Wearne, Julian

From: Troy O'Sullivan (PTV) <Troy.OSullivan@ptv.vic.gov.au>
Sent: Friday, 5 April 2019 1:33 PM
To: Wearne, Julian
Cc: Malcolm Strachan (PTV); Julian Brignell (PTV)
Subject: Route 96 - PTV response to Yarra Council motion (2 April 2019)
Attachments: CA1_TF_04426.txt; Nicholson Street Traffic Modelling Report RevC (Final).pdf; 02042019161450-0001.pdf

Hi Julian,

Further to Yarra Council 'motion' passed on 2 April for the Route 96 project, please find supporting information relating to the motion and VicRoads letter dated 1 April.

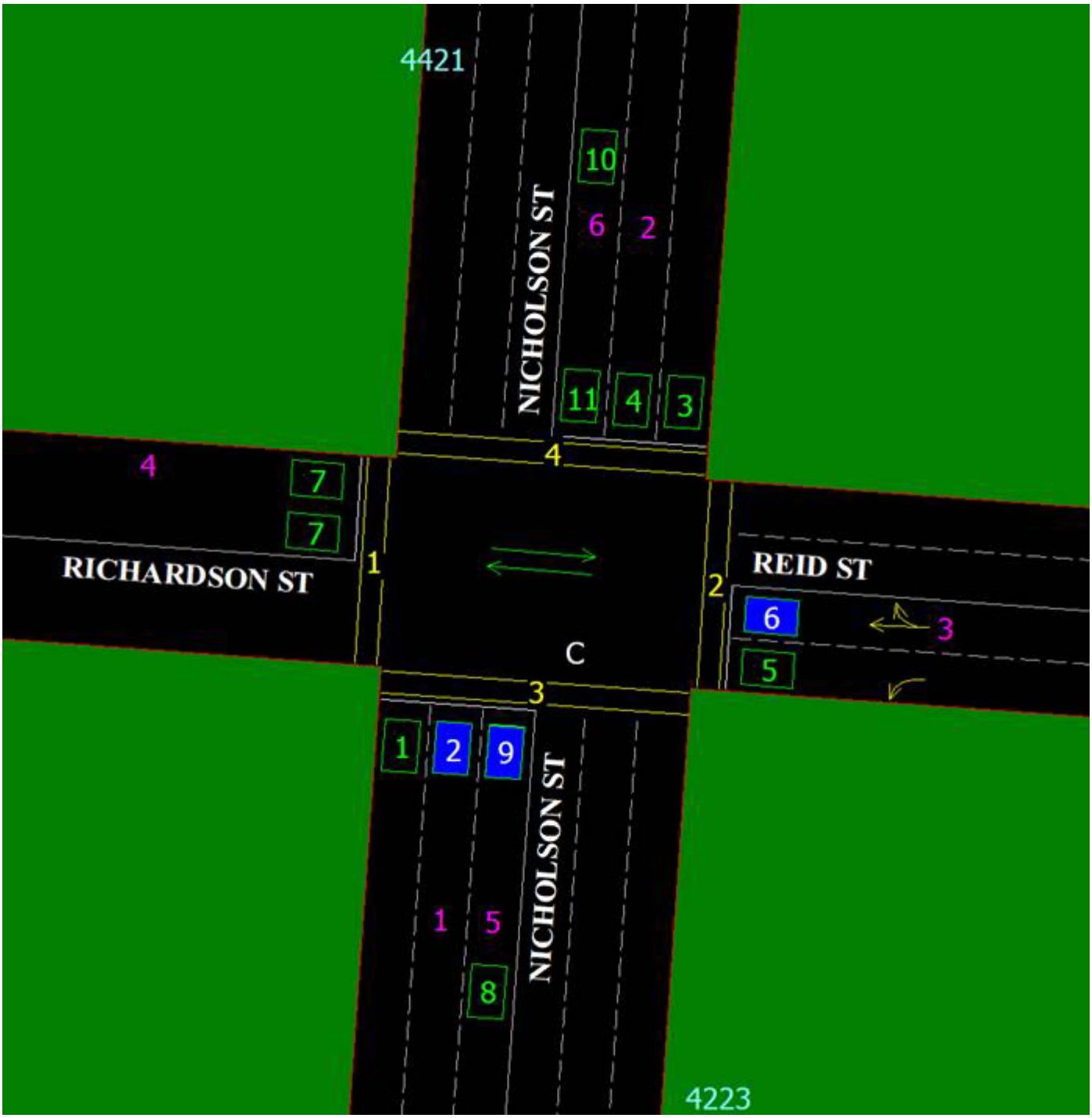
The VicRoads data provided shows that approximately 910 vehicles travel northbound along Reid Street and 940 vehicles travel southbound during peak periods of the day. From site inspections it was noted 1-2 vehicles turn right from these approaches across the tram tracks each cycle, therefore for the analysis it was assumed of these northbound and southbound vehicles approximately 50 vehicles turned right during the peak hours. The 50 vehicles assumption is a fair and balanced assessment for the modelling and could reach between 60-100 vehicles turning right during peak hours during a live one hour period.

Based on the modelling undertaken, with these volumes it has shown that with only one lane north/south along the length of Nicholson Street (including at signals) queuing was a significant issue with right turning vehicles unable to successfully turn right until the end of the phase, meaning that all traffic is at a standstill each time a vehicle attempts to turn right. This is also consistent with current site observations where right turning motorists propped within the intersection and were unable to turn right until the end of the phase due to oncoming trams, motorists and pedestrians crossing in a north/south direction. Given two lanes are currently provided this was not an issue during observations as vehicles could simply use the left lane to avoid any right turning motorists, something which isn't possible having a one lane option all the way along Nicholson Street and why the resulting analysis showed high levels of queuing.

SCATS data (attached) for the site (Nicholson St/Reid St), this data was collected 19th March 2019. Below image provided to assist in locating where the detectors are in relation to northbound and southbound volumes.

Attached:

1. PTV - traffic modelling report used by VicRoads for assessment of mid-block traffic lane reduction in north bound direction past stop 16 , 17 and 18.
2. VicRoads - SCATS data and SIDRA analysis
3. VicRoads letter dated 1 April 2019



Regards,

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Route 96 Project Design

Public Transport Victoria

Nicholson Street Traffic Modelling

IS168200 | C

April 2019

JACOBS

Route 96 Project Design

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Document history and status

Revision	Date	Description	By	Review	Approved
A	6/10/17	Draft report	P Thompson	M De Marco	J Cataldo
B	13/11/17	Draft report – amendments as requested by PTV	P Thompson	M De Marco	J Cataldo
C	05/04/19	Final report	P Thompson	M De Marco	J Cataldo

Contents

Executive Summary

Public Transport Victoria (PTV) commissioned Jacobs to investigate the traffic impacts of potential changes to Nicholson Street, as part of the Route 96 Upgrade Project.

Preliminary design work for the Project has revealed that proposed DDA-compliant tram stops at four locations along Nicholson Street (Stops 13/14, 16, 17 and 18) will be difficult to provide without reducing the number of traffic and/or parking lanes in their vicinity. As a busy primary arterial inner-city route, the traffic impacts of these changes need to be analysed and quantified so an informed decision can be made.

To properly assess the traffic impacts of any lane reductions in Nicholson Street, Jacobs were commissioned by Public Transport Victoria (PTV) to develop a microsimulation model of the section of the road from Gertrude Street to Brunswick Road using the VISSIM modelling software. Key features of the model are:

- Two time periods have been modelled, corresponding to a morning peak period (7:00-9:00am) and afternoon/evening peak period (4:00-6:00pm);
- The geometric features of the model have been coded from high-resolution aerial photographs, while key operational features such as speed limits and parking restrictions have been coded from Google StreetView;
- Other than the signalised intersections, vehicles turning to and from local side streets and parking activity have not been explicitly modelled, as the data requirements were beyond the agreed scope of the current study;
- Traffic demands have been modelled using dynamic routing and origin-destination matrices derived from SCATS detector counts at all the signal installations in the study area. These were used to develop synthesised origin-destination matrices at 15-minute intervals throughout each modelled time period, using the maximum-entropy matrix estimation method;
- All tram operations, including stops, have been included using static routing and published timetable information; and
- Traffic signal operations have been modelled using VISSIM's Vehicle Actuated Programing (VAP) facility. This has enabled the model to closely replicate observed signal phasing and timing behaviour, including pedestrian activity, as revealed by the signal operations sheets and the Intersection Diagnostic Monitor (IDM) data on a selected day.

The approach to calibrating the model centred on traffic signal operations. Once each VAP file was operating correctly in respect to the basic signal logic, successive changes were made to the *maximum extension green time* for each phase, until the modelled phase frequencies, average phase times and average cycle times were a close match to observed operations.

The model was then run, and the modelled detector counts checked against the SCATS counts. In the case of the pedestrian operated signals (POS), the volume of pedestrians (for which no actual data was available) was successively adjusted until there was a reasonable match between the observed and modelled actuations at each location. This process was repeated until the modelled results showed a close correlation to observed data. In the end, the final models replicated the observations very closely.

To validate the model, it was intended to use the Bluetooth vehicle travel time data available from VicRoads. This data was available for two sections of Nicholson Street, but analysis of the data raised concerns about its reliability. For example, one section showed an *average* travel speed of over 60 km/h, for a section that included the Nicholson Street/Alexandra Parade signals. It is possible that the data included such a small sample that by chance, only those few vehicles traversing the section (and the signals) without delay were recorded. Another possibility is that the accuracy of the vehicle detectors can pick up vehicles well before they reach the signal stop-line and incur any delay. Without some independent check on travel times along Nicholson Street, this issue remains unresolved.

The comparisons between the modelled and Bluetooth travel times generally showed a poor level of correspondence between the two. As discussed, the reliability of the Bluetooth data is questionable given its vehicle-location accuracy, and while we do not believe the poor correlation invalidates the model, we note that it remains unvalidated in respect to travel times and would be enhanced by the inclusion of reliable travel time information.

From the base models, two scenarios models were created and tested, namely:

- **Option 1** – One model each for the morning and afternoon periods, where Nicholson Street is narrowed to one lane in each direction at new tram stops 13/14[1], 15, 17 and 18, with 2017 traffic demands; and
- **Option 2** - One model each for the morning and afternoon periods, where Nicholson Street is posted at 40kph between Carlton Street and Brunswick Road, with 2017 traffic demands.

Note that no traffic growth has been included – the assumption has been that inner-city arterials such as Nicholson Street have limited capacity for additional traffic growth.

A total of ten simulation runs were undertaken for each of these scenarios (along with the base cases or 'current condition' models), and the averaged travel times along Nicholson Street compared for the major sections between the signalised intersections. The simulation results showed that:

1) Both Option 1 and Option 2 will result in increased travel times along Nicholson Street during the morning and evening periods;
2) The impacts associated with Option 1 are concentrated at particular locations and time periods, namely:
    - On the northern approach to the Nicholson Street/Alexandra Avenue intersection, where the new tram stop reduces what is presently a continuous through lane to a short lane. This reduces stop-line capacity. The impact at this location occurs throughout the entire morning and afternoon periods;
    - At the new consolidated tram stop at Carlton Street (Stops 13/14), where the combination of a single lane, the operation of the pedestrian signals, and the increase in pedestrian demand, combine to reduce the capacity at this location. The impact at this location is significant for about an hour in the *peak direction only* in each of the morning and afternoon periods; and
    - At the new tram stop near Kay Street (Stop 16), where (similar to Carlton Street) a single lane approach to a mid-block POS creates a capacity restriction. The impact at this location occurs in the peak direction form about 4:40 pm onwards.
3) In the case of Option 2, there are consistent and even travel time increase across all time periods and all sections of Nicholson Street[2]. These travel time impacts would likely be perceived quite differently by motorists, as they arise from changes to ambient travel speeds rather than from capacity restrictions and the associated queueing and stop-start driving conditions.
4) The impacts of Option 1 could be mitigated, at least in part, through careful design of the newly created pedestrian signals. For example, increasing the time to respond to pedestrian calls, and coordination with adjacent signals, would increase traffic capacity, although this would be at the expense of pedestrian levels of service.
5) A further impact of the new tram stop just north of Alexandra Parade (Stop 17) is that uncoordinated operation of the POS leads to queuing along Nicholson Street through the intersection. This POS would need to be coordinated with the Nicholson Street/Alexandra Parade signals to avoid this condition.

[1] Stops 13 and 14 are consolidated into a single stop at Carlton Street under this scenario.
[2] With the exception of the section from Gertrude Street and Carlton Street, where the speed limit is currently set at 40 km/h.

1. Introduction

1.1 Background

Public Transport Victoria (PTV) is currently undertaking preliminary design work for the Route 96 Upgrade project. In broad terms, the project aims to create Melbourne's first fully accessible tram route, and to this end the project scope includes:

" Ÿ *upgrading tram stops to level access, making them safer and accessible*

Ÿ *relocating or removing some tram stops to make sure stops are spaced more evenly, improving access and tram journey times;*

Ÿ *measures to improve service journey time and reliability; and*

Ÿ *new terminus stops at Blyth Street, East Brunswick and Acland Street, St Kilda*."

(Source: *www.ptv.vic.gov.au/projects/trams/route-96-upgrade*)

Jacobs have a current contract with Public Transport Victoria (PTV) for provide detailed engineering design services for the project, and in the course of this work have identified design issues associated with a number of proposed tram stops along the Nicholson Street section of the route. Specifically, there is insufficient space to provide island style, DDA-compliant stops at four locations without reducing the number of adjacent traffic and/or parking lanes. The four locations are:

- Stop Number 13/14, which combes the existing Hanover Street and Bell Street stops into a single stop near Carlton Street;
- Stop Number 16 (near Kay Street);
- Stop Number 17 (near Alexandra Parade); and
- Stop Number 18/19, which combines the existing Freeman Street and Tempany Street stops into a single stop near Fenwick Street.

A variety of design solutions are being investigated, one of which involves prioritising Nicholson Street as a public transport corridor and reducing the number of traffic lanes adjacent to each of these stops.

In addition, PTV wishes to test the implications of reducing the speed limit along Nicholson Street between Carlton Street and Brunswick Road to 40kph.

As a busy primary arterial road, the traffic implications of these changes need to be understood. To provide a sound, quantitative basis for assessing the options, Jacobs have been commissioned by PTV to develop a microsimulation model of this section of Nicholson Street using the VISSIM software platform.

1.2 Purpose of this Report

This Report has been prepared to clearly document the development of, and results obtained from, the Nicholson Street microsimulation model. It is intended to provide sufficient detail such that the PTV, VicRoads and other parties can be confident that the modelling is sufficiently robust for the purposes of the study, and to this end the Report is structured as follows:

- Chapter 2 provides an overview of the modelling approach, and sets out the general modelling specifications;
- Chapter 3 documents the traffic survey and other data used to develop and calibrate the model;
- Chapter 4 sets out the results of the model calibration and validation process;
- Chapter 5 details the alternative options for Nicholson Street, and presents statistics on their relative traffic impacts; and
- Chapter 6 concludes the report by summarising the key findings.

2. Modelling Specification

2.1 General Approach

The section of Nicholson Street under investigation is characterised by a total of 11 closely-spaced signalised intersections, linked to minimise delays to trams and provide formal crossing points for pedestrians. Considering the vehicle and tram-actuated signal logic, and the potential for interactions between intersections (such as queue blockages between adjacent signals), it was evident at the outset of the study that any realistic representation of traffic, tram, and pedestrian/cyclist operations could only be achieved using micro-simulation.

2.2 Study Area

To capture the traffic impacts of options under investigation, the micro-simulation model has been limited to the length of Nicholson Street between Gertrude Street and Brunswick area as shown in Figure 2.1.

We note that limiting the modelled area in this way does not account for any strategic reassignment of traffic as a result of the options.

2.3 Time Periods and Forecast Years

Jacobs previous experience with modelling and analysis work in inner-city locations suggests that the morning and evening peak period can be captured by modelling the following time periods:

- A two-hour morning peak period from 7:00am to 9:00am; and
- A two-hour afternoon peak period 4:00pm to 6:00pm.

Inner-city primary arterial road such as Nicholson Street have limited capacity for additional traffic growth, and for this reason we have not explicitly modelled any particular forecasts year, but have maintained current traffic demands for both the existing and project-case models.

2.4 Other Modelling Parameters

Other features of the VISSIM models are as follows:

- Traffic demands were modelled at for 15-minute intervals throughout each time period, taken from published SCATS detector counts at all available locations within the study area;
- Vehicle route selection was modelled using VISSIM's dynamic routing option and synthesised origin-destination matrices;
- All tram operations, including stops, have been included using static routing and published timetable information;
- Light vehicles and heavy vehicles have not been separately defined;
- VISSIM's Vehicle Actuated Programming (VAP) module has been used to model demand-actuated operation of all traffic signals;
- The simulation has included 15-minute warm-up and cool-down periods at the beginning and end of each time period;

- Reduced speed areas on all turns at intersections and speed humps have been coded;
- Desired vehicle speeds have been identified from posted speed limits; and
- All reported results are the average of 10 simulation runs[3] unless otherwise noted.

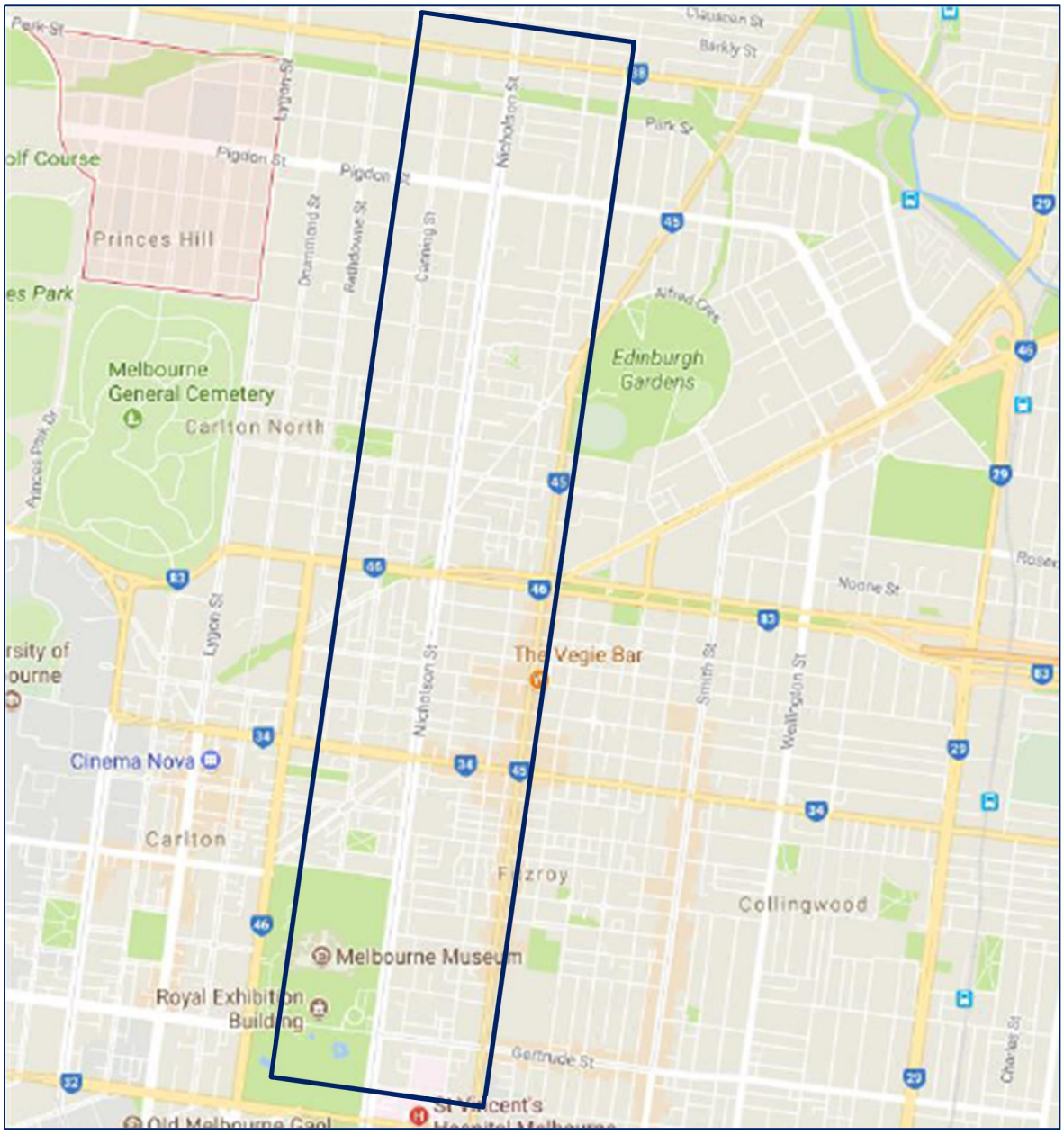

Figure 2.1 : Nicholson Street VISSIM Model Area

[3] Starting random number seed of 42, with increments of 50.

3. Data Sources

3.1 SCATS Data

3.1.1 Detector Counts

The timing and budget for the study precluded traffic and pedestrian surveys being undertaken.

Traffic demands have therefore been taken from the published SCATS detector counts at every signalised intersection within the study area, namely:

- Nicholson Street/Gertrude Street (Site 4419);
- Nicholson Street POS near Hanover Street (Site 4428);
- Nicholson Street POS near Bell Street (Site 4420);
- Nicholson Street/Elgin Street/Johnston Street (Site 3450);
- Nicholson Street POS near Kay Street (Site 4427);
- Nicholson Street/Princes Street/Alexandra Parade (Site 2100);
- Nicholson Street POS near Freeman Street (Site 4423);
- Nicholson Street/Richardson Street/Reid Street (Site 4426);
- Nicholson Street/Pigdon Street/Scotchmer Street (Site 4421);
- Nicholson Street POS near Park Street (Site 3116); and
- Nicholson Street/Brunswick Road/Holden Street (Site 3115);

The data was extracted for 15-minute intervals over the course of the modelled AM and PM periods, for Wednesday August 16th 2017. A single day was selected so there would be compatibility between the traffic demands, signal timings and the observed travel times.

3.1.2 SCATS Intersection Diagnostic Monitor (IDM) Data

The Intersection Diagnostic Monitor (IDM) data for each signalised intersection in the study area was provided by VicRoads, for the selected day and time periods, broken down into 15-minute intervals.

Further details on the IDM data is provided in Section 4.5.3.

3.1.3 Signal Operations Sheets

Signal operations sheets for each signalised intersection were used as the basis for modelling the signal logic. This is discussed in more detail in Section 4.3.

3.2 Bluetooth Travel Time Data

VicRoads now collect travel time data at numerous locations across the road network, where bluetooth detectors located in the signal controller cabinets are able to provide average travel times between collection points throughout the day.

Within the study area, data is available for two routes, namely:

- **Route 1** - Along Nicholson Street between Brunswick Road and Alexandra Parade; and
- **Route 2** - Along Nicholson Street between Elgin Street and Alexandra Parade.

The data for Wednesday August 16th, presented as travel speeds averaged over 5-minute intervals throughout the two peak periods and split by direction, are shown in Figure 3.1 to Figure 3.4.

Inspection of the bluetooth data raises some concerns about its reliability. For example, one section showed an *average* travel speed of over 60 km/h, for a section that included the Nicholson Street/Alexandra Parade signals (Figure 3.3). It is possible that the data included such a small sample that by chance, only those few vehicles traversing the section (and the signals) without delay were recorded. Another possibility is that the accuracy of the vehicle detectors can pick up vehicles well before they reach the signal stop-line and incur any delay. Given that, as we understand it, the accuracy of the vehicle location is only to 50m, both of these scenarios are quite possible. In fact, there is likely to be wide variation in the effective start and stop points between which the travel times for each vehicle are recorded, and the suitability of this data for the purposes of simulation model validation is questionable.

3.3 Other Data Sources

3.3.1 Public Transport

Tram timetables currently in effect were used to model the passage of trams through the study area, including dwell times at the designated tram stops. All routes in operation within the study area were modelled in this way[4].

There are no bus routes with stops along Nicholson Street within the study area, and any routes crossing the study area were not deemed to have sufficient impact on traffic operations along Nicholson Street to warrant inclusions in the model.

3.3.2 Speed Limits and Parking Restrictions

A desktop survey of current posted speed limits and parking restrictions along Nicholson Street was undertaken using Google StreetView. This revealed that:

- Other than a school zone where morning and afternoon time speeds limits of 40km/h are in effect, the entire modelled length of Nicholson Street is posted at 60km/h;
- Two through traffic lanes in each direction are maintained throughout the morning and evening peak periods along the entire modelled section of Nicholson Street.

[4] Corresponding to Routes 96 and 86,

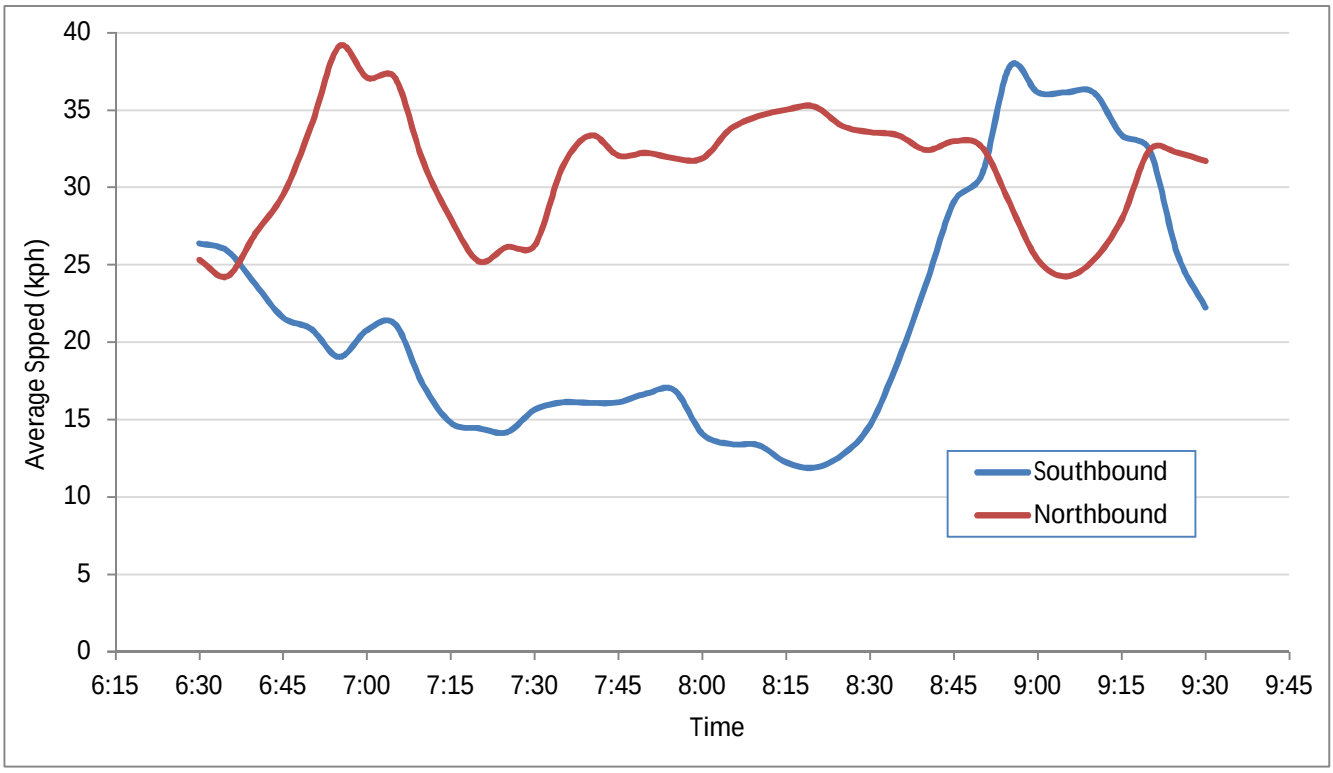

Figure 3.1 : Nicholson Street Travel Speeds, Alexandra Parade to Brunswick Road (AM Period)

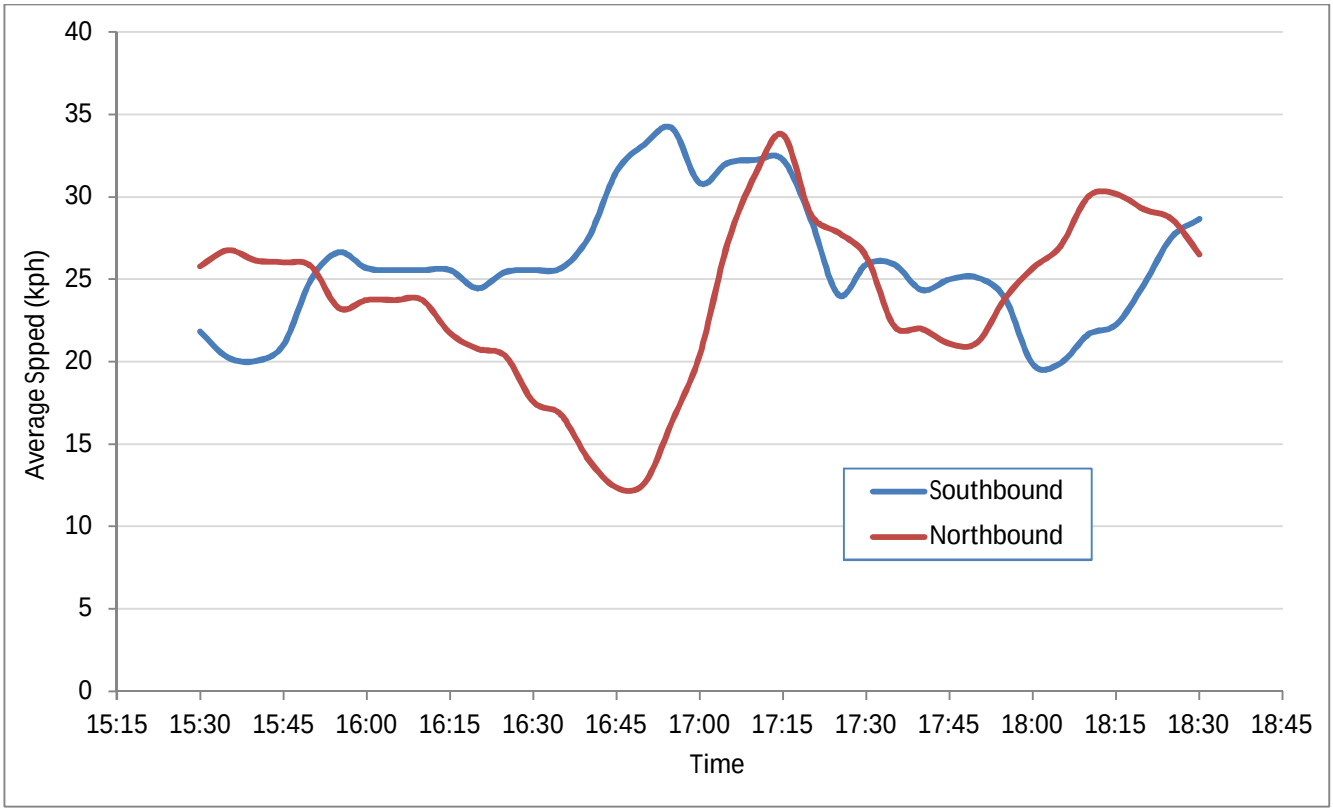

Figure 3.2 : Nicholson Street Travel Speeds, Alexandra Parade to Brunswick Road (PM Period)

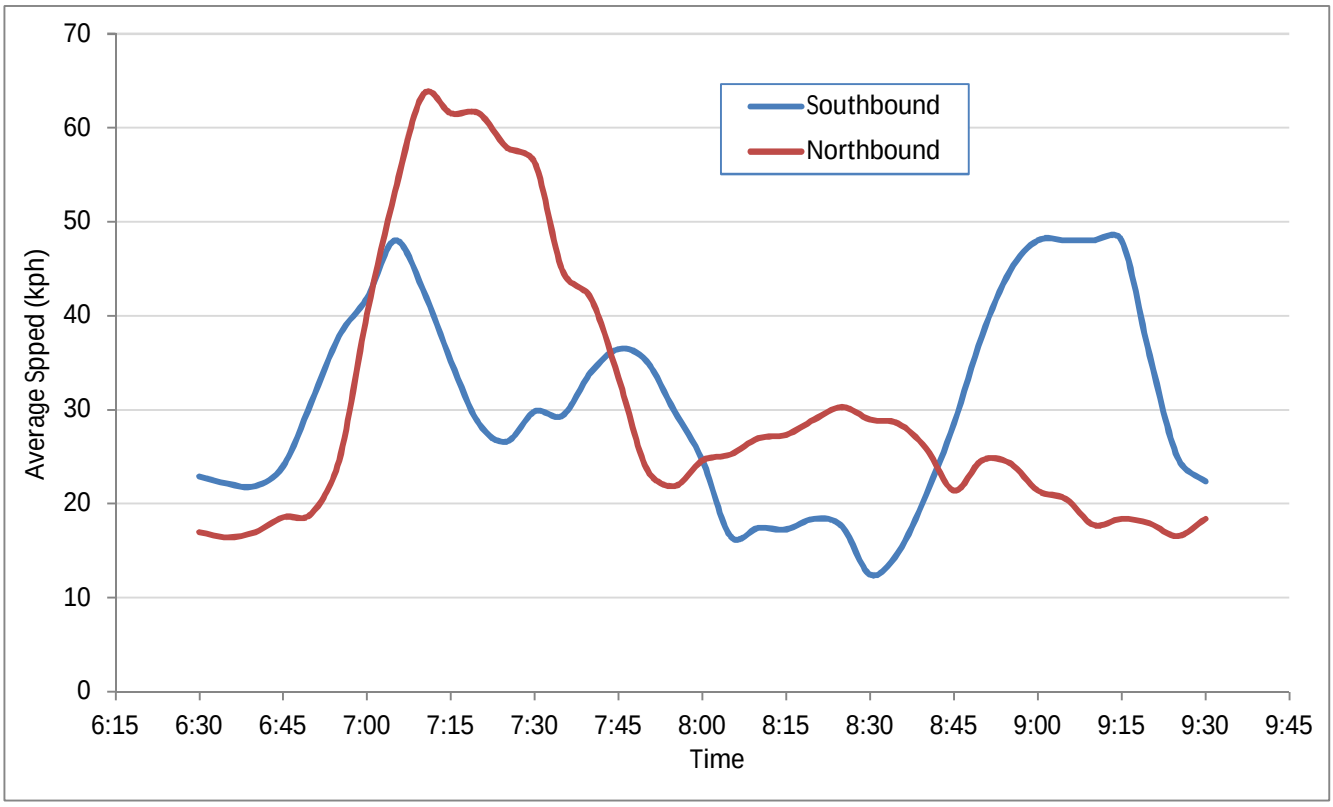

Figure 3.3 : Nicholson Street Travel Speeds, Elgin Street to Alexandra Parade (AM Period)

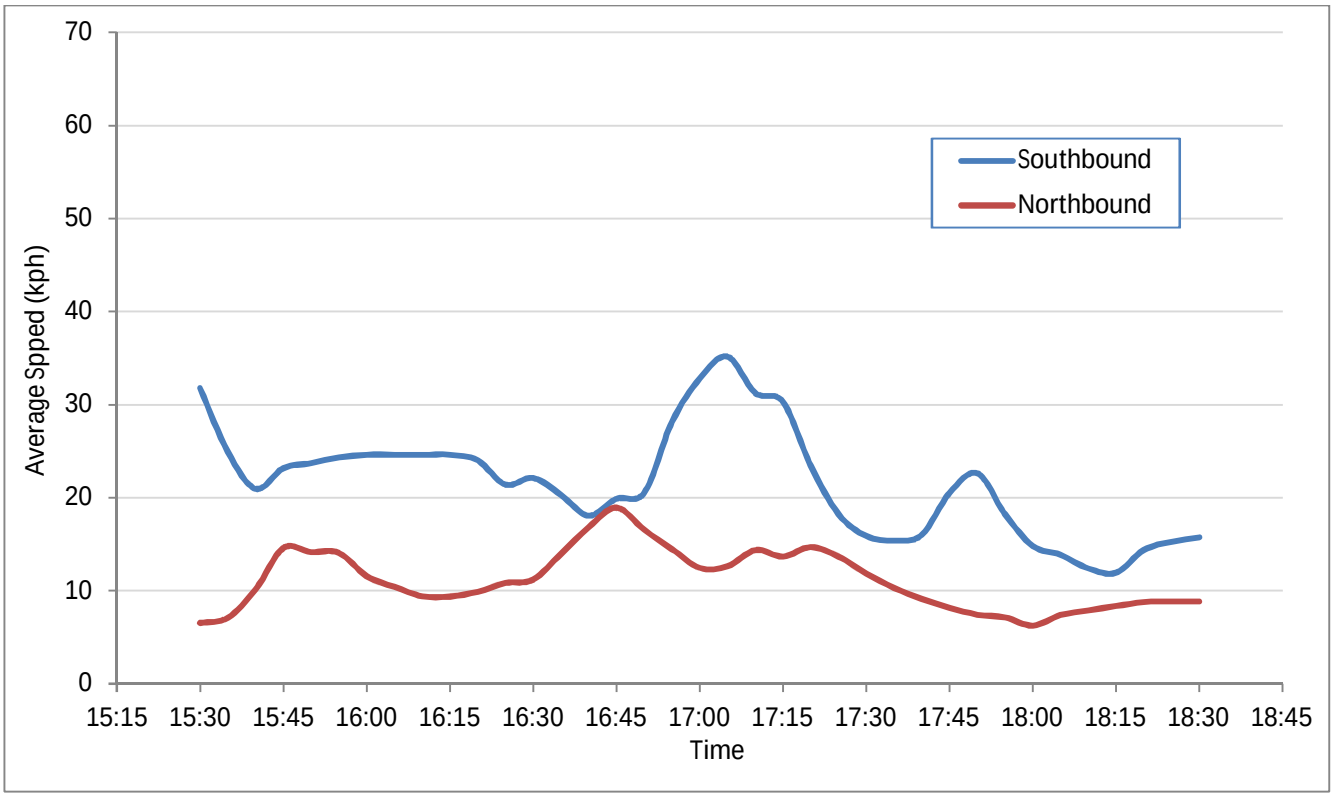

Figure 3.4 : Nicholson Street Travel Speeds, Elgin Street to Alexandra Parade (PM Period)

4. Base Year (2017) Model Development

4.1 Network Coding

The base year networks were coded from high-resolution aerial photographs covering the study area, so the network geometry has been captured to a high level of detail and accuracy.

It should be noted that only the roads at signalised intersections along Nicholson Street have been explicitly modelled. Because no data is available at the numerous priority-controlled intersections and driveways, it has not been possible (or desirable) to model all possible points of vehicle entry and exit along Nicholson Street. Instead, a simplified network has been coded where the side-streets and driveways are represented by 'dummy' links much like the centroid connectors used in strategic transport models. These links act as traffic sources and sinks, allowing for the entry and exit of vehicles not otherwise represented by the major roads, and allowing the traffic discontinuities at successive signalised intersections to be accounted for. By doing this, a demand matrix can be prepared which reproduces the observed SCATS detector counts very accurately.

Given this network representation, current traffic demands have been modelled by developing a synthesised matrix for all traffic between the model entry and exit points, for every 15 minutes over the modelled periods.

The model animations were closely observed to detect any unusual vehicle behaviour and to ensure lane choice, lane changing and observance of priorities, conflicts and '*Keep Clear'* areas was logical.

Other features of the base-year model development and simulation settings are as discussed in Chapter 2.

4.2 Matrix Estimation

As noted, the only traffic data available for the study was that available from recent SCATS detector counts at the signalised intersections and pedestrian crossings.

To convert this incomplete information into a form that could be used for the traffic simulation, a matrix estimation technique was applied to produce synthetic (as opposed to observed) origin-destination patterns for every 15-minute interval within the modelled time periods.

The specific technique employed was the *maximum-entropy* method, for which Jacobs has specially designed software. The mathematical details of this technique can be found in the literature and are not reproduced here, suffice to say that it produces the most probable trip matrix given the constraint that it must also produce the observed traffic movements. Under conditions where a network is coded to allow for unobserved traffic movements and there is a single traffic route between every OD pair, the resultant matrix will reproduce the observed movements almost exactly[5].

4.3 Traffic Signal Operations

Traffic signals in Melbourne operate under the SCATS control system, where phase sequences and green splits are dynamically adjusted according to traffic demand. Replicating this dynamic operation in a micro-simulation model can present a major challenge, especially for intersections with complex control logic.

[5] Subject to round-off error.

In these cases, VISSIM provides a mechanism for modelling dynamic operations using the VAP module. This module enables full control over all aspects of signal operations, so the particular signal logic can be implemented provided that the control logic and timing parameters are available in sufficient detail.

We note that no attempt has been made to mimic the SCATS logic in all its complexity. The objective was to review the IDM data to find the cycle times, and the frequency and duration of the various phases at each site on the selected day, then to implement the logic sufficiently to reproduce these statistics to an acceptable degree of accuracy, based on the logic documented in the signal operations sheets. For most of the signalised intersections, this is achieved when the VAP signal logic includes:

- Vehicle-actuated phases, by allowing phases to skip where no call is recorded (other than the pivot phase), and to terminate a phase when it gaps out;
- Re-allocation of unused green times to other phases within the cycle, in accordance with the SCATS settings for the site;
- Realistic values for inter-greens, minimum and maximum green times, green time extensions, early and late starts, as indicated by the IDM statistics and operations sheets;
- The logic associated with public transport priority, including remote calls from upstream detectors; and
- Pedestrian calls where these are reasonably frequent and where they have a significant influence on vehicle operations.

With these principles in mind, the operations sheets and IDM data for each signal installation was reviewed, and a corresponding VAP file developed to replicate the particular logic at each location.

4.4 Approach to Calibration and Validation

4.4.1 General Approach

The approach to calibrating the model centred on traffic signal operations. Once each VAP file was operating correctly in respect to the basic signal logic, successive changes were made to the *maximum extension green time* for each phase, until the modelled phase frequencies, average phase times and average cycle times were a close match to observed operations.

The model was then run, and the modelled detector counts checked against the SCATS counts. In the case of the pedestrian operated signals, the volume of pedestrians (for which no actual data was available) was successively adjusted until there was a reasonable match between the observed and modelled actuations at each location. This process was repeated until the modelled results showed a close correlation to observed data, as discussed in section 4.5.

4.4.2 Note on Validation

To validate the model, it was intended to use the Bluetooth vehicle travel time data available from VicRoads, as presented in section 3.2. As discussed, this data was available for two sections of Nicholson Street, but analysis of the data raised concerns about its reliability. While we have presented the results of the comparison between modelled and 'observed' travel times (see section 4.5.2), the correlation between the two is poor, and the model remains unvalidated in this respect.

4.5 Base Model Results

4.5.1 Traffic Volumes

The comparison between the observed and modelled traffic volumes is shown in Table 4.1 and Table 4.2 for the morning and evening peak periods respectively. The volumes have been analysed in terms of the turning movements at each signalised location for which a SCATS detector count was available, aggregated for the whole of the modelled period.

The results show a very good correlation between modelled and observed traffic demands. This result is not unexpected – as discussed in section 4.1 and 4.2, the coding of the network along with the matrix estimation methodology were engineered such that a very close correlation would result.

Table 4.1 : Traffic Volume Comparison, AM Period (07:00-09:00)

Location	Approach	Movements	Modelled Volume	Observed Volume	GEH	% Diff.
Gertrude St / Nicholson St	North	Left + Thru	1,131	1,132	0.0	-0.1%
Gertrude St / Nicholson St	East	Left	225	227	0.1	-0.9%
Gertrude St / Nicholson St	East	Right	262	250	0.5	4.8%
Gertrude St / Nicholson St	South	Thru	579	593	0.4	-2.4%
Gertrude St / Nicholson St	South	Right	107	107	0.0	0.0%
NR Hannover St / Nicholson St	North	Thru	1,453	1,453	0.0	0.0%
NR Hannover St / Nicholson St	South	Thru	872	928	1.3	-6.0%
NR Bell St / Nicholson St	North	Thru	1,540	1,543	0.1	-0.2%
NR Bell St / Nicholson St	South	Thru	833	845	0.3	-1.4%
Elgin St / Johnston St / Nicholson St	North	Left + Thru	1,466	1,492	0.5	-1.7%
Elgin St / Johnston St / Nicholson St	North	Right	371	385	0.5	-3.6%
Elgin St / Johnston St / Nicholson St	East	Left + Thru	1,696	1,693	0.1	0.2%
Elgin St / Johnston St / Nicholson St	East	Right	199	194	0.3	2.6%
Elgin St / Johnston St / Nicholson St	South	Left + Thru	700	701	0.0	-0.1%
Elgin St / Johnston St / Nicholson St	South	Right	81	83	0.2	-2.4%
Elgin St / Johnston St / Nicholson St	West	Left	147	147	0.0	0.0%
Elgin St / Johnston St / Nicholson St	West	Thru	742	738	0.1	0.5%
Elgin St / Johnston St / Nicholson St	West	Right	104	108	0.3	-3.7%
NR Kay / Nicholson St	North	Thru	2,032	2,046	0.2	-0.7%
NR Kay / Nicholson St	South	Thru	981	987	0.1	-0.6%
Alexandra / Princes St / Nicholson St	North	Thru	900	909	0.2	-1.0%
Alexandra / Princes St / Nicholson St	North	Right	114	125	0.7	-8.8%
Alexandra / Princes St / Nicholson St	East	Left	944	964	0.5	-2.1%
Alexandra / Princes St / Nicholson St	East	Thru	5,064	5,073	0.1	-0.2%
Alexandra / Princes St / Nicholson St	East	Right	299	295	0.2	1.4%
Alexandra / Princes St / Nicholson St	South	Left + Thru	646	660	0.4	-2.1%
Alexandra / Princes St / Nicholson St	South	Right	279	288	0.4	-3.1%
Alexandra / Princes St / Nicholson St	West	Left	599	626	0.8	-4.3%
Alexandra / Princes St / Nicholson St	West	Thru	3,620	3,604	0.2	0.4%
Alexandra / Princes St / Nicholson St	West	Right	81	80	0.1	1.3%
NR Freeman St / Nicholson St	North	Thru	1,609	1,621	0.2	-0.7%
NR Freeman St / Nicholson St	South	Thru	969	952	0.4	1.8%

Location	Approach	Movements	Modelled Volume	Observed Volume	GEH	% Diff.
Richardson St / Reid St / Nicholson St	North	Left + Thru + Right	1,747	1,780	0.6	-1.9%
Richardson St / Reid St / Nicholson St	East	Left	117	129	0.8	-9.3%
Richardson St / Reid St / Nicholson St	East	Thru + Right	349	349	0.0	0.0%
Richardson St / Reid St / Nicholson St	South	Left + Thru + Right	915	928	0.3	-1.4%
Richardson St / Reid St / Nicholson St	West	Left + Thru + Right	158	163	0.3	-3.1%
Pigdon St / Scotchmer St / Nicholson St	North	Left + Thru + Right	1,775	1,798	0.4	-1.3%
Pigdon St / Scotchmer St / Nicholson St	East	Left + Thru + Right	395	410	0.5	-3.7%
Pigdon St / Scotchmer St / Nicholson St	South	Left + Thru + Right	969	969	0.0	0.0%
Pigdon St / Scotchmer St / Nicholson St	West	Left	100	101	0.1	-1.0%
Pigdon St / Scotchmer St / Nicholson St	West	Thru + Right	264	270	0.3	-2.2%
NR Park St / Nicholson St	North	Thru	1,698	1,725	0.5	-1.6%
Brunswick Rd / Holden St / Nicholson St	North	Left + Thru + Right	1,831	1,855	0.4	-1.3%
Brunswick Rd / Holden St / Nicholson St	East	Left + Thru + Right	838	857	0.5	-2.2%
Brunswick Rd / Holden St / Nicholson St	South	Left + Thru + Right	883	885	0.0	-0.2%
Brunswick Rd / Holden St / Nicholson St	West	Left	116	115	0.1	0.9%
Brunswick Rd / Holden St / Nicholson St	West	Thru	609	611	0.1	-0.3%
Brunswick Rd / Holden St / Nicholson St	West	Right	283	287	0.2	-1.4%
Gertrude St / Nicholson St	South	Departure side	1,283	1,281	0.0	0.2%
Total Volume			**44,975**	**45,362**	**-**	**-0.9%**

Table 4.2 : Traffic Volume Comparison, PM Period (16:00-18:00)

Location	Approach	Movements	Modelled Volume	Observed Volume	GEH	% Diff.
Gertrude St / Nicholson St	North	Left + Thru	805	828	0.6	-2.8%
Gertrude St / Nicholson St	East	Left	240	241	0.0	-0.4%
Gertrude St / Nicholson St	East	Right	405	397	0.3	2.0%
Gertrude St / Nicholson St	South	Thru	1,469	1,467	0.0	0.1%
Gertrude St / Nicholson St	South	Right	217	217	0.0	0.0%
NR Hannover St / Nicholson St	North	Thru	925	949	0.6	-2.5%
NR Hannover St / Nicholson St	South	Thru	2,005	2,170	2.6	-7.6%
NR Bell St / Nicholson St	North	Thru	951	985	0.8	-3.5%
NR Bell St / Nicholson St	South	Thru	1,911	1,926	0.2	-0.8%
Elgin St / Johnston St / Nicholson St	North	Left + Thru	917	939	0.5	-2.3%
Elgin St / Johnston St / Nicholson St	North	Right	201	200	0.0	0.5%
Elgin St / Johnston St / Nicholson St	East	Left + Thru	897	900	0.1	-0.3%
Elgin St / Johnston St / Nicholson St	East	Right	188	187	0.1	0.5%
Elgin St / Johnston St / Nicholson St	South	Left + Thru	1,598	1,600	0.0	-0.1%
Elgin St / Johnston St / Nicholson St	South	Right	210	210	0.0	0.0%
Elgin St / Johnston St / Nicholson St	West	Left	376	377	0.0	-0.3%
Elgin St / Johnston St / Nicholson St	West	Thru	1,718	1,720	0.0	-0.1%
Elgin St / Johnston St / Nicholson St	West	Right	85	88	0.2	-3.4%
NR Kay / Nicholson St	North	Thru	1,299	1,338	0.8	-2.9%
NR Kay / Nicholson St	South	Thru	1,950	1,958	0.1	-0.4%
Alexandra / Princes St / Nicholson St	North	Thru	607	623	0.5	-2.6%

Location	Approach	Movements	Modelled Volume	Observed Volume	GEH	% Diff.
Alexandra / Princes St / Nicholson St	North	Right	81	83	0.2	-2.4%
Alexandra / Princes St / Nicholson St	East	Left	557	569	0.4	-2.1%
Alexandra / Princes St / Nicholson St	East	Thru	3,984	4,044	0.7	-1.5%
Alexandra / Princes St / Nicholson St	East	Right	387	393	0.2	-1.5%
Alexandra / Princes St / Nicholson St	South	Left + Thru	1,400	1,401	0.0	-0.1%
Alexandra / Princes St / Nicholson St	South	Right	475	475	0.0	0.0%
Alexandra / Princes St / Nicholson St	West	Left	1,036	1,077	0.9	-3.8%
Alexandra / Princes St / Nicholson St	West	Thru	3,823	3,813	0.1	0.3%
Alexandra / Princes St / Nicholson St	West	Right	69	67	0.2	3.0%
NR Freeman St / Nicholson St	North	Thru	1,476	1,498	0.4	-1.5%
NR Freeman St / Nicholson St	South	Thru	1,850	1,831	0.3	1.0%
Richardson St / Reid St / Nicholson St	North	Left + Thru + Right	1,427	1,463	0.7	-2.5%
Richardson St / Reid St / Nicholson St	East	Left	149	150	0.1	-0.7%
Richardson St / Reid St / Nicholson St	East	Thru + Right	297	303	0.2	-2.0%
Richardson St / Reid St / Nicholson St	South	Left + Thru + Right	1,800	1,812	0.2	-0.7%
Richardson St / Reid St / Nicholson St	West	Left + Thru + Right	366	362	0.1	1.1%
Pigdon St / Scotchmer St / Nicholson St	North	Left + Thru + Right	1,373	1,388	0.3	-1.1%
Pigdon St / Scotchmer St / Nicholson St	East	Left + Thru + Right	359	366	0.3	-1.9%
Pigdon St / Scotchmer St / Nicholson St	South	Left + Thru + Right	1,694	1,688	0.1	0.4%
Pigdon St / Scotchmer St / Nicholson St	West	Left	187	200	0.7	-6.5%
Pigdon St / Scotchmer St / Nicholson St	West	Thru + Right	374	399	0.9	-6.3%
NR Park St / Nicholson St	North	Thru	1,714	1,726	0.2	-0.7%
Brunswick Rd / Holden St / Nicholson St	North	Left + Thru + Right	1,258	1,237	0.4	1.7%
Brunswick Rd / Holden St / Nicholson St	East	Left + Thru + Right	808	840	0.8	-3.8%
Brunswick Rd / Holden St / Nicholson St	South	Left + Thru + Right	1,763	1,773	0.2	-0.6%
Brunswick Rd / Holden St / Nicholson St	West	Left	252	253	0.0	-0.4%
Brunswick Rd / Holden St / Nicholson St	West	Thru	689	689	0.0	0.0%
Brunswick Rd / Holden St / Nicholson St	West	Right	275	278	0.1	-1.1%
Gertrude St / Nicholson St	South	Departure	981	996	0.3	-1.5%
Total Volume			**49,878**	**50,494**	**-**	**-1.2%**

4.5.2 Travel Times

We have presented the travel time comparisons in the form of:

- A tabulated summary of average travel times for each modelled period, for each of the route (see Table 4.3); and
- A plot of total travel time over the identified routes, by direction, over the course of the entire modelled periods. These are shown in Figure 3.1 to Figure 3.4.

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Table 4.3 : Travel Time Comparison

Nicholson Street Route	AM Period (7:00-9:00)		PM Period (16:00-18:00)	
	Bluetooth	Simulation	Bluetooth	Simulation
Brunswick Street to Alexandra Parade	336	181	236	186
Alexandra Parade to Brunswick Street	180	201	297	159
Alexandra Parade to Elgin Street	77	62	113	62
Elgin Street to Alexandra Parade	63	84	186	88

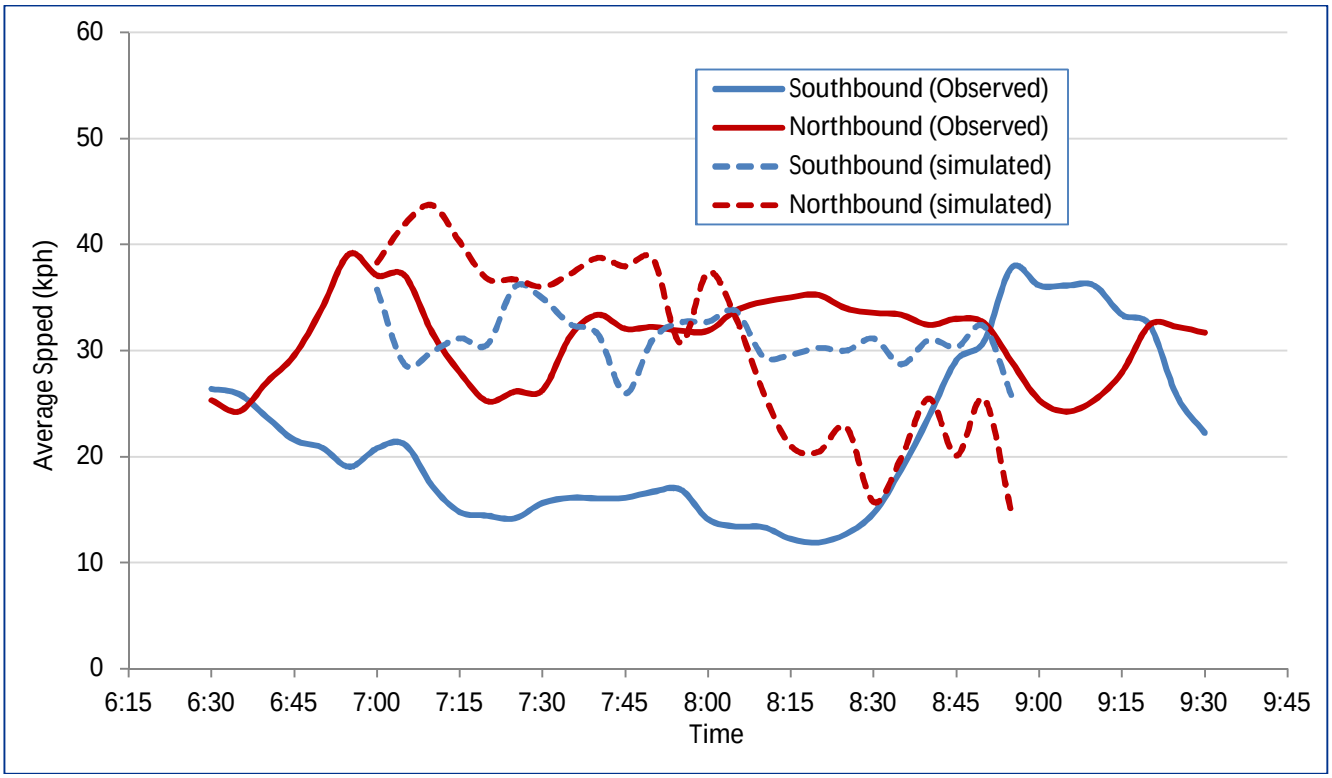

Figure 4.1 : Brunswick Street - Alexandra Parade Travel Speeds (AM Period)

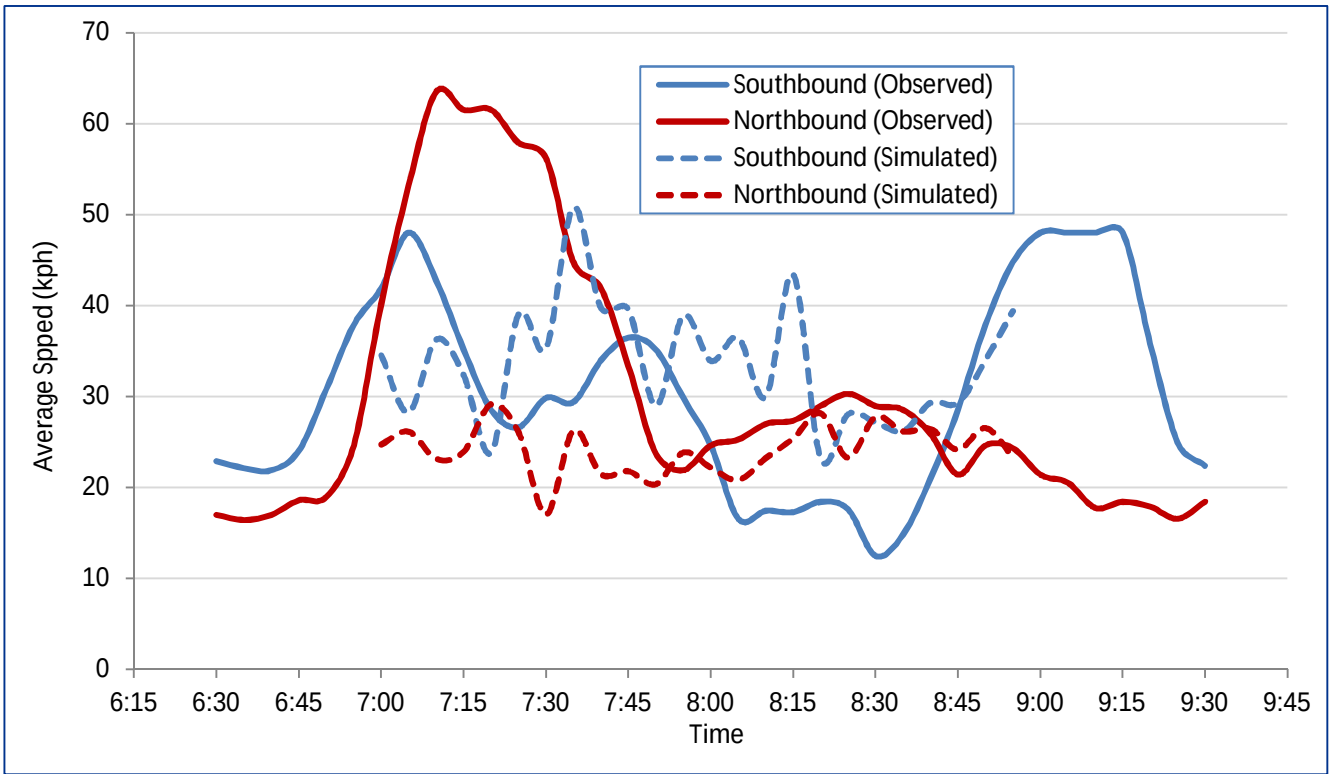

Figure 4.2 : Alexandra Parade - Elgin Street Travel Times (AM Period)

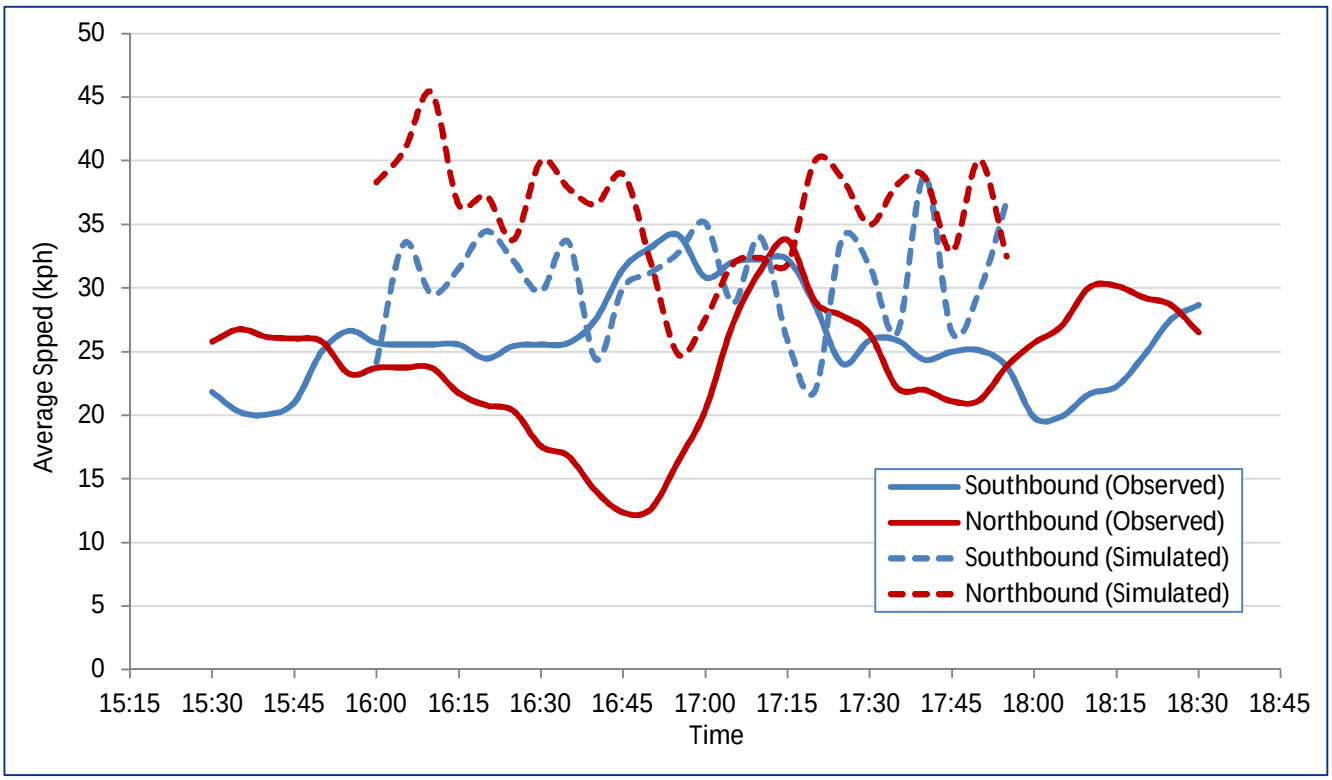

Figure 4.3 : Brunswick Street - Alexandra Parade Travel Speeds (PM Period)

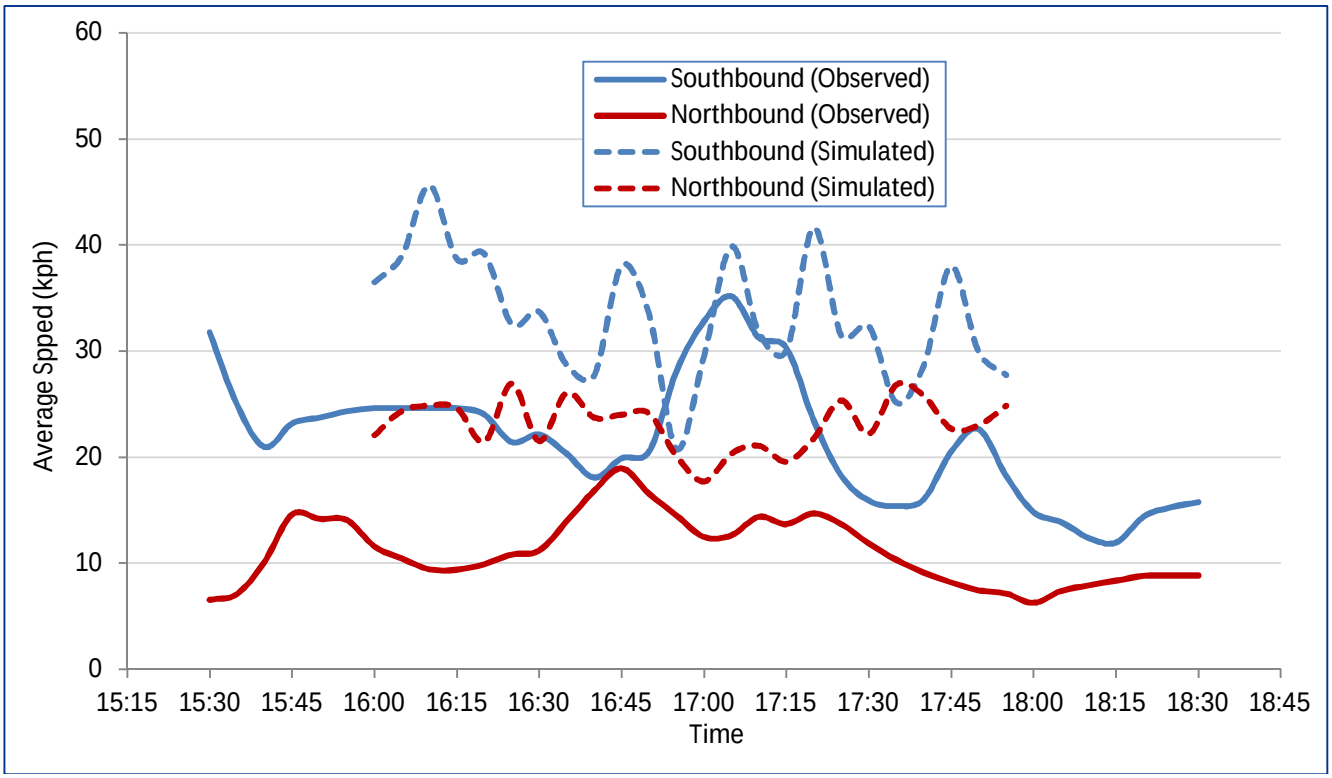

Figure 4.4 : Alexandra Parade - Elgin Street Travel Times (PM Period)

The comparisons generally show a poor level of correspondence between observed and modelled travel times. As discussed, the reliability of the Bluetooth data is questionable given its vehicle-location accuracy, and while we do not believe the poor correlation invalidates the model, we note that it remains unvalidated in respect to travel times and would be enhanced by the inclusion of reliable travel time information.

4.5.3 Traffic Signal Operations

The basic approach was to input the vehicle detectors, signal groups and phases, along with the SCATS timing parameters of minimum green, inter-green and gap-out times, and then manipulate the extension green times for each phase until the average phase times and cycle times from the IDM data were reproduced to an acceptable level of accuracy. This comparison is shown in Table 4.4 to Table 4.15 for all of the signalised intersections.

In terms of the critical statistics of average phase times and cycle times throughout the modelled periods, the Tables show that the simulation represents the observations very well.

Table 4.4 : Gertude Street Intersection - Comparison of Simulated and Observed Phase Times (7:00am-9:00am)

Phase	Frequency		Minimum (s)		Maximum (s)		Average (s)		Average (%)		Total (s)	
	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.
A	95	94	1	36	65	36	35	36	46	47	3,327	3,384
B	19	16	14	14	15	14	14	14	4	3	271	224
C	60	62	6	12	23	22	15	14	12	12	879	857
D	86	93	2	13	33	33	30	29	36	38	2,556	2,700
E	2	-	12	-	13	-	13	-	0	-	25	-
F	9	-	15	-	16	-	16	-	2	-	142	-
G	0	0	0	0	0	0	0	0	0	0	0	0
										Total (s)	**7,200**	**7,164**
										Average Cycle Time (s)	**76**	**76**

Table 4.5 : Gertude Street Intersection - Comparison of Simulated and Observed Phase Times (4:00pm-6:00pm)

Phase	Frequency		Minimum (s)		Maximum (s)		Average (s)		Average (%)		Total (s)	
	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.
A	88	93	1	32	51	32	32	32	39	42	2,794	2,976
B	18	25	14	14	15	14	14	14	4	5	257	350
C	78	78	14	12	23	23	17	15	19	16	1,344	1,178
D	82	93	12	13	35	35	30	28	35	37	2,497	2,645
E	2	-	13	-	13	-	13	-	0	-	26	-
F	18	-	15	-	16	-	16	-	4	-	282	-
G	0	0	0	0	0	0	0	0	0	0	0	0
										Total (s)	**7,200**	**7,149**
										Average Cycle Time (s)	**82**	**77**

Table 4.6 : Elgin Street Intersection - Comparison of Simulated and Observed Phase Times (7:00am-9:00am)

Phase	Frequency		Minimum (s)		Maximum (s)		Average (s)		Average (%)		Total (s)	
	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.
A	70	72	2	27	61	52	36	37	35	37	2,543	2,641
B	10	-	9	-	16	-	11	-	1	-	107	-
C	42	48	5	12	21	19	15	12	9	8	612	598
D	70	72	3	35	56	35	34	35	33	35	2,366	2,484
E	14	16	11	11	11	11	12	11	2	2	165	176
F	62	70	4	12	45	27	22	18	19	18	1,378	1,274
G	5	-	2	-	8	-	6	-	0	-	29	-
										Total (s)	**7,200**	**7,172**
										Average Cycle Time (s)	**103**	**100**

Table 4.7 : Elgin Street Intersection - Comparison of Simulated and Observed Phase Times (4:00pm-6:00pm)

Phase	Frequency		Minimum (s)		Maximum (s)		Average (s)		Average (%)		Total (s)	
	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.
A	69	66	1	26	62	42	34	37	33	34	2,363	2,434
B	9	-	9	-	15	-	10	-	1	-	93	-
C	4	27	12	12	13	15	12	12	1	4	49	315
D	71	66	2	46	62	46	46	46	46	42	3,300	3,003
E	20	15	10	11	11	11	11	11	3	2	210	165
F	67	67	3	18	37	24	17	19	15	17	1,114	1,240
G	10	-	7	-	8	-	7	-	1	-	71	-
									Total (s)		**7,200**	**7,156**
									Average Cycle Time (s)		**101**	**107**

Table 4.8 : Alexandra Parade Intersection - Comparison of Simulated and Observed Phase Times (7:00am-9:00am)

Phase	Frequency		Minimum (s)		Maximum (s)		Average (s)		Average (%)		Total (s)	
	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.
A	49	49	5	68	123	68	68	68	46	46	3,343	3,307
B	19	16	11	11	11	11	11	11	3	2	209	168
C	46	49	6	11	38	21	21	16	13	11	947	799
D	46	49	14	26	52	51	35	38	23	26	1,628	1,838
E	4	5	13	13	13	13	13	13	1	1	52	65
F	45	49	3	13	45	27	23	20	14	14	1,021	981
									Total (s)		**7,200**	**7,158**
									Average Cycle Time (s)		**147**	**146**

Table 4.9 : Alexandra Parade Intersection - Comparison of Simulated and Observed Phase Times (4:00pm-6:00pm)

Phase	Frequency		Minimum (s)		Maximum (s)		Average (s)		Average (%)		Total (s)	
	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.
A	49	47	7	72	106	72	72	72	49	47	3,552	3,361
B	16	18	11	11	11	11	11	11	2	3	176	189
C	43	48	1	11	35	45	24	23	14	16	1,042	1,124
D	47	47	2	23	55	33	32	32	21	21	1,490	1,502
E	3	6	6	13	13	13	9	13	0	1	26	78
F	31	47	13	12	33	33	29	19	13	13	914	900
									Total (s)		**7,200**	**7,153**
									Average Cycle Time (s)		**147**	**149**

Table 4.10 : Reid Street Intersection - Comparison of Simulated and Observed Phase Times (7:00am-9:00am)

Phase	Frequency		Minimum (s)		Maximum (s)		Average (s)		Average (%)		Total (s)	
	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.
A	100	101	5	39	70	108	46	46	63	61	4,557	4,636
B	0		0		0		0		0		0	
C	104	97	5	14	31	31	25	26	37	36	2,643	2,556
D	0		0		0		0		0		0	
										Total (s)	**7,200**	**7,192**
										Average Cycle Time (s)	**72**	**71**

Table 4.11 : Reid Street Intersection - Comparison of Simulated and Observed Phase Times (4:00pm-6:00pm)

Phase	Frequency		Minimum (s)		Maximum (s)		Average (s)		Average (%)		Total (s)	
	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.
A	89	88	3	41	122	122	55	55	68	68	4,912	4,836
B	0		0		0		0		0		0	
C	81	88	14	14	36	34	28	26	32	32	2,288	2,313
D	0		0		0		0		0		0	
										Total (s)	**7,200**	**7,149**
										Average Cycle Time (s)	**81**	**81**

Table 4.12 : Scotchmer Street Intersection - Comparison of Simulated and Observed Phase Times (7:00am-9:00am)

Phase	Frequency		Minimum (s)		Maximum (s)		Average (s)		Average (%)		Total (s)	
	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.
A	103	94	7	46	67	95	45	48	64	63	4,606	4,535
B	0		0		0		0		0		0	
C	98	95	2	16	34	34	26	28	36	37	2,594	2,642
D	0		0		0		0		0		0	
										Total (s)	**7,200**	**7,177**
										Average Cycle Time (s)	**70**	**76**

Table 4.13 : Scotchmer Street Intersection - Comparison of Simulated and Observed Phase Times (4:00pm-6:00pm)

Phase	Frequency		Minimum (s)		Maximum (s)		Average (s)		Average (%)		Total (s)	
	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.
A	83	82	8	56	108	116	59	60	69	68	4,936	4,912
B	0		0		0		0		0		0	
C	84	83	1	16	34	35	27	27	31	32	2,264	2,273
D	0		0		0		0		0		0	
									Total (s)		**7,200**	**7,184**
									Average Cycle Time (s)		**87**	**87**

Table 4.14 : Brunswick Road Intersection - Comparison of Simulated and Observed Phase Times (7:00am-9:00am)

Phase	Frequency		Minimum (s)		Maximum (s)		Average (s)		Average (%)		Total (s)	
	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.
A	79	81	4	29	85	38	31	31	34	35	2,421	2,515
B	0	0	0	0	0	0	0	0	0	0	0	0
C	13	9	12	11	13	11	12	11	2	1	157	99
D	64	65	12	11	25	17	15	13	14	12	978	867
E	73	81	6	15	47	36	29	29	29	32	2,115	2,329
F	24	-	10	-	28	-	14	-	5	-	328	-
G	66	81	5	10	31	19	18	17	17	19	1,201	1,374
									Total (s)		**7,200**	**7,184**
									Average Cycle Time (s)		**91**	**89**

Table 4.15 : Brunswick Road Intersection - Comparison of Simulated and Observed Phase Times (4:00pm-6:00pm)

Phase	Frequency		Minimum (s)		Maximum (s)		Average (s)		Average (%)		Total (s)	
	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.
A	75	74	1	39	66	39	39	39	41	40	2,916	2,886
B	0	0	0	0	0	0	0	0	0	0	0	0
C	12	9	2	11	13	11	11	11	2	2	133	99
D	57	62	12	11	25	17	15	13	12	11	880	812
E	76	75	5	17	51	36	31	30	33	31	2,355	2,254
F	39	-	4	-	23	-	11	-	6	-	428	-
G	37	75	8	10	19	15	13	15	7	16	488	1,112
									Total (s)		**7,200**	**7,162**
									Average Cycle Time (s)		**96**	**95**

Table 4.15: Signalised Intersections - Comparison of Simulated and Observed Pedestrian Actuations (7:00am-9:00am)

Phase	Number of actuations											
	Gertrude Street		Elgin Street		Alexandra Parade		Reid Street		Scotchmer Street		Brunswick Road	
	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.
P1	59	73	62	68	30	31	22	47	99	79	44	56
P2	76	85	65	66	36	42	18	32	100	79	30	42
P3	69	79	67	65	34	37	29	31	81	66	32	35
P4	n/a	n/a	63	68	38	42	58	64	81	66	61	58
P5	n/a	n/a	n/a	n/a	17	20	n/a	n/a	n/a	n/a	n/a	n/a

Table 4.16: Signalised Intersections - Comparison of Simulated and Observed Pedestrian Actuations (4:00pm-6:00pm)

Phase	Number of actuations											
	Gertrude Street		Elgin Street		Alexandra Parade		Reid Street		Scotchmer Street		Brunswick Road	
	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.
P1	64	57	64	53	33	25	34	38	85	79	53	42
P2	81	70	67	53	26	28	39	50	85	78	42	21
P3	73	64	68	53	38	28	34	18	65	53	31	18
P4	n/a	n/a	68	58	38	30	42	28	65	46	50	40
P5	n/a	n/a	n/a	n/a	27	28	n/a	n/a	n/a	n/a	n/a	n/a

Table 4.17: POS - Comparison of Simulated and Observed Pedestrian Actuations (7:00am-9:00am)

Phase	Number of actuations									
	Hannover Street		Bell Street		Kay Street		Freeman Street		Park Street	
	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.
P1	54	72	22	26	33	38	11	9	72	70
P2	26	25	29	31	17	15	17	20	n/a	n/a

Table 4.18: POS - Comparison of Simulated and Observed Pedestrian Actuations (4:00pm-6:00pm)

Phase	Number of actuations									
	Hannover Street		Bell Street		Kay Street		Freeman Street		Park Street	
	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.	IDM	Sim.
P1	34	38	42	46	27	26	25	21	74	70
P2	51	50	22	25	46	41	12	12	n/a	n/a

5. Options Assessment

5.1 Base-Case and Project Options

The base-case models against which the project options are to be compared, are the 2017 calibrated model discussed in the previous chapter.

Four project-case models have been created from the calibrated base-year (2017) models, comprising:

- **Option 1** – One model each for the AM and PM peak, where Nicholson Street is narrowed to one lane in each direction at tram stops 13/14[6], 14, 16, 17 and 18, with 2017 traffic demands;
- **Option 2** - One model each for the AM and PM peak, where Nicholson Street is posted at 40kph between Carlton Street and Brunswick Road, with 2017 traffic demands.

5.2 Future Model Development

5.2.1 Network Coding

To ensure that differences between the model results reflect the options under consideration, all network coding commenced with a copy of the base-year models, following which the proposed changes to the network were then coded in. This ensured that other than the changes directly associated with each of the options being tested, all elements of the model would be otherwise identical between all base-case and option models[7].

5.3 Network Performance Comparison

For the entire network included in the modelled area, Table 5.1 and Table 5.2 provide selected statistics which compare the performance of each option relative to current conditions.

This comparison shows that in terms of average delay, only Option 1 in the evening period shows any significant change from current conditions.

In respect to total travel time, Option 2 show the greatest increase over existing conditions. This result is expected, as the speed reduction along Nicholson Street will increase overall travel times even if delays do not change.

The network-wide statistics, while of interest, do tend to conceal any large but localised impacts of network changes, and a more detailed assessment of Nicholson Street travel times is contained in the next section.

[6] Stops 13 and 14 are consolidated into a single stop at Carlton Street under this scenario.
[7] Including signal operations, which have been left unaltered between the base-case and project options.

Table 5.1 : Average Network Statistics for AM Period (07:00-09:00)

Scenario	Average Delay (s/veh, all vehicles)	Total Travel Time (veh-hrs, all vehicles)	Total Vehicles	Latent Demand
Base Case	60	691	24,098	1
Option 1	60	729 (680*)	25,821	1
Option 2	60	746	24,095	1

* Value when normalised to base case vehicles

Table 5.2 : Average Network Statistics for PM Period (16:00-18:00)

Scenario	Average Delay (s/veh, all vehicles)	Total Travel Time (veh-hrs, all vehicles)	Total Vehicles	Latent Demand
Base Case	59	693	23,589	32
Option 1	65	732	23,660	32
Option 2	58	752	23,579	47

5.4 Nicholson Street Travel Times

As the focus of the study is on the impact of the options on traffic operations along Nicholson Street, the best single measure of impact is the before and after travel times along the sections of Nicholson Street between Gertrude Street and Brunswick Road. This comparison is presented graphically in Figure 5.1 to Figure 5.16 by direction and time period, over the course of each of the AM and PM peak periods.

We have analysed the modelled area of Nicholson Street by separately considering the major sections between signalised intersections, namely:

- Gertrude Street to Elgin Street;
- Elgin Street to Alexandra Parade;
- Alexandra Pare to Reid Street; and
- Reid Street to Brunswick Road.

5.4.1 Option 1

The travel time impacts arising from Option 1 vary considerably, depending on the time of day, and the section on Nicholson Street being considered.

During the morning period, the impacts are mostly insignificant, with two exceptions:

- Southbound traffic between Reid Street and Alexandra Parade show consistently higher travel times throughout the morning period. Closer inspection of the simulations show this is caused by the narrowing of the northern approach to the Nicholson Street/Alexandra Parade intersection, where the lane reduction adjacent to the new tram stop reduces one of the through lanes from a continuous lane to what is effectively a short lane. This reduces the capacity of this intersection approach; and
- Southbound traffic between Elgin Street and Gertrude Street also shown higher travel times from about 7:45 am onwards. This arises because of the combination of reduced traffic lanes at the new POS at Carlton Street, plus the increased pedestrian activity at this pedestrian crossing. In

modelling the new POS servicing the consolidated stops 13 and 14 at Carlton Street, we have assumed the pedestrian demand will be the sum of that currently occurring at Stop 13 (Hanover Street) and 14 (Bell Street). This reduces the green time to traffic movements at a location where there is a single through lane, substantially reducing the traffic capacity at this location compared to the base case.

For the afternoon period, there are three locations/times where Option 1 significantly increases travel times:

- Gertrude Street to Elgin Street, from about 4:45pm onwards;
- Elgin Street to Alexandra Parade through the afternoon period; and
- Reid Street to Alexandra Parade through most of the afternoon period.

In the first two cases, the situation is similar to that described for the morning period, that is, the combination of a single lane approach and a POS reduces stop-line capacity to create a mid-block bottleneck. The magnitude of the delays create at these locations is sensitive to the traffic demands, explaining why the impacts differ according to the time period and location.

In the third case noted above, again the situation is the same as for the morning peak – the conversion of a continuous through lane on the northern approach to a short lane reduces intersection capacity.

5.4.2 Option 2

Option 2 consistently shows higher travel times along all sections of Nicholson Street, during the morning and evening peak periods. This result is expected, as relative to the base case, this option involves a reduction in the posted speed limit to 40kph, with all else being equal.

We note that increased travel time does not necessarily equate to greater delay or congestion as a result of the speed reduction. In fact, the Figure 5.1 to Figure 5.16 show a very consistent increase in travel times relative to the base case across all time periods and road sections, where the line showing the Option 2 travel time closely parallels the corresponding line for the base case.

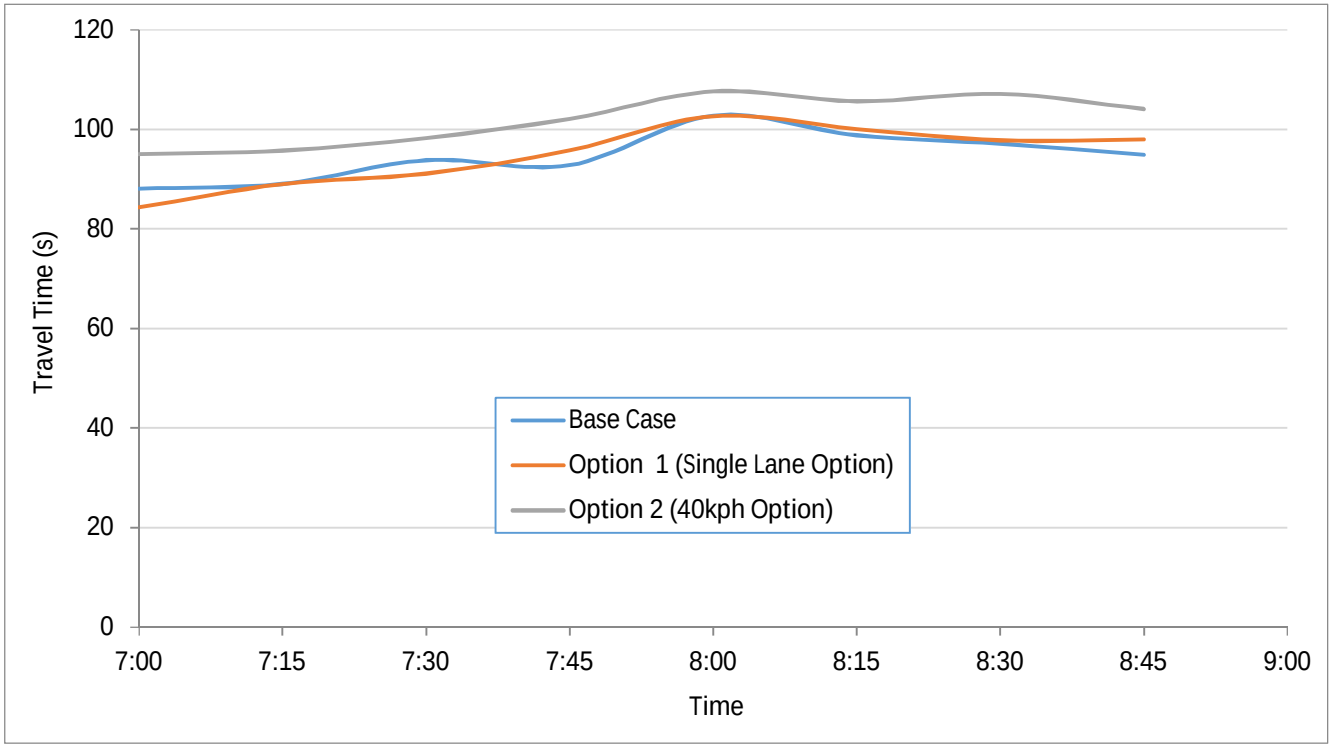

Figure 5.1 : Travel Times Gertrude Street to Elgin Street (AM Peak)

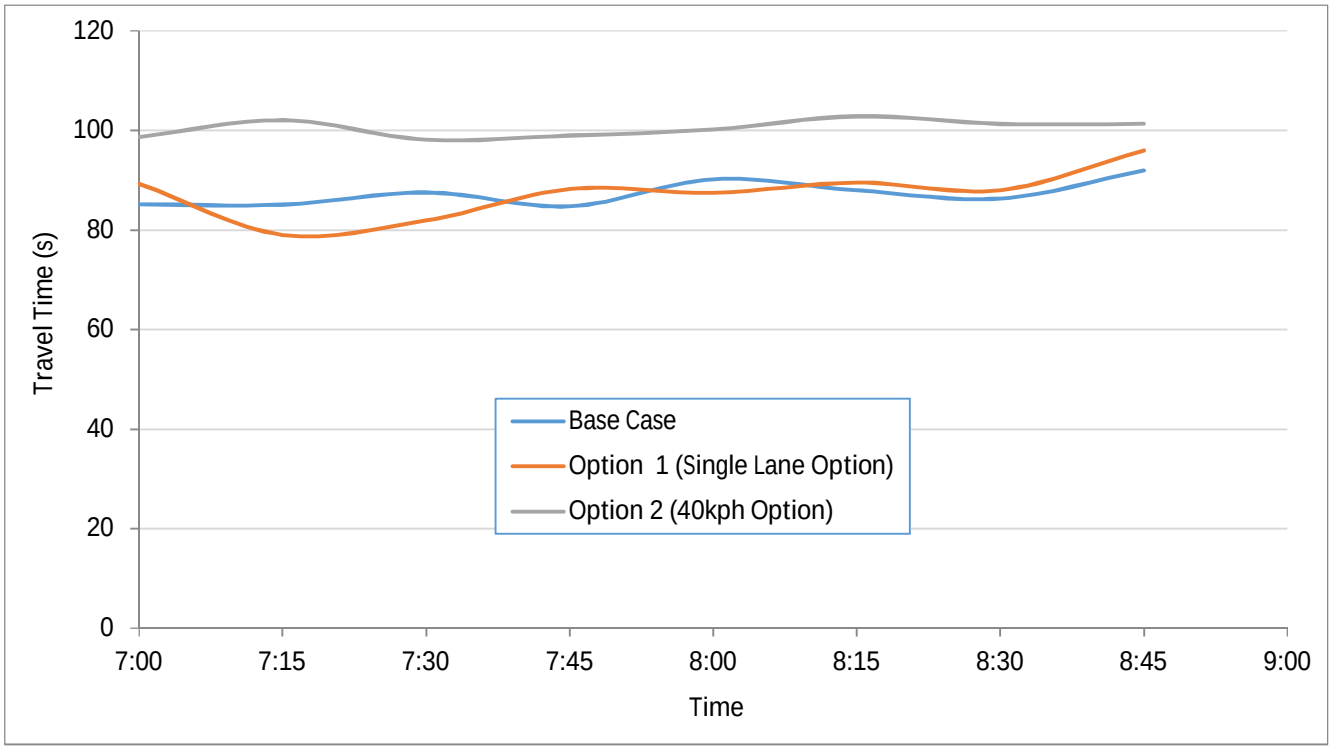

Figure 5.2 : Travel Times Elgin Street to Alexandra Parade (AM Peak)

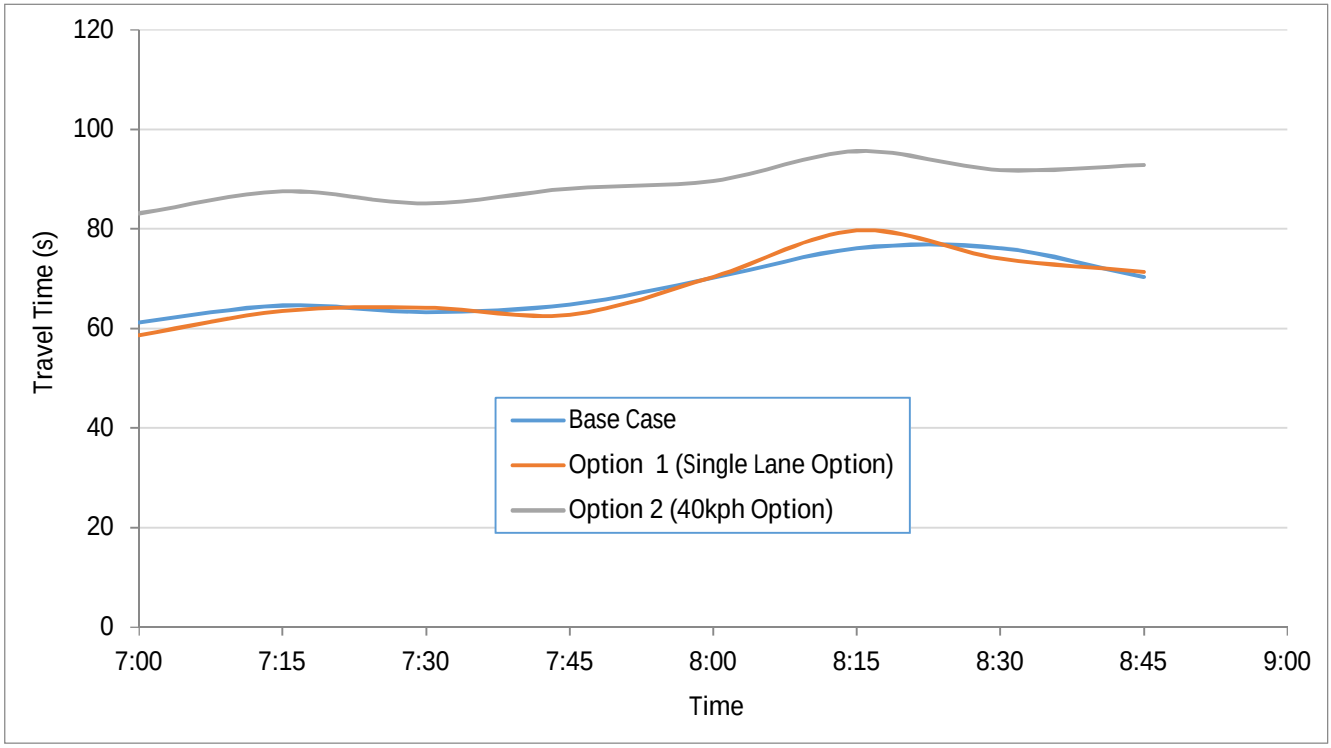

Figure 5.3 : Travel Times Alexandra Parade to Reid Street (AM Peak)

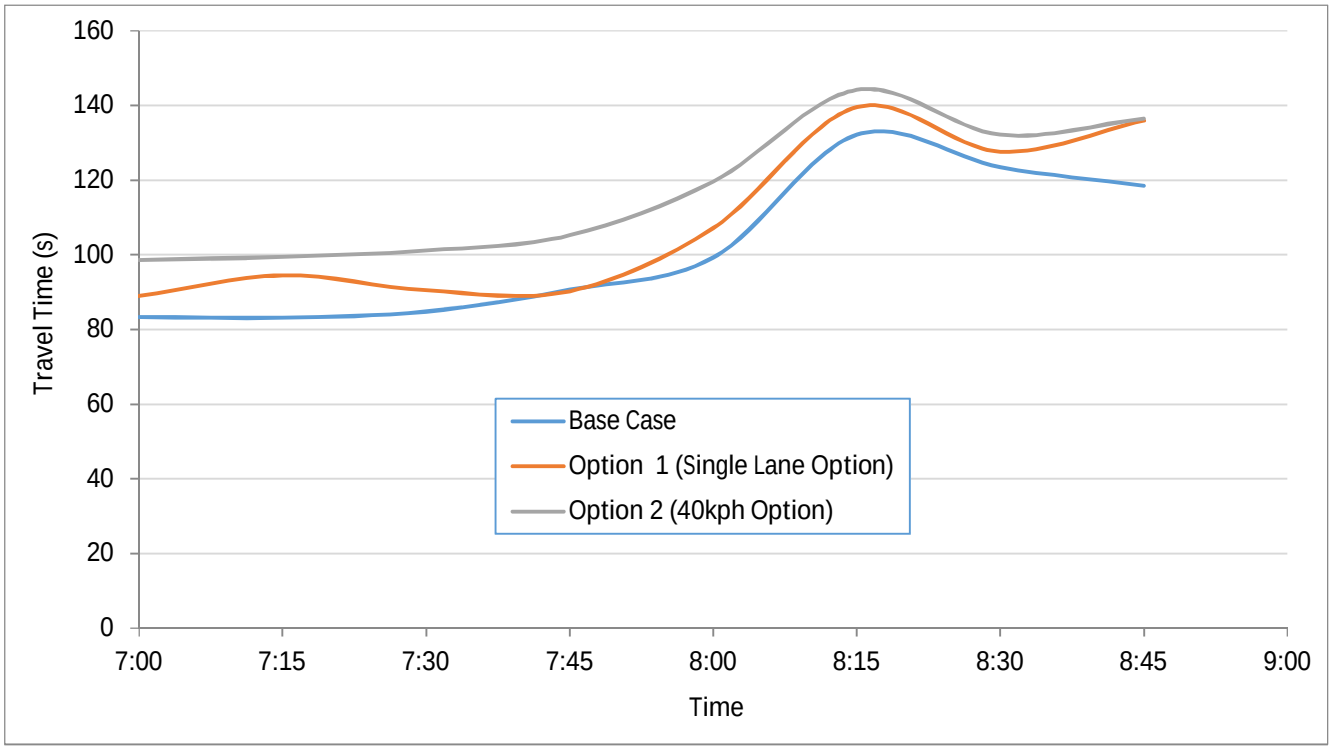

Figure 5.4 : Travel Times Reid Street to Brunswick Road (AM Peak)

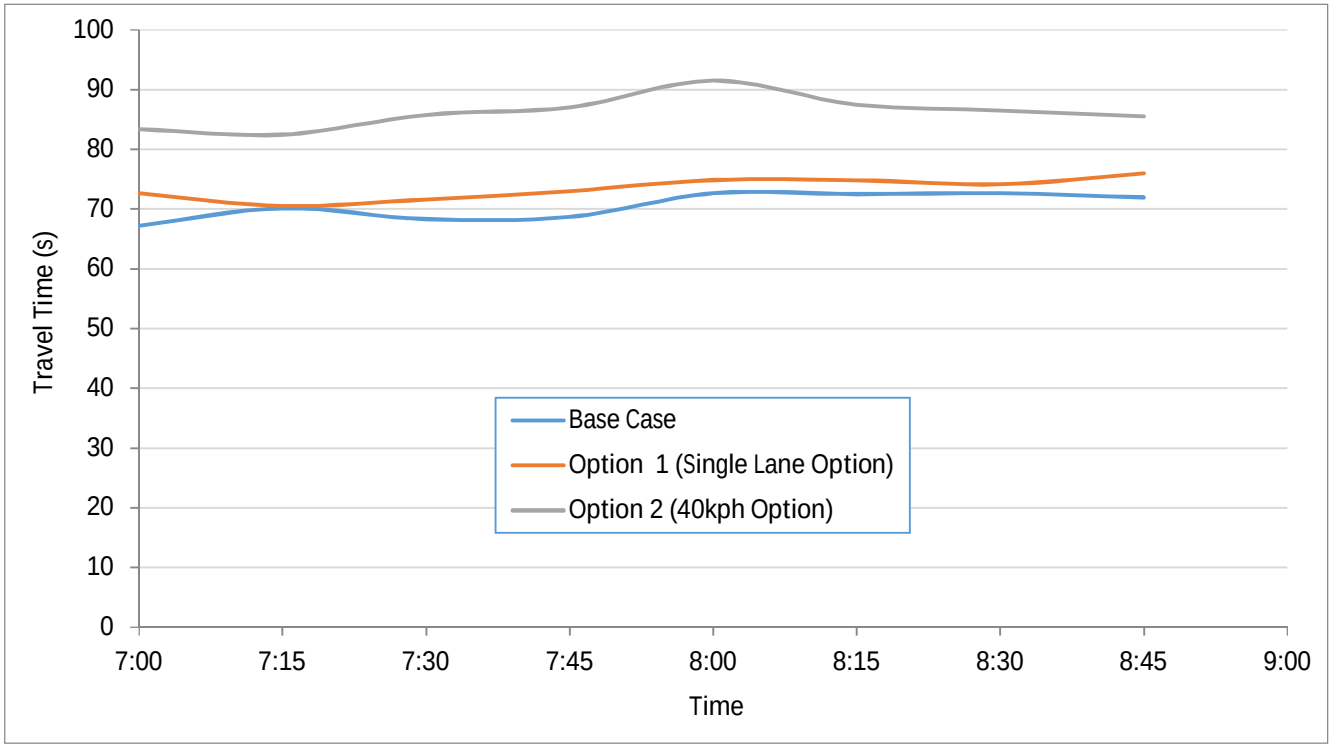

Figure 5.5 : Travel Times Brunswick Road to Reid Street (AM Peak)

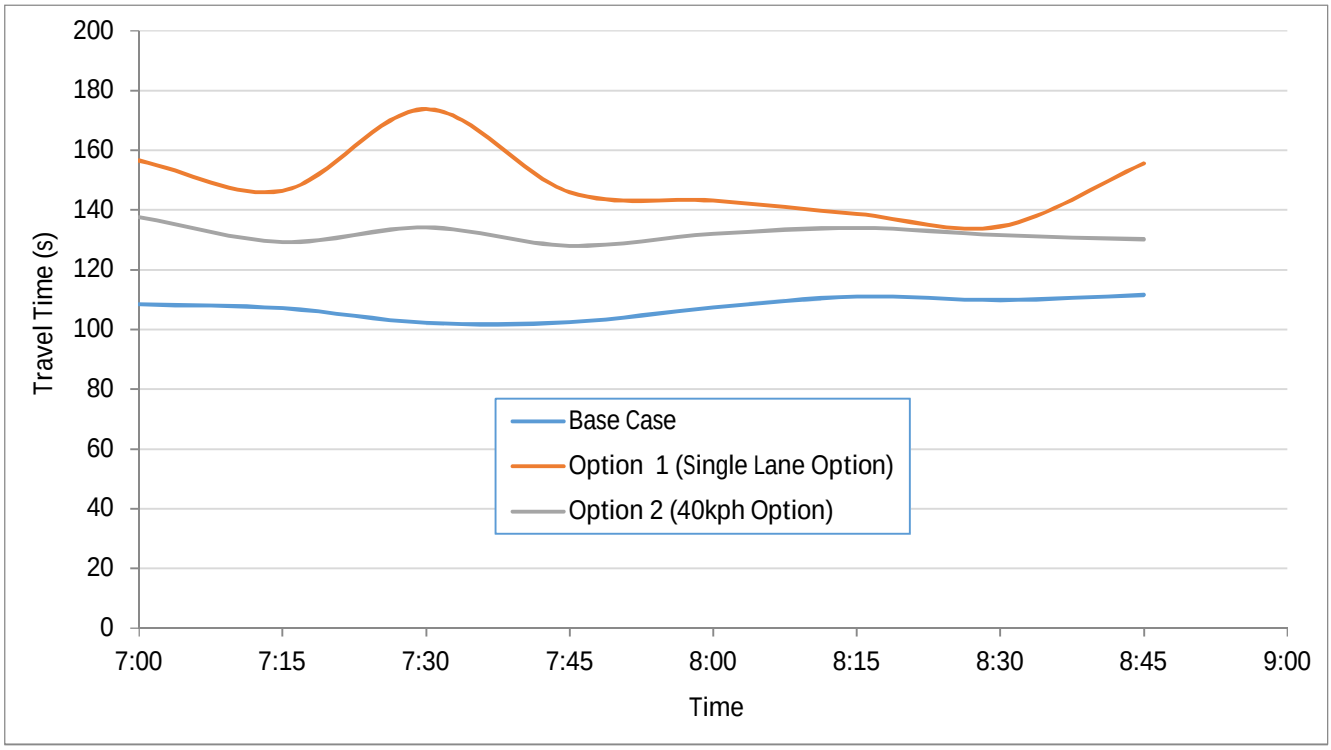

Figure 5.6 : Travel Times Reid Street to Alexandra Parade (AM Peak)

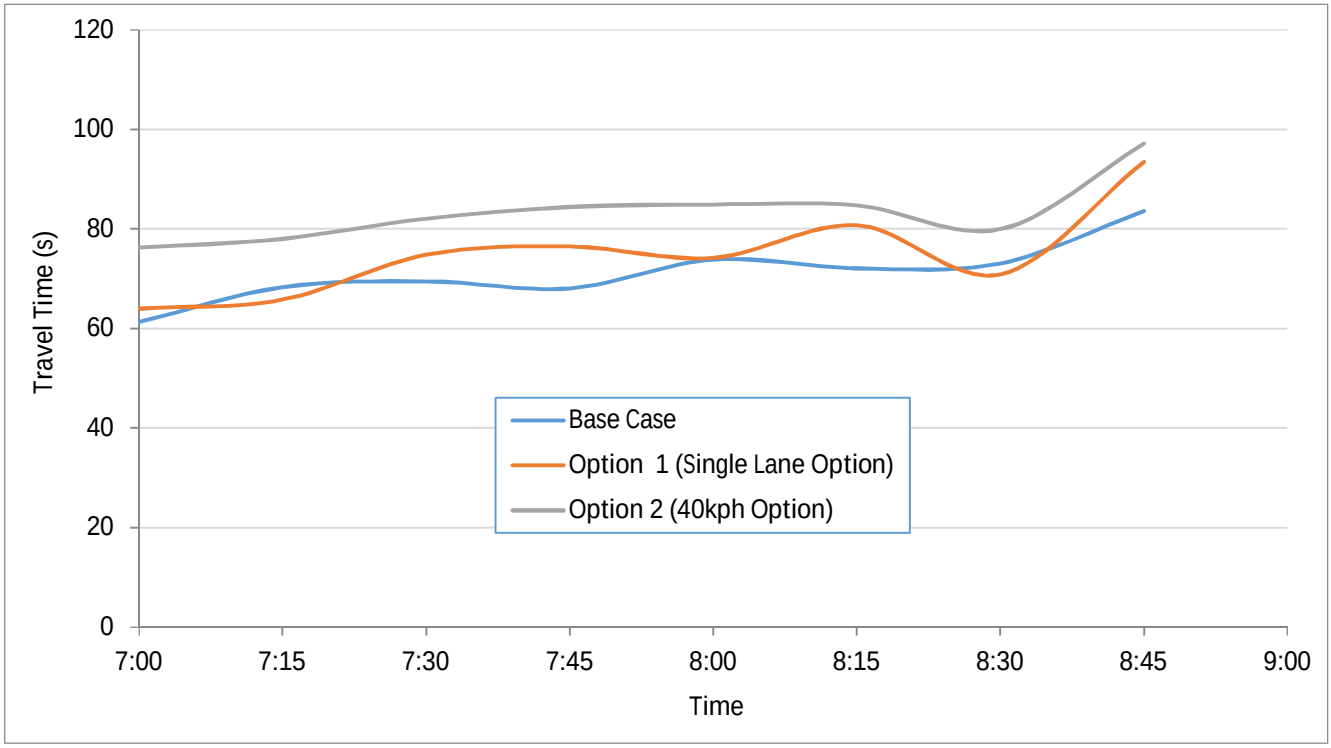

Figure 5.7 : Travel Times Alexandra Parade to Elgin Street (AM Peak)

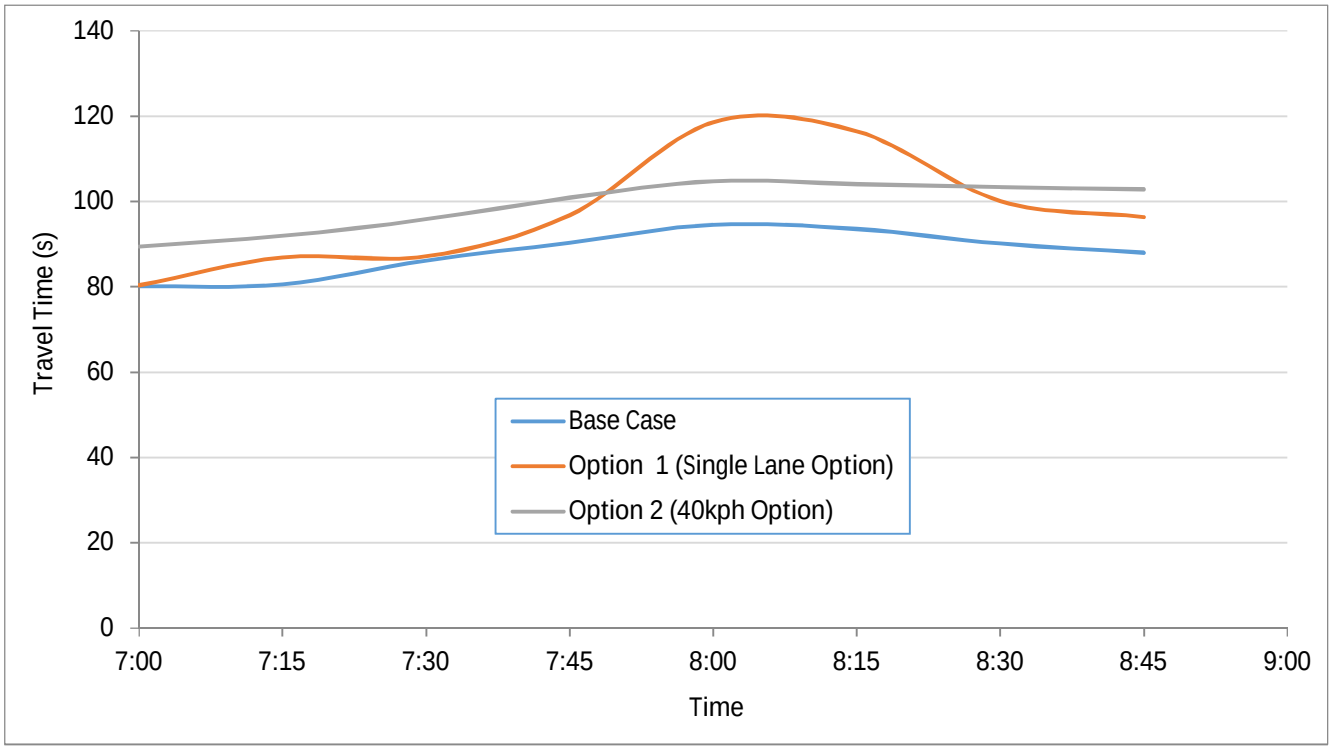

Figure 5.8 : Travel Times Elgin Street to Gertrude Street (AM Peak)

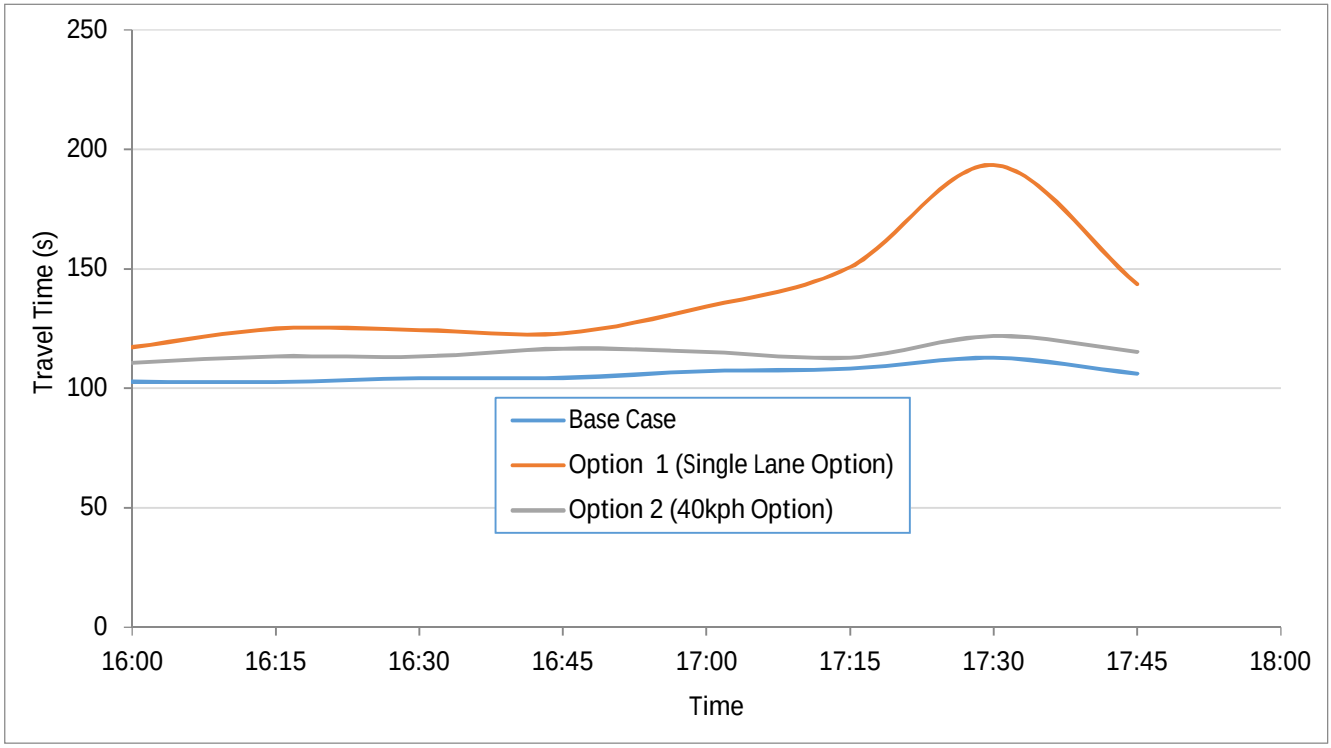

Figure 5.9 : Travel Times Gertrude Street to Elgin Street (PM Peak)

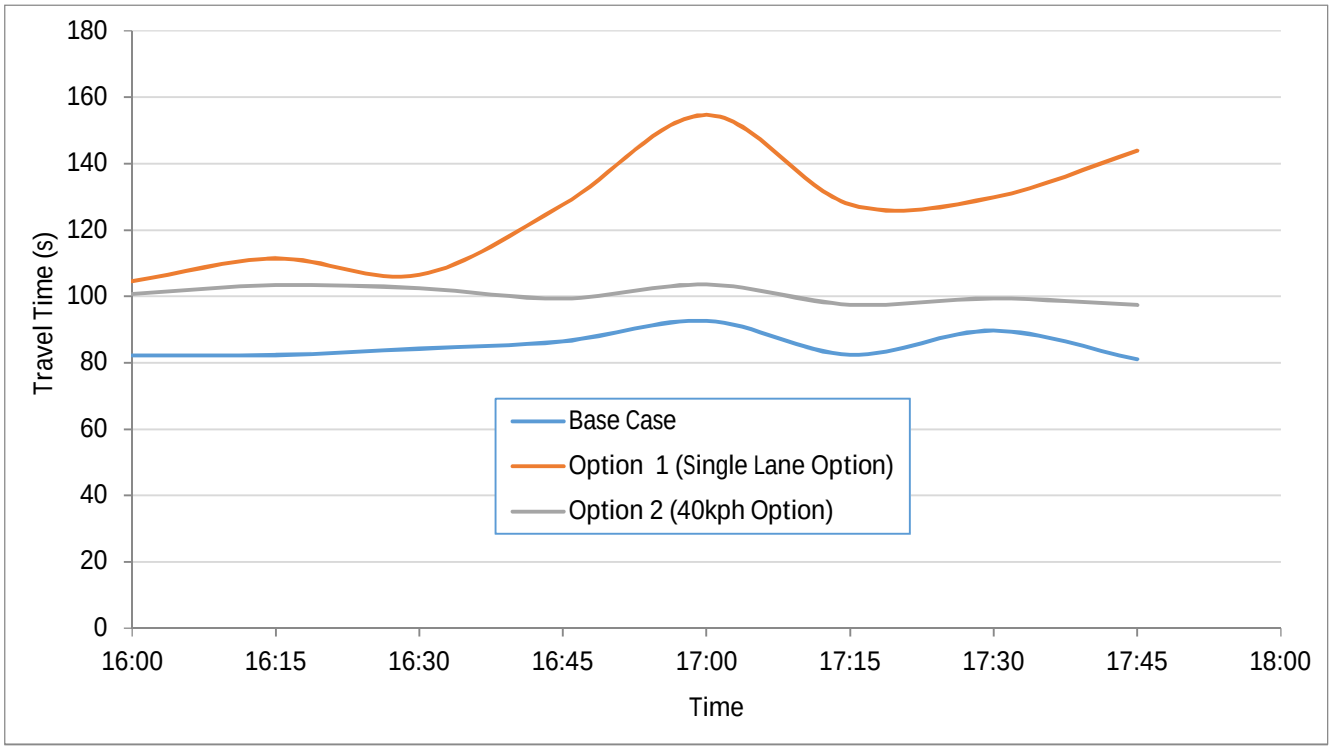

Figure 5.10 : Travel Times Elgin Street to Alexandra Parade (PM Peak)

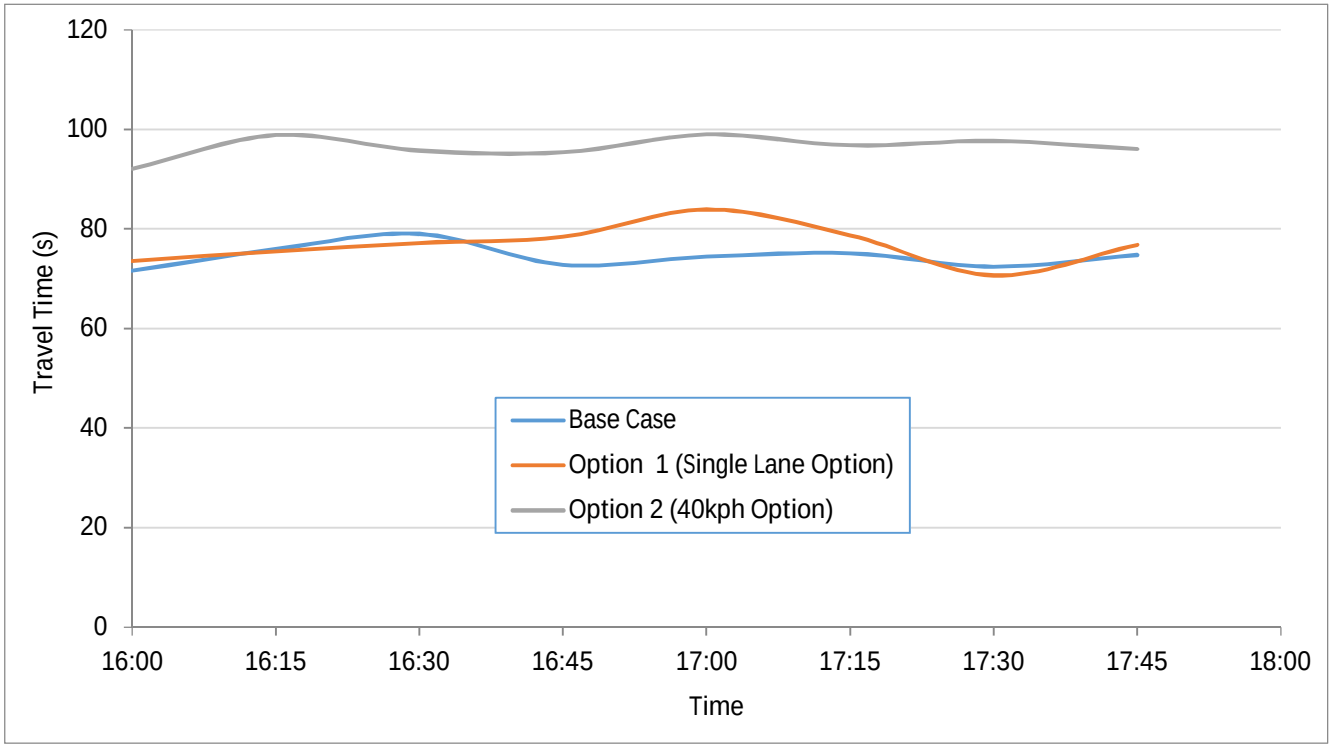

Figure 5.11 : Travel Times Alexandra Parade to Reid Street (PM Peak)

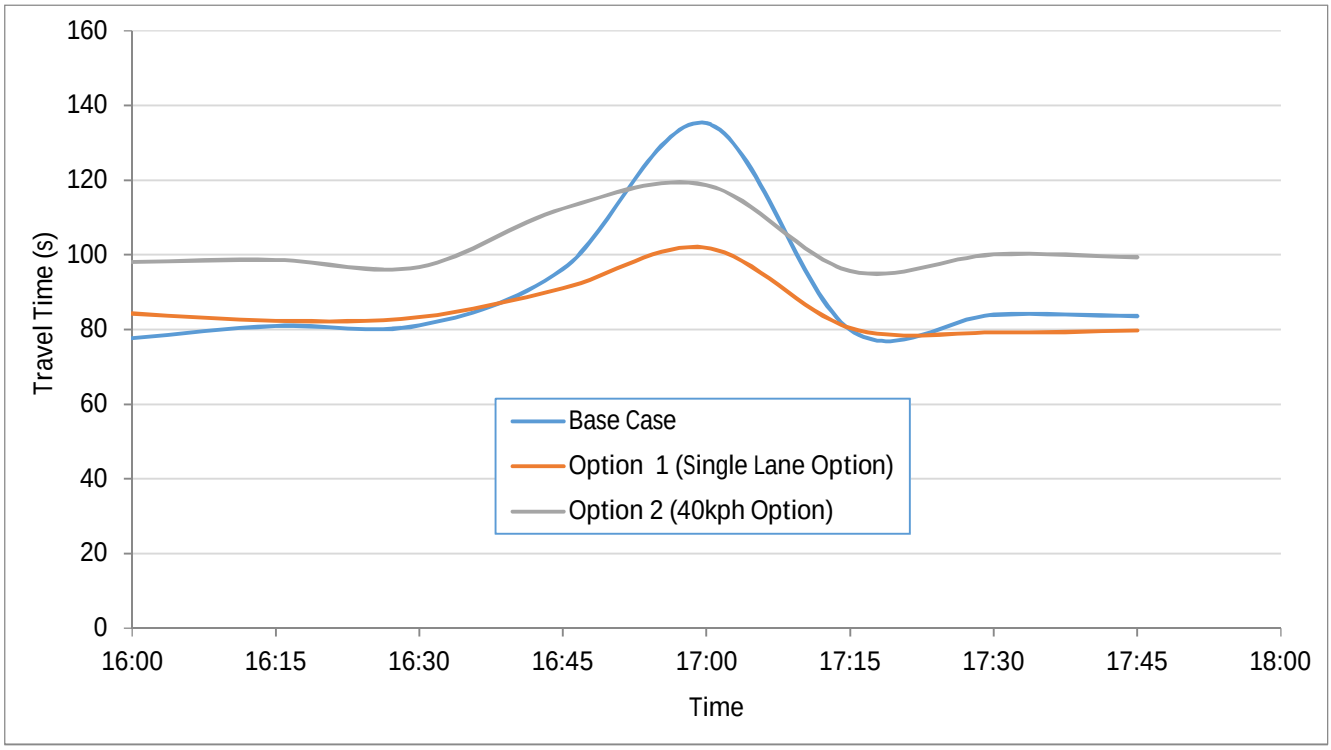

Figure 5.12 : Travel Times Reid Street to Brunswick Road (PM Peak)

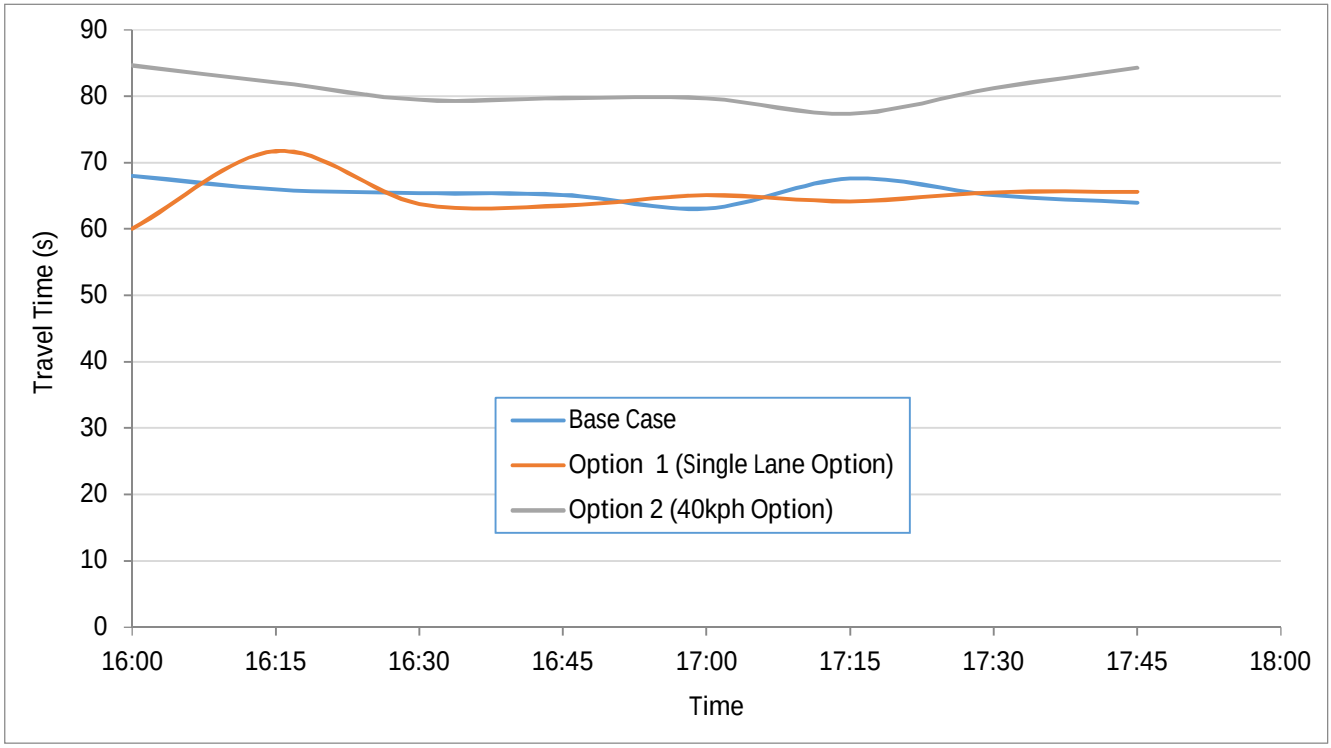

Figure 5.13 : Travel Times Brunswick Road to Reid Street (PM Peak)

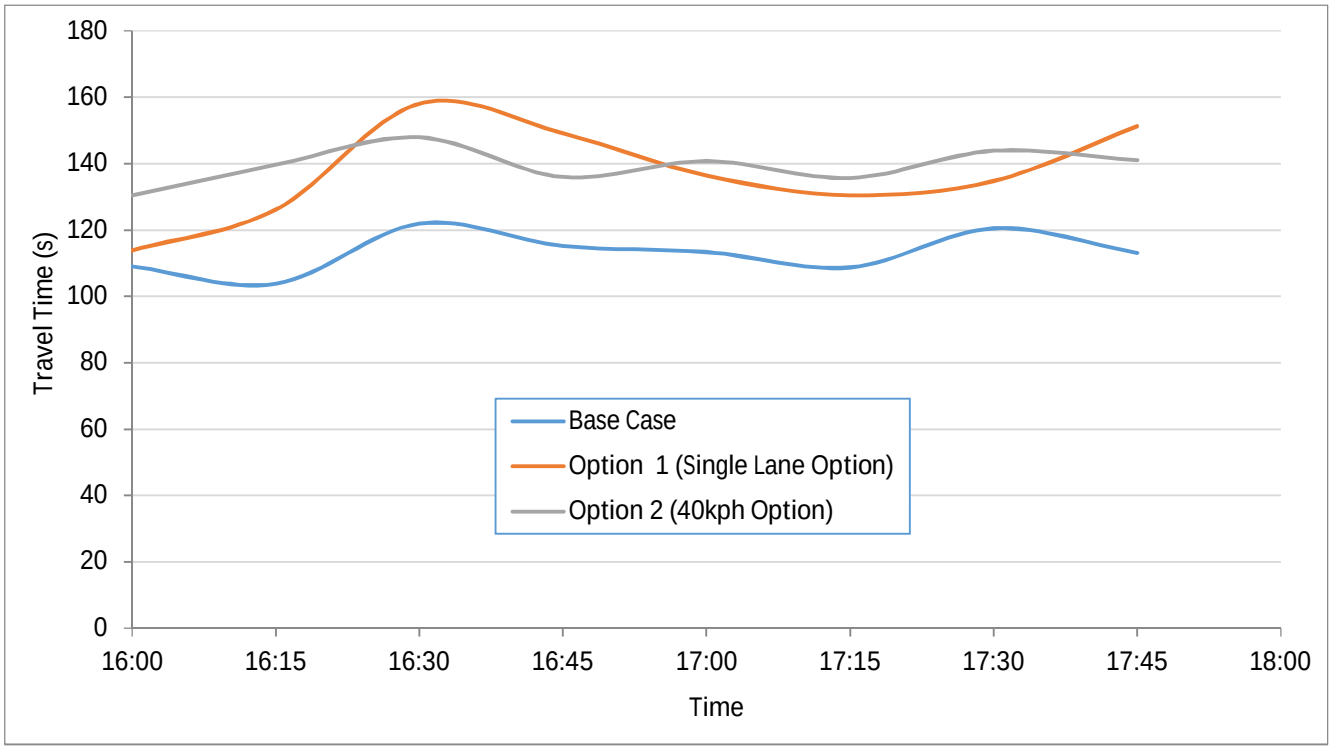

Figure 5.14 : Travel Times Reid Street to Alexandra Parade (PM Peak)

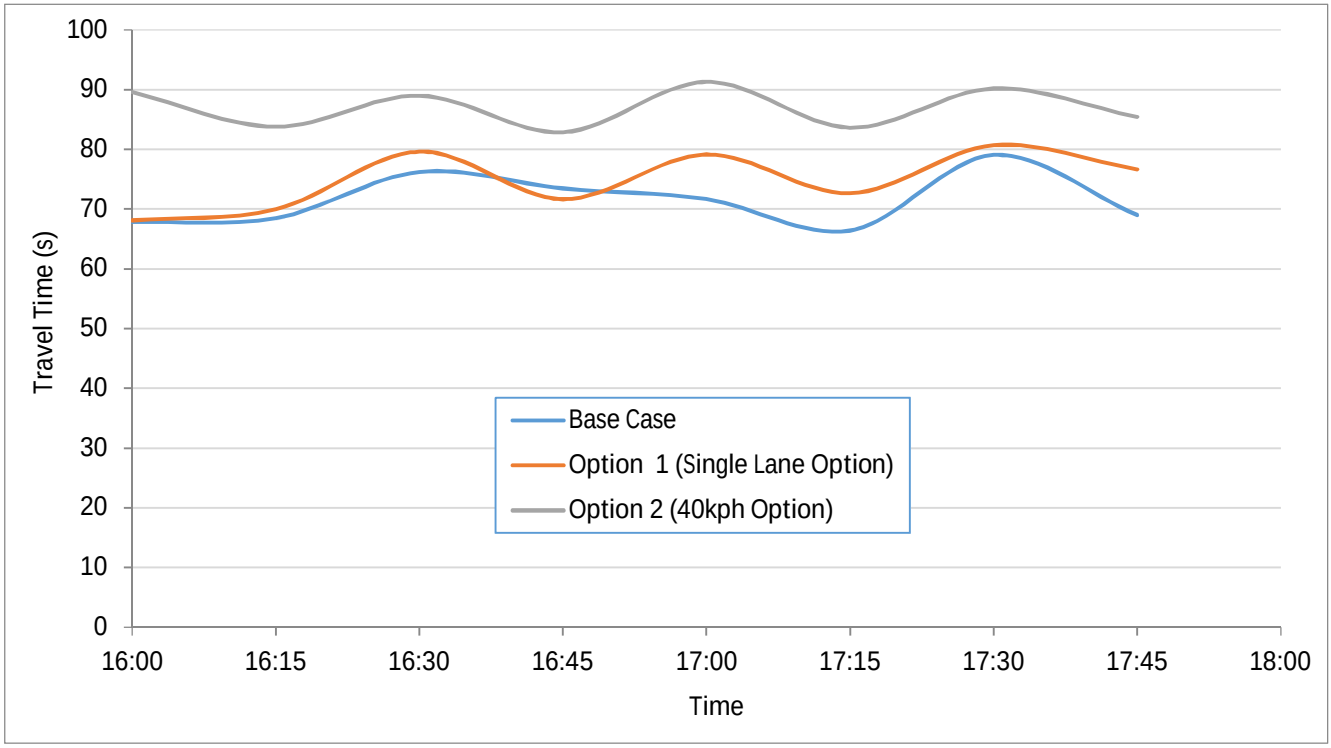

Figure 5.15 : Travel Times Alexandra Parade to Elgin Street (PM Peak)

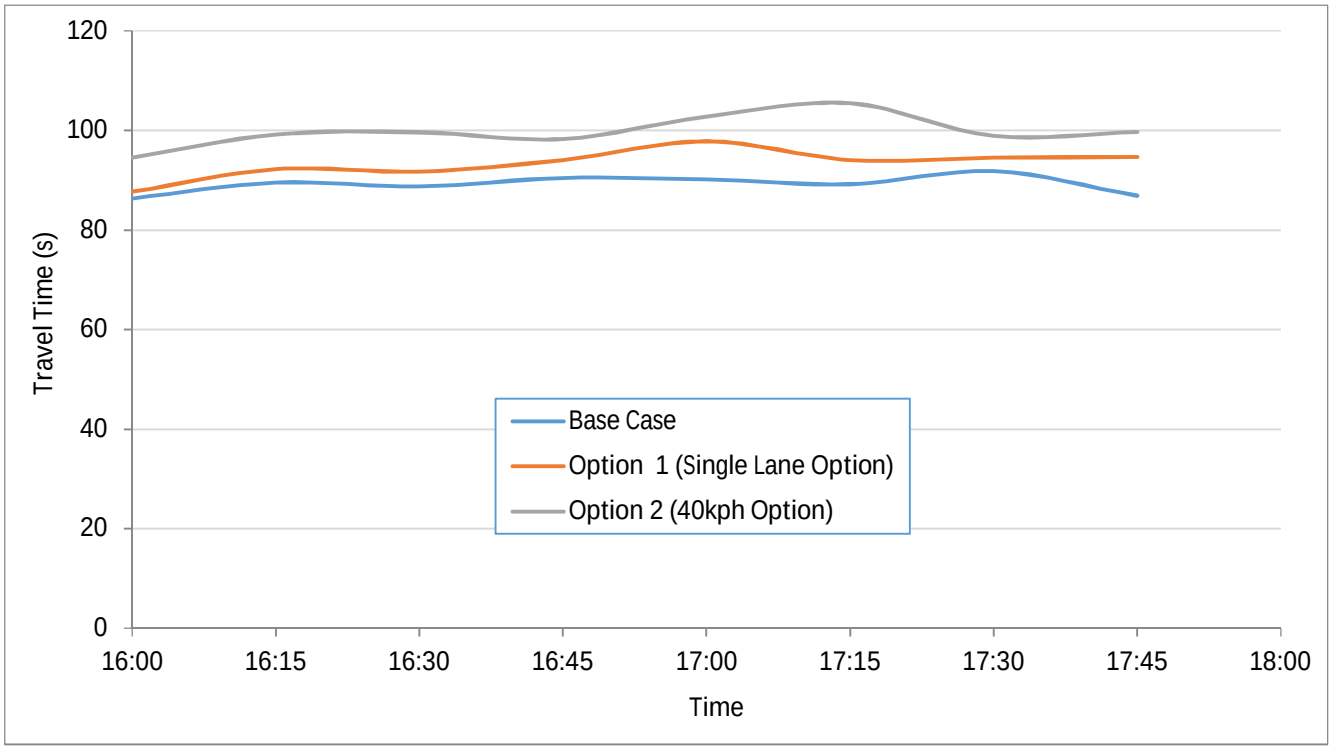

Figure 5.16 : Travel Times Elgin Street to Gertrude Street (PM Peak)

5.5 Option 1 Average Travel Times Along Nicholson Street

The net effect on average travel times along Nicholson Street for the entire modelled periods, is of particular interest to PTV, and this information is set out in Table 5.3 and Table 5.4, and graphically in Figure 5.17 to Figure 5.20.

The results repeat the patterns revealed in the previous sections, where travel time increases tend to be concentrated at specific locations, namely:

- The northern approach the Alexandra Parade (morning and afternoon period); and
- In the peak direction, during the morning and evening peak periods, at the pedestrian signals located at Carlton Street, and at Kay Street, due to the single lane at the stop-line.

Overall, travel time increases for the entire section of Nicholson Street between Gertrude Street and Reid Street are some 55s in the morning peak (or 21% over the base case), and up to 77s in the evening peak (or a 29% increase over the base case).

Table 5.3 : Average Travel Time Comparison for Option 1 (7:00-9:00)

Road Section	Direction	Minimum Travel Time (s)		Maximum Travel Time (s)		Average Travel Time (s)	
		Base Case	Option 1	Base Case	Option 1	Base Case	Option 1
Gertrude to Elgin	Northbound	76	82	116	105	95	95
	Southbound	70	80	110	130	88	98
Elgin to Alexandra	Northbound	55	74	123	99	87	87
	Southbound	45	61	107	95	71	75
Alexandra to Reid	Northbound	54	58	93	81	68	68
	Southbound	84	113	130	199	107	149
Total	Northbound	185	214	332	285	250	250
	Southbound	200	253	347	424	267	322

Table 5.4 : Average Travel Time Comparison for Option 1 (16:00-18:00)

Road Section	Direction	Minimum Travel Time (s)		Maximum Travel Time (s)		Average Travel Time (s)	
		Base Case	Option 1	Base Case	Option 1	Base Case	Option 1
Gertrude to Elgin	Northbound	90	115	127	202	106	139
	Southbound	73	84	110	102	89	93
Elgin to Alexandra	Northbound	59	93	111	180	85	126
	Southbound	46	63	104	89	72	75
Alexandra to Reid	Northbound	59	68	104	90	74	77
	Southbound	87	111	148	180	113	138
Total	Northbound	209	276	341	472	265	342
	Southbound	206	257	362	370	274	306

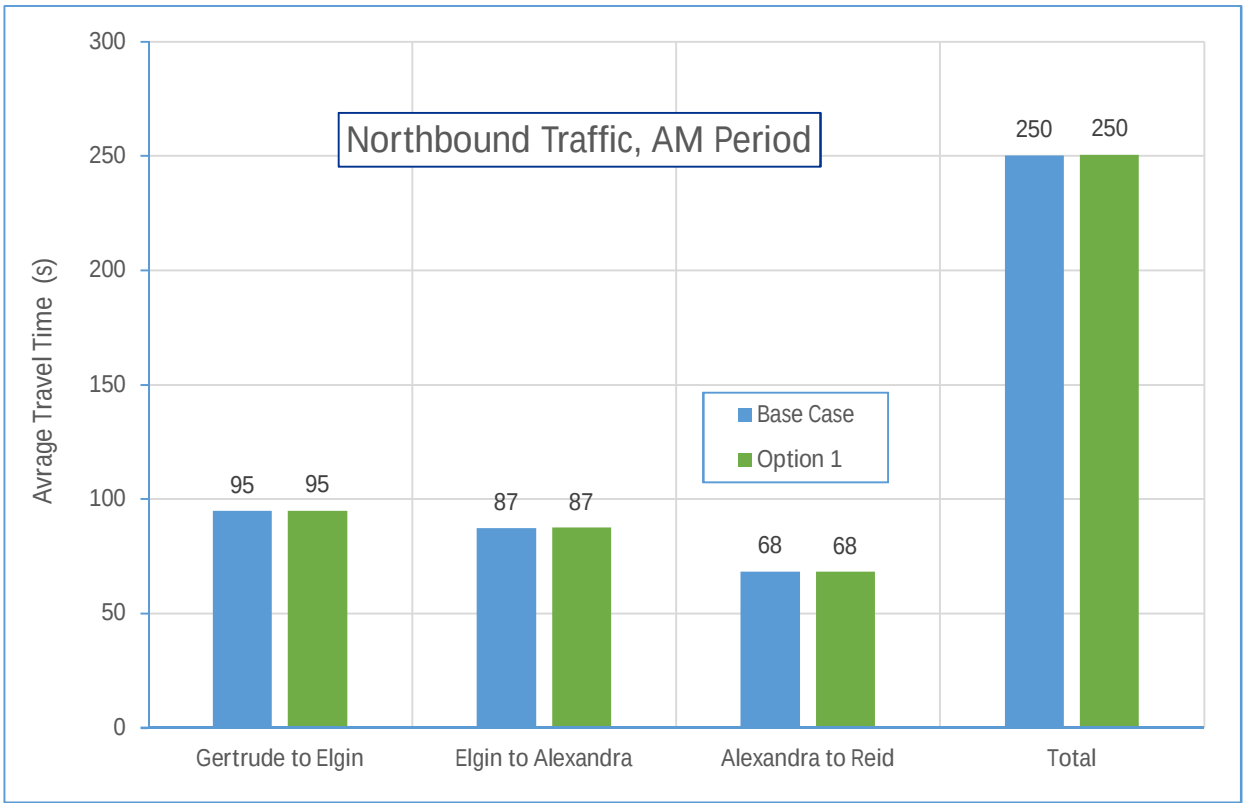

Figure 5.17 : Nicholson Street Average Travel Time Comparison for Option 1 (7:00-9:00, Northbound)

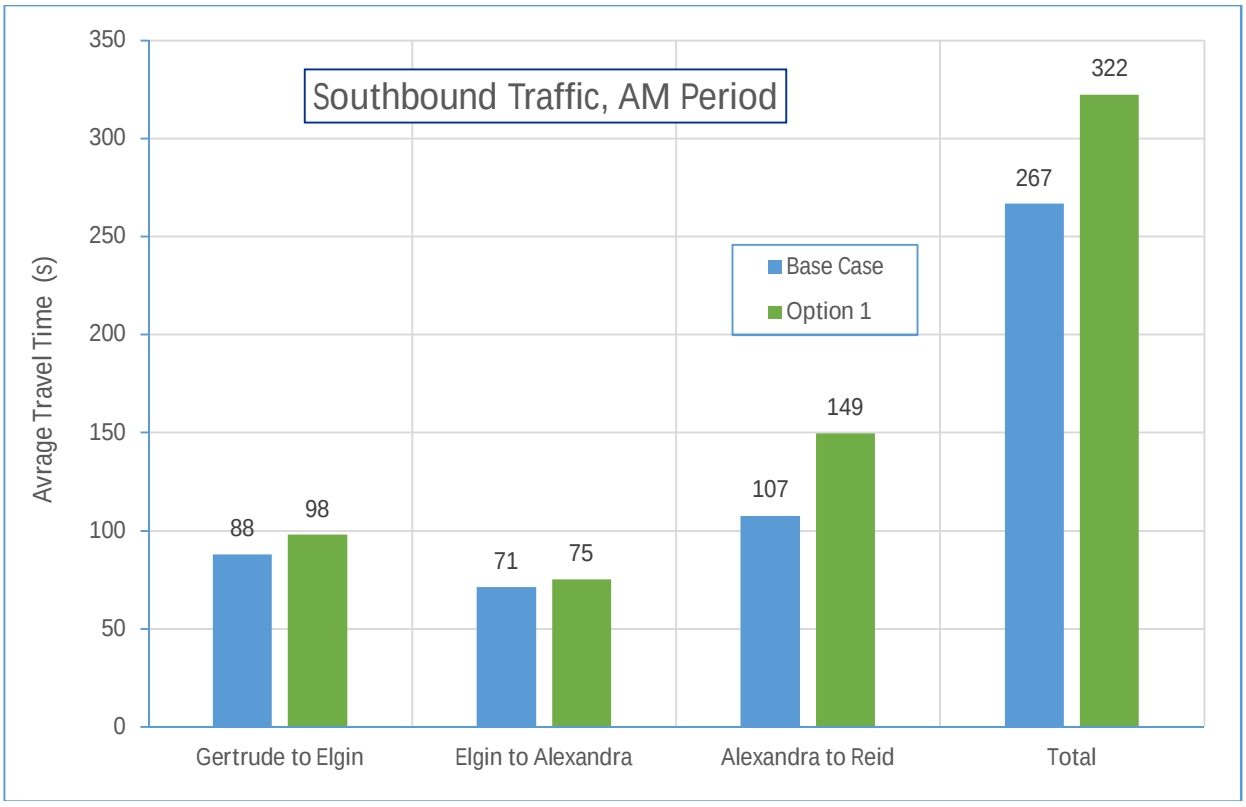

Figure 5.18 : Nicholson Street Average Travel Time Comparison for Option 1 (7:00-9:00, Southbound)

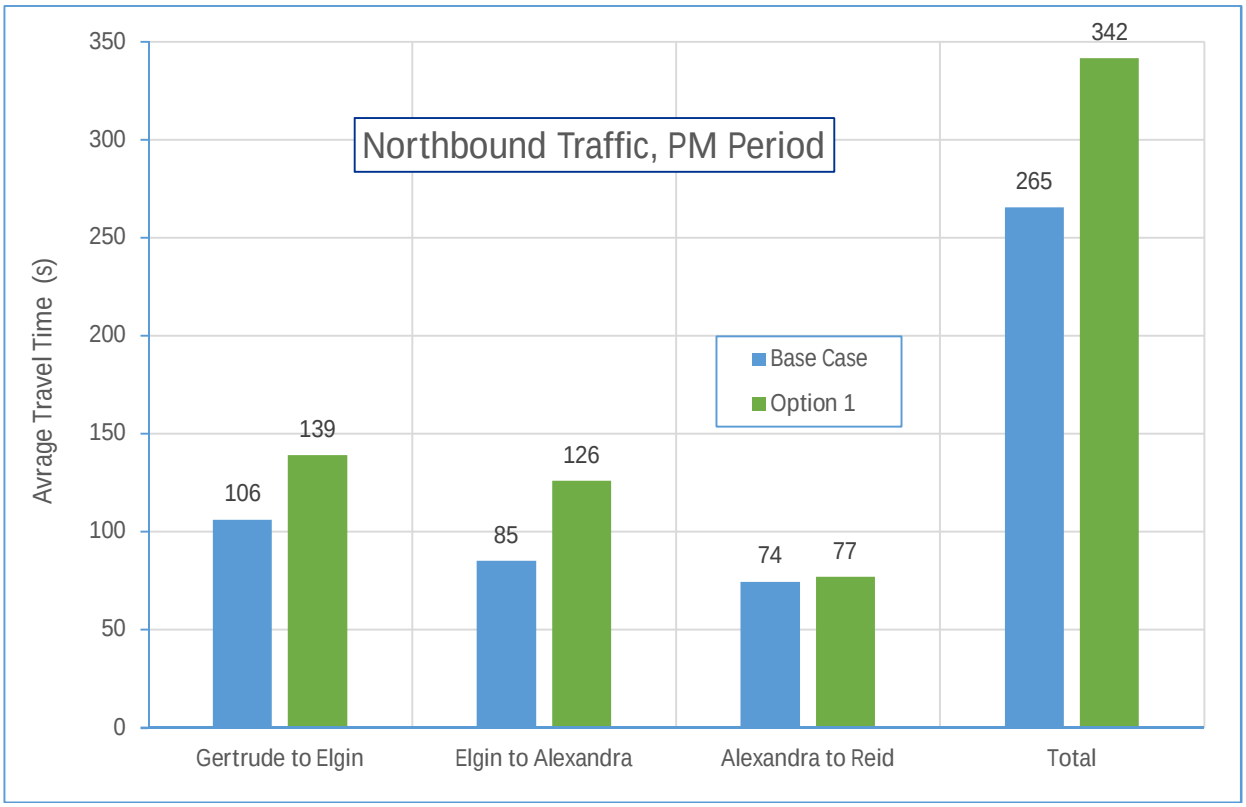

Figure 5.19 : Nicholson Street Average Travel Time Comparison for Option 1 (16:00-18:00, Northbound)

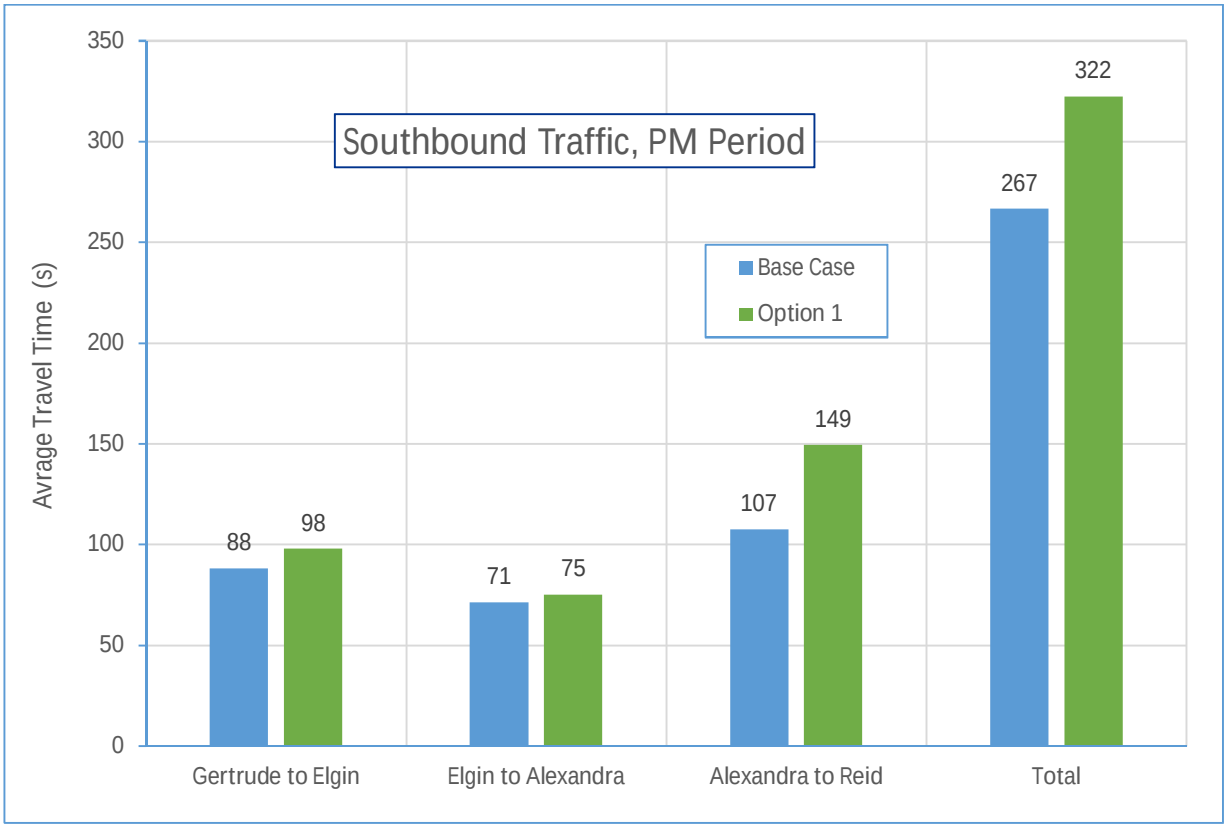

Figure 5.20 : Nicholson Street Average Travel Time Comparison for Option 1 (16:00-18:00, Southbound)

6. Conclusions

Given the results of the simulation modelling, we conclude that:

1) Both Option 1 and Option 2 will result in increased travel times along Nicholson Street during the morning and evening periods;
2) The impacts associated with Option 1 are concentrated at particular locations and time periods, namely:
   - On the northern approach the Nicholson Street/Alexandra Avenue intersection (Stop 17), the reduction of what is presently a continuous through lane to a short lane reduces stop-line capacity. The impact at this location occurs throughout the entire morning and afternoon periods;
   - At the new, consolidated tram stop at Carlton Street (Stop 13/14), where the combination of a single lane, the operation of the pedestrian signals, and the increase in pedestrian demand, combine to reduce the capacity at this location. The impact at this location is significant for about an hour in the *peak direction only* in each of the morning and afternoon periods; and
   - At the new tram stop near Kay Street (Stop 16), where (similar to Carlton Street) a single lane approach to a mid-block POS creates a capacity restriction. The impact at this location occurs in the peak direction from about 4:40 pm onwards.
3) In the case of Option 2, there are consistent and even travel time increase across all time periods and all sections of Nicholson Street[8]. These travel time impacts would likely be perceived quite differently by motorists, as they arise from changes to ambient travel speeds rather than from capacity restrictions and the associated queueing and stop-start driving conditions.
4) The impacts of Option 1 could be mitigated, at least in part, through careful design of the newly created pedestrian signals. For example, increasing the time to respond to pedestrian calls, and coordination with adjacent signals, would increase traffic capacity, although this would be at the expense of pedestrian levels of service; and
5) A further impact of the new tram stop just north of Alexandra Parade is that uncoordinated operation of the POS leads to queuing along Nicholson Street through the intersection. This installation would need to be coordinated with the Nicholson Street/Alexandra Parade signals to avoid this condition.

[8] With the exception of the section from Gertrude Street and Carlton Street, where the speed limit is currently set at 40 kph.

Site: 4426 Thursday, 21 March 2019 Traffic Flow filename:CA1_20190321.VS

Thursday, 21 March 2019

Approach 1, Detector: 1

	01:	02:	03:	04:	05:	06:	07:	08:	09:	10:	11:	12:
	57	27	13	16	15	57	184	210	201	256	249	303
Hourly Total	57	27	13	16	15	57	184	210	201	256	249	303

AM Total: 1588 AM peak 303 11:00 - 12:00

	13:	14:	15:	16:	17:	18:	19:	20:	21:	22:	23:	24:
	322	368	357	494	577	604	469	373	363	307	329	266
Hourly Total	322	368	357	494	577	604	469	373	363	307	329	266

PM Total: 4829 PM peak 604 17:00 - 18:00

Daily Total 6417

Approach 2, Detector: 2

	01:	02:	03:	04:	05:	06:	07:	08:	09:	10:	11:	12:
	106	68	38	32	43	102	219	216	221	249	285	282
Hourly Total	106	68	38	32	43	102	219	216	221	249	285	282

AM Total: 1861 AM peak 285 10:00 - 11:00

	13:	14:	15:	16:	17:	18:	19:	20:	21:	22:	23:	24:
	282	328	280	317	355	329	287	271	349	328	396	275
Hourly Total	282	328	280	317	355	329	287	271	349	328	396	275

PM Total: 3797 PM peak 396 22:00 - 23:00

Daily Total 5658

Approach 3, Detector: 3

	01:	02:	03:	04:	05:	06:	07:	08:	09:	10:	11:	12:
	36	22	15	9	32	122	396	526	521	443	357	302
Hourly Total	36	22	15	9	32	122	396	526	521	443	357	302

AM Total: 2781 AM peak 526 07:00 - 08:00

	13:	14:	15:	16:	17:	18:	19:	20:	21:	22:	23:	24:
	343	346	407	483	518	621	464	354	263	257	200	135
Hourly Total	343	346	407	483	518	621	464	354	263	257	200	135

PM Total: 4391 PM peak 621 17:00 - 18:00

Daily Total 7172

Approach 4, Detector: 4

	01:	02:	03:	04:	05:	06:	07:	08:	09:	10:	11:	12:
	61	45	37	31	58	148	321	356	350	317	305	329
Hourly Total	61	45	37	31	58	148	321	356	350	317	305	329

AM Total: 2358 AM peak 356 07:00 - 08:00

	13:	14:	15:	16:	17:	18:	19:	20:	21:	22:	23:	24:
	295	338	348	314	316	375	339	308	269	240	212	152
Hourly Total	295	338	348	314	316	375	339	308	269	240	212	152

PM Total: 3506 PM peak 375 17:00 - 18:00

Daily Total 5864

Approach 5, Detector: 5

	01:	02:	03:	04:	05:	06:	07:	08:	09:	10:	11:	12:
	3	4	0	0	4	6	31	33	53	31	24	24
Hourly Total	3	4	0	0	4	6	31	33	53	31	24	24

AM Total: 213 AM peak 53 08:00 - 09:00

	13:	14:	15:	16:	17:	18:	19:	20:	21:	22:	23:	24:
	22	21	21	39	20	102	112	57	36	29	25	10
Hourly Total	22	21	21	39	20	102	112	57	36	29	25	10

PM Total: 494 PM peak 112 18:00 - 19:00

Daily Total 707

Approach 6, Detector: 6

	01:	02:	03:	04:	05:	06:	07:	08:	09:	10:	11:	12:
	7	3	2	3	8	14	74	51	76	63	45	31
Hourly Total	7	3	2	3	8	14	74	51	76	63	45	31

AM Total: 377 AM peak 76 08:00 - 09:00

	13:	14:	15:	16:	17:	18:	19:	20:	21:	22:	23:	24:
	34	24	40	67	62	176	203	105	93	51	49	24
Hourly Total	34	24	40	67	62	176	203	105	93	51	49	24

PM Total: 928 PM peak 203 18:00 - 19:00

Daily Total 1305

Approach 7, Detector: 7

	01:	02:	03:	04:	05:	06:	07:	08:	09:	10:	11:	12:
	7	0	1	2	6	16	42	76	115	95	76	89
Hourly												

Total	7	0	1	2	6	16	42	76	115	95	76	89

AM Total: 525 AM peak 115 08:00 - 09:00

	13:	14:	15:	16:	17:	18:	19:	20:	21:	22:	23:	24:
	100	112	157	201	169	211	187	130	75	52	38	24
Hourly Total	100	112	157	201	169	211	187	130	75	52	38	24

PM Total: 1456 PM peak 211 17:00 - 18:00

Daily Total 1981

Approach 8, Detector: 8

	01:	02:	03:	04:	05:	06:	07:	08:	09:	10:	11:	12:
	2	0	0	0	0	4	7	11	8	10	7	8
Hourly Total	2	0	0	0	0	4	7	11	8	10	7	8

AM Total: 57 AM peak 11 07:00 - 08:00

	13:	14:	15:	16:	17:	18:	19:	20:	21:	22:	23:	24:
	8	8	8	10	10	8	9	8	4	4	2	4
Hourly Total	8	8	8	10	10	8	9	8	4	4	2	4

PM Total: 83 PM peak 10 15:00 - 16:00

Daily Total 140

Approach 9, Detector: 9

	01:	02:	03:	04:	05:	06:	07:	08:	09:	10:	11:	12:
	2	0	0	0	0	4	7	11	7	11	7	8
Hourly Total	2	0	0	0	0	4	7	11	7	11	7	8

AM Total: 57 AM peak 11 07:00 - 08:00

	13:	14:	15:	16:	17:	18:	19:	20:	21:	22:	23:	24:
	9	8	8	11	10	8	9	8	5	5	2	4
Hourly Total	9	8	8	11	10	8	9	8	5	5	2	4

PM Total: 87 PM peak 11 15:00 - 16:00

Daily Total 144

Approach 10, Detector: 10

	01:	02:	03:	04:	05:	06:	07:	08:	09:	10:	11:	12:
	0	0	0	0	0	0	0	0	0	0	0	0
Hourly Total	0	0	0	0	0	0	0	0	0	0	0	0

	13:	14:	15:	16:	17:	18:	19:	20:	21:	22:	23:	24:

	0	0	0	0	0	0	0	0	0	0	0	0
Hourly Total	0	0	0	0	0	0	0	0	0	0	0	0

Daily Total	0