy in the vicinity of Iolanthe St and Bent St. Additional works for the roundabout connecting the new bridge approach to the Pacific Hwy and on Villiers St also added to an overall increase of about $16m in the roadworks cost. Additional acquisition costs arising largely from the additional roadworks added a further $6m approximately. These increases were partially offset by a reduction in bridge and viaduct costs of about $15m due to a shorter structure length and lower structure rates generally arising from the more detailed estimate.
14	357	304	-54	Traffic modelling identified additional roadworks to the Pacific Hwy and the Gwydir Hwy in the vicinity of Iolanthe St and Bent St. Additional works for the roundabout connecting the new bridge approach to the Pacific Hwy and a longer approach embankment due to the shorter viaduct also contributed to an overall increase of about $12m in the roadworks cost. Additional acquisition costs arising largely from the additional roadworks added a further $3m approximately. These increases were offset by a substantial reduction in bridge and viaduct costs of about $63m due to a shorter viaduct length on the South Grafton side and lower structure rates generally arising from the more detailed estimate. A reduced allowance for investigation and design of the preferred option contributed to a further $7m reduction.
15	389	340	-49	Traffic modelling identified additional roadworks to the Pacific Hwy and the Gwydir Hwy in the vicinity of Iolanthe St and Bent St. Additional works for the roundabout connecting the new bridge approach to the Pacific Hwy and a longer approach embankment due to the shorter viaduct also contributed to an overall increase of about $17m in the roadworks cost. Additional acquisition costs arising largely from the additional roadworks added a further $7m approximately. These increases were offset by a substantial reduction in bridge and viaduct costs of about $60m due to a shorter viaduct length on the South Grafton side and lower structure rates generally arising from the more detailed estimate. A reduced allowance for investigation and design of the preferred option contributed to a further $8m reduction.

The economic evaluation results have also been fully re-evaluated using the results of the microsimulation and the revised strategic cost estimates.

As shown in Table 39 below, the economic evaluation results are highly dependent on the cost estimates and most changes can be attributed largely to the change in costs.

Table 39: Comparison of *PROR* and *RODR* benefit-cost ratios

Option	*PROR* BCR	RODR BCR	Comments
E	2.5	1.6	Appreciably higher cost estimate has lowered the BCR
A	2.1	1.3	Appreciably higher cost estimate has lowered the BCR
C	2.2	1.6	Appreciably higher cost estimate has lowered the BCR
11	1.6	1.7	No significant change in cost estimate but road user benefits from the microsimulation traffic modelling are comparatively higher for Option 11, resulting in a higher BCR
14	0.7	1.0	Appreciably lower cost estimate has raised the BCR
15	0.6	0.9	Appreciably lower cost estimate has raised the BCR

6.6.2 Develop a strategy to integrate future upgrades into the project

All option layouts have been developed to cater for traffic growth through to 2049, 30 years after opening. In practice, construction of the road network upgrades would be staged over time following construction of the new bridge, as traffic demand increases. While traffic modelling of staged construction has not been carried out, a preliminary assessment of traffic staging

opportunities for each option has been carried out as described in Chapter 4.4.6. Indicative Stage 1 construction works for each option are described in Chapters 4.6 to 4.11. Further detailed investigations of construction staging options will be carried out following selection of the preferred route.

While all options have considered traffic demands through to 2049, traffic demands beyond this date have not been assessed.

6.7 Minimise impact on the environment

This chapter presents the assessment of the route options against the supporting objectives for project objective: Minimise impact on the environment.

6.7.1 Minimise the impact on the social and economic environment, including property impacts

The comparative assessment of the route options against the social impact assessment indicators is presented in Table 40. Potentially directly affected properties and facilities are illustrated in Figure 32, Figure 33, Figure 34, Figure 35, Figure 36 and Figure 37. This chapter should be read in conjunction with the *Technical Paper: Social and Economic Issues* in Volume 2.

Table 40: Comparative assessment of social and economic environment

Supporting objective: Minimise the impact on the social and economic environment, including property impacts							
Indicator		**Option**					
		E	**A**	**C**	**11**	**14**	**15**
Number of residential properties potentially directly affected	Acquisition likely to impact on residence or other major building (No.)	11	20	21	16	1	1
	Acquisition unlikely to impact on residence or other major building (No.)	5	1	3	6	5	0
	TOTAL	***16***	***21***	***24***	***22***	***6***	***1***
Number of community facilities potentially directly affected	Clubs/recreation (No.)	1 • Grafton Showground	1 • Grafton Showground	2 • Grafton Showground • Basmar Hall	2 • Grafton Showground • Fisher Park	1 • Grafton Showground	1 • Grafton Showground
	Education (No.)	0	1 • Grafton Community College	2 • North Coast Institute TAFE • Gummyaney Indigenous Preschool	0	0	0
	River uses (No.)	1 • “Monster Energy Pro Wakeshow” area	1 • Clarence River Sailing Club Course	1 • Clarence River Sailing Club Course	1 • River use at Fry St	0	0
	Places of worship (No.)	2 • St Patrick"s Catholic Church • St Mary"s Catholic Church and Sisters of Mercy Convent	1 • St Patrick"s Catholic Church	1 • St Patrick"s Catholic Church	1 • St Patrick"s Catholic Church	1 • St Patrick"s Catholic Church	1 • St Patrick"s Catholic Church
	Government (No.)	0	0	0	0	0	0
	Services (No.)	2 • Grafton Shopping World • Gurelgham Pty Ltd/ Aboriginal Legal Services	1 • Grafton Shopping World	2 • Grafton Shopping World • Grafton Tourist Information Centre	0	0	0

Supporting objective: Minimise the impact on the social and economic environment, including property impacts							
Indicator		**Option**					
		E	**A**	**C**	**11**	**14**	**15**
	Health and emergency services (No.)	0	0	0	0	0	0
	Infrastructure (No.)	0	4 • Bus interchange South Grafton • South Grafton railway infrastructure • South Grafton infrastructure railway land (adjacent to Derek Palmer Pl) • Grafton railway infrastructure land (adjacent to Salty Seller reserve)	2 • Railway infrastructure land next to Basmar Hall • South Grafton railway infrastructure	0	1 • Waste transfer station	2 • Waste transfer station • Sewage treatment plant
	Parks and reserves (No.)	2 • McKittrick Park • Public open space at corner of Cowan St and Spring St	6 • Silver Jubilee Park • Derek Palmer Pl • Earle Page Park • Salty Seller Reserve • McKittrick Park • Induna Reserve	2 • McKittrick Park • McClymont Pl open space	1 • McKittrick Park	2 • Corcoran Park • McKittrick Park	2 • Corcoran Park • McKittrick Park
	TOTAL	***8***	***15***	***12***	***5***	***5***	***6***
Number of businesses with potential impacts on business viability (No.)		5	14	2	1	1	1
Number of businesses with potential minor impacts (No.)		2	7	2	0	1	0
Number and area of rural properties with potential direct impacts	Rural properties (No.)	0	0	2	2	7	14
	Area (ha)	0	0	4.5	8.0	14.2	26.7
Area of regionally significant farmland potentially directly affected (ha)		0	0	3.4	8.0	13.9	26.5

Supporting objective: Minimise the impact on the social and economic environment, including property impacts						
Indicator	**Option**					
	E	**A**	**C**	**11**	**14**	**15**
Changes to access and disruption to community activities or plans	Disruption of access to high density of community facilities and residences particularly around Villiers St and Victoria St.	Localised disruption to access and community activities.	Localised disruption to access and community activities.	Disruption to movement across Fry St, currently a quiet residential area.	Increased traffic flow has the potential to create a barrier to movement across Prince St, currently a quiet residential area.	Increased traffic flow has the potential to create a barrier to movement across Prince St, currently a quiet residential area.

Residential properties

Option C has the greatest number of potentially directly affected residential properties, followed by Options 11, A and E respectively. It should be noted that in terms of likely acquisition of the main residence or major building within a property, Option A has a higher number of potentially affected properties than Option 11. Options 14 and 15 have the lowest number of potentially directly affected residential properties, as they are located in mainly rural and semi-rural areas.

For Options C and 11 residential property impacts would occur almost entirely in the Grafton area. Option C would impact some residential properties located along Greaves Street, Kent Street, Pound Street and Fitzroy Street while Option 11 would affect residential properties mostly along Fry Street. For Option A residential property impacts would occur both in South Grafton (mostly along Bent Street) and Grafton (along Fitzroy Street). Option E residential impacts would occur in a few properties along the Gwydir Highway in South Grafton and along Villiers Street, Fitzroy Street and Clarence Street in Grafton.

Distributional equity of social impacts and impact on housing affordability was considered as part of the comparative assessment. This has not been included as an indicator as it was noted that any potential short-term impacts upon housing affordability may be offset by improved connectivity to residential growth areas. It is considered that the level of property acquisitions required is unlikely to be high enough to have any significant effect upon Grafton"s overall housing affordability. Also, the distributional equity of impacts was found to be generally fairly balanced. A discussion on distributional equity of social impacts and impact on housing affordability can be found in the *Technical Paper: Social and Economic Issues* in Volume 2.

Community facilities

The number of community facilities potentially directly affected has been classified into clubs/recreation, education, river uses, places of worship, government, services, health and emergency services, infrastructure and parks and reserves. Option C is the only option which would require the demolition of a building structure, Basmar Hall on Pound Street. Options A and C have the greatest impact on community facilities followed by Option E. Options 11, 14 and 15 affect the lowest number of community facilities. This is due to these options passing outside the Grafton and South Grafton CBDs where most of the community facilities are located.

Businesses

Option A has the highest potential impact on businesses due to acquisition on the east side of Bent Street as a result of road widening for additional traffic lanes. Option E has the next highest potential impact on businesses, followed by Option C. Options 11, 14 and 15 will have a comparatively low potential impact on businesses.

The number of affected full time equivalent (FTE) positions was considered as part of the comparative assessment. Information on FTE positions was supplied by businesses that responded to the business survey. Some businesses were not contactable, or declined to participate in the survey. As a result the information collected is incomplete and therefore this indicator has not been included as part of the comparative assessment. A discussion on affected FTE positions based on the information available can be found in the *Technical Paper: Social and Economic Issues* in Volume 2.

Rural properties

Options 14 and 15 both have high impacts on rural properties due to the alignment passing through undeveloped land south of the Clarence River. Option 15 has a greater impact than Option 14 as it also impacts undeveloped land north of the Clarence River. Options E and A have no impact on rural properties.

Option 15 has the highest impact upon regionally significant farmland as the majority of rural properties in the above indicator are considered to be regionally significant farmland. Options E and A have no impacts on regionally significant farmland.

Changes to access and disruption to community activities or plans

Option E is likely to disrupt patterns of movement to community facilities in Villiers Street and Victoria Street, including Clarence Valley Conservatorium and St Mary"s Church. This option is also likely to increase the difficulty of access between the Grafton CBD/Shopping World, and Grafton east of Villiers Street. Given the relatively high density of community facilities in this area, there is a higher possibility for disruption. Option 11 will significantly disrupt ease of north-south movement across Fry Street, currently a quiet residential area. Options 14 and 15 will introduce increased traffic flows travelling back into the CBD along Prince Street, and will therefore create an increased barrier to movements across Prince Street. Options A and C have relatively little impact, with localised disruption to access and community activities.

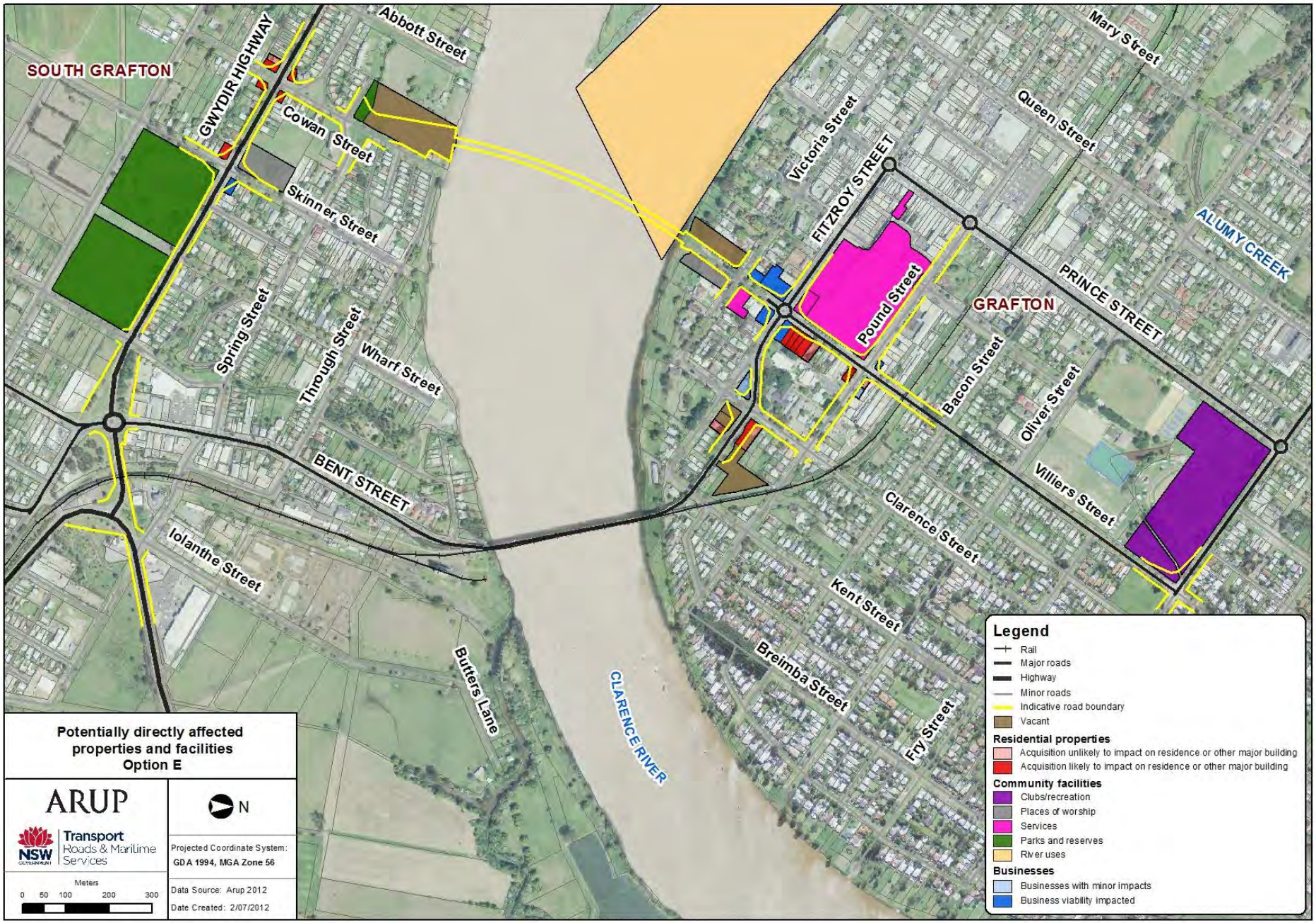

Figure 32: Option E – Potentially directly affected properties and facilities

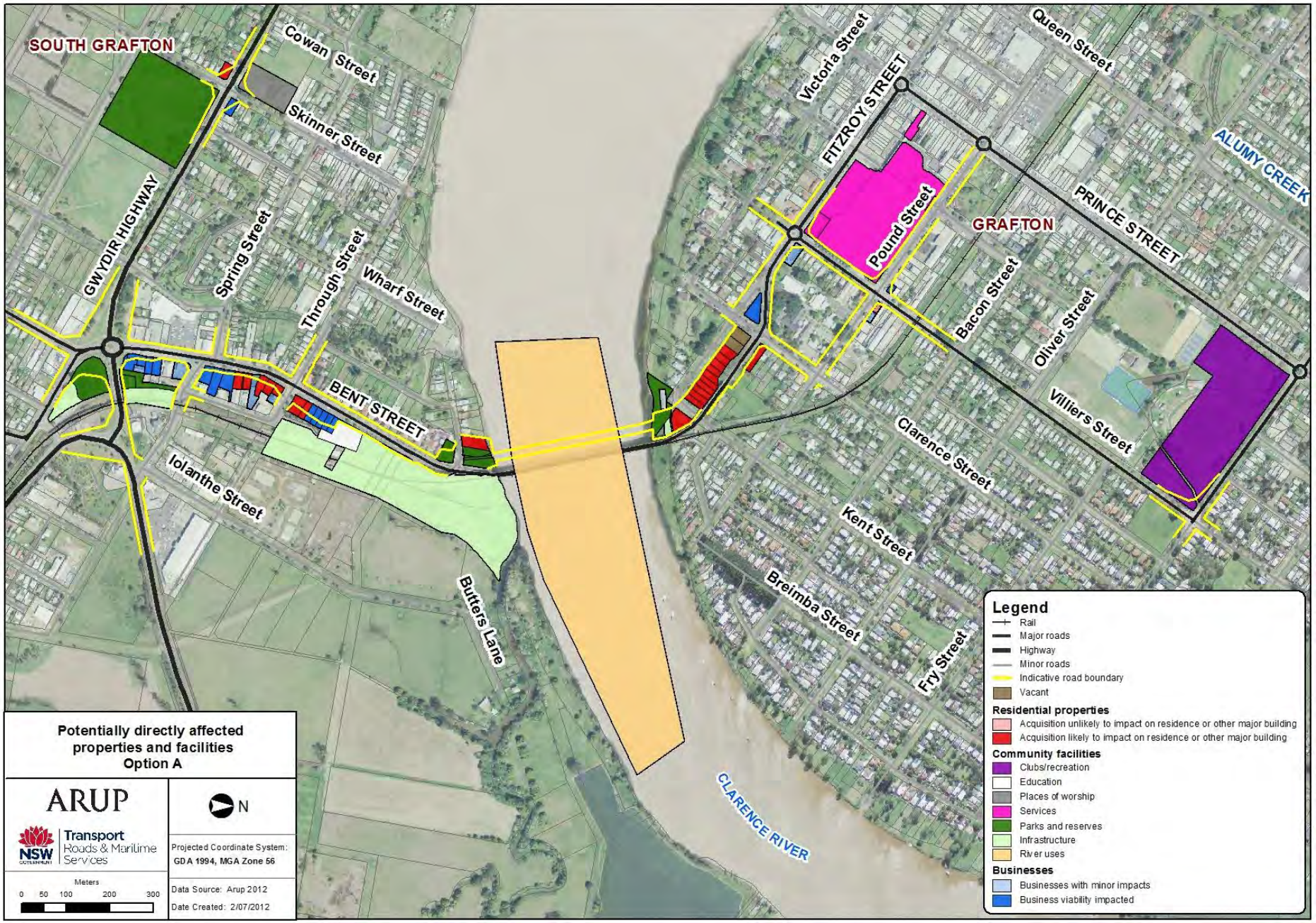

Figure 33: Option A – Potentially directly affected properties and facilities

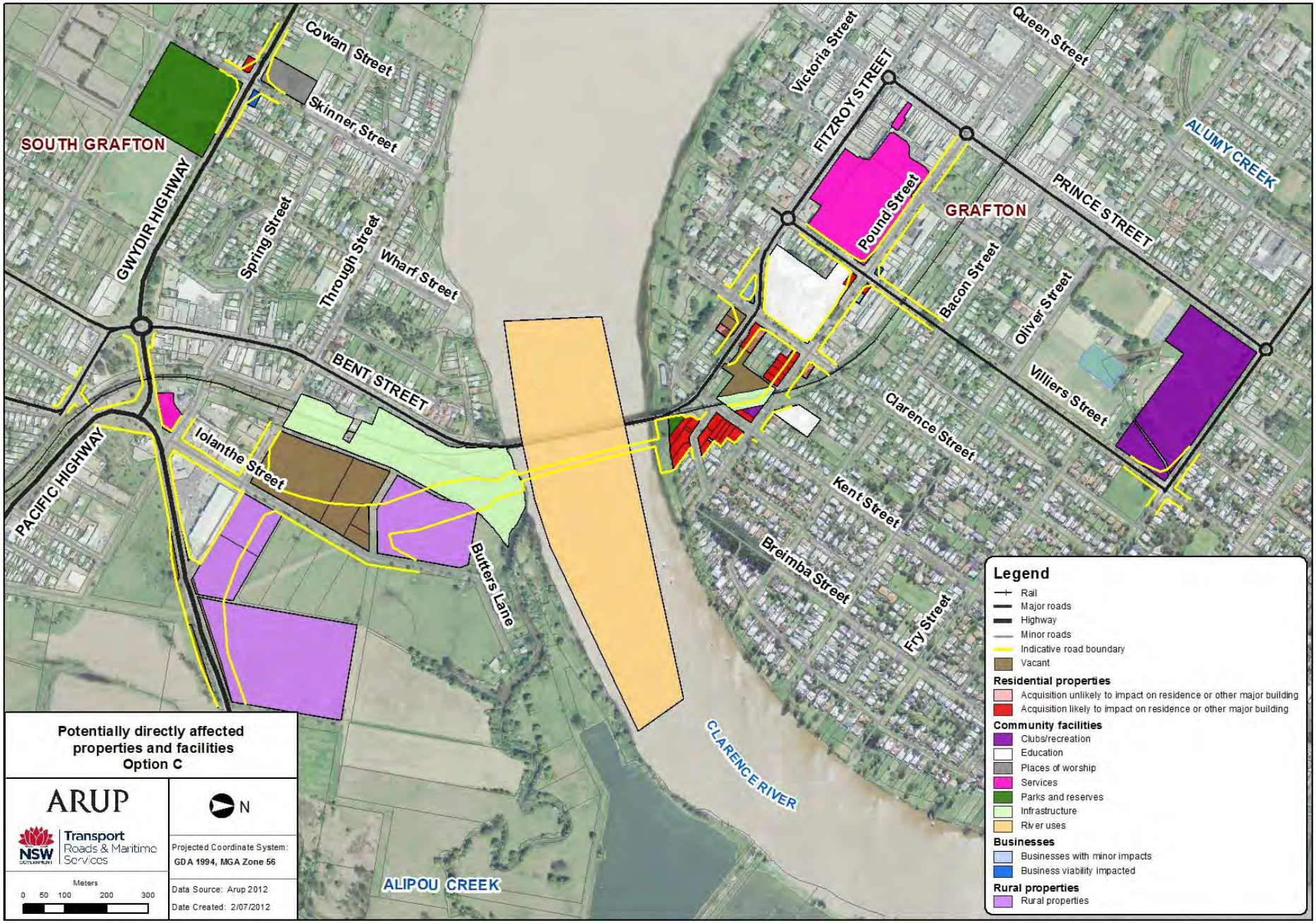

Figure 34: Option C – Potentially directly affected properties and facilities

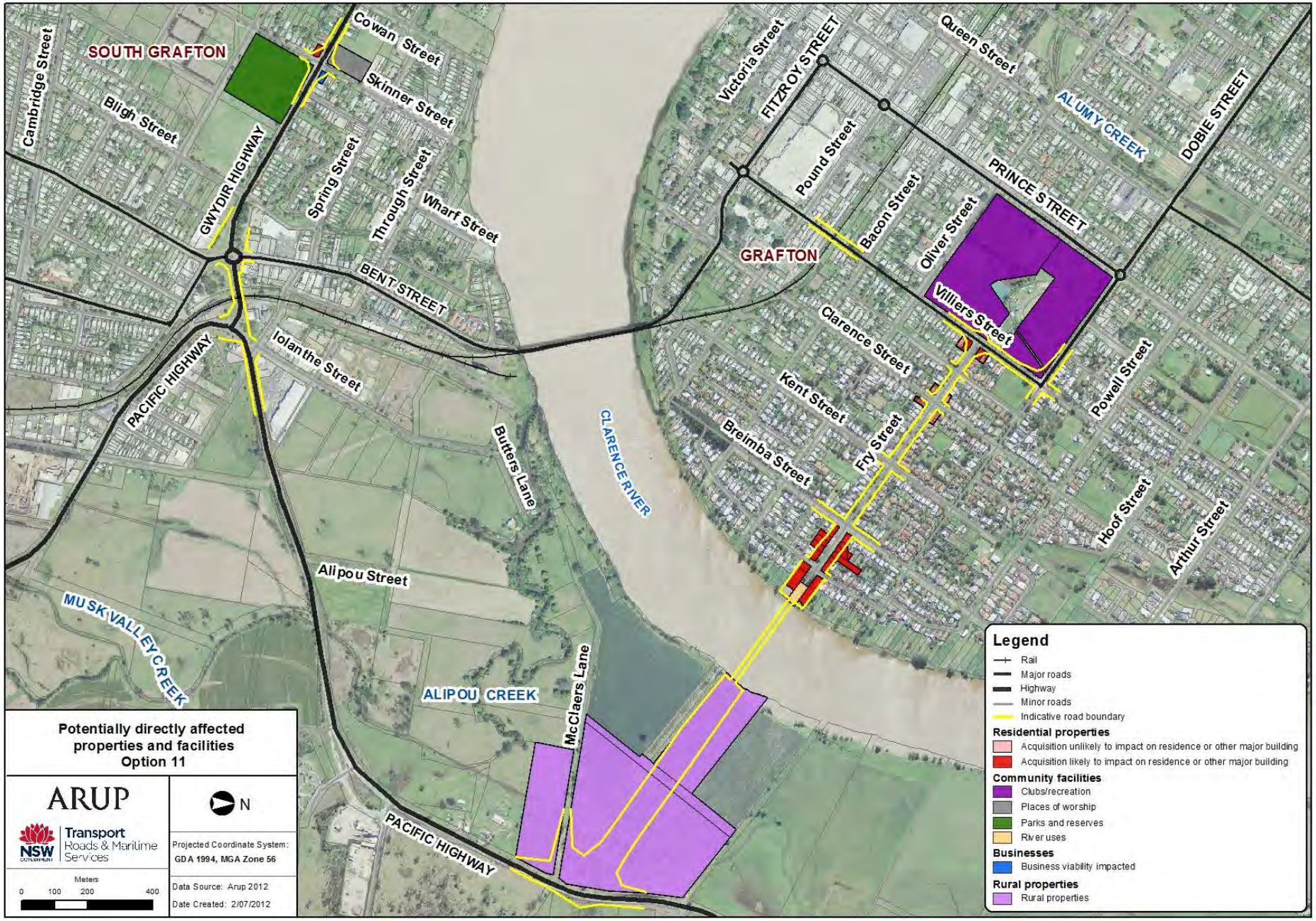

Figure 35: Option 11 – Potentially directly affected properties and facilities

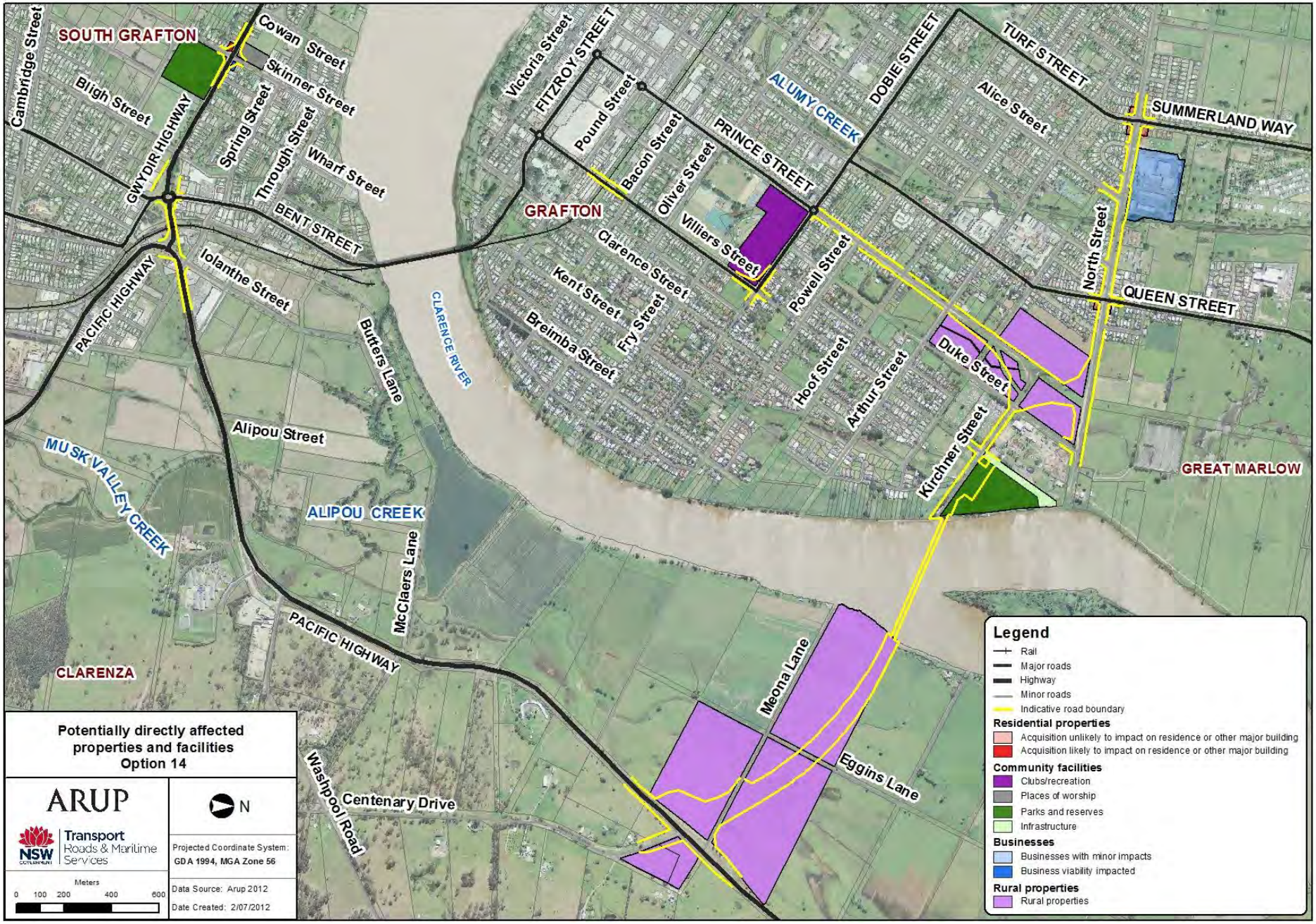

Figure 36: Option 14 – Potentially directly affected properties and facilities

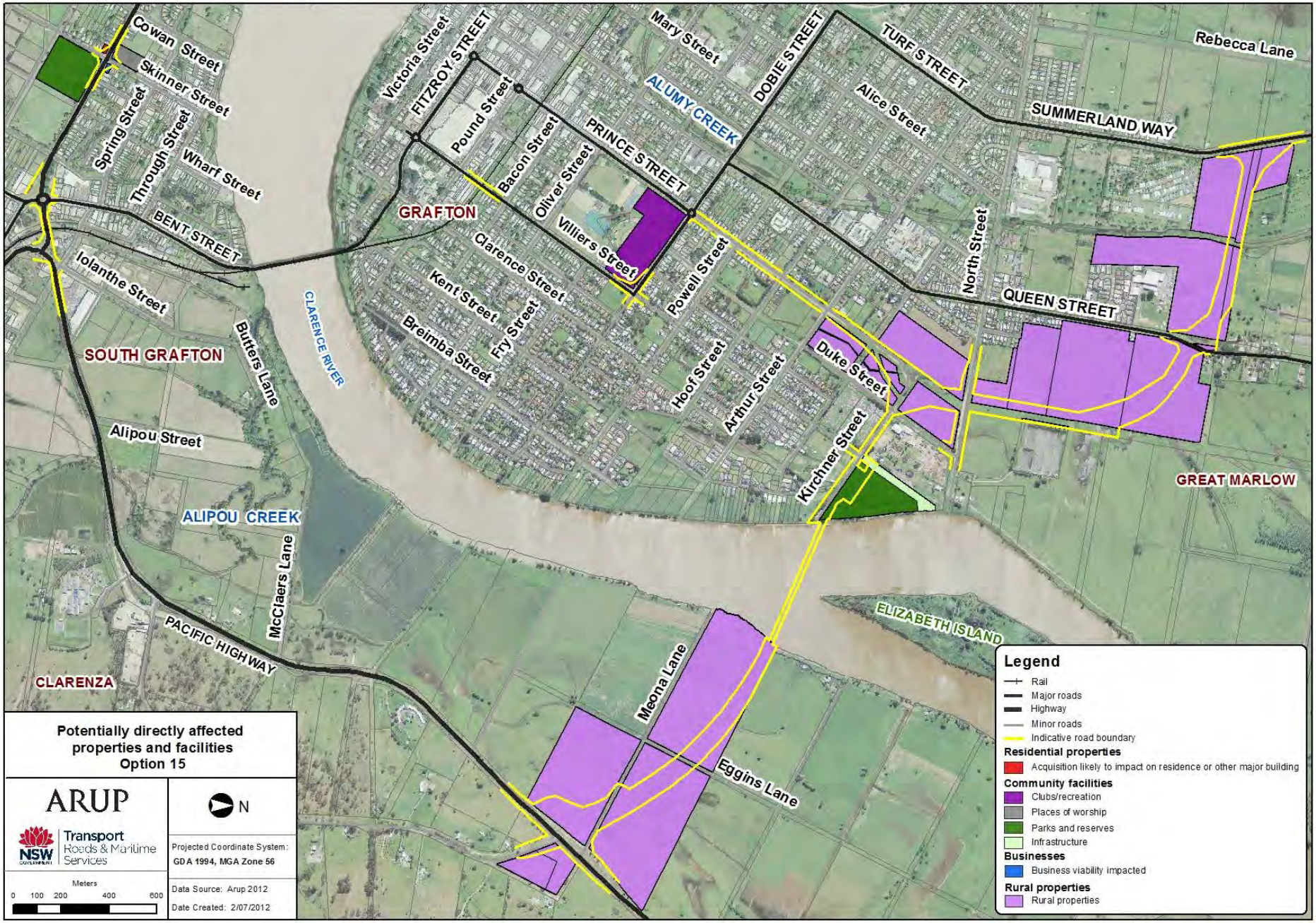

Figure 37: Option 15 – Potentially directly affected properties and facilities

6.7.2 Minimise the impact on residential amenity, including noise, vibration and air quality

The comparative assessment of the route options against the residential amenity indicators is presented in Table 41. This chapter should be read in conjunction with the *Technical Paper: Noise Assessment* in Volume 2. These impacts are presented prior to the consideration of mitigation measures.

Table 41: Comparative assessment of noise and air quality impacts

Supporting objective: Minimise the impact on residential amenity, including noise, vibration and air quality								
Indicator			**Option**					
			E	**A**	**C**	**11**	**14**	**15**
Number of residential properties where noise levels exceed 55 dB(A) during the day or 50 dB(A) during the night, at 10 years after opening (2029)	Day (7am to 10pm) – 55 dB(A) (No.)	„No build" 634	630	612	616	681	663	621
	Night (10pm to 7am) – 50 dB(A) (No.)	„No build" 468	461	448	462	505	477	415
Number of residential properties where noise levels increase by 12 dB or more, at 10 years after opening (2029)	Day (7am to 10pm) (No.)		12	0	1	54	30	21
	Night (10pm to 7am) (No.)		11	0	1	51	30	21
Number of other sensitive land uses where noise levels exceed the criteria in the *NSW Road Noise Policy* (NSW OEH, 2011), at 10 years after opening (2029)	Places of worship, education, childcare and hospitals (No.)		17	17	17	17	17	17
	Open space (No.)		34	34	34	34	36	36
Estimated fuel consumption in urban areas during peak hours at 10 years after opening (2029) (L)			7400	7500	7400	8000	9300	9300

Noise and vibration impacts

Option 11 is the option with the highest number of residential properties that exceed the criteria during both day (55 dB(A)) and night (50 dB(A)). This is primarily due to the concentration of residential receivers on Fry Street. Slightly lower than this is Option 14 which primarily affects a number of properties on North Street. For Options E, A, C and 15 similar numbers of residential properties exceed the criteria. For the majority of options less residential properties exceed the criteria during both day and night compared to the „no build" scenario. This is due to the spreading of traffic throughout the network as a result of construction of an additional crossing.

Option 11 also has the highest number of residential properties where relative noise levels increase by 12 decibels or more. This is due to the concentration of residential receivers that currently experience very little road traffic noise. Options A and C have the lowest number of residential receivers with a relative noise level increase of 12 decibels as they are located close to the existing bridge and urban areas; hence there is little change from the existing noise environment.

The number of other sensitive land uses, including places of worship, education, childcare and hospitals, exceeding the criteria in the *NSW Road Noise Policy* (NSW OEH, 2011) is the same for each of the options. While these exceedances change slightly depending on the introduction of the various route options these fluctuations are not significant (one to three decibels). There is one exception to this for Option E where one receiver location experiences noise levels of up to six decibels higher than for other route options. This facility was previously the McAuley Catholic College. Its current usage is not known, but for the purposes of the assessment it has been assumed to be a place of worship.

For open spaces, the extent of affectation varies considerably depending upon proximity to the roadway. This is due to the often large area which they encompass. The number of open spaces exceeding the criteria in the *NSW Road Noise Policy* (NSW OEH, 2011) is lower for Options E, A, C and 11. For Options 14 and 15, two additional recreational spaces (located adjacent to the Clarence River) exceed the criteria, due to their alignment being remote from the existing arterial roads. The maximum exceedances observed for all options are within one to two decibels of each other. Option A is an exception to this where the new route alignment dissects two parks located on both river banks.

Community Noise Burden (CNB) was considered as part of the comparative assessment. It was calculated to provide an alternative view of potential noise impacts of the route options. This has not been included as an indicator as the results provided similar relativities between the options as the noise indicators used above. A description and discussion on the CNB can be found in the *Technical Paper: Noise Assessment* in Volume 2.

The passage of heavy vehicles could result in vibration impacts. While vibration has not been assessed directly, the noise modelling provides an indication of the relative impacts of heavy vehicles on movements.

Air quality

Fuel consumption is being used as a proxy for air quality. Fuel consumption in urban areas during the 8-9am morning and 4-5pm afternoon peak hours has been estimated as an indicator of relative air quality impacts. Options with higher fuel consumption are likely to have poorer relative air quality. Options C and E would result in the least fuel consumption in urban areas. Option A is the next best performing. Options C, E and A reduce road network delay better than the downstream options and achieve lower overall fuel consumption in urban areas.

Options 14 and 15 have the highest fuel consumption. These options do not reduce delays in the Bent Street/Craig Street/Fitzroy Street corridor to the same extent as the other options, resulting in lower speeds and higher fuel consumption in urban areas.

6.7.3 Minimise the impact on heritage (Aboriginal)

The comparative assessment of the route options against the Aboriginal heritage indicators is presented in Table 42 and illustrated in Figure 38 and Figure 39. This chapter should be read in conjunction with the *Technical Paper: Aboriginal Heritage* in Volume 2.

Table 42: Comparative assessment of Aboriginal heritage

Supporting objective: Minimise the impact on heritage (Aboriginal)						
Indicator	**Option**					
	E	**A**	**C**	**11**	**14**	**15**
Impact on known Aboriginal cultural heritage	Nil	Nil	Impact on the aesthetic value of the Golden Eel site which is in close proximity to the option. Measures would need to be taken during construction to protect the site.	Nil	Direct impact on 1 site - Great Marlow.	Direct impact on 1 site - Great Marlow. In addition, Tracker Robinson"s Camp site is in close proximity to the option and measures would need to be taken during construction to protect the site.
Length through areas of high Aboriginal archaeological potential (m)	0	0	170	0	175	510

Aboriginal cultural heritage

Options 14 and 15 would impact an area of Aboriginal cultural heritage known as Great Marlow. Great Marlow is an area that Aboriginal people commonly used to travel through and contains areas of high significance. Ongoing consultation with Grafton-Ngerrie Local Aboriginal Land Council (GNLALC) will be undertaken to better understand the boundaries and significance of Great Marlow.

Option 15 is in close proximity to Tracker Robinson"s Camp site and measures would need to be taken during construction to protect the site if this option is chosen as the recommended preferred route option. This site relates to an Aboriginal tracker who served the NSW police for 47 years from 1914. It is believed that Tracker Robinson spent a period of time living in the camp site in the early years of his work as a tracker.

Option C is in close proximity to the Golden Eel site and would impact on its aesthetic value. The Golden Eel site rests on Alipou Creek and is an area of high spiritual significance to the Aboriginal people. GNLALC representatives identified the mouth of Alipou Creek where it meets the Clarence River as having particular importance. Measures would need to be taken during construction to protect the site if this option is chosen as the recommended preferred route option and further consultation with GNLALC will be required to determine visual and spiritual impacts to the Golden Eel site.

Options E, A and 11 would not impact any areas of known Aboriginal cultural heritage.

Aboriginal archaeological potential

Option 15 has the greatest length through areas of high Aboriginal archaeological potential. Options C and 14 have shorter lengths through areas of high Aboriginal archaeological potential. Options E, A and 11 would not impact areas of high Aboriginal archaeological potential. All options impact areas of moderate Aboriginal archaeological potential.

Known Aboriginal archaeological sites potentially impacted were considered as part of the comparative assessment. This has not been included as an indicator as the results found that no known Aboriginal archaeological sites occur within any of the options. It was noted that the Golden Eel site is in close proximity to Option C and Tracker Robinson"s Camp site is in close proximity to Option 15. Measures would need to be taken during construction to protect these sites. A discussion on known Aboriginal archaeological sites potentially impacted can be found in the *Technical Paper: Aboriginal Heritage* in Volume 2.

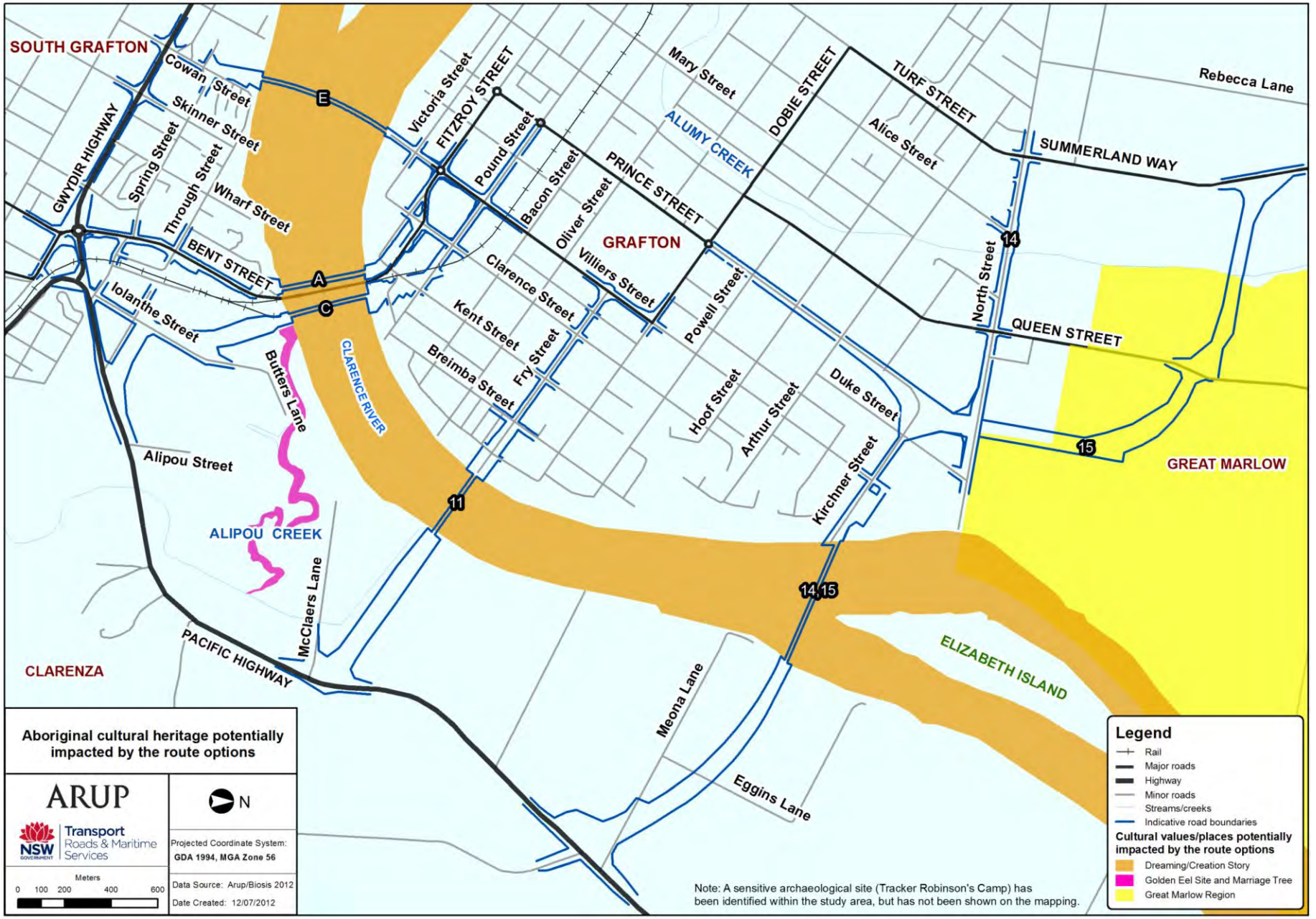

Figure 38: Aboriginal cultural heritage potentially impacted by the route options

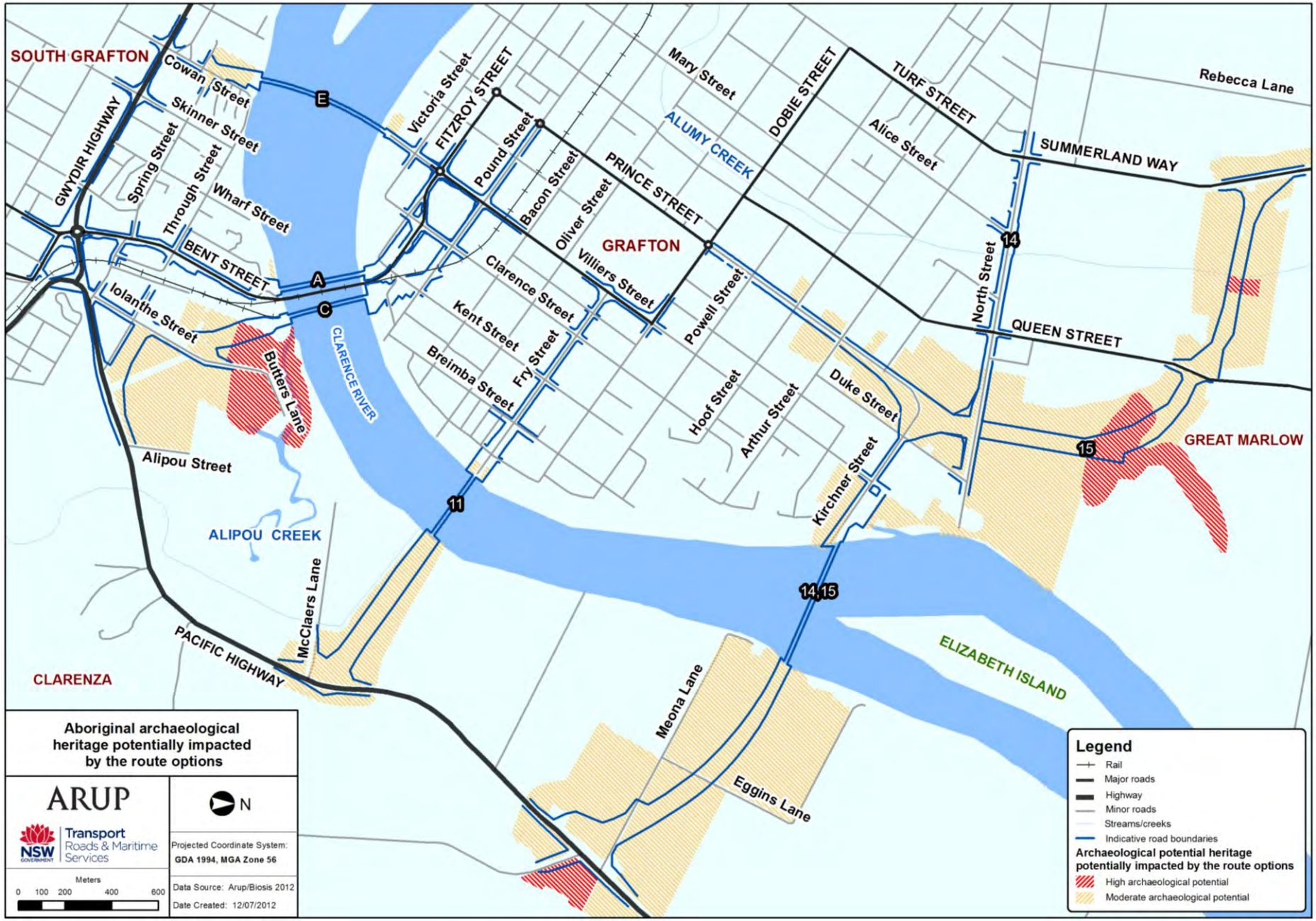

Figure 39: Aboriginal archaeological heritage potentially impacted by the route options

6.7.4 Minimise the impact on heritage (non-Aboriginal)

The comparative assessment of the route options against the non-Aboriginal heritage indicators is presented in Table 43. Non-Aboriginal heritage items/sites, tree avenues and conservation areas potentially impacted by the route options are illustrated in Figure 40. This chapter should be read in conjunction with the *Technical Paper: Non-Aboriginal Heritage* in Volume 2.

Table 43: Comparative assessment of non-Aboriginal heritage

Supporting objective: Minimise the impact on heritage (non-Aboriginal)							
Indicator		**Option**					
		E	**A**	**C**	**11**	**14**	**15**
Number of non-Aboriginal heritage items and archaeological sites that would potentially be directly impacted	Items of State heritage significance (No.)	0	2	0	0	0	0
	Other items (No.)	21	25	24	12	10	10
Contribution of trees as heritage items as well as their collective effect on streetscape and setting	Fig (No.)	15	12	8	12	21	5
	Jacaranda (No.)	84	45	58	63	101	82
	Flame tree (No.)	5	1	3	7	11	1
	Other significant plantings, not listed (No.)	12	7	7	7	7	7
	TOTAL trees (No.)	***116***	***65***	***76***	***89***	***140***	***95***
	Avenues of trees, listed and not listed (No.)	2	3	5	2	3	4
Potential impact on (non-Aboriginal) heritage conservation area (m)		4280	3860	3150	1390	880	880

Non-Aboriginal heritage items and archaeological sites

With the exception of Option A, none of the route options potentially directly impact on any items of State heritage significance.

Option A would potentially have a direct impact on two items of State heritage significance:

- Grafton Rail and Road Bridge over Clarence River. For Option A an allowance has been made for road resurfacing and potential safety barrier upgrade.
- Grafton City Railway Station Group (located in South Grafton).

It should be noted that, due to their location, Options A and C would both result in substantial indirect (visual) impacts to and from the existing bridge. Option E would also indirectly impact the existing bridge by affecting views to and from it; but not to the same degree as with Option A or C.

Options 11, 14 and 15 are considered to be of a sufficient distance away to not directly affect views to and from the existing bridge.

In the case of other heritage items and archaeological sites, Option A would potentially directly impact the largest number of other items, followed by Options C and E, respectively. Options 11, 14 and 15 would potentially directly impact the lowest number of other items, because these route options are located away from Grafton CBD. It should be noted that Grafton CBD is the area where most heritage items are located. A more detailed discussion on the extent of the potential impact can be found in the *Technical Paper: Non-Aboriginal Heritage* in Volume 2.

Non-Aboriginal heritage items and archaeological sites that would potentially be indirectly impacted were considered as part of the comparative assessment. This has not been included as an indicator as the results provided similar relativity between the options as the direct impact indicator used above. A discussion of the non-Aboriginal heritage items including setting and archaeological sites that would potentially be indirectly impacted can be found in the *Technical Paper: Non-Aboriginal Heritage* in Volume 2.

Contribution of trees

Option 14 would have the greatest impact on plantings of cultural significance. The listed plantings (figs, flame trees and jacarandas) for Option 14 are spread throughout Grafton. Option 14 has one listed tree avenue on Skinner Street and two other avenues identified during field work along Kirchner Street and private property in South Grafton. Option A would impact the least number of culturally significant plantings.

Non-Aboriginal heritage conservation areas

Option E has the highest potential impact on non-Aboriginal heritage conservation areas due to the distance passing through the heritage conservation area. Impacts would be high in the area closest to the river bank in Grafton where the Heritage Conservation Area demonstrates the rural, leafy character of the area best, as well as along sections of Pound Street and Victoria Street which retain their heritage character. Impacts to the South Grafton Heritage Conservation Area would be moderate as Option E is in an area where more urban character gives way to farmland.

The Grafton Heritage Conservation Area would be significantly affected by Option A. Potential impacts to a row of houses along the north side of Fitzroy Street would have a significant effect on the heritage character of the area. Alterations to the streetscape would also have a high impact, although this would be mitigated by works already undertaken along Villiers Street. The South Grafton Heritage Conservation Area is expected to sustain a moderate impact in Option A. The border of the Conservation Area runs along the centre of Bent Street, which has already been widened to four lanes and has a footpath on its western side. Impacts in South Grafton would be greater at the point where Option A leaves the current alignment of Bent Street as this would alter the streetscape in this area.

The Grafton Heritage Conservation Area would also sustain a high impact under Option C. Impacts would occur to a number of listed dwellings and groups of dwellings. Acquisition (and possible demolition) of buildings would significantly impact the aesthetic appeal of this area and isolate homes. Option C would potentially impact the visual setting of the railway viaducts in the area, which contribute to a unique neighbourhood of rural homes alongside large railway infrastructure. The aesthetic value of the railway infrastructure is in keeping with the heritage values of this micro neighbourhood.

Option 11 would have a moderate impact to curtilages (land surrounding buildings) within the Grafton Heritage Conservation Area, in addition to the removal of significant trees.

A short section of the Grafton Conservation Area at the intersection of Villiers Street and Dobie Street would be affected by all options. It is expected that impacts to the Conservation Area would be low to moderate as most of the works are proposed within the existing road reserve. A short section of the South Grafton Conservation Area at the intersection of the Gwydir Highway and Skinner Street would also be affected by all options.

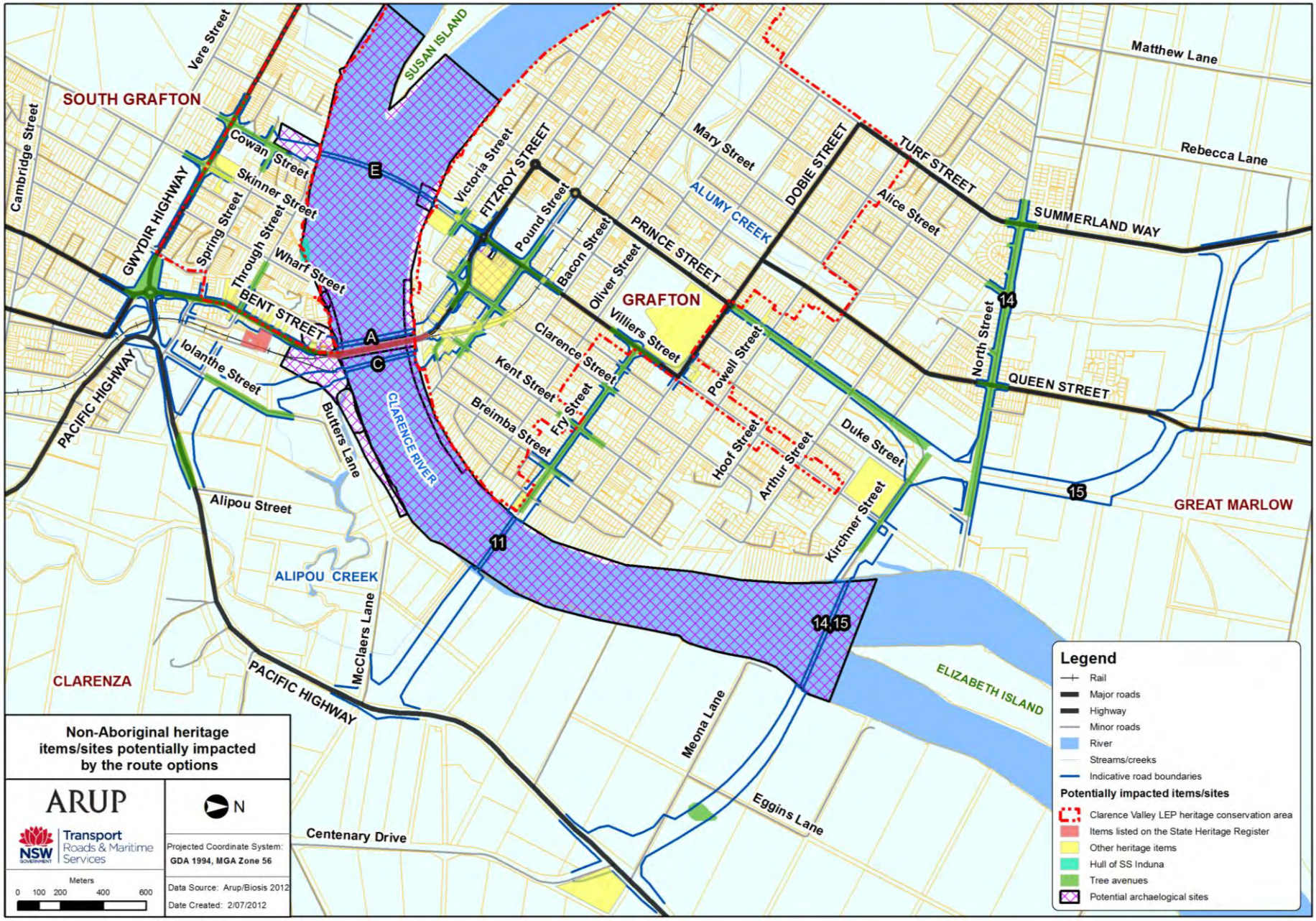

Figure 40: Non-Aboriginal heritage items/sites potentially impacted by the route options

6.7.5 Minimise impact on the natural environment

The comparative assessment of the route options against the natural environment indicators is presented in Table 44. Vegetation potentially directly impacted by the route options is illustrated in Figure 41. This chapter should be read in conjunction with the *Technical Paper: Ecology* in Volume 3.

Table 44: Comparative assessment of impact on the natural environment (ecology)

Supporting objective: Minimise impact on the natural environment							
Indicator		**Option**					
		E	**A**	**C**	**11**	**14**	**15**
Potential direct impact on known threatened flora species		Nil	Nil	Nil	Nil	Nil	Nil
Potential direct impact on identified EEC	Reedlands – freshwater wetlands on coastal floodplain (m²)	100	550	600	0	0	0
	Drainage soak – potential freshwater wetlands on coastal floodplain (m²)	0	0	0	8400	10,500	24,500
	Drainage soak - freshwater wetlands on coastal floodplain (m²)	0	0	0	0	11,500	13,000
	Degraded riparian forest - sub-tropical coastal floodplain forest (m²)	0	0	150	50	0	0
	Remnant eucalypts - sub-tropical coastal floodplain forest (m²)	0	0	700	5800	0	0
	TOTAL EEC (m^2)	***100***	***550***	***1450***	***14,250***	***22,000***	***37,500***
Potential direct impact on other vegetation and habitat	Native and exotic plantings (m²)	30,000	24,500	32,000	19,000	35,500	34,500
	Planted figs (m²)	900	0	0	2000	0	50
	Native revegetation (Induna Reserve) (m²)	0	2400	0	0	0	0
	Weeds and exotics (m²)	0	400	850	0	0	0
	Constructed drainage line with native and exotic vegetation (m²)	0	0	0	0	2600	4100
	TOTAL OTHER (m^2)	***30,900***	***27,300***	***32,850***	***21,000***	***38,100***	***38,650***
Potential direct impact on known habitat for threatened fauna species	Adjacent grey-headed flying-fox maternity roost	Breeding (Susan Island)	Nil	Nil	Nil	Nil	Nil
	20+ grey-headed flying-foxes foraging in figs	Foraging (figs)	Nil	Nil	Nil	Nil	Nil
	Cattle egret breeding colony	Nil	Nil	Nil	Nil	Breeding (wetland)	Breeding (wetland)
	Little bentwing-bat	Nil	Roosting (under bridge)	Roosting (under bridge)	Nil	Nil	Nil
	Eastern bentwing-bat	Nil	Roosting (under bridge)	Roosting (under bridge)	Nil	Nil	Nil

Supporting objective: Minimise impact on the natural environment							
Indicator		**Option**					
		E	**A**	**C**	**11**	**14**	**15**
	Eastern freetail bat	Nil	Foraging (riparian zone)	Foraging (riparian zone)	Nil	Nil	Nil
	Southern myotis	Nil	Nil	Foraging (riparian zone)	Nil	Nil	Nil

Known threatened flora species

None of the route options would potentially directly impact on areas with known listed threatened flora species.

Endangered Ecological Communities

All options traverse areas of Endangered Ecological Communities (EEC). The impact of the options on EEC increases from upstream to downstream. Options 14 and 15 would have the greatest impact on EEC as these options pass through rural and semi-rural areas in Grafton and South Grafton which contain drainage soaks, some of which conform to the freshwater wetlands on the coastal floodplain EEC. Options E, A and C were found to have the lowest impact on EEC as the majority of these routes are located in urbanised areas and therefore the only EEC affected are the reedlands on the river bank and two areas of floodplain forest on the South Grafton side of Option C (degraded riparian forest on the south bank and remnant eucalypts adjoin the Pacific Highway).

Other vegetation and habitat

Options 14 and 15 would have the greatest impact on other vegetation and habitat followed by Options E, A and C. These largely consist of native and exotic plantings plus some constructed drainage lines with native and exotic vegetation. Option 11 would have the least potential direct impact on other vegetation.

Known habitat for threatened fauna species

All options except for Option 11 potentially directly impact on known habitat for listed threatened fauna species. Option E potentially impacts a flight path of the grey-headed flying-fox to its breeding colony on Susan Island and also foraging resources of fig trees on Villiers Street (observed during field work on Villiers Street). Options A and C potentially impact bat roosting habitat under the existing bridge and also impact foraging habitat within the riparian zone of the Clarence River. Options 14 and 15 potentially impact a breeding colony area for the cattle egret on the wetlands between Prince Street and North Street.

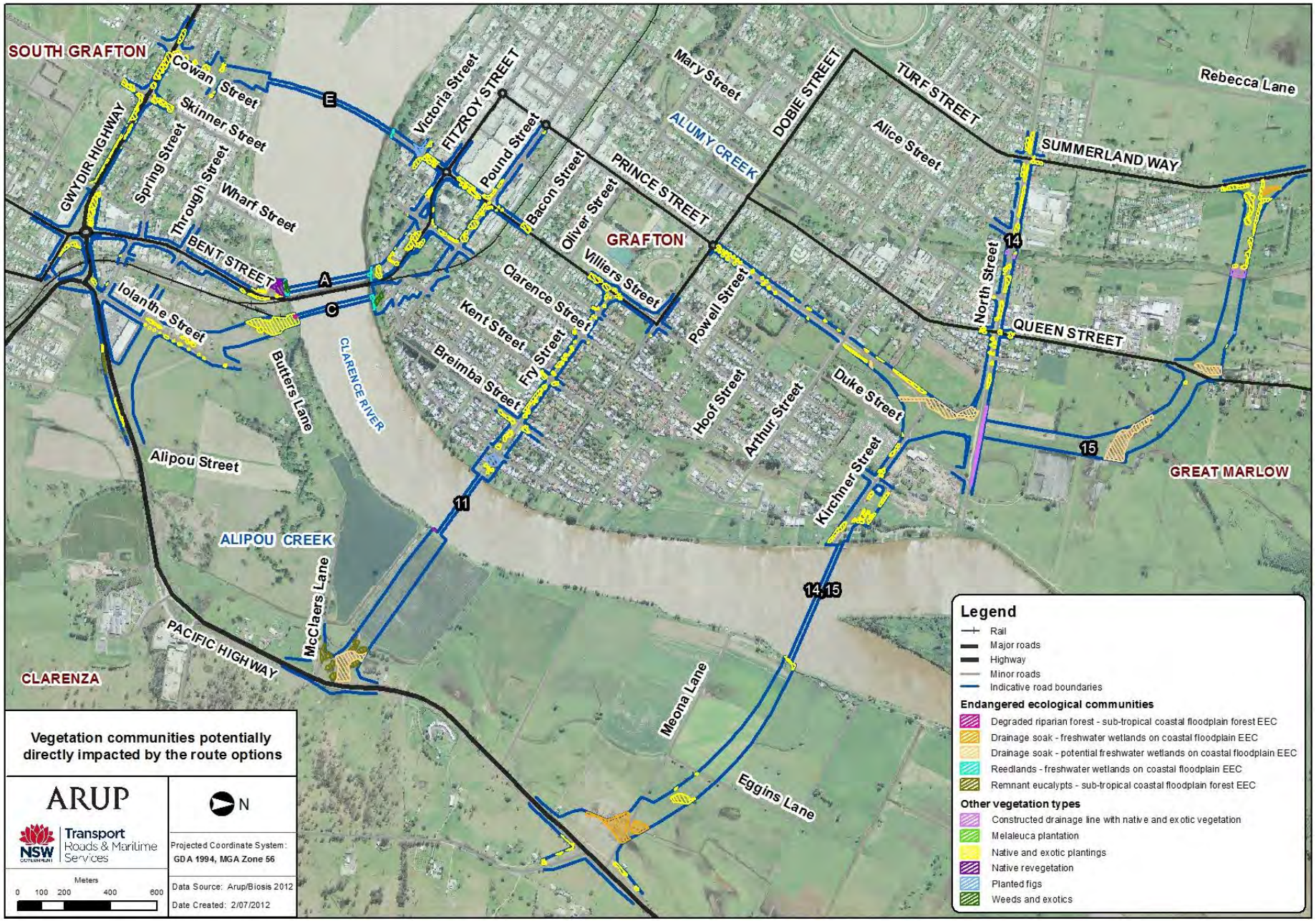

Figure 41: Vegetation potentially directly impacted by the route options

6.7.6 Provide a project that fits sensitively into the built, natural and community context

The comparative assessment of the route options against the indicators of how the project fits sensitively into the built, natural and community context is presented in Table 45. The landscape and urban character of Grafton is illustrated in Figure 42, Figure 43, Figure 44 and Figure 45. This provides an abbreviation of the *Technical Paper: Landscape and Urban Character* in Volume 3, which should be read in conjunction with this chapter. Fit

Table 45: Comparative assessment of sensitivity into the built, natural and community context (landscape and urban character)

Supporting objective: Provide a project that fits sensitively into the built, natural and community context						
Indicator	**Option**					
	E	**A**	**C**	**11**	**14**	**15**
Visual integrity of the existing bridge in its setting	Ability to maintain important and recognisable views from and to the existing and new bridges of Grafton and South Grafton					
	Agree – Maintains the visual integrity of the existing bridge and can be designed to enhance views from foreshores and from the new bridge.	Strongly disagree – Impacts substantially on views to, and visual character of, the existing bridge. Views through the bridge will also be heavily impacted.	Strongly disagree – Impacts substantially on views to, and visual character of, the existing bridge. Views through the bridge will also be heavily impacted.	Agree – Provides adequate distance away to maintain views and provides opportunities for additional view points from the new bridge.	Neutral/no change – No impact on existing views as it is too far downstream and does not provide views of the existing bridge.	Neutral/no change – No impact on existing views as it is too far downstream and does not provide views of the existing bridge.
	Ability of the new bridge to have a complementary scale and form, particularly related to aligning the new bridge deck with the lower (railway) deck of the existing bridge, that still allows the existing bridge to take visual precedence					
	Neutral/no change – Can be designed to have scale and form that compliments existing bridge, and is far enough away to allow existing bridge to take visual precedence and be seen from the new bridge.	Strongly disagree – Scale and form does not compliment existing bridge, height of the new bridge will be located across the middle of the existing bridge between the rail deck and road deck.	Strongly disagree – Scale and form does not compliment existing bridge, height of the new bridge will be located across the middle of the existing bridge between the rail deck and road deck.	Neutral/no change – Can be designed to have scale and form that compliments existing bridge, and is far enough away to allow existing bridge to take visual precedence and be seen from the new bridge.	Neutral/no change – No impact on existing views as it is too far downstream and does not provide views of the existing bridge.	Neutral/no change – No impact on existing views as it is too far downstream and does not provide views of the existing bridge.
	Ability of the new bridge to have an independent visual expression (form and scale) from the existing bridge and the potential to become a landmark in its own right					
	Agree – Distance from existing bridge provides potential for the new bridge to have its own visual expression, designed as a complimentary landmark.	Disagree – The close proximity to existing bridge does not allow the new bridge to have its own visual expression.	Disagree – The close proximity to existing bridge does not allow the new bridge to have its own visual expression.	Agree – Distance from existing bridge provides potential for the new bridge to have its own visual expression, designed as a complimentary landmark.	Strongly agree – Distance from existing bridge requires that the new bridge be designed to have its own visual expression and its own landmark.	Strongly agree – Distance from existing bridge requires that the new bridge be designed to have its own visual expression and its own landmark.
Integrity of existing landscape and street pattern	Ability to minimise the street scale and form of the new bridge approach roads					
	Disagree – Widening of streets on both sides of the river will impact on street scale and form.	Strongly disagree – Widening of streets on both sides of the river will impact on street scale and form plus the viaduct in Grafton is not aligned with the street grid.	Strongly disagree – Widening of streets on both sides of the river will impact on street scale and form in particular on Pound St and on Iolanthe St.	Strongly disagree – Widening of streets on both sides of the river will impact on street scale and form in particular on Fry St in Grafton.	Strongly disagree – Widening of streets on both sides of the river will impact on street scale and form in particular on Kirchner St, North St and Prince St.	Strongly disagree – Widening of streets on both sides of the river will impact on street scale and form in particular on Kirchner St, North St and Prince St.

Supporting objective: Provide a project that fits sensitively into the built, natural and community context						
Indicator	**Option**					
	E	**A**	**C**	**11**	**14**	**15**
	Ability to retain the existing landscape character of the area, including minimising the removal of trees					
	Disagree – Moderate impacts on the existing landscape particularly along Villiers St including the removal of some large Fig trees.	Disagree – Major impacts on the existing landscape character on both sides of the river particularly the southern river bank and the area around Fitzroy St.	Strongly disagree – Impacts substantially on the existing landscape character on both sides of the river particularly the Greave St and Pound St area.	Strongly disagree – Impacts substantially on the existing landscape character on both sides of the river particularly the Fry St area including some large Fig trees.	Strongly disagree – Impacts substantially on the existing landscape character on both sides of the river particularly the southern end of Corcoran Park.	Strongly disagree – Impacts substantially on the existing landscape character on both sides of the river particularly the southern end of Corcoran Park.
	Ability to minimise the size of intersections between the approach roads and the existing local roads					
	Disagree – Some widening of a range of intersections will occur on both sides of the river particularly on Villiers St.	Strongly disagree – Requires large scale intersections on the approach roads on both sides of the river, particularly the large roundabout in South Grafton.	Disagree – Requires large scale intersections on the approach roads on both sides of the river particularly on Iolanthe St and Pound St.	Disagree – Requires large scale intersections on the approach roads on both sides of the river, particularly a large roundabout adjacent to the Pacific Hwy and two on Villiers St.	Strongly disagree – Requires large scale intersections on the approach roads on both sides of the river, particularly four large roundabouts, on the Pacific Hwy, Prince St, Queen St and Turf St.	Strongly disagree – Requires large scale intersections on the approach roads on both sides of the river particularly four large roundabouts, on the Pacific Hwy, Prince St, Lawrence Rd and the Summerland Way.
	Ability to generally maintain existing urban patterns and integrate the geometry of any new approach roads within the existing road reserves					
	Agree – Consistent with the existing street pattern in Grafton, and generally supports the physical and visual experience of the historical street grid. A short section of approach road (265 m) in South Grafton is not aligned with the street grid.	Neutral/no change – The approach road in South Grafton is mostly aligned with the street grid, however it still impacts on land outside the road reserve. The elevated approach road impacts on the urban pattern between Craig St and Fitzroy St.	Disagree – Urban patterns on both sides of the river are not maintained as neither approach road is aligned with existing road reserves. The northern approach road has a major impact on developed land and structures cutting diagonally across the existing urban form.	Agree – The approach road in Grafton is aligned with the street grid, however this option still results in a major impact on developed land and structures expanding outside the road reserves. The southern approach road aligns with the rural landscape pattern.	Disagree – The southern approach road does not align with the rural landscape pattern, cutting diagonally across the river floodplain. The northern approach roads roughly follow the existing urban patterns although in some areas they expand beyond the existing road reserves.	Strongly disagree – The southern approach road does not align with the rural landscape pattern, cutting diagonally across the river floodplain. The northern approach roads roughly follow the existing urban patterns until North St where they expand well beyond the existing road reserves.
Urban context and connections	Ability to minimise the effects of fragmentation on neighbourhoods or precinct areas					
	Agree – Does not result in the fragmentation of the existing patterns of urban settlement.	Disagree – Results in some fragmentation of the existing residential neighbourhoods in Grafton around Fitzroy St and Craig St.	Strongly disagree – Results in some fragmentation of the existing residential neighbourhoods in Grafton.	Strongly disagree – Results in some fragmentation of the existing residential neighbourhoods in Grafton along Fry St.	Disagree – Results in the fragmentation of neighbourhood environments in Grafton along Kirchner St and North St.	Disagree – Results in the fragmentation of neighbourhood environments in Grafton along Kirchner St, North St and the new road to the Summerland Way.

Supporting objective: Provide a project that fits sensitively into the built, natural and community context						
Indicator	**Option**					
	E	**A**	**C**	**11**	**14**	**15**
	Ability to provide more direct connections for local trips and destinations beyond Grafton and South Grafton town centres					
	Neutral/no change – Provides direct connections for local trips in the Grafton area.	Neutral/no change – Close proximity to existing bridge continues to provide same connections for local trips in the Grafton area.	Neutral/no change – Close proximity to existing bridge continues to provide same connections for local trips in the Grafton area.	Disagree – Does not provide direct connections for local trips in the Grafton area; some trips to and from the areas of Clarenza and Junction Hill could benefit from this option.	Strongly disagree – Increased travel distances reduce connections for local trips in the Grafton area; some trips to and from the areas of Clarenza and Junction Hill could benefit.	Strongly disagree – Increased travel distances reduce connections for local trips in the Grafton area; some trips to and from the areas of Clarenza and Junction Hill could benefit.
	Ability to improve connectivity and connection opportunities for pedestrian and cycle networks					
	Strongly agree – Creates new and stronger connections for pedestrians and cyclists being more direct and creating a circular network between the bridges.	Neutral/no change – Does not provide any new or improved connections beyond what is currently available on the existing bridge crossing.	Disagree – Connections are not improved, more removed from the town centres and the shared path would have poor amenity in the industrial area in South Grafton.	Strongly disagree – Provides poor connections due to the distance from the town centres and the lack of shared paths on the existing highway in South Grafton.	Strongly disagree – Provides poor connections due to the distance from the town centres and the lack of shared paths on the existing highway in South Grafton.	Strongly disagree – Provides poor connections due to the distance from the town centres and the lack of shared paths on the existing highway in South Grafton.
	Ability to improve connectivity to existing and proposed riverfront public recreation spaces					
	Strongly agree – Provides improved access to the riverfront recreation spaces by creating a circular path system between Grafton and South Grafton.	Agree – Provides reasonable access to riverfront recreation spaces although it does not encourage new opportunities along the foreshores.	Disagree – Does not provide new or additional access to riverfront recreation spaces or encourage new opportunities along the foreshores.	Strongly disagree – Provides no access to riverfront recreation spaces and removes the boat launch facility at Fry St.	Strongly disagree – Provides access to riverfront recreation at Corcoran Park from South Grafton, however it substantially impacts the park itself.	Strongly disagree – Provides access to riverfront recreation at Corcoran Park from South Grafton, however it substantially impacts the park itself.
	Ability to be integrated with or support future development and revitalisation of existing areas (retail, commercial, industrial, recreation, education, etc)					
	Strongly agree – Potential to improve future development and revitalisation in existing areas and encourage new economic development between the town centres.	Neutral/no change – Continues supporting development patterns and revitalisation in existing areas.	Agree – Potential to support industrial area in South Grafton.	Disagree – Does not support economic development and connections between existing town centres.	Strongly disagree – Increased travel distances do not support economic development and connections between existing town centres.	Strongly disagree – Increased travel distances do not support economic development and connections between existing town centres.
	Ability to minimise the creation of new main street environments and strip development that does not support or connect to the town centres of Grafton and South Grafton					
	Agree – Provides additional access along the existing commercial corridor between the town centres on both sides of the river.	Agree – Continues supporting the existing development patterns and revitalisation in the area on both sides of the river.	Disagree – Increases potential for new strip development to occur that will detract from the two town centres.	Disagree – Increases potential for new strip development to occur that will detract from the two town centres.	Strongly disagree – Increases substantially the potential for new strip development to occur that will detract from the two town centres.	Strongly disagree – Increases substantially the potential for new strip development to occur that will detract from the two town centres.

Visual integrity of the existing bridge

Options E and 11 are the best performing options for maintaining the visual integrity of the existing bridge. These options both maintain important and recognisable views of the bridge as well as provide new opportunities for new viewpoints to be established. Additionally, these options allow for the potential to design a new bridge that has its own independent visual expression.

Options 14 and 15 are too far away from the existing bridge to either impact the visual integrity of the existing bridge, or provide opportunities to enhance important and recognisable views. The location of these options allows for the new bridge to have its own independent visual expression.

Options A and C are the two poorest performing options for maintaining the visual integrity of the existing bridge. The greatest impact results from the new roadway being located across the middle of the steel truss of the existing bridge, between the rail deck and road deck. Pedestrians and cyclists using the path on the existing bridge (adjacent to the new bridge) will primarily see the side of the new bridge and therefore have substantially reduced views of the river and the surrounding area with both options. Recognisable views towards the existing bridge will be substantially impacted by Option A when looking downstream from either the Grafton or South Grafton foreshore area. For Option C, upstream views of the existing bridge will be impacted from the Grafton foreshore and to a much lesser extent, the Clarenza area.

Integrity of existing landscape and street pattern

Under this indicator, all options result in some adverse impact as a result of the new crossing. Of the six options, Option E is the best performing option because it has the least overall impact. Option E is generally consistent with the existing landscape pattern on both sides of the river, and has the smallest physical footprint.

Options A and C both substantially impact the existing urban character of Grafton and South Grafton. This is a result of the large scale of approach roads, including the viaducts and roundabouts, particularly in South Grafton. Street patterns in Grafton are also not maintained, impacting mostly residential land and structures.

Options 11, 14 and 15 are the poorest performing options impacting the existing character on both sides of the river through the creation of large scale approach roads, viaducts and roundabouts. The northern residential neighbourhood areas of Grafton are particularly impacted by these options as they all have large physical footprints and are not consistent with the historical street grid due to the increased scale of the road infrastructure.

Urban context and connections

Option E is the best performing option in that it provides direct connections for local trips in the Grafton area and does not result in the fragmentation of the existing patterns of urban settlement. It has potential to improve future urban development and revitalisation efforts through the connections between the town centres due to the creation of a loop network around the main portion of the commercial/industrial development corridor. This loop network also maximises connections for local traffic, public transport, pedestrians and cyclists. This option provides improved connections and access to both existing and proposed riverfront recreation spaces through a circular path system. Additionally, Option E will provide better connectivity to the Waterview Heights area, which has a higher overall development capacity than the Clarenza area.

Options A and C would provide direct connections for local trips in the Grafton area along the existing commercial/industrial development corridor. Of the two, Option A is marginally better then Option C. Both options have potential to support economic development between existing town centres in the long-term, however, during construction, businesses in South Grafton will be

impacted. This is particularly true in Option A along Bent Street, which will have substantial physical impacts on commercial properties and will require some form of redevelopment of these affected properties.

Options A and C would result in fragmentation of the existing patterns of urban settlement and remove portions of a residential neighbourhood in Grafton. Option A impacts on residential dwellings along one side of Fitzroy Street, while Option C has more substantial impacts, affecting almost an entire block within an established residential neighbourhood. Both options generally maintain the existing connections between the town centres for local traffic and public transport, with no overall benefits for pedestrians and cyclists. Neither option encourages new riverfront recreation opportunities along the foreshores.

Options 11, 14 and 15 are the poorest performing options, as they substantially reduce direct connections for local trips in the Grafton area. These options provide the poorest connections for local traffic and public transport, and none provide access to footpaths in South Grafton for either pedestrians or cyclists, leaving them to walk or ride along the shoulder of the Pacific Highway. All of these options will result in substantial fragmentation of the existing patterns of urban settlement and the continuity of local residential neighbourhoods. These options will negatively impact future urban development and revitalisation efforts in the central Grafton and South Grafton areas and the bypass of the town centres creates the real potential to encourage strip development along the new route corridors that will attract development away from the existing town centres. Finally, each of these options have substantial impacts on access to riverfront recreation by removing boat launching facilities and Options 14 and 15 severely impact on the setting and amenity of Corcoran Park.

A more detailed discussion of the landscape and urban character including the compatibility of the new bridge with the surrounding built environment can be found in the *Technical Paper: Landscape and Urban Character* in Volume 3.

Figure 42: South Grafton town centre

Figure 43: Representative residential streetscape

Figure 44: Clarence River waterfront at Prince Street

Figure 45: Agricultural floodplain

6.7.7 Minimise flooding impact caused by the project

The comparative assessment of the route options against the flooding impact indicators is presented in Table 46. Lengths of flood levees that require raising are illustrated in Figure 46. This chapter should be read in conjunction with *Technical Paper: Flooding* in Volume 3.

Table 46: Comparative assessment of flooding

Supporting objective: Minimise flooding impact caused by the project						
Indicator	**Option**					
	E	**A**	**C**	**11**	**14**	**15**
Maximum Clarence River afflux upstream of option in a 20-year ARI flood event with levee upgrades in place (m)	0.03	0.04	0.05	0.10	0.04	0.04
Length of levees upstream that would need to be upgraded for a 20-year ARI flood event (km)	11.75	16.70	18.10	19.50	16.50	16.50
Flooding emergency response considerations	• Uses current evacuation routes. • No contingency if Grafton CBD evacuation routes are inundated or affected by a crash or congestion.	• Uses current evacuation routes. • No contingency if Grafton CBD evacuation routes are inundated or affected by a crash or congestion.	• Uses current evacuation routes. • No contingency if Grafton CBD evacuation routes are inundated or affected by a crash or congestion. • Access to new bridge may be compromised earlier than in other options.	• Provides an additional evacuation route out of Grafton. • Splits traffic, reducing evacuation congestion in Grafton CBD. • Well located to assist evacuation of Grafton Base Hospital and surrounding aged care facilities.	• Provides an additional evacuation route out of Grafton. • Splits traffic, reducing evacuation congestion in Grafton CBD. • Well located to assist evacuation of Grafton Base Hospital and surrounding aged care facilities.	• Provides an additional evacuation route out of Grafton. • Splits traffic, reducing evacuation congestion in Grafton CBD. • Well located to assist evacuation of Grafton Base Hospital and surrounding aged care facilities.

Maximum Clarence River afflux

Each of the options will lead to flood level increases in the Clarence River. With the existing bridge there is no flooding of Grafton or South Grafton in a 20-year ARI flood event. Without mitigation, the flood level increases within the main river channel would result in significant adverse flood impacts in both Grafton and South Grafton. Flood mitigation measures have been identified for all option designs to manage these flood impacts.

The primary mitigation measure is to raise sections of the existing levees for all options. Option C would also require additional mitigation where the route passes through an area in Grafton with an existing local drainage issue. With the proposed mitigation measures in place there would be minimal change to flood risks during the 20-year ARI flood event.

Lengths of levees upstream that would need to be upgraded

Lengths of flood levees that require raising are illustrated in Figure 46. Options E and A would require an upgrade of 11.75 kilometres and 16.70 kilometres of levee respectively. These two options would require raising sections of the Grafton and South Grafton levee by 0.05 metres. Option A would require an additional slight raising of levee crest levels adjacent to Prince St to mitigate flood level changes.

Option C would require 18.10 kilometres of upgrades through raising sections of the Grafton and South Grafton levee by 0.05 metres and 0.10 metres. This option would also require a pump station and detention basin to manage local drainage issues beneath the existing railway viaduct between Kent Street and Clarence Street in Grafton.

Option 11 would require the greatest distance of upgrades, 19.50 kilometres, through raising sections of the Grafton and South Grafton levee by 0.05 metres and 0.10 metres and sections of the Heber Street levee by 0.10 metres.

Options 14 and 15 each require 16.50 kilometres of upgrades through raising sections of the Grafton, South Grafton and Heber Street levees by 0.05 metres.

Flooding emergency response considerations

Due to their proximity to the existing bridge, Options E, A and C are similar in terms of a response to a flooding emergency. Likewise, Options 11, 14 and 15 also provide a similar response to each other as they are located further away from the existing bridge.

Options E, A and C would use current evacuation routes. They would not provide any further contingency, if the Grafton CBD evacuation routes are inundated or affected by a road crash or traffic congestion.

For Option C, the lowering of the bridge approach road under the railway viaduct may result in access to the new bridge being compromised earlier than in other options.

Options 11, 14 and 15 would provide an additional evacuation route out of Grafton in the event that Grafton CBD routes are inundated or affected by a road crash or traffic congestion. These options would also split the traffic, reducing the evacuation congestion in Grafton CBD. They are also well located to assist evacuation of Grafton Base Hospital and surrounding aged care facilities.

All options would increase the efficiency of mass evacuation of Grafton during a major flood event.

Figure 46: Required levee raising for the route options

7 Next steps

The process to identify a preferred route option is shown in the flow chart in Figure 47 below.

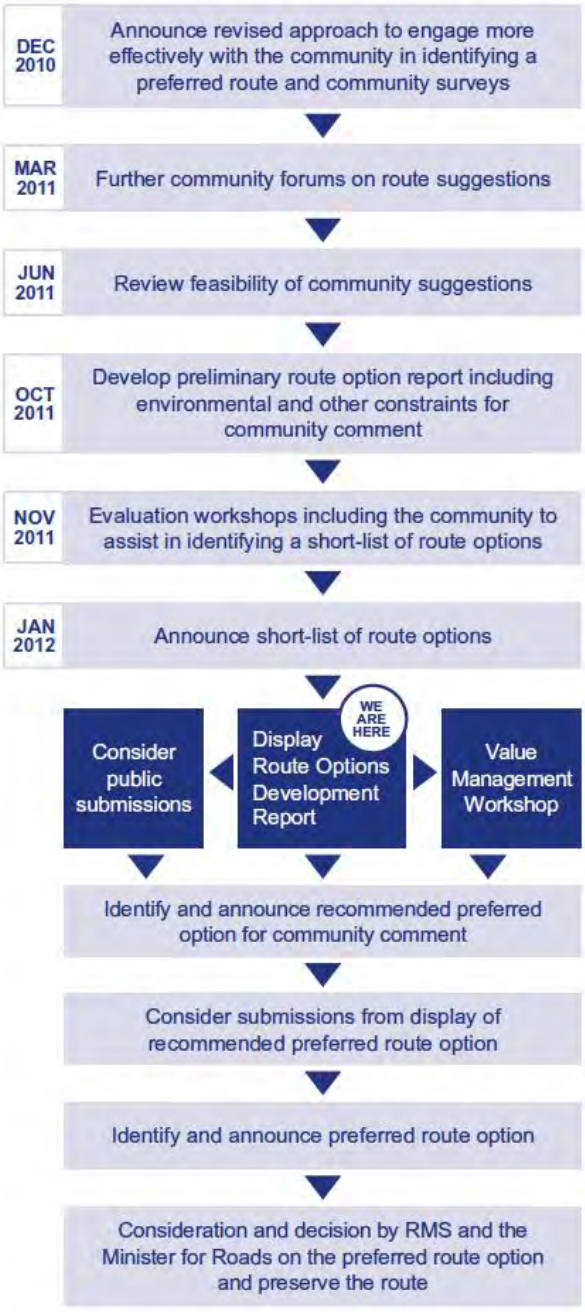

Figure 47: Process to identify a preferred route option as of September 2012

Community comments received on the short-listed options, the investigations undertaken and the outcomes of the value management workshop will input into a decision on the recommended preferred route option.

Community feedback on the recommended preferred route option will be considered before a final decision is made on the preferred option for an additional crossing of the Clarence River at Grafton.

Appendix 1 - Community feedback January to June 2012

This appendix documents the community feedback received on the six route options that were announced on 18 January 2012 through the January 2012 community update.

Between 18 January and 29 June 2012, 38 comments were received from the community in response to the January 2012 community update announcement of the six route options. The comments included verbal feedback recorded by the project team and written feedback by post and email.

The method used to capture the feedback included:

- Feedback was added to the community contact database which has been set up to capture community comment from all consultation (emails, letters, face-to-face discussions, phone calls etc).
- Key issues raised were used as headings to group comments for example traffic, design, social impacts and environment.

The main issues and concerns identified in the feedback were:

- Traffic - traffic congestion in the CBD and Grafton area
- Planning – avoiding impacts in residential areas, avoiding flood prone areas, remove heavy vehicles away from the centre of town
- Social impacts – property acquisitions and amenity
- Economic impacts – concerns about property devaluation
- Design – designing for flood protection
- Community consultation – concerns about the process
- Environment – concerns about flooding, mature trees and heritage buildings.

Many of the comments raised individual option preferences, traffic congestion, heavy vehicles, connectivity and property issues. There is concern amongst the community about how the routes will impact on individual properties, including the acquisition process, amenity and traffic impacts. Several residents have also raised local flooding issues in relation to Option C, which is particularly evident during high levels of rainfall.

Comments received have been captured below. Due to privacy reasons, respondents are not identified other than by an ID number.

Summary of feedback

The community feedback received has been categorised into the following issues: traffic, planning, social impacts, economic impacts, design, community consultation and environment. All feedback has been numbered.

Issue category: Traffic

This category includes comments on traffic congestion in the CBD and Grafton area and how intersections will cope with increased traffic flows.

Table 47: Traffic feedback

Issues raised	Feedback No.
Option E would cause traffic congestion in Prince Street during peak times.	1
Options 14 and 15 are bypasses and would not stop peak hour congestion over the current bridge. Minimal people from southern areas would use this, and only in desperation.	1
Avoid Bridge and Pound Streets as it would be a traffic disaster.	6
The six options will not deliver the traffic outcomes required.	10
Concerned about showground traffic in Fry Street. Traffic would have to turn right then left into Dobie Street as Dobie Street would have been a better option as it is straight through.	13
Concerned about traffic noise on Fry Street.	13
RMS should step back from the options that have been put forward and decide how to resolve the overall traffic concerns for Grafton, South Grafton and the major traffic routes of the Pacific Highway and the Summerland Way.	17
Peak traffic is due to parents driving children to school.	21
A second bridge should keep traffic movement to a minimum and keep unnecessary traffic out of the CBD.	25
The reason for a second bridge should be to alleviate traffic congestion on the existing bridge. The cause of traffic congestion is heavy vehicles, and the vehicles travelling to the schools on the other side of the river.	26
Concerned about Option 11. Fry Street joins Villiers Street at a T intersection and with another roundabout a block up at the Dobie Street and Villiers Street intersection, this would result in two roundabouts within a block of each other. B-doubles have to take a very wide route to exit the roundabout. They often mount the median strip to make the circle and could strike vehicles waiting at the roundabout/give way sign. This is a safety issue.	28
The route must go outside the CBD. Objects to bringing extra traffic through residential and commercial areas.	32
Concerned about Options E, A, C and 11 as they route traffic through the centre of town or residential areas. Concerned about the limitations of taking heavy vehicles through these areas and the safety of residents and children.	33
Avoid using city streets for heavy vehicles and do not build the new bridge near the existing bridge, it will not solve traffic congestion.	34
The aim to reduce traffic on the existing bridge is best achieved by diverting the large number of down-river commuters, while at the same time lowering heavy vehicle numbers on the existing bridge and densely populated urban streets.	36
Concerns that Villiers Street is „extremely dangerous and busy" and that traffic is a major problem that should be addressed along here.	37

Issue category: Social impacts

This category includes comments about property acquisitions, and impacts on residential areas and sensitive land uses.

Table 48: Social impact feedback

Issues raised	Feedback No.
RMS should only buy flood prone farmland and avoid built up areas.	6
Concerned about impacts on private properties.	6, 7
Concerned about noise and amenity if Option C selected.	8
Would make sense to take the bypass away from the bulk of residential areas.	8
Concerned about noise and amenity impacts on properties adjacent to highways, even after noise reduction remediation works.	9
Concerned about impacts on aged persons homes, hospitals and aged care facilities.	16, 31
Endorsing Option 14 due to proximity to hospital which would be an advantage for access by ambulances and down river residents and has the least impact on quiet residential areas.	33
Concerned about Option C and how it might impact all the houses around – may isolate houses between the rail line and the new road.	35
Concerned with the high social cost of the options adjacent to the existing bridge which will require relocation of approximately 40 families and the numbers of heavy vehicles directed through residential streets.	36

Issue category: Economic impacts

This category includes concerns and comments relating to impacts on land value, businesses and primary production, and the cost of the project.

Table 49: Economic impact feedback

Issues raised	Feedback No.
Option 11 may cause economic impacts as passing the Summerland Way traffic would not go near the CBD.	1
Options 14 and 15 would have significant economic impacts and Grafton businesses would suffer.	1
Options 14 and 15 are probably more expensive.	1
Concerned about primary production income if crop production is impacted by the project.	15
Concerned about impact on land value if Option 15 goes ahead.	30

Issue category: Design

This category includes concerns about road design to ensure flood protection.

Table 50: Design feedback

Issues raised	Feedback No.
Option 11 could be improved if it continued down Dobie Street as part of the Summerland Way and met up with the river. People in South Grafton/Coutts wouldn"t use it as it"s a long round trip just to get back to South Grafton.	1
Concerned about flooding impacts of Option C if Pound Street is lowered any further.	5
Fry Street is the exit point for a large stormwater drain which Council has recently spent money on doing up.	13
Any road should take into account the flooding that occurs from Alipou Creek and Musk Valley Creek where they cross the Pacific Highway.	17
With Option C, if traffic is directed under the existing railway viaduct in Pound Street rather than over it, the road would need to be lowered if heavy vehicles are to pass under the train tracks. RMS might need to rethink the viability of this option as Pound Street floods and becomes impassable after heavy rain.	18
Corridor 5 (Options 14 and 15) should be built like a viaduct from the Summerland Way across to the Pacific Highway, leaving farmland below undisturbed. Should be a 4-6 lane freeway to cater for future traffic, should be built now.	34
The current bridge forms the only link between major trunk routes, the Pacific Highway and the Summerland Way. Any new structure should ensure the heavy vehicle traffic that is bound to increase over time, be diverted around the residential areas of Grafton, Junction Hill and Kulcairn to re-join the Summerland Way north of the Clarence Way junction. Bypass must be downstream of Grafton to allow commuter traffic from the lower river communities of Maclean, Iluka, Yamba and Gulmarrad (the two latter areas having been identified as „growth areas" in the *Mid North Coast Regional Strategy*) to access Grafton from the north via the new bridge.	36
The height of the bridge should not be influenced by the height of the boats in town if it is going to increase the cost of the project.	37

Issue category: Planning

This category includes comments relating to the travel needs of Grafton residents and through traffic, including heavy vehicles.

Table 51: Planning feedback

Issues raised	Feedback No.
Minimal people from southern areas would use Options 14 and 15, and only in desperation. These routes would be handy when the Pacific Highway is cut off for some reason, which is rare, but not for everyday use as it"s too far out of Grafton.	1
The route needs to be out of town to cater for B-triples from Casino. Need a link with the upgraded Highway.	6
Has any thought been given to using Centenary Drive as a permanent bypass to the Pacific Highway? Centenary Drive could then link onto Option 14 and 15 and then the intersection.	14
RMS should consider both a Grafton bypass and a crossing between Grafton and South Grafton.	17
Option 15 should commence as shown at the junction of the Pacific Highway and Centenary Drive with a high level junction that allows easy and safe transfer to the Pacific Highway. It should then cross the Clarence River further to the east and if possible have a footing on Elizabeth Island. It should proceed north-east passing east of Junction Hill joining the Summerland Way north east of Koolkhan. To proceed through Junction Hill would be maintaining it as a place of little consequence. This is the best option for a bypass of Grafton as Centenary Drive can be connected to Armidale Road west of South Grafton.	17
The second option for a bypass of Grafton is that proposed on the Pacific Highway between Coffs Harbour and Maclean. It would start at 8 mile road, south of Grafton and then head north to Tremayne also bypassing Ulmarra.	17

Issue category: Community consultation

This category includes concerns about the community involvement process to date.

Table 52: Community consultation feedback

Issues raised	Feedback No.
Unhappy with the process to date.	10
People who live outside the town are not getting involved. Need some way to encourage the wider community to participate as it will affect everyone.	21
Concerned that following a single community consultation meeting to discuss the large number of options put forward by the RTA, that one of the 5 short-listed routes that have now been selected for further investigation was not one of the originals.	36

Issue category: Environment

This category includes concerns about flooding, mature trees and heritage buildings.

Table 53: Environment feedback

Issues raised	Feedback No.
Concerned about impacts of Option 11 on large fig trees and houses in Fry Street that have heritage significance and cannot be removed.	13, 24
For a second crossing of the Clarence River for local commuters both Options A and C will meet with opposition due to the impact on the heritage of the current bridge.	17
Concerns about noise pollution and visual impacts of a major thoroughfare in clearly designated residential suburbs.	33
Do not support any option that imposes additional noise, pollution or increased heavy traffic on existing residents of Grafton and believe a separate dedicated route should be constructed through low density residential areas which are currently farmland. Where this route crossed flood prone country, the road would, by necessity have to be carried along a viaduct which would have a lower impact on that prime agricultural land and allow farming activities to continue beneath it. Does not support any new structure being built on, or in close proximity to either Susan or Elizabeth Islands or along existing residential streets. Concerns about the cultural and environmental sensitivities of Susan Island – it should be noted that, due to natural erosive action, the island is slowly „migrating" downstream and would eventually move under the proposed bridge.	36

Comments regarding preferences

The below table includes community considerations relating to corridor and option preferences and objections.

Table 54: Preference feedback

Comments regarding preferences	Feedback No.
Options A and C are the best. They both terminate near the CBD but not in the actual CBD. They would be best for the community and economically.	1
Preference for Option C (near the existing bridge)	7
Options 14 and 15 are preferable as they are away from the bulk of residential areas.	8

Comments regarding preferences	Feedback No.
The crossing should not be located in Fry Street (Option 11) as it is too narrow and there are too many houses to be acquired.	13
Option 14 is the better option as the street is wider and straight through to the Summerland Way and no houses need to be acquired.	13
Option E is a good option as the viaduct allows high vehicles to pass under and already has traffic noise.	13
If the purpose of the new bridge is an additional safer passage from South Grafton to Grafton and vice versa, Options A, C and E are the best three options.	17
If the purpose of the new bridge is for a bypass of Grafton then Options 14 and 15 are the two options to consider.	17
Option 11 should be discarded as it is a composite of an additional bridge and a bypass and is a poor option as it directs traffic back into Grafton from a starting location in the middle of nowhere on the Pacific Highway.	17
Of Options A and C, C is preferable as it would direct traffic away from the current bottleneck at the junction of the Pacific Highway, the Gwydir Highway, Bent Street and Ryan Street as well as the flooding that occurs in the area.	17
Option E may be the best option although it will severely impact on the functions that occur on the Clarence River and it also crosses the river at its widest point and then feeds traffic back into Grafton. It will also have the concerns with bottlenecks at the junction of the Pacific Highway, the Gwydir Highway, Bent Street and Ryan Street as well as the flooding that occurs in the area.	17
Overall there are major concerns with the options put forward from a technical, heritage and benefits point of view.	17
Supports Option 15 only. B-doubles should not need to go into town unless servicing Grafton. Truck drivers and travellers would prefer this option as it is more direct and has good highway connections.	19
Prefers Option A. With other options there would continue to be traffic delays on the old bridge as workers and shoppers use this as the most convenient route from South Grafton and outer areas. With Option A heavy vehicles would still bypass the CBD when proceeding further north.	22
Against Option 11 as it does not provide direct access to the Summerland Way and continues to channel large vehicles including B-doubles through a heavily built up residential area. It appears to have a much narrower corridor on the western (town) side both for construction and final usage.	24
In favour of Option 15. The distance across the Clarence floodplain is similar to Option 11 and it provides a direct connection between the Pacific Highway and the Summerland Way.	24
Option 15 is preferable as it removes large and heavy vehicles from the residential area, provides more direct access for hauliers and appears to have a wide corridor of less developed land on both sides of the river, provides a more direct route for emergency vehicles from the Pacific Highway to Grafton Base Hospital and connects more directly to the high level detour from the Pacific Highway along Centenary Drive in the event of major flooding of the Clarence River.	24
A second bridge should keep unnecessary traffic out of the CBD. Options A, C and E fail to do this. Option 11 is the best option.	25
The worst option is Option C as it defeats the purpose of having a second bridge, which is to alleviate traffic congestion from heavy vehicles on the existing bridge.	26
The best option is Option 12 as it would allow heavy vehicles to bypass the CBD by continuing along the Pacific Highway and travelling along Arthur Street to Turf Street and on to Casino. It also allows the school traffic from Junction Hill to bypass the centre of Grafton. It is a good option for most users.	26
Objects to Option 15 as it will have a substantial impact on land value.	30
Prefers Option 15.	31, 32
Prefers Option 14.	33
Concerned about Option C.	35
Prefers Option 11 – Options E, A, and C are not suitable.	37
Concerned that cost is a major issue and any option near Option 15 is very expensive.	38

Appendix 2 - Bridge construction methods

This appendix provides an overview of the bridge construction methods likely to be utilised for the construction of an additional crossing of the Clarence River at Grafton.

The three construction methods most likely to be used for the additional crossing:

- Incrementally launched
- Balanced cantilever
- Prestressed beam-and-slab.

These construction methods are described below. Note that the construction methods identified here are based on the preliminary concept designs for the six route options. The construction method will be reviewed following selection of the preferred route option.

Incrementally launched

Incrementally launched shown in Figure 48, is a construction method whereby the box girder (including the deck on which road lanes and shared path are provided) is cast in sections behind one of the abutments and then pushed out over the piers by hydraulic jacks. The box girder sections are cast directly against the preceding sections. Once a section has reached sufficient concrete strength, it is post-tensioned to the previous one and the whole assembly of sections are launched forward a further increment to allow casting of the next unit. The process is repeated until the box girder reaches its final position, usually at the opposite abutment.

Figure 48: Example of incrementally launching construction method – Iron Cove (Sydney)

In order for the incrementally launched method to be used, the horizontal and vertical alignments of the bridge must be either straight or on a constant radius curve and the superstructure needs to have a constant profile.

Balanced cantilever

In the balanced cantilever construction method, shown in Figure 49, segments of the box girder (including the deck on which road lanes and shared path are provided) are cast by form travellers in a symmetrical fashion about each of the piers. The balanced sequence of construction is to minimise the out-of-balance forces on the piers. When the cantilevers from adjacent piers are completed the spans are then closed by an in-situ deck “stitch”. The box girder is then post-tensioned to make the bridge continuous.

Figure 49: Example of balanced cantilever construction method – Brisbane Airport Roundabout Upgrade (Queensland)

This construction method is particularly suited to situations where there are long spans and access beneath the box girder is difficult, for example over rivers or deep valleys.

Prestressed beam-and-slab

In the prestressed beam-and-slab construction method, shown in Figure 50, the box girder (including the deck on which road lanes and shared path are provided) is made up of a series of precast concrete bridge girders lifted and placed by a crane side by side between pier headstocks. The bridge deck is then finished by casting an insitu reinforced concrete slab over the girders.

In Australia, „Super-T girders" are the most popular type of prestressed beam-and-slab bridge.

Figure 50: Example of prestressed beam-and-slab (Super-T girders) construction method – Kempsey (New South Wales)

Appendix 3 - Road safety audit

Roads and Maritime Services

Main Road 83 Summerland Way Additional Crossing of the Clarence River at Grafton

Road Safety Audit

Issue | 11 July 2012

Job number 222052

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Contents

Tables

Figures

Appendices

1 Introduction

1.1 Project Description

This report outlines the findings of a stage one feasibility road safety audit on six short-listed options for a proposed additional crossing of the Clarence River at Grafton and its connections to the existing transport network. These six options are the products of a Preliminary Route Options study undertaken by Arup for the Roads and Maritime Services NSW (January 2012).

1.2 Route Options

The six short-listed route options audited in this report are shown in Figure 1-1 below and summarised as follows:

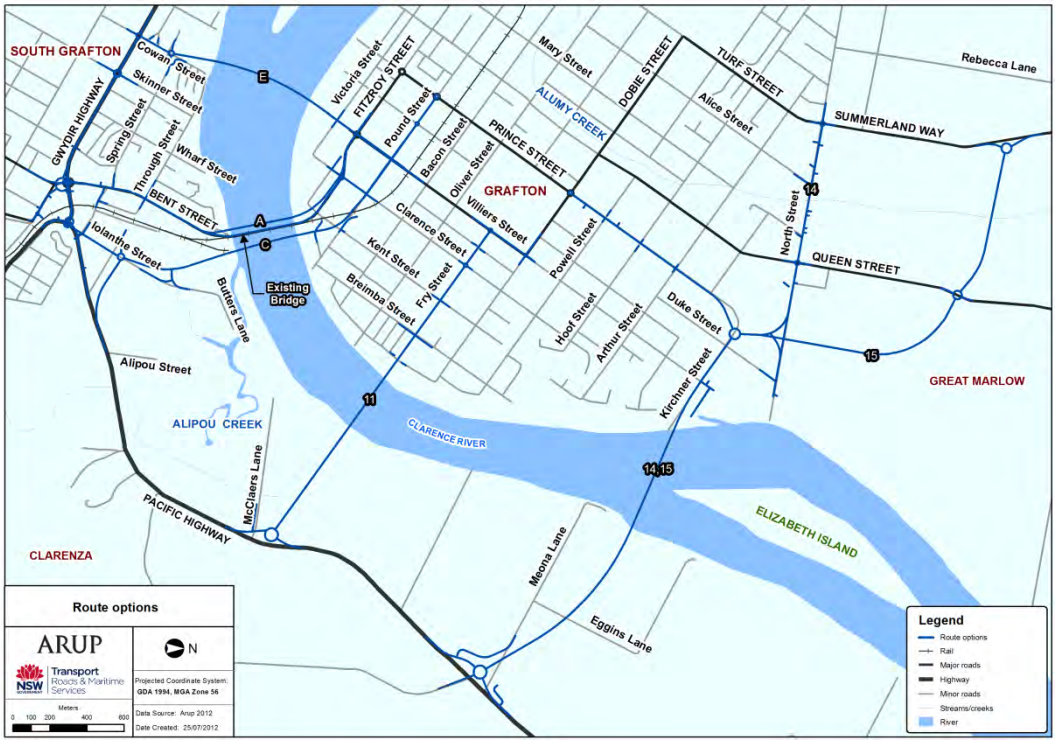
- Option E – Two lane bridge connecting from Cowan Street (South Grafton) to Villiers Street (Grafton) with upgraded connections to/from the Gwydir Highway and the Pacific Highway. This option links with existing road infrastructure on the northern embankment at Grafton. The two major intersections of Villiers Street with Fitzroy and Pound Street are transformed from priority controlled roundabouts to signalised intersections. The southern connection introduces two new roundabout treatments to existing minor 4-way priority controlled intersections. The properties fronting Cowan Street south of Spring Street maintain direct access while the properties north of Spring Street will access the network via Spring Street to the east of the upgraded Cowan Street;
- Option A – Proposed bridge crossing parallel to and immediately upstream of the existing bridge with two northbound lanes and one southbound lane. The lane configuration on the existing bridge is converted from two-way traffic to one southbound traffic lane. Both bridges connect with Bent Street (South Grafton) and Fitzroy Street (Grafton). Upgraded connections are proposed to/from the Gwydir Highway and the Pacific Highway via Bent Street. The proposed route generally follows the existing route with upgrades including signalisation of the Fitzroy Street/ Villiers Street and Villiers Street/ Pound Street intersections. Signalisation has also been provisioned for Through Street, the first intersection at the southern bridge connection. The two major highway intersections on the south side would both operate as roundabouts with no significant alteration to routes;
- Option C – An additional two-lane bridge connecting from Pound Street (Grafton) running parallel to and immediately downstream of the existing bridge. New connections are proposed to the Gwydir Highway and the Pacific Highway. The southern connection is a greenfield site with a new roundabout to provide a connection to the Pacific Highway to the east. The roundabout also provides a connection to the Pacific Highway to the south and the Gywdir Highway through an upgraded Iolanthe Street while maintaining property access to Bunnings Warehouse and other properties;
- Option 11 – An additional two lane bridge further removed from the existing bridge alignment. This crosses in a NW/SE direction connecting

from Fry Street on the north western embankment with a direct connection to the Pacific Highway. The southern connection runs through a greenfield site and a new roundabout provides access to and from the Pacific Highway. Also in this option, Fry Street is upgraded with McHugh Street and Weiley Avenue intersections closed, Breimba Street and Kent Street maintaining priority control and Clarence Street and Villiers Street upgraded to roundabouts.

- Option 14 – An additional two lane bridge connecting from the Pacific Highway north of South Grafton to North Street (Grafton) via Kirchner Street. The northern connection utilises an existing low order route fronted by predominately non-residential developments. Prince Street is upgraded for heavy vehicle access to the CBD. Powel Street, Hoof Street and Crown Street are partly closed to Prince Street. North Street becomes the major route north, connecting to Summerland Way via a proposed roundabout. The southern connection passes through a greenfield site crossing a low order unsealed road which is provided with alternate access to the new roundabout with the Pacific Highway and Centenary Road.
- Option 15 – An additional two lane bridge connecting from the Pacific Highway north of South Grafton to Summerland Way north of Grafton, via Kirchner Street. The northern connection utilises an existing low order route fronted by predominately non-residential developments. Prince Street is upgraded for heavy vehicle access to the CBD. Powel Street, Hoof Street and Crown Street are partly closed to Prince Street. A new route is constructed from Kirchner Street to the Summerland Way across a greenfield site, intersecting with Queen Street becoming the major route north to Summerland Way via a proposed roundabout. The southern connection passes through a greenfield site crossing a low order unsealed road which is provided with alternate access to the new roundabout with the Pacific Highway and Centenary Road.

Overall, all of the options involve constructing a new bridge and retaining some traffic movements over the existing bridge. None of the options include special provisions for public transport and all include a shared path across the new bridge and the approaches, extended to connect back to the existing arterial road network.

Figure 1-1: Additional Crossing Short-listed Options.



1.3 Project Aims

This stage one feasibility road safety audit has examined route options and the layout treatment(s) proposed for the connections to the existing road network on all short-listed concept options. The purpose is to:

- Allow a comparative assessment of the likely safety performance of the six options and how they respond to the specific safety needs of various road users;
- Highlight, where possible, the need for any other works required to safely accommodate the likely changes in traffic volumes and patterns;
- Identify potential safety problems for road users and others affected by each option;
- Consider the impact each option might have on traffic movements through Grafton and identify any broader safety issues that might result, including the potential safety impacts of changes in heavy vehicle travel patterns; and
- Ensure that measures to eliminate or reduce road safety problems are considered fully during the development of the project.

1.4 Current Status of Project

The project is currently in feasibility stage with a total of six short-listed options under assessment. These options have been developed through a preliminary options assessments process conducted by the project team.

1.5 Supporting Information

Drawings of each option were provided as information to undertake the stage one road safety audit. These drawings represent the proposed road layout in 2049, thirty years after the assumed opening year of 2019. A list of these drawings is provided in Appendix A.

Anticipated AM and PM peak period traffic volumes on the existing and proposed bridges were provided from a traffic micro-simulation exercise. These were by direction and for each option for the modelling horizons of 2019, 2029, 2039 and 2049. It is noted that the Do Minimum scenario was only provided for 2011 therefore the micro-simulation results can only be used to consider the relative risk of safety issues associated with each option and on the bridge crossings themselves, i.e. not on any approach roads. A summary of the modelling results is provided in Appendix B.

Cycleway plans and pedestrian and cycle routes through Grafton have been sourced from Clarence Valley Council"s website. These have been used to evaluate the potential changes in exposure to cyclists and pedestrians under each of the options and to determine the likely impact of particular design elements on pedestrians and cyclists.

1.6 Checklist and Reference Material

The six options were audited in accordance with the *Technical Direction TD 2003/RS03 Ver 2* (RTA, August 2005) relative to:

- General topics including function, traffic mix and access to property developments;
- Design and intersection issues;
- Environmental constraints; and
- Pedestrian, cyclist and public transport provisions.

Supplementary reference material used in the process of this audit includes:

- Technical Direction TD 2003/RS03 Ver 2 (RTA, August 2005);
- Accident Reduction Guide Part 2 Road Safety Audits (RTA, 2005); and
- Austroads Guide to Road Safety Part 6: Road Safety Audit (Austroads, 2009).

2 Road Safety Audit Process

2.1 The Road Safety Audit

The *Technical Direction TD 2003/RS03 Ver 2* (RTA, August 2005) defines a road safety audit as:

"a series of formal checks of road and traffic works, both existing and future, in relation to their accident potential and safety performance. It is conducted by a team independent to the project who can provide an objective safety assessment. The purpose of this audit process is to pro-actively manage road safety by identifying and addressing risks associated with road safety deficiencies".

An audit is not a check against the design standards and does not imply compliance with the standards, which may represent the minimum requirements. It does not guarantee safety.

The essential elements of this definition are that the audit is:

- A formal process and not an informal check;
- An independent process;
- Carried out by persons with appropriate experience and training; and
- Restricted to road safety issues.

The objectives of a road safety audit are:

- To identify potential safety problems for all road users and others affected by a road project; and
- To ensure that measures to eliminate or reduce the problems are considered in full.

The benefits of conducting road safety audits include:

- The likelihood of accidents on the road network can be reduced; and
- The severity of accidents can be reduced.

2.2 Methodology

This road safety audit was carried out to identify areas where the proposed feasibility options have the potential to compromise road user safety. It was undertaken in accordance with the practices outlined in the *Technical Direction TD 2003/RS03 Ver 2* (RTA, August 2005).

The audit has been undertaken on the proposed road layout and the estimated traffic volumes on the river crossings in 2049 (thirty years after the assumed opening year of 2019). In general, there is a substantial increase in traffic volumes from 2019 to 2049. This increase is not evenly distributed across the network. Where appropriate, due consideration has been given to the relative differences in estimated 2049 traffic volumes on the bridge crossings.

The audit covers physical features of the project which may affect road user safety and it has sought to identify potential safety hazards. However, no guarantee is made that every deficiency has been identified.

Non-conformances and hazards have been identified using the TD 2003/RS03 Checklist and relevant guidelines or standards, such as Austroads Guides to Traffic Engineering Practice and the RTA Road Design Guide.

Non-conformances or hazards identified in this report have been rated based on the probability and severity of a traffic accident resulting from the identified issue as described in the tables below. These tables have been reproduced from the Austroads Guide to Road Safety Part 6: Road Safety Audit (2009) to provide a consistent and structured approach to the ratings assigned to each safety issue identified.

Table 2.1 – Frequency of the Problem Leading to a Crash.

Frequency	Description
Frequent (F)	Once or more a week
Probable (P)	Once or more per year (but less than once week)
Occasional (O)	Once every five or ten years
Improbable (I)	Less often than once every ten years

Table 2.2 – Severity of Crash.

Severity	Description	Examples
Catastrophic (C)	Likely multiple deaths	High-speed, multi vehicle crash on freeway. Car runs into a crowded bus stop. Bus and petrol tanker collide. Collapse of a bridge or tunnel.
Serious (S)	Likely death or serious injury	High or medium-speed vehicle collisions. High or medium-speed collision with a fixed roadside object. Pedestrian struck at high speed. Cyclist is hit by a car.
Minor (M)	Likely minor injury	Some low-speed vehicle collisions. Cyclist falls from bicycle at low speed. Left-turn rear-end crash in a slip lane.
Limited (L)	Likely trivial injury or property damage only	Some low-speed vehicle collisions. Pedestrian walks into object (no head injury). Car reverses into post.

Table 2.3 – Resulting Level of Risk.

	Frequent	Probable	Occasional	Improbable
Catastrophic	Intolerable	Intolerable	Intolerable	High
Serious	Intolerable	Intolerable	High	Medium
Minor	Intolerable	High	Medium	Low
Limited	High	Medium	Low	Low

Table 2.4 – Treatment.

Risk	Description
Intolerable (I)	Must be corrected
High (H)	Should be corrected or the risk significantly reduced, even if the treatment cost is high.
Medium (M)	Should be corrected or the risk significantly reduced, if the treatment cost is moderate, but not high.
Low (L)	Should be corrected or the risk reduced, if the treatment cost is low.

In assigning a priority rating for identified risks associated with the bridge crossings proper,, consideration was given to the expected traffic volumes in the design horizon of 2049 (refer to Appendix B).

2.3 Audit Team

This road safety audit was undertaken by:

- Lead Road Safety Auditor – Deborah Hutchison
- Assistant Road Safety Auditor – James Newman
- Road Safety Audit Reviewer – Toby Gilmour

Deborah Hutchison and Toby Gilmour are registered on the Queensland Department of Main Roads Road Safety Auditor Register and accredited under the IPWEA Road Safety Auditor Accreditation Scheme as Level 3 road safety auditors.

3 Road Safety Audit Findings

The audit findings for the six short-listed options are presented under the respective headings below. The findings are further separated into those inherent to the design and those able to be addressed relatively easily in later design stages without major changes to the layout. Likely relief to safety issues associated with the existing route through central Grafton and the existing river crossing are also included, with those options that best reduce exposure to those existing issues rated with the lowest safety priority.

3.1 Option E Audit Findings

Table 3.1 – Option E Issues

Issue No.	Location	Issue	Priority
ISSUES INHERENT TO DESIGN			
1	General	Retains traffic movements through centre of town, maximising existing potential for conflict between through traffic (including heavy vehicles) and local access movements. Least effective at addressing heavy vehicle patterns although possibly caters for internal heavy vehicle movements better than the downstream options.	High
2	Existing River Crossing	The existing bridge has sub-standard geometry and the approach viaduct safety barriers may not meet current design guidelines.	Medium
3	Existing River Crossing	This option retains two-way, two lane use of existing bridge albeit with reduced travel demand and fewer heavy vehicle proportions. The existing bridge has sub-standard geometry and safety barriers.	Medium
4	Pedestrian and cycle routes	This option retains the primary highway route through streets that form key connections in the pedestrian and cycle networks, retaining exposure of these vulnerable road users to through traffic and heavy vehicles.	High
5	Pedestrian and cycle routes	This option introduces a number of design elements which will increase potential for conflict between pedestrians and cyclists and motorised vehicles. These include six two-lane roundabouts and left turn slip lanes at the Pacific Highway/Gwydir Highway and Victoria Street/Villiers Street intersections.	Medium
6	Gwydir Highway/ Cowan Street roundabout	The eastbound Gwydir Highway approach to this roundabout allows left turns on to the new bridge from both lanes which may impede cyclists wishing to continue through the intersection and increases the risk of a collision with vehicles turning left from the inside approach lane. It may also cause conflict with other circulating traffic.	Medium

Issue No.	Location	Issue	Priority
7	Gwydir Highway/ Cowan Street roundabout	The westbound Gwydir Highway approach to this roundabout allows right turns from both lanes, increasing the potential for conflict with other circulating traffic.	Low
8	Gwydir Highway/ Cowan Street roundabout	There is a single lane exit to Cowan Street south from the two lane roundabout, increasing the potential for merge and side swipe crashes.	Low
9	Gwydir Highway/ Skinner Street roundabout	There is a single lane exit to Skinner Street south from the two lane roundabout, increasing the potential for merge and side swipe crashes.	Medium
10	Pacific Highway/ Iolanthe Street/ Caltex Service Station intersection	The two minor legs of the intersection are offset with regards to each other. With no turning restrictions there is potential for weaving crashes and conflict with Pacific Highway traffic should vehicles attempt to travel between the petrol station access and Iolanthe St.	Low
11	Pacific Highway/ Iolanthe Street/ Spring Street intersection	The Iolanthe Street/ Spring Street intersection is in very close proximity to the Pacific Highway intersection with Iolanthe Street. The plans do not illustrate how the two are proposed to operate and it is assumed that the existing layout will be maintained. As a result, there is potential for rear-end crashes between vehicles slowing to enter Spring Street and those accelerating from turning into Iolanthe Street. There is also potential for vehicles turning right out of Spring Street to block the Iolanthe Street departure due to restricted storage at the Pacific Highway control line.	Low
12	Spring Street/ Pacific Highway intersection	There is a right turn bay provided into Spring Street from Pacific Highway southbound. The right turn bay is located off the right turn lane into Gwydir Highway. Two adjacent right turn bays may result in motorist confusion and motorists may turn into the Spring Street right turn bay and make unsafe manoeuvres to exit.	Medium
13	Pacific Highway/ Gwydir Highway intersection	The Pacific Highway inside westbound approach lane into Gwydir Highway becomes a right turn only lane (i.e. a trapped lane) and leaves only one through lane continuing along the Pacific Highway. This sudden lane drop is likely to increase the risk of a late lane change and a side-swipe collision.	Medium
14	Pacific Highway between Gwydir Highway and Iolanthe Street	The arrangement of the merge section on the Pacific Highway approaching Iolanthe Street from the south-west dictates vehicles from the Gwydir Highway must merge into the mainline traffic while vehicles wishing to enter Iolanthe Street from the Pacific Highway travelling in the same direction	Medium

Issue No.	Location	Issue	Priority
		must weave across the merge lane. The distance available for the weave is short. This has the potential to increase side-swipe and rear-end collisions as a result of the short weave section and varying speeds.	
15	Cowan Street/ Gwydir Highway between Spring and Skinner Street	The local street connectivity creates a potential for rat-running to avoid a more congested priority route. Late decisions to take the local route could result in conflict at the roundabouts. Similarly there will be a conflict between local street functions and potentially speeding through traffic.	Low
16	Villiers Street/ Dobie Street roundabout	A roundabout slip lane is proposed from Villiers Street (south) to Dobie Street (west). This creates potential for merge crashes where the slip lane meets the departure lanes immediately after the roundabout. They also create difficulties for pedestrians and cyclists to negotiate them, as drivers focus on gaps in traffic from the right, significantly increasing the potential for pedestrian-vehicle conflict.	Medium
17	Villiers Street/ Fitzroy Street intersection	The plans show signalisation of Villiers Street/ Fitzroy Street intersection while the adjoining intersections to the east and west remain or become roundabouts with approximately 200m of separation. Resulting queues at the approaches of Fitzroy Street may extend back to the roundabouts impeding on their operation and increasing the risk of rear-end collisions.	Low
18	Villiers Street/ Pound Street intersection	The plans show signalisation of Villiers Street/ Pound Street intersection while the adjoining intersection to the west remains roundabout controlled with approximately 200m of separation to the signalised approaches. Resulting queues at the approaches of Pound Street may extend back to the roundabout impeding on its operation and increasing the risk of rear-end collisions.	Low
ISSUES FOR LATER DESIGN STAGES			
19	Gwydir Highway between Bent Street and Pacific Highway	The property access directly east of the roundabout on the north side of the highway does not enforce a Left-In/ Left-Out arrangement with the provision of a splitter island. Given the access"s proximity to the Gwydir Highway/ Bent Street roundabout, vehicles turning right into or out of this access may increase the potential for side-on collisions with through traffic.	Medium
20	Pacific Highway between Gwydir Highway and Iolanthe Street	The merge section on the Pacific Highway eastbound extends across the Iolanthe Street intersection. This increases the potential for rear-end collisions as vehicles decelerating turn left into Iolanthe Street conflict with vehicles accelerating to merge.	Medium

Issue No.	Location	Issue	Priority
21	Gwydir Highway/ Bligh Street intersection	This is a four-way priority controlled intersection where the minor legs must pick gaps across a four-lane highway. There is increased potential for intersection turning crashes. In addition, the four-way approach has the potential to create a corridor effect along Bligh Street, particularly at night, where drivers on Bligh Street fail to notice the intersection and continue through.	High
22	Gwydir Highway/ Bligh Street intersection	There is no provision for a separate right turn bay from the Gwydir Highway eastbound into Bligh Street, increasing potential for rear-end crashes as vehicles prop to turn right from the through lane.	High
23	Victoria Street/ Villiers Street intersection	The median details on the two Left-In/Left-Out approaches on Victoria Street are unknown. A low or painted median creates potential for a corridor effect along Victoria Street, particularly at night, where drivers fail to notice the intersection and continue to drive through despite crossing traffic.	High
24	Villiers Street/ Fitzroy Street intersection	The southern approach at Villiers Street does not have a dedicated right turn bay. Without a right turn bay, vehicles turning right into Fitzroy Street will store in the through lane, increasing the potential for rear-end crashes.	Medium
25	Villiers Street/ Fitzroy Street intersection	The outside right turn approach lane of the Fitzroy Street westbound approaches at Villiers Street is not introduced as a turn bay to traffic (i.e. it is a trapped lane). Without sufficient signage further back from the intersection vehicles may make a late lane-change decision increasing the potential for side-swipe and rear-end collisions.	Medium

3.2 Option A Audit Findings

Table 3.2 – Option A Issues

Issue No.	Location	Issue	Priority
ISSUES INHERENT TO DESIGN			
1	General	Retains traffic movements through centre of town, maximising existing potential for conflict between through traffic (including heavy vehicles) and local access movements. Least effective at addressing heavy vehicle patterns although possibly caters for internal heavy vehicle movements better than the downstream options.	High
2	Existing River Crossing	The existing bridge has sub-standard geometry and the approach viaduct safety barriers may not meet current design guidelines. Conversion of existing bridge from two-lane, two-way traffic to one-lane, one-way southbound traffic allows a significant improvement to the poor geometry at either end of the bridge. All heavy vehicles would continue to be able to use the existing bridge and the inclusion in the cost estimates of an allowance for an upgrade of the existing parapets on the approach viaducts further reduces the potential safety hazard relative to other options.	Low
3	Pedestrian and cycle routes	This option retains the primary highway route through streets that form key connections in the pedestrian and cycle networks, retaining exposure of these vulnerable road users to through traffic and heavy vehicles.	High
4	Pedestrian and cycle routes	This option introduces a number of design elements which will increase potential for conflict between pedestrians and cyclists and motorised vehicles. These include four two-lane roundabouts and left turn slip lanes at the Fitzroy Street/Clarence Street intersection.	Medium
5	New river crossing – northern end	The horizontal curve immediately north of the new river crossing appears to be tight, increasing the potential for loss of control or head-on crashes.	Medium
6	Gwydir Highway/ Skinner Street roundabout	There are single lane exits to Skinner Street south from the two lane roundabout, increasing the potential for merge and side swipe crashes.	Medium
7	Bent Street approaching Gwydir Highway	The shared pedestrian/ bicycle path running parallel to Bent Street ends abruptly at a major roundabout with the Gwydir Highway. Pedestrians and cyclists should be led to a safe environment in which they can continue their journey. This arrangement has	Medium

Issue No.	Location	Issue	Priority
		the potential for pedestrians and cyclists to unsafely negotiate the crossing risking conflict with vehicles.	
8	Bent Street/ Spring Street intersection	The plans show a „seagull" partially signalised intersection which can cause uncertainty for unfamiliar users. (Northbound Bent Street is unsignalised)	Low
9	Bent Street/ Through Street intersection	No right turn bays are provided on the eastern, southern or western approaches at this signalised intersection, increasing the potential for rear-end collision as vehicles wishing to make an illegal right turn will prop in the through lane.	Low
10	Bent Street/ Riverside Drive intersection	The diverge from Bent Street northbound into Riverside Drive crosses over the shared path. This arrangement creates difficulties for pedestrians and cyclists attempting to negotiate the crossing as drivers are not expecting to give way at this point. This significantly increases the potential for pedestrian-vehicle conflict.	Medium
11	Bent Street/ Spring Street intersections	A slip lane is proposed from Bent Street (north) to Spring Street (east). These create difficulties for pedestrians and cyclists attempting to negotiate the intersection as drivers focus on gaps in traffic from the right, significantly increasing the potential for pedestrian-vehicle conflict.	Medium
12	Pacific Highway/ Iolanthe Street/ Caltex Service Station intersection	The two minor legs of the intersection are offset with regards to each other. With no turning restrictions there is potential for weaving crashes and conflict with Pacific Highway traffic should vehicles attempt to travel between the access and Iolanthe St.	Low
13	Pacific Highway/ Iolanthe Street/ Spring Street intersection	The Iolanthe Street/ Spring Street intersection is in very close proximity to the Pacific Highway intersection with Iolanthe Street. The plans do not illustrate how the two are proposed to operate and it is assumed that the existing layout will be maintained. As a result, there is potential for rear-end crashes between vehicles slowing to enter Spring Street and those accelerating from turning into Iolanthe Street. There is also potential for vehicles turning right out of Spring Street to block the Iolanthe Street departure due to restricted storage at the Pacific Highway control line.	Low
14	Ryan Street approach to Gwydir Highway/ Pacific Highway roundabout	The right turn bay into the property access appears to have a very short taper, increasing the potential for rear-end crashes.	Low

Issue No.	Location	Issue	Priority
15	Gwydir Highway/ Bent Street roundabout	There are roundabout slip lanes provided on the Bent Street leg of the roundabout. This creates potential for merge crashes where the slip lane facilities merge with the departure lanes immediately after the roundabouts. They are also difficult for pedestrians and cyclists to negotiate. These two movements are anticipated to be high volume movements, creating the potential for conflict between vehicles turning left from the slip lanes and those turning left from the roundabout proper.	High
16	Gwydir Highway/ Pacific Highway roundabouts	There is a close proximity between the two major roundabouts on Pacific Highway and Gwydir Highway. Due to the five approaches at the Gwydir Highway roundabout there may be way-finding issues for motorists coming off the Pacific Motorway roundabout. This may result in "last minute" weave manoeuvres on the short section of the road between the roundabouts and on the roundabout, potentially resulting in accidents.	Medium
17	Gwydir Highway/ Pacific Highway roundabouts	Motorists travelling southbound along Bent Street, requiring to travel southbound on the Pacific Highway are required to undertake a weave in the short segment of road between the two roundabouts. This may result in motorists undertaking unsafe manoeuvres.	Medium
18	Gwydir Highway/ Pacific Highway roundabouts	There is a single lane exit to Ryan Street from the two lane roundabout, increasing the potential for merge and side swipe crashes.	Low
19	Spring Street between Bent Street and the Pacific Highway	This local street creates a short-cut to bypass the two highway roundabouts. Late decisions to take the local route could result in conflict at the roundabouts. Similarly there will be a conflict between local street functions and potentially speeding through traffic.	Medium
20	Bridges northern end/ Clarence Street intersection	The Left-In/Left-Out accesses to Clarence Street are in the form of slip lanes. These create difficulties for pedestrians and cyclists negotiating the intersection as drivers believe they have right of way and enter the side road at higher speeds. Also, on exiting the side road, drivers tend to look to the right for gaps in traffic but not to the left for pedestrians and cyclists.	Medium
21	Southbound diverge to the bridge crossings	There is a decision point for drivers to cross Clarence River using the new bridge or the old bridge. This could cause confusion for unfamiliar drivers, increasing the potential for side-swipe crashes.	Medium
22	Pound Street eastbound between Duke Street and Villiers Street	There is parallel parking on the approach to the Villiers Street turning lanes, increasing potential for conflict between vehicles	Medium

Issue No.	Location	Issue	Priority
		reversing into parking bays and vehicles accelerating to get through a green light. Vehicles indicating left to enter the parking bays could be confused with vehicles indicating left to turn at the intersection.	
23	Villiers Street/ Dobie Street roundabout	A roundabout slip lane is proposed from Villiers Street (south) to Dobie Street (west). This creates potential for merge crashes where the slip lane meets the departure lanes immediately after the roundabout. They also create difficulties for pedestrians and cyclists to negotiate them as drivers focus on gaps in traffic from the right, significantly increasing the potential for pedestrian-vehicle conflict.	Medium
ISSUES FOR LATER DESIGN STAGES			
24	Bent Street/ Property Access south of Spring Street	Bent Street is shown on the plans to have median separation although no median details are provided. Should there only be a painted median, the potential is for vehicles to turn right to or from the access.	Low
25	Bridges northern end/ Clarence Street intersection	The median details along the bridge approach past the two Left-In/Left-Out Clarence Street approaches are unknown. A low or painted median creates potential for a corridor effect along Clarence Street, particularly at night, where drivers fail to notice the intersection and continue to drive through in the face of crossing traffic.	High

3.3 Option C Audit Findings

Table 3.3 – Option C Issues

Issue No.	Location	Issue	Priority
ISSUES INHERENT TO DESIGN			
1	General	Retains traffic movements through centre of town, maximising existing potential for conflict between through traffic (including heavy vehicles) and local access movements. Continues to cater for internal heavy vehicle movements (88% of existing heavy vehicle movements)	Medium
2	Existing River Crossing	The existing bridge has sub-standard geometry and the approach viaduct safety barriers may not meet current design guidelines.	Medium
3	Existing River Crossing	This option retains two-way, two lane use of existing bridge albeit with reduced travel demand, compared to existing volumes, and fewer heavy vehicles.	Medium
4	Pedestrian and cycle routes	This option retains the primary highway route through streets that form key connections in the pedestrian and cycle networks, retaining exposure of these vulnerable road users to through traffic and heavy vehicles.	High
5	Pedestrian and cycle routes	This option introduces a number of design elements which will increase potential for conflict between pedestrians and cyclists and motorised vehicles. These include five two-lane roundabouts and two single lane roundabouts.	Medium
6	New river crossing between bridge and Pacific Highway	Pedestrians and cyclists are not provided with a dedicated crossing opportunity south of the new river crossing. This increases the potential for pedestrians and cyclists to unsafely negotiate crossing the priority route, risking a conflict with vehicles.	Medium
7	New river crossing – northern end	The horizontal curve immediately north of the new river crossing appears to be tight, increasing the potential for loss of control or head-on crashes.	Medium
8	Pacific Highway (old)/ Caltex service station access near Iolanthe Street/ Spring Street intersection	The property access on the Pacific Highway to the east of Iolanthe Street is in very close proximity to the intersection of Iolanthe Street/ Spring Street. Vehicles travelling south-west along Iolanthe Street wishing to enter the property will need to make a left and right turn in quick succession increasing the potential for the vehicle to lose control. There is also an increased risk that vehicles will store here waiting to make a right turn into the property increasing the potential for rear-end collisions with following vehicles.	Low

Issue No.	Location	Issue	Priority
9	Spring Street between Bent Street and the Pacific Highway	This local street creates a short-cut to bypass the two highway roundabouts. Late decisions to take the local route could result in conflict at the roundabouts. Similarly there will be a conflict between local street functions and potentially speeding through traffic.	Low
10	Gwydir Highway/ Pacific Highway roundabout (South)	There is a single lane exit to the Pacific Highway southbound from the two lane roundabout, increasing the potential for merge and side swipe crashes.	Low
11	Iolanthe Street/ Pacific Highway roundabout (North)	There is a single lane exit to the Pacific Highway northbound and to the cul-de-sac from the two lane roundabout, increasing the potential for merge and side swipe crashes.	Medium
12	Gwydir Highway/ Skinner Street	There are single lane exits to Skinner Street from the two lane roundabout, increasing the potential for merge and side swipe crashes.	Medium
13	Pound Street/ Clarence Street intersection	Clarence Street eastern leg is restricted to Left In/ Left Out. This is unusual for a signalised intersection with potential for vehicles turning right or through from Clarence Street to conflict with other movements on the same phase.	Low
14	Connection to Pound Street under rail viaduct.	The shoulder widths appear to have been reduced underneath the rail viaduct. This reduces the available clear zone for errant vehicles, increasing the likely risk and severity of any crashes.	Medium
15	Villiers Street/ Dobie Street roundabout	A roundabout slip lane is proposed from Villiers Street (south) to Dobie Street (west). This creates potential for merge crashes where the slip lane meets the departure lanes immediately after the roundabout. They also create difficulties for pedestrians and cyclists to negotiate them as drivers focus on gaps in traffic from the right, significantly increasing the potential for pedestrian-vehicle conflict.	Medium
ISSUES FOR LATER DESIGN STAGES			
16	Spring Street/ Gwydir Highway/ Pacific Highway (old)	The median details of the two Left-In/Left-Out approaches are unknown. A low or painted median creates potential for a corridor effect along Spring Street and the old leg of the Pacific Highway, particularly at night, where drivers fail to notice the intersection and continue to drive through in the face of oncoming traffic.	High

3.4 Option 11 Audit Findings

Table 3.4 – Option 11 Issues

Issue No.	Location	Issue	Priority
ISSUES INHERENT TO DESIGN			
1	General	Traffic volumes on Fry Street and other residential streets are likely to increase resulting in a conflict between the local residential access function (including driveway access) and the through route function. All heavy vehicle traffic will pass along Fry Street, increasing the risk and severity at any conflict.	Medium
2	Existing River Crossing	The existing bridge has sub-standard geometry and the approach viaduct safety barriers may not meet current design guidelines. This option retains two-way, two lane use of existing bridge albeit with fewer heavy vehicles but increased travel demand compared to existing volumes and the upstream options.	High
3	Existing River Crossing	This option retains two-way, two lane use of existing bridge albeit with fewer heavy vehicles but increased travel demand compared to existing volumes and the upstream options.	High
4	Pedestrian and cycle routes	This option deviates the primary highway route through the core streets that form key connections in the pedestrian and cycle networks. However, it still follows the routes through the northern part of Grafton city centre retaining exposure of these vulnerable road users to through traffic and heavy vehicles.	Medium
5	Pedestrian and cycle routes	This option introduces some design elements which will increase potential for conflict between pedestrians and cyclists and motorised vehicles. These include three two-lane roundabouts and three single lane roundabouts as well as left turn slip lanes at the Gwydir Highway/Pacific Highway, Villiers Street/Fry Street and Kent Street/Fry Street intersections.	Low
6	Spring Street between Bent Street and the Pacific Highway	This local street creates a short-cut to bypass the highway roundabout and priority junction. Late decisions to take the local route could result in conflict at these intersections. Similarly there will be a conflict between local street functions and potentially speeding through traffic.	Low

Issue No.	Location	Issue	Priority
7	Spring Street/ Pacific Highway intersection	There is a right turn bay provided into Spring Street from Pacific Highway southbound. The right turn bay is located off the right turn lane into Gwydir Highway. Two adjacent right turn bays may result in motorist confusion and motorists may accidentally turn into the Spring Street right turn bay and make unsafe manoeuvres to exit.	Medium
8	Gwydir Highway/ Skinner Street	There are single lane exits to Skinner Street from the two lane roundabout, increasing the potential for merge and side swipe crashes.	Medium
9	Pacific Highway between Gwydir Highway and Iolanthe Street	The arrangement of the merge section on the Pacific Highway approaching Iolanthe Street from the south-west dictates vehicles from the Gwydir Highway must merge into the mainline traffic while vehicles wishing to enter Iolanthe Street from the Pacific Highway travelling in the same direction must weave across the merge lane. The distance available for the weave is short. This has the potential to increase side-swipe and rear-end collisions as a result of the short weave section and varying speeds.	Medium
10	Pacific Highway/ Iolanthe Street/ Caltex service station access intersection	The two minor legs of the intersection are offset with regards to each other. With no turning restrictions there is potential for weaving crashes and conflict with Pacific Highway traffic should vehicles attempt to travel between the access and Iolanthe St.	Low
11	Pacific Highway/ Iolanthe Street/ Spring Street intersection	The Iolanthe Street/ Spring Street intersection is in very close proximity to the Pacific Highway intersection with Iolanthe Street. The plans do not illustrate how the two are proposed to operate and it is assumed that the existing layout will be maintained. As a result, there is potential for rear-end crashes between vehicles slowing to enter Spring Street and those accelerating from turning into Iolanthe Street. There is also potential for vehicles turning right out of Spring Street to block the Iolanthe Street departure due to restricted storage at the Pacific Highway control line.	Low

Issue No.	Location	Issue	Priority
12	Pacific Highway/ Gwydir Highway intersection	The Pacific Highway inside westbound approach lane into Gwydir Highway becomes a right turn only lane (i.e. a trapped lane) with no lane marking drawn and leaves only one through lane continuing along the Pacific Highway. Even if lane markings are added, this sudden lane drop is likely to increase the risk of a late lane change and a side-swipe collision.	Medium
13	Fry Street/ Breimba Street intersection	This is a four-way priority controlled intersection where the minor legs must pick gaps across the main road. There is increased potential for intersection turning crashes. In addition, the four-way approach has the potential to create a corridor effect along Breimba Street, particularly at night, where drivers fail to notice the intersection and continue to drive through in the face of crossing traffic.	Medium
14	Villiers Street/ Fry Street roundabout	There are roundabout slip lanes provided on two corners of this roundabout. This creates potential for merge crashes where the bypass facilities merge with the departure lanes immediately after the roundabouts. They are also difficult for pedestrians and cyclists to negotiate.	High
15	Villiers Street/ Dobie Street roundabout	A roundabout slip lane is proposed from Villiers Street (south) to Dobie Street (west). This creates potential for merge crashes where the slip lane meets the departure lanes immediately after the roundabout. They also create difficulties for pedestrians and cyclists to negotiate them as drivers focus on gaps in traffic from the right, significantly increasing the potential for pedestrian-vehicle conflict.	Medium
ISSUES FOR LATER DESIGN STAGES			
16	Pacific Highway/ new bridge approach	Two approach lanes are present on all three legs of the roundabout, however, only one exit lane is indicated on all legs. This arrangement forces vehicles to merge on the roundabout circulating lanes which greatly increases the risk of side-swipe and rear-end collisions.	High
17	Pacific Highway between Gwydir Highway and Iolanthe Street	The merge section on the Pacific Highway eastbound extends across the Iolanthe Street intersection. This increases the potential for rear-end collisions as vehicles decelerating turn left into Iolanthe Street conflict with vehicles accelerating to merge.	Medium
18	Fry Street/ Kent Street intersection	The median details along Fry Street past the two Left-In/Left-Out Kent Street approaches are unknown. A low or painted	High

Issue No.	Location	Issue	Priority
		median creates potential for a corridor effect along Kent Street, particularly at night, where drivers fail to notice the intersection and continue to drive through in the face of crossing traffic.	
19	Gwydir Highway between Bent Street and Pacific Highway	The property access directly east of the roundabout on the north side of the highway does not enforce a Left-In/ Left-Out arrangement with the provision of a splitter island. Given the access"s proximity to the Gwydir Highway/ Bent Street roundabout, vehicles turning right into or out of this access may increase the potential for side-on collisions with through traffic.	Medium

3.5 Option 14 Audit Findings

Table 3.5 – Option 14 Issues

Issue No.	Location	Issue	Priority
ISSUES INHERENT TO DESIGN			
1	General	Bypasses town and avoids residential streets. Bypass to east has more potential to reduce heavy vehicle traffic passing through Grafton and South Grafton.	Low
2	Existing River Crossing	The existing bridge has sub-standard geometry and the approach viaduct safety barriers may not meet current design guidelines. This option retains two-way, two lane use of existing bridge albeit with fewer heavy vehicles, but increased travel demand compared to existing volumes and the upstream options.	High
3	Existing River Crossing	This option retains two-way, two lane use of existing bridge albeit with fewer heavy vehicles, but increased travel demand compared to existing volumes and the upstream options.	High
4	Pacific Highway/ Iolanthe Street/ Caltex Service Station intersection	The two minor legs of the intersection are offset with regards to each other. With no turning restrictions there is potential for weaving crashes and conflict with Pacific Highway traffic should vehicles attempt to travel between the access and Iolanthe St.	Low
5	Pedestrian and cycle routes	This option deviates the primary highway route through the core streets that form key connections in the pedestrian and cycle networks, largely reducing exposure of these vulnerable road users to through traffic and heavy vehicles.	Low
6	Pedestrian and cycle routes	This option introduces some design elements which will increase potential for conflict between pedestrians and cyclists and motorised vehicles. These include three two-lane roundabouts and three single lane roundabouts as well as left turn slip lanes at the Gwydir Highway/Pacific Highway intersection.	Low
7	Pacific Highway/ Iolanthe Street/ Spring Street intersection	The Iolanthe Street/ Spring Street intersection is in very close proximity to the Pacific Highway intersection with Iolanthe Street. The plans do not illustrate how the two are proposed to operate and it is assumed that the existing layout will be maintained. As a result, there is potential for rear-end crashes between vehicles slowing to enter Spring Street and those accelerating from turning into Iolanthe Street. There is also potential for vehicles turning right out of Spring Street to block	Low

Issue No.	Location	Issue	Priority
		the Iolanthe Street departure due to restricted storage at the Pacific Highway control line.	
8	Spring Street/ Pacific Highway intersection	There is a right turn bay provided into Spring Street from Pacific Highway southbound. The right turn bay is located off the right turn lane into Gwydir Highway. Two adjacent right turn bays may result in motorist confusion and motorists may accidentally turn into the Spring Street right turn bay and make unsafe manoeuvres to exit.	Medium
9	Pacific Highway/ Gwydir Highway intersection	The Pacific Highway inside westbound approach lane into Gwydir Highway becomes a right turn only lane (i.e. a trapped lane) and leaves only one through lane continuing along the Pacific Highway. This sudden lane drop is likely to increase the risk of a late lane change and a side-swipe collision.	Medium
10	Gwydir Highway/ Skinner Street	There are single lane exits to Skinner Street from the two lane roundabout, increasing the potential for merge and side swipe crashes.	Medium
11	Pacific Highway between Gwydir Highway and Iolanthe Street	The arrangement of the merge section on the Pacific Highway approaching Iolanthe Street from the south-west dictates vehicles from the Gwydir Highway must merge into the mainline traffic while vehicles wishing to enter Iolanthe Street from the Pacific Highway travelling in the same direction must weave across the merge lane. The distance available for the weave is short. This has the potential to increase side-swipe and rear-end collisions as a result of the short weave section and varying speeds.	Medium
12	North Street/ Davey Ave (west)/ property access intersection	The two minor legs of the intersection are offset with regards to each other. With no turning restrictions. There is potential for weaving crashes and conflict with North Street traffic should vehicles attempt to travel between the minor legs.	Medium
13	Prince Street/ Arthur Street intersection	This is a four-way priority controlled intersection where the minor legs must pick gaps across the main road. There is increased potential for intersection turning crashes. In addition, the four-way approach has the potential to create a corridor effect along Arthur Street, particularly at night, where drivers fail to notice the intersection and continue to drive through in the face of crossing traffic.	Medium
14	Villiers Street/ Dobie Street roundabout	A roundabout slip lane is proposed from Villiers Street (south) to Dobie Street	Medium

Issue No.	Location	Issue	Priority
		(west). This creates potential for merge crashes where the slip lane meets the departure lanes immediately after the roundabout. They also create difficulties for pedestrians and cyclists to negotiate them, as drivers focus on gaps in traffic from the right, significantly increasing the potential for pedestrian-vehicle conflict.	
ISSUES FOR LATER DESIGN STAGES			
15	Gwydir Highway between Bent Street and Pacific Highway	The property access directly east of the roundabout on the north side of the highway does not enforce a Left-In/ Left-Out arrangement with the provision of a splitter island. Given the access"s proximity to the Gwydir Highway/ Bent Street roundabout, vehicles turning right into or out of this access may increase the potential for side-on collisions with through traffic.	Medium
16	Pacific Highway between Gwydir Highway and Iolanthe Street	The merge section on the Pacific Highway eastbound extends across the Iolanthe Street intersection. This increases the potential for rear-end collisions as vehicles decelerating turn left into Iolanthe Street conflict with vehicles accelerating to merge.	Medium
17	Prince Street/ Powell Street and Prince Street/Hoof Street Intersections	Existing 4-way intersections have an approach become a cul-de-sac. There is potential for a corridor effect, particularly at night time as drivers attempt to cross Prince Street.	Medium
18	Pacific Highway / Centenary Drive intersection	This roundabout has two circulating lanes and single departure lanes. This significantly increases the potential for merge and side-swipe crashes.	High
19	Eggins Lane approach to Centenary Drive	This side road has been realigned to intersect with the Pacific Highway west of the roundabout. There is potential, particularly at night, for vehicles to become misguided by headlights on the Pacific Highway and vice-versa.	Medium
20	Kirchner Street/ Duke Street and Villiers Street/ Kirchner Street intersections	Duke Street and Villiers Street south are to be closed to Kirchner Street. Without sufficient mediation works through either signage or landscaping to formally close the intersection, vehicles may try to enter these streets from Kirchner Street increasing the risk of driver disorientation.	Low
21	North Street between Morrison Street and Duke Street	North Street is realigned to form a T-priority controlled intersection. There is potential for a corridor effect particularly at night time along the old alignment, resulting in vehicles leaving the carriageway.	Medium

Issue No.	Location	Issue	Priority
22	North Street/ Challinor Street intersection	North Street is shown on the plans with line marking that implies a Left-In/ Left-Out configuration is intended. However, no splitter island is provided at Challinor Street. Drivers may attempt a right turn into North Street increasing the potential for side-swipe conflicts.	Low

3.6 Option 15 Audit Findings

Table 3.6 – Option 15 Issues

Issue No.	Location	Issue	Priority
ISSUES INHERENT TO DESIGN			
1	General	Bypasses town and avoids residential streets. Bypass to east has more potential to reduce heavy vehicle traffic passing through Grafton and South Grafton.	Low
2	Existing River Crossing	The existing bridge has sub-standard geometry and the approach viaduct safety barriers may not meet current design guidelines. This option retains two-way, two lane use of existing bridge, albeit with fewer heavy vehicles, but increased travel demand compared to existing volumes and the upstream options.	High
3	Existing River Crossing	This option retains two-way, two lane use of existing bridge, albeit with fewer heavy vehicles, but increased travel demand compared to existing volumes and the upstream options.	High
4	Pedestrian and cycle routes	This option deviates the primary highway route through the core streets that form key connections in the pedestrian and cycle networks, largely reducing exposure of these vulnerable road users to through traffic and heavy vehicles.	Low
5	Pedestrian and cycle routes	This option introduces some design elements which will increase potential for conflict between pedestrians and cyclists and motorised vehicles. These include two two-lane roundabouts and five single lane roundabouts as well as left turn slip lanes at the Gwydir Highway/Pacific Highway intersection.	Low
6	Pacific Highway/ Iolanthe Street/ Caltex Service Station intersection	The two minor legs of the intersection are offset with regards to each other. With no turning restrictions there is potential for weaving crashes and conflict with Pacific Highway traffic should vehicles attempt to travel between the access and Iolanthe St.	Low

Issue No.	Location	Issue	Priority
7	Pacific Highway/ Iolanthe Street/ Spring Street intersection	The Iolanthe Street/ Spring Street intersection is in very close proximity to the Pacific Highway intersection with Iolanthe Street. The plans do not illustrate how the two are proposed to operate and it is assumed that the existing layout will be maintained. As a result, there is potential for rear-end crashes between vehicles slowing to enter Spring Street and those accelerating from turning into Iolanthe Street. There is also potential for vehicles turning right out of Spring Street to block the Iolanthe Street departure due to restricted storage at the Pacific Highway control line.	Low
8	Pacific Highway between Gwydir Highway and Iolanthe Street	The arrangement of the merge section on the Pacific Highway approaching Iolanthe Street from the south-west dictates vehicles from the Gwydir Highway must merge into the mainline traffic while vehicles wishing to enter Iolanthe Street from the Pacific Highway travelling in the same direction must weave across the merge lane. The distance available for the weave is short. This has the potential to increase side-swipe and rear-end collisions as a result of the short weave section and varying speeds.	Medium
9	Pacific Highway/ Gwydir Highway intersection	The Pacific Highway inside westbound approach lane into Gwydir Highway becomes a right turn only lane (i.e. a trapped lane) and leaves only one through lane continuing along the Pacific Highway. This sudden lane drop is likely to increase the risk of a late lane change and a side-swipe collision.	Medium
10	Gwydir Highway/ Skinner Street	There are single lane exits to Skinner Street from the two lane roundabout, increasing the potential for merge and side swipe crashes.	Medium
11	Spring Street/ Pacific Highway intersection	There is a right turn bay provided into Spring Street from Pacific Highway southbound. The right turn bay is located off the right turn lane into Gwydir Highway. Two adjacent right turn bays may result in motorist confusion and motorists may accidentally turn into the Spring Street right turn bay and make unsafe manoeuvres to exit.	Medium
12	Villiers Street/ Dobie Street roundabout	A roundabout slip lane is proposed from Villiers Street (south) to Dobie Street (west). This creates potential for merge crashes where the slip lane meets the departure lanes immediately after the roundabout. They also create difficulties for pedestrians and cyclists to negotiate	Medium

Issue No.	Location	Issue	Priority
		them, as drivers focus on gaps in traffic from the right, significantly increasing the potential for pedestrian-vehicle conflict.	
13	Prince Street/ Arthur Street intersection	This is a four-way priority controlled intersection where the minor legs must pick gaps across the main road. There is increased potential for intersection turning crashes. In addition, the four-way approach has the potential to create a corridor effect along Arthur Street, particularly at night, where drivers fail to notice the intersection and continue to drive through.	Medium
14	New link road/North Street intersection	This is a four-way priority controlled intersection where the minor legs must pick gaps across the main road. There is increased potential for intersection turning crashes. In addition, the four-way approach has the potential to create a corridor effect along North Street, particularly at night, where drivers fail to notice the intersection and continue to drive through.	Medium
ISSUES FOR LATER DESIGN STAGES			
15	Gwydir Highway between Bent Street and Pacific Highway	The property access directly east of the roundabout on the north side of the highway does not enforce a Left-In/ Left-Out arrangement with the provision of a splitter island. Given the access"s proximity to the Gwydir Highway/ Bent Street roundabout, vehicles turning right into or out of this access may increase the potential for side-on collisions with through traffic.	Medium
16	Pacific Highway between Gwydir Highway and Iolanthe Street	The merge section on the Pacific Highway eastbound extends across the Iolanthe Street intersection. This increases the potential for rear-end collisions as vehicles decelerating turn left into Iolanthe Street conflict with vehicles accelerating to merge.	Medium
17	Prince Street/ Powell Street and Prince Street/ Hoof Street intersections	Existing 4-way intersections have an approach become a cul-de-sac. There is potential for a corridor effect, particularly at night as drivers attempt to cross Prince St.	Medium
18	Kirchner Street/ Duke Street and Villiers Street/ Kirchner Street intersections	Duke Street and Villiers Street south are to be closed to Kirchner Street. Without sufficient mediation works through either signage or landscaping to formally close the intersection, vehicles may try to enter these streets from Kirchner Street increasing the risk of driver disorientation.	Low
19	Pacific Highway/ Centenary Drive	This roundabout has two circulating lanes and a single departure lane. This	High

Issue No.	Location	Issue	Priority
	intersection	significantly increases the potential for merge and side-swipe crashes.	
20	Eggins Lane approach to Centenary Drive	This side road has been realigned to intersect with the Pacific Highway west of the roundabout. There is potential, particularly at night, for vehicles to become misguided by headlights on the Pacific Highway and vice-versa.	Medium

4 Road Safety Audit Summary

4.1 Audit Details

The audit details are presented in Table 4.1.

Table 4.1 – Road Safety Audit Details

Report number	RTA: D/00369 Arup: 220422
Audited project	Main Road 83 – Summerland Way: Additional crossing of the Clarence River at Grafton NSW.
Audit for	Transport Roads and Maritime Services NSW
Address	31 Victoria Street Grafton 2460
Telephone	(02) 66401300
Project manager	
Audit team	Deborah Hutchison (lead auditor), James Newman (auditor), Toby Gilmour (senior auditor)
Audit type	Stage 1 - Feasibility
Audit dates	27 April 2012 to 13-June-2012
Previous audit	Stage 1 – Preliminary Options, September 2010

4.2 Summary of Findings

Six feasibility options for a second crossing of the Clarence River at Grafton have been reviewed through the road safety audit process. Common road safety issues identified include:

- Mix of local traffic and through highway traffic;
- Relative exposure of pedestrians and cyclist routes to highway traffic;
- Single approach and departure lanes from two-lane roundabouts;
- Use of short sections of slip lanes in urban roundabouts;
- Slip lanes at urban intersections reducing pedestrian and cyclist safety;
- Queuing potential from signalised intersections to adjacent roundabouts;
- Trapped right turn bays;
- Proximity of access to highway intersections and lane merges;
- Potential for rat-running on local streets to avoid roundabouts;
- Four-way priority-controlled intersections, staggered four-way intersections and corridor effects across closed four-way intersections.

The road safety audit findings for each option are summarised in Table 4.2. The options are summarised by number and priority of road safety issues identified and whether these are inherent to the design or able to be readily addressed in subsequent design stages.

Table 4.2 – Road Safety Findings - Summary

	Priority	Option E	Option A	Option C	Option 11	Option 14	Option 15
Inherent to Design	High	2	3	1	3	2	2
	Medium	9	13	10	8	7	7
	Low	7	7	4	4	5	5
For Resolution in Next Stage	High	3	1	1	2	1	1
	Medium	4	-	-	2	5	4
	Low	-	1	-	-	2	1

From Table 4.2, the options with less inherent safety issues, in terms of severity and number, tend to be the options where the second crossing and its connections are built in a greenfield site as these remove traffic from central Grafton, have fewer design constraints and minimise any conflict with land use activities on minor roads. Option A has the highest number of inherent safety issues, followed by Option E. Options C, 11, 14 and 15 have fewer inherent safety issues and would be likely to be the safest options.

5 Formal Statement

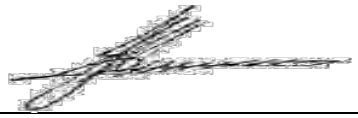
We, the undersigned, declare that we have reviewed the material and data listed in this report and identified the safety and operational deficiencies above.

It should be note that while every effort has been made to identify potential safety hazards, no guarantee could be made that every deficiency has been identified.

We recommend that points of concern be investigated and corrective actions implemented as soon as practicable.

Deborah Hutchison — Lead Road Safety Auditor, Level 3 IPWEA Road Safety Auditor

11 July 2012 (date)



James Newman — Assistant Road Safety Auditor

05 July 2012 (date)

Toby Gilmour — Road Safety Auditor Reviewer, Level 3 IPWEA Road Safety Auditor

11 July 2012 (date)

Appendix A

List of Drawings

A list of drawings supplied includes the following:

Number	Drawing Reference
1	Option E – Plan and Longitudinal Section
2	Option A – Plan and Longitudinal Section
3	Option C – Plan and Longitudinal Section
4	Option 11 – Plan and Longitudinal Section
5	Option 14 – Plan and Longitudinal Section (1 of 2)
6	Option 14 – Plan and Longitudinal Section (2 of 2)
7	Option 15 – Plan and Longitudinal Section (1 of 3)
8	Option 15 – Plan and Longitudinal Section (2 of 3)
9	Option 15 – Plan and Longitudinal Section (3 of 3)