Transport
Roads & Maritime
Services

Additional crossing of the Clarence River at Grafton

Route Options Development Report
Technical Paper – Economic Evaluation

SEPTEMBER 2012

whatwouldyouliketogrow.com.au

Additional Crossing of the Clarence River at Grafton

Route Options Development Report

Arup

August 2012

Technical Paper - Economic Evaluation

Final

Disclaimer

This Report has been prepared by PricewaterhouseCoopers (PwC) at the request of the Arup, to conduct an economic evaluation (EE) of an additional crossing of the Clarence River at Grafton.

The information, statements, statistics and commentary (together the "Information") contained in this Report have been prepared by PwC from material provided by Arup, its technical advisers and from other industry data from sources external to Arup. PwC may at its absolute discretion, but without being under any obligation to do so, update, amend or supplement this document.

PwC does not express an opinion as to the accuracy or completeness of the information provided, the assumptions made by the parties that provided the information or any conclusions reached by those parties. PwC disclaims any and all liability arising from actions taken in response to this report. PwC disclaims any and all liability for any investment or strategic decisions made as a consequence of information contained in this report. PwC, its employees and any persons associated with the preparation of the enclosed documents are in no way responsible for any errors or omissions in the enclosed document resulting from any inaccuracy, mis-description or incompleteness of the information provided or from assumptions made or opinions reached by the parties that provided information.

PwC has based this Report on information received or obtained, on the basis that such information is accurate and, where it is represented by Arup as such, complete. The Information contained in this report has not been subject to an Audit. The information must not be copied, reproduced, distributed, or used, in whole or in part, for any purpose other than detailed in our Consultant Agreement without the written permission of the Arup and PwC.

Comments and queries can be directed to:

Scott Lennon
Partner – PricewaterhouseCoopers
Ph: (02) 8266 2765
Email: scott.lennon@au.pwc.com

Contents

Executive Summary

Background

Roads and Maritime Services (RMS, formerly RTA) is currently undertaking investigations to identify the preferred location for an additional crossing of the Clarence River at Grafton to address short-term and long-term transport needs. Arup (on behalf of RMS) has engaged PricewaterhouseCoopers (PwC) to undertake an economic evaluation of six short-listed route options. This technical paper builds on the work undertaken for the Preliminary Route Options Report Final (PROR) and is an attachment to the Route Options Development Report. This Economic Evaluation (EE) is primarily concerned with transport related outcomes. RMS will determine the recommended route option based on its performance against a wider range of indicators (i.e. environment, amenity, heritage etc.). Information on non-transport indicators will be provided by other technical streams.

Transport issues in the study area

While Grafton and South Grafton have respective residential and employment centres, forecast significant growth in population is expected to add to the existing focus on residential land uses in South Grafton. This will increase demand for trips crossing the river to access employment and services concentrated in Grafton. Population growth in the Grafton area is expected to increase the demand for bridge crossings by 108 per cent over the next 30 years.

Negative social, environmental and economic outcomes occur when the capacity and design of the existing transport network cannot accommodate the growth in the number of trips. The key transport problems in the Grafton area relate to:

- the insufficient capacity of the existing bridge;
- sub-optimal alignment and design of the existing bridge;
- the reliance on the bridge evidenced by the high proportion of total network trips which involve a river crossing; and
- the lack of practical alternative routes crossing the river.

Route options

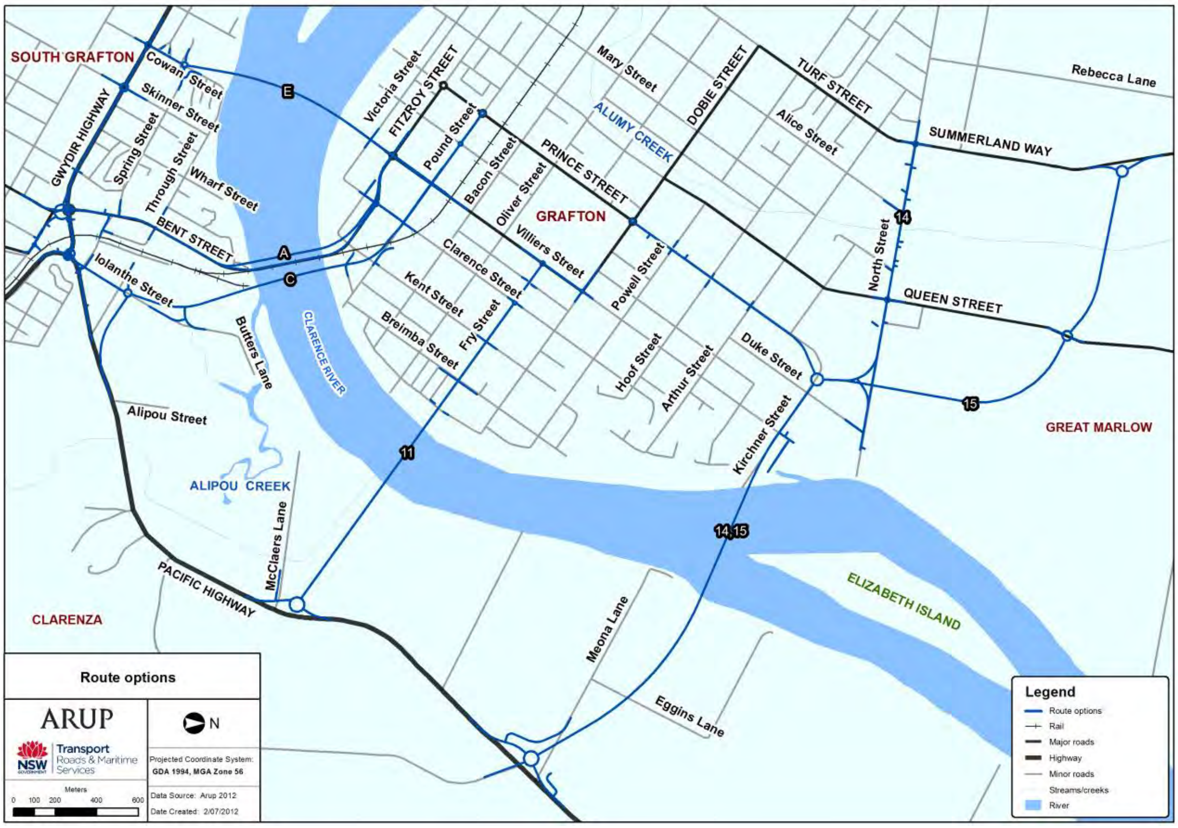
RMS seeks to address the transport problems above through a short-list of six route options. These are shown below in **Table ES 1**. A graphical presentation of the route option alignment follows in **Figure ES 1**.

Table ES 1: Short-listed route options

Route Option	Description
E	Option E includes a new bridge upstream of the existing bridge where it would connect the Gwydir Highway at Cowan Street in South Grafton to Villiers Street in Grafton. Both the new and existing bridge would have one lane in each direction.
A	Option A consists of a new bridge constructed slightly upstream and parallel to the existing bridge. This option would connect Bent Street in South Grafton to Fitzroy Street in Grafton. The new bridge would have two northbound lanes and one southbound lane and the existing bridge will be converted to one southbound lane.
C	Option C involves building a new bridge slightly downstream and parallel to the existing bridge. This option connects the Pacific Highway at Iolanthe Street in South Grafton to Clarence and Pound Street in Grafton. Under Option C, both bridges would have one lane in each direction.
11	Option 11 involves the construction of a new bridge downstream of the existing bridge where it would connect the Pacific Highway at McClaers Lane in South Grafton to Fry Street in Grafton. Option 11 would include two viaduct structures between the Pacific Highway and the Clarence River. It would also include an upgrade of Fry Street to enable it to meet

Route Option	Description
	future traffic volumes and of Villiers Street to accommodate a 5.3m vertical clearance for heavy vehicles beneath the railway viaduct. Both bridges would have one lane in each direction.
14	Option 14 involves the construction of a new bridge downstream of the existing bridge where it connects Pacific Highway at Centenary Drive in South Grafton and North Street via Kirchner Street at Grafton. Both the new and existing bridge would be one lane in each direction.
15	Option 15 involves the construction of a new bridge downstream of the existing bridge where it connects Pacific Highway at Centenary Drive in South Grafton to Summerland Way via Kirchner Street in Grafton. All construction aspects are the same as Option 14; the only difference is the alignment of the connections on the Grafton side.

Figure ES 1: Short-listed route options



Approach to economic evaluation

The economic evaluation of the six route options is undertaken using Cost Benefit Analysis (CBA). CBA measures the economic viability of a route option by comparing the additional benefits of the route option with the additional costs with a route option, over a defined evaluation period. The additional benefits and costs are measured with respect to a Base Case, which is the scenario that would prevail in the absence of the route options.

Road based transport options are commonly appraised using Road User Cost Benefit Analysis (RUCBA). RUCBA is an applied CBA framework which defines and measures the key benefits of road transport options as reductions in:

- vehicle travel time costs (VTTC);
- vehicle operating costs (VOC);
- crash costs (CC); and
- costs of environmental and social effects from vehicle use (externalities).

The first three economic costs are collectively referred to as 'road user costs', while environmental and social effects from transport use are referred to as 'external costs'.

The practical tasks undertaken include:

- 'streaming' of costs with the Base Case and route options. These are based on cashflow profiles provided by Arup while estimates of capital costs are provided by technical consultants MacDonald International;
- collection and 'streaming' of traffic demand forecasts. This is the first step in benefit estimation. Conventional traffic outputs for economic evaluations include network vehicle kilometres travelled, (VKT), vehicle hours travelled (VHT), stops and trips, with the Base Case and the route options. The traffic demand forecasts are provided by technical consultants GTA Consultants;
- estimation of 'conventional' road user and external costs. The methodology for this task involves sourcing and applying the relevant economic unit costs to the annual demand estimates developed above. Conventional benefits estimated include reductions in: travel time cost, vehicle operating cost, stop costs, crash costs and environmental and social externalities such as Greenhouse Gas Emissions (GHG) and water pollution. All economic parameters are sourced from the RMS' Economic Analysis Manual unless otherwise stated; and
- spreadsheeting analysis used to combine the annual benefits and costs with the route options. CBA is based on a Discounted Cashflow (DCF) framework which forecasts the annual benefits and costs over an evaluation period extending 30 years from the first full year of operation of the route option (2019/20 – 2048/49). These future costs and benefits are then 'discounted' using a real discount rate of 7 per cent. These benefits and costs are combined (using specific equations) to produce measures of economic merit including the Benefit Cost Ratio (BCR) and Net Present Value (NPV).

Results of the economic evaluation

The results in **Table ES 2** indicate that all route options generate significant savings in travel time cost, between PV$120 - $160m. Route Options E, C and 11 generate the highest travel time cost savings. Savings in travel time costs also account for the largest proportion of total present value benefits at around 80 per cent for each route option. The next largest benefit component involves the reduction in economic costs associated with a reduction in vehicle stops. This benefit line item accounts for between 15 and 20 per cent of total present value benefits. Route Options E, C and 11 generate similar levels of total present value benefit.

Table ES 2: Discounted incremental infrastructure, road user and external costs by route option ($000)

Cost/Benefit Item	PV$'000					
	E	A	C	11	14	15
Direct Infrastructure Cost						
Capital	127,373	139,037	138,456	123,936	177,040	197,967
Operating and maintenance	-	-	-	-	-	-
Residual	-8,050	-9,017	-8,819	-7,848	-11,740	-13,422
Total Direct Infrastructure Cost	**119,322**	**130,020**	**129,638**	**116,088**	**165,300**	**184,545**
Road User Cost (savings)						
Travel time cost	155,936	139,190	160,819	155,199	126,404	128,168
Vehicle operating cost	7,455	2,860	5,944	5,014	1,009	1,771
Stop cost	28,763	29,128	33,895	34,858	32,805	32,746
Crash cost	956	-31	549	380	-327	-224
Total Road User Cost (savings)	**193,110**	**171,147**	**201,208**	**195,451**	**159,892**	**162,461**
External Cost (Savings)						
Environmental cost	1,485	117	855	674	-85	-142
Total External Cost (savings)	**1,485**	**117**	**855**	**674**	**-85**	**-142**
Total Road User and External Cost Savings	**194,595**	**171,264**	**202,062**	**196,125**	**159,807**	**162,319**

Table ES 3 presents the BCRs and NPVs for each route option.

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

Table ES 3: Measures of economic performance by route option

Performance Measure	PV$'000					
	E	A	C	11	14	15
Net Present Value	75,272	41,244	72,424	80,037	-5,493	-22,226
Benefit Cost Ratio	1.6	1.3	1.6	1.7	1.0	0.9

Conclusions

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

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

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

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

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

Glossary

Abbreviation	Description
BCR	Benefit Cost Ratio
CAGR	Compound Annual Growth Rate
CBA	Cost Benefit Analysis
CC	Crash costs
DCF	Discounted Cashflow Analysis
ERR	Economic Rate of Return
EXT	External costs (e.g. GHG emissions)
FYRR	First Year Rate of Return
GHG	Greenhouse Gas Emissions
M	Metre
NPV	Net Present Value
OD	Origins and destinations
PV	Present Value
PwC	PricewaterhouseCoopers
RMS	Roads and Maritime Services
RODR	Route Options Development Report
RUCBA	Road User Cost Benefit Analysis
VHT	Vehicle Hours Travelled
VKT	Vehicle Kilometres Travelled
VOC	Vehicle Operating Costs
VTTC	Vehicle Travel Time Costs

1 Introduction

This Chapter provides a background to the Economic Evaluation technical paper. It outlines the objectives and scope of the technical paper and provides an overview of the report structure.

1.1 Background

Roads and Maritime Services (RMS, formerly RTA) is currently undertaking investigations to identify an additional crossing of the Clarence River at Grafton to address short-term and long-term transport needs. Arup (on behalf of RMS) has engaged PricewaterhouseCoopers (PwC) to undertake economic investigations.

Since the early 1970s there have been various discussions and studies into an additional crossing of the Clarence River at Grafton. A number of these studies have been carried out during the past ten years and provide the background to the current investigation.

In December 2010, RMS commenced a revised process to work more closely with the community to determine the preferred location for an additional crossing. As part of this revised process, a series of public surveys, community forums and meetings with residents and community groups have been held and various studies and project documents released for public viewing and comment.

In June 2011, RMS released the Feasibility Assessment Report, which describes the assessment undertaken by RMS on the 41 route suggestions identified by the community following the announcement of the revised process in December 2010. The report identified 25 preliminary options within five strategic corridors to go forward for further engineering and environmental investigation.

Between June 2011 and January 2012, RMS carried out investigations in the Grafton area and surrounds to identify constraints relevant to an additional crossing of the Clarence River. The outcomes of these investigations, community comment and a community and stakeholder evaluation workshop provided the inputs to the selection of the short-list of options.

In January 2012, six route options to be investigated further as part of the process to identify a location for the crossing were announced (as shown in Figure 1). The short-listed route options were identified in the Preliminary Route Options Report – Final (January 2012) which also provided details of the technical investigations undertaken on the 25 preliminary options and the process to select the short-listed route options.

This technical paper builds on the work undertaken for the Preliminary Route Options Report Final (PROR) and is an attachment to the Route Options Development Report. This technical paper provides a comparative economic evaluation of the six short-listed route options. The findings of this evaluation will be used as an input to the selection of a recommended preferred route option.

1.2 Objectives and scope of the economic evaluation

PwC was engaged by Arup to undertake an economic evaluation of the six short-listed route options for an additional crossing of the Clarence River at Grafton, NSW. The key objectives of the economic evaluation are to:

- identify and describe the transport problems in Grafton and South Grafton and hence, the need for an additional crossing of the Clarence River;
- define and describe the evaluation Base Case[1] and route options;
- describe the economic evaluation framework used to assess the route options;
- present and discuss the project development, design and direct infrastructure costs with the Base Case and the route options;
- present, discuss and analyse the traffic demand forecasts which are the basis for estimating the road user and external benefits[2];
- estimate and present the changes in road user and external costs with each route option, including presenting the road user and external unit costs and traffic expansion factors;
- undertake a Cost Benefit Analysis (CBA) to produce the conventional economic indicators including Benefit Cost Ratios (BCR) and Net Present Values (NPV) for each route option; and
- undertake a sensitivity analysis to assess the robustness of the economic evaluation results to changes in key assumptions.

Economic evaluation of road initiatives is primarily concerned with transport related outcomes. We understand that RMS will determine the recommended route option based on its performance against a wider range of indicators (i.e. environment, amenity, heritage etc...). Information on non-transport indicators will be provided by other technical streams.

[1] The Base Case refers to the road network scenario which would prevail in the absence of an additional crossing of the Clarence River in Grafton.

[2] The benefit of the route options are attributable to reductions in road user and external costs with the route options compared with the Base Case.

1.3 Structure of this report

This remainder of this Report is structured as follows:

- **Chapter 2** – discusses the transport problems which provide the rationale for an additional crossing of the Clarence River. It also defines the six route options for an additional crossing of the Clarence River and the Base Case. It also provides a comparative analysis of the route options by describing the differences in expected transport outcomes across route options;

- **Chapter 3** – outlines the approach and methodology for the economic evaluation;

- **Chapter 4** – discusses the role of traffic demand in the economic evaluation, and also presents traffic demand forecasts for each of the route options and the Base Case;

- **Chapter 5** – defines and presents the road user and external costs associated with the route options and the Base Case;

- **Chapter 6** – presents the direct infrastructure costs associated with the route options and the Base Case;

- **Chapter 7** – presents the results of the economic evaluation (including sensitivity analyses) for each route option;

- **Chapter 8** – summarises the findings and draws conclusions from the results of the economic evaluation.

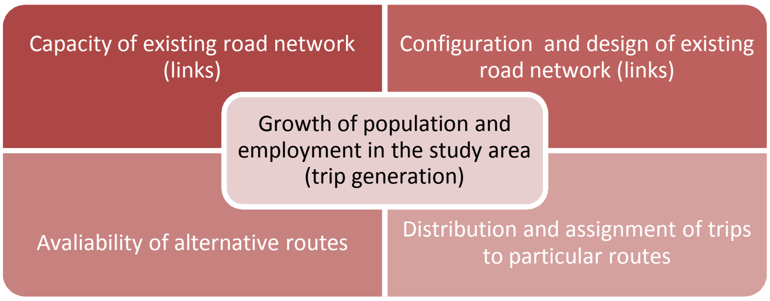
2 Rationale for an additional crossing of the Clarence River

This chapter sets out the rationale for and objectives of an additional crossing of the Clarence River at Grafton. The rationale for the additional crossing is developed by identifying the range of range of existing transport problems which prevent the objectives of the additional crossing being realised. This chapter also defines and describes the economic evaluation Base Case and the six short-listed route options.

2.1 Background

Figure 1 below shows the framework used to define the rationale for an additional crossing of the Clarence River.

Figure 1: Determinants of an additional crossing of the Clarence River



Source: PwC

Central to this framework is the expected change in land use in the Grafton area, ie. the distribution and growth of population and employment.

Changes in land use patterns influence the origins and destinations (ODs) of vehicle trips, which in turn indicate where people reside and where they work, shop, socialise or access other social services such as health and education services (trip distribution). The other main aspect of land use is the number of trips that are undertaken (trip generation), which is in turn influenced by factors such as population and employment growth in the ODs.

The economic cost of the growth in transport trips (measured by road user and external costs defined in **Section 5.1**) over time is determined by travellers being able to access the least cost mode (mode choice) and route (trip assignment).

A mismatch between route choice and/or capacity and land use increases the economic cost of a trip at best or at worst, potentially changes the land use over time by restricting economic activity by suppressing travel.

2.2 Land use in Grafton

2.2.1 Land use

The existing and future land use pattern in the Grafton area underpin the case for an additional crossing as residential and employment/service zones are geographically separated and concentrated on opposite sides of the Clarence River. The other main aspect of land use is the growth in demand for trips, particularly those which include a river crossing. There is evidence that population growth in the Grafton area will be significant, exceeding the rates of growth at the State and regional levels, and that a large proportion of this growth will be concentrated on one side of the Clarence River.

Figure 2 locates the town centres of Grafton and South Grafton on opposite sides of the Clarence River.

Figure 2: Clarence River Crossing – linking Grafton and South Grafton

Source: Google Maps (2012)

Most of the highway-related businesses in South Grafton are located along Bent Street (part of Summerland Way). Bent Street also connects to Grafton via the existing bridge with South Grafton, Armidale Road and the Gwydir Highway. Skinner Street in South Grafton functions as the main street in the South Grafton Central Business District (CBD). South Grafton also features industrial and employment lands to the west of the Pacific Highway between Clarenza and the existing residential areas. The industrial area is connected to South Grafton by the Pacific Highway or through local road linkages through to Armidale Road.

The existing residential areas in South Grafton are bounded to the east by Mackay Street and Rushforth Road to the west. There is also residential development along the Gwydir Highway. The primary developing residential area in South Grafton is the Clarenza Urban Release Area. It is directly east of the existing residential development. The area is intersected by Centenary Drive, with connections to the Pacific Highway provided by Frances, Clarenza and Duncans Roads.

Across the Clarence River, Grafton has a clearly defined urban core, with the primary commercial activities centred along Prince Street. Highway-related businesses are located along Fitzroy Street, which links the existing bridge with Grafton's CBD and also runs perpendicular to Prince Street[3], bringing traffic (and hence, passing trade) off the bridge and in to the main commercial street.

The existing and proposed residential areas are bounded by the Clarence River and North Street to the north. Running perpendicular to Prince Street, Victoria Street is Grafton's civic street, where much of the town's administrative and institutional activities are concentrated. King Street also has an administrative function.

Grafton has a clearly defined urban core, with the primary commercial activities centred along Prince Street. Grafton covers the majority of trip attractants including but not limited to educational facilities (7 of the 10 main educational facilities), Grafton Base Hospital, Grafton Shopping World, emergency services including the police station, and 66 per cent of the businesses surveyed (n=104) as part of the technical investigations for this initiative[4].

2.2.2 Population

Grafton is identified in the Mid North Coast Regional Strategy[5] as a major regional centre and also has the greatest capacity for commercial redevelopment. It is expected to take the majority of future commercial development in the Clarence sub region. Other major regional centres in the Mid North Coast Region are Coffs Harbour, Port Macquarie and Taree.

GTA Consultants (GTA)[6] indicates that population in the Grafton area (Grafton, Junction Hill, South Grafton and Clarenza) will grow at a rate of 1.6[7] per cent per annum between 2011 and 2049[8]. These in turn are based on population forecasts developed from information provided by Clarence Valley Council (CVC) and the Department of Planning and Infrastructure.

These forecasts are based on the dwelling targets established in the Mid North Coast Regional Strategy which identified the need for a minimum of 7,100 dwellings in the Clarence sub-region to 2031. While the Strategy document identified a growth rate of 1.1 per cent across the Mid North Coast as a whole, it identifies Grafton as a major regional centre and one of the four main focal points for growth in the region.

Clarence Valley Council provided a breakdown of the dwelling locations which identified 6,297 new dwellings within Clarence Valley Council as well as their distribution within the Council area based on land capacity. **Table 1** below shows the locations of new dwellings that are within the study area.

---

3 While the recently developed Grafton Shopping World, located on Fitzroy Street, has shifted some of the commercial and retail focus away from the main street environment (Prince Street) to an internalised shopping mall, its close proximity to Prince Street has helped to keep the town centre intact.

4 Jetty Research 2011, *Additional crossing of the Clarence River at Grafton, Online Business Survey Report*, Prepared for the Roads and Traffic Authority, June 2011, p.12.

5 NSW Department of Planning 2009, *Mid North Coast Regional Strategy,* NSW Government.

6 GTA Consultants 2012, *Main Road 83, Summerland Way, Additional Crossing of the Clarence River, Grafton, Route Options Development Report – Technical Paper: Traffic Assessment*, p.6.

7 This rate of growth is significant when compared to forecasts by NSW Planning and Infrastructure which estimates growth at around 1 per cent (2011 – 2036) for Sydney and the Mid-North Coast, NSW.

8 The growth rate is based on advice from Clarence Valley Council (CVC). It assumes that land capacity of the area will be taken up over a 20 year period to 2031, and then extrapolated to 2041 for our 30 year time horizon. In reality, the uptake on the available land and therefore increase in population may take longer than assumed.

Table 1: Forecast dwelling locations in Grafton

Area	Dwellings 2010 – 2021	Dwellings 2021 – 2031
Clarenza	375	375
Grafton	200	0
Junction Hill	500	500
South Grafton	300	330
Total	**1,375**	**1,205**

The CVC recommended the following occupancy rates to convert dwellings to persons:

- 2.47 persons per household was adopted for the period 2010 – 2021; and
- 2.41 persons per household was adopted fort the period 2021 – 2031.

Adopting the above new dwellings and household rates results in an additional 3,396 persons by 2021 and a further 2,904 persons between 2021 and 2031 as outlined.

Table 2 indicates that population growth in the Grafton area (Grafton, Junction Hill, South Grafton and Clarenza) is expected to occur at a rate of approximately 1.6 per cent per annum linear from 2010 for the 31 year period from 2010.

Table 2: Population growth in Grafton

	Year			
Location	**2010**	**2021**	**2031**	**2041**
Grafton	10,761	11,255	11,255	11,255
Junction Hill	1,015	2,250	3,455	3,455
South Grafton	6,065	6,806	7,601	7,601
Clarenza	684	1,610	2,514	5,418
Total	**18,525**	**21,921**	**24,825**	**27,729**
Growth (Linear Growth from 2010)[9]		3,396 (1.6 per cent per year)	2,904 (1.6 per cent per year)	2,904 (1.6 per cent per year)

Growth to year 2021 is expected to occur in Grafton, Junction Hill, South Grafton and Clarenza. Growth between years 2021 and 2031 is expected to be concentrated in Junction Hill, South Grafton and Clarenza. Between years 2031 and 2041 the majority of growth will occur in Clarenza. The geographical profile of population growth is shown in **Figure 3** and **Figure 4** below[10]. The rate of growth of population indicates that the demand for cross river access from the residential areas in South Grafton will continue and increase.

9 Growth beyond 2031 is assumed to be at the same linear growth rate.

10 GTA Consultants 2011a, *Additional crossing of the Clarence River at Grafton, Preliminary Route Options Report – Part Two, Volume 2 Technical paper - Strategic Traffic Assessment*, November 2011, p. 30.

Figure 3: Population growth in the Grafton area (2011 – 2029)

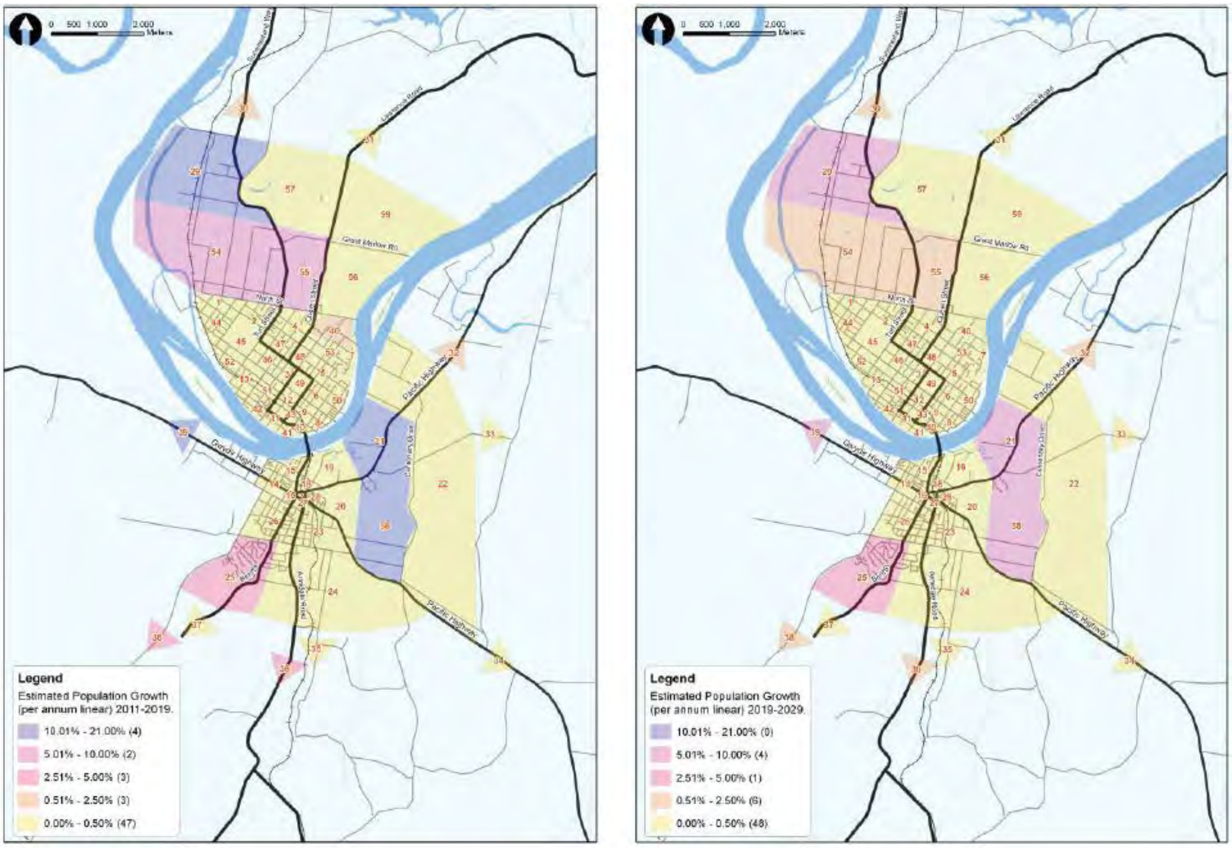
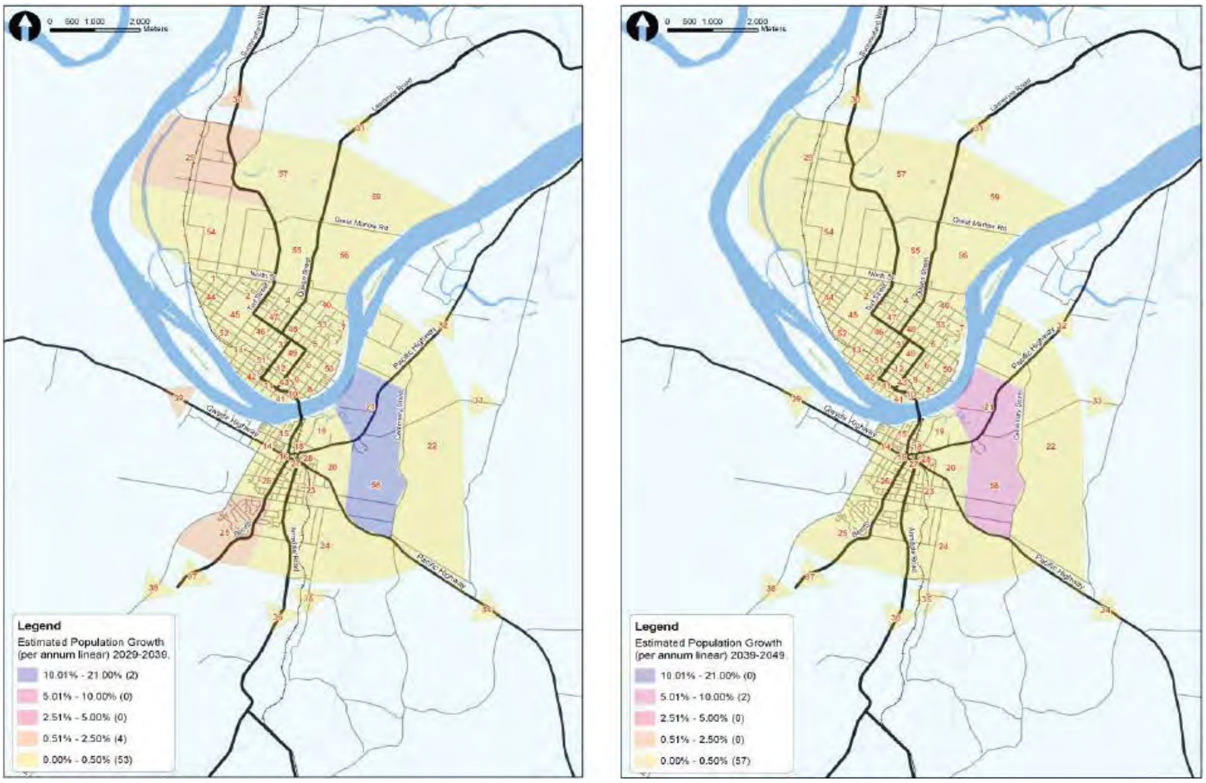


Figure 4: Population growth in the Grafton area (2029-2049)



2.3 Defining the existing transport challenges

While Grafton and South Grafton have respective residential and employment centres, forecast growth in population is expected to add to the existing focus on residential land uses in South Grafton. This will increase demand for trips crossing the River to access employment and services concentrated in Grafton. Population growth in the Grafton area is expected to increase the demand for bridge crossings by 108 per cent over the next 30 years[11].

The increase in the demand for river crossings is not in itself a problem. Negative social, environmental and economic outcomes occur when the capacity and design of the existing transport network cannot accommodate the growth in the number of trips. The reasons for a network's inability to accommodate these changes (effectively and efficiently) comprise the problem. The key transport problems in the Grafton area relate to:

- the capacity of key road links;
- the design of key road links;
- the extent to which travel between key ODs rely on specific routes; and
- the lack of available alternative routes linking the key ODs.

2.3.1 Inefficient configuration and capacity of existing infrastructure

The existing road linking Grafton and South Grafton comprises a four hundred and thirty-eight metre (m) long double deck steel bridge (see **Appendix A**). The lower deck comprises a railway track and two pedestrian/cyclist lanes, while the upper deck comprises two-way road lanes.

Lane widths (see **Figure 5**) constrain capacity to carry the expected growth in the number of trips. The theoretical capacity[12] of the bridge could be considered in the range of 900 to 1,400 vehicles per hour in one direction. Traffic counts undertaken in August 2010 indicate that the bridge was carrying 1,360 vehicles per hour in the northbound direction during the AM peak and 1,330 vehicles per hour in the southbound direction in the PM peak. Based on the traffic flows recorded on the bridge and the information set out in the Austroads Guide, it is apparent that the peak hour traffic flows across the bridge are at, or very close to, capacity on the bridge.

---

[11] GTA Consultants (2012, p. 6).

[12] Austroads 2009, *Guide to Traffic Management Part 3: Traffic Studies and Analysis*, Austroads.

Figure 5: Summerland Way – lane configuration and capacity

Source: Google Maps (2012)

In addition to capacity constraints on the bridge, the configuration of approaches to the bridge also raises a number of transport challenges. Significant queuing and delays occur (during the morning and afternoon peaks) on the bridge approaches as the two lanes of traffic (in each direction) approach the bridge, Fitzroy Street southbound and Bent Street northbound must merge into a single lane on the bridge. **Figure 6** below shows the southern approach to the Clarence River during the AM peak.

Figure 6: Southern approach to Clarence River Bridge during the AM peak

Source: RMS

The existing road also has tight bends on either end of bridge deck. The 'kinks' accommodate the separation of the roadway from the rail line below (see **Figure 7**). It is often necessary for smaller vehicles to stop prior to the bends to make way for larger vehicles which are unable to negotiate the bends while remaining in their own lane. This creates a risk of traffic crashes and also causes traffic in either direction to slow, which increases congestion and delays. There is also a B-double ban on the existing bridge during peak periods – which restricts freight movement.

Figure 7: Grafton Bridge 'kinks'

Source: Google Maps (2012)

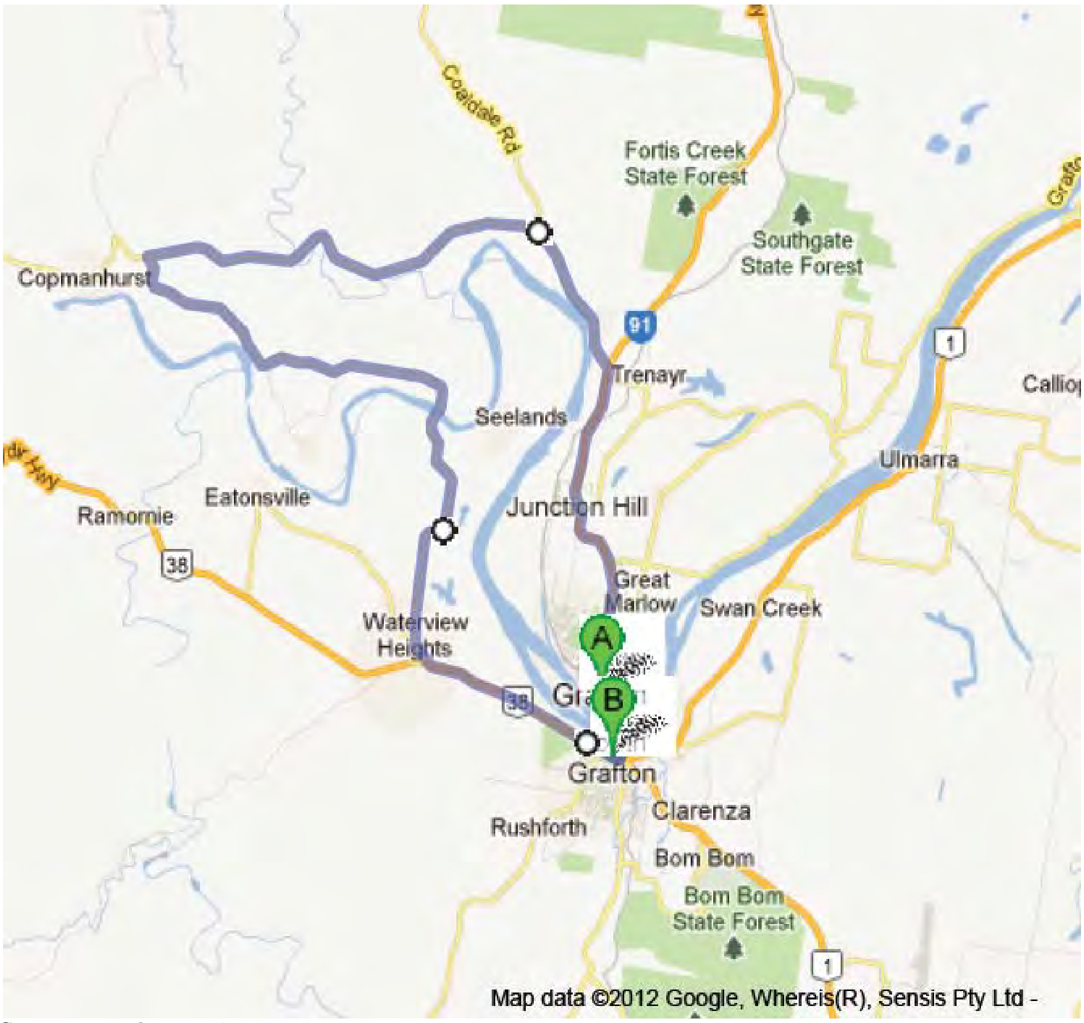
2.3.2 Reliance on the existing bridge

The reliance on the existing route across the Clarence River is attributable to two main factors:

- the trip ODs implied by the existing land use pattern (discussed above); and
- the absence of practical alternative routes across the Clarence River.

The absence of a practical alternative route is the key challenge to accommodating the expected growth in trip demand. The trip length between Grafton and South Grafton (using the existing bridge) is approximately 3 km (see **Figure 2**). The figure below shows an alternative route via Rogan Bridge Road and the Gwydir Highway. The trip distance in comparison to the existing route is significantly longer at around 60 km.

Figure 8: Alternative River crossing route – Rogan Bridge Road and Gwydir Highway



Source: Google Maps (2012)

The reliance on the existing cross river route is clearly demonstrated in an OD survey conducted[13] by GTA[14]. The survey indicates that 97 per cent of trips which crossed the Grafton Bridge started and/or finished in Grafton or South Grafton. In particular GTA found that:

- approximately 63 per cent of northbound vehicles crossing the Clarence River have an origin in South Grafton
- approximately 90 per cent of southbound vehicles crossing the Clarence River have an origin in Grafton and 65 per cent travel to a destination in South Grafton
- approximately 62 per cent of heavy vehicles travelling northbound across the Clarence River have an origin in South Grafton and 80 per cent travel to a destination in Grafton
- approximately 72 per cent of heavy vehicles travelling southbound across the Clarence River have an origin in Grafton and 56 per cent travel to a destination in South Grafton.

[13] The survey was undertaken between 5 am and 7pm on 19th August 2010.

[14] GTA Consultants (2012, p. 4).

Moreover, the traffic demand modelling undertaken by GTA[15] indicates that trip ODs which involve a bridge crossing account for large proportion of network trips. **Figure 9** below indicates that during the AM and PM peak periods, over 30 per cent of network trips cross the Clarence River use the existing route. This proportion increases to nearly 40 percent by 2049.

Figure 9: Number of bridge crossings as a proportion of total trips

Year	AM Peak (7am to 9am)			PM Peak (3pm – 5pm)		
	Trips crossing bridge	Total trips	% crossing bridge	Trips crossing bridge	Total trips	% crossing bridge
2011	3,783	12,456	30.37	4,603	14,641	31.44
2019	4,285	14,040	30.52	5,549	15,963	34.76
2029	6,103	18,130	33.81	7,507	20,554	36.52
2039	7,152	21,232	33.69	8,627	23,833	36.20
2049	8,099	23,047	35.14	9,544	25,577	37.31

Source: GTA (2012)

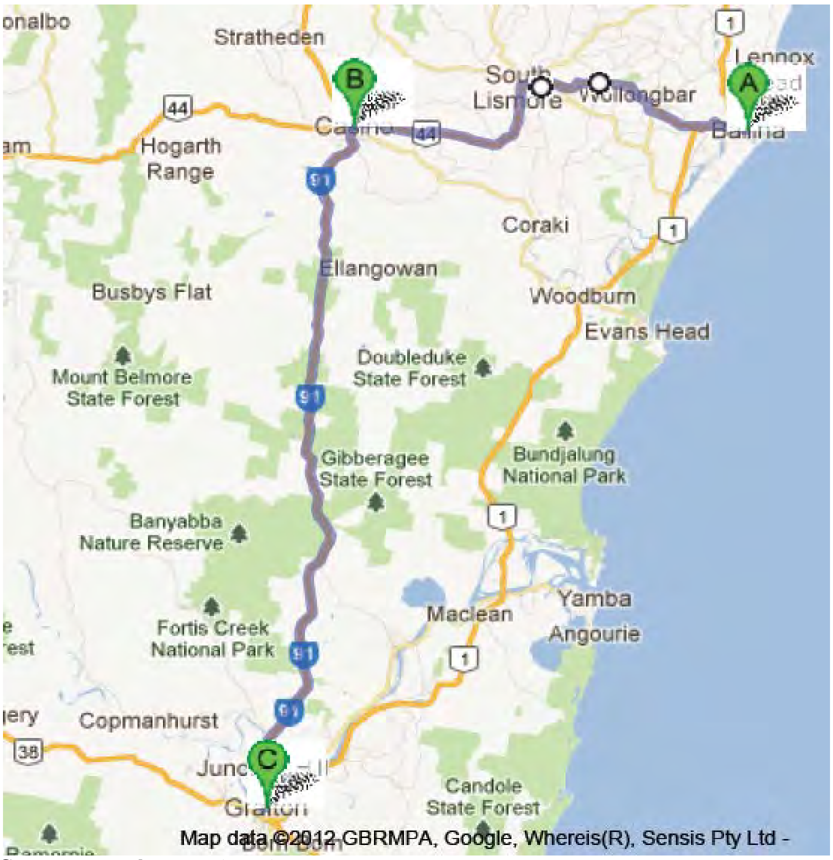
2.3.3 Network redundancy

The existing cross-river route provides network redundancy during incident responses on the Pacific Highway – particularly during flood events and traffic incidents. This role exacerbates the problems discussed above. For example, in January 2012, flooding led to the closure of the Pacific Highway near Grafton and at Corindi. Southbound light and heavy vehicles were diverted at Ballina onto the Bruxner Highway to Casino, then onto Summerland Way to Grafton. The extent of diversion shown below in **Figure 10** demonstrates the importance of the river crossing to the regional road network.

It is noted that the reliance on the bridge as a detour will be significantly reduced following the upgrade of the Pacific Highway to dual carriageway.

15 *ibid.*

Figure 10: Diversions to Summerland Way during flooding of Pacific Highway



Source: Google Maps (2012)

2.4 Outcomes of the existing transport challenges

The transport problems identified above have led to a number of negative outcomes:

- there are significant traffic delays and constraints on the existing Grafton Bridge during peak periods;
- there are delays to emergency vehicles responding to incidents on the Pacific Highway due to the delays caused on the existing bridge[16];
- there is conflict with heavy vehicles on the bends on the existing bridge;
- there is a B-double ban on the existing bridge during peak periods – which restricts freight movement;
- the existing bridge is causing an impact on access to services and facilities due to delays[17];

16 However, this risk is mitigated to some extent by contingency plans by emergency services including the placement of personnel and vehicles on either side of the bridge during the peak periods.

17 Jetty Research (2011).

- there are safety issues with the pedestrian/cycle access on the existing bridge – no dedicated pedestrian or bicycle paths are provided at the vehicular level (bridge upper deck)[18]; and
- the existing bridge and approach roads do not facilitate the economic viability of the South Grafton business area (Skinner St) – this area is bypassed by the current approach roads.

These challenges impact negatively on the following traffic outcomes:

- network vehicle hours travelled (VHT) and vehicle kilometres travelled (VKT) over the entire road network;
- estimated average trip travel times across the network and between key ODs such as: Grafton and South Grafton; the Pacific Highway and the Summerland Way; and
- estimated average total delay across the network.

Deterioration in network performance increases the economic cost of travel. Significant increases in trip costs can change travel behaviour, particularly for commercial trips. For example, a survey of businesses and bus companies in the region found that[19]:

- most companies established routes to avoid areas of peak hour traffic congestion;
- some companies have arranged business times so that deliveries are made outside of the peak periods, although at times this was noted to be unavoidable;
- the bridge curfew during morning and afternoon peak periods has a significant effect on business operations (e.g. scheduling);
- late running of services due to bridge congestion led to additional cost in the operation of catch up and head off services; and
- perceptions of incidents on the bridge were a concern due to a lack of access to and from each side of the bridge in emergency situations for ambulances and the like.

More broadly, traffic delays in peak periods are changing people's travel behaviour and daily activity patterns, and as a result may be constraining development. It would appear from the traffic count data that bridge users have timed their trip to avoid the peak period traffic congestion. Grafton and South Grafton are to some extent operating as separate towns[20].

---

[18] Roads and Maritime Services (RMS) 2012a, *Additional crossing of the Clarence River at Grafton, Preliminary Route Options Report*, Final January 2012, p.40.

[19] GTA (2011a, p. 3).

[20] ibid (p. 5).

2.5 Objectives and outcomes sought from a solution

The key objectives for the additional crossing of the Clarence River at Grafton are to:

- enhance road safety for all road users over the length of the project;
- improve traffic efficiency between and within Grafton and South Grafton;
- support regional and local economic development;
- involve all stakeholders and consider their interests;
- provide value for money; and
- minimise impact on the environment.

The following supporting objectives assist in achieving the project objectives.

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

- reduce the potential for road crashes and injuries on the bridge and approaches including any intersections and connecting roads
- provide safe facilities for pedestrians and cyclists

Improve traffic efficiency between and within Grafton and South Grafton

- provide efficient access for a additional crossing of the Clarence River and for the State road network
- 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
- provide adequate vertical clearance for heavy vehicles
- consider demand management strategies to minimise delays to local and through traffic.

Support regional and local economic development

- provide transport solutions that complement existing and future land uses and support development opportunities
- provide improved opportunities for economic and tourist development for Grafton
- provide for commercial transport including B-Doubles where required
- 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
- provide navigational clearance from the additional crossing for river users.

Involve all stakeholders and consider their interests

- develop solutions that consider community expectations for the project
- satisfy the technical and procedural requirements of RMS with respect to the planning and design of the project

- integrate input from the community into the development of the project through the implementation of a comprehensive program of community consultation and participation.

Provide value for money

- achieve a justifiable benefit-cost ratio at an affordable cost
- develop a strategy to integrate future upgrades into the project.

Minimise impact on the environment

- minimise the impact on the social and economic environment, including property impacts
- minimise the impact on residential amenity, including noise, vibration, air quality etc
- minimise the impact on heritage
- minimise impact on the natural environment
- provide a project that fits sensitively into the built, natural and community context
- minimise flooding impact caused by the project.

2.6 Definition of the Base Case

The Base Case for this economic evaluation comprises the 2011 road network. It also includes four upgrade projects that would be required by 2019 with and without the additional crossing route options. These upgrade projects include:

- upgrading Pound Street to two lanes in each direction between Villiers Street and Prince Street;
- upgrading of Gwydir highway to two traffic lanes in each direction between Pacific Highway and Bent Street;
- upgrading of the Villiers Street and Dobie Street roundabout to improve turning movements for heavy vehicles; and
- upgrading the Gwydir Highway and Skinner Street roundabout from a single roundabout to a two lane roundabout.

The Base Case, as with the route options, also assumes that the Glenugie to Tyndale Upgrade of the Pacific Highway (which bypasses South Grafton) is opened to traffic by 2019.

The direct infrastructure costs included in this economic evaluation are incremental, ie. they are net of direct infrastructure costs that would also occur with the Base Case. Therefore, the Base Case is not explicitly costed. However, as discussed in **Section 6.1**, the costs of these projects are deducted from route option costs to ensure the route option costs are incremental.

2.7 Description of the proposed route options

The process used to identify the six short-listed route options is discussed in Chapter 1.1 of the Route Options Development Report. These six route options are described below in **Table 3**.

Table 3: Additional crossing route options by corridor

Route Option	Description
E	Option E includes a new bridge upstream of the existing bridge where it would connect the Gwydir Highway at Cowan Street in South Grafton to Villiers Street in Grafton. The vertical clearance of Villiers Street would be upgraded to 5.3m to accommodate heavy vehicles under the railway viaduct. Both the new and existing bridge would have one lane in each direction.
A	Option A consists of a new bridge constructed slightly upstream and parallel to the existing bridge. This option would connect Bent Street in South Grafton to Fitzroy Street in Grafton. The vertical clearance of Villiers Street would be upgraded to 5.3 m to accommodate heavy vehicles under the railway viaduct. The new bridge would have two northbound lanes and one southbound lane and the existing bridge will be converted to one southbound lane.
C	Option C involves building a new bridge slightly downstream and parallel to the existing bridge. This option connects the Pacific Highway at Iolanthe Street in South Grafton to Clarence and Pound Street in Grafton. Villiers Street would have its vertical clearance upgraded to 5.3m to accommodate heavy vehicles under the railway viaduct. Under Option C, both bridges would have one lane in each direction.
11	Option 11 involves the construction of a new bridge downstream of the existing bridge where it would connect the Pacific Highway at McClaers Lane in South Grafton to Fry Street in Grafton. Option 11 would include two viaduct structures between the Pacific Highway and the Clarence River. It would also include an upgrade of Fry Street to enable it to meet future traffic volumes and of Villiers Street to accommodate a 5.3m vertical clearance for heavy vehicles beneath the railway viaduct. Both bridges would have one lane in each direction.
14	Option 14 involves the construction of a new bridge downstream of the existing bridge where it connects Pacific Highway at Centenary Drive in South Grafton and North Street via Kirchner Street at Grafton. Both the new and existing bridge would be one lane in each direction. Option 14 involves a number of constructions and upgrades: • Kirchner, North and Turk Street would require an upgrade to accommodate future traffic volumes; • a viaduct structure would be required from the Pacific Highway to the Clarence River; and • Villiers Street would need to be upgraded to increase the vertical clearance for heavy

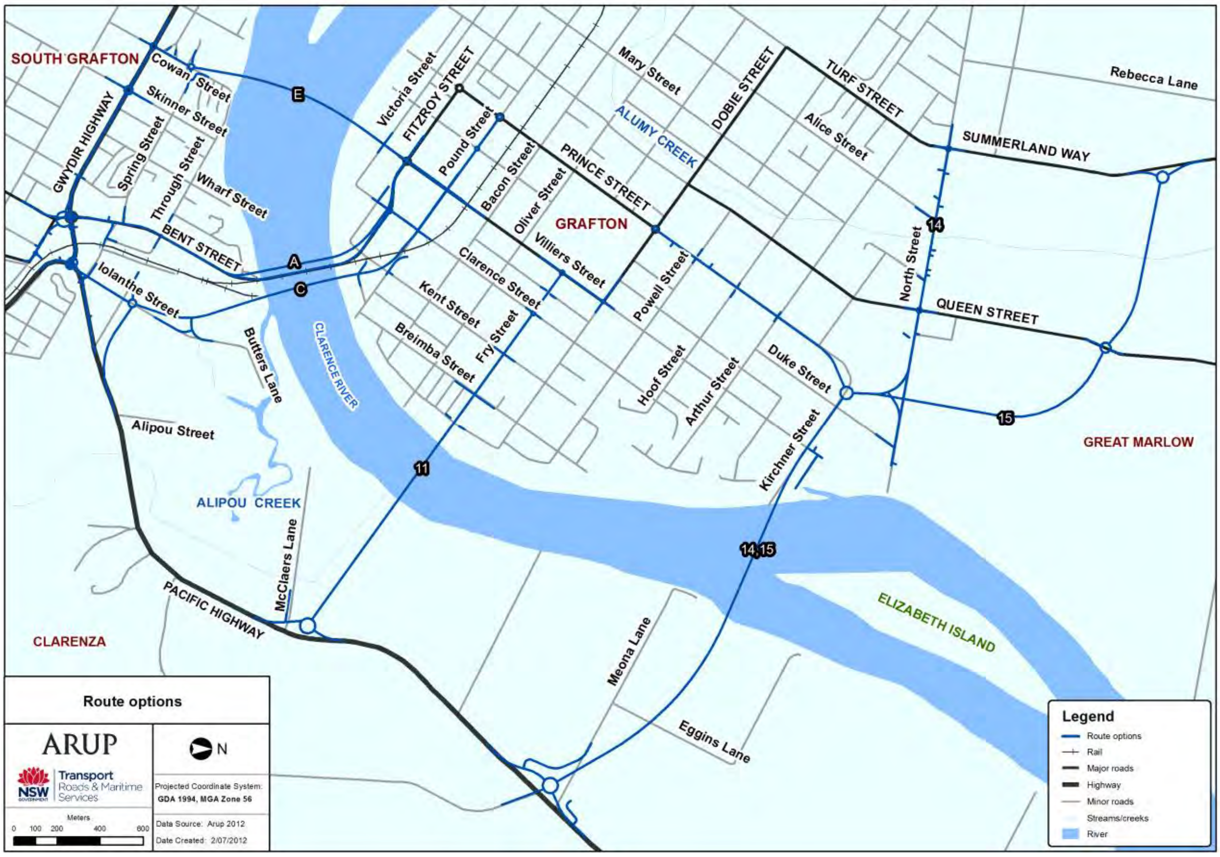
Route Option	Description
	vehicles to 5.3m. • Prince, Kirchner and Dobie Street would need to be upgraded for heavy vehicle access into central Grafton.[21]
15	Option 15 involves the construction of a new bridge downstream of the existing bridge where it connects Pacific Highway at Centenary Drive in South Grafton to Summerland Way via Kirchner Street in Grafton. All construction aspects are the same as Option 14; the only difference is the alignment of the bridge after it connects in Grafton. As a result, Option 15 has the same implications as Option 14 in constructing an additional crossing of the Clarence River.

Source: RMS (2012)

[21] ARUP (2012) *Additional Crossing of the Clarence River at Grafton – Preliminary Route Options Report Final*, prepared for Roads and Maritime Services, p121

The short-listed route options are illustrated in **Figure 11**.

Figure 11: Map of short listed route options



Source: Arup

3 Economic evaluation methodology

This chapter outlines the methodology for the economic evaluation. It is based on the Road User Cost Benefit Analysis (RUCBA) approach. This approach uses discounted cash flow analysis (DCFA). The key assumptions of DCFA such as discount rate and evaluation period are defined. This chapter also highlights key aspects of the economic evaluation methodology including the specific treatment and role of traffic demand produced from a microsimulation traffic model and selection of appropriate traffic expansion factors to estimate benefits of relieving network congestion during peak periods.

3.1 Economic evaluation approach

The economic evaluation of the six route options in this Report is undertaken using CBA. CBA measures the economic viability of a route option by comparing the additional benefits of the route option with the additional costs[22] with a route option, over a defined evaluation period.

Microsimulation traffic modelling was used to estimate the traffic demand for this economic evaluation. This approach was selected over a strategic (unconstrained) link based traffic model given the significant transport problems in the Grafton area (see **Section 2.3**). As a vehicular based approach, microsimulation is ideal for simulating traveller behaviour in congested road networks. However, it poses a number of challenges to producing outputs for economic evaluation including the difficulty in producing sufficient capacity for long term traffic forecasts and the potential for the modelling to suppress travel altogether beyond certain levels of road congestion. These challenges are identified and addressed in **Section 4.2.1**. Microsimulation traffic modelling is discussed further in the Route Options Development Report: Technical Paper – Traffic Assessment.

The microsimulation modelling of the Grafton area was unable to produce traffic demand forecasts (for all forecast years) with the Base Case. While the discussion in **Chapter 4** outlines an approach for dealing with this issue, it is applied with a number of qualifications and caveats. Therefore, the results should only be used to demonstrate the ***relative*** economic merit of the route options (ie. a comparative assessment), rather than providing an accurate measure of the absolute net economic benefit of a particular route option.

A route option is considered economically viable if the additional benefits exceed the additional costs.

Road based transport options are commonly appraised using Road User Cost Benefit Analysis (RUCBA). RUCBA is an applied CBA framework which defines and measures the key benefits of road transport options as reductions in:

- vehicle travel time costs (VTTC);
- vehicle operating costs (VOC);
- crash costs (CC); and
- costs of environmental and social effects from vehicle use (externalities).

[22] The additional or incremental benefits and costs are measured with respect to the Base Case.

The first three economic costs are collectively referred to as 'road user costs', while environmental and social effects from transport use are referred to as 'external costs'.

Changes in road user and external costs are compared to the fixed and recurrent infrastructure costs to assess economic viability of the route options.

The RUCBA is applied using discounted cash-flow analysis (DCFA). The DCFA is based on a spreadsheet model which 'streams' the annual benefits and costs with the Base Case and the route option. These annual values are presented over a defined period into the future (commonly 30 years from the first full year of operation of the route option).

The DCFA converts all future values to a common time dimension. The common time dimension in DCF is referred to as Present Value (PV). Present values are calculated by discounting future values (which reflects the time value of money, ie. a dollar today is worth more than a dollar in the future) using a recommended discount rate.

The general assumptions used in this DCFA:

- cashflows are expressed for financial years ending June (YEJ);
- cashflows are included in the period within which the associated expenditures or benefits occur;
- the Base Year of the economic evaluation is 2010/11[23];
- all values are expressed in real dollars[24];
- prices are expressed in 2011/12 dollars (unless otherwise stated);
- all road user cost parameters are sourced from the latest version of the RMS's Economic Analysis Manual, ie. 2009[25].
- the evaluation period starts in 2019/20[26] and ends in 2048/49. This is in line with the RMS Guidelines which requires that projects are evaluated over a 30 year period from the first year of full operation of the road initiative;
- future net benefits are discounted to the respective base years using a real discount rate of 7 per cent[27];
- incremental road maintenance cost is assumed to be zero for each scenario (see **Section 6.2**); and
- the demand modelling assumes that the transport effects of the ultimate route option design will be realised in the first year of operation. In reality, some infrastructure components of the route options may be staged over time.

---

23 To maintain consistency, the Base Year is assumed to be 2010/11 to maintain consistency with the Base Year of the traffic demand modelling.

24 Real values exclude inflation.

25 The latest road user and external cost parameters are included in Appendix B of RMS's Economic Analysis Manual 2009. Inquiries made during this study indicate that Austroads are yet to release updated parameter values for Road User Effects, and that provisional indicators suggest that the current valuation of benefits are approximately 6.4 per cent higher than those shown in the 2009 version of the RMS's Economic Analysis Manual.

26 For the purposes of assessment, it is assumed that the additional crossing would be opened to traffic in 2019. Since the economic evaluation is based on financial years, the first full year of operation is 2019/2020.

27 In line with guidance from Infrastructure Australia, NSW Treasury and RMS.

This RUCBA reports on the following measures of economic performance:

- Net Present Value (NPV) – the difference between the present value (PV) of total incremental benefits (avoided road user and external costs) and the present value of the total incremental infrastructure costs. The NPV is used as the primary measure of merit where budgets are un-constrained; and

- Benefit Cost Ratio (BCR) – ratio of the PV of total incremental benefits over the PV of total incremental costs. The BCR is used as the primary measure of merit where budgets are constrained.

Route options with a positive NPV indicate that the incremental benefits exceed the incremental infrastructure costs over the evaluation period. A BCR greater than 1.0 indicates that a project is also economically viable. If there is no constraint on the availability of funds, NSW Treasury guidelines suggest the use of NPV as this enables economic benefits to be maximised. The BCR is the most commonly used evaluation criteria within the RMS.

3.2 RUCBA methodology

The RUCBA approach is outlined in RMS's Economic Analysis Manual[28]. However, specific methodologies are required at certain stages. These methodologies are identified below and reference is provided to the relevant section in the report where these specific treatments are discussed.

Having defined and documented the: transport problems (see **Section 2.3**); objectives and outcomes of a solution (see **Section 2.5**) and the proposed solutions and the Base Case (see **Section 2.6**), the following comprise the key steps in the RUCBA:

- 'streaming'[29] of costs with the Base Case and route options. These are based on cashflow profiles provided by Arup [30]. The key issue with this task is ensuring that the costs are appropriately measured and defined for economic (rather than financial) evaluation. This includes ensuring that costs are in real and resource terms, excluding inflation and transfers such as taxes and profit. The detailed costing methodology is outlined in **Chapter 6**.

- collection and 'streaming' of traffic demand forecasts. This is the first step in benefit estimation. Conventional traffic outputs for economic evaluations include network VKT, VHT, stops and trips, with the Base Case and the route option. The key methodological issues outlined in **Chapter 4** includes:

    - clear identification of the land use and population assumptions adopted and whether these change between the Base Case and the route options;

    - identification of the appropriate peak period to daily forecast to ensure that the economic benefits are not overestimated; and

    - developing an approach to address suppressed demand with the Base Case due to capacity constraints with microsimulation traffic modelling.

- estimation of 'conventional' road user and external costs. The methodology for this task is outlined in **Chapter 5** and involves sourcing and applying the relevant economic unit costs to the annual

---

28 RMS 1999, *Economic Analysis Manual,* Version 2, RMS, NSW.

29 Streaming refers to assigning the cost or benefit to the year in which it is expected to occur. Capital costs are streamed in line with the construction profile of the route options (see Section **6.1.3**). Benefits in this economic evaluation are defined as reductions in road user and external costs (compared with the Base Case). The road use and external costs are in turn a function of changes in traffic demand and hence, benefits are streamed in line with the traffic demand forecast profiles. The role of traffic demand forecasts in estimating road user and external costs is discussed in **Section 4.2**.

30 Email dated 13th February 2012.

demand estimates developed above. Conventional benefits estimated include reductions in: travel time cost, vehicle operating cost, stop costs, crash costs and environmental and social externalities such as Greenhouse Gas Emissions (GHG) and water pollution;

- **Chapter 7** discusses the spreadsheeting analysis used to combine the annual benefits and costs with the route options. CBA is based on a DCF which forecasts the annual benefits and costs over an evaluation period extending 30 years from the first full year of operation of the route option. These future costs and benefits are then 'discounted' using a real discount rate of 7 per cent. These benefits and costs are combined (using specific equations) to produce measures of economic merit including the BCR and NPV. This task also includes sensitivity analyses which assess the robustness of the economic viability of the route option under alternative assumptions relating to different levels of capital cost, demand, land use assumptions, discount rate etc...

4 Demand (traffic) analysis

This Chapter details the role of traffic demand forecasts in the economic evaluation. It also presents estimated traffic demand for each of the additional crossing route options. Finally, it discusses the approach used to address the challenges posed by using microsimulation traffic demand forecasts for economic evaluation.

4.1 Background

4.1.1 Traffic forecasting approach

The traffic forecasts used in this economic evaluation are produced by GTA using Q-Paramics, a microsimulation traffic model. The traffic modelling approach and outputs are detailed in GTA's technical paper[31].

4.1.2 Study area

The study area modelled includes the existing Grafton Bridge connecting Grafton and South Grafton, as well as the areas of Junction Hill, Carrs Creek, Great Marlow, Clarenza, Waterview Heights and South Grafton. The model considers traffic movements within these areas and includes traffic movements to and from the Pacific Highway north and south, the Summerland Way, the Gwydir Highway and Armidale Road.

The study area is shown in **Appendix B**.

4.1.3 Model period and years

The flow of traffic varies throughout the day. Theoretically, traffic demand could be forecast on an hourly basis for a 24-hour period. However, traffic demand is usually estimated for specific blocks or periods during the day which share common traffic flow characteristics.

GTA forecast traffic demand for a two hour period in both the AM peak (7am to 9am) and PM peak (3pm-5pm). The decision on the model period is based on the need to assess effects in different time periods compared with using average annual daily estimates. In the case of the Grafton Bridge, peak travel places the greatest demand on bridge capacity.

The model has a base year of 2011 and forecast years 2019, 2029, 2039 and 2049.

4.1.4 Expansion factors

The microsimulation model is a peak period model.

GTA developed a series of factors that are used to translate the peak period volumes to daily volumes. Congestion on the existing bridge and approaches is largely a peak phenomenon. Adopting an expansion factor which would apply peak congestion relief benefits to trips which are taken outside the peak, and hence would not have experienced the same level of congestion, would likely overestimate the net economic benefits of the route options.

---

[31] GTA (2012, p.7).

Therefore, GTA undertook an exercise which involved re-running the traffic demand model for each of the six route options in unconstrained conditions. The exercise identified the hourly VKT and VHT for the unconstrained conditions for each of the route options. Finally, using existing daily traffic counts, the unconstrained VKT and VHT were apportioned over the entire day to determine appropriate peak to daily values. These daily values are then annualised using a factor of 335[32].

4.1.5 Traffic growth – future years

A number of key assumptions were used in undertaking the microsimulation modelling assessment, in particular those for the future year model. A summary of the key assumptions used by GTA to determine the future year growth is provided by GTA[33]:

- the forecasts do not reflect the potential traffic impacts (particularly on heavy vehicles) of the proposed inland port located in the vicinity of the NSW and Queensland border;
- the forecasts (conservatively) assume that the future industrial estate and freight hub planned for Casino will have no impact on heavy vehicle movements on the Summerland Way;
- all future year modelling has assumed that the future upgrade of the Pacific Highway which would bypass of South Grafton would be open by 2019;
- it is assumed that infill development would offset the population reductions due to declining household size predicted by the Australian Bureau of Statistics. Therefore, the zonal population forecasts for the traditional areas of Grafton and South Grafton are assumed to remain constant;
- the key residential growth areas include Junction Hill, South Grafton,Waterview Heights, and Clarenza. The development sequence assumed is Junction Hill and South Grafton, followed by Waterview Heights and finally Clarenza; and
- growth in cross-river demand was constrained in the model between 2011 and 2019 due to the limited capacity of the existing bridge and as such traffic was redistributed within Grafton and South Grafton in order to realistically capture anticipated growth.

The network traffic growth assumptions are shown below in **Table 4**.

Table 4: Network traffic growth assumptions

Year	AM Peak (7am to 9am)		PM Peak (3pm to 5pm)	
	Total Trips (Vehicles)	Traffic Growth Rate (% per year)	Total Trips (Vehicles)	Traffic Growth Rate (% per year)
2011	12,456		14,641	
2019	14,040	1.5	15,963	1.1
2029	18,130	2.6	20,554	2.6
2039	21,232	1.6	23,833	1.5
2049	23,047	0.8	25,577	0.7

Source: GTA (2012, p. 18)

32 GTA (2012).

33 GTA (2011a, p.28).

4.2 The role of traffic demand in RUCBA

Traffic demand measures the use of the road network, with and without the route options. It therefore also indicates the resources used in the course of undertaking a trip on the road network. The primary objective of most road infrastructure initiatives is to reduce the resource cost of trips on the network.

The total economic cost of a trip within RUCBA is determined by the type of road treatment being analysed and defined according to transport economic theory. **Table 5** below identifies the conventional road user costs which comprise the total economic cost of a trip. Importantly, it also identifies the unit cost driver, which relates to the estimated measure of traffic demand.

Table 5: Determinants of road user costs

Road user cost (RUC)	Unit	Description	Determinant
Savings in travel time costs (VTT)	$/vehicle hour travelled	• private occupant travel time costs; • business occupant travel time costs; • commercial driver wage cost; and • freight contents delay costs – reflects the impacts of goods delays on the productive process of the economy.	• vehicle type (e.g. car, light commercial, rigid truck, etc); • vehicle composition (% of traffic accounted for by respective vehicle types); • distribution of traffic flow by time of day; and • vehicle occupancy.
Vehicle operating costs (VOC)	$/vehicle kilometre travelled	• fuel and lubricant costs; • tyre costs; • vehicle repair and maintenance costs; • depreciation, consumption of capital investment; and • vehicle operator overhead costs.	• vehicle type (e.g. car, light commercial, rigid truck, etc.); • vehicle composition (% of traffic accounted for by respective vehicle types); • travel speed; • pavement condition; and • grade and curvature.
Vehicle stops	$/stop	• fuel and lubricant costs; • tyre costs; • vehicle repair and maintenance costs; and • depreciation, consumption of capital investment.	• number of stops
Crash costs	$/incident	• fatal crash costs; • injury crash costs; and • property damage crash costs	• crash rates; • type of road; • vehicle type; and • vehicle occupancy.
Environmental external costs	$/vehicle kilometre travelled	• noise; • air pollution; • water pollution; • greenhouse; • nature and landscape; and • urban separation costs.	• vehicle type; and • urban/rural setting.

Source: RMS (RTA) (1999)

4.2.1 Treatment of suppressed demand with the Base Case

For most projects there are sufficient alternative traffic routes to allow the Base Case model to be established in future years, although travel speeds may be low and travel times high. However, for this project, there are no suitable alternative routes to cross the Clarence River in Grafton and cross-river traffic does not have any choice but to use the existing bridge (see **Section 2.3**).

Economic evaluations undertaken as part of the *Preliminary Route Options Report (PROR)*[34] used traffic demand forecasts produced by strategic traffic models. These models are link based and allow traffic to pass through the network at slower and slower speeds with demand well beyond the practical capacity of the network. The result is that in later years the travel speeds with the Base Case model reduced to unrealistically low average network speeds of less than 5 km/h.

Increasingly, microsimulation modelling is being used in congested traffic conditions, such as the Grafton network. This is because it becomes difficult to forecast sensible performance metrics using strategic link based models[35]. Unlike strategic traffic models, microsimulation is vehicular based and as such, physically prevents vehicles from passing through a congested network. However, adoption of microsimulation modelling for this study means that when the peak cross-river traffic demand exceeds the physical capacity of the link between Grafton and South Grafton then vehicles are unable to pass through the congested network and the result is gridlock in the model. The microsimulation model showed that the existing road network would be over-congested even by 2029 and as a result the Base Case option could not be modelled for 2029, 2039 or 2049. Only a 2019 Base Case microsimulation model was established.

This is a stylised outcome of the modelling. In reality, travellers would undertake any number of adaptations with the Base Case, including but not limited to:

- re-timing their trip;
- changing the number of trips undertaken;
- changing their route and/or origin and destination.

There could also be more significant land use changes including declines in population and employment growth rates and changes in land use patterns (e.g. location, timing and area of development of residential, commercial and employment lands). These non-marginal changes would in turn impact on the trip generation phase of the traffic demand model and hence, impact total demand.

In this situation, an alternative approach to estimating the economic benefits is adopted. In discussions with RMS it was agreed that benefits would be estimated by generating an indicative Base Case for future years. Establishment of this indicative Base Case acknowledges the reality that the existing road network would continue to function beyond 2019 even without an additional bridge. Travellers would adapt to increasing congestion in the middle of the peak periods by for example re-scheduling trips to less congested periods and would also accept higher levels of future congestion because of the absence of an alternative route.

Development of the indicative Base Case is intended to replicate the increase in delays and congestion that would occur over time without an additional bridge. It is established by taking the 2019 Base Case model and factoring up the annual VKT and VHT parameters at similar rates to the increases observed in Route Options 14 and 15. The reason for adopting the rates of increase for these route options is that due to their distance from the existing bridge and the town centres of Grafton and South Grafton, the majority of the traffic is shown to continue using the existing bridge. Therefore, they are the most constrained in terms of capacity between South Grafton and Grafton and therefore are likely to more closely represent what would happen in the indicative Base Case without a new bridge. In fact this would be a conservative approach, especially for VHT growth, because without the additional bridge it is likely that VHT growth for the Base Case would be higher than for Route Options 14 and 15 which have spare capacity on the new bridge, albeit with longer travel times.

---

34 RMS (2012).

35 Austroads 2006, *The Use and Application of Microsimulation Traffic Models,* AP – R286/06, Austroads, Sydney, NSW, p. 18.

The use of higher VHT growth rates for the Base Case would increase the economic benefits of all of the route options and for this reason adopting the VKT and VHT growth rates from Route Options 14 and 15 is itself a conservative approach. The method would be more likely to underestimate rather than overestimate the economic benefits and BCR of all route options, but ensures that the relativity when comparing the economic performance of all route options is retained. Therefore, for the purposes of this comparative assessment, this is considered a suitable and robust approach.

4.3 Results of traffic demand modelling

The discussion (below) in **Chapter 5** defines the role of the traffic demand modelling outputs in estimating the change in road user and external costs. This discussion indicates that the key traffic parameters include network VHT, VKT, stops and average speeds. These results of the traffic demand modelling are summarised in terms of these parameters below. Each section presents the absolute annual observation for the traffic parameter by forecast year. This is followed by a table which shows the incremental annual observation which is calculated with respect to the Base Case. Negative incremental values mean that the route options lead to a reduction in the respective parameter relative to the Base Case.

4.3.1 Vehicle hours travelled

Table 6 below shows the annualised network vehicle hours travelled by vehicle type, option and forecast year.

Table 6: Annual vehicle hours travelled ('000)

Option	2011	2019	2029	2039	2049
Base Case					
Light	1,822	2,149	3,128	3,760	4,270
Heavy	197	221	322	387	440
E					
Light	1,822	1,729	2,301	2,709	3,013
Heavy	197	178	237	277	303
A					
Light	1,822	1,782	2,373	2,824	3,182
Heavy	197	185	246	291	303
C					
Light	1,822	1,709	2,267	2,678	2,971
Heavy	197	179	237	279	307
11					
Light	1,822	1,673	2,308	2,784	3,075
Heavy	197	175	239	286	314
14					
Light	1,822	1,710	2,478	3,014	3,425
Heavy	197	176	254	304	340
15					
Light	1,822	1,700	2,489	2,963	3,373
Heavy	197	178	257	304	339

Source: GTA (2012)
Note: Private car comprises the 'Light vehicles' category, while the heavy vehicle category includes buses, light commercials, rigid trucks and articulated vehicles.

Table 7 below shows the annualised incremental network vehicle hours travelled by vehicle type, option and forecast year for existing travellers.

Table 7: Incremental annual vehicle hours travelled ('000)

Option	2011	2019	2029	2039	2049
E					
Light	-	-420	-827	-1,051	-1,256
Heavy	-	-43	-85	-111	-136
A					
Light	-	-367	-754	-936	-1,088
Heavy	-	-37	-76	-96	-136
C					
Light	-	-440	-861	-1,082	-1,299
Heavy	-	-42	-85	-109	-133
11					
Light	-	-477	-820	-976	-1,195
Heavy	-	-46	-83	-101	-126
14					
Light	-	-439	-650	-746	-845
Heavy	-	-46	-69	-83	-99
15					
Light	-	-449	-639	-797	-897
Heavy	-	-44	-65	-84	-101

Source: GTA (2012)
Note: Private car comprises the 'Light vehicles' category, while the heavy vehicle category includes buses, light commercials, rigid trucks and articulated vehicles.

4.3.2 Vehicle kilometres travelled

Table 8 below shows the annualised network vehicle kilometres travelled by vehicle type, option and forecast year.

Table 8: Annual vehicle kilometres travelled by forecast year ('000)

Option	2011	2019	2029	2039	2049
Base Case					
Light	77,809	86,458	114,497	134,012	145,733
Heavy	8,709	9,106	12,059	14,114	15,349
E					
Light	77,809	85,828	113,233	132,364	144,111
Heavy	8,709	8,805	11,622	13,486	14,499
A					
Light	77,809	86,750	114,680	134,367	146,333
Heavy	8,709	8,999	11,927	13,951	15,078
C					
Light	77,809	86,205	113,631	133,108	144,924
Heavy	8,709	8,940	11,792	13,768	14,848
11					
Light	77,809	86,212	114,012	133,797	145,567
Heavy	8,709	8,929	11,809	13,760	14,901
14					
Light	77,809	87,247	115,616	135,134	147,112
Heavy	8,709	8,932	11,859	13,774	14,877
15					
Light	77,809	86,893	114,934	134,918	146,858
Heavy	8,709	9,053	12,023	13,968	14,995

Source: GTA (2012)
Note: Private car comprises the 'Light vehicles' category, while the heavy vehicle category includes buses, light commercials, rigid trucks and articulated vehicles.

Table 9 below shows the annualised incremental network vehicle kilometres travelled by vehicle type, option, demand segment and forecast year.

Table 9: Annual incremental vehicle kilometres travelled by forecast year ('000)

Option	2011	2019	2029	2039	2049
E					
Light	-	-630	-1,264	-1,648	-1,621
Heavy	-	-300	-436	-629	-850
A					
Light	-	291	183	355	600
Heavy	-	-107	-131	-163	-271
C					
Light	-	-254	-867	-904	-809
Heavy	-	-166	-267	-346	-501
11					
Light	-	-246	-486	-214	-166
Heavy	-	-177	-250	-354	-447
14					
Light	-	789	1,119	1,122	1,379
Heavy	-	-174	-200	-340	-472
15					
Light	-	434	436	906	1,125
Heavy	-	-53	-36	-146	-354

Source: GTA (2012)
Note: Private car comprises the 'Light vehicles' category, while the heavy vehicle category includes buses, light commercials, rigid trucks and articulated vehicles.

4.3.3 Vehicle stops

Table 10 below shows the annualised network vehicle stops[36] by vehicle type, option and forecast year.

Table 10: Annual vehicle stops by forecast year ('000)

Option	2011	2019	2029	2039	2049
Base Case					
Light	68,209	86,161	173,946	214,972	251,924
Heavy	6,511	8,210	16,575	20,485	24,006
E					
Light	68,209	54,563	76,695	93,333	111,503
Heavy	6,511	5,354	7,468	8,980	10,536
A					
Light	68,209	53,519	74,438	94,129	113,453
Heavy	6,511	5,177	7,191	8,984	10,767
C					
Light	68,209	44,045	61,283	75,709	90,006
Heavy	6,511	4,480	6,212	7,620	9,073
11					
Light	68,209	34,230	60,367	81,953	95,136
Heavy	6,511	3,526	5,919	7,995	9,180
14					
Light	68,209	35,198	70,224	89,508	105,099
Heavy	6,511	3,368	6,579	8,314	9,767
15					
Light	68,209	35,236	72,381	86,644	101,564
Heavy	6,511	3,511	6,906	8,344	9,530

Source: GTA (2012)
Note: Private car comprises the 'Light vehicles' category, while the heavy vehicle category includes buses, light commercials, rigid trucks and articulated vehicles.

[36] The definition of a stop used in this study is a vehicle dropping from a speed above 15 km/h to a speed below 5 km/h.

Table 11 below shows the annualised incremental network vehicle stops by vehicle type, option, forecast year and demand segment.

Table 11: Incremental annual vehicle stops by forecast year ('000)

Option	2011	2019	2029	2039	2049
E					
Light	-	-31,597	-97,252	-121,639	-140,421
Heavy	-	-2,856	-9,107	-11,505	-13,470
A					
Light	-	-32,642	-99,509	-120,843	-138,471
Heavy	-	-3,033	-9,385	-11,501	-13,239
C					
Light	-	-42,115	-112,663	-139,263	-161,918
Heavy	-	-3,731	-10,363	-12,864	-14,933
11					
Light	-	-51,931	-113,579	-133,019	-156,788
Heavy	-	-4,684	-10,656	-12,490	-14,826
14					
Light	-	-50,962	-103,722	-125,463	-146,825
Heavy	-	-4,843	-9,997	-12,170	-14,239
15					
Light	-	-50,925	-101,565	-128,328	-150,360
Heavy	-	-4,699	-9,669	-12,141	-14,476

Source: GTA (2012)
Note: Private car comprises the 'Light vehicles' category, while the heavy vehicle category includes buses, light commercials, rigid trucks and articulated vehicles.

5 Estimating road user and external costs

This Chapter defines the road user and external costs that are contained in the economic evaluation. It also defines the road user cost estimation methodologies by type and presents the assumptions that are used to calculate the change in road user and external costs by route options.

5.1 Definition of road user external costs

The incremental benefits of each route option are measured in terms of savings (reductions) in road user and external costs. As identified above in **Table 5**, these savings arise from a reduction in VHT, VKT, stops and an improvement in average network speeds, compared with the Base Case.

The benefits associated with the route options include:

- savings in travel time costs;
- savings in vehicle operating costs including stops;
- savings in crash costs;
- savings in environmental costs; and
- residual value of assets.

A summary of the determinants of road user travel costs are shown earlier in **Table 5.**

5.2 Travel time costs

Annualised incremental VHT from GTA's traffic forecasts are used to estimate savings in travel time cost with the route options, relative to the Base Case.

This involves applying an appropriate value of travel time (VOTT) to the annual VHT with the Base Case and route options. The VOTT is sourced from the RMS Economic Analysis Manual, Version 2, 1999[37], and is reported by vehicle type to the extent to which vehicle type implies trip purpose – i.e. commercial versus private vehicle use – and the proportion of the vehicle fleet comprised by each vehicle type.

The RMS Guidelines[38] classify Grafton as a rural area for the purposes of economic evaluation.

However, the VOTT used in this analysis uses the urban values presented in the RMS Guidelines, which are in turn, based on the observed concentration of traffic during the peak periods in the study catchment. The VOTT parameter for non-urban areas is more appropriate for road networks characterised by higher speed limits and travel speeds.

The weighted average VOTT for this evaluation is calculated using data from Tables 7, 8 and 9 of Appendix B of RMS Economic Analysis Manual – Economic Parameters for 2009, which present urban vehicle composition, occupancy by time of day and value of travel time (urban).

---

[37] RMS 1999, *RMS Economic Analysis Manual, Version 2, 1999,* RMS Corporate Finance and Strategy, Economic Parameters for 2009.

[38] RMS Guidelines base categorisation from ABS categorisation in ABS Survey of Motor Vehicle Use (SMVU) Australia 9208.0 p.43 (2008).

Vehicle occupancy rates in the RMS Guidelines have been adopted for this study. These are shown below in **Table 12**.

Table 12: Assumed vehicle occupancies (number of passengers per vehicle)

Hours	Private Car	Business Car	Commercial	
			Light	Heavy
Peak	1.12	1.2	1.3	1.0
Business	1.5	1.4	1.3	1.0
Other	1.97	1.4	1.3	1.0

Source: RMS (1999, 2009 update of Appendix B, Table 8, p.9)

The model results supplied by GTA indicate that the composition of the traffic demand in the peak differs to the vehicle compositions presented in Table 7 of Appendix B of RMS Economic Analysis Manual – Economic Parameters for 2009. The study specific compositions are adopted in this economic evaluation. These are compared to the RMS compositions below in **Table 13**.

Table 13: Study specific vehicle compositions

Hours	Private Car	Business Car	Commercial	
			Light	Heavy
RMS Peak (%)	80.0	5.0	11.0	4.0
Model Peak (%)	88.5	5.5	4.4	1.6
Business	63.0	22.0	10.0	5.0
Other hours	85.0	5.0	7.0	3.0

Source: RMS (1999, 2009 update of Appendix B, Table 7, p.9)

This economic evaluation uses the values of travel time in **Table 14** to estimate travel time cost savings.

Table 14: Value of travel time (urban)

<table>
<tr><th rowspan="3">Hours</th><th>Private Car</th><th>Business Car</th><th colspan="2">Commercial light</th><th colspan="2">Commercial heavy</th></tr>
<tr><th rowspan="2">$/person hour</th><th rowspan="2">$/person hour</th><th>Occupant</th><th>Freight</th><th>Occupant</th><th>Freight</th></tr>
<tr><th>$/person Hour</th><th>$/veh. Hour</th><th>$/person hour</th><th>$/veh. hour</th></tr>
<tr><td>Peak and Business</td><td>11.89</td><td>38.05</td><td>23.31</td><td>1.26</td><td>24.75</td><td>22.13</td></tr>
<tr><td>Other</td><td>11.89</td><td>11.89</td><td>23.31</td><td>25.5</td><td>11.89</td><td>11.89</td></tr>
</table>

Source: RMS (1999, 2009 update of Appendix B, Table 9, p.9)

Based on the assumptions identified in **Table 12**, **Table 13** and **Table 14,** values of travel time used in this evaluation are:

- light vehicles – $22.82/VHT; and
- heavy vehicles – $36.07/VHT.

To estimate the change in travel time costs, the VOTT parameters are combined with the VHT output from the traffic demand forecasts by option.

Table 15 below shows the incremental annual travel time cost for each forecast year and in total over the evaluation period (undiscounted and in present value terms). Negative values indicate cost savings. The totals are calculated by interpolating values between forecast years.

Table 15: Incremental travel time costs by forecast year ($'000), total ($'000) and total discounted (PV$'000)

Option	$'000	PV$'000	2011	2019	2029	2039	2049
E							
Light	-633,543	-133,916	-	-9,586	-18,866	-23,985	-28,670
Heavy	-105,249	-22,020	-	-1,550	-3,068	-3,992	-4,919
A							
Light	-563,401	-119,618	-	-8,371	-17,213	-21,355	-24,823
Heavy	-95,337	-19,572	-	-1,318	-2,738	-3,457	-4,919
C							
Light	-655,528	-139,027	-	-10,038	-19,646	-24,687	-29,105
Heavy	-103,627	-21,792	-	-1,531	-3,074	-3,914	-4,693
11							
Light	-614,628	-133,766	-	-10,875	-18,701	-22,266	-26,721
Heavy	-99,730	-21,433	-	-1,676	-2,991	-3,645	-4,448
14							
Light	-477,653	-108,029	-	-10,020	-14,832	-17,018	-19,280
Heavy	-83,121	-18,376	-	-1,642	-2,474	-3,010	-3,581
15							
Light	-494,270	-110,324	-	-10,250	-14,574	-18,196	-20,221
Heavy	-81,813	-17,844	-	-1,572	-2,349	-3,015	-3,580

Source: GTA (2012), PwC
Note: Private car comprises the 'Light vehicles' category, while the heavy vehicle category includes buses, light commercials, rigid trucks and articulated vehicles.

5.3 Vehicle operating costs

The change in vehicle operating costs (VOC) with the route options is estimated by applying the modelled vehicle compositions, VKT and journey speeds to the freeway model outlined in RMS (2009, Appendix B, p.5). The freeway model is used to ensure that there is no double counting of benefits associated with the reduction in stops, which are estimated explicitly below. The freeway model equation is shown below:

$c = C_0 + C_1V + C_2V^2$, where:

- c = VOC per kilometre;
- V = is journey speed (km/hr); and
- C_0, C_1 and C_2 are estimated model coefficients linked to vehicle type.

The traffic modelling provided by GTA includes estimates of annual weighted average (across AM and PM peaks) network speeds for the Base Case (2019) and each option by forecast year. Speeds are provided by vehicle class. However, due to the large proportion of the total number of trips accounted for by private vehicles, the total network speeds approximate those for 'light' vehicles.

For simplicity, this EE adopts a total network average speed that is determined by the microsimulation traffic model, rather than by vehicle class. These are shown below in **Table 16**.

Table 16: Average network journey speed

Option	2011	2019	2029	2039	2049
Base Case	42.9	40.3	36.7	35.7	34.2
E	42.9	49.6	49.2	48.8	47.8
A	42.9	48.7	48.3	47.6	46.0
C	42.9	50.4	50.1	49.7	48.7
11	42.9	51.5	49.4	48.1	47.4
14	42.9	51.0	46.7	44.9	43.0
15	42.9	51.1	46.2	45.6	43.6

Source: GTA (2012), PwC

The next step in applying the VOC model is to estimate the C coefficients.

Particular C coefficients are assigned by vehicle class. The vehicle classes reported in the RMS Economic Analysis Manual do not align directly with those reported by GTA. The classifications are aggregated to yield light and heavy vehicle coefficients. Assumed vehicle compositions for the Grafton area are also adopted to allow the calculation of average weighted coefficients across the vehicle class. The assumptions by vehicle class and modelled compositions are shown below in **Table 17**.

Table 17: Freeway operating model coefficients and vehicle compositions

RMS Manual Appendix B Table 4 Classification	RMS Manual Appendix B Table 7 classification	GTA classification for Grafton	Assumed Com-position (% of fleet)	C_0	C_1	C_2
Cars						
Private (new)	Car	Car	44.2	33.2	-0.07	0.00051
Private (used)	Car	Car	44.2	30.34	-0.072	0.00055
Business	Car	Car	5.5	53.26	-0.065	0.00052
Commercial						
Light commercial	Commercial light	Heavy	4.4	40.84	-0.158	0.00099
Rigid Truck	Commercial heavy	Heavy	0.5	86.52	-0.437	0.00299
Articulated Truck	Commercial heavy	Heavy	0.5	155.33	-0.76	0.00494
Buses	Commercial heavy	Heavy	0.5	147.34	-0.892	0.00609

Source: GTA (2012); RMS (1999, 2009 Appendix B update, p. 6)

The resultant weighted average coefficients are:

- C_0 = 35;
- C_1 = -0.08; and
- C_2 = 0.001

Based on the data presented in **Table 16** and **Table 17** and vehicle compositions, the appropriate VOC parameters for this analysis are calculated based on the average network speed achieved in each year of the evaluation period.

The unit VOCs estimated from the freeway model are identified below in **Table 18**.

Table 18: Unit VOC estimated from freeway vehicle operating model ($/VKT)

Option	2011	2019	2029	2039	2049
Base Case	0.3229	0.3237	0.3251	0.3254	0.3261
E	0.3229	0.3211	0.3212	0.3212	0.3215
A	0.3229	0.3213	0.3214	0.3215	0.3220
C	0.3229	0.3209	0.3209	0.3210	0.3213
11	0.3229	0.3206	0.3211	0.3214	0.3216
14	0.3229	0.3207	0.3218	0.3223	0.3228
15	0.3229	0.3207	0.3219	0.3221	0.3227

Source: GTA (2012), (1999, 2009 Appendix B update, p. 6)

The incremental unit VOC is applied to the total VKTs with each of the route options to calculate the incremental VOC for the analysis period. The approach seeks to identify the incremental change in unit VOC as a result of improvements in network speed. Therefore, the incremental change is captured in the unit cost and applies to absolute total VKTs travelled with each option, as opposed to the incremental VKTs identified above in **Table 9**. The incremental VOC are shown below in **Table 19**.

Table 19: Incremental vehicle operating costs by forecast year ($'000), total ($'000) and total discounted (PV$'000)

Option	$'000	PV$'000	2011	2019	2029	2039	2049
E	-34,762	-7,455	-	-555	-1,041	-1,355	-1,532
A	-13,152	-2,860	-	-176	-452	-517	-555
C	-27,554	-5,944	-	-408	-885	-1,054	-1,195
11	-22,012	-5,014	-	-431	-737	-778	-915
14	-4,630	-1,009	-	-88	-119	-216	-226
15	-7,345	-1,771	-	-165	-271	-253	-299

Source: GTA (2012), PwC
Note: Private car comprises the 'Light vehicles' category, while the heavy vehicle category includes buses, light commercials, rigid trucks and articulated vehicles.

5.4 Vehicle stops

The economic cost of stops (as opposed to delays) is counted on intersections only. VOC per stop (without fuel) measures the cost of wear on brake components and additional transmission wear from stop start conditions.

The RMS Economic Analysis Manual (Table 1) indicates that the unit economic cost per stop (excluding fuel) is $0.042. This unit cost is applied to the forecast number of stops with the Base Case and the route options.

Table 20 below shows the incremental annual cost of vehicle stops for each forecast year and in total over the evaluation period (undiscounted and in present value terms). Negative values indicate cost savings.

Table 20: Incremental cost of stops by forecast year ($'000), total ($'000) and total discounted (PV$'000)

Option	$'000	PV$'000	2011	2019	2029	2039	2049
E							
Light	-129,533	-26,299	-	-1,327	-4,085	-5,109	-5,898
Heavy	-12,221	-2,464	-	-120	-383	-483	-566
A							
Light	-129,975	-26,613	-	-1,371	-4,179	-5,075	-5,816
Heavy	-12,329	-2,515	-	-127	-394	-483	-556
C							
Light	-150,706	-31,054	-	-1,769	-4,732	-5,849	-6,801
Heavy	-13,846	-2,842	-	-157	-435	-540	-618
11							
Light	-149,862	-31,888	-	-2,181	-4,770	-5,587	-6,478
Heavy	-14,038	-2,970	-	-197	-448	-525	-612
14							
Light	-140,404	-29,924	-	-2,140	-4,356	-5,269	-6,167
Heavy	-13,564	-2,882	-	-203	-420	-511	-598
15							
Light	-141,419	-29,919	-	-2,139	-4,266	-5,390	-6,216
Heavy	-13,423	-2,827	-	-197	-406	-510	-597

Source: GTA (2012), PwC
Note: Private car comprises the 'Light vehicles' category, while the heavy vehicle category includes buses, light commercials, rigid trucks and articulated vehicles.

5.5 Vehicle crash costs

Unit crash costs for the economic evaluation are drawn from Table 14 in Appendix B of the RMS Economic Analysis Manual. It identifies average crash costs by road type for crashes on local/sub-arterial roads. The unit costs selected are different for light and heavy vehicles. It is assumed that heavy vehicles' average crash costs are equivalent to that of an average bus[39]. The values used are:

- light vehicles – $0.0656/VKT; and
- heavy vehicles – $0.1060/VKT.

These unit costs are applied to the incremental annual VKT to calculate the incremental crash costs for the road network.

Table 21 below shows the incremental annual cost of vehicle crashes for each forecast year and in total over the evaluation period (undiscounted and in present value terms).

Table 21: Incremental crash costs by forecast year ($'000), total ($'000) and total discounted (PV$'000)

Option	$'000	PV$'000	2011	2019	2029	2039	2049
E							
Light	-2,704	-581	-	-41	-83	-108	-106
Heavy	-1,789	-375	-	-32	-46	-67	-90
A							
Light	674	145	-	19	12	23	39
Heavy	-530	-114	-	-11	-14	-17	-29
C							
Light	-1,530	-333	-	-17	-57	-59	-53
Heavy	-1,032	-216	-	-18	-28	-37	-53
11							
Light	-608	-167	-	-16	-32	-14	-11
Heavy	-999	-213	-	-19	-26	-38	-47
14							
Light	2,246	522	-	52	73	74	90
Heavy	-944	-195	-	-18	-21	-36	-50
15							
Light	1,436	294	-	28	29	59	74
Heavy	-425	-70	-	-6	-4	-15	-38

Source: GTA (2012), PwC
Note: Private car comprises the 'Light vehicles' category, while the heavy vehicle category includes buses, light commercials, rigid trucks and articulated vehicles.

[39] This assumption is made because the RMS only provides average crash costs by road type for car crashes and bus crashes.

5.6 External costs

Road use produces external costs on society in terms of the economic costs of environmental impacts. Therefore, changes in VKT will translate into changes in associated environmental costs. The environmental unit costs used in this economic evaluation are based on the parameters presented in Appendix B, Table 18 of the RMS EAM 2009, and include:

- noise;
- air pollution;
- water pollution;
- Greenhouse Gas Emissions (GHG);
- nature and landscape; and
- urban separation costs.

For an urban road network the RMS manual considers four classes of vehicle for which they provide separate environmental externality values:

- passenger vehicles;
- buses;
- light vehicles; and
- heavy vehicles.

5.6.1 Passenger vehicles and buses

Environmental unit costs for passenger vehicles are expressed in dollars per VKT in the RMS Economic Analysis Manual. The unit costs are directly applied to the change in VKT to estimate the change in environmental costs by route option. The average environmental external costs per VKT used primarily for these vehicles are:

- passenger vehicles – $0.0683/VKT; and
- buses – $0.5214/VKT.

In order to convert the above environmental cost parameters into annual environmental costs by option, the passenger vehicle and buses costs per VKT above are applied to the annual VKT for each vehicle type in each option.

5.6.2 Freight vehicles

For freight vehicles, the RMS expresses environmental unit costs in cents per tonne kilometre (tkm), which requires conversion for application to this economic evaluation. The tkm unit costs are converted to dollars per VKT using NSW average tonne per trip for the light and heavy vehicle types taken from the latest Australian Bureau of Statistics “Survey of Motor Vehicle Use”.

The survey provides different average freight loads for ‘Light Commercial’, ‘Heavy Commercial – Rigid’ and ‘Heavy Commercial – articulated’ which requires an additional traffic classification step to match this approach with the approach used in Table 18 of the RMS manual.

A summary of the traffic classification, the assumed vehicle composition, the average load per trip, and the calculated environmental externality value for each component of traffic is provided in **Table 22.**

Table 22: Calculation assumptions for environmental externality values

ABS Survey of Motor Vehicle Use classification[40]	RMS Manual Appendix B Table 18 classification	Assumed traffic composition (%)	Average freight load (tonnes)	Environmental externality values per VKT ($)
Passenger vehicles	Passenger vehicles	94.0	n/a	0.0683
Buses	Buses	0.5	n/a	0.5214
Light commercial	Light Vehicles	4.4	0.00046	0.1479
Heavy commercial – Rigid	Heavy Vehicles	0.5	0.00599	0.2265
Heavy commercial – Articulated	Heavy vehicles	0.5	0.02222	0.8401

These calculated results from this approach are expressed in terms of 'cars' and 'heavy vehicles' (as provided by the GTA modelling) through appropriate weighting. These values are:

- value for cars – $0.0683/VKT; and
- value for heavy vehicles – $0.2489/VKT.

These unit costs are applied to the incremental annual VKT to calculate the incremental external costs for the road network. **Table 23** below shows the incremental annual external cost of vehicle for each forecast year and in total over the evaluation period (undiscounted and in present value terms).

[40] Australian Bureau of Statistics 2010, *Survey of Motor Vehicle Use, Australia*, 9208.0 - 12 months ended 31 October 2010.

Table 23: Incremental external costs by forecast year ($'000), total ($'000) and total discounted (PV$'000)

Option	$'000	PV$'000	2011	2019	2029	2039	2049
E							
Light	-2,815	-605	-	-43	-86	-113	-111
Heavy	-4,200	-880	-	-75	-109	-156	-212
A							
Light	702	151	-	20	12	24	41
Heavy	-1,245	-269	-	-27	-33	-41	-67
C							
Light	-1,593	-346	-	-17	-59	-62	-55
Heavy	-2,422	-508	-	-41	-66	-86	-125
11							
Light	-633	-174	-	-17	-33	-15	-11
Heavy	-2,346	-500	-	-44	-62	-88	-111
14							
Light	2,338	544	-	54	76	77	94
Heavy	-2,216	-459	-	-43	-50	-85	-117
15							
Light	1,495	306	-	30	30	62	77
Heavy	-999	-164	-	-13	-9	-36	-88

Source: GTA (2012), PwC
Note: Private car comprises the 'Light vehicles' category, while the heavy vehicle category includes buses, light commercials, rigid trucks and articulated vehicles.

6 Direct infrastructure costs

6.1 Capital costs

6.1.1 Definitions

Capital cost estimates were provided by Arup's technical advisor, MacDonald International. The estimates are defined in terms of the following categories:

- project development;
- investigation and design;
- property acquisition;
- public utility adjustments;
- construction; and
- handover.

The cost estimation approach is detailed in MacDonald International's Cost Estimates Report[41]. The assumptions which are relevant for the economic evaluation include[42]:

- costs are in 2012 prices (Quarter 2);
- no profit margin was allowed in the construction cost estimates to ensure that values are in real terms[43];
- the indicative cost of the four upgrades with the Base Case (see **Section 2.6**) is based on measuring the pavement areas, making allowances based on the length of kerb, and using proportions of construction costs from the current route options. These upgrades would also occur with the route option cases. MacDonald International advises that the total cost of the Base Case projects is in the order of $18 million which includes construction costs, contingency, project development, investigation and design, utilities and handover. Given that the Base Case is not explicitly costed, the cost of Base Case upgrades is wholly deducted from the construction cost component of each route option to ensure that construction costs are incremental;
- costs are not estimated using a probabilistic approach. However, MacDonald International indicates that estimates are equivalent to a P90 estimate; and
- MacDonald International disaggregated the construction cost categories by asset type so that residual values could be estimated. This process also allocated indirect costs such as contingency, project management, sponsor costs and insurance across asset type.

---

[41] MacDonald International 2012, *Main Road 83 – Summerland Way, Additional Crossing of the Clarence River at Grafton: Route Options Development Report – Technical Paper: Strategic Cost Estimate,* August.

[42] These assumptions are implied in the MacDonald International Technical Paper.

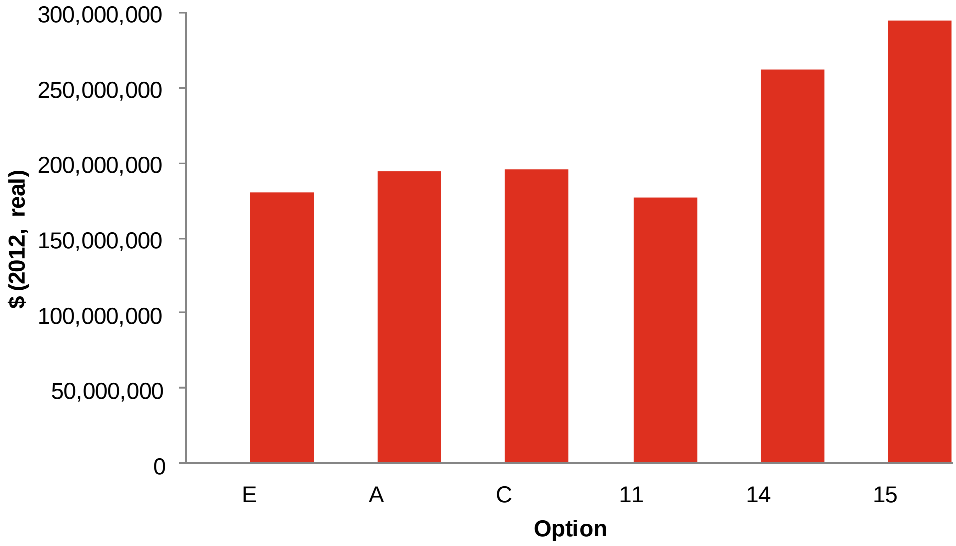
[43] PwC adjusted the direct infrastructure costs by removing the profit margin identified by MacDonald International.

6.1.2 *Undiscounted capital costs*

The total undiscounted capital costs by option are shown below in **Figure 12**. The costs exclude a 9 per cent profit margin and are incremental to the upgrade works that would take place with the Base Case. The figure shows that Route Option 14 and Route Option 15 have the highest cost, while Route Options E and 11 have the lowest.

The capital costs are in the range of $170-$300 million.

Figure 12: Undiscounted total capital costs by option

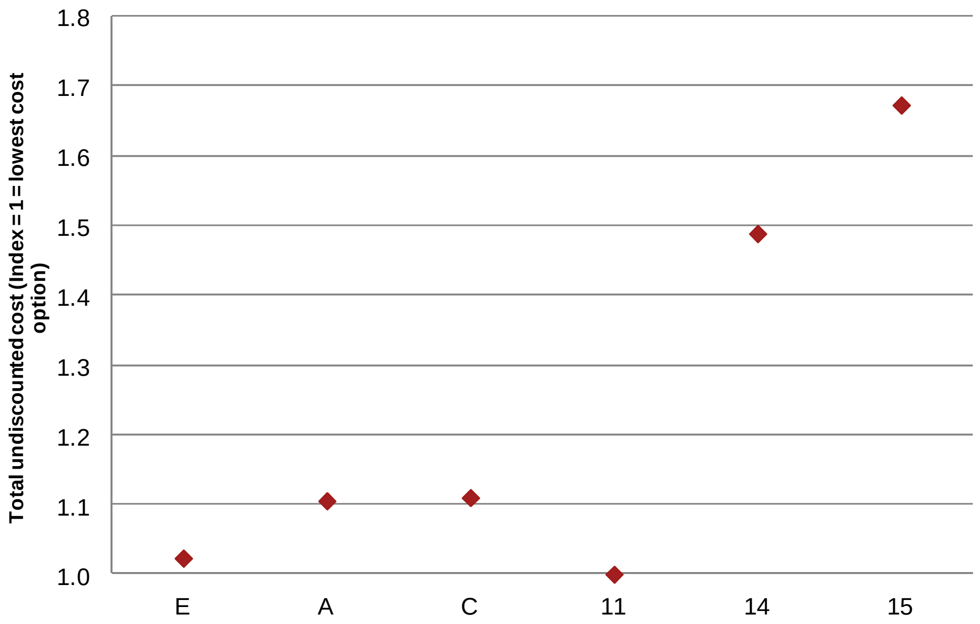


Source: MacDonald International (2012)
Note: Excludes 9 per cent profit margin and Base Case upgrade costs.

The range of total cost by option is relatively wide.

Figure 13 presents the total costs by option as an Index, where an index value of 1 indicates the lowest cost option. **Figure 13** indicates that Route Option 11 has the lowest cost, with the total cost of Route Options 14 and 15 being around 50 per cent and 70 per cent higher than Route Option 11, respectively.

Figure 13: Undiscounted total capital costs by option – Index = 1 = lowest cost option

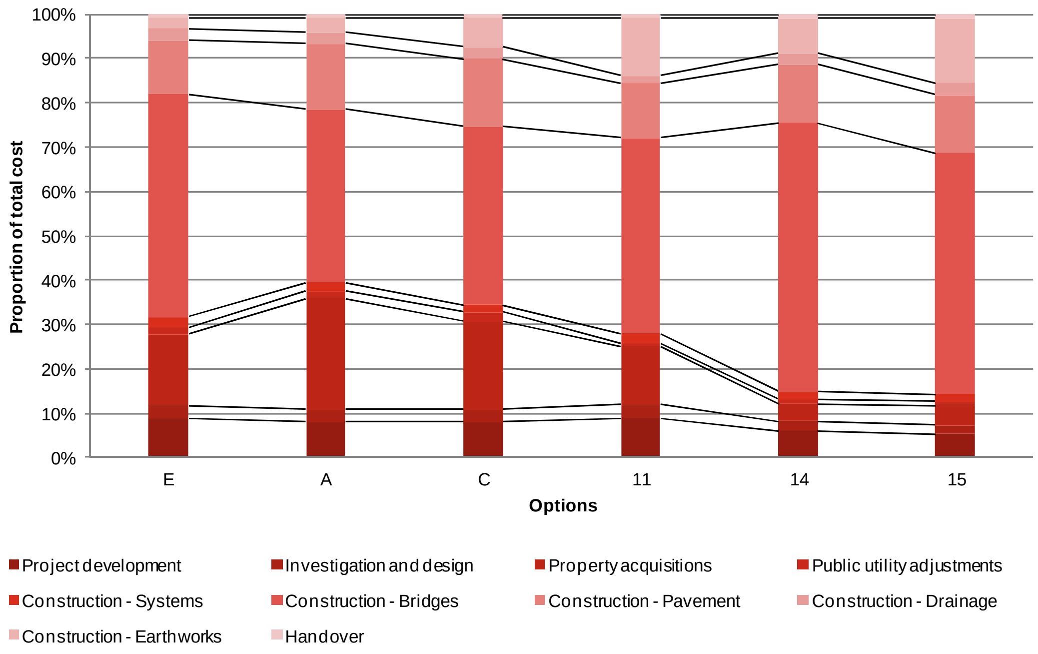


Source: MacDonald International (2012).
Note: Excludes 9 per cent profit margin and Base Case upgrade costs.

Detailed, unadjusted estimates of capital costs are included in **Appendix C**.

The capital cost of each route option is comprised of a number of relatively low cost items which account for similar proportions of total cost. The difference in total cost by route option is driven by magnitude of high cost items. **Figure 14** breaks down the total capital costs in **Figure 12** by cost component to identify the high cost items.

Figure 14: Break down of undiscounted capital costs



Source: MacDonald International (2012); Email dated 2[nd] February 2012.
Note: Excludes 9 per cent profit margin and Base Case upgrade costs.

Figure 14 indicates that the project development and investigation and design costs account for around 7-12 per cent of total cost for all route options. Similarly, public utility adjustments and construction systems account for a small and equal proportion of total capital costs across all route options.

However, property acquisition cost does vary across route option, with property acquisition accounting for 25 per cent of total cost of Route Option A and 20 per cent for Route Option C, compared with only 4 per cent and 5 per cent for Route Options 14 and 15, respectively.

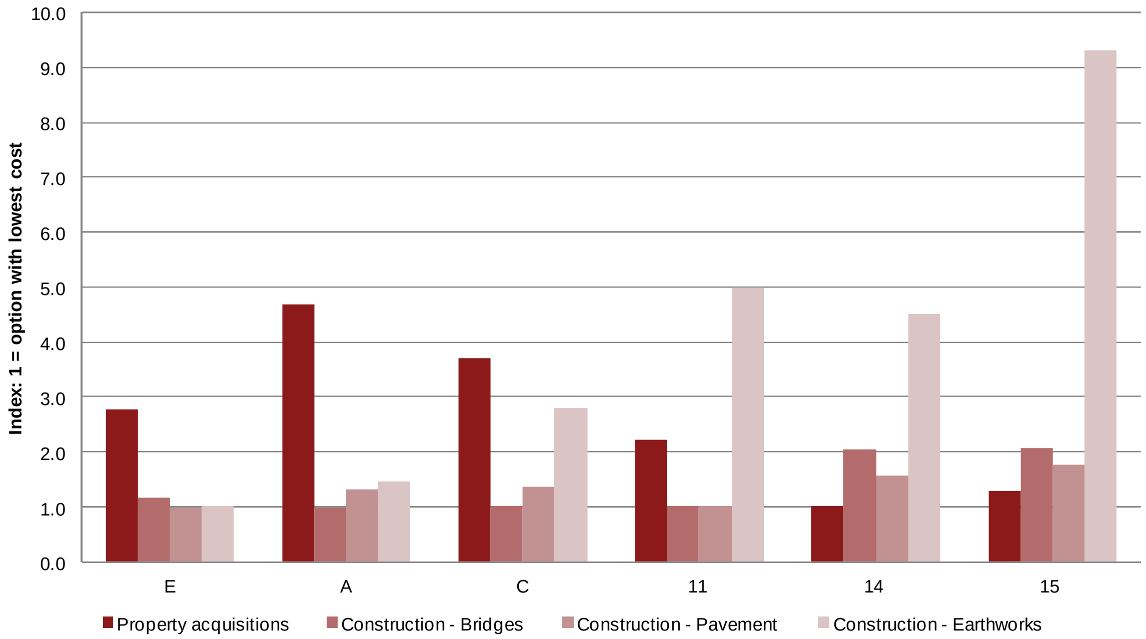
The bridge component of construction cost (which includes the main river crossing, approach viaducts and minor creek crossings) accounts for the largest proportion of total capital cost. There is a relatively significant variation in bridge cost proportions across route options, with Route Options A and C featuring around 40 per cent of total cost on bridge works. This increases to 50 per cent and 54 per cent with Route Options E and 15, respectively. At 61 per cent, Route Option 14 has the largest proportion of total capital cost which is accounted for by bridge works.

The other construction component which shows some variation across the route options is earthworks. Around 13-15 per cent of the total cost of Route Options 11 and 15 is accounted for by earthworks compared to between 7 and 8 per cent for Route Options C and 14 and only 3 per cent for Route Options A and E.

Figure 14 indicates that the largest cost components include property acquisition, bridge construction, pavement construction, and earthworks. The key drivers of capital costs are further explained in **Figure 15**.

Figure 15 identifies the relative magnitudes of the high cost items as an index, where the Base (=1) is the route option which features the lowest level for a particular cost item. For example, Route Option 14 has the lowest property acquisition costs with an index value of 1 whereas the property acquisition cost of Route Option A is the highest at nearly 5 times that of Route Option 14.

Figure 15: Index of capital cost items by route option

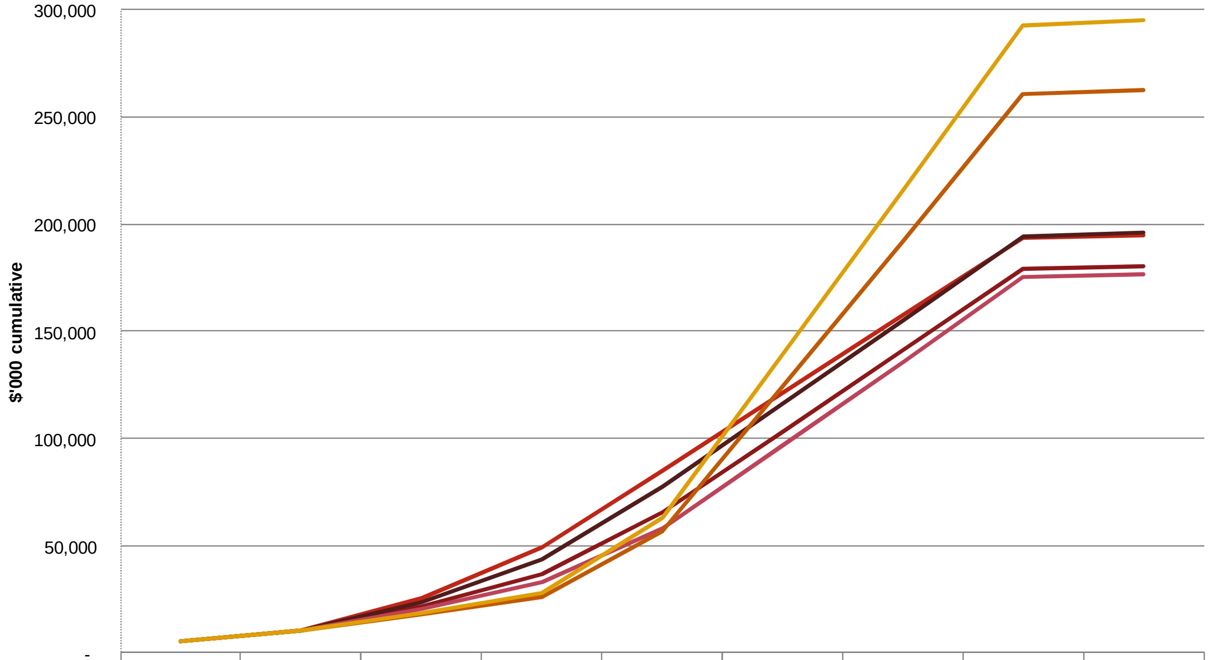


Source: MacDonald International (2012)

6.1.3 Capital cost cash flow profile

Arup defined the likely cash flow profiles of capital costs by item and route option. This is used to distribute the capital costs over time, based on when expenditure is expected to occur. The information provided by Arup also indicates that the construction period, including pre-construction activities, commences in 2011 and ends in 2019 with handover. The handover accounts for a small cost and is not construction related. The first full year of operation of the additional crossing of the Clarence River at Grafton is assumed to be 2019/20. The cashflow profiles are applied to the total undiscounted infrastructure costs by route option to generate the cashflows shown below in **Figure 16**.

Figure 16: Capital cost cash flows by route option



	2011	2012	2013	2014	2015	2016	2017	2018	2019
E	5,192	10,384	21,364	36,967	65,220	103,174	141,127	179,081	180,493
A	5,192	10,384	25,348	49,239	85,183	121,339	157,496	193,653	195,006
C	5,192	10,384	23,320	43,757	77,215	116,277	155,338	194,400	195,839
11	5,192	10,384	20,186	32,724	58,235	97,155	136,076	174,996	176,424
14	5,192	10,384	17,664	25,903	56,756	124,599	192,441	260,284	262,663
15	5,192	10,384	18,276	27,774	62,797	139,371	215,946	292,521	295,186

Source: MacDonald International (2012), Arup (2012, email dated 13th February 2012)

The streamed costs are discounted at a real discount rate of 7 per cent and expressed in present value terms. These are shown below in **Table 24**. These costs do not include residual values.

Table 24: Incremental capital costs by route option

Route option	Undiscounted total ($'000, 2012 m)	Discounted total (PV$'000)
Option E	180,493	127,373
Option A	195,006	139,037
Option C	195,839	138,456
Option 11	176,424	123,936
Option 14	262,663	177,040
Option 15	295,186	197,967

Source: Arup (2012), MacDonald International (2012).

Detailed capital cost cashflows are provided in **Appendix D**.

6.2 Recurrent costs

Recurrent, or variable, costs are defined as those costs that recur, as opposed to capital, or fixed, costs, which are concentrated at the beginning of a project's life.

It has been assumed that recurrent costs are the same for the Base Case as for bridge route options. While newer roads under the route options are likely to require lower levels or frequency of maintenance as older roads, the route options are expected to result in additional maintenance from additional road surfaces. This has been assumed to result in recurrent costs for the route options equalling the Base Case, i.e. incremental recurrent costs are negligible.

6.3 Residual (terminal) values

This economic evaluation includes the residual values of road infrastructure assets.

The residual value reflects the fact that some assets have economic lives which extend beyond the evaluation period. Residual values are entered in the last year of the evaluation period (2048/49) to represent the unused portion of assets that have lives greater than the evaluation period.

The economic lives, by asset class, adopted in this economic evaluation are shown below in **Table 25**.

It should be noted that land does not depreciate and hence, its full value is retained at the end of the evaluation period.

Table 25: Economic lives by asset type

Asset type	Economic Life[1]	Economic Life Remaining in 2048/49[5]
Systems[2]	25	-
Bridges[3]	120	90
Pavement	50	20
Drainage[4]	110	80
Earthworks	125	95
Property	Infinite	Full

Source: Australian Transport Council 2006, National Guidelines for Transport Systems Management in Australia, Volume 4, Urban Transport, p. 44.

Notes:

[1] The 'systems' construction component is assumed to have an economic life similar to that for traffic lights.

[2] In some cases, the ATC Guidelines present a range of economic lives for a particular type of asset. The analysis adopts a mid-point value of the range.

[3] Refers to the economic life of a concrete bridge.

[4] Refers to the economic life of culverts.

[5] Assumes that depreciation of all assets commences from the first full year of operation.

The residual values are calculated by applying straight-line depreciation. Depreciation of assets for each route option is assumed to commence in 2019/20. Given that the period of analysis is for a further 30 years from the first full year of operation, the residual value is identified for 2048/49. These residual values are shown below in **Table 26**.

Table 26: Residual value by asset type ($000, undiscounted, 2048/49)

Asset Type	Route Option					
	E	**A**	**C**	**11**	**14**	**15**
Systems	-	-	-	-	-	-
Bridges	68,144	57,128	58,915	58,380	119,243	120,396
Pavement	8,741	11,570	12,052	8,782	13,825	15,554
Drainage	3,346	3,506	3,913	2,177	5,027	5,801
Earthworks	3,496	5,129	9,814	17,444	15,761	32,584
Property	28,938	48,861	38,719	23,049	10,440	13,499
Total	**112,665**	**126,194**	**123,413**	**109,833**	**164,296**	**187,834**

Source: MacDonald International (2012), PwC

7 Results

This Chapter of the report presents discounted total direct infrastructure, road user and external costs by route option. These incremental costs are combined to produce the measures of economic performance including BCR and NPV. It also presents the results of sensitivity analysis undertaken on a selection of key assumptions.

7.1 RUCBA results

The changes in direct infrastructure, road user and external costs detailed in **Chapter 5** and **Chapter 6** are presented below in **Table 27**. Positive values associated with the direct infrastructure cost components indicate increases compared with the Base Case whereas positive values with the road user and external cost components refer to savings (or cost reductions).

The results indicate that all route options generate significant savings in travel time cost, between PV$120 - $160m. Route Options E, C and 11 generate the highest travel time cost savings. Savings in travel time costs also account for the largest proportion of total present value benefits at around 80 per cent for each route option.

The next largest benefit component involves the reduction in economic costs associated with a reduction in vehicle stops. This benefit line item accounts for between 15 and 20 per cent of total present value benefits.

Route Options E, C and 11 generate similar levels of total present value benefit.

Table 27: Discounted incremental infrastructure, road user and external costs by route option ($'000)

Cost/Benefit Item	PV$'000					
	E	**A**	**C**	**11**	**14**	**15**
Direct Infrastructure Cost						
Capital	127,373	139,037	138,456	123,936	177,040	197,967
Operating and maintenance	-	-	-	-	-	-
Residual	-8,050	-9,017	-8,819	-7,848	-11,740	-13,422
Total Direct Infrastructure Cost	**119,322**	**130,020**	**129,638**	**116,088**	**165,300**	**184,545**
Road User Cost (savings)						
Travel time cost	155,936	139,190	160,819	155,199	126,404	128,168
Vehicle operating cost	7,455	2,860	5,944	5,014	1,009	1,771
Stop cost	28,763	29,128	33,895	34,858	32,805	32,746
Crash cost	956	-31	549	380	-327	-224
Total Road User Cost (savings)	**193,110**	**171,147**	**201,208**	**195,451**	**159,892**	**162,461**
External Cost (Savings)						
Environmental cost	1,485	117	855	674	-85	-142
Total External Cost (savings)	**1,485**	**117**	**855**	**674**	**-85**	**-142**
Total Road User and External Cost Savings	**194,595**	**171,264**	**202,062**	**196,125**	**159,807**	**162,319**

The detailed streams of road user and external costs are shown in **Appendix E**.

Table 28 below combines the data in **Table 27** to produce BCRs and NPVs for each route option.

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

Table 28: Measures of economic performance by route option

Performance Measure	PV$'000					
	E	A	C	11	14	15
Net Present Value	75,272	41,244	72,424	80,037	-5,493	-22,226
Benefit Cost Ratio	1.6	1.3	1.6	1.7	1.0	0.9

7.2 Sensitivity analyses

This section presents a range of sensitivity analyses. Sensitivity analyses assess the robustness of the core results (see **Table 28**) with respect to changes in key parameters and assumptions.

7.2.1 Alternate discount rates

Table 29 and **Table 30** present the results of the core analysis under alternative discount rates of 4 per cent and 10 per cent, respectively.

Table 29: Alternative discount rates – 4 per cent

Performance Measure	PV$'000					
	E	A	C	11	14	15
Net Present Value	235,645	182,523	238,349	236,439	113,534	99,179
Benefit Cost Ratio	2.9	2.4	2.8	2.9	1.6	1.5

Table 30: Alternative discount rates – 10 per cent

Performance Measure	PV$'000					
	E	A	C	11	14	15
Net Present Value	5,762	-18,108	842	11,367	-51,189	-66,941
Benefit Cost Ratio	1.1	0.8	1.0	1.1	0.6	0.6

The results of the sensitivity analysis show a significant increase in NPV and BCR values for all options when a discount rate of 4 per cent is adopted, and the road user and external benefits would appreciably exceed the capital cost for all route options including Options 14 and 15.

Using a discount rate of 10 per cent, the road user and external benefits reduce significantly. For Route Options E, C and 11 the road user and external benefits slightly exceed the capital cost, but for Route Options A, 14 and 15 the benefits would be marginally lower than the cost.

7.2.2 Changes in capital costs

Table 31 and **Table 32** present the results of the core analysis under an increase and decrease in capital costs of 20 per cent, respectively.

Table 31: Change in capital cost – 20 per cent increase in capital costs

Performance Measure	PV$'000					
	E	A	C	11	14	15
Net Present Value	49,798	13,437	44,733	55,250	-40,901	-61,819
Benefit Cost Ratio	1.3	1.1	1.3	1.4	0.8	0.7

Table 32: Change in capital cost – 20 per cent decrease in capital costs

Performance Measure	PV$'000					
	E	A	C	11	14	15
Net Present Value	100,747	69,052	100,116	104,825	29,915	17,367
Benefit Cost Ratio	2.1	1.7	2.0	2.1	1.2	1.1

The sensitivity analysis suggests that with a capital cost increase of 20 per cent, road user and external benefits would still exceed the capital cost for Route Options E, A, C and 11, while for Route Options 14 and 15 the benefits become appreciably lower than the cost.

If capital costs reduce by 20 per cent the results suggest that the road user and external benefits would exceed the capital cost for all route options, including Route Options 14 and 15.

7.2.3 Translating road user parameters to current dollars

The latest road user and external cost parameters are included in Appendix B of RMS's Economic Analysis Manual 2009. Inquiries made during this study indicate that Austroads are yet to release updated parameter values for Road User Effects, and that provisional indicators suggest that the current valuation of benefits are approximately 6.4 per cent higher than those shown in the 2009 version of the RMS's Economic Analysis Manual.

Table 33 shows a small increase in NPV and BCR values following a rate increase of 6.4 per cent in road user and external parameters. For Route Options E, C and 11 the road user and external benefits appreciably exceed the capital cost. For Route Option 14 the benefits would be marginally higher than the cost and for Route Option 15 the estimated benefits would be marginally lower than the cost.

Table 33: Indexing all road user and external cost parameters to 2012 dollars

Performance Measure	PV$'000					
	E	A	C	11	14	15
Net Present Value	87,727	52,205	85,356	92,589	4,734	-11,838
Benefit Cost Ratio	1.7	1.4	1.7	1.8	1.0	0.9

7.2.4 Impacts of lower road user and external benefits

Traffic forecasts under various land use scenarios were not supplied for this economic evaluation. The rate of traffic growth directly impacts on the road user and external cost savings in a particular year. However, the relationship between population and traffic growth is not linear.

This sensitivity analysis undertakes a coarse assessment of the robustness of the results to changes in population and traffic growth by assessing the impacts of a conservative reduction in total present value benefits of 30 per cent.

Table 34 shows an appreciable decrease in the NPV and BCR values following a 30 per cent reduction in total present value benefits. For Route Options E, C and 11 the road user and external benefits slightly exceed the capital cost. For Route Option A the benefits would be slightly lower than the cost and for Route Options 14 and 15 the estimated benefits would be appreciably lower than the cost.

Table 34: 30 per cent decrease in present value benefits

Performance Measure	PV$'000					
	E	A	C	11	14	15
Net Present Value	16,894	-10,135	11,806	21,200	-53,435	-70,922
Benefit Cost Ratio	1.1	0.9	1.1	1.2	0.7	0.6

8 Conclusions

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

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

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

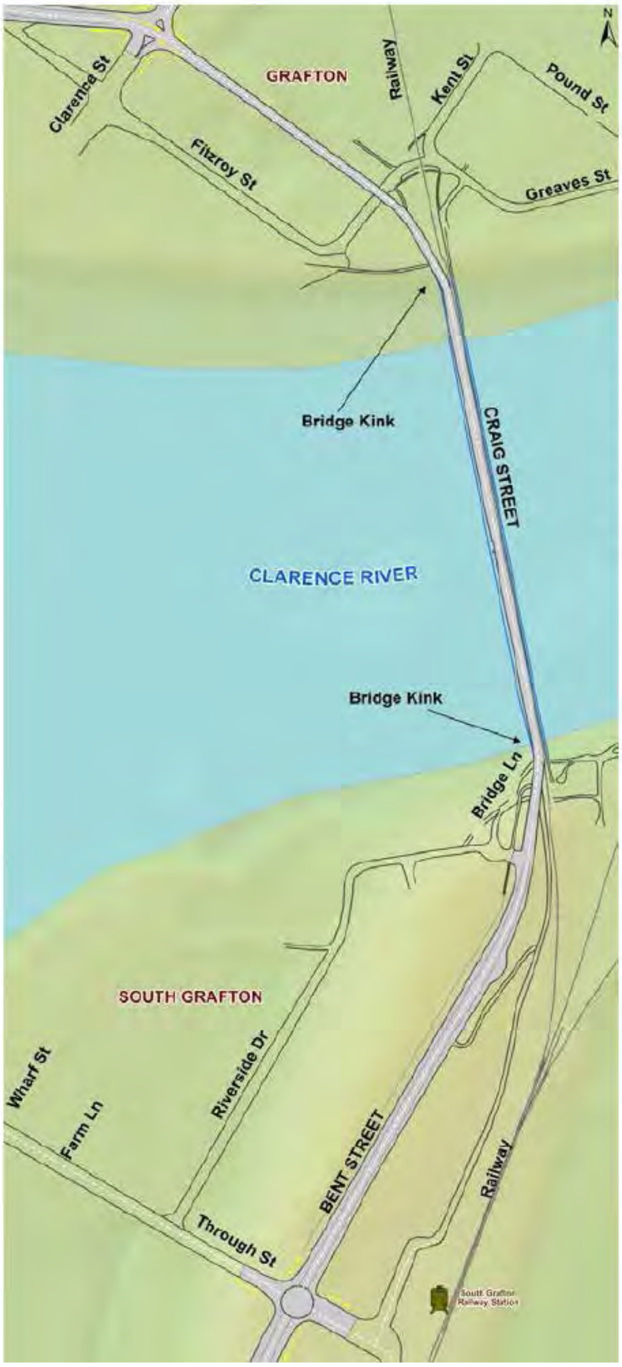
Route Option A performs does not perform as well as Route Options E, C and 11 because the road user cost savings are lower with Route Option A and it has a comparatively high capital cost.

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

Appendices

Appendix A Grafton Bridge

Figure A 1: The existing Grafton Bridge

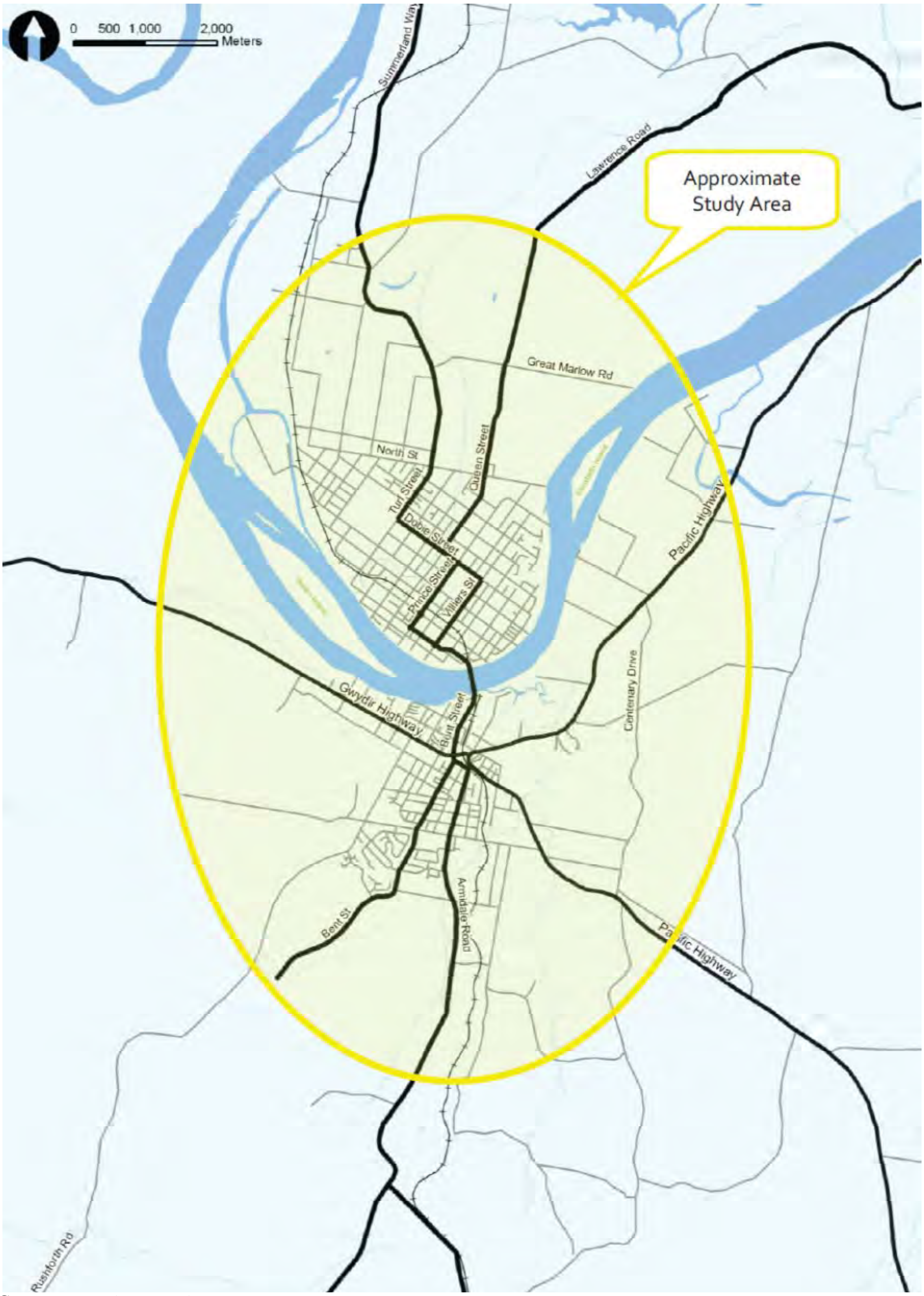


Grafton Bridge
Owner: Australian Rail Track Corporation (ARTC).
Construction date: 1932
Construction cost (1932 $): $827,346
Bridge type: Steel double deck.
Deck arrangements: two-way railway lanes and two pedestrian/cyclist lanes on the lower deck and two-way road lanes on the upper deck.
Bridge length: 438 metres
Bridge width: 8.9 metres
Number of spans: 8
Spans types:
2 x Riveted Spans,
5 x 240 feet (73.2 metres) Trusses,
1 x 84 feet (25.6 metres) Bascule
Number of piers: 7
Pier type: Concrete. Foundations on solid rock at depths between 9 to 23 metres below high water level.
Abutment: Concrete

Source: Arup (2012, p. 23)

Appendix B Traffic modelling study area

Figure B 1: Definition of traffic modelling study area



Source: GTA (2012, p.9)

Appendix C Unadjusted capital cost estimates

Figure C 1: Capital cost estimate: Route Option E

Project: MR 83 Summerland Way - Additional Crossing of the Clarence River at Grafton Option E - Route Options Development Report		Prepared by:	MacDonald International 49 Berry Street Nowra Ph (02) 44230566 Fax (02) 44233228
Summary	DRAFT 6		
Project No: SC090010	Date: 19/07/12	Estimate Type: Strategic	

Item	Base Estimate (excluding contingency)	Contingency %	Contingency Amount	Estimate (including contingency)	% of Total Estimate	Comments / Assumptions
1. Project Development						
1 (a) Route / Concept / EIS	$12,000,000	25%	$3,000,000	$15,000,000		Lump sum allowance for all options
1 (b) Project Management Services	$360,000	25%	$90,000	$450,000		3% of Route / Concept / EIS
1 (c) Sponsor	$36,000	25%	$9,000	$45,000		10% of Project Management Services
1 (d) Community Liaison	$1,200,000	25%	$300,000	$1,500,000		10% of Route / Concept / EIS
Sub total	**$13,596,000**	**25%**	**$3,399,000**	**$16,995,000**	**7.9%**	
2. Investigation and Design						
2 (a) Investigation and Design	$4,200,000	40%	$1,680,000	$5,880,000		2-4% of Construction Cost (common cost for all options)
2 (b) Project Management Services	$126,000	40%	$50,400	$176,400		3% of Investigation and Design
2 (c) Sponsor	$12,600	40%	$5,040	$17,640		10% of Project Management Services
Sub total	**$4,338,600**	**40%**	**$1,735,440**	**$6,074,040**	**2.8%**	
3. Property Acquisitions						
3 (a) Acquire Property	$18,740,000	57%	$10,770,000	$29,510,000		
3 (b) Professional Services for Property	$1,311,800	50%	$655,900	$1,967,700		7% of Acquire Property Cost
3 (c) Project Management Services	$39,354	50%	$19,677	$59,031		3% of Professional Services for Property
3 (d) Sponsor	$3,935	50%	$1,968	$5,903		10% of Project Management Services
Sub total	**$20,095,089**	**57%**	**$11,447,545**	**$31,542,634**	**14.7%**	
4. Public Utility Adjustments						
4 (a) Adjust Utilities	$1,750,000	50%	$875,000	$2,625,000		
4 (b) Project Management Services	$52,500	40%	$21,000	$73,500		3% of Utility Costs
4 (c) Sponsor	$5,250	40%	$2,100	$7,350		10% of Project Management Services
Sub total	**$1,807,750**	**50%**	**$898,100**	**$2,705,850**	**1.3%**	
5. Construction						
5 (a) - 5 (c) Infrastructure	$106,457,285	41%	$43,486,387	$149,943,671		
5 (d) Project Management Services	$3,193,719	40%	$1,277,487	$4,471,206		3% of Infrastructure
5 (e) Sponsor	$319,372	40%	$127,749	$447,121		10% of Project Management Services
5 (f) PAI Insurance	$595,140	40%	$238,056	$833,196		0.55% of Infrastructure + Utility Costs
Sub total	**$110,565,515**	**41%**	**$45,129,679**	**$155,695,194**	**72.6%**	
6. Handover						
6 (a) Refurbish Old Route	$0	40%	$0	$0		
6 (b) Project data & Completion Review	$1,064,573	40%	$425,829	$1,490,402		1% of Construction Cost
6 (c) Project Management Services	$31,937	40%	$12,775	$44,712		3% of Project Data Costs
6 (d) Sponsor	$3,194	40%	$1,277	$4,471		10% of Project Management Services
Sub total	**$1,099,704**	**40%**	**$439,882**	**$1,539,585**	**0.7%**	
TOTAL	**$151,502,658**	**42%**	**$63,049,645**	**$214,552,303**	**100%**	

Source: MacDonald International (2012)

Figure C 2: Capital cost estimate: Route Option A

Project: MR 83 Summerland Way - Additional Crossing of the Clarence River at Grafton Option A - Route Options Development Report		Prepared by:	MacDonald International 49 Berry Street Nowra Ph (02) 44230566 Fax (02) 44233228
Summary	DRAFT 6		
Project No: SC090010	Date: 19/07/12	Estimate Type: Strategic	

Item	Base Estimate (excluding	%	Contingency Amount	Estimate (including	% of Total Estimate	Comments / Assumptions
1. Project Development						
1 (a) Route / Concept / EIS	$12,000,000	25%	$3,000,000	$15,000,000		Lump sum allowance for all options
1 (b) Project Management Services	$360,000	25%	$90,000	$450,000		3% of Route / Concept / EIS
1 (c) Sponsor	$36,000	25%	$9,000	$45,000		10% of Project Management Services
1 (d) Community Liaison	$1,200,000	25%	$300,000	$1,500,000		10% of Route / Concept / EIS
Sub total	**$13,596,000**	**25%**	**$3,399,000**	**$16,995,000**	**7.4%**	
2. Investigation and Design						
2 (a) Investigation and Design	$4,200,000	40%	$1,680,000	$5,880,000		2-4% of Construction Cost (common cost for all options)
2 (b) Project Management Services	$126,000	40%	$50,400	$176,400		3% of Investigation and Design
2 (c) Sponsor	$12,600	40%	$5,040	$17,640		10% of Project Management Services
Sub total	**$4,338,600**	**40%**	**$1,735,440**	**$6,074,040**	**2.6%**	
3. Property Acquisitions						
3 (a) Acquire Property	$32,070,000	55%	$17,710,000	$49,780,000		
3 (b) Professional Services for Property	$2,244,900	50%	$1,122,450	$3,367,350		7% of Acquire Property Cost
3 (c) Project Management Services	$67,347	50%	$33,674	$101,021		3% of Professional Services for Property
3 (d) Sponsor	$6,735	50%	$3,367	$10,102		10% of Project Management Services
Sub total	**$34,388,982**	**55%**	**$18,869,491**	**$53,258,473**	**23.1%**	
4. Public Utility Adjustments						
4 (a) Adjust Utilities	$2,200,000	50%	$1,100,000	$3,300,000		
4 (b) Project Management Services	$66,000	40%	$26,400	$92,400		3% of Utility Costs
4 (c) Sponsor	$6,600	40%	$2,640	$9,240		10% of Project Management Services
Sub total	**$2,272,600**	**50%**	**$1,129,040**	**$3,401,640**	**1.5%**	
5. Construction						
5 (a) - 5 (c) Infrastructure	$101,996,729	41%	$41,811,209	$143,807,938		
5 (d) Project Management Services	$3,059,902	40%	$1,223,961	$4,283,863		3% of Infrastructure
5 (e) Sponsor	$305,990	40%	$122,396	$428,386		10% of Project Management Services
5 (f) PAI Insurance	$573,082	40%	$229,233	$802,315		0.55% of Infrastructure + Utility Costs
Sub total	**$105,935,703**	**41%**	**$43,386,798**	**$149,322,502**	**64.8%**	
6. Handover						
6 (a) Refurbish Old Route	$0	40%	$0	$0		
6 (b) Project data & Completion Review	$1,019,967	40%	$407,987	$1,427,954		1% of Construction Cost
6 (c) Project Management Services	$30,599	40%	$12,240	$42,839		3% of Project Data Costs
6 (d) Sponsor	$3,060	40%	$1,224	$4,284		10% of Project Management Services
Sub total	**$1,053,626**	**40%**	**$421,450**	**$1,475,077**	**0.6%**	
TOTAL	**$161,585,511**	**43%**	**$68,941,220**	**$230,526,731**	**100%**	

Source: MacDonald International (2012)

Figure C 3: Capital cost estimate: Route Option C

Project: MR 83 Summerland Way - Additional Crossing of the Clarence River at Grafton Option C - Route Options Development Report				Prepared by:		MacDonald International 49 Berry Street Nowra Ph (02) 44230566 Fax (02) 44233228
	Summary		Draft 6			
Project No: SC090010		Date:	19/07/12	Estimate Type: Strategic		

Item	Base Estimate (excluding contingency)	Contingency %	Contingency Amount	Estimate (including contingency)	% of Total Estimate	Comments / Assumptions
1. Project Development						
1 (a) Route / Concept / EIS	$12,000,000	25%	$3,000,000	$15,000,000		Lump sum allowance for all options
1 (b) Project Management Services	$360,000	25%	$90,000	$450,000		3% of Route / Concept / EIS
1 (c) Sponsor	$36,000	25%	$9,000	$45,000		10% of Project Management Services
1 (d) Community Liaison	$1,200,000	25%	$300,000	$1,500,000		10% of Route / Concept / EIS
Sub total	**$13,596,000**	**25%**	**$3,399,000**	**$16,995,000**	**7.3%**	
2. Investigation and Design						
2 (a) Investigation and Design	$4,200,000	40%	$1,680,000	$5,880,000		2-4% of Construction Cost (common cost for all options)
2 (b) Project Management Services	$126,000	40%	$50,400	$176,400		3% of Investigation and Design
2 (c) Sponsor	$12,600	40%	$5,040	$17,640		10% of Project Management Services
Sub total	**$4,338,600**	**40%**	**$1,735,440**	**$6,074,040**	**2.6%**	
3. Property Acquisitions						
3 (a) Acquire Property	$25,850,000	52%	$13,550,000	$39,400,000		
3 (b) Professional Services for Property	$1,809,500	50%	$904,750	$2,714,250		7% of Acquire Property Cost
3 (c) Project Management Services	$54,285	50%	$27,143	$81,428		3% of Professional Services for Property
3 (d) Sponsor	$5,429	50%	$2,714	$8,143		10% of Project Management Services
Sub total	**$27,719,214**	**52%**	**$14,484,607**	**$42,203,820**	**18.2%**	
4. Public Utility Adjustments						
4 (a) Adjust Utilities	$3,050,000	50%	$1,525,000	$4,575,000		
4 (c) Sponsor	$9,150	40%	$3,660	$12,810		10% of Project Management Services
Sub total	**$3,150,650**	**50%**	**$1,565,260**	**$4,715,910**	**2.0%**	
5. Construction						
5 (a) - 5 (c) Infrastructure	$108,431,299	42%	$45,499,721	$153,931,020		
5 (d) Project Management Services	$3,252,939	40%	$1,301,176	$4,554,115		3% of Infrastructure
5 (e) Sponsor	$325,294	40%	$130,118	$455,411		10% of Project Management Services
5 (f) PAI Insurance	$613,147	40%	$245,259	$858,406		0.55% of Infrastructure + Utility Costs
Sub total	**$112,622,679**	**42%**	**$47,176,273**	**$159,798,952**	**69.1%**	
6. Handover						
6 (a) Refurbish Old Route	$0	40%	$0	$0		
6 (b) Project data & Completion Review	$1,084,313	40%	$433,725	$1,518,038		1% of Construction Cost
6 (c) Project Management Services	$32,529	40%	$13,012	$45,541		3% of Project Data Costs
6 (d) Sponsor	$3,253	40%	$1,301	$4,554		10% of Project Management Services
Sub total	**$1,120,095**	**40%**	**$448,038**	**$1,568,133**	**0.7%**	
TOTAL	**$162,547,238**	**42%**	**$68,808,618**	**$231,355,856**	**100%**	

Source: MacDonald International (2012)

Figure C 4: Capital cost estimate: Route Option 11

Project: MR 83 Summerland Way - Additional Crossing of the Clarence River at Grafton
Option 11 - Route Options Development Report
Prepared by: MacDonald International, 49 Berry Street, Nowra, Ph (02) 44230566 Fax (02) 44233228
DRAFT 6
Summary
Project No: SC090010 Date: 19/07/12 Estimate Type: Strategic

Item	Base Estimate (excluding contingency)	Contingency %	Contingency Amount	Estimate (including contingency)	% of Total Estimate	Comments / Assumptions
1. Project Development						
1 (a) Route / Concept / EIS	$12,000,000	25%	$3,000,000	$15,000,000		Lump sum allowance for all options
1 (b) Project Management Services	$360,000	25%	$90,000	$450,000		3% of Route / Concept / EIS
1 (c) Sponsor	$36,000	25%	$9,000	$45,000		10% of Project Management Services
1 (d) Community Liaison	$1,200,000	25%	$300,000	$1,500,000		10% of Route / Concept / EIS
Sub total	**$13,596,000**	**25%**	**$3,399,000**	**$16,995,000**	**8.1%**	
2. Investigation and Design						
2 (a) Investigation and Design	$4,200,000	40%	$1,680,000	$5,880,000		2-4% of Construction Cost (common cost for all options)
2 (b) Project Management Services	$126,000	40%	$50,400	$176,400		3% of Investigation and Design
2 (c) Sponsor	$12,600	40%	$5,040	$17,640		10% of Project Management Services
Sub total	**$4,338,600**	**40%**	**$1,735,440**	**$6,074,040**	**2.9%**	
3. Property Acquisitions						
3 (a) Acquire Property	$15,060,000	56%	$8,430,000	$23,490,000		
3 (b) Professional Services for Property	$1,054,200	50%	$527,100	$1,581,300		7% of Acquire Property Cost
3 (c) Project Management Services	$31,626	50%	$15,813	$47,439		3% of Professional Services for Property
3 (d) Sponsor	$3,163	50%	$1,581	$4,744		10% of Project Management Services
Sub total	**$16,148,989**	**56%**	**$8,974,494**	**$25,123,483**	**11.9%**	
4. Public Utility Adjustments						
4 (a) Adjust Utilities	$750,000	50%	$375,000	$1,125,000		
4 (b) Project Management Services	$22,500	40%	$9,000	$31,500		3% of Utility Costs
4 (c) Sponsor	$2,250	40%	$900	$3,150		10% of Project Management Services
Sub total	**$774,750**	**50%**	**$384,900**	**$1,159,650**	**0.6%**	
5. Construction						
5 (a) - 5 (c) Infrastructure	$108,095,044	42%	$45,588,939	$153,683,982		
5 (d) Project Management Services	$3,242,851	40%	$1,297,141	$4,539,992		3% of Infrastructure
5 (e) Sponsor	$324,285	40%	$129,714	$453,999		10% of Project Management Services
5 (f) PAI Insurance	$598,648	40%	$239,459	$838,107		0.55% of Infrastructure + Utility Costs
Sub total	**$112,260,828**	**42%**	**$47,255,252**	**$159,516,080**	**75.8%**	
6. Handover						
6 (a) Refurbish Old Route	$0	40%	$0	$0		
6 (b) Project data & Completion Review	$1,080,950	40%	$432,380	$1,513,331		1% of Construction Cost
6 (c) Project Management Services	$32,429	40%	$12,971	$45,400		3% of Project Data Costs
6 (d) Sponsor	$3,243	40%	$1,297	$4,540		10% of Project Management Services
Sub total	**$1,116,622**	**40%**	**$446,649**	**$1,563,271**	**0.7%**	
TOTAL	**$148,235,788**	**42%**	**$62,195,735**	**$210,431,524**	**100%**	

Source: MacDonald International (2012)

Figure C 5: Capital cost estimate: Route Option 14

Project: MR 83 Summerland Way - Additional Crossing of the Clarence River at Grafton Option 14 - Route Options Development Report				Prepared by:		MacDonald International 49 Berry Street Nowra
			DRAFT 6			Ph (02) 44230566 Fax (02) 44233228
Project No: SC090010	Summary	Date:	19/07/12	Estimate Type: Strategic		
Item	**Base Estimate (excluding contingency)**	**Contingency %**	**Contingency Amount**	**Estimate (including contingency)**	**% of Total Estimate**	**Comments / Assumptions**
1. Project Development						
1 (a) Route / Concept / EIS	$12,000,000	25%	$3,000,000	$15,000,000		Lump sum allowance for all options
1 (b) Project Management Services	$360,000	25%	$90,000	$450,000		3% of Route / Concept / EIS
1 (c) Sponsor	$36,000	25%	$9,000	$45,000		10% of Project Management Services
1 (d) Community Liaison	$1,200,000	25%	$300,000	$1,500,000		10% of Route / Concept / EIS
Sub total	**$13,596,000**	**25%**	**$3,399,000**	**$16,995,000**	**5.6%**	
2. Investigation and Design						
2 (a) Investigation and Design	$4,200,000	40%	$1,680,000	$5,880,000		2-4% of Construction Cost (common cost for all options)
2 (b) Project Management Services	$126,000	40%	$50,400	$176,400		3% of Investigation and Design
2 (c) Sponsor	$12,600	40%	$5,040	$17,640		10% of Project Management Services
Sub total	**$4,338,600**	**40%**	**$1,735,440**	**$6,074,040**	**2.0%**	
3. Property Acquisitions						
3 (a) Acquire Property	$7,000,000	52%	$3,620,000	$10,620,000		
3 (b) Professional Services for Property	$490,000	50%	$245,000	$735,000		7% of Acquire Property Cost
3 (c) Project Management Services	$14,700	50%	$7,350	$22,050		3% of Professional Services for Property
3 (d) Sponsor	$1,470	50%	$735	$2,205		10% of Project Management Services
Sub total	**$7,506,170**	**52%**	**$3,873,085**	**$11,379,255**	**3.7%**	
4. Public Utility Adjustments						
4 (a) Adjust Utilities	$1,800,000	50%	$900,000	$2,700,000		
4 (b) Project Management Services	$54,000	40%	$21,600	$75,600		3% of Utility Costs
4 (c) Sponsor	$5,400	40%	$2,160	$7,560		10% of Project Management Services
Sub total	**$1,859,400**	**50%**	**$923,760**	**$2,783,160**	**0.9%**	
5. Construction						
5 (a) - 5 (c) Infrastructure	$179,349,088	42%	$74,793,260	$254,142,349		
5 (d) Project Management Services	$5,380,473	40%	$2,152,189	$7,532,662		3% of Infrastructure
5 (e) Sponsor	$538,047	40%	$215,219	$753,266		10% of Project Management Services
5 (f) PAI Insurance	$996,320	40%	$398,528	$1,394,848		0.55% of Infrastructure + Utility Costs
Sub total	**$186,263,928**	**42%**	**$77,559,196**	**$263,823,125**	**86.9%**	
6. Handover						
6 (a) Refurbish Old Route	$0	40%	$0	$0		
6 (b) Project data & Completion Review	$1,793,491	40%	$717,396	$2,510,887		1% of Construction Cost
6 (c) Project Management Services	$53,805	40%	$21,522	$75,327		3% of Project Data Costs
6 (d) Sponsor	$5,380	40%	$2,152	$7,533		10% of Project Management Services
Sub total	**$1,852,676**	**40%**	**$741,070**	**$2,593,747**	**0.9%**	
TOTAL	**$215,416,774**	**41%**	**$88,231,552**	**$303,648,326**	**100%**	

Source: MacDonald International (2012)

Figure C 6: Capital cost estimate: Route Option 15

Project: MR 83 Summerland Way - Additional Crossing of the Clarence River at Grafton Option 15 - Route Options Development Report				Prepared by:		MacDonald International 49 Berry Street Nowra Ph (02) 44230566 Fax (02) 44233228
	Summary		DRAFT 6			
Project No: SC090010		Date:	19/07/12	Estimate Type: Strategic		

Item	Base Estimate (excluding contingency)	Contingency %	Contingency Amount	Estimate (including contingency)	% of Total Estimate	Comments / Assumptions
1. Project Development						
1 (a) Route / Concept / EIS	$12,000,000	25%	$3,000,000	$15,000,000		Lump sum allowance for all options
1 (b) Project Management Services	$360,000	25%	$90,000	$450,000		3% of Route / Concept / EIS
1 (c) Sponsor	$36,000	25%	$9,000	$45,000		10% of Project Management Services
1 (d) Community Liaison	$1,200,000	25%	$300,000	$1,500,000		10% of Route / Concept / EIS
Sub total	**$13,596,000**	**25%**	**$3,399,000**	**$16,995,000**	**5.0%**	
2. Investigation and Design						
2 (a) Investigation and Design	$4,200,000	40%	$1,680,000	$5,880,000		2-4% of Construction Cost (common cost for all options)
2 (b) Project Management Services	$126,000	40%	$50,400	$176,400		3% of Investigation and Design
2 (c) Sponsor	$12,600	40%	$5,040	$17,640		10% of Project Management Services
Sub total	**$4,338,600**	**40%**	**$1,735,440**	**$6,074,040**	**1.8%**	
3. Property Acquisitions						
3 (a) Acquire Property	$9,070,000	51%	$4,660,000	$13,730,000		
3 (b) Professional Services for Property	$634,900	50%	$317,450	$952,350		7% of Acquire Property Cost
3 (c) Project Management Services	$19,047	50%	$9,524	$28,571		3% of Professional Services for Property
3 (d) Sponsor	$1,905	50%	$952	$2,857		10% of Project Management Services
Sub total	**$9,725,852**	**51%**	**$4,987,926**	**$14,713,778**	**4.3%**	
4. Public Utility Adjustments						
4 (a) Adjust Utilities	$1,850,000	50%	$925,000	$2,775,000		
4 (b) Project Management Services	$55,500	40%	$22,200	$77,700		3% of Utility Costs
4 (c) Sponsor	$5,550	40%	$2,220	$7,770		10% of Project Management Services
Sub total	**$1,911,050**	**50%**	**$949,420**	**$2,860,470**	**0.8%**	
5. Construction						
5 (a) - 5 (c) Infrastructure	$200,863,186	42%	$84,645,861	$285,509,047		
5 (d) Project Management Services	$6,025,896	40%	$2,410,358	$8,436,254		3% of Infrastructure
5 (e) Sponsor	$602,590	40%	$241,036	$843,625		10% of Project Management Services
5 (f) PAI Insurance	$1,114,923	40%	$445,969	$1,560,892		0.55% of Infrastructure + Utility Costs
Sub total	**$208,606,594**	**42%**	**$87,743,224**	**$296,349,817**	**87.2%**	
6. Handover						
6 (a) Refurbish Old Route	$0	40%	$0	$0		
6 (b) Project data & Completion Review	$2,008,632	40%	$803,453	$2,812,085		1% of Construction Cost
6 (c) Project Management Services	$60,259	40%	$24,104	$84,363		3% of Project Data Costs
6 (d) Sponsor	$6,026	40%	$2,410	$8,436		10% of Project Management Services
Sub total	**$2,074,917**	**40%**	**$829,967**	**$2,904,883**	**0.9%**	
TOTAL	**$240,253,012**	**41%**	**$99,644,976**	**$339,897,988**	**100%**	

Source: MacDonald International (2012)

Appendix D Capital cost cashflows by route option

Figure D 1: Capital cost cashflows – Route Option E

Option Capital Costs		Total ($m)	PV ($m)	0 2011	1 2012	2 2013	3 2014	4 2015	5 2016	6 2017	7 2018	8 2019
Capex as per Cost Input Page (i.e. $m real, adjusted to exclude 9% profit margin and Base Case upgrade costs)												
Option E	Project development	12,461	15,054	4,154	4,154	4,154	-	-	-	-	-	-
	Contingency	3,115	3,764	1,038	1,038	1,038	-	-	-	-	-	-
	Investigation and design	3,980	2,937	-	-	-	1,990	1,990	-	-	-	-
	Contingency	1,592	1,175	-	-	-	796	796	-	-	-	-
	Property acquisitions	18,436	13,893	-	-	3,687	7,374	7,374	-	-	-	-
	Contingency	10,502	7,915	-	-	2,100	4,201	4,201	-	-	-	-
	Public utility adjustments	1,658	1,224	-	-	-	829	829	-	-	-	-
	Contingency	824	608	-	-	-	412	412	-	-	-	-
	Construction - Systems	3,263	2,064	-	-	-	-	326	979	979	979	-
	Contingency	1,338	846	-	-	-	-	134	401	401	401	-
	Construction - Bridges	64,438	40,766	-	-	-	-	6,444	19,332	19,332	19,332	-
	Contingency	26,420	16,714	-	-	-	-	2,642	7,926	7,926	7,926	-
	Construction - Pavement	15,498	9,804	-	-	-	-	1,550	4,649	4,649	4,649	-
	Contingency	6,354	4,020	-	-	-	-	635	1,906	1,906	1,906	-
	Construction - Drainage	3,263	2,064	-	-	-	-	326	979	979	979	-
	Contingency	1,338	846	-	-	-	-	134	401	401	401	-
	Construction - Earthworks	3,263	2,064	-	-	-	-	326	979	979	979	-
	Contingency	1,338	846	-	-	-	-	134	401	401	401	-
	Handover	1,009	549	-	-	-	-	-	-	-	-	1,009
	Contingency	404	220	-	-	-	-	-	-	-	-	404
	Total (excl. residual)	**180,493**	**127,373**	**5,192**	**5,192**	**10,980**	**15,603**	**28,254**	**37,953**	**37,953**	**37,953**	**1,412**
	Residual	-	- 8,050	-	-	-	-	-	-	-	-	-
	Total (incl. residual)		**119,322**	**5,192**	**5,192**	**10,980**	**15,603**	**28,254**	**37,953**	**37,953**	**37,953**	**1,412**

Source: MacDonald International (2012); Arup Email dated 2nd February 2012.

What would you like to grow?

Capital cost cashflows by route option

Figure D 2: Capital cost cashflows – Route Option A

Option Capital Costs		Total ($m)	PV ($m)	0 2011	1 2012	2 2013	3 2014	4 2015	5 2016	6 2017	7 2018	8 2019
Capex as per Cost Input Page (i.e. $m real, adjusted to exclude 9% profit margin and Base Case upgrade costs)												
Option A	Project development	**12,461**	**15,054**	4,154	4,154	4,154	-	-	-	-	-	-
	Contingency	**3,115**	**3,764**	1,038	1,038	1,038	-	-	-	-	-	-
	Investigation and design	**3,980**	**2,937**	-	-	-	1,990	1,990	-	-	-	-
	Contingency	**1,592**	**1,175**	-	-	-	796	796	-	-	-	-
	Property acquisitions	**31,550**	**23,776**	-	-	6,310	12,620	12,620	-	-	-	-
	Contingency	**17,311**	**13,046**	-	-	3,462	6,925	6,925	-	-	-	-
	Public utility adjustments	**2,085**	**1,539**	-	-	-	1,042	1,042	-	-	-	-
	Contingency	**1,036**	**764**	-	-	-	518	518	-	-	-	-
	Construction - Systems	**2,735**	**1,730**	-	-	-	-	274	821	821	821	-
	Contingency	**1,121**	**709**	-	-	-	-	112	336	336	336	-
	Construction - Bridges	**54,021**	**34,175**	-	-	-	-	5,402	16,206	16,206	16,206	-
	Contingency	**22,149**	**14,012**	-	-	-	-	2,215	6,645	6,645	6,645	-
	Construction - Pavement	**20,514**	**12,978**	-	-	-	-	2,051	6,154	6,154	6,154	-
	Contingency	**8,411**	**5,321**	-	-	-	-	841	2,523	2,523	2,523	-
	Construction - Drainage	**3,419**	**2,163**	-	-	-	-	342	1,026	1,026	1,026	-
	Contingency	**1,402**	**887**	-	-	-	-	140	421	421	421	-
	Construction - Earthworks	**4,787**	**3,028**	-	-	-	-	479	1,436	1,436	1,436	-
	Contingency	**1,963**	**1,242**	-	-	-	-	196	589	589	589	-
	Handover	**967**	**526**	-	-	-	-	-	-	-	-	967
	Contingency	**387**	**210**	-	-	-	-	-	-	-	-	387
	Total (Excl. Residual)	**195,006**	**139,037**	**5,192**	**5,192**	**14,964**	**23,891**	**35,943**	**36,157**	**36,157**	**36,157**	**1,353**
	Residual	-	- 9,017	-	-	-	-	-	-	-	-	-
	Total (Incl. Residual)		**130,020**	**5,192**	**5,192**	**14,964**	**23,891**	**35,943**	**36,157**	**36,157**	**36,157**	**1,353**

Source: MacDonald International (2012); Arup Email dated 2nd February 2012.

Figure D 3: Capital cost cashflows – Route Option C

Option Capital Costs		Total ($m)	PV ($m)	0 2011	1 2012	2 2013	3 2014	4 2015	5 2016	6 2017	7 2018	8 2019
Capex as per Cost Input Page (i.e. $m real, adjusted to exclude 9% profit margin and Base Case upgrade costs)												
Option C	Project development	**12,461**	**15,054**	4,154	4,154	4,154	-	-	-	-	-	-
	Contingency	**3,115**	**3,764**	1,038	1,038	1,038	-	-	-	-	-	-
	Investigation and design	**3,980**	**2,937**	-	-	-	1,990	1,990	-	-	-	-
	Contingency	**1,592**	**1,175**	-	-	-	796	796	-	-	-	-
	Property acquisitions	**25,430**	**19,165**	-	-	5,086	10,172	10,172	-	-	-	-
	Contingency	**13,289**	**10,014**	-	-	2,658	5,315	5,315	-	-	-	-
	Public utility adjustments	**2,891**	**2,133**	-	-	-	1,445	1,445	-	-	-	-
	Contingency	**1,436**	**1,060**	-	-	-	718	718	-	-	-	-
	Construction - Systems	**2,273**	**1,438**	-	-	-	-	227	682	682	682	-
	Contingency	**955**	**604**	-	-	-	-	95	286	286	286	-
	Construction - Bridges	**55,320**	**34,997**	-	-	-	-	5,532	16,596	16,596	16,596	-
	Contingency	**23,234**	**14,699**	-	-	-	-	2,323	6,970	6,970	6,970	-
	Construction - Pavement	**21,218**	**13,423**	-	-	-	-	2,122	6,366	6,366	6,366	-
	Contingency	**8,912**	**5,638**	-	-	-	-	891	2,674	2,674	2,674	-
	Construction - Drainage	**3,789**	**2,397**	-	-	-	-	379	1,137	1,137	1,137	-
	Contingency	**1,591**	**1,007**	-	-	-	-	159	477	477	477	-
	Construction - Earthworks	**9,094**	**5,753**	-	-	-	-	909	2,728	2,728	2,728	-
	Contingency	**3,819**	**2,416**	-	-	-	-	382	1,146	1,146	1,146	-
	Handover	**1,028**	**559**	-	-	-	-	-	-	-	-	1,028
	Contingency	**411**	**224**	-	-	-	-	-	-	-	-	411
	Total (excl. residual)	**195,839**	**138,456**	**5,192**	**5,192**	**12,936**	**20,437**	**33,458**	**39,062**	**39,062**	**39,062**	**1,439**
	Residual	-	- 8,819	-	-	-	-	-	-	-	-	-
	Total (Incl. residual)		**129,638**	**5,192**	**5,192**	**12,936**	**20,437**	**33,458**	**39,062**	**39,062**	**39,062**	**1,439**

Source: MacDonald International (2012); Arup Email dated 2nd February 2012.

Capital cost cashflows by route option

Figure D 4: Capital cost cashflows – Route Option 11

Option Capital Costs		Total ($m)	PV ($m)	0 2011	1 2012	2 2013	3 2014	4 2015	5 2016	6 2017	7 2018	8 2019
Capex as per Cost Input Page (i.e. $m real, adjusted to exclude 9% profit margin and Base Case upgrade costs)												
Option 11	Project development	**12,461**	**15,054**	4,154	4,154	4,154	-	-	-	-	-	-
	Contingency	**3,115**	**3,764**	1,038	1,038	1,038	-	-	-	-	-	-
	Investigation and design	**3,980**	**2,937**	-	-	-	1,990	1,990	-	-	-	-
	Contingency	**1,592**	**1,175**	-	-	-	796	796	-	-	-	-
	Property acquisitions	**14,816**	**11,165**	-	-	2,963	5,926	5,926	-	-	-	-
	Contingency	**8,233**	**6,205**	-	-	1,647	3,293	3,293	-	-	-	-
	Public utility adjustments	**711**	**525**	-	-	-	355	355	-	-	-	-
	Contingency	**353**	**261**	-	-	-	177	177	-	-	-	-
	Construction - Systems	**2,811**	**1,778**	-	-	-	-	281	843	843	843	-
	Contingency	**1,181**	**747**	-	-	-	-	118	354	354	354	-
	Construction - Bridges	**54,817**	**34,679**	-	-	-	-	5,482	16,445	16,445	16,445	-
	Contingency	**23,023**	**14,565**	-	-	-	-	2,302	6,907	6,907	6,907	-
	Construction - Pavement	**15,461**	**9,781**	-	-	-	-	1,546	4,638	4,638	4,638	-
	Contingency	**6,494**	**4,108**	-	-	-	-	649	1,948	1,948	1,948	-
	Construction - Drainage	**2,108**	**1,334**	-	-	-	-	211	633	633	633	-
	Contingency	**886**	**560**	-	-	-	-	89	266	266	266	-
	Construction - Earthworks	**16,164**	**10,226**	-	-	-	-	1,616	4,849	4,849	4,849	-
	Contingency	**6,789**	**4,295**	-	-	-	-	679	2,037	2,037	2,037	-
	Handover	**1,024**	**557**	-	-	-	-	-	-	-	-	1,024
	Contingency	**404**	**220**	-	-	-	-	-	-	-	-	404
	Total (excl. residual)	**176,424**	**123,936**	**5,192**	**5,192**	**9,802**	**12,538**	**25,511**	**38,920**	**38,920**	**38,920**	**1,429**
	Residual	**-**	**- 7,848**	-	-	-	-	-	-	-	-	-
	Total (Incl. residual)		**116,088**	**5,192**	**5,192**	**9,802**	**12,538**	**25,511**	**38,920**	**38,920**	**38,920**	**1,429**

Source: MacDonald International (2012); Arup Email dated 2nd February 2012.

Figure D 5: Capital cost cashflows – Route Option 14

Option Capital Costs		Total ($m)	PV ($m)	0 2011	1 2012	2 2013	3 2014	4 2015	5 2016	6 2017	7 2018	8 2019
Capex as per Cost Input Page (i.e. $m real, adjusted to exclude 9% profit margin and Base Case upgrade costs)												
Option 14	Project development	12,461	15,054	4,154	4,154	4,154	-	-	-	-	-	-
	Contingency	3,115	3,764	1,038	1,038	1,038	-	-	-	-	-	-
	Investigation and design	3,980	2,937	-	-	-	1,990	1,990	-	-	-	-
	Contingency	1,592	1,175	-	-	-	796	796	-	-	-	-
	Property acquisitions	6,886	5,190	-	-	1,377	2,755	2,755	-	-	-	-
	Contingency	3,553	2,678	-	-	711	1,421	1,421	-	-	-	-
	Public utility adjustments	1,706	1,259	-	-	-	853	853	-	-	-	-
	Contingency	847	625	-	-	-	424	424	-	-	-	-
	Construction - Systems	3,477	2,200	-	-	-	-	348	1,043	1,043	1,043	-
	Contingency	1,460	924	-	-	-	-	146	438	438	438	-
	Construction - Bridges	111,965	70,832	-	-	-	-	11,197	33,590	33,590	33,590	-
	Contingency	47,025	29,750	-	-	-	-	4,703	14,108	14,108	14,108	-
	Construction - Pavement	24,340	15,398	-	-	-	-	2,434	7,302	7,302	7,302	-
	Contingency	10,223	6,467	-	-	-	-	1,022	3,067	3,067	3,067	-
	Construction - Drainage	4,868	3,080	-	-	-	-	487	1,460	1,460	1,460	-
	Contingency	2,045	1,293	-	-	-	-	204	613	613	613	-
	Construction - Earthworks	14,604	9,239	-	-	-	-	1,460	4,381	4,381	4,381	-
	Contingency	6,134	3,880	-	-	-	-	613	1,840	1,840	1,840	-
	Handover	1,700	925	-	-	-	-	-	-	-	-	1,700
	Contingency	680	370	-	-	-	-	-	-	-	-	680
	Total (excl. residual)	**262,663**	**177,040**	**5,192**	**5,192**	**7,280**	**8,239**	**30,853**	**67,843**	**67,843**	**67,843**	**2,380**
	Residual	-	- 11,740	-	-	-	-	-	-	-	-	-
	Total (Incl. residual)		**165,300**	**5,192**	**5,192**	**7,280**	**8,239**	**30,853**	**67,843**	**67,843**	**67,843**	**2,380**

Source: MacDonald International (2012); Arup Email dated 2nd February 2012.

Figure D 6: Capital cost cashflows – Route Option 15

Option Capital Costs		Total ($m)	PV ($m)	0 2011	1 2012	2 2013	3 2014	4 2015	5 2016	6 2017	7 2018	8 2019
Capex as per Cost Input Page (i.e. $m real, adjusted to exclude 9% profit margin and Base Case upgrade costs)												
Option 15	Project development	**12,461**	**15,054**	4,154	4,154	4,154	-	-	-	-	-	-
	Contingency	**3,115**	**3,764**	1,038	1,038	1,038	-	-	-	-	-	-
	Investigation and design	**3,980**	**2,937**	-	-	-	1,990	1,990	-	-	-	-
	Contingency	**1,592**	**1,175**	-	-	-	796	796	-	-	-	-
	Property acquisitions	**8,923**	**6,724**	-	-	1,785	3,569	3,569	-	-	-	-
	Contingency	**4,576**	**3,449**	-	-	915	1,830	1,830	-	-	-	-
	Public utility adjustments	**1,753**	**1,294**	-	-	-	877	877	-	-	-	-
	Contingency	**871**	**643**	-	-	-	436	436	-	-	-	-
	Construction - Systems	**3,511**	**2,221**	-	-	-	-	351	1,053	1,053	1,053	-
	Contingency	**1,475**	**933**	-	-	-	-	147	442	442	442	-
	Construction - Bridges	**113,048**	**71,517**	-	-	-	-	11,305	33,914	33,914	33,914	-
	Contingency	**47,480**	**30,037**	-	-	-	-	4,748	14,244	14,244	14,244	-
	Construction - Pavement	**27,384**	**17,324**	-	-	-	-	2,738	8,215	8,215	8,215	-
	Contingency	**11,501**	**7,276**	-	-	-	-	1,150	3,450	3,450	3,450	-
	Construction - Drainage	**5,617**	**3,554**	-	-	-	-	562	1,685	1,685	1,685	-
	Contingency	**2,359**	**1,493**	-	-	-	-	236	708	708	708	-
	Construction - Earthworks	**30,193**	**19,101**	-	-	-	-	3,019	9,058	9,058	9,058	-
	Contingency	**12,681**	**8,022**	-	-	-	-	1,268	3,804	3,804	3,804	-
	Handover	**1,904**	**1,035**	-	-	-	-	-	-	-	-	1,904
	Contingency	**761**	**414**	-	-	-	-	-	-	-	-	761
	Total (excl. residual)	**295,186**	**197,967**	**5,192**	**5,192**	**7,892**	**9,498**	**35,023**	**76,575**	**76,575**	**76,575**	**2,665**
	Residual	**-**	**- 13,422**	-	-	-	-	-	-	-	-	-
	Total (Incl. residual)		**184,545**	**5,192**	**5,192**	**7,892**	**9,498**	**35,023**	**76,575**	**76,575**	**76,575**	**2,665**

Source: MacDonald International (2012); Arup Email dated 2nd February 2012.

Appendix E Detailed road user and external cost profiles

Figure E 1: Incremental annual travel time cost

Road User and External Costs – Travel Time Cost	Total ($'000)	PV$'000	Class	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Period												0	1	2	3	4	5	6	7	8	9
E	- 633,543	- 133,916	Light	-	-	-	-	-	-	-	-	- 9,586	- 10,318	- 11,088	- 11,898	- 12,751	- 13,647	- 14,590	- 15,581	- 16,622	- 17,717
	- 105,249	- 22,020	Heavy	-	-	-	-	-	-	-	-	- 1,550	- 1,669	- 1,795	- 1,928	- 2,067	- 2,214	- 2,368	- 2,530	- 2,701	- 2,880
		155,936																			
A	- 563,401	- 119,618	Light	-	-	-	-	-	-	-	-	- 8,371	- 9,065	- 9,795	- 10,565	- 11,376	- 12,230	- 13,129	- 14,074	- 15,068	- 16,114
	- 95,337	- 19,572	Heavy	-	-	-	-	-	-	-	-	- 1,318	- 1,429	- 1,547	- 1,670	- 1,800	- 1,937	- 2,082	- 2,233	- 2,393	- 2,561
		139,190																			
C	- 655,528	- 139,027	Light	-	-	-	-	-	-	-	-	- 10,038	- 10,796	- 11,595	- 12,434	- 13,317	- 14,246	- 15,222	- 16,248	- 17,326	- 18,458
	- 103,627	- 21,792	Heavy	-	-	-	-	-	-	-	-	- 1,531	- 1,653	- 1,781	- 1,915	- 2,057	- 2,206	- 2,363	- 2,528	- 2,701	- 2,883
		160,819																			
11	- 614,628	- 133,766	Light	-	-	-	-	-	-	-	-	- 10,875	- 11,501	- 12,157	- 12,846	- 13,569	- 14,327	- 15,121	- 15,954	- 16,827	- 17,742
	- 99,730	- 21,433	Heavy	-	-	-	-	-	-	-	-	- 1,676	- 1,781	- 1,891	- 2,006	- 2,127	- 2,254	- 2,388	- 2,528	- 2,675	- 2,829
		155,199																			
14	- 477,653	- 108,029	Light	-	-	-	-	-	-	-	-	- 10,020	- 10,421	- 10,838	- 11,271	- 11,722	- 12,191	- 12,679	- 13,186	- 13,713	- 14,261
	- 83,121	- 18,376	Heavy	-	-	-	-	-	-	-	-	- 1,642	- 1,710	- 1,782	- 1,857	- 1,935	- 2,016	- 2,100	- 2,188	- 2,280	- 2,375
		126,404																			
15	- 494,270	- 110,324	Light	-	-	-	-	-	-	-	-	- 10,250	- 10,618	- 10,998	- 11,393	- 11,801	- 12,224	- 12,661	- 13,115	- 13,584	- 14,071
	- 81,813	- 17,844	Heavy	-	-	-	-	-	-	-	-	- 1,572	- 1,636	- 1,703	- 1,773	- 1,846	- 1,922	- 2,000	- 2,082	- 2,168	- 2,257
		128,168																			

Travel Time Cost	Class	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
Period		10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
E	Light	- 18,866	- 19,328	- 19,801	- 20,284	- 20,778	- 21,283	- 21,800	- 22,328	- 22,868	- 23,420	- 23,985	- 24,421	- 24,864	- 25,313	- 25,771	- 26,235	- 26,707	- 27,186	- 27,673	- 28,167	- 28,670
	Heavy	- 3,068	- 3,151	- 3,236	- 3,323	- 3,412	- 3,503	- 3,597	- 3,692	- 3,790	- 3,890	- 3,992	- 4,078	- 4,165	- 4,254	- 4,345	- 4,436	- 4,530	- 4,625	- 4,721	- 4,819	- 4,919
A	Light	- 17,213	- 17,589	- 17,973	- 18,366	- 18,766	- 19,176	- 19,593	- 20,020	- 20,456	- 20,900	- 21,355	- 21,679	- 22,009	- 22,343	- 22,682	- 23,026	- 23,375	- 23,729	- 24,088	- 24,453	- 24,823
	Heavy	- 2,738	- 2,803	- 2,869	- 2,937	- 3,007	- 3,078	- 3,150	- 3,224	- 3,300	- 3,378	- 3,457	- 3,593	- 3,732	- 3,872	- 4,015	- 4,160	- 4,307	- 4,457	- 4,608	- 4,762	- 4,919
C	Light	- 19,646	- 20,103	- 20,569	- 21,046	- 21,533	- 22,031	- 22,539	- 23,059	- 23,590	- 24,133	- 24,687	- 25,148	- 25,615	- 26,090	- 26,573	- 27,064	- 27,562	- 28,068	- 28,583	- 29,105	- 29,105
	Heavy	- 3,074	- 3,150	- 3,227	- 3,307	- 3,388	- 3,471	- 3,555	- 3,642	- 3,731	- 3,821	- 3,914	- 3,995	- 4,077	- 4,161	- 4,246	- 4,333	- 4,421	- 4,510	- 4,601	- 4,693	- 4,693
11	Light	- 18,701	- 19,031	- 19,365	- 19,706	- 20,053	- 20,406	- 20,765	- 21,131	- 21,502	- 21,881	- 22,266	- 22,729	- 23,200	- 23,678	- 24,165	- 24,659	- 25,162	- 25,673	- 26,193	- 26,721	- 26,721
	Heavy	- 2,991	- 3,051	- 3,112	- 3,174	- 3,237	- 3,302	- 3,368	- 3,435	- 3,504	- 3,574	- 3,645	- 3,728	- 3,813	- 3,899	- 3,987	- 4,076	- 4,167	- 4,259	- 4,353	- 4,448	- 4,448
14	Light	- 14,832	- 15,039	- 15,248	- 15,461	- 15,675	- 15,893	- 16,112	- 16,335	- 16,560	- 16,788	- 17,018	- 17,232	- 17,448	- 17,667	- 17,889	- 18,114	- 18,341	- 18,572	- 18,805	- 19,041	- 19,280
	Heavy	- 2,474	- 2,523	- 2,573	- 2,624	- 2,676	- 2,729	- 2,783	- 2,838	- 2,894	- 2,951	- 3,010	- 3,063	- 3,117	- 3,172	- 3,227	- 3,284	- 3,341	- 3,400	- 3,459	- 3,519	- 3,581
15	Light	- 14,574	- 14,903	- 15,238	- 15,581	- 15,931	- 16,289	- 16,654	- 17,027	- 17,409	- 17,798	- 18,196	- 18,411	- 18,628	- 18,848	- 19,070	- 19,295	- 19,523	- 19,753	- 19,986	- 20,221	- 20,221
	Heavy	- 2,349	- 2,409	- 2,470	- 2,533	- 2,597	- 2,663	- 2,730	- 2,799	- 2,869	- 2,941	- 3,015	- 3,073	- 3,133	- 3,194	- 3,256	- 3,319	- 3,382	- 3,447	- 3,513	- 3,580	- 3,580

Source: GTA (2012), MacDonald International (2012); Arup Email dated 2nd February 2012, RMS (1999, Appendix B 2009 Update), PwC

Figure E 2: Incremental annual vehicle operating cost

VOC	Total ($'000)	PV$'000	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Period											0	1	2	3	4	5	6	7	8	9
E	- 34,762	- 7,455	-	-	-	-	-	-	-	-	- 555	- 594	- 636	- 679	- 724	- 771	- 821	- 872	- 926	- 983
		7,455																		
A	- 13,152	- 2,860	-	-	-	-	-	-	-	-	- 176	- 197	- 221	- 245	- 270	- 297	- 325	- 355	- 386	- 418
		2,860																		
C	- 27,554	- 5,944	-	-	-	-	-	-	-	-	- 408	- 446	- 486	- 528	- 572	- 619	- 667	- 718	- 771	- 827
		5,944																		
11	- 22,012	- 5,014	-	-	-	-	-	-	-	-	- 431	- 456	- 483	- 510	- 539	- 569	- 600	- 632	- 666	- 701
		5,014																		
14	- 4,630	- 1,009	-	-	-	-	-	-	-	-	- 88	- 92	- 95	- 98	- 101	- 104	- 107	- 110	- 113	- 116
		1,009																		
15	- 7,345	- 1,771	-	-	-	-	-	-	-	-	- 165	- 175	- 184	- 194	- 204	- 215	- 225	- 236	- 248	- 259
		1,771																		

VOC	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
Period	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
E	- 1,041	- 1,070	- 1,099	- 1,128	- 1,159	- 1,190	- 1,221	- 1,254	- 1,287	- 1,321	- 1,355	- 1,363	- 1,371	- 1,378	- 1,386	- 1,394	- 1,401	- 1,409	- 1,417	- 1,425	- 1,532
A	- 452	- 458	- 465	- 471	- 477	- 483	- 490	- 496	- 503	- 510	- 517	- 511	- 506	- 500	- 494	- 488	- 482	- 475	- 469	- 462	- 555
C	- 885	- 901	- 917	- 933	- 949	- 966	- 983	- 1,000	- 1,018	- 1,036	- 1,054	- 1,058	- 1,062	- 1,067	- 1,071	- 1,075	- 1,079	- 1,083	- 1,087	- 1,091	- 1,195
11	- 737	- 742	- 746	- 750	- 755	- 759	- 763	- 767	- 770	- 774	- 778	- 782	- 785	- 789	- 793	- 797	- 801	- 804	- 808	- 812	- 915
14	- 119	- 128	- 137	- 146	- 155	- 165	- 174	- 184	- 195	- 205	- 216	- 208	- 199	- 191	- 182	- 174	- 165	- 155	- 146	- 136	- 226
15	- 271	- 270	- 268	- 267	- 265	- 264	- 262	- 260	- 258	- 255	- 253	- 248	- 243	- 238	- 233	- 228	- 223	- 217	- 211	- 206	- 299

Source: GTA (2012), MacDonald International (2012); Arup Email dated 2nd February 2012, RMS (1999, Appendix B 2009 Update), PwC

Figure E 3: Incremental annual vehicle stop cost

Road User and External Costs																																						
Period												0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Vehicle Stops	Total ($'000)	PV$'000		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
E	-129,533	-26,299	Light	-	-	-	-	-	-	-	-	-1,327	-1,511	-1,712	-1,930	-2,167	-2,425	-2,705	-3,009	-3,339	-3,697	-4,085	-4,177	-4,272	-4,368	-4,467	-4,568	-4,672	-4,777	-4,885	-4,996	-5,109	-5,183	-5,258	-5,334	-5,411	-5,489	-5,569	-5,649	-5,731	-5,814	-5,898
	-12,221	-2,464	Heavy	-	-	-	-	-	-	-	-	-120	-137	-157	-177	-200	-224	-251	-280	-311	-346	-383	-392	-401	-410	-420	-430	-440	-451	-461	-472	-483	-491	-499	-507	-515	-523	-531	-540	-548	-557	-566
		28,763																																								
A	-129,975	-26,613	Light	-	-	-	-	-	-	-	-	-1,371	-1,559	-1,764	-1,986	-2,228	-2,491	-2,776	-3,086	-3,421	-3,785	-4,179	-4,261	-4,345	-4,430	-4,517	-4,606	-4,696	-4,788	-4,882	-4,978	-5,075	-5,145	-5,216	-5,288	-5,360	-5,434	-5,508	-5,584	-5,660	-5,737	-5,816
	-12,329	-2,515	Heavy	-	-	-	-	-	-	-	-	-127	-145	-165	-186	-209	-234	-261	-290	-322	-357	-394	-402	-411	-419	-428	-436	-445	-454	-464	-473	-483	-490	-497	-504	-511	-518	-526	-533	-541	-548	-556
		29,128																																								
C	-150,706	-31,054	Light	-	-	-	-	-	-	-	-	-1,769	-1,970	-2,188	-2,425	-2,682	-2,960	-3,261	-3,586	-3,939	-4,320	-4,732	-4,833	-4,937	-5,043	-5,151	-5,261	-5,374	-5,489	-5,606	-5,726	-5,849	-5,938	-6,028	-6,120	-6,213	-6,307	-6,403	-6,500	-6,599	-6,699	-6,801
	-13,846	-2,842	Heavy	-	-	-	-	-	-	-	-	-157	-176	-196	-218	-242	-268	-297	-327	-361	-396	-435	-445	-454	-464	-475	-485	-496	-506	-517	-529	-540	-548	-557	-565	-574	-582	-591	-600	-609	-618	-618
		33,895																																								
11	-149,862	-31,888	Light	-	-	-	-	-	-	-	-	-2,181	-2,361	-2,554	-2,763	-2,989	-3,233	-3,495	-3,779	-4,085	-4,415	-4,770	-4,848	-4,927	-5,006	-5,086	-5,168	-5,250	-5,333	-5,417	-5,501	-5,587	-5,679	-5,774	-5,869	-5,967	-6,066	-6,166	-6,268	-6,372	-6,478	-6,478
	-14,038	-2,970	Heavy	-	-	-	-	-	-	-	-	-197	-214	-233	-253	-275	-298	-324	-351	-381	-413	-448	-455	-462	-470	-477	-485	-493	-501	-508	-516	-525	-534	-543	-552	-562	-572	-581	-592	-602	-612	-612
		34,858																																								
14	-140,404	-29,924	Light	-	-	-	-	-	-	-	-	-2,140	-2,298	-2,467	-2,649	-2,844	-3,054	-3,279	-3,520	-3,779	-4,058	-4,356	-4,440	-4,526	-4,613	-4,702	-4,792	-4,884	-4,978	-5,073	-5,170	-5,269	-5,353	-5,438	-5,524	-5,612	-5,700	-5,791	-5,883	-5,976	-6,070	-6,167
	-13,564	-2,882	Heavy	-	-	-	-	-	-	-	-	-203	-219	-235	-253	-272	-292	-314	-338	-363	-391	-420	-428	-437	-445	-454	-463	-473	-482	-491	-501	-511	-519	-527	-536	-544	-553	-562	-571	-580	-589	-598
		32,805																																								
15	-141,419	-29,919	Light	-	-	-	-	-	-	-	-	-2,139	-2,292	-2,456	-2,631	-2,819	-3,021	-3,237	-3,468	-3,716	-3,981	-4,266	-4,367	-4,470	-4,576	-4,685	-4,796	-4,909	-5,025	-5,144	-5,265	-5,390	-5,476	-5,563	-5,652	-5,742	-5,834	-5,927	-6,022	-6,118	-6,216	-6,216
	-13,423	-2,827	Heavy	-	-	-	-	-	-	-	-	-197	-212	-228	-245	-263	-283	-304	-327	-352	-378	-406	-415	-425	-435	-445	-455	-466	-476	-487	-498	-510	-519	-528	-538	-547	-557	-567	-577	-587	-597	-597
		32,746																																								

Source: GTA (2012), MacDonald International (2012); Arup Email dated 2nd February 2012, RMS (1999, Appendix B 2009 Update), PwC

Figure E 4: Incremental annual crash cost

Road User and External Costs																																						
Period												0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Crash Cost	Total ($'000)	PV$'000		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
E	-2,704	-581	Light	-	-	-	-	-	-	-	-	-41	-45	-48	-52	-56	-60	-64	-68	-73	-78	-83	-85	-88	-90	-92	-95	-97	-100	-103	-105	-108	-108	-108	-108	-108	-107	-107	-107	-107	-107	-106
	-1,789	-375	Heavy	-	-	-	-	-	-	-	-	-32	-33	-34	-36	-37	-38	-40	-41	-43	-45	-46	-48	-50	-52	-54	-56	-58	-60	-62	-64	-67	-69	-71	-73	-76	-78	-80	-83	-85	-88	-90
		956																																								
A	674	145	Light	-	-	-	-	-	-	-	-	19	19	18	18	17	16	15	15	14	13	12	13	14	15	16	17	18	20	21	22	23	25	26	28	29	31	33	34	36	38	39
	-530	-114	Heavy	-	-	-	-	-	-	-	-	-11	-12	-12	-12	-12	-13	-13	-13	-13	-14	-14	-14	-15	-15	-15	-16	-16	-16	-17	-17	-17	-18	-19	-21	-22	-23	-24	-25	-26	-27	-29
		-31																																								
C	-1,530	-333	Light	-	-	-	-	-	-	-	-	-17	-20	-23	-27	-30	-34	-38	-43	-47	-52	-57	-57	-57	-58	-58	-58	-58	-59	-59	-59	-59	-59	-58	-58	-57	-56	-56	-55	-54	-54	-53
	-1,032	-216	Heavy	-	-	-	-	-	-	-	-	-18	-18	-19	-20	-21	-22	-23	-25	-26	-27	-28	-29	-30	-31	-31	-32	-33	-34	-35	-36	-37	-38	-40	-41	-43	-45	-46	-48	-50	-51	-53
		549																																								
11	-608	-167	Light	-	-	-	-	-	-	-	-	-16	-17	-19	-20	-22	-23	-25	-26	-28	-30	-32	-30	-29	-27	-25	-24	-22	-20	-18	-16	-14	-14	-13	-13	-13	-13	-12	-12	-12	-11	-11
	-999	-213	Heavy	-	-	-	-	-	-	-	-	-19	-19	-20	-21	-22	-22	-23	-24	-25	-26	-26	-27	-28	-30	-31	-32	-33	-34	-35	-36	-38	-38	-39	-40	-41	-42	-43	-44	-45	-46	-47
		380																																								
14	2,246	522	Light	-	-	-	-	-	-	-	-	52	54	56	57	60	62	64	66	68	71	73	74	74	74	74	74	74	74	74	74	74	75	77	78	80	82	83	85	87	89	90
	-944	-195	Heavy	-	-	-	-	-	-	-	-	-18	-19	-19	-19	-20	-20	-20	-20	-21	-21	-21	-22	-24	-25	-27	-28	-30	-31	-33	-34	-36	-37	-39	-40	-41	-43	-44	-46	-47	-49	-50
		-327																																								
15	1,436	294	Light	-	-	-	-	-	-	-	-	28	29	29	29	29	29	29	29	29	29	29	31	34	37	40	43	46	49	53	56	59	61	62	64	65	66	68	69	71	72	74
	-425	-70	Heavy	-	-	-	-	-	-	-	-	-6	-5	-5	-5	-5	-5	-5	-5	-4	-4	-4	-5	-6	-7	-8	-9	-10	-12	-13	-14	-15	-18	-20	-22	-24	-26	-28	-31	-33	-35	-38
		-224																																								

Source: GTA (2012), MacDonald International (2012); Arup Email dated 2nd February 2012, RMS (1999, Appendix B 2009 Update), PwC

Figure E 5: Incremental annual external cost

Road User and External Costs

External Cost	Total ($'000)	PV$'000		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Period												0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
E	-2,815	-605	Light	-	-	-	-	-	-	-	-	-43	-47	-50	-54	-58	-62	-67	-71	-76	-81	-86	-89	-91	-94	-96	-99
	-4,200	-880	Heavy	-	-	-	-	-	-	-	-	-75	-78	-81	-84	-87	-90	-94	-97	-101	-105	-109	-113	-117	-122	-126	-131
		1,485																									
A	702	151	Light	-	-	-	-	-	-	-	-	20	19	19	18	18	17	16	15	14	13	12	14	15	16	17	18
	-1,245	-269	Heavy	-	-	-	-	-	-	-	-	-27	-27	-28	-28	-29	-30	-30	-31	-31	-32	-33	-33	-34	-35	-36	-36
		117																									
C	-1,593	-346	Light	-	-	-	-	-	-	-	-	-17	-21	-24	-28	-32	-36	-40	-44	-49	-54	-59	-59	-60	-60	-60	-61
	-2,422	-508	Heavy	-	-	-	-	-	-	-	-	-41	-43	-46	-48	-50	-53	-55	-58	-61	-63	-66	-68	-70	-72	-74	-76
		855																									
11	-633	-174	Light	-	-	-	-	-	-	-	-	-17	-18	-20	-21	-22	-24	-26	-27	-29	-31	-33	-32	-30	-28	-27	-25
	-2,346	-500	Heavy	-	-	-	-	-	-	-	-	-44	-46	-47	-49	-51	-52	-54	-56	-58	-60	-62	-65	-67	-69	-72	-74
		674																									
14	2,338	544	Light	-	-	-	-	-	-	-	-	54	56	58	60	62	64	66	69	71	74	76	77	77	77	77	77
	-2,216	-459	Heavy	-	-	-	-	-	-	-	-	-43	-44	-45	-45	-46	-47	-47	-48	-48	-49	-50	-53	-56	-59	-63	-66
		-85																									
15	1,495	306	Light	-	-	-	-	-	-	-	-	30	30	30	30	30	30	30	30	30	30	30	33	36	38	42	45
	-999	-164	Heavy	-	-	-	-	-	-	-	-	-13	-13	-13	-12	-12	-11	-11	-11	-10	-10	-9	-11	-14	-16	-19	-22
		-142																									

External Cost		2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
Period		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
E	Light	-101	-104	-107	-110	-113	-112	-112	-112	-112	-112	-112	-111	-111	-111	-111
	Heavy	-136	-141	-146	-151	-156	-162	-167	-172	-178	-183	-189	-194	-200	-206	-212
A	Light	19	20	22	23	24	26	27	29	31	32	34	36	37	39	41
	Heavy	-37	-38	-39	-40	-41	-43	-46	-48	-51	-54	-56	-59	-62	-64	-67
C	Light	-61	-61	-61	-62	-62	-61	-61	-60	-59	-59	-58	-57	-57	-56	-55
	Heavy	-78	-80	-82	-84	-86	-90	-93	-97	-101	-105	-109	-113	-117	-121	-125
11	Light	-23	-21	-19	-17	-15	-14	-14	-14	-13	-13	-13	-12	-12	-12	-11
	Heavy	-77	-80	-82	-85	-88	-90	-93	-95	-97	-99	-102	-104	-106	-109	-111
14	Light	77	77	77	77	77	78	80	82	83	85	87	89	90	92	94
	Heavy	-70	-73	-77	-81	-85	-88	-91	-94	-97	-100	-104	-107	-110	-114	-117
15	Light	48	51	55	58	62	63	65	66	68	69	71	72	74	75	77
	Heavy	-24	-27	-30	-33	-36	-41	-46	-51	-56	-61	-66	-72	-77	-83	-88

Source: GTA (2012), MacDonald International (2012); Arup Email dated 2nd February 2012, RMS (1999, Appendix B 2009 Update), PwC

pwc.com.au