Appendix F

Economic Appraisal

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Prepared for

Roads and Maritime Services

Prepared by

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1.0 Singleton Bypass Economic Appraisal

1.1 Background

An economic appraisal has been conducted to determine whether the Options for the Singleton Bypass Project deliver value for money to the community. The appraisal measures the economic benefits generated and compares them to the expenditure required to implement the Options.

This report presents the methodology, assumptions and results of the economic appraisal.

1.2 Methodology

The economic appraisal has been carried out according to NSW Government guidelines. These guidelines are provided by two documents: the *Economic Analysis Manual*[1], Version 2, 1999 (with 2009 update of Appendix B) produced by the NSW Roads and Traffic Authority (now Roads and Maritime Services) and the NSW Government's *Guidelines for Economic Appraisals (TPP 97-2)*[2], which addresses issues that are not explicitly covered by the *Economic Analysis Manual*.

1.3 Economic parameters

Key parameters used in this economic appraisal are discussed as follows:

Discount rate: A 7 per cent real discount rate is adopted in the evaluation to calculate present values. This study also undertakes sensitivity tests at the discount rates of 4 per cent and 10 per cent.

Price Year: All costs and benefits in the evaluation are presented in 2012 prices.

The latest update of Appendix B of the Manual presents parameter values in September 2009 prices. These values were updated to 2012 prices by using ABS price indexes as outlined in that Appendix. In order to account for real increases in average weekly earnings (AWE) during the appraisal period, value of time and crash cost parameters were increased at a (real) rate of 0.9% per annum which reflects the expected real increase in AWE over time. This assumption assumes continuing nominal AWE growth of 3.7% per annum and average CPI of 2.8% per annum. Both of these growth assumptions are based on the 15-year average annual growth rate in AWE and CPI.

Evaluation horizon: An evaluation horizon of 30 years from the conclusion of construction has been adopted for this study. A two-year construction period for each option has been assumed, with completion by the end of the year 2019 and full scheme operation from 2020.

The Treasury Guidelines do not pre-specify the evaluation horizon. It does suggest a horizon of 20 years, but notes that individual projects may have a longer or shorter life. It concludes by noting that there is no single appropriate horizon, but due to the difficulties in forecasting cash flows beyond 30 years, 30 years should be considered as a maximum horizon. Given the long-life nature of road assets, an investment horizon of 30 years has been adopted for this appraisal.

Three economic indicators were calculated as outputs of the economic appraisal to evaluate the attractiveness of the project. A brief description of each indicator is provided as follows:

Net Present Value (NPV): NPV measures the difference between benefits and costs, whilst accounting for the timing of benefits and costs. Net cash flows are discounted at the prescribed discount rate of 7 per cent, reflecting the notion that future benefits and costs have less value compared to current benefits and costs. A project with a Net Present Value greater than zero would be considered economic, with the project having the highest modelled Net Present Value being the most economic.

[1] RTA, *Economic Analysis Manual*, Version 2, prepared by the Economic Services and Support Branch, July 1999.
[2] NSW Treasury, *NSW Government - Guidelines for Economic Appraisal*, TPP97-2, June 1997

NPV Per Dollar of Investment (NPVI): NPVI measures the return on a dollar of investment, calculated by dividing the net present value by the present value of investment. A project with a NPVI greater than zero would be considered economic, with the project having the highest modelled NPVI being the most economic.

Benefit Cost Ratio (BCR): BCR measures the return received per dollar of costs. The Benefit Cost Ratio is calculated by dividing the present value of all benefits by the present value of all costs. A project with a Benefit Cost Ratio greater than one would be considered economic, with the project having the highest Benefit Cost Ratio being the most economic.

The NPVI and the BCR provide a scale in which to compare the relative attractiveness of different projects where the level of expenditure varies between projects.

It is important to note that the above economic indicators, individually, have various weaknesses in assessing the project. Hence, RMS and NSW Treasury Guidelines suggest a range of economic indicators to appraise a project.

1.4 Description of options

This appraisal considers the following four Options identified for the bypass of Singleton:

- Northern Option 1 – the bypass departs from the New England Highway (NEH) in a northerly direction approximately 1.5 km north of the Golden Highway intersection and passes along Singleton's eastern extent;
- Northern Option 2 – the bypass has a similar alignment to Option 1 but departs from the NEH approximately 5 km north of Option 1;
- Central Option – the bypass departs from the NEH at approximately the same location as Northern Option 2 and passes north-west of Singleton town centre, crossing Putty Road about 4 km south of the NEH; and
- Southern Option – the bypass departs from the NEH at the Golden Highway (about 10 km south of Singleton) and follows the general alignments of the Golden Highway and Putty Road until it diverges from the latter heading due north.

The main aim of the identified Options is to increase corridor capacity for through traffic and improve town amenity in Singleton through the removal of through traffic particularly heavy vehicles. The identification of a bypass route in anticipation of the further expansion of Singleton urban area also would ensure the reservation of adequate land for future infrastructure requirements.

1.5 Traffic volumes

The methodology used to calculate traffic volumes is discussed in Section 6.3. **Table 1** and **Table 2** show annual vehicle kilometres and vehicle hour forecasts incremental to the Base Case (positive numbers represent more vehicle hours or vehicle kilometres in the Options and negative numbers represent less vehicle hours or vehicle kilometres in the Options).

Table 1: Forecasts for vehicle kilometres – incremental to the Base Case

Year	2025	2030	2040
VKT – Light (000s)			
Northern Option 1	7,134	7,178	7,288
Northern Option 2	7,134	7,178	7,288
Central Option	12,087	13,000	14,072
Southern Option	4,743	4,622	4,388

VKT – Heavy (000s)			
Northern Option 1	681	683	688
Northern Option 2	681	683	688
Central Option	894	943	1,001
Southern Option	957	945	918

Source: AECOM
Note: Traffic estimates were provided for the years 2012, 2025, 2030 and 2040 for a 1-hour AM and1-hour PM peak. Forecasts for the years in between were interpolated using the appropriate growth rates for the periods. Annual traffic forecasts were derived using an expansion factor of 2,081 based on applying the methodology of Table 10 of Appendix B of the RMS *Economic Analysis Manual* to the daily traffic time profile for Singleton (refer Section 3.1.2).

Table 2: Forecasts for vehicle hours – incremental to the Base Case

Year	2025	2030	2040
VHT – Light (000s)			
Northern Option 1	-806	-846	-957
Northern Option 2	-806	-846	-957
Central Option	-773	-809	-915
Southern Option	-643	-675	-774
VHT – Heavy (000s)			
Northern Option 1	-99	-102	-114
Northern Option 2	-99	-102	-114
Central Option	-101	-105	-117
Southern Option	-86	-89	-101

Source: AECOM
Note: Traffic estimates were provided for the years 2012, 2025, 2030 and 2040 for a 1-hour AM and1-hour PM peak. Forecasts for the years in between were interpolated using the appropriate growth rates for the periods. Annual traffic forecasts were derived using an expansion factor of 2,081 based on applying the methodology of Table 10 of Appendix B of the RMS *Economic Analysis Manual* to the daily traffic time profile for Singleton (refer Section 3.1.2).

1.6 Project costs

1.6.1 Capital costs

The construction cost for the Options identified for the bypass of Singleton were compiled in accordance with the RTA's *Project Estimating Manual,* Version 2.0 (31 March, 2008) and account for the following items:

- Project development;
- Investigation and Design;
- Property Acquisitions;
- Public Utility Adjustments;
- Construction; and
- Handover

The cost estimates are at a strategic stage and were prepared by M Raven Consulting. They include an average contingency allowance of 56%.

Table 3 shows the range of estimated capital expenditure for each Option. The lower end of the range corresponds to the reduced length options, while the higher end corresponds to the full length options.

Table 3: Range of capital expenditure by Option

Option	Total ($m, 2012 prices, undiscounted)
Northern Option 1	720 – 784
Northern Option 2	598 – 649
Central Option	462 - 578
Southern Option	523 – 564

Source: M Raven Consulting, August 2012

For appraisal purposes, it has been assumed that construction occurs in the years 2018 and 2019 with expenditure being evenly split between those years.

1.6.2 Operating costs

Operation and Maintenance (O&M) costs for each Option are assumed to be 1% of the capital expenditure required to implement that Option. O&M costs are incurred from the year of opening until the end of the appraisal period.

Table 4: Range of O&M costs by Option

Option	($m, 2012 prices, undiscounted)	
	Annual	Total
Northern Option 1	7.2 – 7.8	216 - 235
Northern Option 2	6.0 – 6.5	179 - 195
Central Option	4.6 – 5.8	139 - 174
Southern Option	5.2 – 5.6	157 - 169

Source: AECOM

1.7 Project benefits

1.7.1 Overview

Project benefits have been estimated as the sum of:

- Travel time savings for light and heavy vehicles;
- Vehicle operating cost savings for light and heavy vehicles;
- Crash cost savings;
- Environmental cost savings.

In order to quantify these impacts, unit values for each parameter are required. These have been derived by reference to Appendix B of the *Economic Analysis Manual* and are summarised in the following sections.

1.7.2 Travel time savings

Rural values of travel time (VOT) parameters for light and heavy vehicles were used for the economic appraisal. VOT for light and heavy vehicles are a weighted average of VOT for the different vehicle classes and the vehicle composition in rural areas (**Table 5**). Since the economic parameters in the RMS *Economics Analysis Manual* are in 2009 prices, these were inflated to 2012 using the latest information available for Average Weekly Earnings in NSW.

Table 5: Value of travel time for light and heavy vehicles in rural areas

Vehicle category	Vehicle type	% of Vehicle type in vehicle fleet	Adjusted % for weighted average calculation a/	Value of Time (2009$/veh-hour)	Value of Time (2012 $/veh-hour, weighted average)
Light	Private Car	46.9%	47.03%	21.36	35.06
	Business Car	25.2%	25.32%	52.58	
	Light Commercial	27.6%	27.65%	30.91	
Heavy	Heavy Commercial	0.3%	94.29%	40.66	46.10
	B-Double/ Road Train	0.02%	5.71%	63.33	

Source: RMS *Economic Analysis Manual*, Appendix B, Table 11
Note: a/ Calculated by dividing the percentage of vehicle type in vehicle fleet by the total sum of vehicle composition for Light or Heavy Vehicles.

Travel time savings for each of the Options were calculated by taking the difference between travel time costs (i.e. VOT multiplied by vehicle hours) for the Base Case and Option selected.

1.7.3 Vehicle operating costs

Vehicle operating costs (VOC) estimates prepared for this economic appraisal comprise:

- Fuel and oil costs;
- Depreciation;
- Maintenance costs; and
- Cost of wear on tyres and brakes.

The VOC parameters used in this economic appraisal are based on urban road VOC parameters in the Base Case, reflecting the built-up town area in which travel is located, and regional highway VOC parameters for bypass travel. VOC for light and heavy vehicles are a weighted average of VOC for the different vehicle classes and the vehicle composition for regional highways (**Table 6**). Since the economic parameters in the RMS *Economic Analysis Manual* are in 2009 prices, the VOCs were inflated to 2012 using the latest information available for the Consumer Price Index – Private Motoring for Sydney.

Table 6: Vehicle operating costs for light and heavy vehicles in rural areas

Vehicle category	Vehicle type	% of vehicle types in Regional Highways	Adjusted % for weighted average calculation a/	VOC (2009 cents/km)		VOC (2012 $/km hr)	
				Urban	Rural	Urban	Rural
Light	Car	60.6%	72.3%	23.61	23.47	0.31	0.30
	2 axle 4	23.2%	27.7%	43.78	41.90		
Heavy	2 axle 6	4.2%	25.6%	79.95	77.02	1.06	0.99
	3 axle	2.5%	15.2%	81.37	76.13		
	4 axle	3.6%	22.0%	101.24	94.34		
	5 axle	2.6%	15.9%	109.38	99.77		
	6 axle	2.1%	12.8%	119.38	107.63		
	B-Double	1.4%	8.5%	147.94	137.08		

Source: RMS *Economic Analysis Manual*, Appendix B, Table 3.
Note: a/ Calculated by dividing the percentage of vehicle type in Regional Highways by the total sum of vehicle composition for light or heavy vehicles.

Vehicle operating cost savings for each of the Options were calculated by taking the difference between Vehicle Operating Costs (i.e. VOC multiplied by vehicle kilometres) for the Base Case and Option selected.

1.7.4 Crash cost savings

Avoided crash costs will accrue as a result of traffic using a high standard bypass rather than travelling in an urban area with a mix of different types of traffic including pedestrians, cyclists, local cars and heavy vehicle through traffic. Avoided crashes by type under the Options are shown in **Table 7**.

Table 7: Avoided annual crashes by Option

Option	Fatal	Injury	PDO
Northern Option 1	0.24	1.3	1.9
Northern Option 2	0.38	1.8	2.3
Central Option	0.41	2.5	3.2
Southern Option	0.20	3.1	4.6

Source: AECOM Crash Statistics Analysis, 5 April 2012

To calculate crash cost savings, the avoided crashes by type are then multiplied by the relevant average crash cost. **Table 8** shows the Urban Cost per Crash for both the Human Capital and Willingness to Pay approaches. Since the economic parameters in the RMS *Economics Analysis Manual* are in 2009 prices, these were inflated to 2012 using the latest information available for Average Weekly Earnings in NSW.

Table 8: Urban cost per crash by crash type

Approach	Fatal (2012 $/crash)	Injury (2012 $/crash)	PDO (2012 $/crash)
Human Capital	$1,964,194	$192,212	$8,953
Willingness to Pay	$4,767,380	$466,525	$21,729

Source: RMS *Economic Analysis Manual,* Appendix B, Tables 13 & 17, escalated to 2012 prices

In this study, the main economic appraisal uses the Urban Cost per Crash from the Human Capital approach and undertakes sensitivity analysis using the Urban Cost per Crash from the Willingness to Pay approach.

1.7.5 Avoided environmental externality costs

Avoided environmental externality costs will accrue as a result of traffic (particularly heavy vehicles) diverting from an urban road to a town bypass. The differential between the urban and rural values of environmental externalities can be applied to the traffic projected to use the bypass which, in the Base Case, used the NEH through town. The traffic modelling indicated that about 82% of light vehicles and 63% of heavy vehicles were in this category.

The RMS *Economic Analysis Manual* (Appendix B Table 18) provides parameter values for environmental externality costs in urban and rural areas in September 2009 prices. These values were updated to 2012 prices using the latest information for Consumer Price Index (All groups).

The derivation of differential environmental externality costs between urban and rural areas is set out in **Table 9**.

Table 9: Differential environmental externality costs between urban and rural areas (2012 prices) [a/]

Environmental externality	Car ($/km)	Light goods vehicle		Total light vehicles [b/] ($/km)	Heavy vehicles	
		$/1,000 tonne-km	$/km [b/]		$/1,000 tonne-km	$/km [b/]
Noise	0.01	30.86	0.01	0.01	3.64	0.05
Air pollution	0.03	180.96	0.08	0.04	23.89	0.32
Water pollution	0.00	26.87	0.01	0.01	2.17	0.03
Greenhouse gas emissions	0.00	0.00	0.00	0.00	0.00	0.00
Nature & landscape	0.00	19.93	0.01	0.00	-3.64	-0.05
Urban separation	0.01	29.53	0.01	0.01	2.69	0.04
Total	**0.04**	**288.14**	**0.13**	**0.07**	**28.75**	**0.39**

Source: Derived from RMS *Economic Analysis Manual*, Appendix B, Table 18, escalated to 2012 prices
Notes:
a/ Totals may not correspond to sum of rows due to rounding.
b/ Based on average load carried of 445 kg for light goods vehicles and 13.5 tonnes for heavy vehicles (ABS *Survey of Motor Vehicle Usage 2010*, Table 16).
c/ Weighted average of cars and light goods vehicles using the percentage composition in Table 6.

1.8 Summary of costs and benefits

Sections **1.6** and **1.7** have described the costs and benefits for both options. **Table 10** provides a summary of undiscounted benefits for two future modelled years. **Table 11** and **Table 12** summarise the present value (at 7 per cent real discount rate) of the total costs and benefit streams under each Option.

Table 10: Summary of benefits by future modelled year ($000s, 2012 prices, undiscounted)

Benefit	Travel Time - Heavy		Travel Time - Light		Vehicle Operation - Heavy		Vehicle Operation – Light [a/]		Safety		Environmental	
Option	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030
Northern Option 1	3,885	4,720	24,142	29,663	349	425	-1,055	-1,048	1,106	1,106	12,606	14,018
Northern Option 2	3,885	4,720	24,142	29,663	349	425	-1,055	-1,048	1,384	1,384	12,606	14,018
Central Option	3,967	4,835	23,190	28,372	150	168	-2,488	-2,811	1,509	1,509	12,927	14,416
Southern Option	3,369	4,835	19,260	23,681	91	168	-363	-274	1,048	1,048	12,539	13,935

Source: AECOM
Note: a/ Negative values mean that the Option performs worse than the Base Case.

Table 11: Summary of benefits ($000s, 2012 prices, discounted)

Option	Travel Time – Heavy	Travel Time - Light	Vehicle Operation - Heavy	Vehicle Operation – Light [a/]	Safety	Environmental	Total
Northern Option 1	36,129	226,894	3,267	-8,071	8,545	107,257	374,021
Northern Option 2	36,129	226,894	3,267	-8,071	10,698	107,257	376,175
Central Option	36,924	217,351	1,340	-21,332	11,659	110,250	356,191
Southern Option	31,531	181,954	1,314	-2,068	8,100	106,604	327,436

Source: AECOM
Note: a/ Negative values mean that the Option performs worse than the Base Case.

Table 12: Summary of range of costs ($000s, 2012 prices, discounted)

Option	Capital expenditure	O&M	Total
Northern Option 1	463,904 – 505,424	55,619 – 60,597	519,523 – 566,021
Northern Option 2	385,246 – 418,272	46,189 – 50,148	431,435 – 468,420
Central Option	297,626 – 372,852	35,684 – 44,703	333,310 – 372,852
Southern Option	337,237 – 363,839	40,433 – 43,622	377,670 – 407,462

Source: AECOM

1.9 Economic appraisal

1.9.1 Criteria

Economic indicators are calculated in terms of discounted cash flows over the evaluation period. Three economic indicators were calculated as outputs of the economic appraisal (as described in **Section 1.3**), to evaluate the relative attractiveness of the Options against the Base Case:

- Net Present Value (NPV)
- Benefit Cost Ratio (BCR)
- Net Present Value per Dollar of Investment (NPVI)

1.9.2 Main results

The results, using a 7 per cent discount rate, for the Options are shown in **Table 13**. Overall, the economic appraisal shows that the range of net present values for each Option is negative, except for the Central Option which has positive net present values at the lower end of its capital cost range (the maximum NPV is $23 million for a capital cost of $462 million).

Similarly, the range of benefit-cost ratios for each option is below 1.0, except for the Central Option which has positive benefit-cost ratios at the lower end of its capital cost range (the maximum BCR is 1.1 for a capital cost of $462 million).

Table 13: Economic appraisal results (at 7% real discount rate)

Indicator	Northern Option 1		Northern Option 2		Central Option		Southern Option	
	Low	High	Low	High	Low	High	Low	High
Capital Cost ($M) a/	720	784	598	649	462	578	523	564
Net Present Value ($M) b/	-146	-192	-55	-92	23	-61	-50	-80
Benefit Cost Ratio (BCR)	0.7	0.7	0.9	0.8	1.1	0.9	0.9	0.8
Net Present Value per $ of Investment c/	-0.3	-0.4	-0.1	-0.2	0.1	-0.2	-0.1	-0.2

Source: AECOM
Notes:
a/ Undiscounted, in 2012 prices.
b/ In 2012 prices. Negative value means that the Option performs worse than the Base Case.
c/ Using strategic cost estimate including contingency allowance as indicator of investment.

1.9.3 Sensitivity analysis

Cost-benefit analysis involves making estimates of a number of factors which are subject to uncertainty. Sensitivity analysis is used to assess the possible impacts of uncertainty. It tests the main assumptions of the model to identify how the outcome would vary if key variables change. Sensitivity tests were conducted on the following parameters:

- Discount rate: 4 per cent and 10 per cent
- Capital expenditure: plus and minus 20 per cent
- Traffic volume: plus and minus 20 per cent
- Growth scenarios: high and low (the results in Table 13 are based on the medium growth scenario which has mining sector growth rates applying for the first two years of the forecast period, then the background traffic growth rates apply; the high growth scenario has mining sector growth rates applying for the first five years of the forecast period, then the background traffic growth rates apply; the low growth scenario has the background traffic growth rates applying throughout the forecast period).

- Crash savings using the Willingness to Pay values (refer to Section **1.7.4**).

The results of the sensitivity analysis are shown in **Table 14.** For clarity, only the BCR values have been presented. None of the tests undertaken affects the relative attractiveness of the Options - the lower discount rate and the high growth scenario have the most influence on the BCR value.

Table 14: Benefit Cost Ratio sensitivity analysis results

Test	Northern Option 1		Northern Option 2		Central Option		Southern Option	
	Low	High	Low	High	Low	High	Low	High
Base Case	**0.7**	**0.7**	**0.9**	**0.8**	**1.1**	**0.9**	**0.9**	**0.8**
Discount rate 4%	1.0	0.9	1.2	1.1	1.5	1.2	1.2	1.1
Discount rate 10%	0.5	0.5	0.7	0.6	0.8	0.6	0.7	0.6
Capital expenditure (+20%)	0.6	0.6	0.7	0.7	0.9	0.7	0.7	0.7
Capital expenditure (-20%)	0.9	0.8	1.1	1.0	1.3	1.0	1.1	1.0
Traffic volume (+ 20%)	0.8	0.8	1.0	0.9	1.2	1.0	1.0	0.9
Traffic volume (- 20%)	0.6	0.6	0.7	0.7	0.9	0.7	0.8	0.7
High traffic growth	1.0	0.9	1.2	1.1	1.4	1.1	1.2	1.1
Low traffic growth	0.6	0.5	0.7	0.7	0.9	0.7	0.7	0.7
Safety WTP values	0.7	0.7	0.9	0.8	1.1	0.9	0.9	0.8

Source: AECOM

1.9.4 Conclusion

Overall, the economic appraisal shows that the range of net present values for each Option is negative, except for the Central Option which has positive net present values at the lower end of its capital cost range (the maximum NPV is $23 million for a capital cost of $462 million).

Similarly, the range of benefit-cost ratios for each option is below 1.0, except for the Central Option which has positive benefit-cost ratios at the lower end of its capital cost range (the maximum BCR is 1.1 for a capital cost of $462 million). None of the tests undertaken alters the relative attractiveness of the Options.