Waimea Road

Job No. 287

Issue No 2 (08 July 2009)

Options Report

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Quality Assurance

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Executive Summary

Nelson City Council commissioned baseplus Limited (baseplus) to develop an S-Paramics microscopic simulation model for the Rutherford Street and Waimea Road corridor. This report focuses on the development and analysis of the option models.

In total, seven signal options plus the base have been modelled and analysed in this report:

- Option 1: Signals at Waimea/Motueka, with no right turn
- Option 2: Signals at Waimea/Motueka, with right turn
- Option 3: Option 1 plus signals at Boundary/Market
- Option 4: Option 2 plus signals at Boundary/Market
- Option 5: No pedestrian signals at crossing north of Hampden
- Option 6: Option 3 plus no pedestrian signals
- Option 7: Option 4 plus no pedestrian signals

The options have been assessed in both the morning peak and evening peak models comparing network statistics, level of service and journey times. Journey times have focused on three peak five minute intervals within each model (9am peak 0840-0845, 3pm peak 1520-1525, 5pm peak 1710-1515), based on the peaks established during the journey time surveys.

In summary the analysis concludes the following:

- If signals are to be installed at Motueka St only, (i.e Options 1 and 2) then Option 2 provides the most benefits. However, the benefits will only be gained during the 5pm peak.
- If signals are to be implemented at Motueka St and Boundary/Market (i.e Options 3 and 4), then Option 4 will provide the most benefit. Furthermore, the results show that applying signals at both of these intersections is more beneficial than just applying signals at Motueka Street. Option 4 will provide benefits during the 9am and 5pm peaks.
- If the pedestrian signals are to be removed (i.e Options 5, 6 and 7), then Option 7 will provide the most benefits. This option will provide benefits during the 9am, 3pm and 5pm peaks.

Overall, Option 7 provides the most benefits. However, this is based on the proposed signalised intersections providing two through lanes and it is anticipated if the double through lanes are removed, then the signal benefits will be lost.

Furthermore, the purpose of the model is to also analyse bus priority proposals, however, it is suspected that the proposed designs do not allow much room for bus lanes.

It is therefore recommended that prior to undertaking additional option testing of the proposed new bus schedule and bus lanes, the design of the signal options and bus lanes need to be further considered and confirmed, to ensure the proposed modelled designs are able to be implemented in reality.

1 Introduction

Nelson City Council commissioned baseplus Limited (baseplus) to develop an S-Paramics microscopic simulation model for the Rutherford Street and Waimea Road corridor. This report focuses on the development and analysis of the option models.

In total, seven signal options have been modelled and analysed in this report. These options include various combinations of signals at Motueka/Waimea, signals at Boundary/Waimea and the removal of pedestrian signals north of Hampden St.

In the initial proposal, bus priority measures were also proposed for testing. However, it is recommended that the results of the signal options first be considered before additional bus lane options are assessed.

This Options Report provides details of the development of the option models and compares the following analysis measures:

- Network Statistics;
- Journey Times; and
- Delay/Level of Service.

For further information regarding background to this project, reference should be made to the following reports:

- Calibration Report: Waimea Road Calibration Report, baseplus
- Proposal: Rutherford Road and Waimea Road Corridor Modelling, baseplus, 28 August 2008
- Bus Scheme Descriptions: Indicative Bus Priority Scheme Rutherford Street and Waimea Road Corridor, Nelson City Council, April 13, 2007
- Bus Phases: Regional Passenger Transport Plan, Nelson City Council, August 2008

2 Option Models

The following model option matrix has been developed to define each of the options developed and analysed within this report.

	Option							
Description	Base	1	2	3	4	5	6	7
Motueka Signalised (banned right turn)		O		O			O	
Motueka Signalised (allowed right turn)			O		O			O
Signalising Market Street				O	O		O	O
Remove Pedestrian Signals						O	O	O

Figure 1 – Option Matrix

2.1 Motueka/Waimea Intersection

The signal layouts and phasing applied in the model for the proposed signalised intersection at Motueka/Waimea is drafted in the following figures.

Option 1

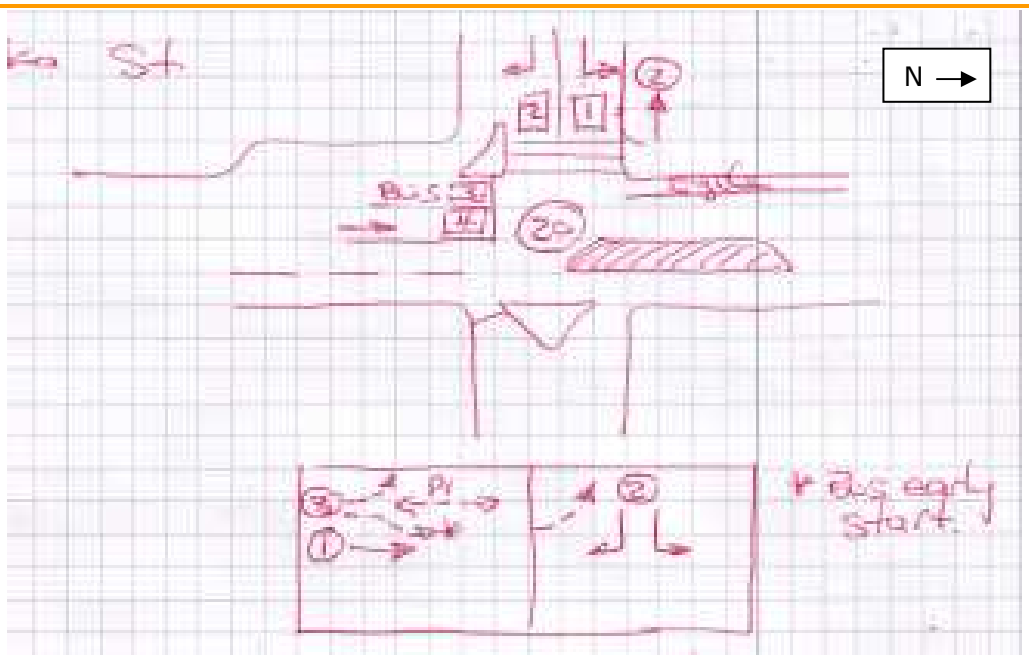

Figure 2 – Motueka Signalised Banned Right Turn

This option bans the following existing movements:

- Right turn movement from Waimea south approach into Motueka east
- Right turn movement from Motueka east approach into Waimea
- Through movements from Motueka east and Motueka west approaches

This option does not signalise the movements from Waimea north approach or from Motueka Street east approach.

Option 2

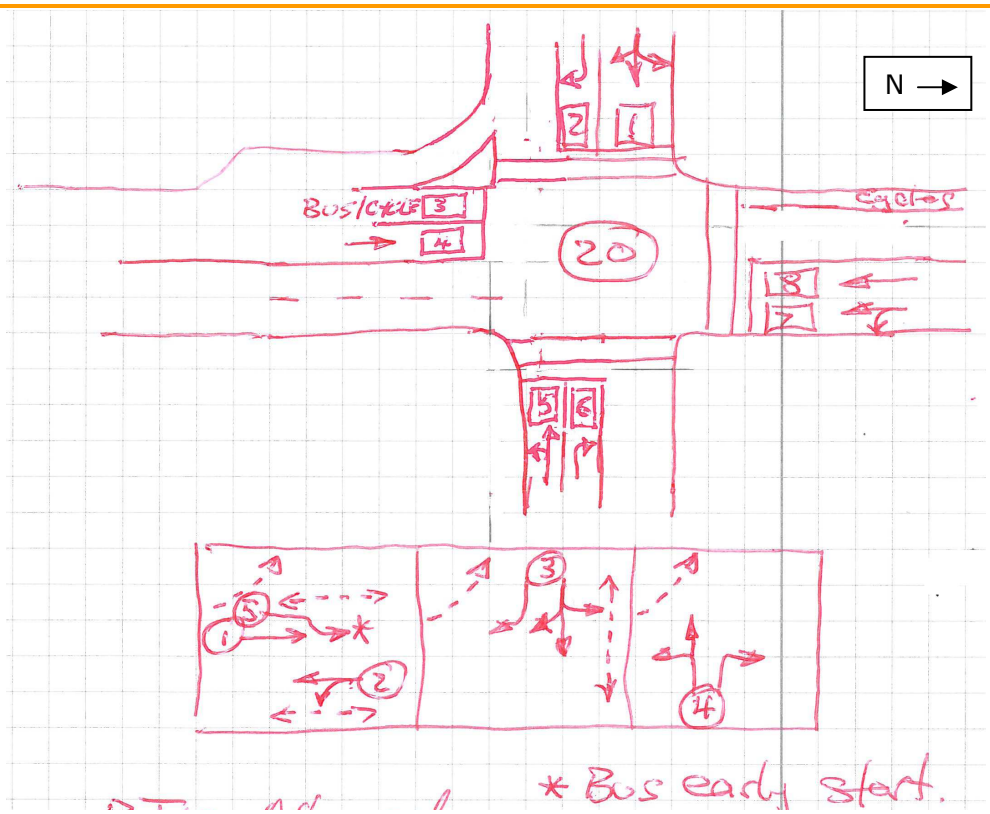

Figure 3 - Motueka Signalised - Right Turns Allowed

The length of the double southbound through lanes along Waimea Road and the double right turn lanes from Motueka Street have been approximated in the model to ensure the signal design is successful. The approximate lengths applied in the model are:

- Double southbound through lanes 50m
- Double right turn lanes from Motueka Street 50m

2.2 Boundary/Market/Waimea Intersection

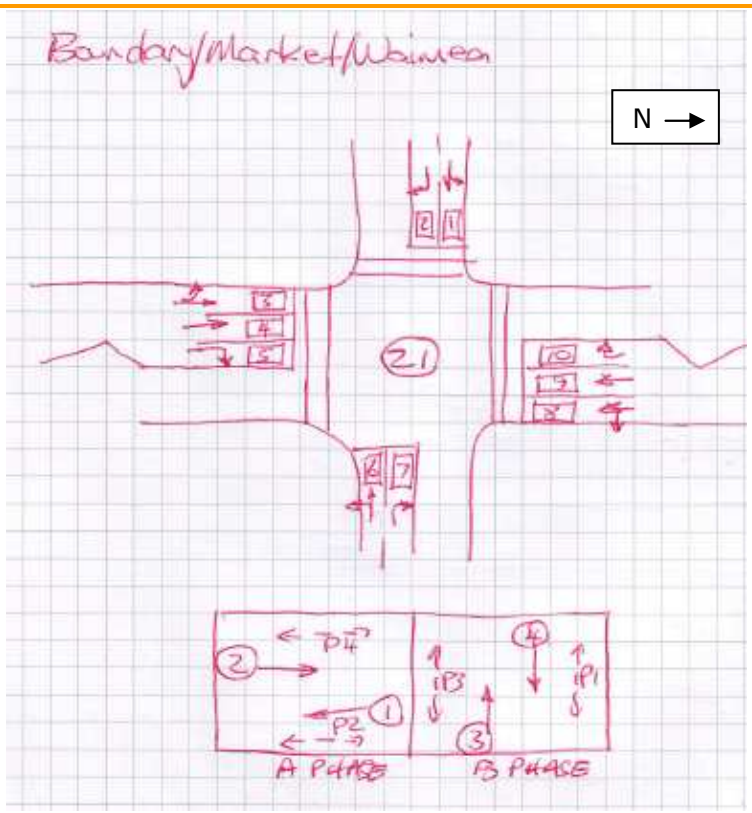

Figure 4 – Boundary/Market Signalised - Right Turns Allowed

This design assumes Boundary Road and Market Street, which are currently offset tees, are realigned to form a single intersection.

The lengths of the double southbound and northbound lanes have been approximated in the model to ensure the signal design is successful. The approximate lengths applied in the model are:

- Double southbound through lanes 40m
- Double northbound through lanes 120m

3 Option Analysis

3.1 Network Statistics

The overall network statistics are calculated for the full model period for each of the following measures, for 'All Vehicles':

- Mean Delay
- Total Distance
- Total Number of Vehicles
- Mean Speed
- Total Network Travel time

The full analysis results are presented in tables in Appendix A.

The Network Average Travel Time is also presented in the following figures for each full model period, for All Vehicles. The figures show the range of the total average travel time over five model runs, by presenting the minimum, maximum and average values.

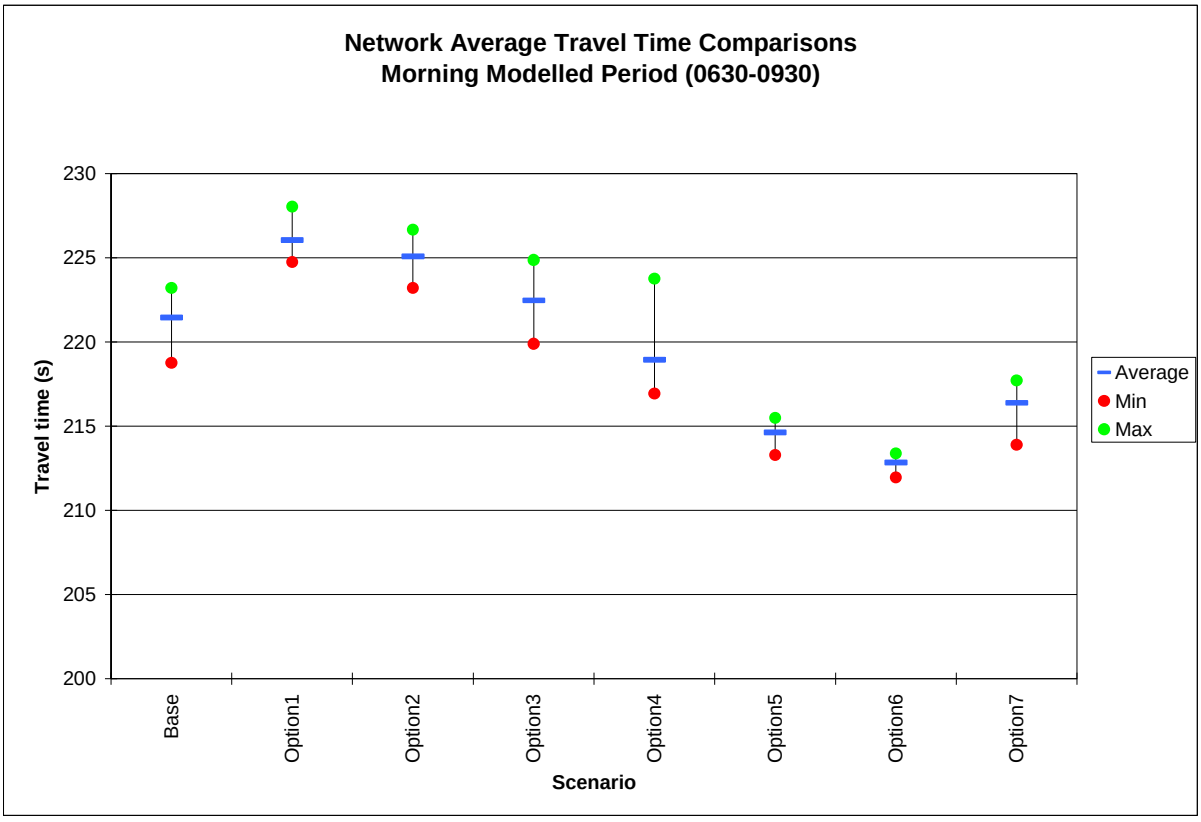

Figure 5 – Network Average Travel Time - Morning Model Period – All Vehicles

The above figure shows the options change the network travel time by 1% to 4 % compared to the base. Options 1 and 2 increase the average overall network travel time compared to the base by 2%. Options 5, 6 and 7 show the biggest improvements, with total network time decreasing by 3%, 4% and 2% respectively.

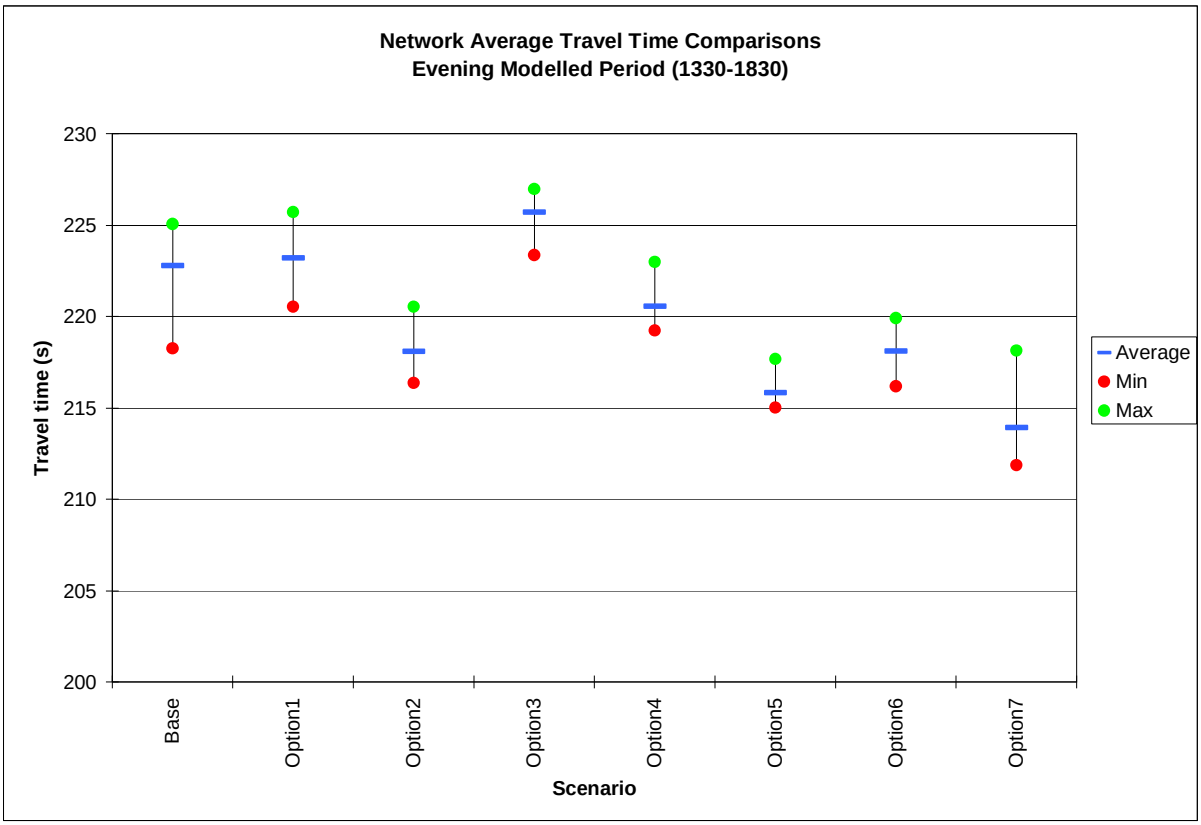

Figure 6 - Network Average Travel Time - Evening Model Period – All Vehicles

The above figure shows the options change the network travel time by 1% to 4 % compared to the base. Option 3 is the only option with an increase to the average overall network travel time compared to the base, however the range of results for this option does overlap the base results. Options 5 and 7 show the biggest improvements, with total network time decreases of 3% and 4% respectively.

3.2 Journey Times

Journey time comparisons have been made for each modelled period, for the following two routes used during calibration:

- Waimea Rd/Rutherford St northbound from Whakatu Drive to Bridge Street
- Waimea Rd/Rutherford St southbound from Bridge Street to Whakatu Drive

The journey time analysis has been undertaken for all vehicles, in each direction, for a representative 'free flow' period and for a peak period as summarised in the following table.

Period	Direction	Analysis Period
AM	Southbound	Free Flow: 0700-0900
	Northbound	Free Flow: 0840-0845
		9am Peak: 0840-0845
PM	Southbound	Free Flow: 1405-1410
		3pm Peak: 1520-1525
		5pm Peak: 1710-1715
	Northbound	Free Flow: 1400-1800

Table 1 – Journey Time Analysis

The graphs for the free flow results are contained in Appendix B. In summary these graphs show there is little variation in the overall travel time in the northbound or southbound direction when the traffic is operating in freeflow conditions.

The graphs for the peak periods are shown in the following sections. While interpreting these graphs it should be noted that the journey time profiles shown are calculated 'average' runs, based on the results of five runs. Furthermore, comparing travel time profiles between runs, shows journey times are sensitive and variable. Hence where the travel times are close, it cannot be fully concluded that one option is better or worse than another.

Morning Peak

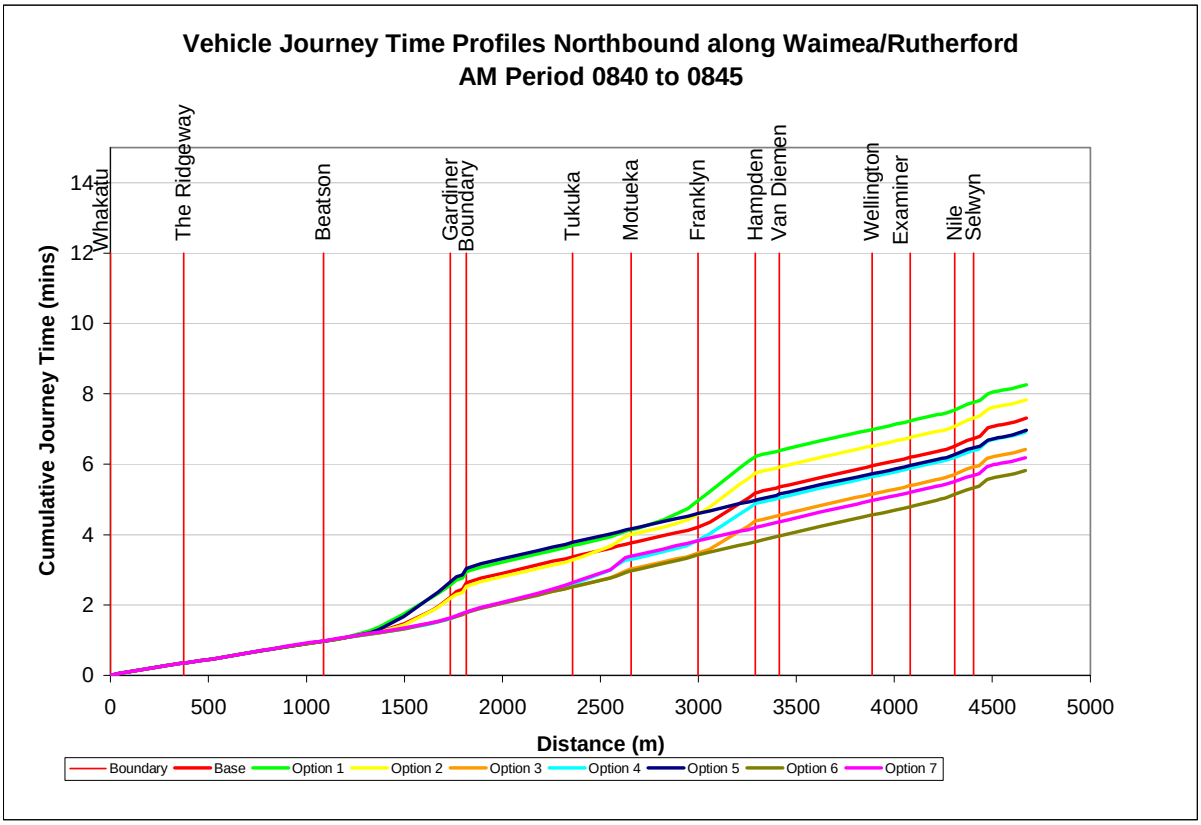

Figure 7 - Northbound Journey Travel Time – 1840-0845 – All Vehicles

The above graph shows the following for the northbound travel time during the 9am peak:

- Options 1 and 2 show a slight increase due to signals at Motueka Street.
- Options 3 and 4, which include signals at Motueka and Boundary/Market, show an improvement in northbound travel time, which is aided by the two through lanes at the Boundary signals.
- Option 5, no pedestrian signals, shows a slightly better northbound travel time than the base.
- Option 6 and 7, which both include signals at Motueka, signals at Boundary/Market and no pedestrian signals, show a further improvement to the results with a decrease in total northbound travel time of approximately 90 and 60 seconds respectively.
- Overall, Option 6 provides the best northbound travel time during the AM peak. Option 6 is slightly better than Option 7 since it has less phases than Option 7 and hence is able to provide more green time to the northbound traffic.
- However, as stated early in this report, there is variation in the model runs and hence the graphed journey times are 'averages'. Hence, caution should be given to not over interpreting the above results since the journey times are generally all within 2 minutes.

Evening Peak

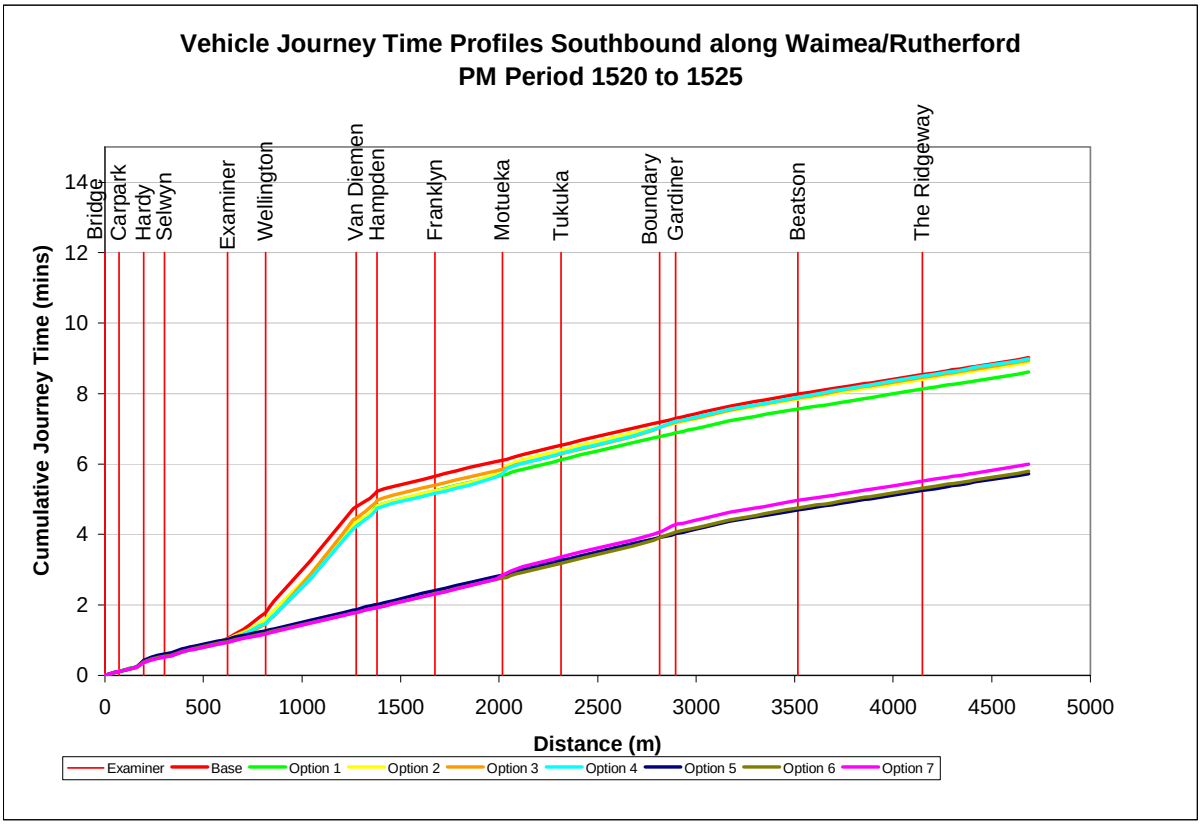

Figure 8 - Southbound Journey Travel Time – 1520-1525 – All Vehicles

The above graph shows the following for the southbound travel time during the 3pm peak:

- Options 1 and 3 operate similar to the base, due to no signals impeding the southbound traffic.
- Options 2 and 4, also operate similar to the base. In these options the graphs show a small delay incurred at Motueka Street due to the signals. However, due to the small cycle times and optimal phase splits applied at the signals, the level of delay to the southbound vehicles is negligible.
- Options 5, 6 and 7, all options with no pedestrian signals, show a significant decrease in journey times of approximately 3 minutes. This is expected, since during the 3pm peak the pedestrian signals come in frequently and hence it has a significant effect on the traffic delay.

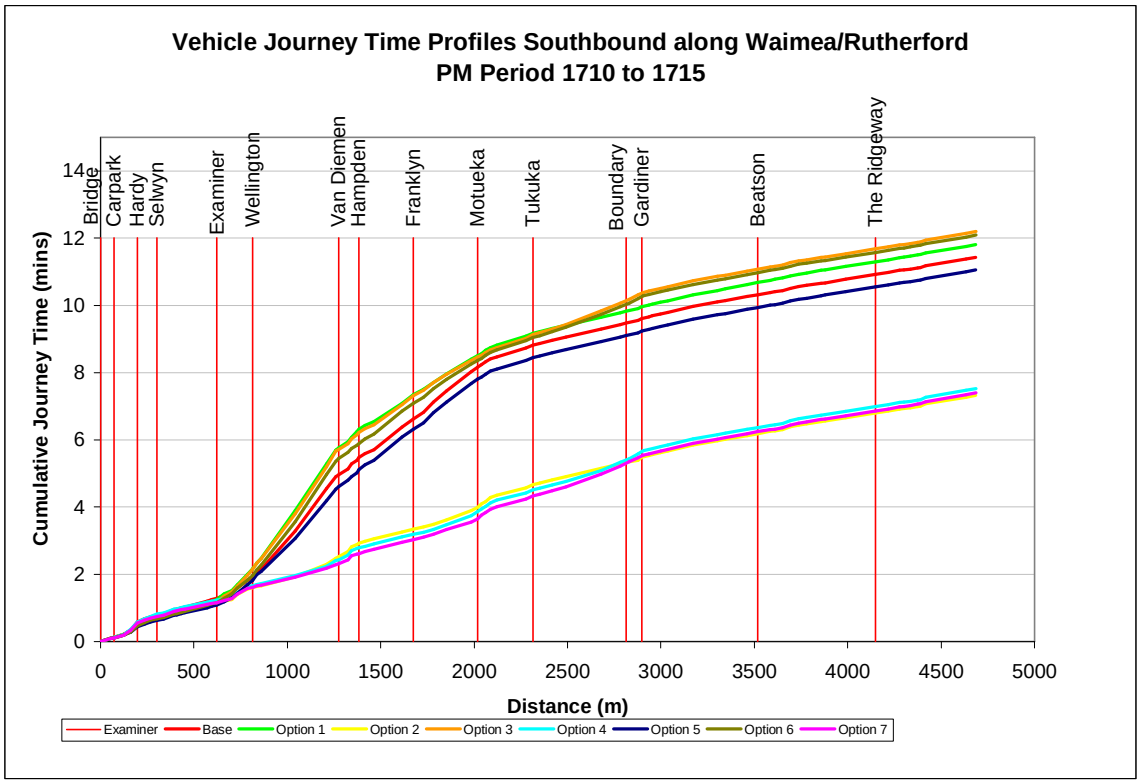

Figure 9 - Southbound Journey Travel Time – 1710-1715 – All Vehicles

The above graph shows the following for the southbound travel time during the 5pm peak:

- Options 1, 3 and 6, all options with signals at Motueka with no right turns, show a slight increase to the southbound journey time. This increase may be attributed to the merge operation south of Motueka Street; where the southbound vehicles merge with the right turners from Motueka. In these options the right turners now approach the merge in platoons from the signals, causing the southbound traffic to break more excessively.
- Option 5, no pedestrian signals, operates only slightly better than the base, since the pedestrian signals do not operate much during the evening peak.
- However, as stated early in this report, these journey times are 'averages' and there is variation in the model runs. The minimal difference between the base and Options 1, 3, 5 and 6, which are all within 1 minute, is therefore not fully conclusive and could be considered to result in similar journey times for the southbound traffic.
- Options 2, 4 and 7, all options with signals at Motueka including right turns, show a significant decrease in travel time by approximately 4 minutes. This result is due to the increased throughput capacity at the junction due to the two through lane configuration and the merge operation south of Motueka Street. For the southbound traffic, the merge is only utilised by the through traffic as vehicles commence on the green light. In this situation, vehicles are already going slowly and hence do not have to break excessively at the merge, which in the base causes a shock wave effect. Once the two lane capacity has dissipated, the vehicles on the green then generally only use one lane through the junction and therefore no merge action results. The successful operation of this movement is also a result of sufficient green time being given to this phase. This is enabled due to minimal time required by the Motueka west approach phase which also

has two lanes for the right turners. In effect, the signals have resulted in a more controlled merge.

3.3 Level of Service

Estimates of level of service (LOS) have been made for the peak hour for the base and option models, for each movement, approach and intersection. The LOS criteria used is detailed below:

LOS	Average Delay (s)
A	<10
B	10 to 20
C	20 to 35
D	35 to 55
E	55 to 80
F	> 80

Table 2 – Level of Service Criteria (Highway Capacity Manual)

Summary tables are shown on the following pages detailing the Volume, Delay and LOS for the movements at Waimea/Motueka intersection and Waimea/Boundary/Market intersections. Waimea/Van Dieman intersection has also been included in the evening peak to show the effects of the proposals further north along the corridor.

Morning Peak

At Waimea/Motueka the results show

- Options 1, 3, and 6, all options with signals at Motueka with no right turns, all show a decrease in delay for vehicles turning out of Motueka West from LOS D to B, while retaining the LOS from Waimea north approach at level A.
- Options 2, 4 and 7, all options with signals at Motueka with right turns, all operate similarly at Motueka St; they all show a decrease in LOS for traffic out of Motueka West to LOS C. However, this decrease is not as great as that resulting in Options 1, 2 and 3. Options 2, 4 and 7 also retain the LOS from Waimea north approach at level A but shows a slight increase in the delay for Waimea south approach vehicles, reducing the LOS for the through movement from A to B or C.
- Option 5 results in similar LOS to that achieved in the base model.

At Waimea/Boundary/Market the results show

- Options 1, 2, and 5, all options without signals at Boundary/Market, all operate similar to the base model.
- Options 3, 4, 6 and 7, all options with signals at Boundary/Market, all show the LOS for through movements at the Waimea south and north approaches operating at an acceptable LOS A. These options also improve the LOS for vehicles from Boundary west approach from LOS F to B.

Movement			Vol	Base		Option 1		Option 2		Option3		Option4		Option5		Option6		Option7	
				Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
Motueka/Waimea	Waimea North	l	9	3	A	1	A	7	A	2	A	6	A	2	A	3	A	6	A
		s	706	2	A	3	A	7	A	3	A	8	A	2	A	2	A	8	A
	Motueka East	l	15	7	A	7	A	7	A	7	A	30	C	8	A	9	A	27	C
		r	58	51	D			27	C			30	C	54	D			29	C
	Waimea South	l	312	4	A	5	A	12	B	5	A	14	B	4	A	5	A	17	B
		s	1092	3	A	7	A	20	B	7	A	23	C	3	A	7	A	25	C
		r	17	8	A			25	C			25	C	7	A			28	C
	Motueka West	l	24	42	D	14	B	23	C	17	B	25	C	40	D	15	B	28	C
		r	135	42	D	17	B	25	C	18	B	27	C	30	C	19	B	26	C
Intersection Results				7	A	6	A	17	B	6	A	19	B	6	A	6	A	21	C
Boundary/Market/Waimea	Waimea North	l	45							6	A	5	A			5	A	6	A
		s	738							6	A	7	A			7	A	6	A
		r	34	43	D	44	D	44	D	30	C	28	C	44	D	30	C	30	C
	Market East	l	118	5	A	6	A	6	A	21	C	21	C	5	A	21	C	21	C
		r	111	6	A	6	A	6	A	24	C	25	C	6	A	24	C		A
	Waimea South	l	51							8	A	8	A			7	A	24	C
		s	1314							9	A	9	A			9	A	17	A
		r	55	30	C	30	C	26	C	12	B	13	B	29	C	12	B	12	B
	Boundary West	l	5	125	F	138	F	87	F	15	B	18	B	74	E	13	B	15	B
		r	37	91	F	109	F	70	E	16	B	20	B	91	F	20	B	16	B
Intersection Results										10	A	10	A			10	B	10	A

Table 3 – LOS Summary - Morning Peak Hour

Evening Peak

At Waimea/Motueka the results show

- Options 1, 3, and 6, all options with signals at Motueka with no right turns, all show a decrease in delay for vehicles turning out of Motueka West from LOS F to B or C, while retaining the LOS from Waimea north approach at level D.
- Options 2, 4 and 7, all options with signals at Motueka with right turns, all operate similarly at Motueka St; they all show a decrease in LOS for traffic out of Motueka West to LOS C. However, this decrease is not as great as that resulting in options 1, 2 and 3. Options 2, 4 and 7 also improve the LOS from Waimea north approach from LOS D to B, but show a slight increase in the delay for Waimea south approach vehicles, reducing the LOS for the through movement from A to B.
- Option 5 results in similar LOS to that achieved in the base model.

At Waimea/Boundary/Market the results show

- Options 1, 2, and 5, all options without signals at Boundary/Market, all operate similar to the base model.
- Options 3, 4, 6 and 7, all options with signals at Boundary/Market, all show the LOS for through movements at the Waimea south and north approaches operating at an acceptable LOS A and B respectively. However, the right turn from Waimea South into Market Street does show an decrease in LOS from B to D or E, as only one or two vehicles are able to get through at the end of each green phase.

At Waimea/VanDieman the results show:

- Options 2, 4 and 7 show a significant decrease to the delay at Van Dieman east approach left turn movement, from LOS E to B or C, and also for the Waimea north approach through traffic, from LOS D to B or A.

Movement			Vol	Base		Option 1		Option2		Option3		Option4		Option5		Option6		Option7	
				Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
Motueka/Waimea	Waimea North	l	17	44	D	46	D	12	B	44	D	13	B	47	D	45	D	14	B
		s	1235	47	D	54	D	16	B	53	D	16	B	48	D	52	D	16	B
	Motueka East	l	30	106	F	101	F	12	B	76	E	29	C	102	F	104	F	27	C
		r	31	129	F			24	C			29	C	131	F			28	C
	Waimea South	l	326	4	A	4	A	8	A	5	A	5	A	5	A	5	A	7	A
		s	790	4	A	9	A	18	B	10	A	14	B	4	A	9	A	16	B
		r	4	31	C			55	D			25	C	31	C			26	C
	Motueka West	l	29	67	E	10	B	25	C	11	B	26	C	80	E	10	B	24	C
		r	321	96	F	19	B	31	C	21	C	29	C	112	F	19	B	28	C
Intersection Results				37	D	31	C	17	B	31	C	15	B	40	D	30	C	16	B

Boundary/Market/Waimea	Waimea North	l	71							15	B	14	B			14	B	15	B
		s	1433							14	B	16	B			15	B	14	B
		r	7	21	C	20	C	16	B	24	C	28	C	14	B	25	C	24	C
	Market East	l	121	24	C	24	C	25	C	22	C	26	C	23	C	24	C	22	C
		r	60	13	B	14	B	17	B	23	C	23	C	14	B	23	C	25	C
	Waimea South	l	38							6	A	7	A			7	A	23	C
		s	1070							8	A	8	A			7	A	15	A
		r	75	12	B	11	B	12	B	40	D	76	E	11	B	41	D	40	D
	Market West	l	18	32	C	21	C	25	C	22	C	32	C	29	C	24	C	22	C
		r	200	47	D	37	D	42	D	36	D	44	D	48	D	34	C	36	D
Intersection Results										14	B	17	B			15	B	14	B

VanDieman/Wai	Waimea North	l	16	62	E	57	E	24	C	68	E	14	B	42	D	60	E	9	A
		s	912	49	D	62	E	14	B	59	E	9	A	38	D	50	D	6	A
	VanDieman Eas	l	372	78	E	70	E	27	C	65	E	20	B	44	D	51	D	12	B
		r	6	89	F	70	E	40	D	76	E	31	C	39	D	63	E	31	C
	Waimea South	s	696	2	A	2	A	2	A	2	A	2	A	1	A	1	A	1	A
		r	253	24	C	22	C	17	B	23	C	15	B	20	B	18	B	10	A
Intersection Results				37	D	40	D	13	B	38	D	10	A	26	C	32	C	6	A

Table 4 – LOS Summary - Evening Peak Hour

4 Summary and Conclusions

Seven options have been analysed for the Waimea Road corridor for both the morning peak and evening peak periods. Within these two models there are three significant peak periods, which for simplicity have been referred as the 9am, 3pm and 5pm peaks.

To summarise the options and their benefits, a matrix table has been created as shown below. The table includes a description of each option and shows the peak periods in which each option has network benefits.

Option	Signal Descriptions				Peak Period Benefits		
	Signals at Motueka – No Right Turn	Signals at Motueka – Including Right Turn	Signals at Market	No Pedestrian Signals	9 AM	3 PM	5 PM
Base							
1	✓						
2		✓					✓
3	✓		✓		✓		
4		✓	✓		✓		✓
5				✓	✓	✓	
6	✓		✓	✓	✓	✓	
7		✓	✓	✓	✓	✓	✓

Table 5 – Option Description and Benefit Summary

The table concludes the following:

- If signals are to be installed at Motueka St only, (i.e Options 1 and 2) then Option 2 provides the most benefits. However, the benefits will only be gained during the 5pm peak.
- If signals are to be implemented at Motueka St and Boundary/Market (i.e Options 3 and 4), then Option 4 will provide the most benefit. Furthermore, the results show that applying signals at both of these intersections is more beneficial than just applying signals at Motueka Street. Option 4 will provide benefits during the 9am and 5pm peaks.
- If the pedestrian signals are to be removed (i.e Options 5, 6 and 7), then Option 7 will provide the most benefits. This option will provide benefits during the 9am, 3pm and 5pm peaks.

Overall, Option 7 will provide the most benefits. However, to enable the traffic signal options to work successfully, the intersection designs have included two through lanes on Waimea Road, on the approach and departure to the signals at the following locations:

- southbound through lanes at Motueka St;
- southbound through lanes at Market/Boundary; and
- northbound through lanes at Market/Boundary.

The layout of these options has been designed without exact knowledge of the existing road width or width extension limitations. However, it is suspected with these proposed designs there is not much room left for bus lanes. Furthermore, it is anticipated that if the proposed double through lanes are removed, then the signal benefits will be lost.

5 Recommendation

It is recommended that prior to undertaking additional option testing of the proposed new bus schedule and bus lanes, the design of the signal options and bus lanes need to be further considered and confirmed, to ensure the proposed modelled designs are able to be implemented in reality.

Appendix A

Network Statistics

Option	Average Travel Time (s)	Total Distance (m)	Total Number of Vehicles	Mean Speed (kph)
Evaluation Base	221	23,281	9,603	39
1	226	23,532	9,618	39
2	225	23,294	9,587	39
3	222	23,984	9,744	40
4	219	23,264	9,603	40
5	215	23,286	9,611	41
6	213	23,455	9,609	41
7	216	23,278	9,607	40
% Difference Compared to Evaluation Base				
1	2%	1%	0%	-1%
2	2%	0%	0%	-1%
3	0%	3%	1%	1%
4	-1%	0%	0%	1%
5	-3%	0%	0%	3%
6	-4%	1%	0%	5%
7	-2%	0%	0%	2%

Table 6 - Morning Model 0630-0930, Network Statistics (Five Runs)- All Vehicles

Option	Average Travel Time (s)	Total Distance (m)	Total Number of Vehicles	Mean Speed (kph)
Evaluation Base	223	54,329	24,154	36
1	223	54,503	24,176	36
2	218	54,388	24,164	37
3	226	54,447	24,165	36
4	221	54,328	24,173	37
5	216	54,332	24,168	37
6	218	54,428	24,169	37
7	214	54,301	24,158	38
% Difference Compared to Evaluation Base				
1	0%	0%	0%	0%
2	-2%	0%	0%	2%
3	1%	0%	0%	-1%
4	-1%	0%	0%	1%
5	-3%	0%	0%	3%
6	-2%	0%	0%	2%
7	-4%	0%	0%	4%

Table 7 - Morning Model 1330-1830, Network Statistics (Five Runs)- All Vehicles

Appendix B

Journey Times

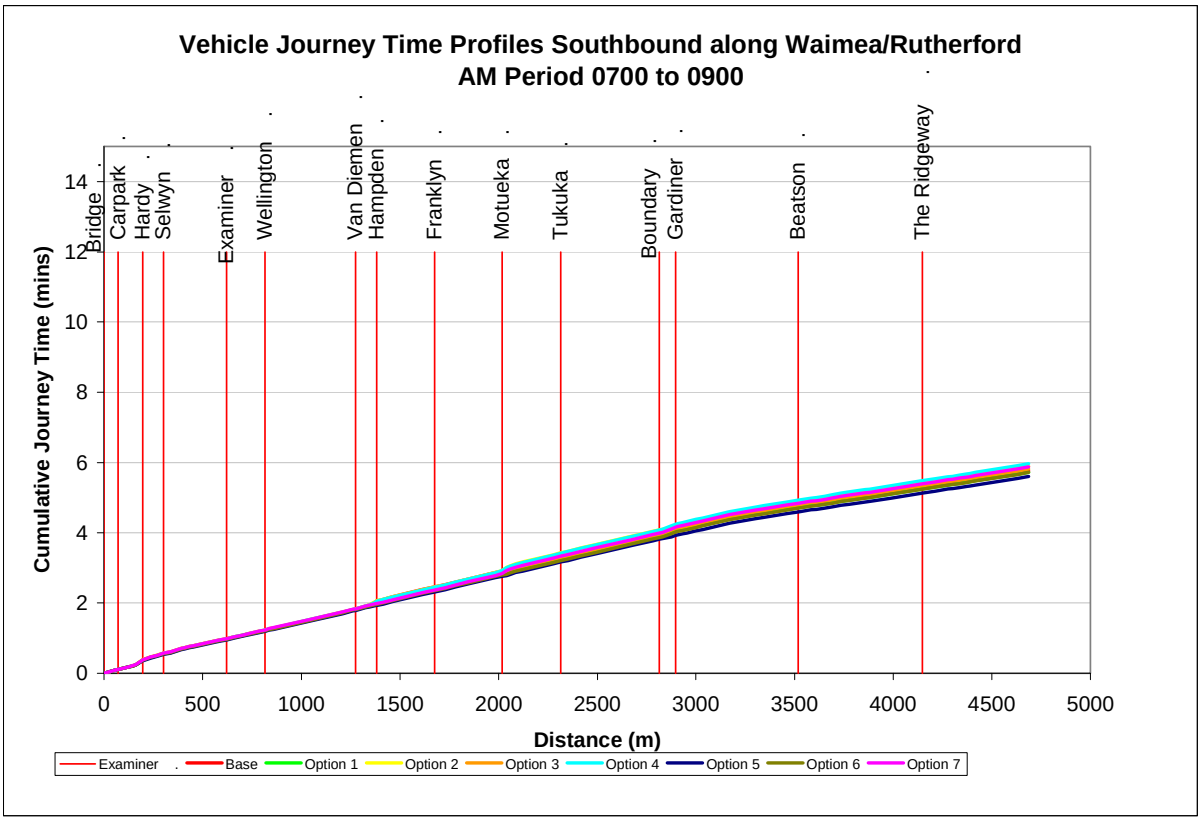

Figure 10 - Southbound Journey Travel Time - Morning Freeflow 0700-0900

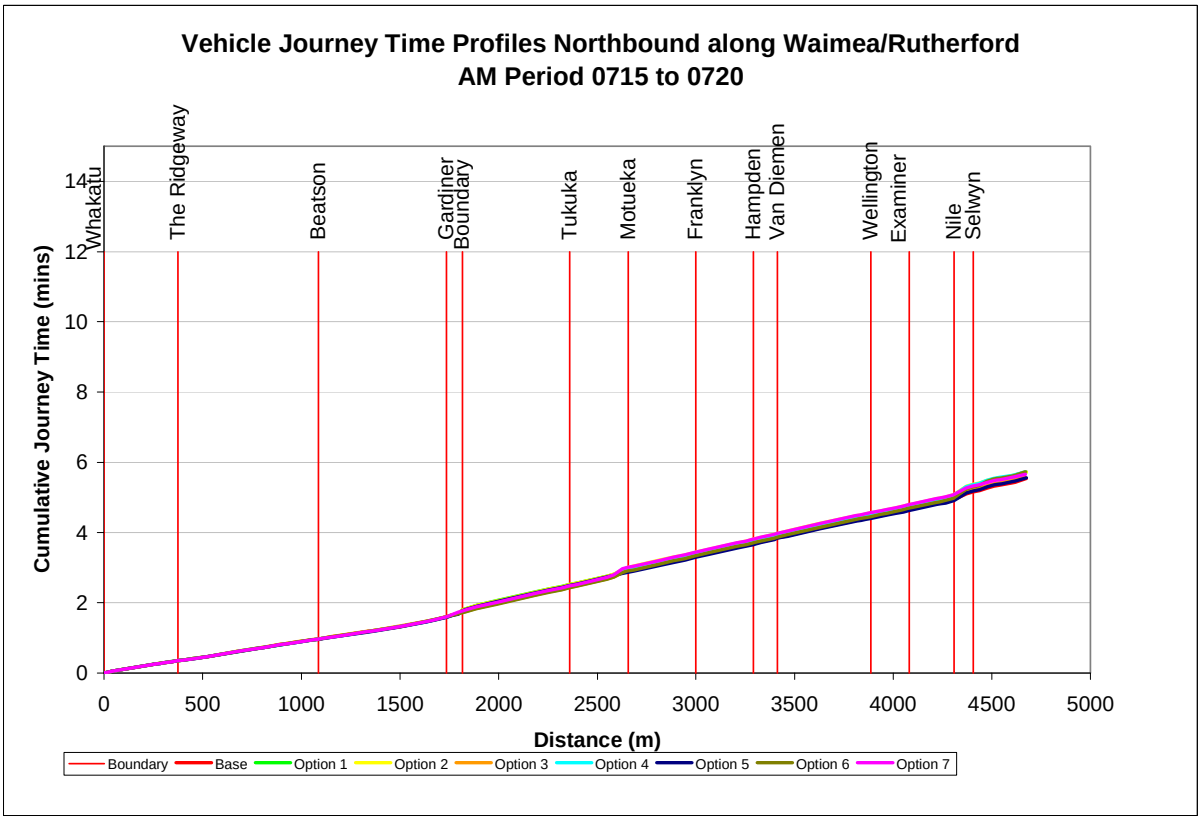

Figure 11 - Northbound Journey Travel Time - Morning FreeFlow 0715-0720

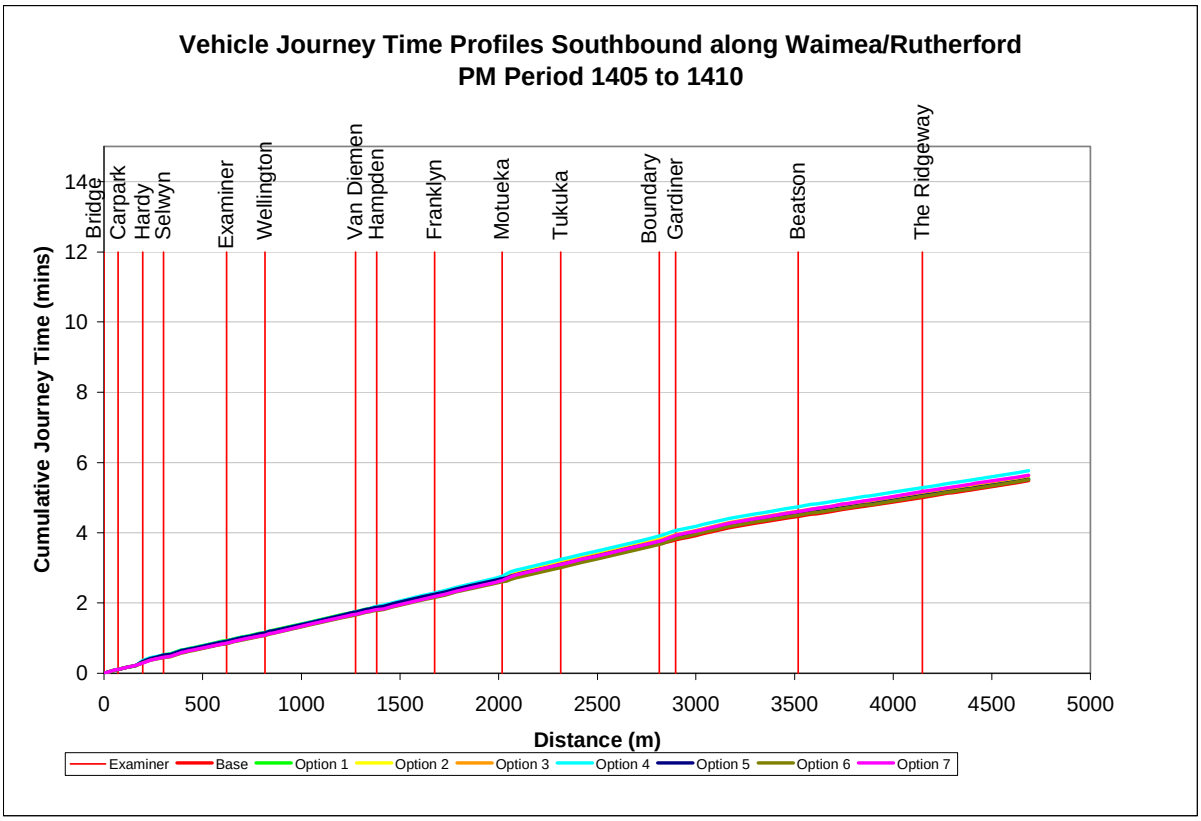

Figure 12 - Southbound Journey Travel Time - Evening FreeFlow 1405-1410

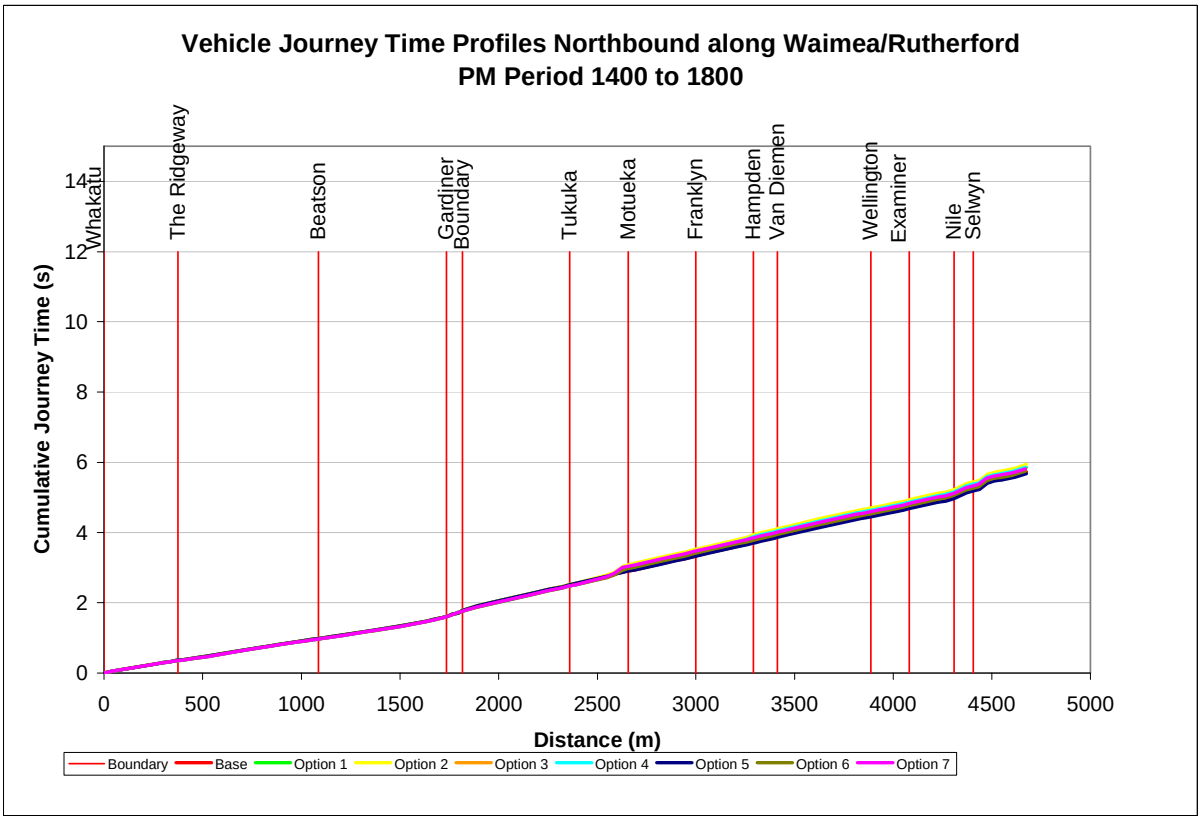

Figure 13 - Northbound Journey Travel Time - Evening FreeFlow 1400-1800

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Waimea Road
Nelson City Council

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1. Introduction

In August 2008 Nelson City Council commissioned baseplus to develop an S-Paramics microscopic simulation model and undertake option testing along the Rutherford Street/ Waimea Road corridor. Various signalised intersection designs were investigated and the following reports were developed:

- Waimea Road, Calibration Report, Issue No 2 (23 March 2009), baseplus
- Waimea Road, Options Report, Issue No 1 (23 March 2009), baseplus

In June 2009, NCC commissioned Aurecon, who acquired baseplus in April 2009, to undertake additional option testing, Phase B. This option testing included two signal variations, Options 8 and 9, and the evaluation of bus lanes.

This Option Assessment Report provides details of the development of the option models and compares the following analysis measures:

- Network Statistics
- Journey Times, all vehicles and buses
- Level of Service

The statistics are only compared with the base model outputs and not the other original options, as the original schemes are now considered superseded by the final preferred designs, Options 8 and 9. The original options have been superseded due to the intersection designs, particularly at Market Street, being changed by NCC from those used in the original modelled options.

2. Option Descriptions

The options analysed in this report are summarised below with further descriptions in the following sections:

- Option 8: Signals at Motueka/Waimea and signals at Market/Waimea
- Option 9: Signals at Motueka/Waimea, signals at Market/Waimea, removal of the signalised crossing north of Hampden
- Option 8 Evaluation Base: Option 8, plus the Phase A bus schedules
- Option 9 Evaluation Base: Option 9, plus the Phase A bus schedules
- Option 8 Bus Lanes: Option 8, plus the Phase A bus schedules, plus the priority bus lanes
- Option 9 Bus Lanes: Option 9, plus the Phase A bus schedules, plus the priority bus lanes

2.1 Signalised Intersection Designs

Option 8 and 9 includes the same intersection layouts at Motueka/Waimea, Market/Waimea and Hardy/Rutherford as shown in the following diagrams. Note the signal arrangements used in the Option Base models and the Option Evaluation Base models are the same, however, layout for the Bus Lane Options are modified to include bus priority lanes and signals.

Motueka/Waimea

Figure 1 shows the layout used for Options 8 and 9, Base and Evaluation Base. Figure 2 then shows the signal layout with the bus lanes operational at Motueka St. The option without bus lanes operates similar to that with the bus lanes, except the northbound left turn is a separate slip lane and the southbound left turn shares the outside through lane.

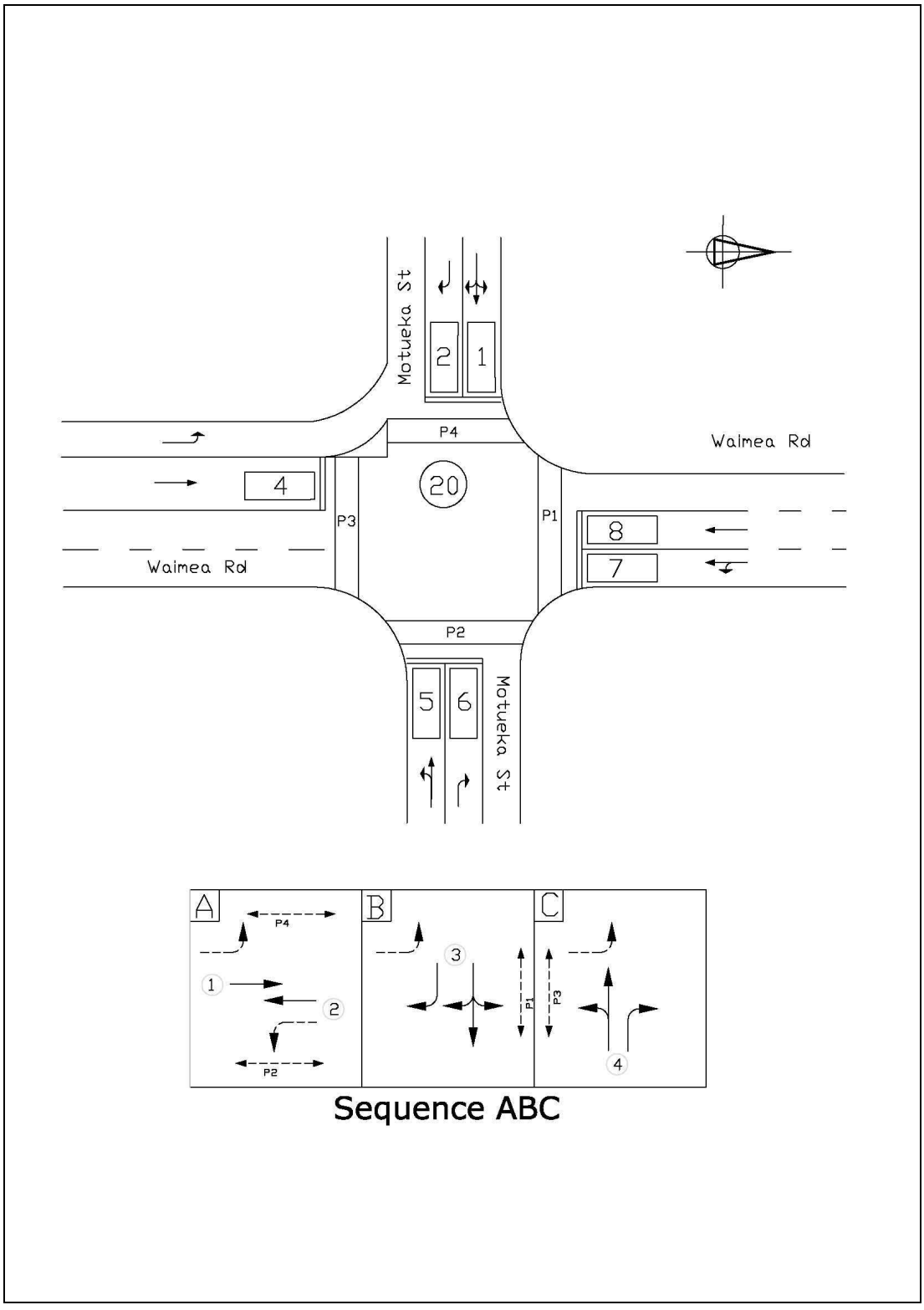

Figure 1 Motueka/Waimea Signalised Intersection without Bus Lanes

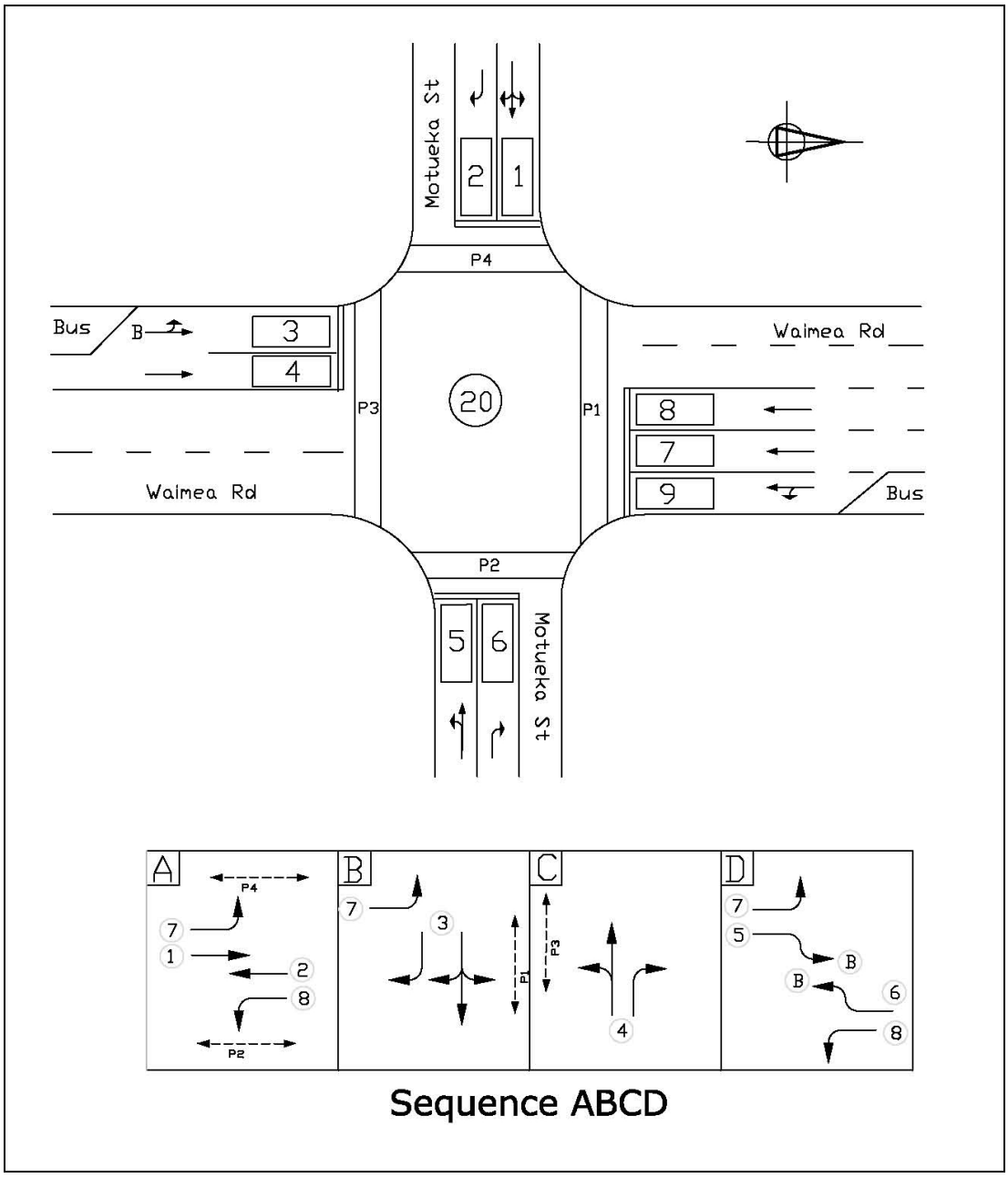

Figure 2 Motueka/Waimea Signalised Intersection with Bus Lanes

Market/Waimea

Figure 3 shows the layout used for Options 8 and 9, Base and Evaluation Base. Figure 4 then shows the signal layout with the bus lanes operational at Market St. The option without bus lanes operates similar to that with the bus lanes, except the northbound bus lane does not exist and the southbound left turn lane shares the outside through lane.

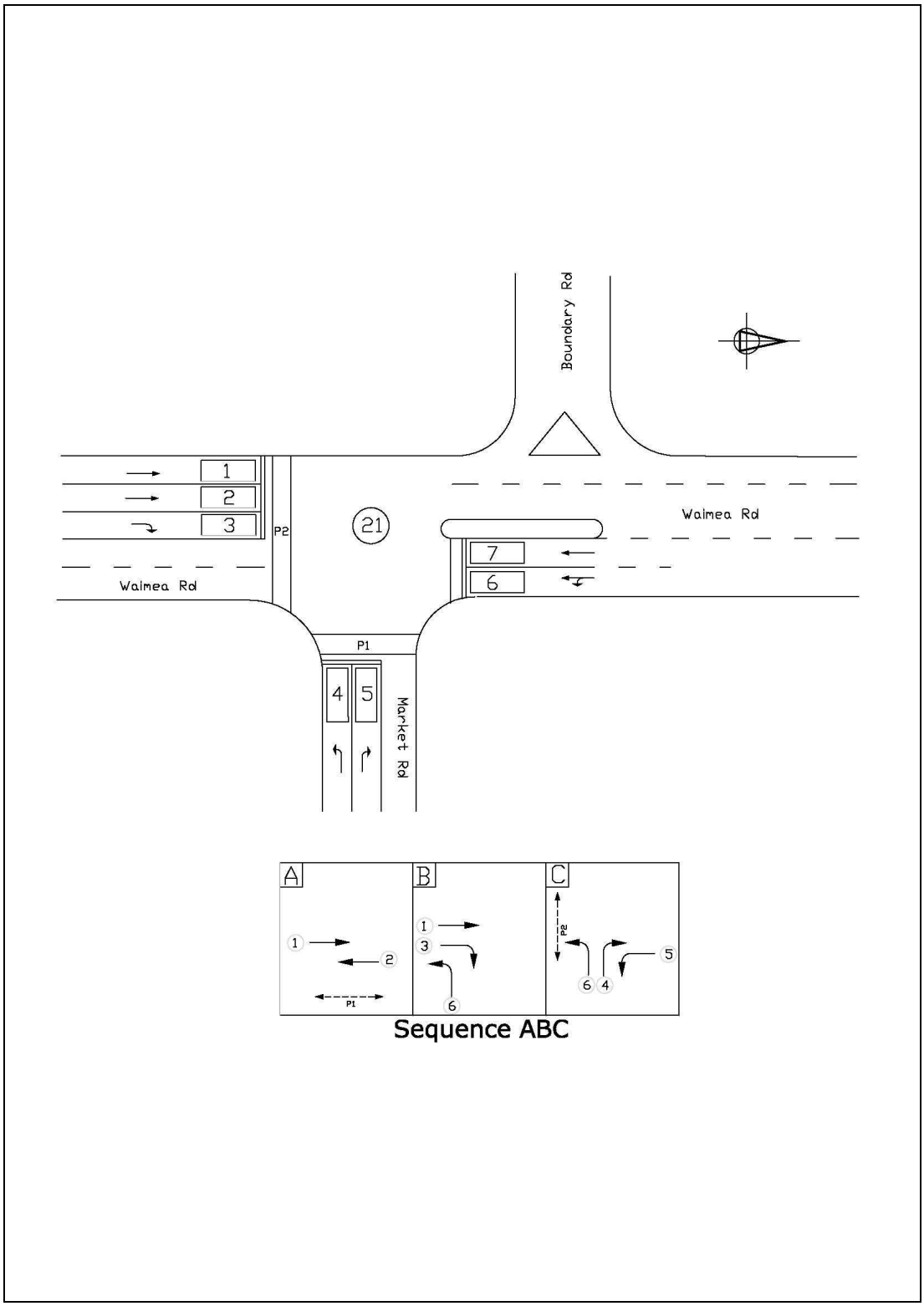

Figure 3 Market/Waimea Signalised Intersection without Bus Lanes

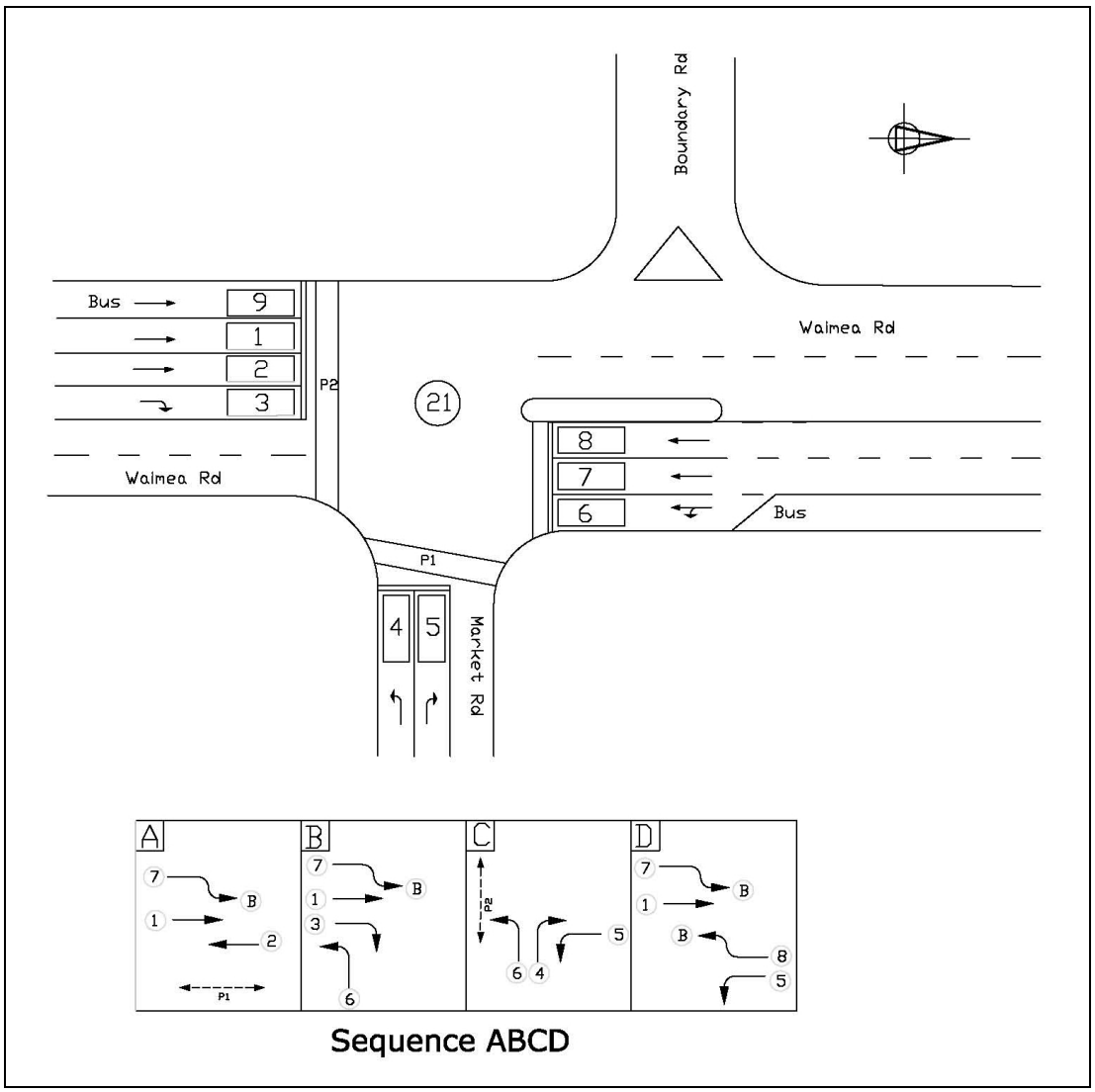

Figure 4 Market/Waimea Signalised Intersection with Bus Lanes

Hardy/Rutherford

Figure 5 shows the layout used for Options 8 and 9, Base and Evaluation Base. Figure 6 then shows the signal layout with the bus lanes operational at Hardy St. The option without bus lanes operates similar to that with the bus lanes, except the southbound direction operates with three lanes in the form of a left lane, through lane and a right turn lane.

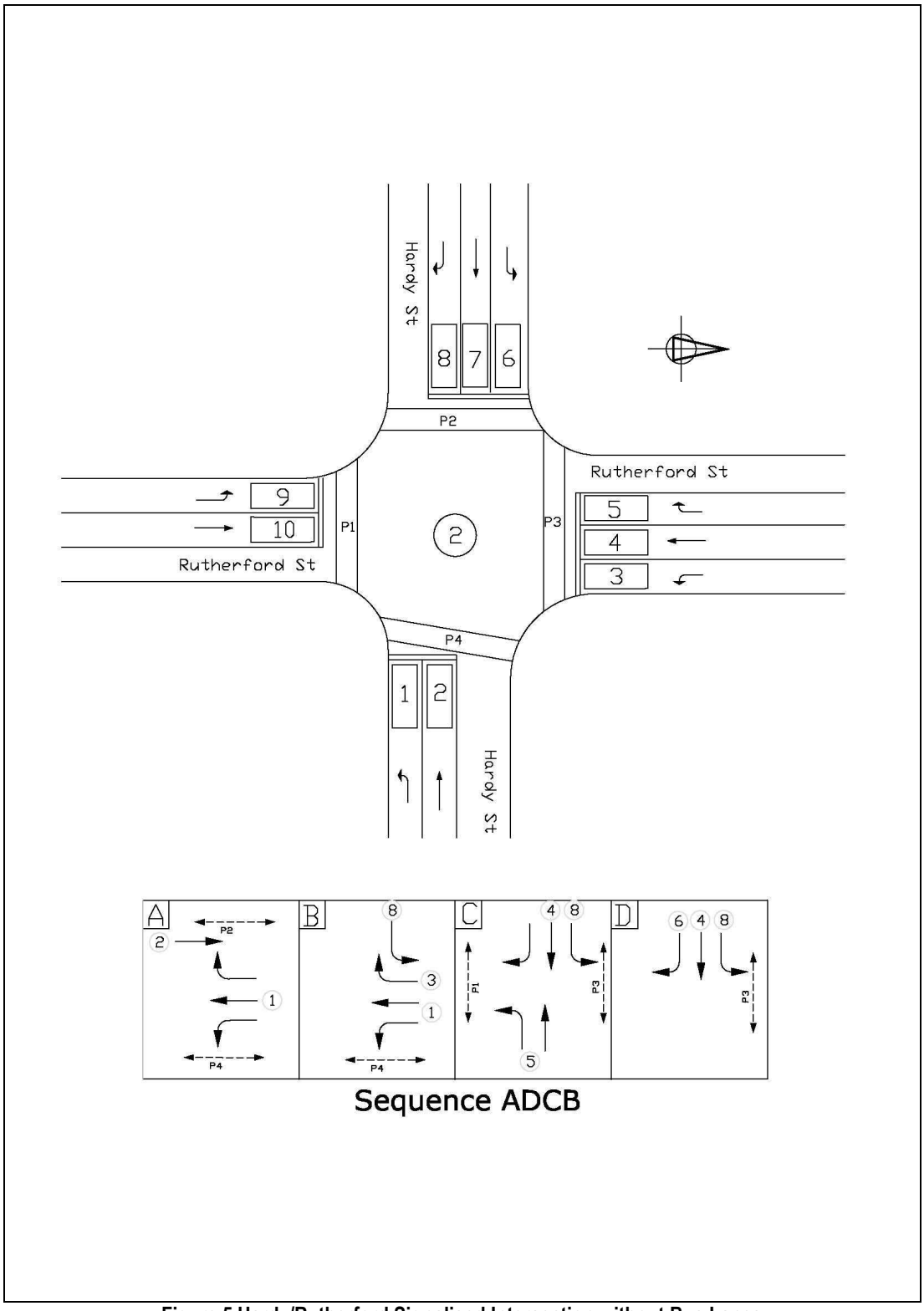

Figure 5 Hardy/Rutherford Signalised Intersection without Bus Lanes

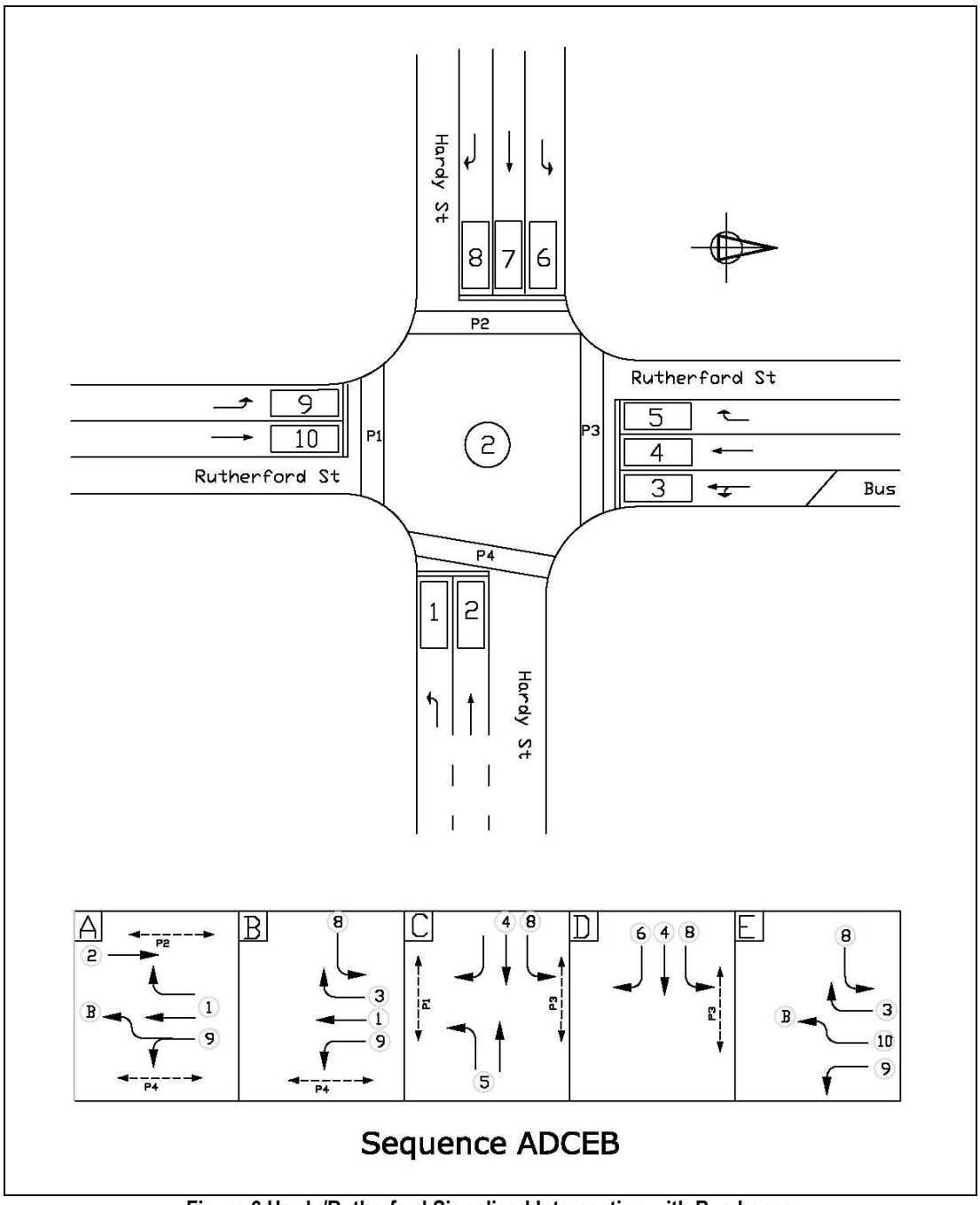

Figure 6 Hardy/Rutherford Signalised Intersection with Bus Lanes

2.2 Signalisation of Options 8 and 9

Base Option Description

Option 8 and 9 includes the same intersection layouts at Motueka/Waimea, Market/Waimea and Hardy/Rutherford as shown in the diagrams depicted in the previous section.

Base Option - Model Form Changes

Various changes have been made to the model to incorporate the new intersection layouts described above. Additional changes have also been made to the model to ensure correct lane utilisation and merge operation.

Base Option - Model Demand Changes

In the signalised options vehicles cannot turn right from Boundary St. It is therefore assumed that these vehicles will reroute to use Motueka St. This assumption was made in consultation with NCC, who suggested Tukuku St would be too difficult to turn right from and hence all vehicles would likely reroute to Motueka.

Since route choice is not available between Boundary Road and Motueka St, the demand matrices have been manually modified to include this rerouting.

2.3 Evaluation Options

Evaluation Option Description

The Evaluation Options have been developed so that the true benefit/cost of applying the bus priority lanes can be assessed.

The Evaluation Options include the same intersection layouts as those in the Base Option models.

The Evaluation Options include the Phase B bus schemes, as described below and illustrated in the following figure:

- One express bus route northbound (Pink in diagram)
- One express bus route southbound (Red in diagram)
- One secondary bus route northbound and southbound (Blue in diagram)

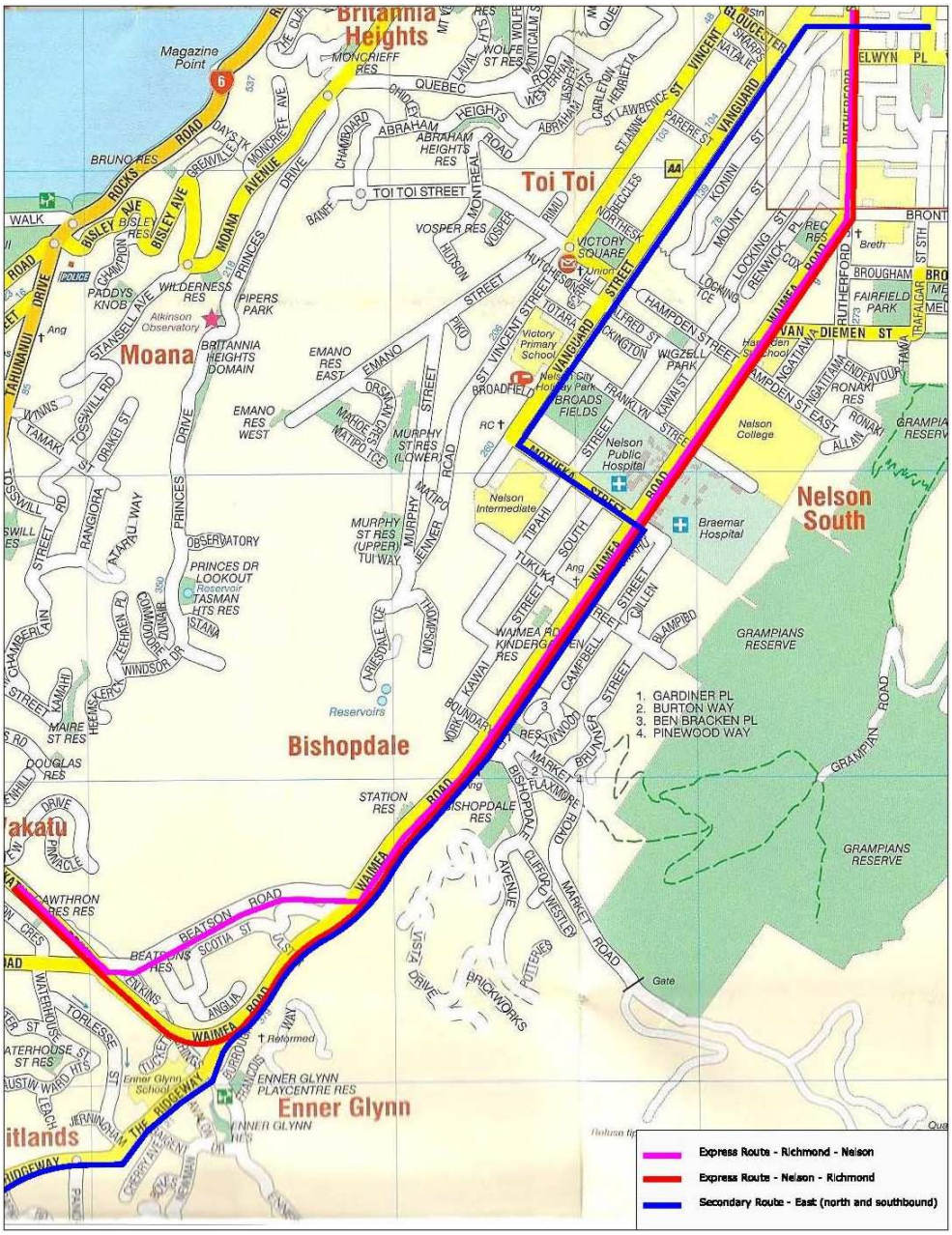

Figure 7 Hardy/Rutherford Signalised Intersection

As shown in the figure, the express northbound route goes through Beatson Road. The bus priority through Beatson Road is provided by the installation of a bus gate (two rising bollards) at the beginning of Beatson Road just off the Whakatu Roundabout. The bus gate will only operate during the morning peak, during which time visitors to local residents will have to access property via Ulster Street or the northern end of Beatson Road. The existing speed bumps along Beatson Road will be removed.

Evaluation Option - Model Form Changes

To replicate the Phase A bus scheme in the model a number of model changes have been required.

A restriction has been applied to the Beatson Road entrance link off Whakatu roundabout, to only allow buses and vehicles travelling to this area (zone 120) to use this entrance link. This is based on the assumption that all traffic going to the area off Beatson Ave (zone 120) in the morning peak are residents, hence no rerouting of vehicles via Ulster Street or the northern entrance is required.

To enable this restriction, a second matrix has been created in the model, which only includes the vehicles to zone 120. This second matrix only applies to vehicle type 9, which is an additional vehicle type created for traffic going to zone 120. Hence it is only vehicle type 9 to which the restriction along Beatson Road, as described above, applies.

To reflect the speed bumps being taken out of Beatson Ave, the links along Beatson Road are increased from 25kph to a 45kph category in the model. However, analysis of the results show that, although the AM restriction stops vehicles using the southern entrance to Beaston Ave during the AM peak, in other direction in the AM peak and in both directions in the PM peak, vehicles do choose to use Beatson Ave as a cut through. This effect is discussed further in the analysis section of this report.

However, it is assumed that appropriate measures will be put in place to stop this rerouting. Hence the model has been developed on the assumption Beatson Ave will not be used as a cut through. To do this the links along Beatson have remained at 25kph as opposed to increasing to 45kph.

Evaluation Option - Model Demand Changes

No demand changes have been made to the general traffic, with the exception of separating the demand matrix into vehicle types. However, the bus schedules have been updated to reflect the Phase A bus scheme, as detailed in the following table.

Bus Route	Schedule
Express Route - Richmond to Nelson	From 0630 to 1830 - Every 30 mins from Richmond From 1830 to 2330 – Every 60 mins from Richmond
Express Route - Nelson to Richmond	From 0630 to 1830 - Every 30 mins from Nelson From 1830 to 2330 – Every 60 mins from Nelson
Secondary Route East- Richmond to Nelson	From 0630 to 1830 - Every 30 mins from Richmond From 1830 to 2330 – Every 60 mins from Richmond
Secondary Route East- Nelson to Richmond	From 0630 to 1830 - Every 30 mins from Nelson From 1830 to 2330 – Every 60 mins from Nelson

Table 1 Phase A Bus Timetables

Note the bus schedule information suggests that these routes in addition to a third route along the corridor to the West, will result in a combined frequency of one bus every 10 minutes. It is therefore assumed that the Express and Secondary bus route timetables will be staggered and hence in the model the express bus is scheduled to leave 10 minutes after the secondary bus.
Both routes use the same stop locations and times as applied in the base models.

2.4 Bus Lane Options

Evaluation Option Description

The location and length of bus lanes is based on scheme design information and consultation from NCC. The location of the bus lanes are summarised below:

- Northbound:
  - From Beatson to Boundary
  - From Tukuku to Motueka

- Southbound:
  - From Montgomery Carpark to Hardy
  - From Selwyn to Bronte
  - From opposite Hospital Entrance to Motueka
  - From half way between Tukuku/Boundary to Market

In conjunction with these bus lanes, early starts have been provided for buses at the following signalised intersection locations:

- Southbound at Hardy
- Southbound and northbound at Motueka
- Southbound and northbound at Market

At all locations where the bus lane extends up to an intersection approach, the lane configuration allows left turn vehicles to enter the bus lane.

Evaluation Option - Model Form Changes

To replicate the bus lanes in the model additional network changes have been included.

At the signalised intersections where early starts have been applied to buses, the approach links have been split, to allow the bus priority signals to be mapped as separate movements for Wintraff.

Additional detectors were also applied at these locations. These detectors however, cannot distinguish between left turning cars and buses in the buslane. Hence, the signals provide an early start regardless of the vehicle type in the 'bus lane'. To minimise this affect, the detectors have been placed back from the stop line so that only stopped buses at the stopline or more than one car will activate the detector.

To ensure only left turning vehicles use the bus lanes at the approaches and not general vehicle through movements, restrictions have been applied to the model. These restrictions only allow buses and vehicle type 10 to use the combined bus/left turn lanes. To enable these restrictions, a third matrix has been created in the model, which includes the vehicle demands to zones 104, 113, 115 120 124 and this matrix is only applied to vehicle type 10.

NCC also requested that the location of the following stops be amended:

- A new northbound bus stop is located just south of Market/Waimea intersection
- The southbound bus stop has been relocated from 50m north of Tutkuka to 260m south of Tukuka.

Evaluation Option - Model Demand Changes

No demand changes have been made to the general traffic, with the exception of separating the demand matrix as described previously.

3. Option Analysis

3.1 Network Statistics

The overall network statistics are calculated for "All Vehicles" during the full model period, which includes analysis of the following statistics:

- Mean Delay
- Total Distance
- Total Number of Vehicles
- Mean Speed
- Total Network Travel time

The full analysis results has been completed for each above mentioned statistic however only the Network Average Travel Time is presented in this report as shown below. The figures show the range of the total average travel time over five model runs, by presenting the minimum, maximum and average values.

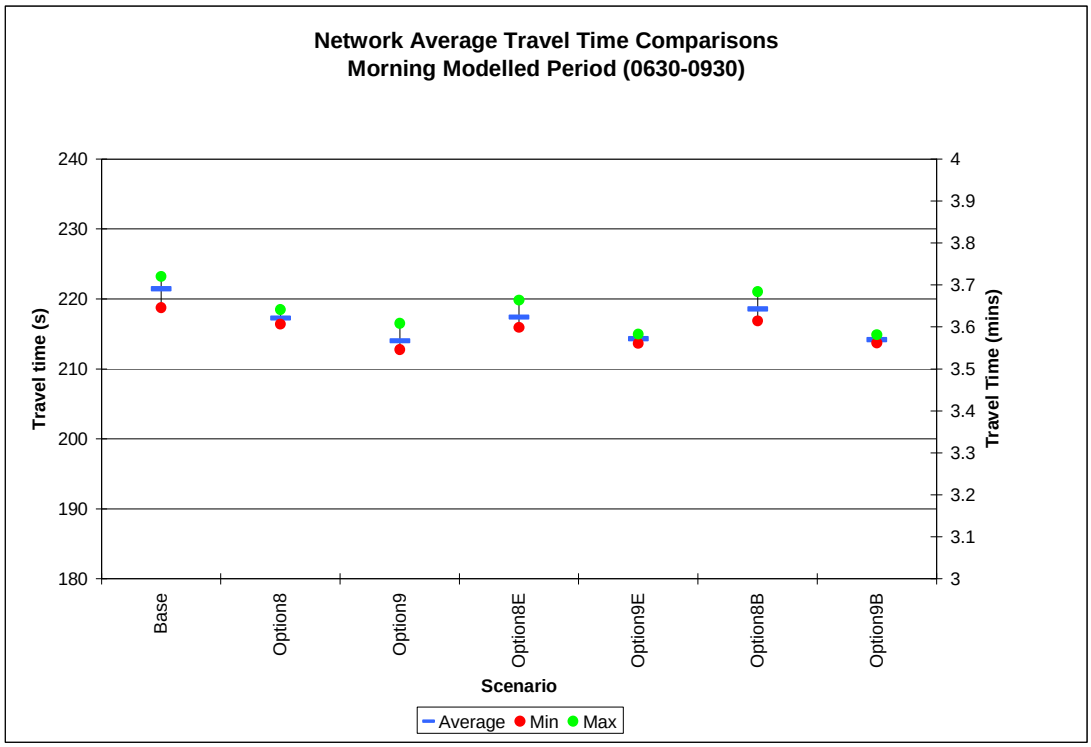

Figure 8 AM Model Network Average Travel Time Summary

The above figure shows Option 8 and 9 reduce the average network travel time by 2% and 3%, respectively. Furthermore, the overall network operates similar in the Evaluation Base and Bus models compared to their respective Base Option models.

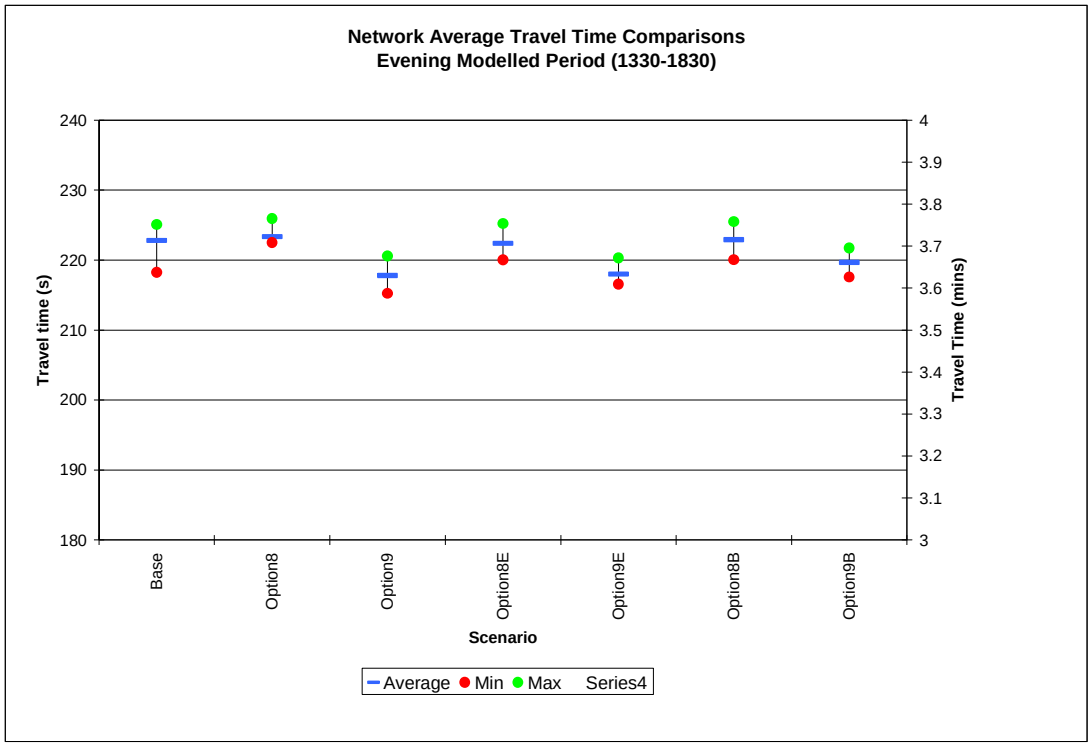

Figure 9 PM Model Network Average Travel Time Summary

The above figure shows Option 8 operates similar to the base and Option 9 reduces the average network travel time by 2%. Furthermore, the overall network operates similar in the Evaluation Base and Bus models compared to their respective Base Option models.

3.2 Journey Times

3.2.1 Option Assessment

General Vehicle Journey Time Comparison

To assess the benefit of signalising the intersections in Option 8 and Option 9, the travel time northbound and south bound have been compared to the base model for each modelled period, for the two routes used during calibration defined as follows:

- Waimea Rd/Rutherford St northbound from Whakatu Drive to Bridge Street
- Waimea Rd/Rutherford St southbound from Bridge Street to Whakatu Drive

Analysis has shown that various options do not make any difference to the journey time during off peak periods. Hence this report only shows comparison during the peak period and direction, defined as follows:

- AM Peak - Northbound 0840 (9am peak)
- PM Peak – Southbound 1520 (3pm peak)and 1710 (5pm peak)

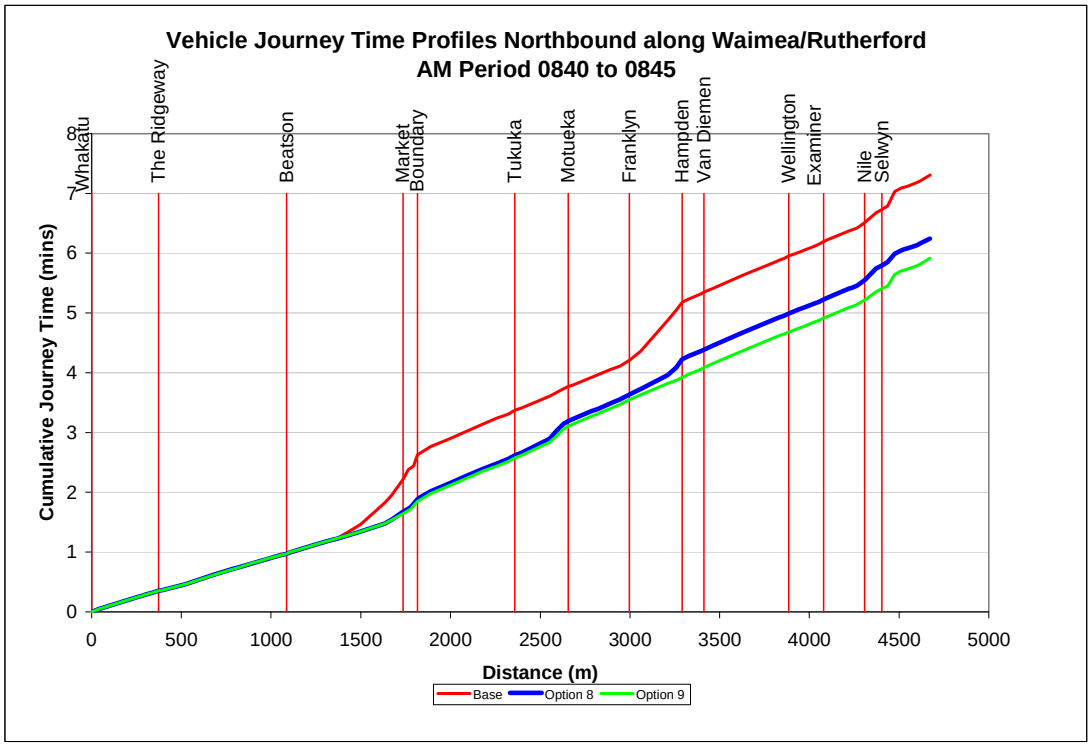

Figure 10 Northbound Journey Travel Time 0840-0845 – All Vehicles

The above graph shows Option 8 and 9 both reduce the northbound travel time compared to the base model, during the 9 am peak.

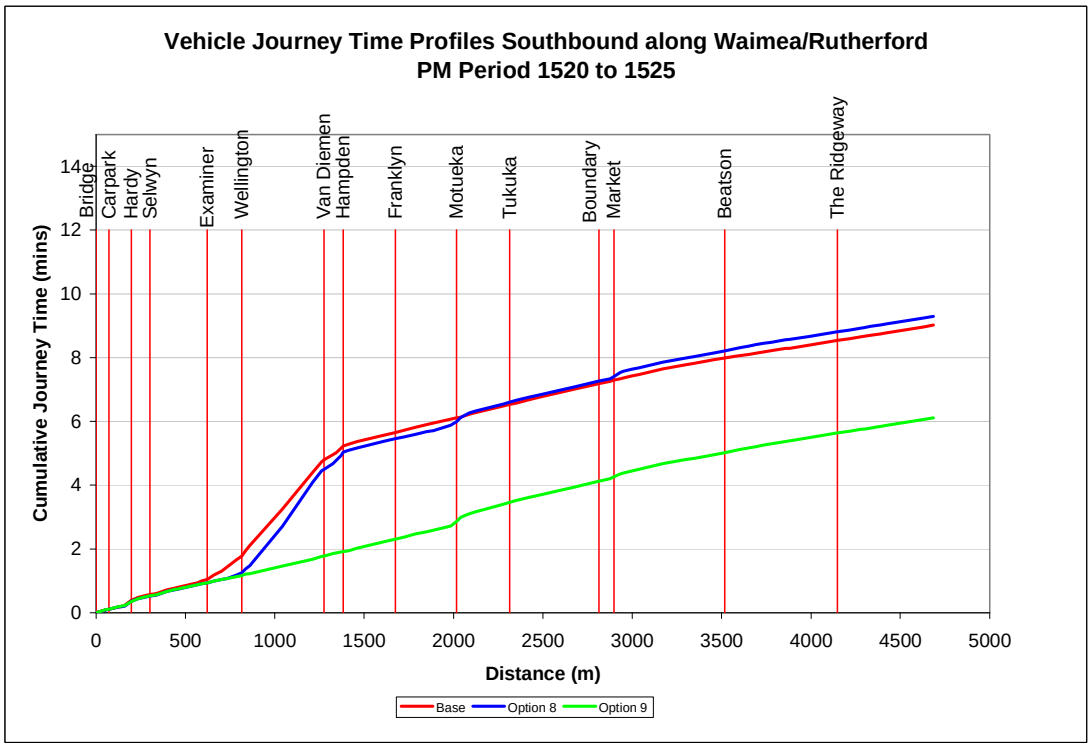

Figure 11 Southbound Journey Travel Time 1520-1525 – All Vehicles

The above graph shows the southbound travel time in Option 8 is similar to the bus, during the 3pm peak. Option 9 however, has no pedestrian crossing signals north of Hardy, and hence reduces the journey time by approximately three minutes.

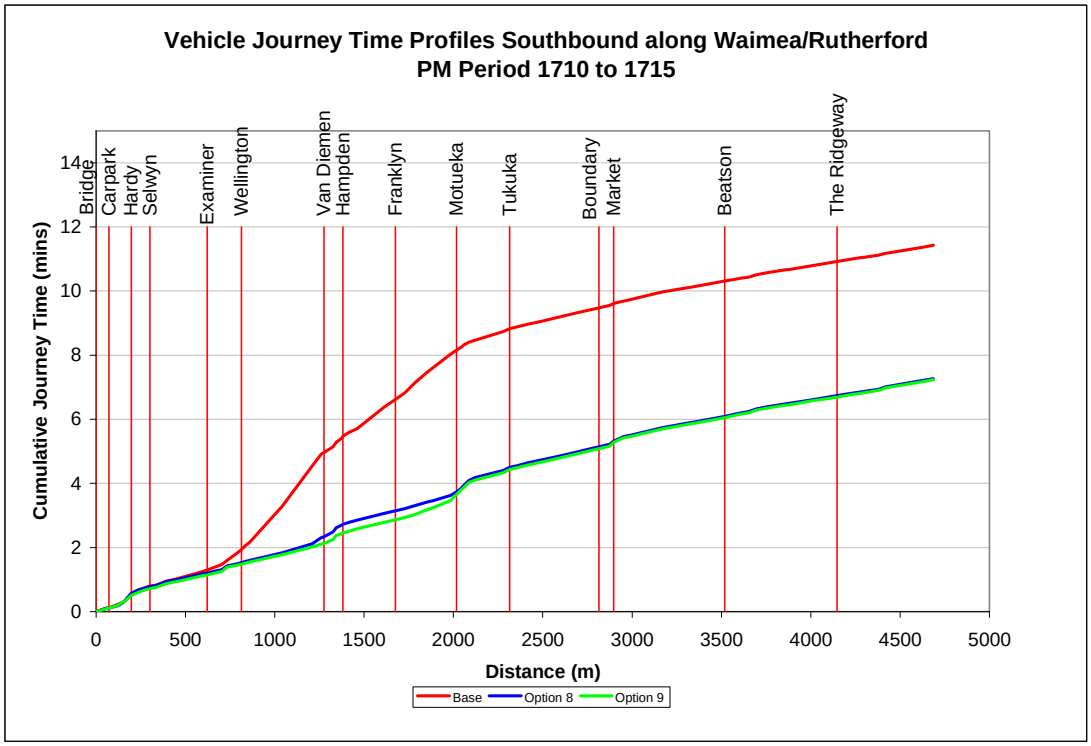

Figure 12 Southbound Journey Travel Time 1710-1715 – All Vehicles

The above graph shows Option 8 and 9 both reduce the southbound travel time compared to the base model, during the 5pm peak, by approximately 4 minutes.

Overall it is concluded that Option 8 provides journey time benefits to all vehicles, but only during the peak periods, in particular during the 9am peak in the northbound direction and around 5pm in the southbound direction. The removal of the pedestrian signals, Option 9, provides no additional benefit to the journey times compared to Option 8, except during the 3 pm peak, which on site exists between the period of 3:00 and 3:25.

Bus Journey Time Comparison

To assess the benefit of the bus lanes the bus travel time has been compared between the buslane models and evaluation base models, along the Express Bus Route, during the peak period and direction, defined as follows:

- AM Peak - Northbound 0840 (9am peak)
- PM Peak – Southbound 1520 (3pm peak)and 1710 (5pm peak)

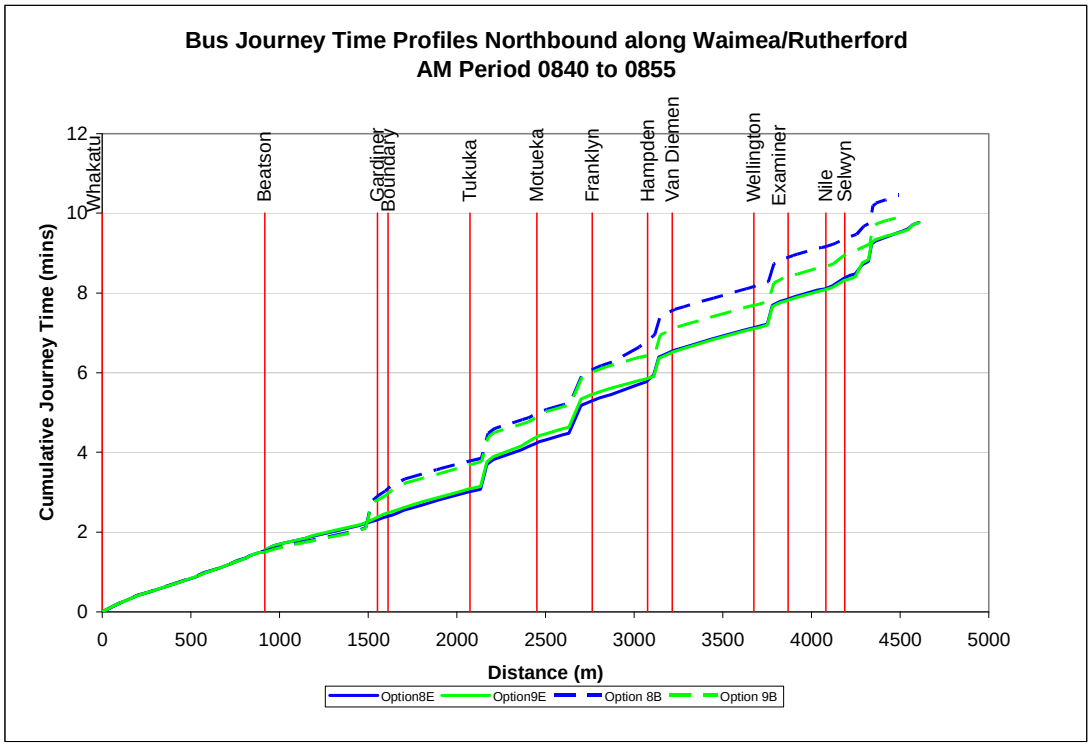

Figure 13 Northbound Journey Travel Time 0840-0855 – Buses

The above graph shows the buslanes options, Option 8B and 9B, both result in a slight increase in the bus journey times during the 9am peak. However, this increase is due to the additional bus stop proposed at Boundary Road as part of the bus lane schemes.

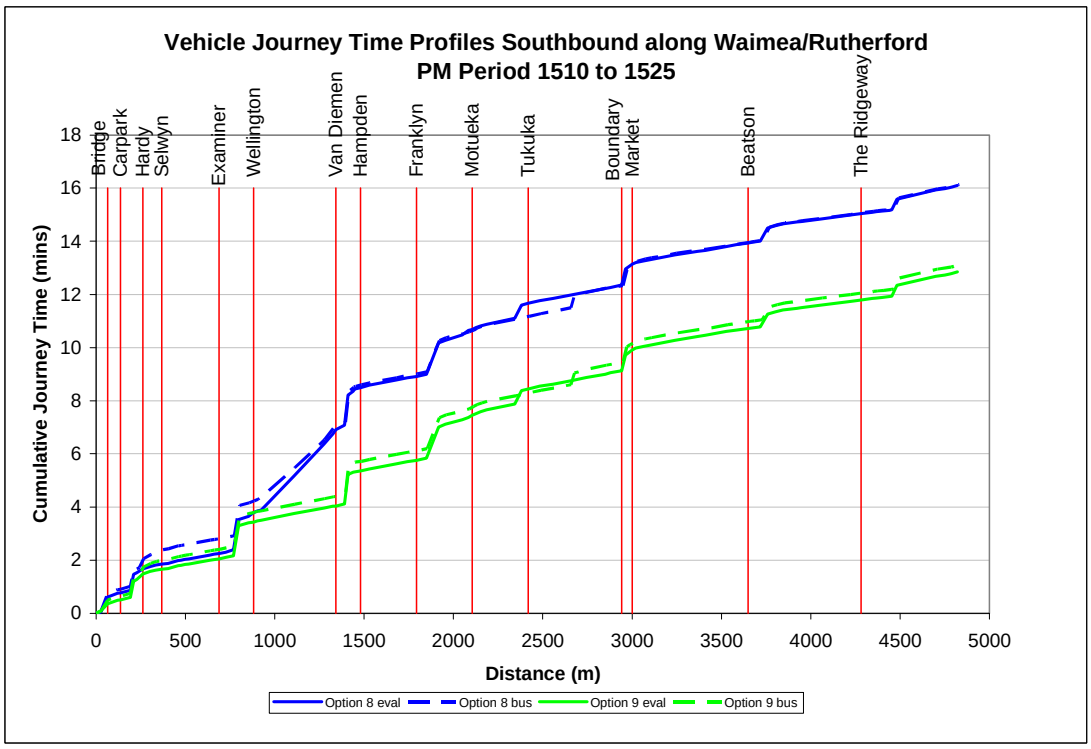

Figure 14 Southbound Journey Travel Time 1510-1525 – Buses

The above graph shows the buslanes options, Option 8B and 9B, both result in similar bus journey times to the respective evaluation base during the 3pm peak. The only difference in the graphs is at Tukuku, where the bus stop originally near Tukuku is shifted further south, between Tukuku and Boundary, in conjunction with the buslane options.

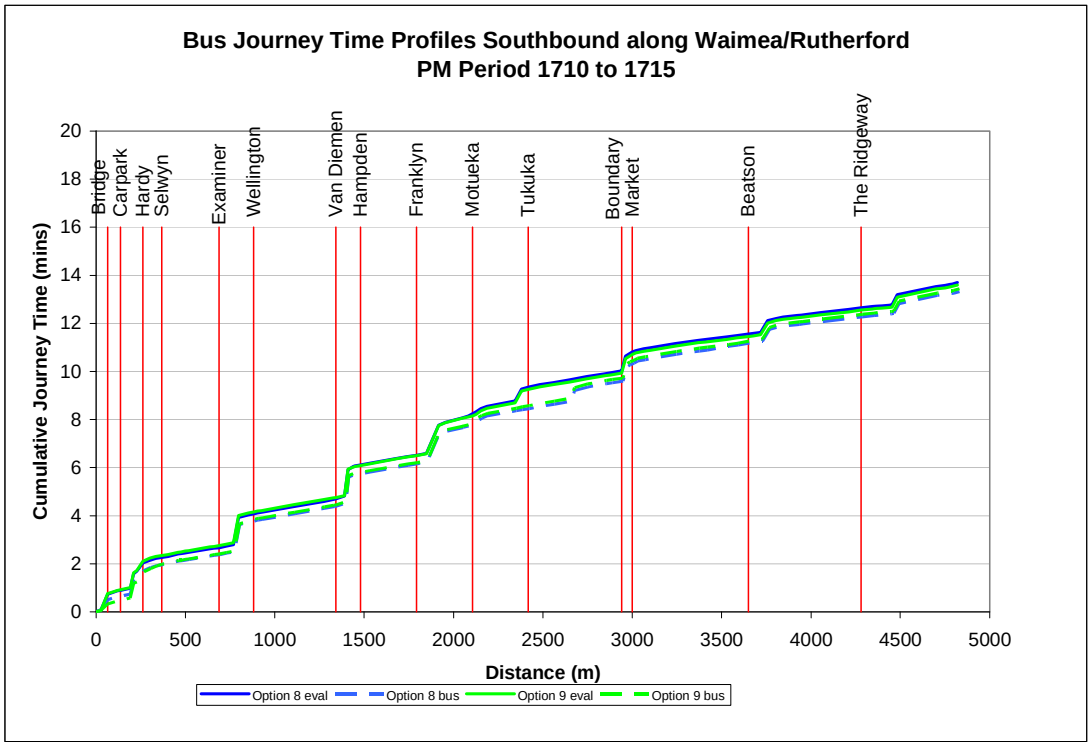

Figure 15 Southbound Journey Travel Time 1710-1715 – All Vehicles

The above graph shows the buslanes options, Option 8B and 9B, both result in similar bus journey times to the evaluation base during the 5pm peak. The only difference in the graphs is at Tukuku, where the bus stop originally near Tukuku is shifted further south, between Tukuku and Boundary, in conjunction with the buslane options.

3.3 Level of Service

3.3.1 Option Assessment

Estimates of level of service (LOS) have been made for the peak hour for the base, option and bus models, for each movement, approach and intersection. The LOS criteria used is detailed below:

LOS	Average Delay (s)
A	<10
B	10 to 20
C	20 to 35
D	35 to 55
E	55 to 80
F	> 80

Table 2 Level of Service Criteria (Highway Capacity Manual)

Summary tables are shown on the following pages detailing the Volume, Delay and LOS for the movements at Waimea/Motueka intersection and Waimea/Boundary/Market intersections. Waimea/Van Dieman intersection has also been included in the evening peak to show the effects of the proposals further north along the corridor.

3.3.2 Morning Peak

Movement			Vol	Base		Vol	Option 8		Option 9		Option 8B		Option 9B	
				Delay	LOS		Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
Motueka/Waimea	Waimea North	l	9	3	A	8	6	A	8	A		A		A
		s	706	2	A	707	8	A	7	A	9	A	7	A
	Motueka East	l	15	7	A	16	25	B	26	C	28	C	27	C
		r	58	51	D	56	28	C	26	C	30	C	29	C
	Waimea South	l	312	4	A	310	10	A	11	B	12	B	8	A
		s	1092	3	A	1097	16	B	16	B	19	B	16	B
		r	17	8	A									
	Motueka West	l	24	42	D	24	22	B	24	B	29	C	26	C
		r	135	42	D	155	25	B	25	B	29	C	28	C
Intersection Results				7	A		14	B	14	B	16	B	14	B
Market/Wain	Waimea North	s			A	759	9	A	7	A	10	A	9	A
	Market East	l	118	5	A	117	12	B	12	B	12	B	13	B
		r	111	6	A	112	19	B	18	B	19	B	19	B
	Waimea South	s			A	707	6	A	6	A	7	A	6	A
		r	55	30	C	54	11	B	10	B	12	B	11	B
Intersection Results							8	A	8	A	9	A	8	A

Table 3 Level of Service 0800-0900

At Waimea/Motueka the results show

- Options 8 and 9 both show:
  - Waimea north approach LOS is retained at LOS A.
  - Motueka east approach reduces the LOS for the left turn form A to B or C, but improves the LOS for the right turn from D to C.
  - Waimea south approach LOS reduces from LOS A to B.
  - Motueka west approach improves in LOS from D to B.
- The bus lane options, Options 8B and 9B, show similar results to the base Options 8 and 9, respectively. At Motueka west approach the LOS increases from B to C, however looking at the delay values, the increase is only slight; up to 4 seconds. This shows the implementation of bus lanes does not significantly affect the LOS operation for general vehicles.

At Waimea/Market the results show

- Options 8 and 9 both show:

- Market East approach increase in LOS from A to B
- Waimea north and south through movements retain a LOS of A
- Waimea south right turn movement improves in LOS from C to B

- The bus lane options Options 8B and 9B show similar results to the base Options 8 and 9, respectively.

3.3.3 Evening Peak

Movement			Vol	Base		Vol	Option 8		Option 9		Option 8B		Option 9B	
				Delay	LOS		Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
Motueka/Waimea	Waimea North	l	17	44	D	17	16	B	20	B		A		A
		s	1235	47	D	1241	18	B	23	B	24	B	19	B
	Motueka East	l	30	106	F	29	33	C	34	C	35	C	29	C
		r	31	129	F	31	29	C	32	C	29	C	30	C
	Waimea South	l	326	4	A	325	4	A	4	A	5	A	5	A
		s	790	4	A	793	14	B	14	B	15	B	15	B
		r	4	31	C									
	Motueka West	l	29	67	E	30	27	C	37	C	34	C	35	C
		r	321	96	F	506	36	C	42	C	42	C	40	C
Intersection Results				37	D		20	B	23	B	22	B	21	B
Market/Waim	Waimea North	s			A	1661	9	A	8	A	10	B	10	A
	Market East	l	121	24	C	122	18	B	20	B	18	B	20	B
		r	60	13	B	59	26	C	26	C	25	C	28	C
	Waimea South	s				572	4	A	4	A	5	A	5	A
		r	75	12	B	75	18	B	23	B	22	B	21	B
Intersection Results							8	A	9	A	9	A	9	A
VanDieman/Wai	Waimea North	l	16	62	E	15	16	B	11	B	16	B	12	B
		s	912	49	D	913	11	B	6	A	9	A	6	A
	VanDieman Eas	l	372	78	E	375	23	B	14	B	18	B	12	B
		r	6	89	F	5	31	C	35	C	38	C	28	C
	Waimea South	s	696	2	A	698	2	A	1	A	2	A	1	A
		r	253	24	C	252	15	B	11	B	15	B	12	B
Intersection Results				37	D	2258	11	B	7	A	9	A	6	A

Table 4 Level of Service 1630-1730

At **Waimea/Motueka** the results show

- Options 8 and 9 both show:
  - Waimea north approach LOS improves from D to B.
  - Motueka east approach LOS improves from F to C.
  - Waimea south approach LOS decreases from LOS A to B for the through movement.
  - Motueka west approach improves in LOS from E/F to C, even given the turning movement volume increases form 321vph to 509vph, due to reassignment of right turners from Boundary Road.
- The bus lane options Options 8B and 9B show similar results to the base Options 8 and 9, respectively. This shows the implementation of bus lanes does not significantly affect the LOS operation for general vehicles.

At **Waimea/Market** the results show

- Options 8 and 9 both show:
  - Market east approach improves the LOS for the left turn from C to B , but decreases it for the right turn from B to C
  - Waimea north and south through movements retain a LOS of A
  - Waimea south right turn movement remains at LOS B
- The bus lane options Options 8B and 9B show similar results to the base Options 8 and 9, respectively.

At **Waimea/Van Diemen** the results show

- Option 8 shows the LOS improves throughout the intersection, with overall levels imporveing from LOS D to B
- Option 9 shows the LOS further improves with the removal of the signalised pedestrian crossing, with overall levels improving to LOS A
- The bus lane option Option 8B, shows a slight further improvement, to the base Option 8, resulting in LOS A.
- The bus lane option Option 9B, shows similar results to base Option 9, retaining a LOS A.

In addition to the above results, the results at **Whakatu/Waimea** and **Ridgeway/Waimea** have also been observed during the PM peak:

- At Whakatu/Waimea it was observed that the queuing north and west at Whakatu/Waimea roundabout is longer in the option models than the base during the PM peak. This is likely a result of improved efficiency through the network and the vehicles to the Waimea south approach now arriving in platoons from the signals at Market St. The client should be made aware of this potential disbenefit, however, the impact is not expected to be significant.
- At Ridgeway/Waimea it was observed that queuing along Ridgeway is decreased in the option models compared to the base during the PM peak. This is a result of vehicles exiting from the Market/Waimea signals in platoons, allowing vehicles turning right from Ridgeway to more easily find appropriate gaps in the southbound traffic.

3.4 Rerouting Along Beatson Avenue

To reflect the speed bumps being taken out of Beatson Ave, the links along Beatson Road were increased from 25kph to 45kph category within the model. However, analysis showed that up to 50% of vehicles may re route along Beaston Ave when the road category is modified and there are no restrictions, such as bollard in place.

For the purpose of bus lane assessment, it is assumed that appropriate measures will be put in place to stop this rerouting. Hence the model has been developed on the assumption Beatson Ave will not be used as a cut through. To do this the links along Beatson have remained at 25kph as opposed to increasing to 45kph.

However, the potential for re routing should be noted. The resulting rerouting proportions are not highly accurate given the level of calibration given to rerouting in the base model. On site observations suggested shortcutting through Beatson Ave is minimual and hence the links along Beatson Ave in the base model have been coded to reflect no rat running along Beatson Ave. However, sensitivity of rerouting along Beatson has not been undertaken and hence the proportion of rerouting is only indicative.

4. Summary and Conclusions

Two signalised options have been analysed for the Waimea Road corridor:

- Option 8: Signals at Motueka/Waimea and signals at Market/Waimea
- Option 9: Signals at Motueka/Waimea, signals at Market/Waimea, removal of the signalised crossing north of Hampden

Both models have been analysed for the AM and PM peak periods, within which three specific peak intervals are evident, which within this report have been referred to as the 9am, 3pm and 5pm peaks.

Option 8 shows that the implementation of signals at these intersections will result in overall network improvement, with particular improvement for the northbound journey time in the 9am peak and southbound journey times in the 5pm peak.

Option 9 shows similar improvement to the Option 8 scenario, but with additional journey time benefits to southbound vehicles during the 3pm peak.

Evaluation base models, Option 8E and 9E, were created to allow assessment of the proposed bus lanes, Option 8B and 9B. The assessment showed that there were minimal improvements to the bus journey times with the addition of the bus lanes. This is due to the Options in themselves significantly reducing the congestion and hence the expected potential benefit of the bus lanes on the existing corridor is no longer gained. Furthermore, the current bus timetable only includes one bus per half hour along the main corridor (the Express Route) and hence any total bus journey time savings that could be gained would be minimal overall given the low frequency of buses.

Modelling also suggested that there is potential for vehicles to reroute along Beatson Ave when the speed bumps are removed and no bollards are in place. It is recommended that this potential result should be monitored on site and a contingency plan be developed to eliminate this occurrence if it develops.