

*Pacific Highway
Upgrade Program
Economic Appraisal
2011 Update*

Report

*Roads and Traffic
Authority of NSW*

October 2011

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Executive Summary

PricewaterhouseCoopers (PwC) in association with High Range Analytics (HRA) was engaged by the Roads and Traffic Authority (RTA) of New South Wales to undertake an economic appraisal (EA) of the options to upgrade the remainder of the Pacific Highway from Newcastle to Tweed Heads. This study appraises the net economic benefits upgrading the Port Macquarie to Raleigh and Woolgoolga to Ballina sections of the Pacific Highway (PH) to either dual carriageway or motorway standard.

The Highway serves the rapidly expanding coastal communities on the north coast and mid-north coast of New South Wales. The PH corridor between Beresfield and the Queensland border is also the key strategic interstate transport route for the transport of freight and people between Sydney and Brisbane.

With current funding commitments by mid 2014, the NSW and Australian Governments will have converted just over 60 per cent of the PH between Hexham, near Newcastle and the Queensland border to dual carriageway. The next priority of the joint funded program is to extend dual carriageways from the south to Coffs Harbour, with the Woolgoolga to Ballina section to follow. This would complete a four lane divided highway from Sydney to the border and beyond.

The EA is conducted in accordance with relevant guidelines including those issued by the RTA, NSW Department of Planning and NSW Treasury.

The RTA provided a range of inputs to this study including project sequencing, timings and costs. The RTA also provided upgrade standard information, as well as a range of inputs into the traffic demand modelling undertaken by HRA including traffic volume data, mapping of the route, and crash data.

The EA is based on a generalised Road User Cost Benefit Analysis (RUCBA) framework. This framework assesses the potential change in economic welfare with the scenarios in the context of the following road user, external and direct infrastructure cost parameters:

- project capital costs;
- project recurrent costs;
- vehicle operating costs;
- road user travel time costs;
- crash costs; and
- environmental costs.

This Report appraises the economic viability of three highway upgrade scenarios compared with a “do nothing” Base Case.

Core analysis: program completion

This Report appraises three Pacific Highway upgrade scenarios which are compared with a “do nothing” Base Case to estimate incremental values. The two project links being assessed are:

- **Link 1:** Port Macquarie to Raleigh; and
- **Link 2:** Woolgoolga to Ballina.

The Base Case and the three scenarios assessed are defined below:

- **Scenario 1 Base Case** – this is a “do nothing” Base Case, including only works already committed and that will be completed and open to traffic by June 2014. The undiscounted total cost of the Base Case is \$2.8 b. This expenditure is not related to the proposed Link 1 and 2, and will occur with or without further upgrades of these two links;
- **Scenario 2 Link 1 completed by 2016** – this scenario assumes that the Port Macquarie to Raleigh project link is upgraded to a dual carriageway with a mix of A and M design standards by June 2016. The total undiscounted cost of Scenario 2 is \$3.4 b from July 2010 to June 2016;
- **Scenario 3 Link 1 and 2 completed by 2016** – this scenario assumes that both the Port Macquarie to Raleigh and Woolgoolga to Ballina will be upgraded concurrently to dual carriageway by June 2016 with a mix of A and M standard at a total undiscounted cost of approximately \$7.8 b from July 2010 to June 2016; and
- **Scenario 4 Link 2 completed by 2019** – this scenario assumes that the completion of the Woolgoolga to Ballina is deferred to June 2019 following completion of the Port Macquarie to Raleigh link in 2016. In order to assess the incremental economic benefits of delayed completion of Link 2, the Base Case is adjusted to include Link 1 by June 2016. The total undiscounted cost of Scenario 4 is \$4.4 billion.

The EA considers the benefits and costs of upgrading the two links on the PH over the period 2010/11¹ to 2048/49.²

The upgrade scenarios are appraised against a “do-nothing” Base Case using discounted cash flow (DCF) and a real discount rate of 7 per cent. Alternative discount rates of 4 per cent and 10 per cent are also used by way of sensitivity analysis in accordance with NSW Treasury guidelines.

Estimates of the discounted benefits and costs by scenario are shown below in **Table 1**.

Table 1: Incremental benefits and costs by Scenario (PV\$m)

		Scenario 2	Scenario 3	Scenario 4
Incremental costs	Capital costs	2,586	5,882	2,925
	Recurrent costs	-	-	-
Incremental Road User Benefits	Vehicle travel time savings	1,248	2,178	755
	Vehicle operating cost savings	957	1,619	585
	Environmental cost savings	18	28	10
	Crash cost savings	140	432	262
	Residual Value	61	163	48
Total Incremental		2,424	4,415	1,655

¹ The Base year of the economic appraisal. Incremental project benefits do not commence until the completion of the links.

² In line with the RTA Guidelines, the analysis period extends 30 years from the first year of full operation of the last link to be upgraded.

	Scenario 2	Scenario 3	Scenario 4
Benefits			
Net Benefits	-162	-1,462	-1,265

Notes:

- a) Values are discounted at a 7 per cent real discount rate
- b) Costs and benefits presented are incremental to the Base Case
- c) Totals may not add due to rounding

The results of the core analysis are shown in **Table 2** and are presented in terms of the following key economic performance measures:

- 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; and
- Benefit Cost Ratio (BCR) – ratio of the incremental benefits relative to incremental costs in PV terms, i.e. a BCR greater than 1.0 indicates PV benefits outweigh PV costs.

Table 2: Summary of economic appraisal results by Scenario

	Economic indicator	Scenario 2	Scenario 3	Scenario 4
Core appraisal	NPV (\$m)	-162	-1,462	-1,265
	BCR (ratio)	0.9	0.8	0.6

Notes:

- a) Values are discounted at a 7 per cent real discount rate

Key findings

The key findings from the core economic appraisal are that:

- the three upgrade scenarios return BCRs lower than 1.0 when compared to a Base Case; and
- delaying some capital expenditure to beyond June 2016 with Scenario 4 does not result in a higher ratio of economic benefits. This is because the reduction in the PV of capital expenditure by delaying works is more than offset by the reduction in incremental benefits given Scenario 2 comprises the Base Case for Scenario 4.

However, it should be noted that the economic rationale for the PHUP has been established on a whole of program basis.

Incremental or staged delivery of significant infrastructure projects is not uncommon. However, incremental analysis of links may show that individual projects will have different levels of economic performance on a stand-alone basis, yet when assessed as part of a program, contribute to an economically viable outcome.

The results of the current analysis should be viewed in the context of the following:

- the program wide analysis (from its commencement in 1994/95³), undertaken by PwC in 2008, found the completion of the PHUP has a BCR of 2.7;
- the EA undertaken by PwC in 2008, which assessed the net economic benefits of completing the PHUP (assuming no further upgrades works with the Base Case beyond 2009), returned a BCR of around 1.7 (including the updated willingness to pay values of Value of Statistical Life and an up-rate of the value of travel time for business vehicles by 10 per cent (according to theory of Wider Economic Benefits). The conventional BCR was around 1.5; and
- the results of the current appraisal reflect the escalation in capital costs of between 4-6 per cent per year compared to estimates in 2008 and the fact that the Base Case for the current 2011 appraisal includes works (and hence, benefits) committed through to 2014⁴, compared with the 2008 study, which had a Base Case only including works to 2009. Therefore, the timing at which the EA is undertaken will determine the Base Case and hence, the incremental economic viability of completing the PHUP. This is largely arbitrary and hence, the economic viability of the completing the PHUP should be assessed on a program wide basis.

³ The methodology for the program-wide analysis dated back to 1994/95 was adjusted slightly (compared with the core analysis) to accommodate the fact that a component of the analysis period is ex-post (i.e. has already occurred). This was addressed by deflating all road user cost parameters and estimates of capital expenditure to 1994/95 (base year) dollars using the appropriate deflation factors.

⁴ Planning has advanced with Priority 2 projects nearing project approval and concept design is advanced on Priority 3.

1 Introduction

This section of the Report sets out the rationale and objectives of the road upgrade scenarios, outlines the objective of the economic appraisal and provides an overview of the Report structure.

The report investigates whether it is economically viable to **complete** the upgrade of the Pacific Highway to at least dual carriageway standard

1.1 Background

The Pacific Highway (PH) serves the rapidly expanding coastal communities on the north coast and mid-north coast of New South Wales (NSW). The PH corridor between Beresfield and the Queensland border is also the key strategic interstate transport route for the transport of freight and people between Sydney and Brisbane.

With current funding commitments to mid-2014, the NSW and Australian Governments will have converted just over 60 per cent of the Pacific Highway between Hexham, near Newcastle and the Queensland border to dual carriageway. The next priority of the joint funded program is to extend dual carriageways from the south to Coffs Harbour, with the Woolgoolga to Ballina section to follow. This would complete a four lane divided highway from Sydney to the border and beyond.

The Coffs Harbour Bypass and F3 to Raymond Terrace projects are likely to be completed sometime later, but could be brought forward to address arising issues as needed.

In 2008, PricewaterhouseCoopers (PwC) in association with Masson Wilson Twiney (MWT) was engaged by the Roads and Traffic Authority (RTA) to undertake an economic appraisal (EA) of completing the PH Upgrade Program (PHUP) and an *ex-post* appraisal of the program as a whole from its commencement in 1994/95.

The RTA is now investigating options for completing the Pacific Highway Upgrade Program (PHUP). Scenarios for the next phase of the program include upgrading the Port Macquarie to Raleigh and Woolgoolga to Ballina sections of the PH, to either dual carriageway or motorway standard by either December 2016 or June 2019. The estimated capital cost of these two upgrade options is approximately \$7.8 billion (2011 dollars), in addition to the \$3.6 billion that is already committed to projects that will be completed over the next five years to June 2014.

In March 2011, the RTA recommissioned PwC, in conjunction with High Range Analytics (HRA), to undertake an EA of upgrading a further two links, namely:

- **Link 1: Port Macquarie to Raleigh** – which includes the following projects:
 - Oxley Highway to Kempsey⁵;
 - Frederickton to Eungai;
 - Warrell Creek to Nambucca Heads; and
 - Nambucca Heads to Urunga.

⁵ The Kempsey Bypass is currently being built and therefore is included in the Base Case.

The rationale for the upgrade program is to improve the safety, capacity and efficiency of the Pacific Highway given the expected strong growth in passenger and freight task over the next 20 years.

- **Link 2: Woolgoolga to Ballina** – which includes the following projects:
 - Woolgoolga to Wells Crossing;
 - Wells Crossing to Iluka Road;
 - Iluka Road to Woodburn; and
 - Woodburn to Ballina.

These two links are the focus of the next phase of work of the PHUP following completion of major links between Hexham to Port Macquarie and Ballina to Tweed Heads. Pre-construction works are assumed to commence in 2010/11 for construction completion by 2015/16.

1.2 Problem assessment

1.2.1 Rationale of the Pacific Highway upgrade program

The PH is a substantial component of the Sydney to Brisbane transport corridor, which also includes the New England Highway and railway lines. This has been one of the fastest growth regions in Australia, and it is estimated that approximately 40 per cent of Australia's population lives along this corridor⁶. The condition and configuration of the existing road assets in these two links has raised significant concerns over the safety, capacity and efficiency, given the expected population growth within the corridor over the next 20 years (34 – 41 percent).⁷

Improving the capacity to meet increasing demand and improve safety on the PH is the main driver of the PHUP. The RTA indicates that from 1996 to 2002 there was a 28 per cent increase in traffic on the PH. On sections that had not been upgraded to dual carriage way, there was a **13 per cent increase** in crashes. On sections that had been upgraded to dual carriage way, there was a **19 per cent decrease** in crashes. It is estimated that once the entire PH is upgraded to dual carriageway, there would be 25 less fatalities (lives lost – compared to 1996 levels) each year, and the rate of series injuries would be halved.⁸

Improvements in road safety, while a key outcome sought with most road upgrade programs, usually comprises a relatively small proportion of total present value (PV) benefits within conventional transport EAs. The reasons for these are largely two-fold: further work needs to be done to improve the estimates of changes in and composition of crash rates and, more importantly, the economic cost of crashes is commonly estimated using the Human Capital (HC) approach. The Human Capital approach is essentially an *ex-post* measure of the foregone productivity of individuals involved in road crashes and associated the property damage and response costs.

⁶ Australian Government (2007), *Sydney – Brisbane Corridor Strategy 2007*, p.ii.

⁷ New South Wales. Parliament, Legislative Council, General Purpose Standing Committee No. 4, (2006), *Pacific Highway Upgrades Report ; no. 16 Final Report*, p.6.

⁸ New South Wales. Parliament, Legislative Council, General Purpose Standing Committee No. 4, (2006), *Pacific Highway Upgrades Report ; no. 16 Final Report*, p.5.

The HC approach does not capture what individuals would be *willing to pay* to reduce their risk of being involved in a crash and the external and non-tangible costs of road crashes. The RTA 2009 Economic Analysis Manual (EMA) includes an estimate of the Value of Statistical Life (VoSL) of just over \$2.3 m per incident.

In 2007-2008, the RTA commissioned PwC, in association with the Institute of Transport and Logistics Studies (University of Sydney), to estimate the *willingness to pay* measures for risk reduction associated with road fatalities, various categories of injuries and property damage. This study found that the willingness to pay measure of the VoSL was over twice the value produced by the HC measure.

The willingness to pay measure is used as part of the sensitivity analysis in this EA. However, it is emphasised that, conventional EA frameworks are limited in their ability to fully assess a range of important transport infrastructure outcomes such as safety, land-use and capacity increases. The results of this EA should be viewed within the context of these limitations.

In addition to improvements in road safety, by increasing road capacity, the PHUP is also expected to decrease congestion and improve road reliability for road users. The upgrades completed to June 2006 were estimated to result in travel time savings of 80 minutes from Newcastle to the Queensland border, with a further 90 minutes of travel savings times from the remaining upgrade works along the PH.⁹ The PHUP provides improved travel reliability, particularly during holiday periods and an increase in efficiency for freight, which is expected to almost triple over the next 20 years.¹⁰

1.2.2 Rationale of the additional project links

The rationale for the upgrade of the Port Macquarie to Raleigh and Woolgoolga to Ballina links is consistent with the rationale for the broader PHUP, which seeks to improve the capacity and quality of the PH and hence, improve safety, travel times and reliability. Completion of these two links is necessary to connect the upgrades completed south of Port Macquarie and north of Ballina. Not completing the next two links would mean that only a proportion of the \$4.4 – 4.7 b of program wide benefits estimated in the 2008 study would be captured, and could risk the creation of congestion bottlenecks between the sections of PH that have and have not been upgraded.

The PH between Port Macquarie and Coffs Harbour currently extends over 151 kilometres (km), when upgraded it will reduce to 146 km.¹¹ This section of the PH services the regional centres of Kempsey and Nambucca Heads. Specific concerns in this section of the PH which will be addressed by the upgrade include:

- road safety, particularly in the Nambucca Heads to Urunga sections where there is an emerging crash cluster (including 4 fatal crashes in 2010 and a further fatal crash on 28 March 2011). Although there are interim measures being implemented, such as reduced speed limits, removal of short overtaking lanes and providing wire rope median separation to address this issue, these measures also reduce transport efficiency;

⁹ New South Wales. Parliament, Legislative Council, General Purpose Standing Committee No. 4, (2006), *Pacific Highway Upgrades Report ; no. 16 Final Report*, p.6.

¹⁰ Australian Government (2007), *Sydney – Brisbane Corridor Strategy 2007*, p.ii.

¹¹ http://www.rta.nsw.gov.au/roadprojects/projects/pac_hwy/port_macquarie_coffs_harbour/index.html

- major floods on the Macleay River, Nambucca and Bellinger River floodplains at around 10 year flood average recurrence interval (ARIs) and hence have a negative impact on corridor reliability and infrastructure condition;
- the short remaining useful life of the steel truss bridge over the Nambucca River at Macksville – significant attention is being paid to this bridge to ensure that it remains able to carry highway loads, however it is susceptible to collision damage. If the bridge were to fail, there is no proximate alternative, particularly for freight vehicles during what could be an extended period to repair or replace the bridge;
- traffic and amenity issues including holiday period congestion at Macksville and the road noise impacts of traffic in Macksville, Bellwood and Urunga.

The PH between Coffs Harbour and Ballina currently extends over a distance of 209 km, when upgraded it will have a length of 203 km.¹² This section of the PH services the regional centres of Grafton and Casino and Lismore, the latter two of which are not located directly on the PH.

Specific concerns in this section are:

- impacts of major flooding of the Clarence and Richmond River floodplains. Some locations on the PH in these floodplains are inundated at around a 5 year ARI. During the January 2011 and May 2010 floods, the PH was cut for a week at Harwood. As a minimum, the PH would have elevation above the 20 year ARI flood event;
- some sections of the PH are also susceptible to collapse into the Clarence and Richmond Rivers. Collapses are usually able to be repaired quickly, but a major collapse taking out lanes for both traffic directions is possible. Upgrade of this section of the PH is expected to decrease the likelihood of collapse of into the river;
- traffic and amenity issues in Broadwater, Woodburn, Ulmarra and Grafton. In particular the relatively recent decrease of speed limit over considerable lengths to 50km/h in Broadwater and Woodburn has reduced traffic efficiency;
- pavement condition on much of the PH is relatively poor. Damage in this last summer period has seen some lengths with reduced speed limits to avoid severe damage to vehicles and the road surface.

The proposed upgrades to the Port Macquarie to Raleigh and Woolgoolga to Ballina sections of the PH will improve the safety and efficiency for users by addressing the location specific issues identified above.

By improving the quality and capacity of the Pacific Highway, the upgrade program will deliver improved outcomes for users and affected communities.

1.3 Objectives of the upgrades

The upgrade scenarios will deliver a number of improvements to the PH corridor which include:

- increase in the km of double lane divided road;
- improved road quality and conditions;
- decrease in interrupted highway traffic flow;
- improved access on and off the PH for local residents; and
- construction of rest areas for drivers.

¹² http://www.rta.nsw.gov.au/roadprojects/projects/pac_hwy/coffs_harbour_ballina/index.html

These outputs will result in a number of improved outcomes for users and affected communities:

- improved traffic safety, including addressing ‘blackspots’;
- reduced traffic incidents;
- decrease in congestion, which would result in improved travel reliability and travel times; particularly in holiday periods and during road incidents;
- reduced vehicle operating costs; and
- improved amenity for local communities

1.4 Objective of the economic appraisal

This EA is undertaken in accordance with the relevant guidelines provided by NSW Treasury and in line with the Australian Transport Council (ATC) and the RTA Economic Analysis Manual 2009 (Appendix B). The NSW Treasury guidelines define the aims of the appraisal thus:

‘The prime contribution of economic appraisal is to provide the best possible information to decision makers at various levels within Government. In respect of capital works decisions, it will assist in the choice between projects.’

From an economic perspective, the key challenge for Government is to determine whether the NSW community will enjoy a net benefit from the completion of the PHUP. As such, the objective of this Report is to estimate and compare the net economic benefit of different options to complete the project links from Port Macquarie to Raleigh and Woolgoolga to Ballina and hence, guide the efficient allocation of public resources.

1.5 Report structure

The report structure focuses on presenting the methodology, key assumptions and economic appraisal results for the core analysis, which relates to completing the PHUP.

- **Section 2 - Methodology** – sets out the EA framework and key assumptions that form the core EA;
- **Section 3 - Scenarios** – defines the scenarios that are analysed in the core appraisal;
- **Section 4 – Demand (traffic) analysis** – presents detail on the role of traffic demand in the EA, and also presents estimated traffic demand for each of the scenarios;
- **Section 5 - Benefits and costs** – presents the cost and benefit profiles for the core appraisal scenarios;
- **Section 6 - Results** – presents the findings of the core EA for each of the scenarios, including a sensitivity analysis is presented of the scenarios; and
- **Section 7 - Conclusions** – summarises the key findings of the report.

Key data and calculations that underpin the EA and traffic demand modelling are provided in a series of Appendices provided at the end of the Report.

The appraisal objective is to analyse the economic merit of the Pacific Highway upgrade program in line with NSW Treasury, ATC, and RTA requirements and guidelines

2 Methodology

This section of the report presents the appraisal framework and key assumptions that form the core economic appraisal.

2.1 Economic appraisal framework

A generalised road user cost benefit analysis methodology is used to undertake the economic appraisal

The EA framework used to appraise the economic viability of completing the PHUP is based on the generalised road user cost benefit analysis (RUCBA) methodology. RUCBA is a cost benefit analysis (CBA) framework that is commonly used to appraise road infrastructure projects. Like all CBA frameworks, RUCBA requires the appraisal of road projects on an incremental basis, i.e. comparing the upgrade scenarios to a Base Case.

The RUCBA in this study is used to assess the upgrade scenarios in the context of changes in the direct infrastructure, road user and external costs:

- project capital costs;
- project recurrent costs;
- vehicle operating costs (VOC);
- road user travel time costs;
- crash costs; and
- costs of environmental and social effects from vehicle use.

The 2008 EA was conducted from a corridor (rather than an individual project or link) perspective to capture the net economic benefits from the program in its entirety. By contrast, this analysis assesses the incremental benefits of the two links from Port Macquarie to Raleigh and Woolgoolga to Ballina.

This EA provides a view of the net economic benefits of completing these two additional links, following completion of upgrades north and south of these links, rather than the net benefits of the entire program.

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; and
- **Benefit Cost Ratio (BCR)** – ratio of the PV of total incremental benefits over the PV of total incremental costs.

Scenarios that yield a positive NPV indicate that the incremental benefits of the upgrade options 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 RTA.

2.2 Economic appraisal framework

The general assumptions used in this economic appraisal are as follows:

- cashflows are expressed for financial years ending June (YEJ);
- cashflows are included in the period in which they occur;
- the base year is 2010/11;
- all values are expressed in constant dollars;
- prices are expressed in 2010/11 dollars (unless otherwise stated);
- all road user cost parameters are sourced from the latest version of the RTA's EAM, ie. 2009.
- the evaluation period starts in 2010/11 and ends in 2048/49 (30 years after Scenario 4 is finalised and open for traffic in 2019/20). This is in line with the RTA Guidelines which requires that projects are evaluated over a 30 year period from the first year of full operation of the last link to be upgraded;
- future net benefits are discounted to the respective base years using a real discount rate of 7 per cent; and
- **incremental** road maintenance cost is assumed to be zero for each scenario.

3 Upgrade scenarios

This section of the Report defines the scenarios that are analysed as part of the core appraisal to complete the two links from Port Macquarie to Raleigh and Woolgoolga to Ballina

3.1 Definition of appraisal scenarios

This EA appraises three upgrade scenarios which are compared with a “do nothing” Base Case to generate incremental values. As stated in **Section 1.1**, the two project links assessed are:

- **Link 1** – Port Macquarie to Raleigh; and
- **Link 2** – Woolgoolga to Ballina.

The Base Case and the three scenarios assessed are defined below:

- **Scenario 1 - Base Case** – this is a “do nothing” Base Case, including only works already committed and that will be completed and open to traffic by June 2014. The undiscounted total cost of the Base Case is \$2.8 billion from now until June 2014. This expenditure is not related to the proposed Link 1 and 2, and will occur with or without further upgrades of these two links;
- **Scenario 2 - Link 1 completed by 2016** – Scenario 2 assumes that the Port Macquarie to Raleigh project link is upgraded to a dual carriageway with a mix of A and M design standards by June 2016. The total undiscounted capital cost of Scenario 2 is \$3.4 billion from July 2010 to June 2016;
- **Scenario 3 - Link 1 and 2 completed by 2016** – Scenario 3 assumes that both the Port Macquarie to Raleigh and Woolgoolga to Ballina will be upgraded concurrently to dual carriageway by June 2016 with a mix of A and M standard at a total cost of approximately \$7.8 billion from July 2010 to June 2016; and
- **Scenario 4 - Link 2 completed by 2019** – this scenario assumes that there is delayed completion of the Woolgoolga to Ballina link to June 2019 following completion of the Port Macquarie to Raleigh link in 2016. In order to assess the incremental economic benefits of a delayed completion of Link 2, the Base Case has been adjusted to include Link 1 completed by June 2016. The total undiscounted cost of Scenario 4 is \$4.4 billion.

Table 3 provides a summary of each of the scenarios, relevant links and completion timing and the capital expenditure involved. The links upgraded and the upgrade standards for each scenario are shown below in **Table 4**.

Table 3: Summary of scenarios and capital expenditure

Scenario	Project Case	Completion date	Incremental Capital Cost (\$b – 2008)
Scenario 2	Link 1	2016	3.4
Scenario 3	Link 1 and 2	2016	7.8
Scenario 4	Link 2	2019	4.4

Source: RTA

The core appraisal includes four scenarios for completing the PHUP

Table 4: Link upgrade standards by scenario

Project Case	Project	Existing standard	Base Case	Scenario 2	Scenario 3 & 4	Date open to traffic	
		(March 2011)	(June 2014)	(June 2016)	(June 2019)	Scenario 2 & 3	Scenario 4
Base Case	Bulahdelah Bypass	Single CW	Motorway	Motorway	Motorway	December 2012	
	Hérons Creek to Stills Road	A Class	Motorway	Motorway	Motorway	December 2012	
	Kempsey Bypass	Single CW	Motorway	Motorway	Motorway	April 2013	
	Sapphire to Woolgoolga	Single CW	Motorway	Motorway	Motorway	December 2013	
	Ballina Bypass	Single CW	Motorway	Motorway	Motorway	December 2011	
	Tintenbar to Ewingsdale	Single CW	Motorway	Motorway	Motorway	June 2014	
	Banora Point Upgrade	A Class	Motorway	Motorway	Motorway	December 2012	
Link 1	Oxley Highway to Kempsey	Single CW	No upgrade	A Class	A Class	December 2016	
	Frederickton to Eungai	Single CW	No upgrade	Motorway	Motorway	June 2016	
	Warrell Creek to Nambucca Heads	Single CW	No upgrade	Motorway	Motorway	December 2016	
	Nambucca Heads to Urunga	Single CW	No upgrade	Motorway	Motorway	December 2016	
Link 2	Woolgoolga to Wells Crossing	Single CW	No upgrade	No upgrade	A Class	December 2016	June 2018
	Wells Crossing to Harwood	Single CW	No upgrade	No upgrade	Motorway	December 2016	June 2019
	Harwood to Iluka Road	Single CW	No upgrade	No upgrade	A Class	December 2016	June 2019
	Iluka Road to Woodburn	Single CW	No upgrade	No upgrade	A Class	December 2016	June 2019
	Woodburn to Ballina	Single CW	No upgrade	No upgrade	Motorway	December 2016	June 2018

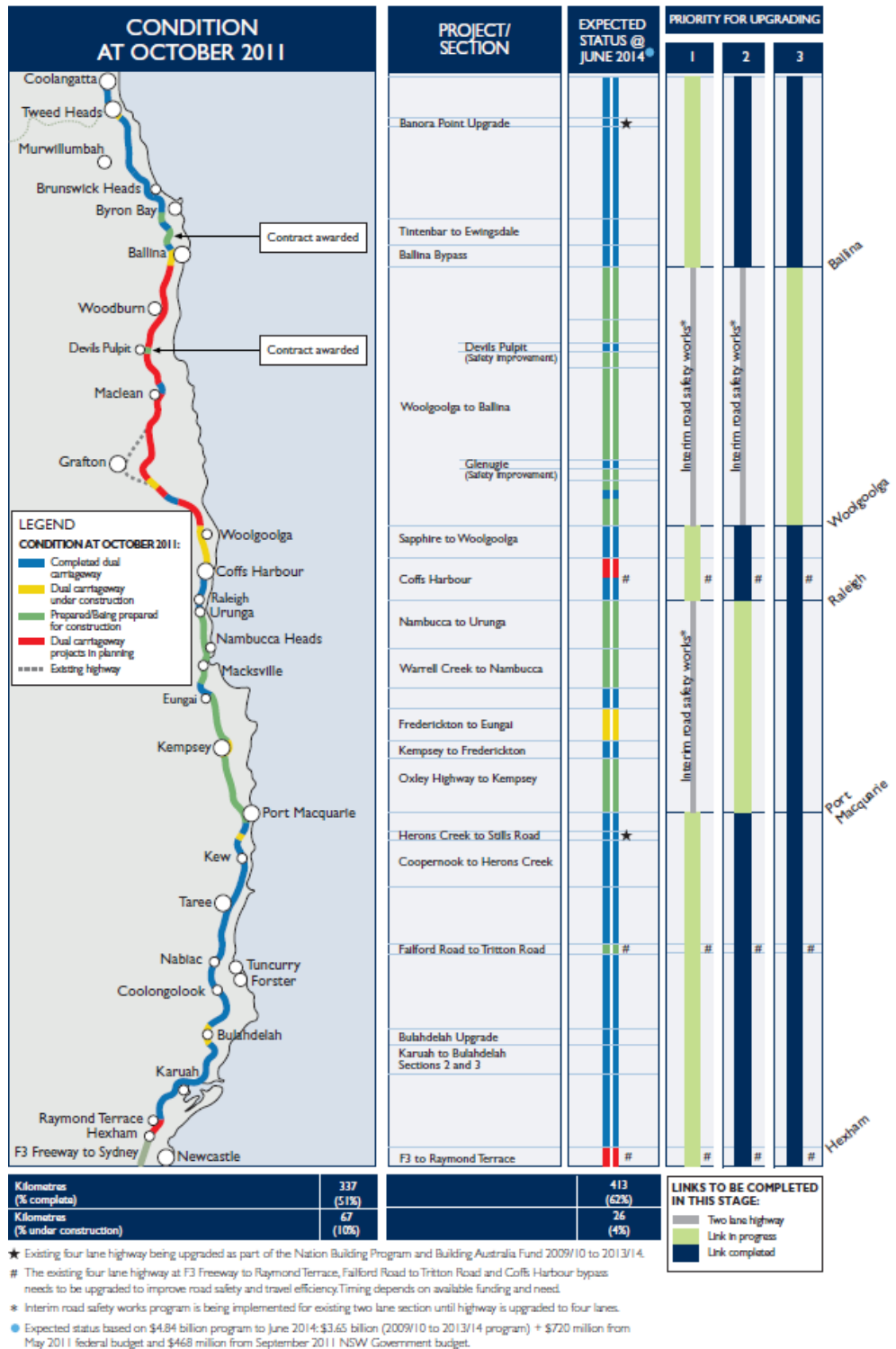
Source: RTA

Note:

¹Single CW refers to single carriageway

The links comprising the upgrade scenarios are identified below in the PHUP priority map in **Figure 1**.

Figure 1: PHUP Priority Map



4 Demand (traffic) analysis

This section of the Report provides detail on the role of traffic demand in the appraisal, and also presents estimated traffic demand for each of the scenarios contained in the core appraisal.

4.1 The role of traffic demand in RUCBA

The objective of the upgrade scenarios is to reduce the transport cost of undertaking a trip on the PH, compared with that which would occur with the Base Case. This is accomplished by inducing a change in traveller behaviour such that:

- the existing trips with the Base Case are redistributed such that a larger proportion of trips are undertaken on a higher standard road (which exhibits a lower average cost of travel); and in turn,
 - non-induced vehicle kilometres (VKT) and hours travelled (VHT) are reduced compared with the Base Case as a result of shorter travel distances and higher design speeds with the scenarios.
- travellers that would otherwise not have travelled in the corridor are induced to travel given the increased user benefits from a higher standard road.

Estimation of traffic demand for road use under the three upgrade scenarios and the Base Case enables an understanding of the impact each scenario would have on the traveller behaviours listed above.

4.2 Estimation of traffic demand

Traffic demand in this EA is measured in terms of daily VKT and VHT. These were estimated by HRA based on the links in each of the scenarios and traffic volume data sourced from the RTA and from the 2009 Bureau of Infrastructure, Transport and Regional Economics (BITRE) “National road network intercity traffic projections to 2030”, Working Paper 75¹³.

The traffic modelling incorporates the following sources of traffic demand:

- *normal day network operations from link based analysis* – this is the most significant source of VKT and VHT. It is calculated by applying a link-based rural model (NIMPAC), to represent PH and New England Highway road links;¹⁴
- *delay from incidents and associated road closures* – delays from incidents under the upgrade scenarios and the Base Case are estimated and applied to normal day operations using the rates of three types of incidents (fatal crashes, road works and other incidents) to estimate frequency of occurrence. Delay rules were then applied to generate road user costs;

¹³ Please see Appendix A for description of approach adopted to adapt BITRE projections.

¹⁴ Note: NIMPAC = National Association of Australian State Road Authorities (NAASRA) Improved Model for Project Assessment and Costing (NIMPAC).

- *side road delays* – HRA applied a side road delay model to estimate the delays faced by turning traffic at side roads, capturing changes in delays between the Base Case and upgrade scenarios; and
- *flood mode operation adjusted for probability of flooding* – flood analysis was conducted on a catchment basis to encompass costs under flood situations that are derived from diverting traffic to identified flood routes.
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Road user costs per VKT and VHT vary depending on the type of road and type of vehicle. Therefore, traffic demand is estimated by road and vehicle type as per the following standards and categories:

- single carriageway (light and heavy vehicle);
- dual carriageway / A Class (light and heavy vehicle);
- motorway / M Class (light and heavy vehicle); and
- urban carriageway¹⁶ (light and heavy vehicle).

A further key aspect of the traffic analysis is that the demand for trips on the Pacific Highway has been segmented into *existing (non-induced) demand* and *induced demand* trips. The different motives for travel by each imply differences in willingness to pay (WTP) for a trip. The trip types are defined below:

- *non-induced trips* – these are trips in the PH corridor that would take place regardless of the upgrade occurring, based on existing demand. The ‘existing demand’ case modelled in the traffic analysis quantifies the impact of the scenarios assuming that the total number of trips in the network remains constant, i.e. the scenarios only lead to a redistribution (across road types) of existing trips compared with the Base Case. Existing and diverted trips are assumed to enjoy the full extent of any savings in travel cost with each scenario; and
- *induced trips* – relate to trips that would only be undertaken in the PH corridor with the upgrade. These travellers are motivated to travel by a reduction in trip cost resulting from upgrade to road standard (such as vehicle operating costs and accident costs). Unlike existing trips, induced travellers would not have otherwise undertaken a trip in the PH corridor prior to the upgrade. Therefore, the benefits accruing to induced trips are scaled down by applying the ‘rule of the half’. However, from a societal perspective, the crash and externality costs generated by induced trips are incurred in full.

¹⁵ Note: these are also sources for vehicle operating costs for the scenarios and Base Case.

¹⁶ Note: these are links through towns along the route.

4.3 Results of traffic demand modelling

Vehicle hours travelled

The VHT (per day) estimates for the scenarios based on the forms of demand discussed above are shown in **Figure 2**.

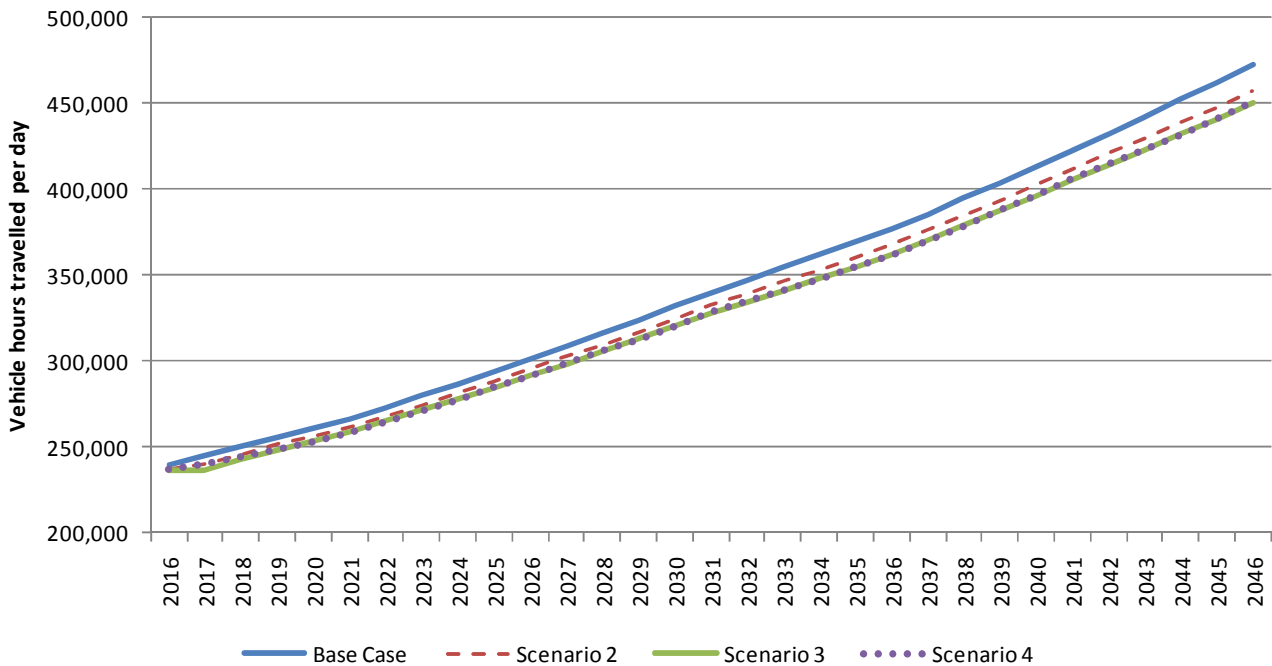
The key findings of **Figure 2** as it relates to VHT is that:

- all scenarios are expected to result in an incremental decrease in vehicle hours travelled per day;
- Scenario 3 results in the largest incremental fall in daily VHT for any particular year;
- as a proportion of daily Base Case VHT, the incremental reduction with Scenario 2, 3 and 4, comprises a maximum of 3 per cent, 5 per cent and 2 per cent, respectively. While these maximums are not realised until the end of the evaluation period, Scenarios 2 and 3 lead to relatively large reductions in daily VHT as a proportion of the Base Case.

Reduction in VHT with the upgrade scenarios is primarily due to a reduction in normal day link based hours travelled. Flooding, side road and incident delay hours are also reduced under the upgrade scenarios, though to a smaller extent.

Daily figures are annualised by multiplying by 365.

Figure 2: Daily vehicle hours travelled for non-induced and induced demand by scenario



Source: High Range Analytics modelling 2011

Vehicle kilometres travelled

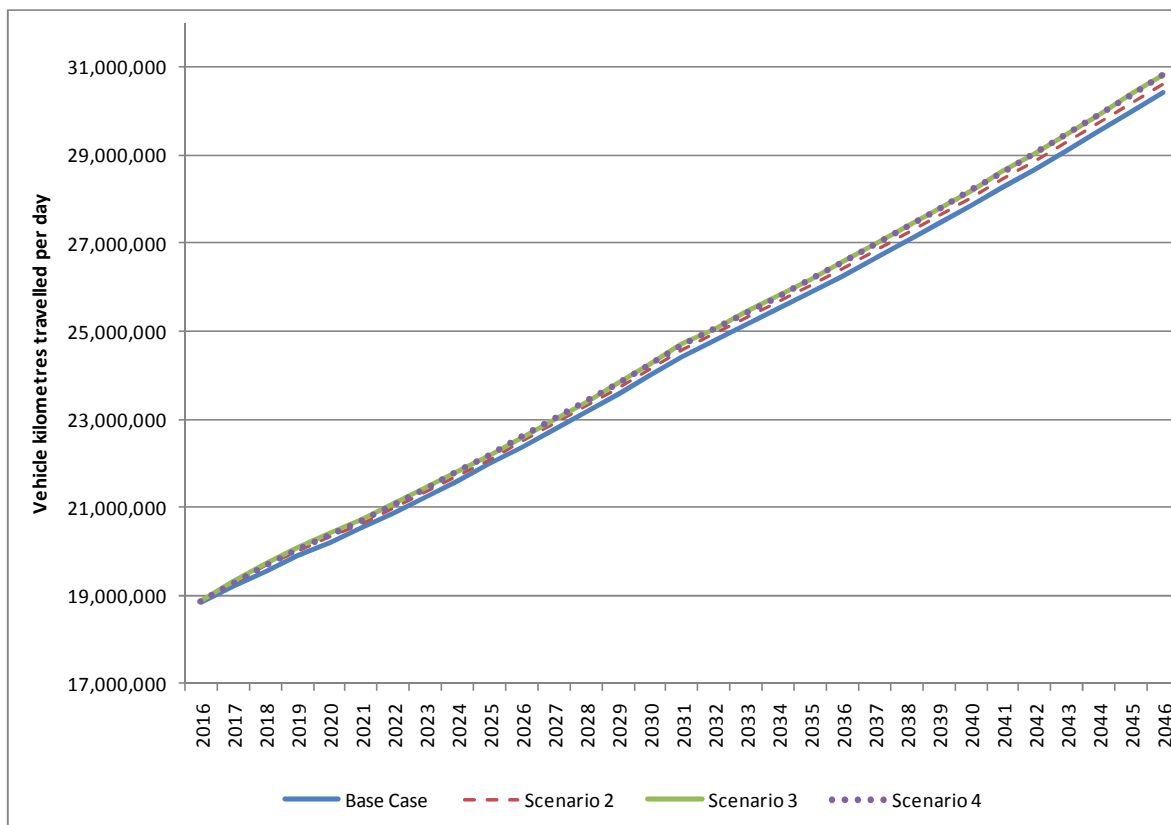
The VKT for the Base Case and the three scenarios are shown in **Figure 3**.

The upgrade scenarios are estimated to reduce VKT due to shorter travel distances. However, induced demand in the three scenarios offsets the reduced distances. As **Figure 3** indicates, this results in less VKT under the Base Case. Analysis without inclusion of induced demand indicates that each of the scenarios has lower VKT than the Base Case.

The impacts on VKT are discussed further below:

- increased demand from construction of scenarios would increase VKT in each of those scenarios – HRA traffic forecasts estimate that the capacity increases would induce sufficient additional VKT to result in higher VKT than the Base Case, despite route distance reductions;
- shorter travel distances reduce upgrade scenario VKT – shorter travel distances are expected from upgrading the road standards as a result of a reduction in normal day link based hours travelled. In addition, a reduction in kilometres travelled due to flooding was also a source of savings given that the average return interval for the upgraded road links is higher. The analysis framework assumes that changes in vehicle kilometres travelled are not material for incidents and side road delays; and
- the impact of shorter travel distances on scenario VKT is not as significant as the impact of induced demand in those scenarios, resulting in the Base Case total VKT being lower relative to the upgrade scenarios.

Figure 3: Daily vehicle kilometres travelled for non-induced and induced demand by scenario



Source: High Range Analytics modelling 2011

Daily figures are annualised by multiplying by 365.

Based on the VKT and VHT results for each of the scenarios, vehicle, environmental and other costs were determined (discussed in more detail in Section 5).

The traffic demand modelling outcomes are presented as a separate attachment in **Appendix B**.

5 Benefits and costs

This section of the Report defines and presents the economic cost and benefit profiles of the Pacific Highway upgrade scenarios

5.1 Definition of economic benefits

Benefits of the scenarios are cost savings in comparison to the Base Case, including:

- travel cost savings;
- vehicle operating cost savings;
- environmental cost savings;
- accident cost savings; and
- residual value of assets

The benefits of each of the scenarios for completion of the PHUP are related to savings in road user and external costs due to a reduction in VHT and VKT compared with the Base Case, as well as the residual value of assets remaining at the end of the analysis period.

The benefits associated with the upgrade scenarios include:

- road user cost savings:
 - savings in travel time costs;
 - savings in vehicle operating costs;
 - savings in crash costs; and
 - savings in environmental costs; and
- residual value of assets.

A summary of the determinants of road user travel costs are shown in **Table 2**.

Table 5: Determinants of road user costs

Road user cost (RUC)	Unit	Description	Determinant
Savings in travel time costs (VTT)	\$/vehicle hour travelled	<ul style="list-style-type: none"> • 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. 	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • fuel and lubricant costs; • tyre costs; • vehicle repair and maintenance costs; • depreciation, consumption of capital investment; and • vehicle operator overhead costs. 	<ul style="list-style-type: none"> • 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.
Crash costs	\$/incident	<ul style="list-style-type: none"> • fatal crash costs; • injury crash costs; and • property damage crash costs 	<ul style="list-style-type: none"> • crash rates; • type of road; • vehicle type; and • vehicle occupancy.
Environmental external costs	\$/vehicle kilometre travelled	<ul style="list-style-type: none"> • noise; • air pollution; • water pollution; • greenhouse; • nature and landscape; and • urban separation costs. 	<ul style="list-style-type: none"> • vehicle type; and • urban/rural setting.

5.2 Estimating the incremental economic benefits of the upgrade

Each of these road user and external costs are discussed below in the context of savings relative to the Base Case.

5.2.1 Travel time cost savings

Travel times from the traffic forecasts are used to estimate savings in travel time cost for the three upgrade scenarios relative to the Base Case. This involves estimation of travel time costs for all scenarios based on the hourly value of travel time (VOTT) multiplied by the vehicle hours travelled for the scenarios. The VOTT is sourced from the RTA EMA 2009 (Appendix B), 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 VOTT used in this analysis varies for rural and urban, in line with RTA guidelines that treat RUC in urban and rural settings separately. This reflects the impact in 'local' urban areas of dense road networks and generally higher traffic levels. In non-urban areas, this is contrasted by generally higher speed limits and speeds of travel.

Rural

To determine rural travel time costs, a weighted average value of travel time is required for 'light' and 'heavy' vehicles. The RTA EMA 2009 (Appendix B) presents the VOTT for rural occupants and freight. This is applied to the composition of PH vehicle fleet (split into light, heavy, private and commercial vehicles) sourced from the HRA traffic demand model. The vehicle compositions are based on an average for each scenario across the analysis period, based on HRA vehicle compositions for the following years: 2007/08, 2015/16 and 2050/51.

Given the slight variation in fleet vehicle composition by scenario (i.e. the upgrade scenarios are characterised by an increased proportion of heavy vehicles relative to the Base Case), the average weighted VOTT for rural links varies by scenario. The average VOTT used for rural links in the analysis are presented in **Table 6**.

Table 6: Average weighted VOTT for light and heavy vehicles by scenario (\$/VHT)

Vehicle Type	Base Case	Scenario 2	Scenario 3	Scenario 4
Light	32.29	32.29	32.29	32.29
Heavy	51.44	51.38	51.41	51.41

Note: based on average vehicle compositions over the evaluation period

Urban

The approach used to calculate the weighted average VOTT in the urban context is based on Tables 7 and 8 of the RTA EMA Appendix B which presents urban vehicle composition and occupancy by time of day. Vehicle occupancies are then applied to the VOTT contained in Table 9 of the “RTA Economic Analysis Guidelines” – Economic Parameters for 2009, based on default yearly hours travelled on average contained in Table 10, to estimate urban VOTT by time of day for occupants and freight.

Based on this, the average weighted VOTT used for urban links are:

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

The weighted VOTT are combined with the VHT from the traffic demand forecast to produce travel time cost by scenario. It was found that in comparison to the Base Case, the upgrade scenarios resulted in lower total vehicle travel time costs. These are expressed as savings in travel time costs in **Table 7**.

Scenario 3 results in the highest savings in travel time costs.

Table 7: Savings in travel time costs for non-induced and induced trips – incremental to the Base Case (PV\$m)

	Scenario	Discounted Total (PV\$m) (2010/11 – 2048/49)
Non-induced trips	2	1,092
	3	1,870
	4	617
Induced trips	2	155
	3	308
	4	138
Total trips	2	1,248
	3	2,178
	4	755

Source: HRA and PwC 2011

Note: positive values indicate savings compared with the Base Case

Note: incremental values indicate differences between the Base Case and the upgrade scenarios, i.e. positive values indicate the Base Case costs would be higher by these amounts.

5.2.2 Vehicle operating cost savings

The savings in vehicle operating costs (VOC) with the upgrade scenarios are estimated by HRA by combining the incremental VKTs with unit vehicle operating costs estimated implicitly in the traffic model.

The VOC parameters used in this analysis vary for rural and urban travel. The key assumptions associated with urban and rural VOC are discussed below.

Rural

The annual VOCs for the Base Case and each of the upgrade scenarios are estimated as part of the traffic demand forecasting exercise. For the upgrade standards classified as ‘rural’ (i.e. single carriageway, dual carriageway and motorway), the traffic forecast model uses VEHOP rural vehicle operating unit rates from Table 3 of the RTA’s 2009 economic parameters in the EMA 2009 Appendix B applied to the vehicle compositions on rural road sections derived from the HRA traffic model.

Based on the vehicle compositions, the weighted average rural VOC is approximately \$0.32/VKT for the period 2012 to 2046 and \$0.34/VKT over the entire forecast period to 2061 (including the resource cost component of fuel).

Urban

As with the rural VOC parameter, the HRA traffic forecast model uses VEHOP urban vehicle operating unit rates from Table 3 of the RTA's 2009 economic parameters in the EMA Appendix B and applies them to the vehicle compositions on urban sections derived from the HRA traffic model.

Based on the vehicle compositions, the weighted average urban VOC is approximately \$0.34/VKT for the period 2012 to 2046 and \$0.35/VKT over the entire forecast period to 2061 (including the resource cost component of fuel).

The relevant unit VOC are applied to the VKTs in the Base Case and the scenarios to calculate the incremental VOC by scenario for the analysis period.

The vehicle operating costs for the scenarios are found to be lower relative to the Base Case for the majority of the analysis period. Incremental to the Base Case, a reduction in VOCs results from the reduction in normal day link based VKT, and a reduction in VKT due to improved flood protection. The analysis framework assumes that changes in VOCs are not material for incidents and side road delays.

Table 8 presents a summary of the savings in VOCs by scenario (compared with the Base Case) split into non-induced and induced trips.

Table 8: Savings in vehicle operating costs for non-induced and induced trips – incremental to the Base Case (PV\$m)

	Scenario	Discounted Total (PV\$m) (2010/11 – 2048/49)
Non-induced trips	2	785
	3	1,261
	4	418
Induced trips	2	172
	3	359
	4	167
Total trips	2	957
	3	1,619
	4	585

Source: HRA and PwC 2011

Note: positive values indicate savings compared with the Base Case.

Note: Incremental values indicate differences between the Base Case and the upgrade scenarios, i.e. positive values indicate the Base Case costs would be higher by these amounts.

For induced trips, associated vehicle operating costs relate to the benefit received by travellers motivated to travel by a reduction in vehicle operating costs resulting from the upgrade. As **Table 8** indicates, Scenario 3 results in the greatest benefits from reduced operating costs.

5.2.3 Crash cost savings

Crash costs for each scenario are incorporated into the analysis for both rural and urban travel.

Crash data is provided for PH crashes between 1995 and 2007 by the RTA. Data were analysed to identify prevailing crash rates for sections of the PH. In the analysis of upgrades, if a section of the PH is not upgraded then the current crash rate is applied; where the PH is upgraded, then crash rates of 9 crashes per 100 million vehicle kilometres of travel for motorway standard and 15 crashes per 100 million vehicle kilometres of travel for A class dual carriageway are applied. Crash rates on other links (e.g. New England Highway and Flood Diversion Routes) use the applicable rates from the Road Environment Safety Update No 22 – Rural Road Crash Rates by Road Stereotype (RTA, April 2004).

Rural

In order to determine annual crash costs for the Pacific Highway scenarios, HRA estimated daily rural crash numbers for each of the scenarios based on observed and forecast incident data as discussed above.

The following crash types were included in the analysis:

- fatalities (7.1 per cent of annual crashes);
- injuries (53 per cent of annual crashes); and
- non-injury crashes (property damage) (40.9 per cent of annual crashes).

Table 9 presents the total number of rural crashes estimated for each of the scenarios over the period of analysis, as well as the number of crashes avoided under the upgrade scenarios relative to the Base Case.

Table 9: Crashes avoided

	Total no. crashes avoided (2010/11 to 2048/49)	No. lives saved (2010/11 to 2048/49)	No. injuries avoided (2010/11 to 2048/49)	No. non-injury accidents avoided (2010/11 to 2048/49)
Scenario 2	3,066	216	1,609	1,241
Scenario 3	8,039	565	4,218	3,255
Scenario 4	4,781	336	2,509	1,936

Source: HRA 2011

As **Table 9** indicates, a significantly higher number of crashes occur on the rural sections of the PH corridor with the Base Case. Under all upgrade scenarios, a significant number of lives are saved, and between 4,200 and 1,600 injuries are avoided. Scenario 3 results in the highest relative number of crashes avoided.

The annual rural crash numbers estimated as part of the traffic analysis are applied to the generic crash costs from Table 13 of Appendix B of the RTA “Economic Analysis Guidelines” to determine the annual crash costs for each scenario. The crash cost parameters used are summarised in **Table 10**.

Table 10: Generic costs per crash (rural)

Crash type	Cost per crash (\$)
Fatality	2,339,363
Injury	197,707
Property damage	8,148

Source: RTA Economic Parameters for 2009 (Table 13), RTA, PwC (2009 dollars).

Urban

Crash rates for the 'local' urban road sections in the PH corridor are drawn from Table 15 in Appendix B of the RTA EMA 2009 for average crash cost by road type for all car crashes in an urban area of **\$66,000 per crash**. This unit cost is applied to the crash rates in the Base Case and scenarios to calculate the incremental crash costs for urban road sections.

Table 11 presents a summary of the savings in incremental accident costs split into non-induced and induced trips. These data show that the scenarios reduce crash costs compared with the Base Case over the evaluation period, with Scenario 4 resulting in the greatest savings in crash costs.

Table 11: Savings in crash costs for non-induced and induced trips – incremental to the Base Case (PV\$m)

	Scenario	Discounted Total (PV\$m) (2010/11 – 2048/49)
Non-induced trips	2	178
	3	502
	4	289
Induced trips	2	-39
	3	-70
	4	-27
Total trips	2	140
	3	432
	4	262

Source: HRA and PwC 2011

Note: positive values indicate savings compared with the Base Case.

Note: incremental values indicate differences between the Base Case and the upgrade scenarios, i.e. positive values indicate the Base Case costs would be higher by these amounts.

As shown in **Table 11**, the crash costs associated with induced trips confer a net cost on to society as these trips are not otherwise undertaken with the Base Case. Scenario 4 results in the highest crash cost saving.

5.2.4 Environmental cost savings

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 EA are based on the parameters presented in Appendix B, Table 18 of the RTA EMA 2009, and include:

- noise;
- air pollution;
- water pollution;
- greenhouse;
- nature and landscape; and
- urban separation costs.

Light vehicles

Environmental unit costs for passenger vehicles are expressed in dollars per VKT in the RTA EMA 2009. The unit costs are directly applied to the change in VKT to estimate the change in environmental costs per scenario. The average environmental external costs per VKT used primarily for light vehicles in the analysis are:

- rural light vehicles – \$0.0271/VKT; and
- urban light vehicles – \$0.0683/VKT.

In order to convert the above environmental cost parameters into annual environmental costs for by scenarios, the passenger vehicle costs per VKT above are applied to the annual VKT of each scenario.

Heavy vehicles

For freight vehicles, the RTA expresses environmental unit costs in cents per tonne kilometre (tkm), which required conversion for application to this economic appraisal. The tkm unit costs are converted to dollars per VKT using NSW average tonne kilometres and average VKT for the two truck types taken from the latest Australian Bureau of Statistics “Survey of Motor Vehicle Use”.

In order to convert the \$/VKT environmental cost parameters into annual environmental costs for the scenarios, further analysis is required to determine the proportion of freight vehicle types in the demand forecast in order to apply the relevant \$/VKT costs by vehicle type.

The vehicle compositions provided by HRA are applied to the RTA environmental externality values to yield a weighted external cost parameter for heavy vehicles. The resultant heavy vehicle environmental cost per VKT are shown below:

- rural heavy vehicles – \$0.187/VKT; and
- urban heavy vehicles – \$0.656/VKT.

As with light vehicles, in order to convert the above environmental cost parameters into annual environmental costs for the scenarios, the heavy vehicle costs per VKT are applied to the annual VKT of each scenario.

The resultant savings in both light and heavy vehicle environmental costs are summarised in **Table 12** below, with costs split into non-induced and induced trips. These data indicate that each of the scenarios result in environmental cost savings in total over the analysis period. Scenario 3 results in the highest relative savings. One of the main sources of environmental cost savings is a reduction in vehicle kilometres travelled on urban roads under the upgrade scenarios, as vehicles shift to motorway, dual or single carriageway road surfaces. Urban travel results in greater environmental externalities, resulting in the scenarios reducing environmental costs through less urban trips.

Table 12 also indicates that environmental costs that occur as a result of any induced trips in the upgrade scenarios are costs incremental to the Base Case, given that no induced trips occur in the Base Case.

Table 12: Savings in environmental costs for non-induced and induced trips – incremental to the Base Case (PV\$m)

	Scenario	Discounted Total (PV\$m) (2010/11 – 2048/49)
Non-induced trips	2	70
	3	134
	4	60
Induced trips	2	-51
	3	-106
	4	-49
Total trips	2	18
	3	28
	4	10

Source: HRA and PwC 2011

Note: positive values indicate savings compared with the Base Case.

Note: incremental values indicate differences between the Base Case and the upgrade scenarios, i.e. positive values indicate the Base Case costs would be higher by these amounts.

5.2.5 Residual (terminal) values

The economic appraisal includes the residual values of road assets. The residual value reflects the fact that some road assets may 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.

Previous RUCBAs undertaken for specific links on the PH are used to source the estimated asset life assumptions for road works. These are summarised below in **Table 13**.

Table 13: Typical asset lives for road components

Asset type	Asset life (years)
Structures	100
Earthworks	100
Formation	40
Drainage	40
Pavement	40
Flood mitigation measures	40
Furniture / delineation	20
Interchanges	20
Local roads	20
Vehicle rest area	20

Source: RTA provided structures and earthworks asset lives; other asset lives from previous Pacific Highway RUCBAs

Depreciation of assets for each of the projects in the upgrade scenarios is assumed to commence in the year after completion of each link upgrade project. Given that the period of analysis is for a further 30 years beyond the final link being constructed (and hence, 33 years for Scenarios 2 and 3), the majority of the asset components for each of the scenarios are assumed to be fully depreciated by the final year in the evaluation period. Structures and earthworks have an economic life of 100 years, indicating that at the end of the analysis period there could be up to 70 years of economic life remaining in these assets.

The RTA provided PwC with the proportion capital expenditure which is comprised of structures and earthworks for each of the links. The residual values are calculated by applying straight-line depreciation to the proportion of capital costs attributed to structures and earthworks following the final year of construction for each link. The resultant residual values are shown below in **Table 14**.

Table 14: Residual values (PV\$m)

Scenario	Discounted Total (PV\$m) (2010/11 – 2048/49)
Scenario 2	61
Scenario 3	163
Scenario 4	48

Source: HRA and PwC 2011

Note: positive values indicate savings compared with the Base Case

Note: incremental values indicate differences between the Base Case and the upgrade scenarios, i.e. positive values indicate the Base Case costs would be higher by these amounts.

The largest residual values are exhibited by Scenario 3, which has the highest relative capital cost.

5.3 Costs of the upgrade scenarios

5.3.1 Capital costs

The key cost associated with the upgrade scenarios is capital cost of construction. It is assumed that incremental recurrent costs are negligible.

The capital costs vary between the Base Case and the three upgrade scenarios, with the Base Case including only works completed prior to June 2014. In comparison the scenarios vary from \$3.4 billion to \$7.8 billion in capital costs.

The project costs reflect a high confidence level, referred to as P90, which means that there is a 90 per cent probability that the project's estimate will not be exceeded. This confidence level is achieved by incorporating into the estimate a higher level of contingency to allow for a wide range of project risks, such as scope/design deficiencies, labour availability, market cost escalation, contractor performance and force majeure type events.

Table 15 presents the total costs and the present value of the capital costs for each scenario.

Table 15: Incremental Capital costs by scenario (PV\$m)

Scenario	Undiscounted Total (2010/11 – 2048/49)	Discounted Total (PV\$m) (2010/11 – 2048/49)
Scenario 2	3,400	2,586
Scenario 3	7,800	5,882
Scenario 4	4,400	2,925

Source: RTA

The cashflows used to determine the present value of incremental capital costs were provided by the RTA.

The key cost of the scenarios is capital cost. The study assumes that incremental recurrent costs are negligible.

5.3.2 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. The annual cost of salaries, utilities, maintenance, materials, and replacement of worn-out capital are recurrent costs which continue as long as the Pacific Highway corridor operates.

It has been assumed that recurrent costs are the same for the Base Case as for the upgrade scenarios. While newer roads under the upgrade scenarios are likely to require lower levels or frequency of maintenance as older roads, the upgrade to dual highway and motorway in the scenarios is expected to result in additional maintenance from wider road surfaces. This has been assumed to result in recurrent costs for the scenarios equalling the Base Case, i.e. incremental recurrent costs are negligible.

5.4 Summary of costs and benefits

A summary of the discounted benefits and costs of each of the scenarios (incremental to the Base Case) is presented in **Table 16** below.

Table 16: Incremental benefits and costs (PV\$m)

		Scenario 2	Scenario 3	Scenario 4
Incremental costs	Capital costs	2,586	5,882	2,925
	Recurrent costs	-	-	-
	Vehicle travel time savings	1,248	2,178	755
Incremental Road User Benefits	Vehicle operating cost savings	957	1,619	585
	Environmental cost savings	18	28	10
	Crash cost savings	140	432	262
Residual Value		61	163	48
Total Incremental Benefits		2,424	4,415	1,655
Net Benefits		-162	-1,462	-1,265

Notes:

- Values are discounted at a 7 per cent real discount rate
- Costs and benefits presented are incremental to the Base Case
- Totals may not add due to rounding

6 Results

This section of the report presents the findings of the core EA for each of the scenarios, and also presents the results of sensitivity analysis undertaken on a selection of key assumptions.

6.1 Cost benefit analysis results

Scenario 2 returns the highest NPV and BCR

The benefits and costs described in the preceding section are aggregated over the evaluation period to yield the incremental total benefits and costs below in **Table 17**.

Table 17: Summary EA results – incremental to the Base Case, (PV\$m)

Scenario	Benefits (non-induced trips)	Benefits (induced trips)	Total Benefits	Residual	Total Costs
Scenario 2	2,126	237	2,362	61	2,586
Scenario 3	3,767	490	4,257	163	5,882
Scenario 4	1,384	228	1,612	48	2,925

Source: PwC 2011

The benefits and costs of the scenarios incremental to the Base Case are used to derive the key economic appraisal indicators presented in **Table 18**.

Table 18: Economic appraisal indicators

Scenario	NPV (\$m)	BCR
Scenario 2	-162	0.9
Scenario 3	-1,462	0.8
Scenario 4	-1,265	0.6

Source: PwC 2011

Table 18 indicates that, when analysed on a link basis, the economic performance of the scenarios is reduced when compared to their contribution to the overall economic performance of the PHUP.

6.2 Sensitivity analysis

The scenarios are most impacted by an increased discount rate

Three main sensitivity analyses are undertaken as part of this economic appraisal.

6.2.1 Sensitivity analysis – alternate discount rates

The first sensitivity analysis involves re-calculating NPV and BCR assuming alternate discount rates of 4 per cent and 10 per cent. The results of this sensitivity test are shown below in **Table 19**.

Table 19: Sensitivity test – alternate discount rates

Scenario	4 per cent		7 per cent (core analysis)		10 per cent	
	NPV (\$m)	BCR	NPV (\$m)	BCR	NPV (\$m)	BCR
Scenario 2	1,432	1.5	-162	0.9	-837	0.6
Scenario 3	1,278	1.2	-1,462	0.8	-2,553	0.5
Scenario 4	-424	0.9	-1,265	0.6	-1,502	0.4

Source: PwC 2011

This sensitivity analysis indicates that the adoption of the lower discount rate of four per cent would result in Scenarios 2 and 3 achieving BCRs greater than 1.0.

6.2.2 Sensitivity analysis – change in construction costs

The second sensitivity test involves increasing and decreasing construction costs by 20 per cent. The results of this sensitivity test are shown below in **Table 20**.

Table 20: Sensitivity test – change in construction costs

Scenario	20 per cent decrease in construction costs		No change in construction costs (core analysis)		20 per cent increase in construction costs	
	NPV (\$m)	BCR	NPV (\$m)	BCR	NPV (\$m)	BCR
Scenario 2	355	1.2	-162	0.9	-680	0.8
Scenario 3	-286	0.9	-1,462	0.8	-2,638	0.6
Scenario 4	-680	0.7	-1,265	0.6	-1,850	0.5

Source: PwC 2011

This sensitivity analysis indicates that Scenario 2 becomes economically viable with a 20 per cent reduction in capital costs.

6.2.3 Sensitivity analysis – willingness to pay values for road crashes

As discussed earlier, the central case results are based on Human Capital estimates of crash costs.

This sensitivity analysis utilises the willingness to pay measures for crashes as shown in Table 17 of the RTA EMA Appendix B 2009.

Table 21: Sensitivity test – Willingness to Pay measures for crashes

Scenario	Willingness to Pay		Human Capital	
	NPV (\$m)	BCR	NPV (\$m)	BCR
Scenario 2	30	1.0	-162	0.9
Scenario 3	-825	0.9	-1,462	0.8
Scenario 4	-867	0.7	-1,265	0.6

Source: PwC 2011

Adoption of the willingness to pay measures for road safety improves the economic viability of all scenarios compared to the central case. Scenario 2 becomes viable (albeit marginally).

7 Conclusions

The key findings from the core economic appraisal are that:

- the three upgrade scenarios return BCRs lower than 1.0 when compared to a Base Case; and
- delaying some capital expenditure to beyond June 2016 with Scenario 4 does not result in a higher ratio of economic benefits. This is because the reduction in the PV of capital expenditure by delaying works is more than offset by the reduction in incremental benefits given Scenario 2 comprises the Base Case for Scenario 4.

However, it should be noted that the economic rationale for the PHUP has been established on a whole of program basis.

Incremental or staged delivery of significant infrastructure projects is not uncommon. However, incremental analysis of links may show that individual projects will have different levels of economic performance on a stand-alone basis, yet when assessed as part of a program, contribute to an economically viable outcome.

The results of the current analysis should be viewed in the context of the following:

- the program wide analysis (from its commencement in 1994/95¹⁷), undertaken by PwC in 2008, found the completion of the PHUP has a BCR of 2.7;
- the EA undertaken by PwC in 2008, which assessed the net economic benefits of completing the PHUP (assuming no further upgrades works with the Base Case beyond 2009), returned a BCR of around 1.7 (including the updated willingness to pay values of Value of Statistical Life and an up-rate of the value of travel time for business vehicles by 10 per cent (according to theory of Wider Economic Benefits). The conventional BCR was around 1.5; and
- the results of the current appraisal reflect the escalation in capital costs of between 4-6 per cent per year compared to estimates in 2008 and the fact that the Base Case for the current 2011 appraisal includes works (and hence, benefits) committed through to 2014¹⁸, compared with the 2008 study, which had a Base Case only including works to 2009. Therefore, the timing at which the EA is undertaken will determine the Base Case and hence, the incremental economic viability of completing the PHUP. This is largely arbitrary and hence, the economic viability of the completing the PHUP should be assessed on a program wide basis.

¹⁷ The methodology for the program-wide analysis dated back to 1994/95 was adjusted slightly (compared with the core analysis) to accommodate the fact that a component of the analysis period is ex-post (i.e. has already occurred). This was addressed by deflating all road user cost parameters and estimates of capital expenditure to 1994/95 (base year) dollars using the appropriate deflation factors.

¹⁸ Planning has advanced with Priority 2 projects nearing project approval and concept design is advanced on Priority 3.

Appendices

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Appendix A Traffic growth rates

Background

In preparing inputs to the traffic analysis framework, projections of traffic growth rates are an important determinant of the performance of different standards of road in a long term project, such as the PHUP. The proposed approach for the current analysis is consistent with previous (2008) analyses, that is, applying published inter-city corridor traffic growth rates produced by the relevant Commonwealth Agency, BITRE.

Previous traffic analyses used the latest published growth rates available, BITRE (then BTRE) Working Paper 66 Demand Projections for AusLink Non-Urban Corridors: Methodology and Projections, published in 2006. This round of traffic analysis is to use the most recently produced projections, contained in BITRE Working Paper 75 National Road Network Intercity Traffic Projections, published in 2009.

This note compares these two sets of projected growth rates for the Pacific Highway and the New England Highway. It identifies potential issues with the most recent projections of growth rates (especially for heavy vehicles) and outlines an approach to deal with this, for heavy vehicles at least, within the timeframe of the current project.

Comparison of projections

The 2006 projections cover the period 1999 to 2025 and the 2009 projections cover 2005 to 2030.

The 2009 light vehicle annual growth rates projections are between 16% and 41% lower, with the growth rate for the section between Grafton and Ballina a full percentage point per annum lower, at 1.42%. As these growth rates are compounded over the analysis period, the net result of this on the quantity of traffic volume growth is more marked: for the section between Coffs Harbour and Grafton, over 20 years the 2006 series results in a growth factor of 1.49 and the 2009 series gives a growth factor of 1.32.

For heavy vehicles the reductions in annual growth rates from the 2006 to the 2009 series are more marked at between 55% and 67% lower. This represents between 1.7 and 2.3 percentage point reductions per annum. Again, due to compounding of growth rates, the differences are much more marked: for the section between Coffs Harbour and Grafton, over 20 years the 2006 series results in a growth factor of 1.9, whereas the 2009 series yields a 20 year growth factor of 1.3.

Of particular note are the growth rate relativities between light and heavy vehicles for the 2006 series and for the 2009 series. Typically the 2006 series had heavy vehicle growth rates one and a quarter to more than one and a half times greater than light vehicles.

The 2009 series has reversed this with heavy vehicle growth rates from about half to the same as light vehicle growth rates.

These differences are very substantial.

A similar comparison was undertaken for the New England Highway.

It indicates that the 2009 series projects higher growth rates for light vehicles along the New England Highway, except between Scone and Armidale, where growth rates are projected to be lower.

Even though the 2009 series applies higher growth rates for light vehicles, projected growth rates for heavy vehicles along the New England Highway have been reduced by between two thirds and unity in the 2009 series.

Sources of difference

The two projection series use different input assumptions, among other things, relating to:

- population growth and its distribution;
- Gross Domestic Product (GDP);
- sectoral activity levels; and
- heavy vehicle productivity assumptions

Since preparation of these inputs, economic trends have taken some major turns. Updating the inputs to the latest information on population and income growth would be a valuable process.

The assumption that appears to cause the biggest impact on the heavy vehicle growth rates relates to heavy vehicle productivity. WP 75 (pg xxxiv) says:

“For these projections, BITRE assumed heavy vehicle productivity improves by 2 per cent per annum, between 1999 and 2030, for interregional road freight and 1 per cent per annum for shorter distance intra - regional road freight...The heavy vehicle productivity improvement assumption is a major change from the earlier BITRE non - urban corridor heavy vehicle traffic projections (BTRE 2006a)¹⁹, which, for simplicity, assumed no change in heavy vehicle productivity over the projection horizon.”

More recent work by the BITRE, Research Report 123: Road truck productivity: sources, trends and future prospects (March 2011), specifically examines this aspect of road freight transport. While identifying substantial historical increases in heavy vehicle productivity (as measured by average loads per vehicle), the report states (pp 66 - 67) that:

“Fleet - wide average loads [with no significant regulatory reform] are likely to grow by less than 10 per cent between 2010 and 2030 – an average annual rate of growth of 0.3 per cent per annum. This is well below growth in average vehicle loads experienced since 1991 – approximately 2.0 per cent per annum...”

With higher uptake of larger heavy vehicle combinations, the report concludes that:

“...increased use of these vehicles could potentially account for 3 per cent of all road freight by 2030. Because these vehicles are only able to operate across a fraction of the total road network, their impact on fleet - wide average loads would be relatively minor.”

If network access for these larger heavy vehicle combinations was extended:

“The share of freight carried by these vehicles could be as much as 17 per cent of freight by 2030. Under these assumptions, fleet - wide articulated truck average loads could increase to around 22.5 tonnes by 2030, equivalent to 0.3 per cent per annum.”

¹⁹ Working Paper 66.

From this analysis, it is unlikely that the assumption for improvements in heavy vehicle productivity used in Working Paper 75 would hold. It seems that a more likely heavy vehicle productivity improvement scenario would be:

- 0.3 per cent per annum through to 2030 – largely reflecting ongoing gains from past reforms;
- at some point there would be a likely increase in the uptake of larger heavy vehicle combinations, but this is likely to only make an appreciable improvement in productivity when improved network access for these vehicles is provided. When this occurs a further 0.3 per cent per annum improvement in heavy vehicle productivity might occur. We have assumed these gains would start to be realised around 2020, at half this rate, ramping up over two years to the full rate (i.e., 0.15 per cent in 2020, 0.225 per cent in 2021, 0.3 per cent in 2022).

Adjusted heavy vehicle growth rates

A new set of traffic growth rates for use in this study have been produced, using the following approach:

- take WP 75 heavy vehicle growth rates and remove the effect of productivity assumptions;
- apply a heavy vehicle productivity assumption of 0.3 per cent per annum from 2005 to 2030; and
- apply a further 0.3 per cent per annum heavy vehicle assumption from 2020 to 2030, with ramp - up as noted above.

Conclusions

It is proposed to apply adjusted heavy vehicle growth factors from the tables below in developing the traffic inputs for this EA.

Figure 4: Adjusted heavy vehicle factors for the Pacific Highway

Pacific Highway	Sydney - Bulahdelah	Buladelah - Port Macquarie	Port Macquarie - Kempsey	Kempsey - Nambucca Heads	Nambucca Heads - Coffs Harbour	Coffs Harbour - Grafton	Grafton - Ballina	Ballina - Qld Border
Raw	1.09	1.11	1.32	1.35	1.29	1.28	1.42	1.12
Add back BITRE WP 75 adjustment for productivity	3.09	3.11	3.32	3.35	3.29	3.28	3.42	3.12
2005 to 2019 (0.3 %pa)	2.79	2.81	3.02	3.05	2.99	2.98	3.12	2.82
2020 (0.3%pa +0.15%)	2.64	2.66	2.87	2.90	2.84	2.83	2.97	2.67
2021 (0.3%pa +0.225%)	2.57	2.59	2.80	2.83	2.77	2.76	2.90	2.60
2022 to 2030 (0.6% pa)	2.49	2.51	2.72	2.75	2.69	2.68	2.82	2.52
Resulting growth factor profile								
Year								
2005	1.0279	1.0281	1.0302	1.0305	1.0299	1.0298	1.0312	1.0282
2006	1.0279	1.0281	1.0302	1.0305	1.0299	1.0298	1.0312	1.0282
2007	1.0279	1.0281	1.0302	1.0305	1.0299	1.0298	1.0312	1.0282
2008	1.0279	1.0281	1.0302	1.0305	1.0299	1.0298	1.0312	1.0282
2009	1.0279	1.0281	1.0302	1.0305	1.0299	1.0298	1.0312	1.0282
2010	1.0279	1.0281	1.0302	1.0305	1.0299	1.0298	1.0312	1.0282
2011	1.0279	1.0281	1.0302	1.0305	1.0299	1.0298	1.0312	1.0282
2012	1.0279	1.0281	1.0302	1.0305	1.0299	1.0298	1.0312	1.0282
2013	1.0279	1.0281	1.0302	1.0305	1.0299	1.0298	1.0312	1.0282
2014	1.0279	1.0281	1.0302	1.0305	1.0299	1.0298	1.0312	1.0282
2015	1.0279	1.0281	1.0302	1.0305	1.0299	1.0298	1.0312	1.0282
2016	1.0279	1.0281	1.0302	1.0305	1.0299	1.0298	1.0312	1.0282
2017	1.0279	1.0281	1.0302	1.0305	1.0299	1.0298	1.0312	1.0282
2018	1.0279	1.0281	1.0302	1.0305	1.0299	1.0298	1.0312	1.0282
2019	1.0279	1.0281	1.0302	1.0305	1.0299	1.0298	1.0312	1.0282
2020	1.0264	1.0266	1.0287	1.0290	1.0284	1.0283	1.0297	1.0267
2021	1.0257	1.0259	1.0280	1.0283	1.0277	1.0276	1.0290	1.0260
2022	1.0249	1.0251	1.0272	1.0275	1.0269	1.0268	1.0282	1.0252
2023	1.0249	1.0251	1.0272	1.0275	1.0269	1.0268	1.0282	1.0252
2024	1.0249	1.0251	1.0272	1.0275	1.0269	1.0268	1.0282	1.0252
2025	1.0249	1.0251	1.0272	1.0275	1.0269	1.0268	1.0282	1.0252
2026	1.0249	1.0251	1.0272	1.0275	1.0269	1.0268	1.0282	1.0252
2027	1.0249	1.0251	1.0272	1.0275	1.0269	1.0268	1.0282	1.0252
2028	1.0249	1.0251	1.0272	1.0275	1.0269	1.0268	1.0282	1.0252
2029	1.0249	1.0251	1.0272	1.0275	1.0269	1.0268	1.0282	1.0252
2030	1.0249	1.0251	1.0272	1.0275	1.0269	1.0268	1.0282	1.0252
25-year growth factor	1.98	1.99	2.10	2.12	2.09	2.08	2.16	2.00
BITRE WP 75 25-year growth factor	1.31	1.32	1.39	1.40	1.38	1.37	1.42	1.32

Figure 5: Adjusted heavy vehicle factors for the New England Highway

New England Highway	Newcastle - Maitland	Maitland - Singleton	Singleton - Muswellbrook	Muswellbrook - Tamworth	Tamworth - Armidale	Armidale - Glen Innes	Glen Innes - Border
Raw	0.84	0.49	0.21	0.21	0.04	0.03	0.25
Add back BITRE WP 75 adjustment for productivity	2.84	2.49	2.21	2.21	2.04	2.03	2.25
2005 to 2019 (0.3 %pa)	2.54	2.19	1.91	1.91	1.74	1.73	1.95
2020 (0.3%pa +0.15%)	2.39	2.04	1.76	1.76	1.59	1.58	1.80
2021 (0.3%pa +0.225%)	2.32	1.97	1.69	1.69	1.52	1.51	1.73
2022 to 2030 (0.6% pa)	2.24	1.89	1.61	1.61	1.44	1.43	1.65
Resulting growth factor profile							
Year							
2005	1.0254	1.0219	1.0191	1.0191	1.0174	1.0173	1.0195
2006	1.0254	1.0219	1.0191	1.0191	1.0174	1.0173	1.0195
2007	1.0254	1.0219	1.0191	1.0191	1.0174	1.0173	1.0195
2008	1.0254	1.0219	1.0191	1.0191	1.0174	1.0173	1.0195
2009	1.0254	1.0219	1.0191	1.0191	1.0174	1.0173	1.0195
2010	1.0254	1.0219	1.0191	1.0191	1.0174	1.0173	1.0195
2011	1.0254	1.0219	1.0191	1.0191	1.0174	1.0173	1.0195
2012	1.0254	1.0219	1.0191	1.0191	1.0174	1.0173	1.0195
2013	1.0254	1.0219	1.0191	1.0191	1.0174	1.0173	1.0195
2014	1.0254	1.0219	1.0191	1.0191	1.0174	1.0173	1.0195
2015	1.0254	1.0219	1.0191	1.0191	1.0174	1.0173	1.0195
2016	1.0254	1.0219	1.0191	1.0191	1.0174	1.0173	1.0195
2017	1.0254	1.0219	1.0191	1.0191	1.0174	1.0173	1.0195
2018	1.0254	1.0219	1.0191	1.0191	1.0174	1.0173	1.0195
2019	1.0254	1.0219	1.0191	1.0191	1.0174	1.0173	1.0195
2020	1.0239	1.0204	1.0176	1.0176	1.0159	1.0158	1.0180
2021	1.0232	1.0197	1.0169	1.0169	1.0152	1.0151	1.0173
2022	1.0224	1.0189	1.0161	1.0161	1.0144	1.0143	1.0165
2023	1.0224	1.0189	1.0161	1.0161	1.0144	1.0143	1.0165
2024	1.0224	1.0189	1.0161	1.0161	1.0144	1.0143	1.0165
2025	1.0224	1.0189	1.0161	1.0161	1.0144	1.0143	1.0165
2026	1.0224	1.0189	1.0161	1.0161	1.0144	1.0143	1.0165
2027	1.0224	1.0189	1.0161	1.0161	1.0144	1.0143	1.0165
2028	1.0224	1.0189	1.0161	1.0161	1.0144	1.0143	1.0165
2029	1.0224	1.0189	1.0161	1.0161	1.0144	1.0143	1.0165
2030	1.0224	1.0189	1.0161	1.0161	1.0144	1.0143	1.0165
25-year growth factor	1.86	1.70	1.59	1.59	1.52	1.52	1.60
BITRE WP 75 25-year growth factor	1.23	1.13	1.05	1.05	1.01	1.01	1.06

Appendix B Traffic demand

The 2011 High Range Analytics (HRA) report on inputs into the traffic estimates: “Pacific Highway Upgrade – Traffic Inputs to Economic Analysis”, is attached to this report in hard copy and electronic format.

Appendix C Estimation of value of travel time parameter

In order to determine the incremental travel time cost savings, this EA includes an estimate of the value of travel time parameter for the scenarios. The VOTT is sourced from the RTA EMA 2009 Appendix B, and is reported for 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 of the vehicle types.

The VOTT used in this analysis varies for rural and urban applications, in line with RTA guidelines that treat RUC in urban and rural settings separately. This reflects the impact in urban areas of dense road networks and generally higher traffic levels. In non-urban areas, this is contrasted by generally higher speed limits and speeds of travel.

Step 1 – Calculate rural VOTT

To implement this EA, a weighted average value of travel time is required for 'light' and 'heavy' vehicles. The RTA EMA 2009 Appendix B presents the proportion of the vehicle fleet that are private versus commercial vehicles in rural networks, as well as the associated occupancy and VOTT for occupants and freight. While the composition of the vehicle fleet varies by section, this EA uses the implied weighted average vehicle composition on the PH as provided by the traffic demand model developed by HRA. **Table 22** presents the heavy and light splits as derived from the HRA traffic modelling, combined with the split of light vehicles into private and business cars provided in the RTA EMA 2009 Appendix B. The overall trend is for light vehicles to reduce slightly in their proportion relative to heavy vehicles, and to a greater extent under the upgrade scenarios than the Base Case.

Table 22: Composition of vehicle fleet on the PH

	Vehicle type	Percentage of vehicle fleet			
		Base Case	Scenario 2	Scenario 3	Scenario 4
Light	Private car	52.7	52.7	52.2	52.7
	Business car	28.4	28.4	28.1	28.4
Heavy	Light commercial	0.8	0.8	0.9	0.8
	Heavy commercial	8.7	8.8	9.1	8.8
	B-Double/Road Train	9.4	9.3	9.7	9.3

Source: HRA & RTA Economic Parameters for 2009 (Appendix B, Table 7)

The vehicle types reported in the RTA EMA 2009 Appendix B" have separate values of travel time are shown in **Table 23**. These VOTTs per VHT were applied to the scenarios based on the weighting of vehicle type in **Table 22**, to determine weighted VOTT.

Table 23: Rural value of travel time parameters

	Vehicle type	Value of travel time (\$/VHT) ²⁰
Light	Private car	21.36
	Business car	52.58
Heavy	Light commercial	30.91
	Heavy commercial	40.66
	B- Double / Road Train	63.33

Source: RTA Economic Parameters for 2009, Table 11

Based on the data presented in **Table 22** and **Table 23**, the average weighted VOTT used for rural links are shown in **Table 24**.

Table 24: Average weighted VOTT for light and heavy vehicles by scenario (\$/VHT)

	Base Case	Scenario 2	Scenario 3	Scenario 4
Light	32.29	32.29	32.29	32.29
Heavy	51.44	51.38	51.41	51.41

Step 2 – Calculate urban VOTT

The approach adopted to calculate the weighted average VOTT in the urban context commenced with defining the assumed vehicle compositions and occupancy by vehicle type as above. The assumptions accord with those recommended by the RTA EMA 2009 Appendix B and are presented below in Table 25. The key difference compared with the rural application is that the vehicle composition is reported by time of day.

Table 25: Composition of vehicle fleet on the Pacific Highway: urban sections

Hours	Vehicle type							
	Private car		Business car		Light commercial		Heavy commercial	
	Composition (%)	Occupancy (persons)	Composition (%)	Occupancy (persons)	Composition (%)	Occupancy (persons)	Composition (%)	Occupancy (persons)
Peak	80	1.1	5	1.2	11	1.3	4	1
Business	63	1.5	22	1.4	10	1.3	5	1
Off peak	85	2.0	5	1.4	7	1.3	3	1

Source: RTA Economic Parameters for 2009 (Table 8 and Table 9)

Vehicle occupancies are then applied to the VOTT per person hour contained in Table 9 of the RTA “Economic Analysis Guidelines”. The resultant VOTT by time of day for occupants and freight are summarised below in **Table 26**.

²⁰ Note: includes value of travel time associated with freight carried by commercial vehicles which reflects the benefits to freight consignees, as distinct from vehicle operators, for improved travel time.

Table 26: Urban values of travel time parameters (2009 values)

Period of day	Vehicle type	VOTT (\$/VHT)
Peak	Private car	13.32
	Business car	45.66
	Light commercial	31.56
	Heavy commercial	46.88
Business	Private car	17.84
	Business car	53.27
	Light commercial	31.56
	Heavy commercial	46.88
Other	Private car	23.42
	Business car	16.65
	Light commercial	30.30
	Heavy commercial	48.30

Source: RTA Economic Parameters for 2009 (Appendix B, Tables 8 & 9)

The VOTT parameters in **Table 26** are then re-cast to allow the grouping of vehicle type into ‘light’ and ‘heavy’ vehicle categories, based on the default yearly hours contained in Table 10 in Appendix B of the RTA updated 2009 “Economic Analysis Guidelines” (in 2007 values). Table 10 classifies yearly hours into peak, business and other periods. The weighted VOTT are shown below in **Table 27**.

Table 27: Urban values (weighted) of travel time parameters (2009 values)

Period of day	Vehicle type	Weighted VOTT (\$/VHT)
Peak	Private car	2.86
	Business car	0.61
	Light commercial	5.28
	Heavy commercial	2.85
Business	Private car	5.21
	Business car	5.43
	Light commercial	8.29
	Heavy commercial	6.15
Other	Private car	8.36
	Business car	0.35
	Light commercial	8.02
	Heavy commercial	5.48

Source: RTA Economic Parameters for 2009 (Appendix B, Tables 9)

Based on this, the average weighted VOTT used for urban links are:

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

Appendix D Capital costs by upgrade scenario

Table 28: Actual capital expenditure from 2010 to 2016 (\$mill)

Projects	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	Total
Oxley Highway to Kempsey	19.5	31.4	25.1	196.1	328.5	291.4	208.0	1,100.0
Frederickton to Eungai	13.3	11.9	22.5	190.0	280.0	152.5	-	670.2
Warrell Creek to Nambucca	23.1	31.0	21.2	118.8	235.7	240.0	210.3	880.0
Nambucca to Urunga	19.9	17.7	27.5	168.7	257.0	240.0	19.4	750.0
Woolgoolga to Ballina	72.8	76.4	219.0	611.7	1227.4	1,358.1	834.7	4,400
Total	148.5	168.4	315.2	1,285.3	2,328.6	2,282.0	1,272.3	7,800.2

Source: RTA

Benefit and cost profiles by upgrade scenario
Figure 8: Scenario 2 Capital cost and residual value

DR		7%																																			
Evaluation Period																																					
Project Year																																					
FY		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
Base Case 1																																					
Incremental - Capex																																					
Project Case - Scenario 2	Grade	Length (km)	(\$m 2011)	(PV\$m 2011)																																	
Oxley Highway to Kempsey	M	37.1	1,100	828	20	31	25	196	329	291	208	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Frederickton to Eungai	M	26.4	670	522	13	12	23	190	280	153	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Warrell Creek to Nambucca	M	20	880	659	23	31	21	119	236	240	210	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nambucca to Urunga	M	22	750	578	20	18	27	169	257	240	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total			3,400	2,586	76	92	96	674	1,101	924	438	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Incremental - Residual																																					
Project Case - Scenario 2	Grade	Length (km)	(\$m 2011)	(PV\$m 2011)																																	
Oxley Highway to Kempsey	M	37.1	168.76	15.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168.8
Frederickton to Eungai	M	26.4	202.48	19.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	202.5
Warrell Creek to Nambucca	M	20	147.79	13.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	147.8
Nambucca to Urunga	M	22	133.90	12.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	133.9
Total			652.92	61	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	652.9

Benefit and cost profiles by upgrade scenario
Figure 9: Scenario 3 (Non-induced) Benefits

	\$m	PV\$m	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
Value of Travel Time																																									
scLV VHT	16,531	-4,130	-	0	0	0	0	-127	-360	-367	-375	-381	-387	-394	-402	-409	-417	-425	-435	-444	-454	-464	-475	-484	-493	-502	-512	-522	-529	-536	-543	-549	-556	-568	-581	-593	-606	-619	-646	-674	-702
scHV VHT	9,692	-2,364	-	0	0	0	0	-61	-203	-208	-213	-214	-215	-220	-224	-229	-233	-238	-244	-250	-256	-263	-269	-276	-283	-289	-297	-304	-310	-317	-324	-331	-338	-347	-357	-366	-376	-386	-400	-415	-430
dcLV VHT	6,543	1,706	-	0	0	0	0	78	156	158	161	163	165	168	170	173	175	178	181	183	186	189	192	194	196	199	201	203	205	208	210	213	215	218	221	223	226	229	232	235	238
dcHV VHT	3,609	894	-	0	0	0	0	33	77	79	81	82	84	85	87	89	90	93	95	97	99	101	104	106	108	110	113	115	118	120	123	126	129	132	134	138	141	144	147	151	
mLV VHT	5,375	1,399	-	0	0	0	0	23	134	135	137	139	140	142	144	146	148	149	151	153	155	157	159	161	163	164	166	168	169	171	173	174	176	178	180	182	183	185	187	189	191
mHV VHT	3,942	967	-	0	0	0	0	14	85	87	89	90	90	92	94	96	98	99	102	104	106	109	111	114	116	119	121	124	127	129	132	135	138	141	144	148	151	154	158	162	165
uLV VHT	1,058	-226	-	0	0	0	0	0	-16	-16	-17	-17	-18	-19	-19	-20	-21	-22	-23	-23	-24	-25	-26	-27	-28	-29	-30	-32	-33	-35	-36	-38	-39	-42	-44	-47	-50	-52	-57	-63	-68
uHV VHT	585	-117	-	0	0	0	0	0	-8	-8	-9	-9	-9	-9	-10	-10	-10	-11	-11	-12	-12	-13	-13	-14	-15	-15	-16	-17	-18	-18	-19	-20	-21	-23	-24	-26	-28	-30	-32	-35	-39
Total	8,376	-1,870	-	0	0	0	0	-40	-137	-140	-145	-148	-152	-157	-162	-167	-173	-179	-186	-194	-202	-211	-219	-228	-237	-247	-257	-267	-273	-280	-287	-294	-300	-315	-330	-345	-361	-378	-415	-454	-494
Vehicle Operating Cost																																									
	5,203	-1,261	-	-	-	-	-	-20	-108	-110	-113	-114	-115	-118	-121	-123	-126	-129	-132	-135	-138	-142	-145	-149	-152	-156	-160	-164	-168	-172	-175	-179	-183	-188	-192	-197	-202	-207	-215	-223	-231
Total	5,203	-1,261	-	-	-	-	-	-20	-108	-110	-113	-114	-115	-118	-121	-123	-126	-129	-132	-135	-138	-142	-145	-149	-152	-156	-160	-164	-168	-172	-175	-179	-183	-188	-192	-197	-202	-207	-215	-223	-231
Crash Costs																																									
Rural	1,786	459	-	-	-	-	-	13	42	43	44	44	45	45	46	47	47	48	49	50	50	51	52	53	53	54	55	56	56	57	58	59	60	60	61	62	63	64	65	66	67
Urban	170	43	-	-	-	-	-	0.10	3.89	3.96	4.03	4.09	4.15	4.23	4.30	4.38	4.45	4.53	4.62	4.70	4.79	4.88	4.97	5.05	5.12	5.20	5.28	5.37	5.45	5.54	5.62	5.71	5.80	5.89	5.98	6.08	6.18	6.27	6.37	6.48	6.58
Total	1,956	502	-	-	-	-	-	13	46	47	48	48	49	50	50	51	52	53	53	54	55	56	57	58	59	59	60	61	62	63	64	64	65	66	67	68	69	70	71	72	73
Environmental Externalities																																									
Rural	37.8	11	-	-	-	-	-	0.4	1.3	1.3	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	
Urban	600.4	-145	-	-	-	-	-	0.14	-12.42	-12.75	-13.09	-13.26	-13.43	-13.74	-14.06	-14.71	-15.05	-15.43	-15.81	-16.21	-16.61	-17.02	-17.41	-17.81	-18.21	-18.63	-19.06	-19.49	-19.93	-20.38	-20.85	-21.32	-21.81	-22.31	-22.82	-23.34	-23.88	-24.43	-24.99	-25.56	
Total	563	-134	-	-	-	-	-	1	11	11	12	12	12	13	13	14	14	14	15	15	15	16	16	17	17	18	18	19	19	20	20	21	21	22	22	23	23	24	25		
Fatalities	-645	-	-	-	-	-	-	3	15	15	16	16	16	16	17	17	17	18	18	18	19	19	19	19	20	20	20	20	21	21	21	22	22	22	23	23	23	24	24	24	
Injuries	-4,817	-	-	-	-	-	-	26	113	115	117	118	120	122	123	125	127	129	132	134	136	138	141	143	145	147	149	151	153	155	157	159	162	164	166	169	171	174	177	179	182
Non Injuries	-3,718	-	-	-	-	-	-	20	87	89	90	91	92	94	95	97	98	100	102	103	105	107	108	110	112	113	115	116	118	120	121	123	125	127	128	130	132	134	136	138	140
Total	-9,180	-	-	-	-	-	-	49	215	219	223	225	228	232	235	239	243	247	251	255	259	263	268	272	275	279	283	287	291	295	300	304	308	313	317	322	327	331	336	342	

Figure 10: Scenario 3 (Induced) Benefits

	\$m	PV\$m	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
Value of Travel Time																																									
scLV VHT	1	0	-	-	-	-	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
scHV VHT	0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
dcLV VHT	381	89	-	-	-	-	0	1	7	7	7	8	8	8	8	9	9	9	9	10	10	10	11	11	11	11	12	12	12	13	13	13	14	14	15	15	16	16	17	17	18
dcHV VHT	239	53	-	-	-	-	0	0	1	4	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	7	7	7	7	7	8	8	8	9	9	10	10	11	11	12	12
mLV VHT	330	79	-	-	-	-	0	1	7	7	7	7	7	7	8	8	8	8	8	9	9	9	9	10	10	10	10	10	11	11	11	11	12	12	12	13	13	13	14	14	14
mHV VHT	259	57	-	-	-	-	0	0	1	5	5	5	5	5	5	6	6	6	6	6	7	7	7	7	8	8	8	8	9	9	9	10	10	10	11	11	12	12	12	13	
uLV VHT	86	21	-	-	-	-	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	4	4	4	4		
uHV VHT	36	7	-	-	-	-	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2		
Total	-1,333	308	-	-	-	-	0	3	17	26	27	28	28	29	30	31	31	32	33	34	36	37	38	39	40	41	42	43	45	46	48	50	51	53	54	56	58	59	60	62	
Vehicle Operating Cost																																									
	-1,573	-359	-	-	-																																				

