NZ TRANSPORT AGENCY
WAKA KOTAHI

Roads of national significance

16 20 Western Ring Route – Waterview Connection

Operational Model Validation Report

Beca

newzealand.govt.nz

Quality Assurance Statement

Prepared by: Catherine Rochford, Senior Transportation Planner (Beca) / Reena Solanki, Senior Transportation Engineer (Beca)

Reviewed by: Andrew Murray , Technical Director – Transportation (Beca)

Approved for Release : Amelia Linzey , Technical Director – Planning (Beca)

NZ Transport Agency

Contents

Appendices

Executive Summary

In 2009 the NZ Transport Agency (NZTA) confirmed its intention that the 'Waterview Connection Project' would be lodged with the Environmental Protection Authority as a Proposal of National Significance. The Project includes works previously investigated and developed as two separate projects: being the SH16 Causeway Project and the SH20 Waterview Connection. The key elements of the Waterview Connection Project are:

- Completing the Western Ring Route (which extends from Manukau to Albany via Waitakere);
- Improving resilience of the SH16 causeway between the Great North Road and Rosebank Interchanges to correct historic subsidence and "future proof" it against sea level rise;
- Providing increased capacity on the SH16 corridor (between the St Lukes and Te Atatu Interchanges);
- Providing a new section of SH20 (through a combination of surface and tunnelled road) between the Great North Road and Maioro Street Interchanges; and
- Providing a cycleway throughout the surface road elements of the Waterview Connection Project corridor.

This report details the development and validation of the updated operational model developed for the assessment of the Waterview Connection project. The model is part of a hierarchy of models used for the project, comprising of the Auckland Regional Council's (ARC) multi-modal strategic demand model, a detailed traffic assignment model (reported separately), and a localised operational model for more detailed consideration of design and operational issues (the subject of this report).

The scale of this project requires assessment of both the strategic, long-term multi-modal effects over the wider Auckland region, and detailed operational issues within this specific corridor. It is not feasible to capture this range of strategic and detailed functionality in a single model, and as such this hierarchy of models was adopted. This is a commonly used approach for such projects, and has been used for most major transport projects in the Auckland region for the last 15 years.

The purpose of the operational model is to look at the operation of the corridor in more detail than can be achieved in the project assignment model, especially weaving, queuing, merges and gradients.

The model documented in this report is similar in structure to the previous models used for the analysis of this project, separately covering the weekday morning and evening 4-hour peak periods, being developed in the S-Paramics software and being linked to the project assignment model which is in turn linked to the regional multi-model model. The key driver to update the modelling system was the desire to link the traffic models to the comprehensively updated regional multi-model model recently completed by the ARC (ART3).

The base year operational traffic model covers the SH16 corridor, from the Royal Road interchange in the West to the Newton Road interchange in the east, and a number of arterial roads which feed onto the State Highway. Traffic demands in the form of origin-to-destination trip matrices were obtained form the project assignment model then calibrated to match known and observed traffic patterns, and then validated against independent traffic observations. This report describes the specification, calibration and validation of that base year 2006 model. The use of the models for future forecasting will be reported separately in the Technical Report G.25: *Traffic Modelling Report*, and result summarised in the Transport Assessment report.

The approach to the update of the model was first developed in a Model Scoping workshop, which was agreed NZTA, and also with the appointed independent peer review team. Throughout the development of the base year model, the study team worked interactively with the independent peer review team to discuss issues arising and agree detailed elements of the methodology and outcomes. The issues raised related to items such as suggested network coding, demand profiles, model parameters and validation tolerance. These were addressed by discussing the suggested methods or parameters and incorporating if necessary, and supplying detailed model data to aid the peer review process.

The model update consisted of development of a new network, derived from the previous Traffic Design Group model for SH16, development of a new model zoning system, creation of a new interface with the project assignment model and calibration and validation of the model to an extensive set of observed traffic count and travel time surveys.

The fit of the model to observed 2006 data was measured by standard statistical tests used in NZ and overseas, and especially the NZTA's Economic Evaluation Manual. These tests showed a 'high' level of correlation against observed data and hence an acceptable level of model validation.

As such, the operational model developed for this project is deemed appropriate for evaluating the Waterview Connection project.

1. Introduction

1.1 Background

In 2009 the NZTA confirmed its intention that the 'Waterview Connection Project' would be lodged with the Environmental Protection Authority as a Proposal of National Significance. The Project includes works previously investigated and developed as two separate projects: being the SH16 Causeway Project and the SH20 Waterview Connection. The key elements of the Waterview Connection Project are:

- Completing the Western Ring Route (which extends from Manukau to Albany via Waitakere);
- Improving resilience of the SH16 causeway between the Great North Road and Rosebank Interchanges to correct historic subsidence and "future proof" it against sea level rise;
- Providing increased capacity on the SH16 corridor (between the St Lukes and Te Atatu Interchanges);
- Providing a new section of SH20 (through a combination of surface and tunnelled road) between the Great North Road and Maioro Street Interchanges; and
- Providing a cycleway throughout the surface road elements of the Waterview Connection Project corridor.

Beca Infrastructure Ltd, (Beca), has been commissioned by NZTA to undertake transport modelling to assess the effects of the completion of the Waterview Connection and the widening of SH16.

This work included development of a modelling system suitable to undertake the necessary forecasting for this project. A key component of this modelling is the development and subsequent validation and calibration of the traffic models to base year (2006) conditions.

1.2 Report Purpose

The purpose of this report is to document the specification and calibration of the base year micro-simulation (or 'Operational') traffic model. Prior to developing this traffic model, a detailed scoping workshop was held and attended by NZTA, Beca and Sinclair Knight Merz (SKM) (in their role as independent peer reviewer for the project). That workshop investigated the requirements of the model, considered the options available and proposed a structure and development process.

It should be noted that some aspects of the modelling which were outlined in the scoping memorandum were changed during its development, for example the areas of network detail and the final steps in matrix adjustment. These and other aspects of the model were finalised following the scoping in discussion with peer reviewers, (e.g. the assignment process).

1.3 Report Structure

The reminder of this report is structured as follows:

Chapter 2	Details the model structure and background;
Chapter 3	Discusses the model network and zoning system;
Chapter 4	Discusses the model demands;
Chapter 5	Details the assignment process;
Chapter 6	Contains the calibration and validation methodology;
Chapter 7	Discusses the effects of matrix estimation;
Chapter 8	Describes the validation results;
Chapter 9	Provides results of the sensibility checks undertaken on the model validation;
Chapter 10	Discusses the peer review process that has been undertaken; and
Chapter 11	Contains the summary and conclusions of this report.

2. Traffic Model Background and Structure

This chapter details the background and structure of the traffic model.

2.1 Traffic Model Background

A considerable amount of traffic modelling has been undertaken to assess the effects of both the SH20 extension, and the widening of SH16 over the past ten years. To date, the assessment of these projects has been undertaken independently in separate traffic models. The following two sections provide a brief summary of the operational modelling undertaken on these two projects to date.

2.1.1 Previous SH20 - Waterview Connection Modelling

Beca developed an operational model in 2003 in the AIMSUN NG software to investigate the operational effects of the SH20 Waterview Connection. That model covered SH20 between the Maioro Street Interchange and the Great North Road Interchange, as well as the length of SH16 between the Rosebank Road and St Lukes Road Interchanges. The model also included sections of Great North Road, Blockhouse Bay Road and New North Road to enable the assessment of a Central Interchange, and also the immediate area surrounding the Maioro Street Interchange. That model was a forecast model only, and was used to assess the operational impacts of the SH20 Waterview Connection until early 2009.

2.1.2 Previous SH16 Modelling

The Traffic Design Group (TDG) developed an operational model in 2007 in the S-Paramics software to investigate the effects of the various options to increase the capacity of SH16. This model was validated to a 2006 base, and used forecast demands provided by the Beca developed SH16 Strategic model (as discussed in the project assignment model validation report)1. The 2006 network what was developed as part of that study formed the basis of the network for the model that is the subject of this report.

2.1.3 Current Traffic Model

The new operational model documented in this report has been developed in response to the need to update the modelling to reflect forecasts in the new regional model, and also the need to assess the impacts of the the

[1] Western Ring Route - Waterview Connection Project Assignment Traffic Model Validation Report, February 2010

Waterview Connection (SH20 extension and SH16 widening), as a whole rather then separately as has been in the case in the previous studies discussed above.

The scoping workshop (discussed in **Chapter 1**) was undertaken to consider the needs and options for modelling the project. The recommended approach from that workshop is implemented and documented in this report.

2.2 Traffic Model Structure

The WRR project follows the hierarchical modelling structure used successfully on other major projects across the Auckland region since the early 1990's. This involves the following three components:

- A strategic **Demand** model that relates land use (such as population and employment), to person travel patterns at a strategic, region-wide level;
- A **Project Assignment** model, which is similar to the demand model, but has a more refined network in the project area. This model loads the vehicle trip patterns predicted by the demand model onto the road network to test various options and investigate the traffic effects at a more detailed level; and
- An **Operational** model, which uses micro-simulation to look at specific intersections and connections in even greater detail.

It is the **Operational** model which is the subject of this validation report. The specification, calibration and validation of the new regional model (ART3), developed by the ARC, is documented separately, and reference should be made to the ARC in relation to that model. The project assignment model is also the subject of a separate model validation report[2].

The hierarchy of models is required as it is not practical to develop a system in a single model to cover both the strategic demand issues across the whole region and the detailed local intersection effects. This hierarchical system has been used successfully on most major projects in the Auckland region (and elsewhere) and is a common modelling approach.

Figure 2.1 details the model structure, and the **Demand**, **Project Assignment** and **Operational** models components are described following.

[2] Western Ring Route – Waterview Connection Project Assignment Traffic Model Validation Report, February 2010

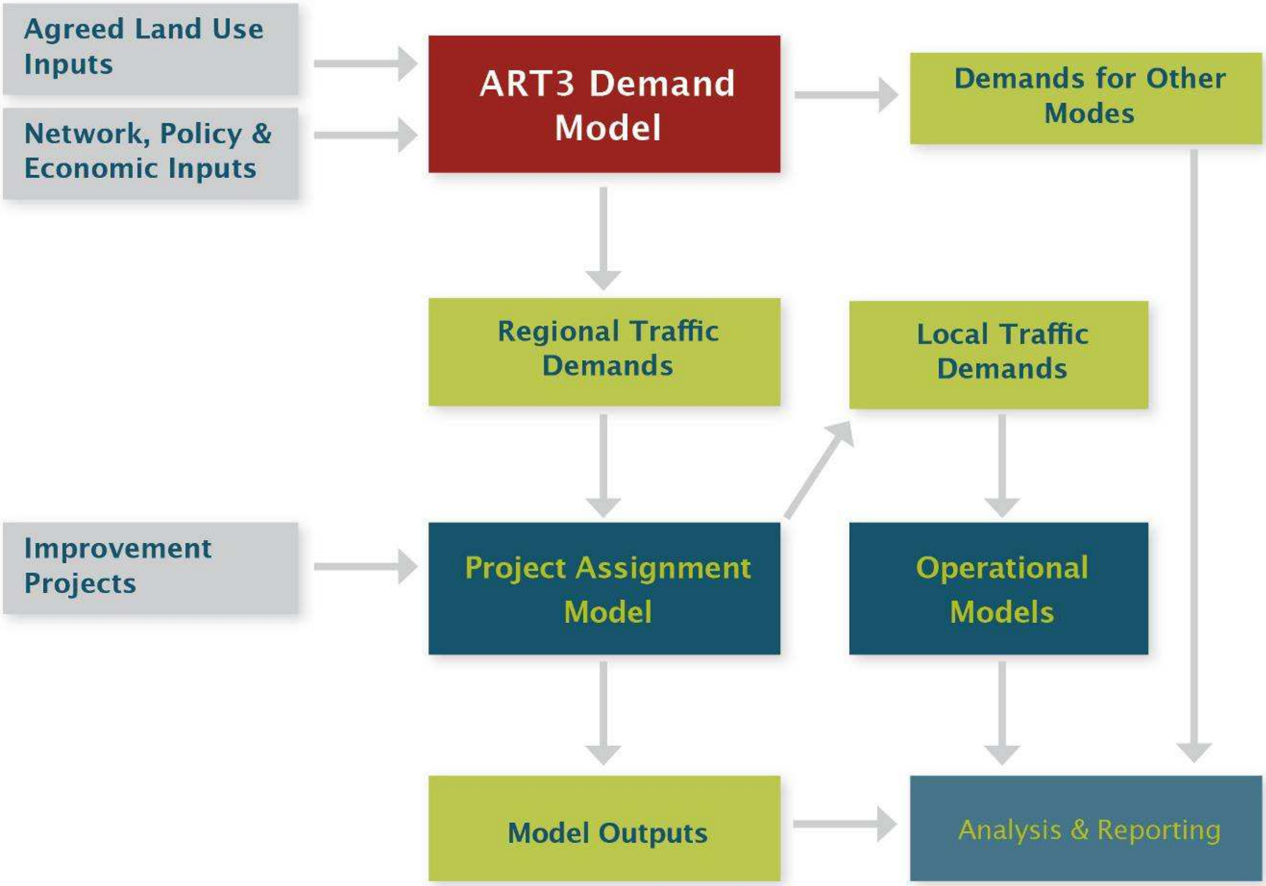


Figure 2.1 – Model Structure

2.3 ART3 Demand Model

The ART3 model is a 4-step multi-modal model. This model has recently been developed based on extensive data collected in 2006 (the 'ART3' model). It has a base year of 2006 which was developed using Census data, and a full model validation exercise was undertaken. The ART3 model produces demands for five periods of the day, and separate assignment models exist for the morning and evening peak and weekday inter-peak periods.

The model itself comprises of the following key modules:

- **Trip Generation**. This is where the number of person-trips are estimated as a function of the land use data (population, employment, school roll etc);
- **Mode Choice**. This is where the choice of preferred travel mode is determined, based on the relative costs of the various modes. The ART3 modes for mode choice are car (driver and passengers combined) and passenger transport; trips by car are converted into vehicle trips later in the model; The model also

estimates the number of active mode trips, such as walking and cycling, although these are not fully modelled through to link flows;

- **Trip Distribution**. This is where the trips produced in each zone (generally by the households), are matched to a preferred destination. This distribution is predicted as a function of the relative attractiveness of each destination zone and the travel costs to reach each destination;

- **Time of Day**. This is where the proportion of daily trip making occurring in each period is calculated. These proportions change in response to changes in travel costs; and

- **Trip Assignment**. This is where the resulting travel demands, in the form of origin to destination trip tables, are loaded to the road and public transport networks. For the road assignment an iterative process is used to firstly identify the lowest-cost route between each origin and destination, followed by an estimation of the speeds and delays on each route associated with the predicted traffic flows on the route.

The ART3 model is operated by the ARC and is implemented in the EMME software, which is a well-used and proven platform for this kind of analysis.

It is therefore the ART3 model that predicts the overall regional traffic patterns, based on the inputs and forecasts of population and employment growth, together with the assumed level of road and public transport infrastructure. This model also predicts how trip making will change in response to a major project, such as the WRR. Details of the inputs and results of the future year modelling are reported separately.

2.4 Project Assignment Model

The project assignment model is owned by NZTA and operated on their behalf by Beca. The EMME assignment model is similar to the assignment module in the ART3 model, but represents the road network in the immediate study area in significantly greater detail. It is only an 'assignment' model in that it takes the traffic demands from the ART3 model and 'assigns' them to the road network. Land use data is not used directly in this part of the model, and it only includes vehicle traffic (not passenger transport trips). As with the regional model, the project assignment model is implemented in the EMME software.

The project assignment model covers the same wider area as the ART3 model, namely the whole of the Auckland Region. However, it covers the area around the Waterview Connection and SH16 in greater detail than the ART3 model.

Detail regarding the network, zoning structure and demands for the project assignment model can be found in the previously reference project assignment model validation report.

2.5 Paramics (Operational) Model

The operational model is a micro-simulation model developed originally by TDG, but extend and refined by Beca in the S-Paramics software. It represents the road network in the study area in great detail. It is primarily a corridor model, concentrating primarily on SH16 and SH20, but with some coverage of the local arterial road network.

Detail regarding the network, zoning structure and demands for the operational model are included in the following chapters.

3. Operational Model Network and Zoning Structure

This chapter provides detail regarding the traffic model network and zoning structure.

3.1 Approach

Within the operational model it is important to be able to capture the operational effects of the whole corridor, and also key adjacent intersections on the arterial road network. Subsequently the geographical coverage of the model is such as to capture the full effects of the project on the State Highway, whilst also being able to effectively assess the local effects of the project of the road network in the vicinity of the project.

As discussed in **Chapter 2** previous operational models were developed covering either SH16 or SH20, with neither having the necessary level of detail or coverage in terms of either network or zoning system required for this study.

Following the aforementioned scoping workshop it was decided to develop a new operational model which would contain the necessary level of detail in order to fully assess the project, and which would then also be linked to the new project assignment model, which, as discussed in **Chapter 2**, is in turn linked to the regional ART3 model. It was decided that the model would be developed in the S-Paramics software and would use the network developed by TDG as part of their work on the SH16 study as a basis for this work, but the network would be extended and modified as necessary.

The following sections provide greater detail on the network and zoning structure adopted.

3.2 Networks

3.2.1 Network Extent

As discussed in **Section 3.1** a major feature of the operational model is to capture the operational effect on both SH20 and SH16, as well as on the local network in the immediate vicinity of both State Highways. The 2006 model extends from the St Lukes interchange in the east to the Royal Road interchange in the west, incorporating all intermediate motorway interchanges, the model also contains some coverage of the local arterial road network in the immediate vicinity of SH16, including St Lukes Road, Great North Road, Te Atatu Road and Lincoln Road. **Figure 3.1** shows the network coverage for the 2006 base year model.

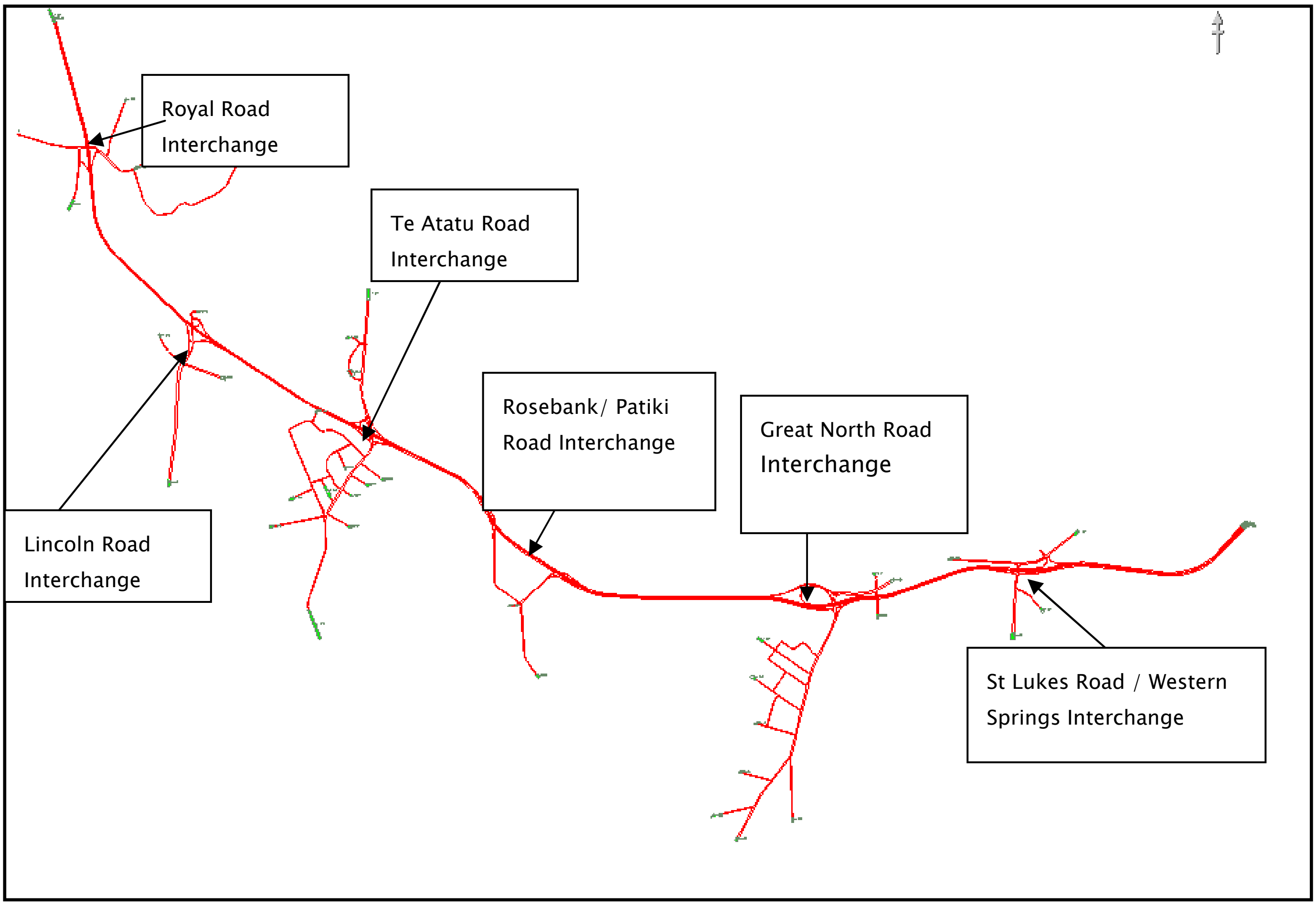


Figure 3.1 – Network Extent

3.2.2 Network Zoning

The model includes a total of 44 zones to allow traffic onto and off the model network. The zoning system in the vicinity of the local road network (as opposed to the State Highway), is based on that adopted in the project assignment model. **Figure 3.2** shows an overview of the model zoning system.

The AM and PM demand matrices were split into eight further matrices to represent the traffic destined for eight destination areas in the network. These are:

- Destination Area 1: To SH16 Westbound (Hobsonville)
- Destination Area 2: To Royal Road
- Destination Area 3: To Lincoln Road

- Destination Area 4: To Te Atatu
- Destination Area 5: To Rosebank
- Destination Area 6: To Waterview
- Destination Area 7: To St Lukes
- Destination Area 8: To SH16 Eastbound (City)

The matrices were split into these eight levels to help with lane restrictions for certain vehicle movements as well as to visually observe land usage and colour code the vehicles by these destination zones.

The zones coded in the network within each of these eight destination areas are shown in **Table 3.1** below.

Table 3.1 – Zones Coded within the Destination Areas

Destination Area	Zones
Area 1	1
Area 2	3,4,5,6
Area 3	7,10-12
Area 4	8,9,13-20,24,25,31
Area 5	21,22
Area 6	23,26-28,32-37
Area 7	29,30,38,39
Area 8	40-42

Please note that zones 2, 43 and 44 are origin zones and therefore not listed in the **Table 3.1**.

3.2.3 Network Parameters

The 'global' Paramics parameters which affect the vehicle/drive behaviour characteristics (represented by aggression and awareness factors in the model) were not modified. The Paramics default values for these factors were used in the AM and PM models. The default "minimum gap" behaviour parameter was however reduced from 2m to 1.6m. This 1.6m is the recommended minimum gap for the 2007.1version of Paramics. This change results in the modelled minimum distance between the crawling/queued vehicles in the network being 3.2m instead of 4m and hence better reflecting the behaviour of vehicles in a congested urban network during peak periods.

3.2.4 Assignment Method

The S-Paramics software employs dynamic assignment where routing choices are available for vehicles in the network. The dynamic feedback assignment method assumes that drivers who are familiar with the network will re-route if information on the present state of traffic conditions is fed back to the drivers. Limited routing choice is available for arterial and local road traffic in the network. There is no routing choice available for vehicles travelling along SH16. It is considered that when heavy congestion occurs in the network unrealistic routing occurs for arterial and local road vehicles in the model. The dynamic routing was therefore not applied in the model.

3.2.5 Link Type

Each link in the model is classified by its environment, to enable consistent allocation of delay parameters and to enable model detailed reporting of results. The link type classification was developed to describe both the road hierarchy and the general environment of the link, these link types are those standard to the S-Paramics software. **Table 3.2** displays the link classification that has been adopted. **Table 3.2** also shows the assumed lane width for each link type classification. The speed limit is also included in the table which was agreed with the peer reviewers.

Table 3.2 – Adopted Link Types

Link Category	Description	Speed Limit	Lane Width (per lane)
1 – 4	Urban Major	30 kph	3.7m
5 – 8	Urban Major	50 kph	3.7m
9 – 12	Urban Major	60 kph	3.7m
13 – 16	Urban Major	70 kph	3.7m
17 – 22	Urban Major	80 kph	3.7m
23 – 28	Urban Major	90 kph	3.7m

It should be noted that in consultation with the peer reviewer, the decision was made to use the categories 23 – 28 'Urban Major' for the State Highway. This was because the use of the 'Highway' link classification implements the 'return to left' rule, meaning vehicles always return to the left hand lane. This was not considered appropriate for the area covered in this model, therefore the 'Urban Major' link type was assumed.

3.2.6 Vehicle Classifications

Four vehicle classes were defined in the models. These included:

- Car;
- Light Goods Vehicles (LGV);
- Other Good Vehicles 1 (OGV1); and
- Other Goods Vehicles 2 (OGV2).

Matrices 1-8 for each modelled period (**Table 4.1**) represented cars and LGV vehicle type whilst matrices 9-16 represented the OGV1 and OGV2 vehicle types. The proportions of car/LGV (Matrices 1-8) and OGV1/OGV2 (Matrices 9-16) for each of the eight destination areas were taken from the project assignment models. These proportions are shown in **Table 3.3**.

Table 3.3 – Vehicle Proportions Based on Project Assignment AM and PM Models

Destination Areas	AM		PM	
	LCVs	HCVs	LCVs	HCVs
To SH16 – WBD (Hobsonville)	92.3%	7.7%	95.1%	4.9%
To Royal Road	95.0%	5.0%	97.3%	2.7%
To Lincoln	94.8%	5.2%	95.5%	4.5%
To Te Atatu	92.1%	7.9%	94.4%	5.6%
To Rosebank/Patiki	93.5%	6.5%	89.3%	10.7%
To Waterview	97.7%	2.3%	98.0%	2.0%
To St Lukes	97.7%	2.3%	97.6%	2.4%
To SH16 – EBD (City)	95.2%	4.8%	94.5%	5.5%

The proportional split between cars and LGV in Matrices 1-8 and proportion split between OGV1 and OGV2 in matrices 9-16 for each destination types were further calculated for the AM and PM models. These were based on the ATMS data which classifies vehicle types into four length bins (0.0-5.5m, 5.5-11.0m, 11.0m-17.0 and >17.0m). These proportions are shown in **Tables 3.4** and **3.5**.

Table 3.4 – Vehicle Proportions Based on ATMS Data (AM Model)

Destination Areas	Matrices 1-8		Matrices 9-16	
	Cars	LGVs	OGV1s	OGV2s
To SH16 – WBD (Hobsonville)	98.1%	1.9%	48.8%	51.2%
To Royal Road	97.5%	2.5%	33.2%	66.8%

Destination Areas	Matrices 1-8		Matrices 9-16	
	Cars	LGVs	OGV1s	OGV2s
To Lincoln	97.0%	3.0%	67.6%	32.4%
To Te Atatu	96.4%	3.6%	63.6%	36.4%
To Rosebank/Patiki	95.3%	4.7%	79.1%	20.9%
To Waterview	98.8%	1.2%	19.9%	80.1%
To St Lukes	98.8%	1.2%	19.9%	80.1%
To SH16 – EBD (City)	98.1%	1.9%	48.8%	51.2%

Table 3.5 – Vehicle Proportions Based on ATMS Data (PM Model)

Destination Areas	Matrices 1-8		Matrices 9-16	
	Cars	LGVs	OGV1s	OGV2s
To SH16 – WBD (Hobsonville)	98.4%	1.6%	67.8%	32.2%
To Royal Road	96.5%	3.5%	35.7%	64.3%
To Lincoln	98.3%	1.7%	69.4%	30.6%
To Te Atatu	96.7%	3.3%	61.7%	38.3%
To Rosebank/Patiki	97.3%	2.7%	83.7%	16.3%
To Waterview	98.1%	1.9%	27.1%	72.9%
To St Lukes	98.1%	1.9%	27.1%	72.9%
To SH16 – EBD (City)	98.4%	1.6%	67.8%	32.2%

In addition, buses have also been coded in the network with 'single decker bus' vehicle type defined in the vehicles files, in the models. The schedules bus services and the service frequencies in the AM and PM modelled periods are detailed in **Section 3.3**.

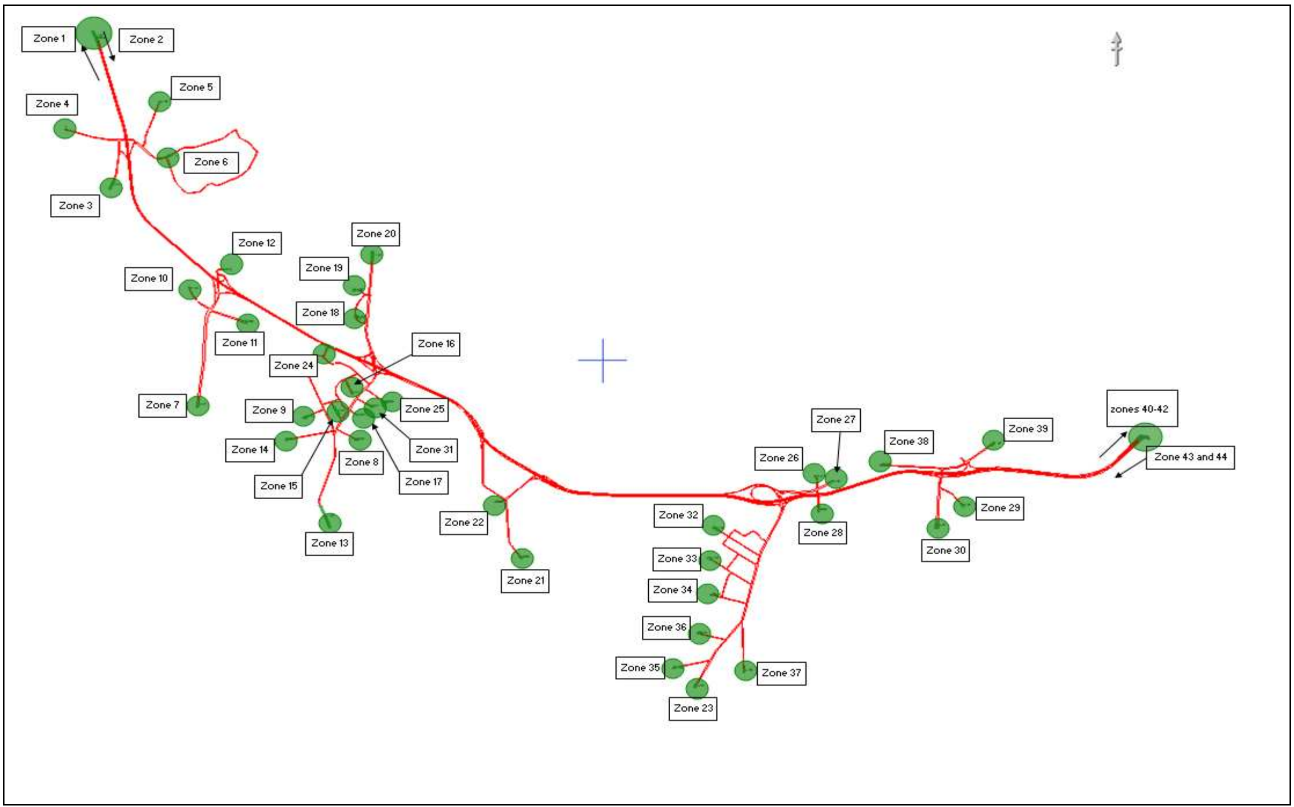


Figure 3.2 – Zoning System Overview

3.3 Bus Services

Scheduled bus routes, stops and the frequencies of the bus services were included in the AM and PM models. Bus lanes were coded in the models to represent the 2006 bus lane operations. Where they were multiple bus stops along the same link, the bus stops were coded as a single stop and modelled as a dynamic stop with a specified length. The dynamic stops thus allowed buses to stop anywhere along this link length. The bus services and the service frequencies for the AM and PM modelled periods are shown in **Tables A.1** and **A.2** in **Appendix A.**

4. Matrix Development Process

The process for the disaggregation of demands from the regional ART3 model to the project assignment model is detailed in **Chapter 4** of the Project Assignment Model Validation Report. This chapter of this report concentrates on the disaggregation of demand from the Project Assignment model for use in the Operational model.

4.1 Approach to Project Assignment Model to -Operational Model Interface and Model Time Periods

2006 project assignment model cordon matrices were used in the base 2006 AM and PM models. Traversal cut points from the EMME cordon were aggregated to produce the Paramics zones. 44 zones were produced from initial 54 traversal cuts, with none of the cut points split into multiple zones. This grouping is able to be carried through to the EMME-Paramics interface in future year models.

The objective of this was to use same interface for the future models in a consistent way. The Western Ring Route project assignment models are two hour peak periods covering AM (07:-09:00), Inter-Peak (two hour average of 09:00 – 15:00) and PM periods (16:00-18:00).

The 2006 operational model covers two, 4-hour weekday time periods:

- AM Peak – 06:00 – 10:00; and
- PM Peak -14:45 – 18:45.

Calibration (discussed further in **Chapter 7**), has been undertaken for the one hour peak period (07:30 – 08:30) and 16:15 – 17:15), and for the average hour over the 3.5 hour period (06:15 – 09:45 and 15:00 – 18:30).

The area used in the project assignment model to obtain the demands for the operational model is shown in **Figure 4.1**.

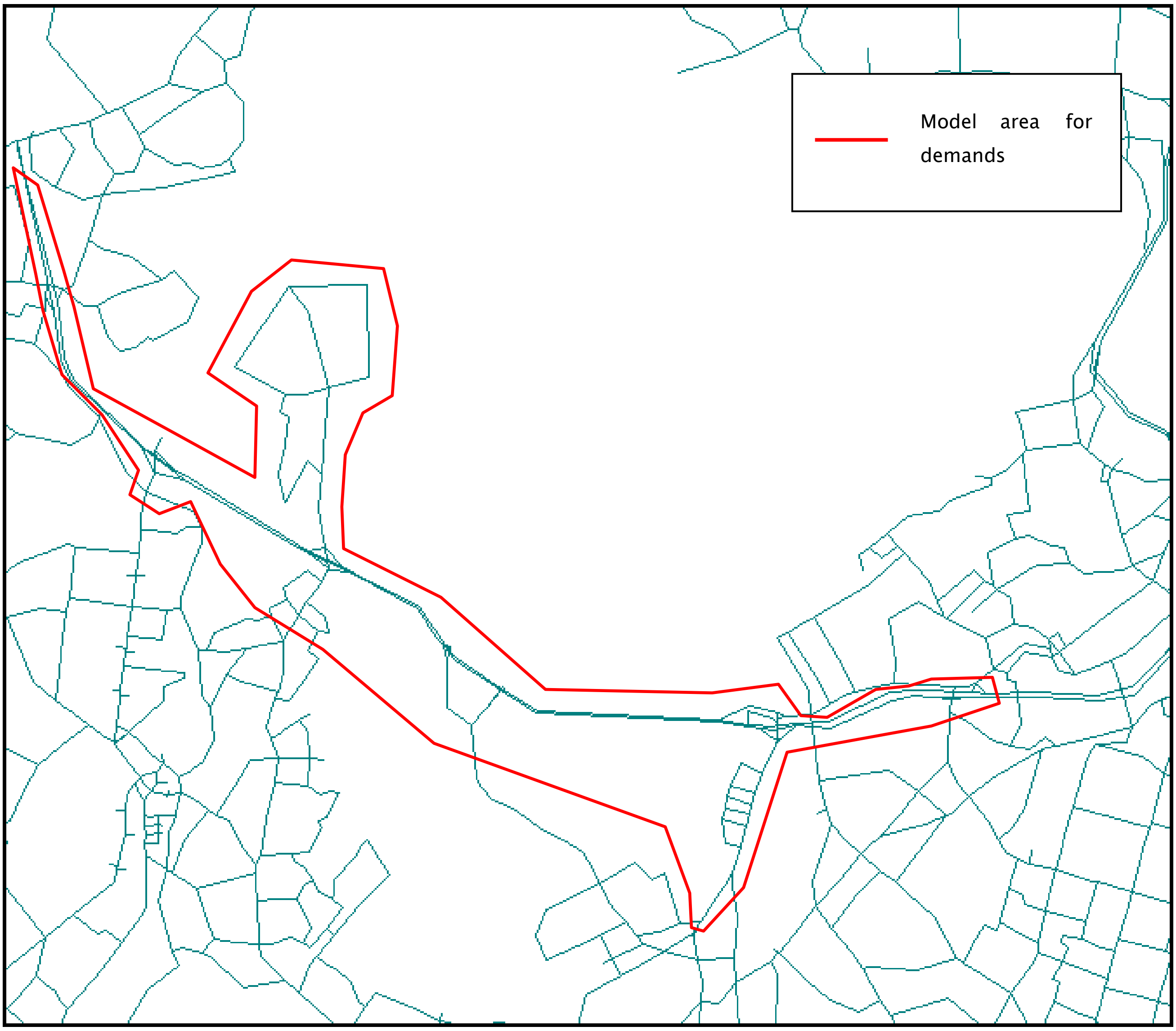


Figure 4.1 – Project Assignment Model Area for Demands

Project assignment model demands were obtained for the following three weekday periods:

- AM Peak (07:00 to 09:00);
- Inter-Peak (a two hour average of the 09:00 – 15:00 period); and
- PM Peak (16:00 to 18:00).

Matrices were received for the following vehicle classes:

- Light Vehicles; and

- Heavy vehicles (including medium heavy vehicles).

The process to convert the matrices in to the format used in the operational model is discussed in detail in the following sections.

4.2 Time Slicing

The approach taken to transfer the project assignment model matrices to the operational model included creating separate matrices (6 matrices in the AM period and 4 matrices in the PM period), from the peak and inter-peak matrices.

This approach was used to better retain the project assignment model changes in trip patterns through the operational model time periods. However, this approach led to completely new profiles for the two models. The process undertaken for calculating the new profiles is discussed in **Section 6**.

4.3 Project Assignment Model to Operational Model

The objective is to use the cordon matrices from the project assignment model directly in the operational model, to enable the same approach to be used for future models in a consistent way.

The project assignment model cordon matrices for the AM, inter-peak (IP) and PM periods were extracted and imported into a spreadsheet. The project assignment model cordon matrices were split into light and heavy vehicle matrices.

Proportions of these AM, IP and PM cordon matrices were then used to create the matrices for the AM and PM operational models (see **Figures 4.2 – 4.5**). 15 minutes profiles of these proportions from the AM, IP and PM periods were validated against the following four mainline count sites:

- Eastbound at Great North Road interchange;
- Westbound at Great North Road interchange;
- Eastbound at Lincoln Road interchange; and
- Westbound at Lincoln Road interchange.

Emphasis was placed on the peak direction of travel, (SH16 eastbound in the AM peak and SH16 westbound in the PM peak), during the validation process, with the objective of obtaining the best fit at these four count sites. The validation process was initially undertaken for the four hour simulation period to reduce the effect of any sudden changes in demand at the transition point between the peak and inter-peak EMME assignment models. However, the full four hour modelled period in the AM and PM models were split into smaller time periods to better represent the peak and inter-peak percentages that were validated over the 15 minute periods.

The proportions were summed over each time period and applied to the project assignment model cordon matrices to create the composite six time period demand matrices for AM peak and four time period demand matrices for PM peak. These proportions were applied to the project assignment model light and heavy cordon matrices.

The operational modelled periods are shown in **Table 4.1** below.

Table 4.1 – Time periods for Operational model demand matrices

Period	Morning peak	Evening peak
1	6:00 – 8:45	14:45 – 15:45
2	8:45 – 9:00	15:45 – 16:45
3	9:00 – 9:15	16:45 – 17:45
4	9:15 – 9:30	17:45 – 18:45
5	9:30 – 9:45	
6	9:45 – 10:00	

As discussed in **Section 3.2.2** the AM and PM demand matrices were segmented into eight demand matrices to represent the traffic travelling to each of the eight destination zones.

The proportion of cars/LCVs and HCVS differs between each of the eight traffic destination zones, and these were based on the assumed proportions from the project assignment model matrices and ATMS data (as discussed in **Section 3.2.4**). Hence, these proportions were applied to each of the eight matrices. This resulted in a total of 16 matrices. That is, each demand file imported into the operational model included 16 matrices. As previously discussed, matrices 1-8 represent car/ LCVs whilst matrices 9 -16 represent HCVs.

The total numbers of matrices for the models therefore were:

- AM model: 96 matrices (6 periods x 2 user classes x 8 destinations zones); and
- PM model: 64 matrices (4 periods x 2 user classes x 8 destination zones).

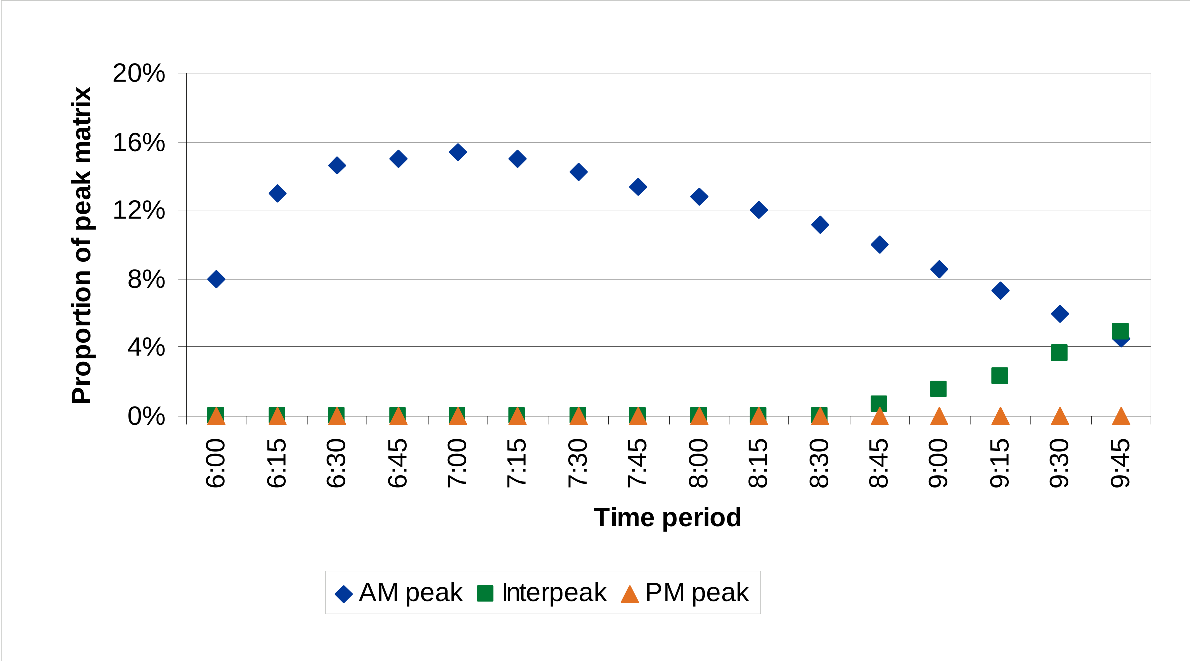


Figure 4.2 – Proportions to create morning peak demand matrices

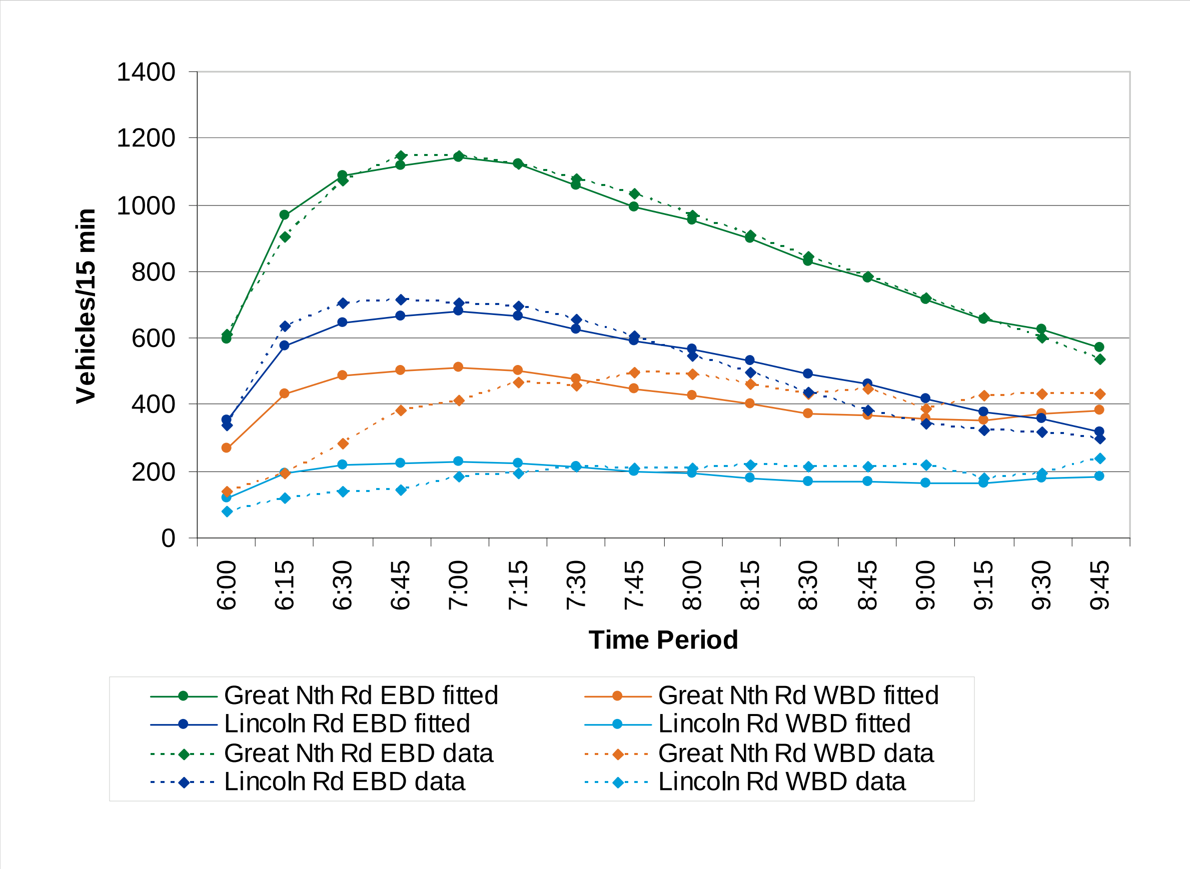


Figure 4.3 – Calibration of morning peak proportions

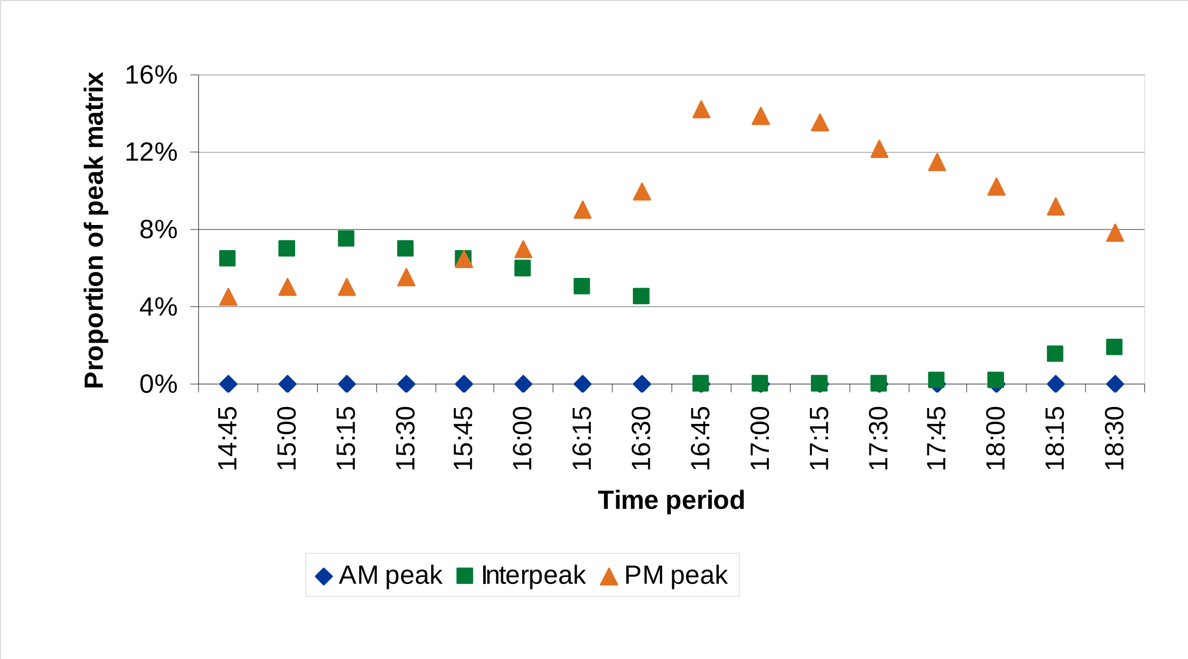


Figure 4.4 – Proportions to create evening peak demand matrices

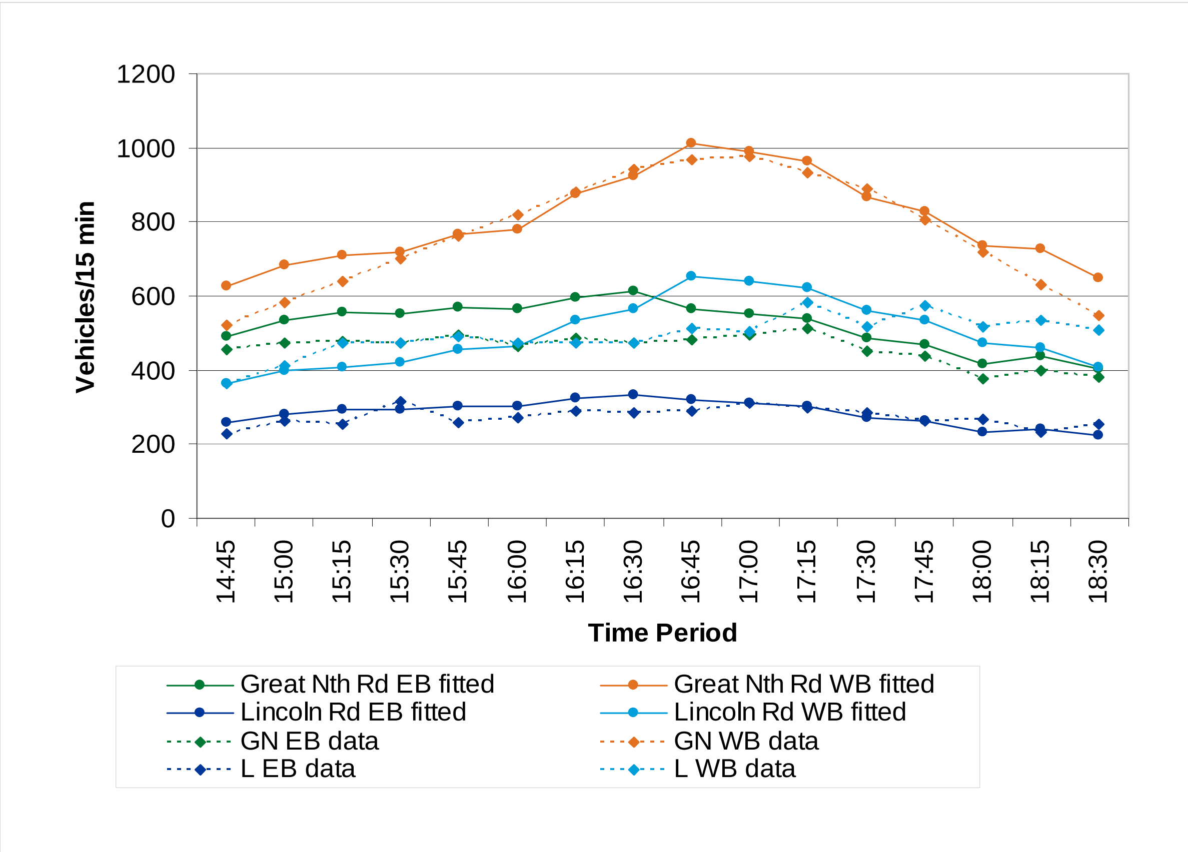


Figure 4.5 – Calibration of evening peak proportions

5. Matrix Estimation Procedure

This chapter describes the matrix estimation process undertaken for the operational AM and PM models.

5.1 Matrix Estimation Process

The Matrix Estimation process included four inputs which included:

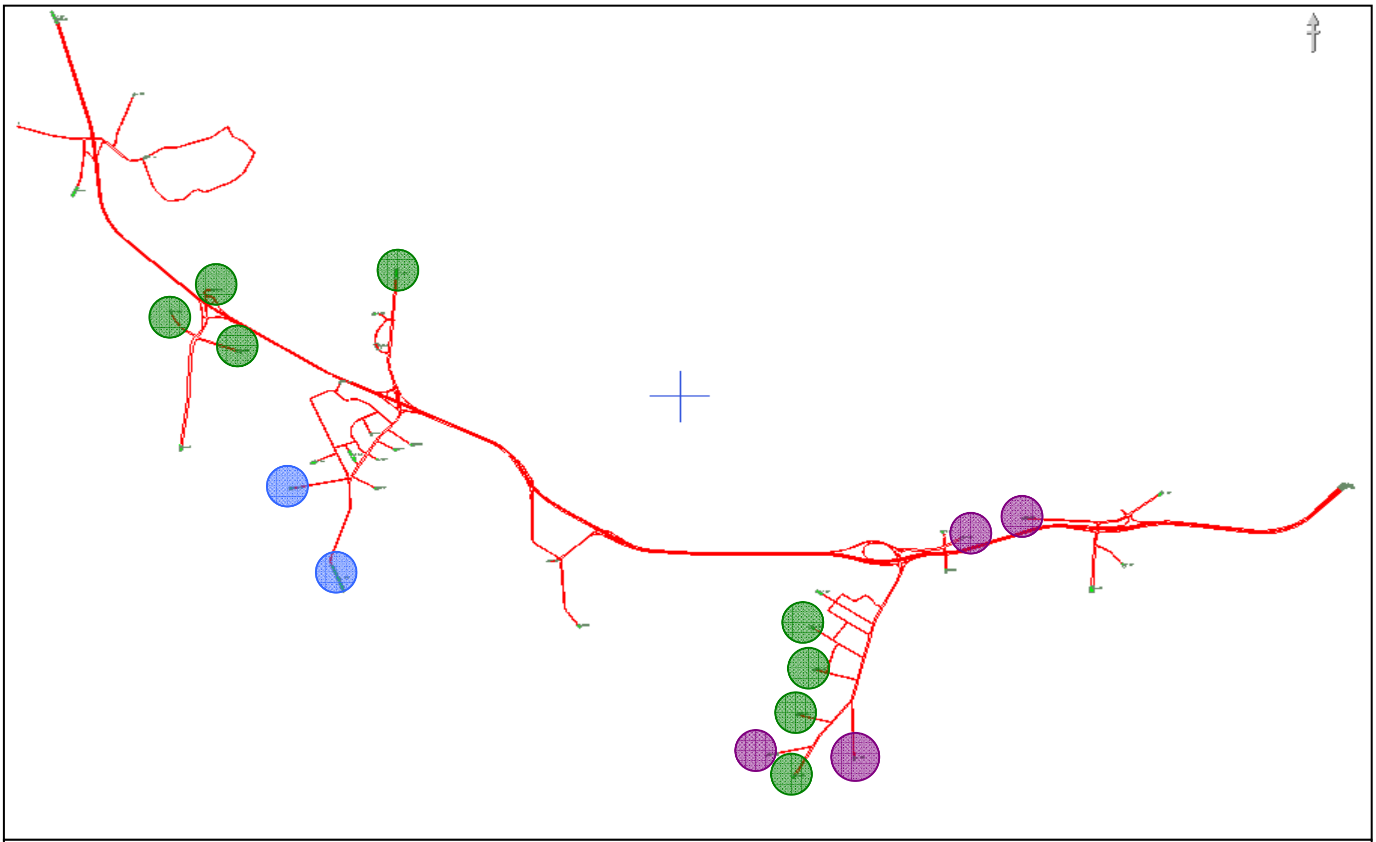
- The Paramics model of the network
- A 'prior' matrix (the project assignment model cordon matrix),
- Traffic counts observed data; and
- Routeing data (collected from running the model with the 'prior' matrix).

The traffic counts that were used for matrix estimation included on /off ramp ATMS counts, SH16 mainline ATMS counts at either ends of the model (eastbound at Royal Road and westbound east of Waterview for AM and vice versa for PM) and some side road traffic counts (SCATS / manual / tube counts) adjoining the arterial roads. The remaining SH16 ATMS mainline count data and the arterial road counts were used for independent validation of the flows. The counts used in matrix estimation are listed in **Table B.1 in Appendix B**.

Constraints were added to some total demands entering or leaving certain zones. This included applying constraints to balance the trips entering / leaving zones 27 and 38 on Great North Road in Western Springs/ Pt Chevalier.

The constraints added to the matrix estimation included:

- Trips from Zones: 10, 11, 12,20, 23,27,33 – 38
- Trips to Zones: 13,14,27,35,37,38
- These zones are highlighted in **Figure 5.1** below.



Constraints added for trips travelling to and from a zone
Constraints added for trips travelling to a zone
Constraints added for trips travelling from a zone

Figure 5.1 – Zones with Constraints Applied in Matrix Estimation

The demand matrices representing the different time periods in the AM and PM models were aggregated to form a single four hour demand matrix for each model. This four hour matrix represented the 'prior' or initial matrix which was imported into the Paramics matrix estimation tool. That is, the matrix estimation was undertaken on a single four hour matrix for the AM and PM models which included the light and heavy vehicles.

The matrix calculated by the matrix estimator (ME) was again initially split into six demand matrices for the AM model and four demands matrices for the PM model. This was undertaken by calculating the demand proportion for each (Origin-Destination) O-D pair in the prior matrices and applying these percentages to the ME matrices (post matrix estimated matrices).

The ME matrices were again segmented into six and four demand matrices for the AM and PM model respectively and then further segmented into eight matrices to represent the traffic destined for the eight destination zones. That is, the same methodology was undertaken with the initial cordon matrices to disaggregate the ME matrices with the final matrices 1-8 representing car/ LCVs and matrices 9 -16 representing HCVs.

It is noted that the matrix aggregation and disaggregation process was undertaken in a manner that ensured that the trip patterns as well as the light and heavy vehicles proportion from the project assignment models, for the study area were retained and applied to the operational models.

It is also noted that changes to the ME demands were made during the calibration/validation process, for both AM and PM demand matrices to provide more robust results with regards to flow calibration. The modification of the ME demands matrices resulted in change in trip totals of less than 1% over the four hour modelled period. This is not considered to be a significant change in the trip totals for the AM and PM models given the high number of trips in the network.

5.2 Changes in Trip Totals

The changes in trip totals as a result of matrix estimation have been assessed at an individual O-D pair level as well as at a sector/destination zones level. The sectors or destination zones are the same as those defined for splitting the demands into the eight levels (see **Section 4.3**).

Table 5.1 contains the changes in trip totals before and after matrix estimation at these destination zone levels. **Appendix C** contains more detail such as the actual trip totals for the prior and post estimation matrices (ME matrices) as well as differences at an individual O-D pair level for the demand matrices. It should be noted that with the O-D pair percentage changes, some large changes may have occurred where there were low trip numbers.

Table 5.1- Changes in Trip Totals – AM and PM Models

	Prior Matrix Total (4 hour)	Trip Changes (Cars/LCVs/HCVs)	Trip Changes (Cars/LCVs/HCVs) %
AM Model	87,376	-3,801	-4.4%
PM Model	92,407	-359	-0.4%

6. Profiling and Traffic Assignment

This chapter details the profiling that was applied to the operational model demands

6.1 Profile Description

The AM and PM models were divided into seven sectors, which were considered likely to experience similar demand profiles. These sectors were:

- Hobsonville/ Royal Road;
- Lincoln;
- Te Atatu;
- Rosebank;
- Great North Road (Waterview);
- St Lukes; and
- City.

These sectors can be seen in **Figure 6.1**.

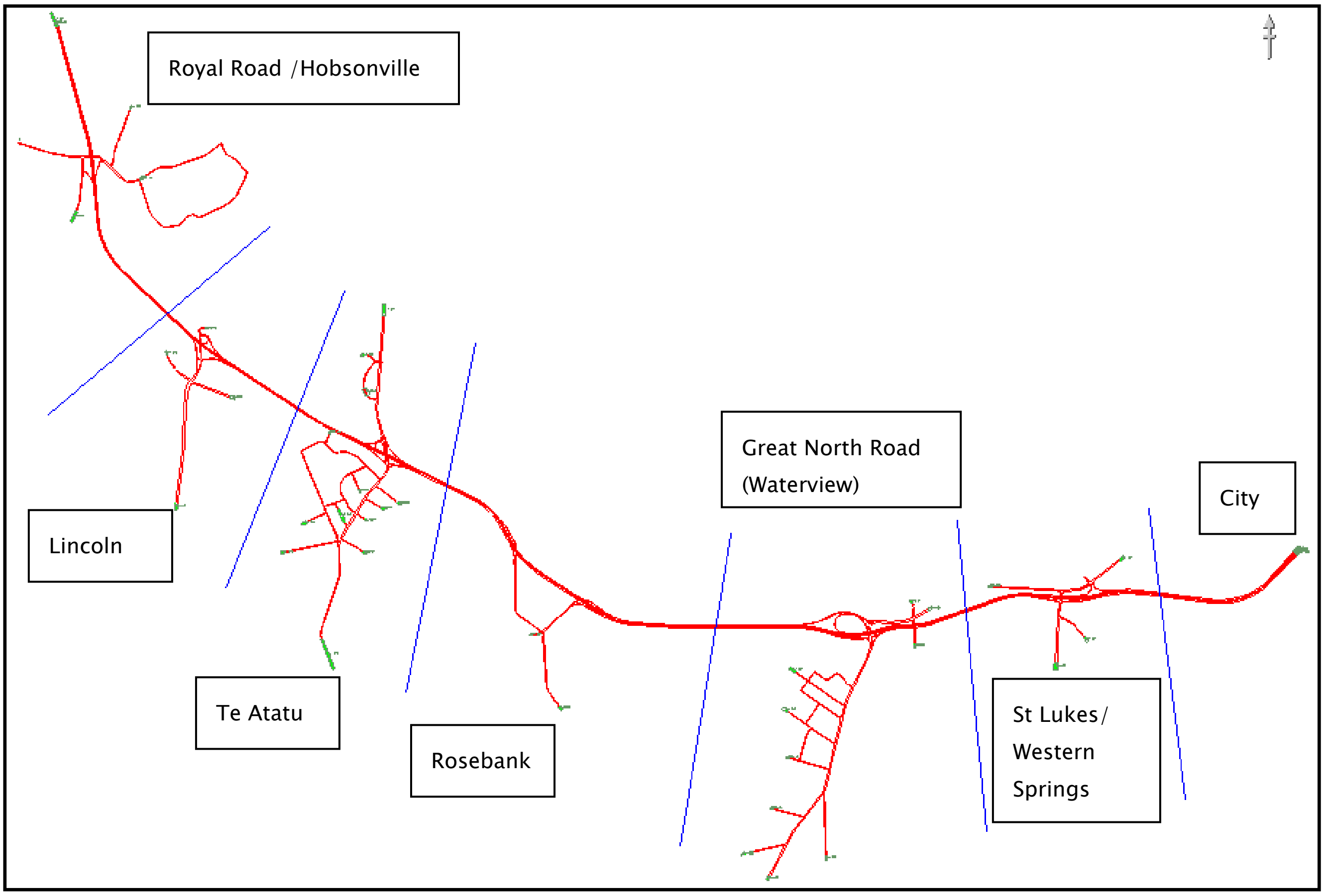


Figure 6.1 – Sector Area for Demands

It was considered that the arrival patterns of vehicles travelling along SH16 from each of these sectors would differ due to the difference in the journey times/distance from each sector to the east and west along SH16. In addition, it was also considered that the vehicle arrival patterns for traffic entering SH16 would differ for each direction of travel (eastbound and westbound) during the AM and PM commuting periods.

Hence, to represent the actual arrival patterns of vehicles entering SH16 network from each of these sectors, 14 profiles were developed for each (AM and PM) model.

The profiles were developed using a one day ATMS data, which was available in 15 minute periods, through loop counts on SH16 mainline and the ramps (dates shown in **Table 6.1**). Tuesday or Wednesday was considered to represent a 'typical' weekday for commuter traffic on the road network and hence a Tuesday or Wednesday 2006 ATMS counts data was used to develop the profile.

The profiles for Hobsonville and City sectors were developed based on the off-ramp and mainline ATMS counts. The off-ramp counts were considered to represent vehicles making local trips and the mainline counts represented vehicle travelling to the east or west along SH16 from these two sectors.

The profiles for these two end sectors (Hobsonville and City) were defined as 'local' and 'further' trips. At the eastern end, the 'City' sector included 'City to St Lukes' and 'City to Further' profiles. The 'City to St Lukes' profile was assigned to trips travelling from the City to St Lukes/Western Springs and the 'City to Further' profile was assigned to trips from the city to the other six sectors to the west.

At the western end of the model, the 'Royal Road / Hobsonville' sector included 'Royal Road Local' and 'Royal Road to Further' profiles. The 'Royal Road Local' profile was assigned to trips travelling within the Massey/Lincoln sector whilst the 'Royal Road to Further' profile was assigned to trips from Royal Road to the other sectors to the east.

The remaining five sectors included westbound and eastbound profiles. The 'westbound' and 'eastbound' profiles were based on westbound and eastbound on-ramp ATMS counts respectively.

Local trips were assigned the westbound profiles in the AM model and the eastbound profiles in the PM model.

These 14 profiles are indicated in **Table 6.1** below.

Table 6.1 – Profiles Developed for the Models

Profile	Profile Names	ATMS Data Used	ATMS Data Date
1	Royal Road / Hobsonville Local	Lincoln EBD off-ramp	Tuesday 29/08/06
2	Royal Road / Hobsonville Further	Lincoln Road EBD Mainline (at interchange)	Tuesday 29/08/06
3	Lincoln Road Local and Westbound	Lincoln Road WBD on-ramp	Tuesday 26/09/06
4	Lincoln Road Eastbound	Lincoln Road EBD on-ramp	Tuesday 29/08/06
5	Te Atatu Local and Westbound	Te Atatu WBD on-ramp	Tuesday 29/08/06
6	Te Atatu Eastbound	Te Atatu EBD on-ramp	Wednesday 30/08/06
7	Rosebank / Patiki Westbound	Patiki WBD on-ramp	Tuesday 26/09/06
8	Rosebank / Patiki Eastbound	Rosebank EBD on-ramp	Tuesday 29/08/06
9	Great North Road (Waterview) Westbound	Great North Road WBD on-ramp	Tuesday 29/08/06
10	Great North Road (Waterview)	Great North Road EBD	Tuesday 29/08/06

	Westbound	on-ramp	
11	St Lukes Westbound	St Lukes WBD on-ramp	Tuesday 29/08/06
12	St Lukes Eastbound	St Lukes EBD on-ramp	Tuesday 29/08/06
13	City Further	St Lukes WBD Mainline (at interchange)	Tuesday 18/07/06
14	City Local	St Lukes WBD off-ramp	Tuesday 18/07/06

6.2 Profile Development Methodology

As indicated in **Section 6.1**, the profiles were developed using the ATMS data, which was available in 15 minute periods, for loops on the SH16 mainline and the ramps. The ATMS count data for each 15 minute period was converted into a proportion of the total AM and PM counts for the full four hour modelled periods. This created an initial 15 minute interval profiles for the full 4 hour modelled period for the two models.

To account for the travel times of traffic entering the model at the various sectors and travelling to the ATMS count locations, some profiles were adjusted by moving forward the vehicle release times by 5 minute. That is, if the count location sensor reading was undertaken at 6:05am, this corresponded to a 6:00am entry of vehicles (in a particular sector) into the model. The profiles for which this was undertaken are as follows:

- Royal Road / Hobsonville Local (AM)
- Royal Road / Hobsonville Local Further (AM)
- Lincoln Eastbound (AM)
- Te Atatu Eastbound (AM)
- Great North Road (AM)
- St Lukes Eastbound (AM)
- Lincoln Road Westbound (AM)
- City Westbound (PM)

In addition, to account for queuing effects, adjustments were also made to some profiles by moving forward the vehicle releases times.

The trips in the transition periods between each segmented matrices (6 demand matrices in the AM model and 4 demand matrices in the PM model) was checked for any large step changes and 'smoothed' where required.

The profiles were then expanded from the initial 15 minutes intervals into 5 minute intervals. The process for this included equally proportioning each 15 minute period profiles into three 5 minute intervals. This also required 'smoothing' of the profiles to prevent any large step changes between each period.

The equation for the smoothing the profiles from 15 minute interval into 5 minute segments is as follows:

$$Smoothed_t = \frac{1}{3} \times \frac{E_t \times E_{t'}}{E_{t-15} + E_t + E_{t+15}} + \frac{2}{3} E_t$$

$$t' = \left\{ \begin{matrix} if \ t \bmod 15 = 0 & t-15 \\ if \ t \bmod 15 = 5 & t \\ if \ t \bmod 15 = 10 & t+15 \end{matrix} \right\}$$

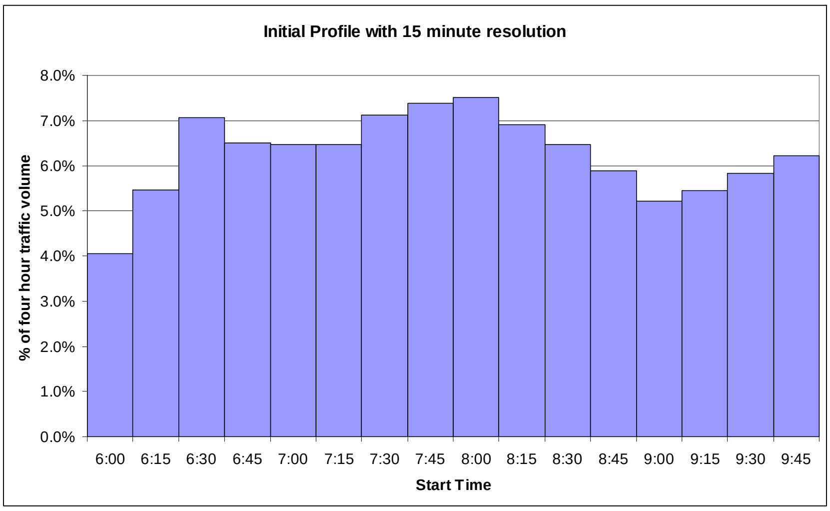
Where:

t is the start time of the period (in minutes); and

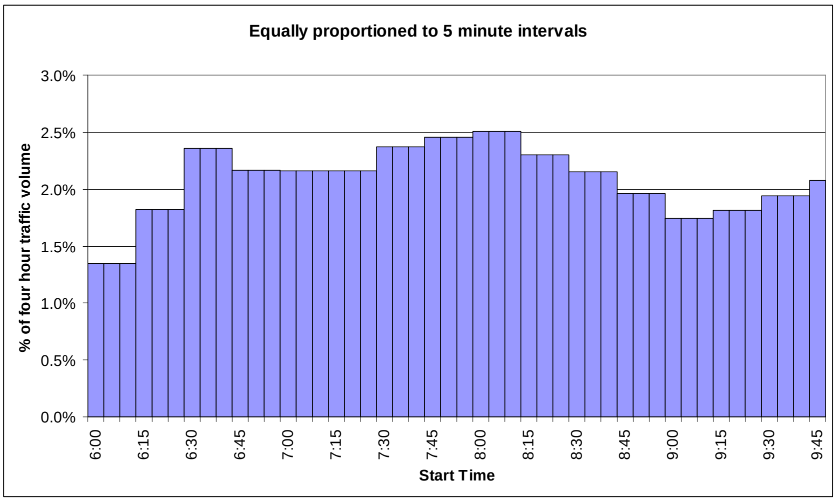
E_t is the equally proportioned profile amount at time t.

An example of the process undertaken to 'smooth' the profiles is illustrated below.

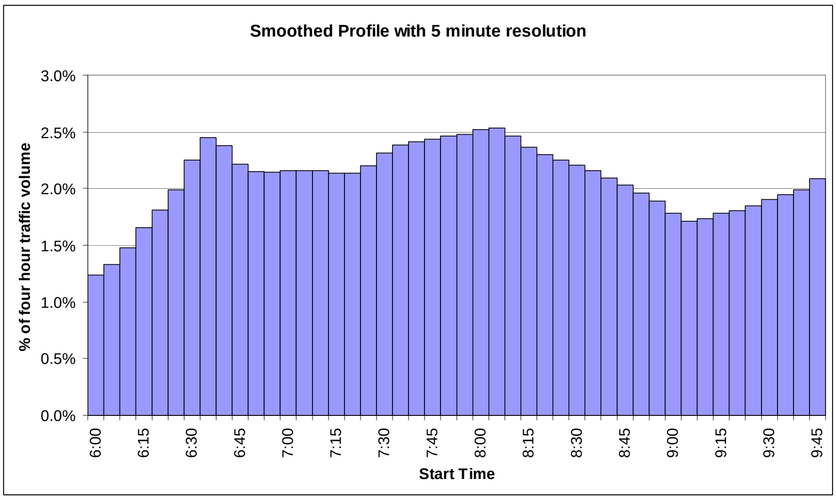
The initial profile with 15 minute resolution was calculated from the TMS data.



Data for each 15 minute period was equally proportioned to the three 5 minute periods that period contains.



Data was then smoothed to prevent large step changes (at 6:15 for example).



The ATMS count used to develop the flow profiles represented the throughput profiles rather than demand profiles which represents arrival of vehicles at the back of any non-transitory queue rather than being trips affected by the capacity of the lanes along the road network. Hence, the profiles were also adjusted to reflect the likely traffic demands of vehicles travelling along the SH16, in particular.

The profiles developed for the full four hour modelled periods were then imported into the AM and PM extended models.

As stated above, the combining of the peak and inter-peak matrices from the project assignment model cordon matrices in both AM and PM models included creating these new profiles. However, further refinement of some of these profiles was necessitated when calibrating the models against the peak hour link flows. This is discussed further in **Section 7.3.5**.

6.3 Assignment

The 14 profiles assigned to trips originating from the seven sectors (from 44 zones) are summarised in **Table 6.2**. The local trips (trips originating and ending within the local road network) in Lincoln, Te Atatu, Rosebank/Patiki, Waterview and St Lukes areas were assumed to travel in the off-peak direction and hence assigned the 'west' profiles in AM model and 'east' profiles in the PM model.

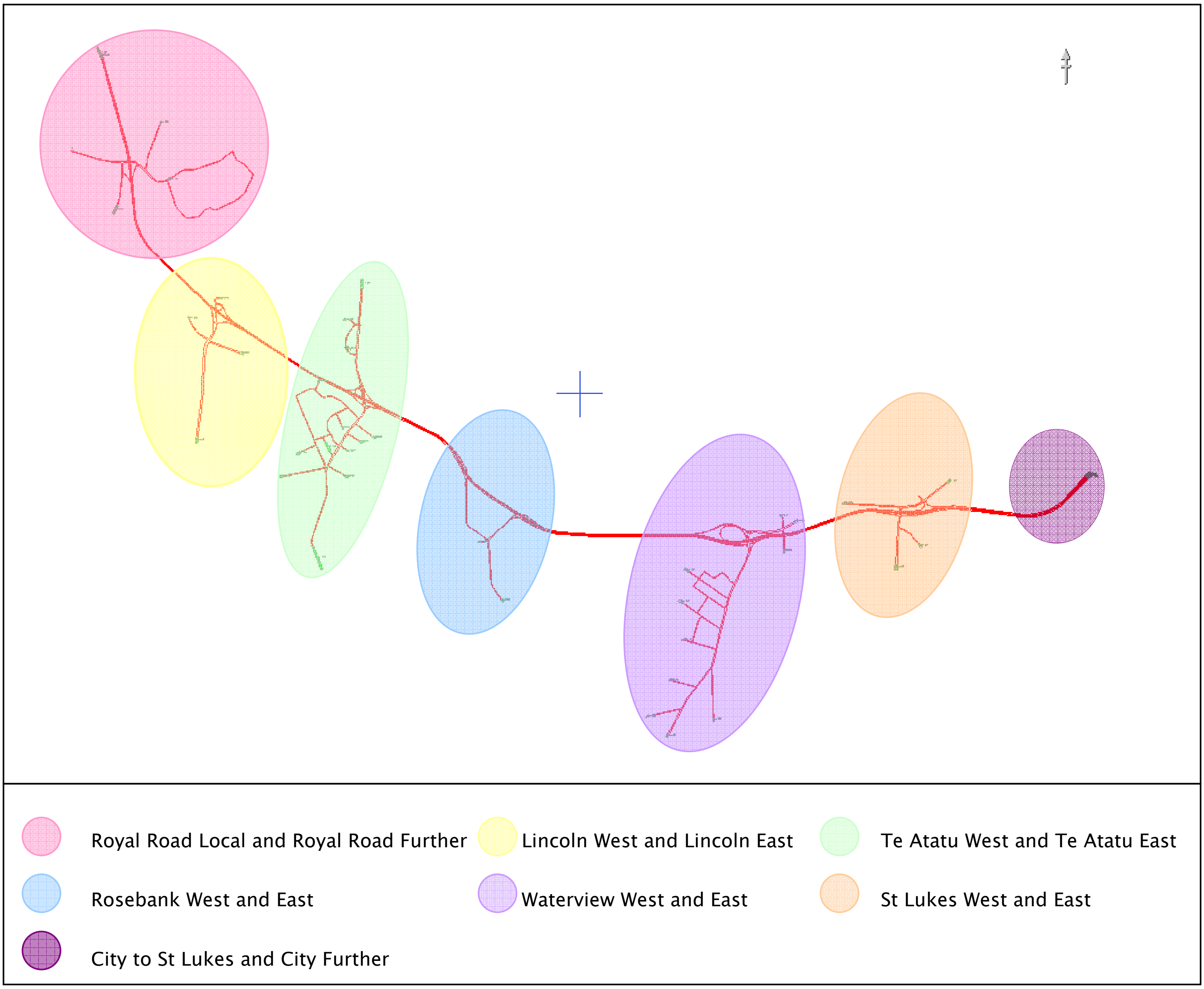


Figure 6.2 – Profiles Developed for the Models

The profile assignment by each of the seven sectors discussed above is illustrated in **Figure 6.3** below.

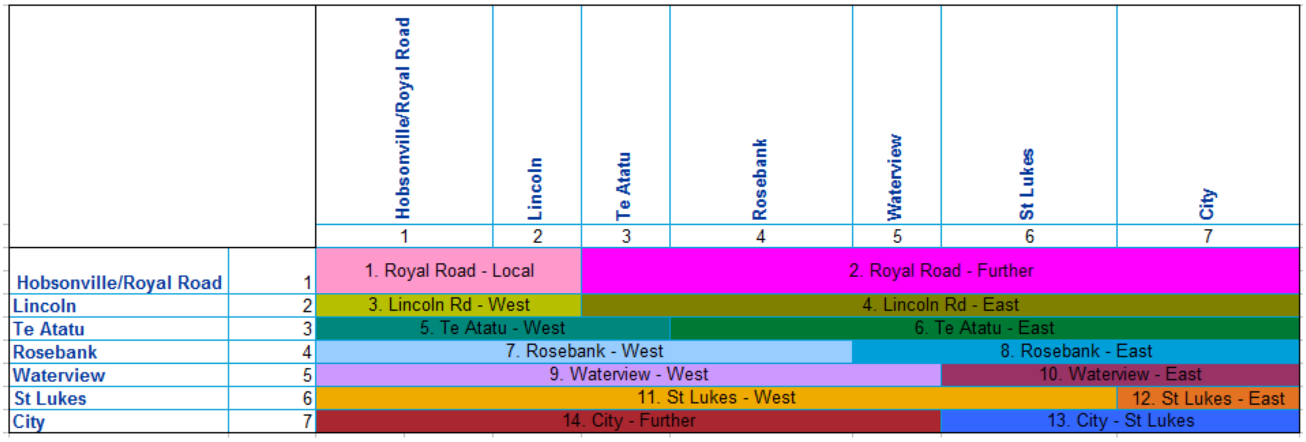


Figure 6.3 – Assignment of Profiles by Sector

Table 6.2 – Assignment of Profiles to Zones

Profile	Profile Name	Origin Location	Origin Zones	Destination Location	Destination Zones
1	Royal Road – Local	Royal Road (Massey)/Hobsonville	1,2,3,4,5,6	Hobsonville, Massey and Lincoln	1,2,3,4,5,6,7,10,11,12
2	Royal Road – Further	Royal Road (Massey)/Hobsonville	1,2,3,4,5,6	Te Atatu, Rosebank, Waterview, St Lukes, City	8,9,13-42
3	Lincoln Road – West	Lincoln Road	7,10,11,12	Hobsonville, Massey and local trips within Lincoln	1-7,10,12
4	Lincoln Road – East	Lincoln Road	7,10,11,12	Te Atatu, Rosebank, Waterview, St Lukes, City	8-9,13-42
5	Te Atatu – West	Te Atatu	8,9,13-20,24-	Hobsonville, Massey,	1-20, 24,25,31

Profile	Profile Name	Origin Location	Origin Zones	Destination Location	Destination Zones
			25,31	Lincoln and local trips within Te Atatu	
6	Te Atatu - East	Te Atatu	8,9,13-20,24-25,31	Rosebank, Waterview, St Lukes, City	21-23, 26-30,32-42
7	Rosebank - West	Rosebank	21,22	Hobsonville, Massey, Lincoln, Te Atatu, and local trips within Rosebank	1-22,24,25,31
8	Rosebank - East	Rosebank	21,22	Waterview, St Lukes, City	23,26-30,32-42
9	Waterview - West	Waterview	23,26-28,32-37	Hobsonville, Massey, Lincoln, Te Atatu, Rosebank and local trips within Waterview	1-28,31-37
10	Waterview - East	Waterview	23,26-28,32-37	St Lukes and City	29,30,38-42
11	St Lukes - West	St Lukes Road/ Great North Road (Western Springs)	29,30, 38,39	Local trips within St Lukes/Western Springs, Waterview, Rosebank, Te Atatu, Lincoln, Massey, Hobsonville	1-39
12	St Lukes - East	St Lukes Road/ Great North Road (Western	29,30,	City	40-42

Profile	Profile Name	Origin Location	Origin Zones	Destination Location	Destination Zones
		Springs)	38,39		
13	City to St Lukes	Eastern end - to Newton Road	43, 44	St Lukes, City	29,30,38,39,40-42
14	City - Further		43, 44	Waterview, Rosebank, Te Atatu, Lincoln, Massey, Hobsonville	1-28, 31-37

7. Calibration Methodology

This chapter discusses the approach to model calibration and validation that was adopted.

7.1 Approach

The calibration/validation philosophy was to obtain satisfactory replication of the existing (2006) conditions without excessive change to the project assignment model demands. The main steps in the process were as follows:

1. Start with the unmodified project assignment model demands and Paramics network;
2. Calibrate network parameters ('global' factors i.e. driver aggression/awareness, vehicle minimum gap);
3. Make reasonable and realistic adjustments to the network (visibility, hazards, stop lines adjustments etc);
4. Adjust the matrix using matrix estimation (this was minimal to start with);
5. Review network and assignment;
6. Step 3 repeated – Make reasonable and realistic adjustments to the network (visibility, hazards, stop lines adjustments etc); and
7. Review the effects of matrix estimation.

7.2 Calibration/Validation Approach

Model calibration was undertaken to review the overall model operation under the estimated demand and covered the following main tasks:

- Model parameters; and
- Network coding.

The calibration process was typically undertaken in two phases. The first phase involved a thorough check of input data that is, road geometry, traffic demand matrices, verification of vehicle routes (this was not relevant for the models as there is no route choice for vehicles travelling along SH16 and minimal route choices available along the arterial / side roads in the network). On completion of these checks, and confirming that they are acceptable, the second stage of the analysis was to compare modelled output statistics (link flow/ journey times) to observed survey data. If the observed to modelled comparisons are within recommended guidelines, and the visualisation of the vehicles is realistic, then the model is deemed to be adequately calibrated.

The criteria for the calibration of the model were based on the GEH assessment criteria from the UK Design Manual for Roads and Bridges3 (DMRB). The assessment criteria are described below:

1) Difference in link flow within 15% for flows 700-2,700vph
2) Difference in link flow within 100vph for flows < 700vph
3) Difference in link flow within 400vph for flows >2,700vph

(items 1–3: greater than 85% of links)

4) GEH Statistic: less than 5 for greater than 85% of links

The GEH Statistic (a form of Chi-squared statistic) is given by the formula:

$$GEH = \sqrt{\frac{(M-C)^2}{(M+C)/2}}$$

Where:

GEH is the GEH statistic

M is the modelled flow; and

C is the observed flow.

The nature of the study area network is such that traffic congestion, queue lengths and travel times tend to vary significantly from day to day. In order to account for this kind of variation in a micro-simulation model, a number of modelled runs are typically undertaken. Each run is assigned random seed (seed 0) which produces different results for each model run. Results are then combined to represent an average situation.

To ensure the robustness of the AM and PM models, five different seed values were run for calibration /validation purposes. The link volumes incorporated in the calibration were the average link flows for the five seed values.

The AM and PM models include four hour modelled periods with the calibration undertaken over 3.5hours (with exclusion of the first 15 minutes and last 15 minutes of the modelled period) and the peak one hour period.

Detailed statistics for the calibration of link flows are presented in **Appendix D**.

After calibration of the model network (Step 1 in **Section 7.1**) the results of the peak hour (7:30-8:30am and 4:15-5:15pm) and average hour (6:15-9:45am and 3:00-6:30pm) of the 3.5 hour period, were retrieved for the AM and PM models. This process included the prior matrices in the AM and PM model. The results

[3] Volume 12, Section 2, Part 1 Traffic Appraisal of Roads Schemes – Traffic Appraisal in Urban Areas Assignment Validation: Acceptability Guidelines

indicated that the modelled link flows along SH16 and the arterial/local roads in the network did not meet the GEH assessment criteria. The AM and PM models achieved a GEH value of less than 5 for less than 50% of links in the network. The calibration results for the AM and PM peak hour period also indicated potential difference in profiling (vehicle releases) against what was reflected in reality in the network.

Matrix estimation (ME) on the EMME cordon matrices was hence considered appropriate to ensure that the demand matrices in the models produced traffic flows that accurately reflected the existing (2006) traffic flows and hence met the model calibration acceptance targets described above.

7.3 Calibration/Validation Data

A large amount of data was used in the calibration and validation stages of the model. This was primarily count and travel time data, both of which are described in detail in the following sections.

7.3.1 Link Count Data

There were four main sources of link count data used in the development of the operational model. These were as follows:

- ATMS data;
- Tube counts;
- SCATS data; and
- Manual counts.

It is noted that SCATS data is considered to have a level of uncertainty associated with in congested conditions however; due to limited availability of 2006 manual counts and tube counts on the arterial and local roads, SCATS data was generally used to give an indication of the level of link flow calibration on these roads.

ATMS was unavailable at some locations along SH16 and therefore, virtual counts were calculated at these locations using the on/off-ramp data.

This data was arranged into three sets for the purposes of model calibration. These sets were as follows:

- Set 1 – SH16 On and Off Ramp data – ATMS counts;
- Set 2 – SH16 mainline data – ATMS counts; and
- Set 3 – Intersection data (tube, SCATS and manual counts).

Please note that Set 3 only includes arterial and local road intersection counts and not State Highway count data.

The ATMS data was unavailable at some of the locations along SH16 and therefore counts at these locations were balanced using the on/off-ramps ATMS data.

Set 1 and some of the Set 3 data was used in the matrix estimation process. With the exception of two counts (at either ends of the model), the mainline counts (Set 2) was used as independent data set for matrix estimation. Therefore, these mainline ATMS counts along SH16 (including the virtual mainline counts) were used as independent data with which to validate the modelled link flows.

The ATMS on/off ramps which were used in matrix estimation were used to calibrate the modelled flows against in the AM and PM models.

The counts that were used in the matrix estimation process (AM and PM models) are indicated in **Appendix C**.

7.3.2 Travel Time Data

Travel time data on SH16 was collected in 2006 as part of the ART3 model validation exercise. As the operational model has a 2006 base year, and is linked to the ART3 model, the ART3 travel time data was utilised here.

The DMRB criteria were also adopted for the travel time validation process. The DMRB states that 85% of modelled average journey times should be within 15% of the observed journey time, or within one minute, if higher.

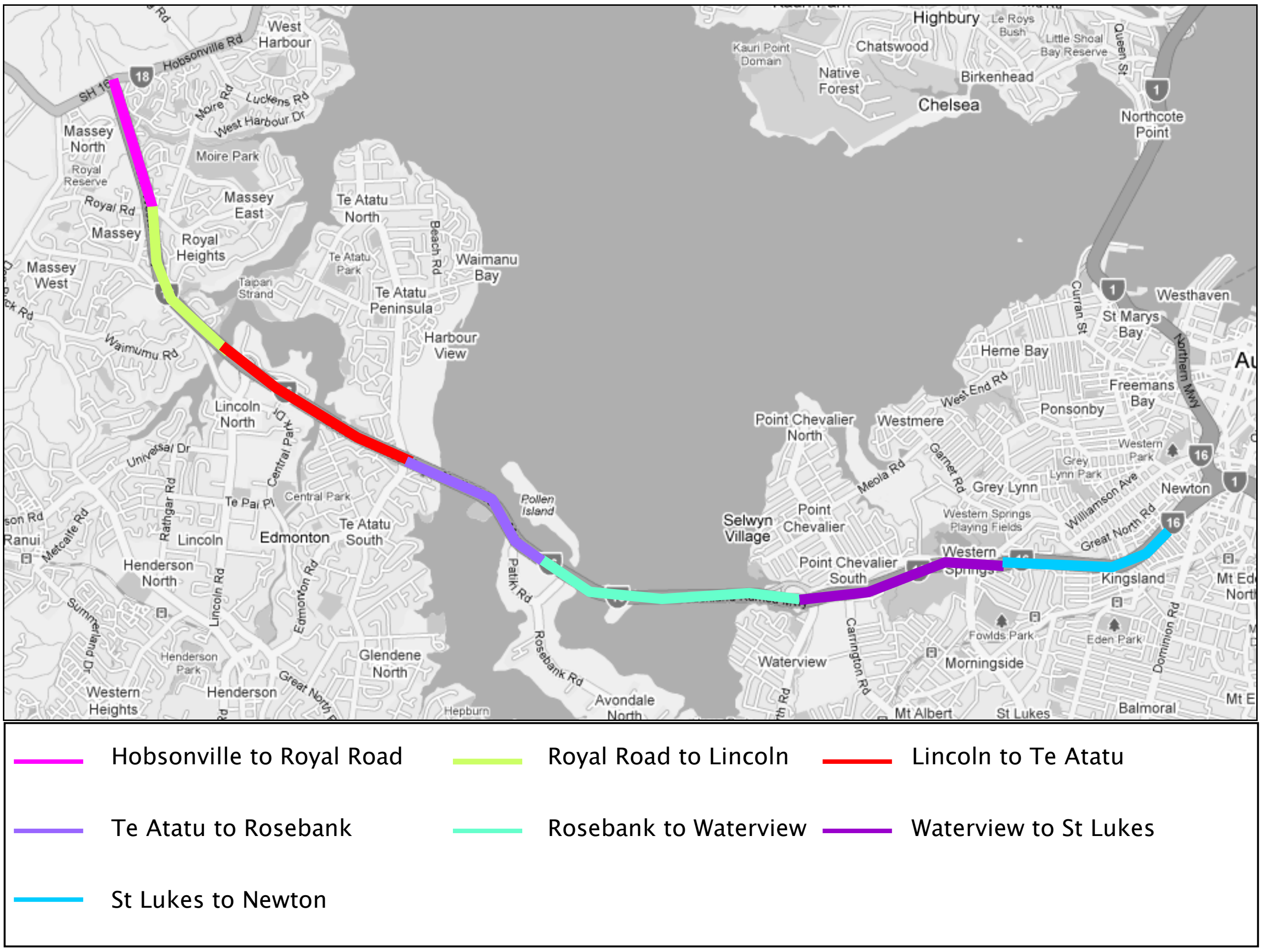
The total model travel time was collected for the entire length of the SH16 corridor. However, the travel time paths in the operational model was also broken down into seven sections for the purpose of comparing the travel times between the highway interchanges and determining sections where the travel times were too fast or slow. The travel time calibration process and results are discussed in detail in Section 8.

These sections are:

- Hobsonville to Royal Road;
- Royal Road to Lincoln Interchange;
- Lincoln Road Interchange to Te Atatu Interchange;
- Te Atatu Interchange to Rosebank Road/Patiki Road Interchange;
- Rosebank Road/Patiki Road Interchange to Waterview Interchange;
- Waterview Interchange to St Lukes Road/Western Springs Interchange; and

- St Lukes Road/Western Springs to Eastern end of model (at Newton Road)

These sections are illustrated in **Figure 7.1** below.



Map courtesy of Wises

Figure 7.1 – Intermediate Travel Time Paths for AM and PM models

7.4 Calibration Process

The following calibration steps were taken to ensure model robustness through meeting the calibration target criteria.

- Signal Timing Adjustments;
- Headway Factor Adjustments;

- Node Feature Changes;
- Link Features Changes;
- Modification of Profiles; and
- Matrix Estimation (discussed in Chapter 5)

These are discussed in detail in the following sections.

7.4.1 Signal Settings

The signals that were used in AM and PM models have been based on the SCATS IDM data for each signalised intersection in the network. The intersections and the days covered by the SCATS data are shown in **Table 7.1** below.

Table 7.1 – Intersection and Analyses Dates for SCATS Data

SCATS Site	SCATS IDM Data Dates	Description
3044	16-22 October 2006	Royal Road / Makora Road
3906	16 -22 October 2006	Royal Road Westbound Off-ramp / Makora Road
3043	16-22 October 2006	Royal Road / Moire Road
3902	16-22 October 2006	Selwood Road / Lincoln Road / Lincoln Road Eastbound Off-ramp
3024	16-22 October 2006	Lincoln Road / Triangle Road / Central Park Drive
3901	16-22 October 2006	Te Atatu Road / Te Atatu Westbound On-ramp / Te Atatu Westbound Off-ramp
3028	16 -19 October 2006	Te Atatu Road / Vera Road / Jaemont Avenue
2119	16 -19 October 2006	Great North Road / Great North Road Eastbound Off-ramp / Great North Road Eastbound On-ramp

SCATS Site	SCATS IDM Data Dates	Description
2119	16 -19 October 2006	Great North Road / Great North Road Westbound Off-ramp / Great North Road Westbound On-ramp
2026	16 -19 October 2006	Great North Road / Pt. Chevalier Road / Carrington Road
2184	16 -19 October 2006	Great North Road / Herdman Street
2123	16 -19 October 2006	Great North Road / Alford Street
2124	16 – 19 October 2006	Great North Road / Blockhouse Bay Road
2169	6 – 10 November 2008	St Lukes Road / Great North Road

The IDM data reported the minimum, maximum and average phase times/cycle times and phasing information that was split into three time periods for all intersections:

- 7:00am – 9:00am
- 10:00am – 4:00pm
- 4:00pm – 6:00pm

A Tuesday was considered to represent a 'typical' day for commuter traffic in the road network and therefore, Tuesday IDM information from the above SCATS data was used to code in the signal settings for all intersections in the network. A check of this Tuesday SCATS data for all intersections was however also undertaken against a Monday, Wednesday and Thursday IDM data to ensure that there were not high variability in the average or minimum and maximum phase and cycle timings at any intersections between these days.

Additional signalised intersections that were coded as part of the extended network and the days covered by the SCATS IDM data for these intersections are shown in **Table 7.2**.

Table 7.2 – Intersection and Analyses Dates for SCATS Data

SCATS Site	SCATS IDM Data Dates	Description
2913	11 -15 August 2008	St Lukes Road / St Lukes Road Westbound On ramp / St Lukes Road Eastbound Off-ramp

SCATS Site	SCATS IDM Data Dates	Description
2170	11 -14 August 2008	Great North Road / Great North Road Eastbound On-ramp / Great North Road Eastbound Off-ramp, Western Springs
3054	23 - 27 November 2008	Te Atatu Road / Covil Avenue

2006 SCATS IDM data for the above sites was not available therefore; 2008 data for these intersections was obtained. The SCATS IDM data for these three intersections was checked against the CIS (Controller Information System) data to ensure that the signal phasing information in the 2008 IDM data were consistent with what was applied in 2006. The CIS data confirmed that the phasing indicated in the 2008 SCATS data is consistent with the 2006 phasing at these intersections.

The AM and PM base models initially incorporated the average signal timings that were indicated in the IDM data for all intersections. Adjustments to these initial settings were made where considered necessary to obtain the appropriate behaviour of traffic whilst calibrating against the surveyed counts at the intersections. The range of these adjustments was limited to keep the green times between the actual minimum and maximum times recorded by SCATS during the appropriate peak period.

These base models included signal plans that were incorporated in the model to accounts for the changes in phases, phasing times and cycle times between the peak hours and the rest of the peak/inter-peak periods in the full four hour modelled period.

The signal plans for the AM model included the inter-peak period of 9:00am - 10:00am for all signalised intersection in the models. As discussed in **Section 4.3**, six time periods were modelled in the AM model.

For Period 1 and 2 (6:00 - 8:45am) IDM data for 7:00-9:00am was used for all intersections, in the AM base model. For the rest of the four periods (9:00 - 10:00am) the 10:00 - 4:00pm (inter-peak) period signal settings were applied. As stated above the 9:00am-10:00am period is considered as inter-peak period and therefore it was considered appropriate to use inter-peak signal settings for the modelled periods 3-6.

The PM model includes four modelled periods. A signal plan for the period 16:15 - 18:45 (modelled Period 2) was created for the PM model for all intersections in the extended model. The signal settings was therefore split into an inter-peak (14:45 - 16:15) period and peak period (16:15 - 18:45).

7.4.2 Headway Factors

The travel times for the eastbound and westbound direction for vehicles travelling along SH16 mainline were initially collected from the AM model. The observed travel time data (7:00-9:00am) used for the project assignment macro modelling validation was used as a comparison basis for the Paramics modelled times.

The AM modelled travel times for the two hour peak period indicated the vehicles travelled faster travel along the entire length of SH16, in the eastbound direction (AM period) and westbound direction (PM period) when compared to the observed (surveyed) 2006 data.

The default headway factor applied to links in Paramics is 1.0s. However, there is some evidence that in reality the headway between vehicles is higher along a highway or motorway. This is observed particularly during the congestion periods when vehicles tend to brake more often and generally travels at slower speeds.

The travel time calibration process therefore, included changing the headway factor on the SH16 links to accurately reflect the actual 2006 travel times for eastbound vehicles (AM period) and westbound vehicles (PM period).

A range of headway factors were tested initially for the AM model for the eastbound links along SH16. The final headway factor that provided a more realistic travel time along the SH16 in the eastbound direction was 1.25s.

The headway factor for the vehicles travelling along the study area length in 2006 was calculated using the 2006 ATMS counts and AMTS spot speed survey data. The methodology included calculating the time taken for a vehicle to traverse its length (assumed as 5.5m) and subtracting this value from the total time (in seconds) taken to travel along a lane along the SH16 (based on the spot speeds measured at an interchange). The calculated results indicate a wide range of headway factors for vehicles travelling along the state highway. This included minimum of 1.0s and maximum of greater than 20.0s.

In addition, these values were also checked against the surveyed headway factors recorded in the ATMS data. The ATMS data collates the surveyed headway factors into four 'bins' at the following two locations:

- St Lukes Interchange; and
- Waterview Interchange.

The four 'bins' represent the range of the surveyed headway factors observed along SH16. The headway factor range corresponding to the four 'bins' are:

- Bin 1: 0 – 1.5s
- Bin 2: 1.5 – 2.0s
- Bin 3: 2.0 – 5.0s
- Bin 4: > 5.0s

The collated headway data for eastbound and westbound traffic along SH16 are shown in **Tables 7.3** and **7.4** below.

Table 7.3 – ATMS Headway Data for 2006 (average 7:30 - 8:30am)

Location on SH16	Bin 1 (0 -1.5s)	Bin 2 (1.5-2.0s)	Bin 3 (2.0-5.0s)	Bin 4 (>5.0s)	TOTAL
St Lukes Interchange – Eastbound direction	20%	19%	49%	13%	100%
Waterview Interchange – Eastbound direction	19%	14%	47%	20%	100%

Table 7.4 – ATMS Headway Data for 2006 (average 4:15 – 5:15pm)

Location on SH16	Bin 1 (0 -1.5s)	Bin 2 (1.5-2.0s)	Bin 3 (2.0-5.0s)	Bin 4 (>5.0s)	TOTAL
St Lukes Interchange – Westbound direction	32%	17%	38%	13%	100%
Waterview Interchange – Westbound direction	29%	19%	42%	10%	100%

The ATMS data indicates vehicles generally travelled with headways that range over 1.0s along SH16 at these two locations with most vehicles travelling with headways of 2.0s -5.0s. Therefore, it is considered that the adjusted headway factor of 1.25s along SH16 in the eastbound and westbound directions, in the AM and PM periods respectively, is a reasonable assumption.

The 1.25s headway factor was therefore applied along the entire study length on the SH16 links. For the purpose of keeping the headway factor consistent in the peak travelling directions between the AM and PM periods, headway factor of 1.25s was also applied to links on SH16 in the PM model. However, the change in headway was not applied in the section between the eastern end of the model and St Lukes interchange (east of westbound off-ramp). This is because the modelled travel times in this section was higher than the observed 2006 travel times. The ATMS data indicates that vehicles in this section generally travel at closer headway gaps than at the Waterview interchange.

The calibrated traffic flow data also indicates that by increasing the headway factor in this section reduces the throughput of vehicles in the section east of St Lukes interchange which, in effect creates underestimation of westbound traffic flows at Waterview as well as other interchanges. Hence, to better represent the actual travel times and the traffic flows along SH16, it was therefore considered appropriate to apply headway factor of 1.25s between St Lukes (west of westbound off-ramp) and western end of the model (at Hobsonville).

7.4.3 Nodes Features Changes

Node features include the position of the node itself, the corresponding position of kerbs and stop lines, and the hazard distances.

The modelled nodes were firstly located on road centrelines and the position of the default kerbs then altered to reflect the location of actual kerbs in the study area. The position of the stop lines were then altered, where necessary, to ensure that they were positioned accurately to reflect the location where vehicles needed to stop at the intersections in the study area.

As discussed in **Section 3.2.2**, the links along SH16 were coded as 'Urban major' rather than 'Highway' category. The hazard (signposting) posting distance in Paramics is indicated as a distance from a decision point at which vehicles are notified that a change in behaviour may be required.

In Paramics a 'Highway' link has a default signposting distance of 750m whilst an 'Urban Major' link included default signposting distance of 250m. The default signposting distance along SH16 (as well as on/off-ramps) has been altered at some nodes to replicate the actual behaviour of traffic travelling along SH16.

It is also be noted that the sign posting on the SH16 link at the eastern end of the model (before the eastbound link splits into three sections) was altered to accurately replicate the 'weaving' of eastbound traffic, in the section just east of St Lukes / Western Springs on-ramp. It is considered that this alternation in signposting would not have any effects on the future models as these forecast year models would include the Central Motorway junction (CMJ) which would include a different road network and therefore a change in network coding, at this eastern extremity of the model.

7.4.4 Link Features Changes

Link features include the flags and modifiers that can be assigned to each link to ensure acceptable vehicle behaviour.

The "GA look next" flag has been used on some links to force vehicles approaching intersections to consider vehicles, not only travelling on the link immediately adjacent, but also the following link when giving way at the intersection. The use of this flag was necessary to ensure correct give-way behaviour at intersections with very short approach links (such as along Great North Road).

The "visibility" modifier, which has a default value of zero, was adjusted on links where vehicles may have to give way. With the visibility set at the default of zero, vehicles are forced to stop at an intersection stop line before calculating an acceptable gap between opposing vehicles, to enter the intersection. When the visibility is greater than zero, vehicles approaching a stop line can begin to calculate their gap before the stop line, so they do not need to come to a complete stop if there are no opposing vehicles travelling through the intersection. This change allows the behaviour of modelled vehicles to better represent actual behaviour.

The eastern extremity of the model was coded with separate number of zones to replicate the 'weaving' of traffic that occurred for eastbound travelling traffic, particularly in the AM peak period. Three zones were coded at this end in the network. Vehicles exiting SH16 at Newton Road off-ramp travelled to Zone 40. Vehicles entering the southern motorway travelled to Zone 41 and vehicles travelling north or towards the port travelled to Zone 42.

The number of lanes coded at the eastern end of the model was also changed from what was actually 'on the ground' in 2006 (prior to the CMJ being completed). The numbers of lanes leading to the southern motorway (zone 41) in 2006 were two. However, the network operated at a highly congested level when only one lane was coded in the network to terminate at this zone. This led to a false level of congestion and extent of queuing for eastbound traffic. As this section is located at the extremity of the modelled network, this network coding would not affect the future models when the CMJ is in place.

7.4.5 Profile Modifications

The profiles calculated for the models were based on on-ramps and SH16 mainline data. These were then adjusted to reflect what was considered as demands along the state highway rather than the throughput of vehicles along the corridor.

The peak hour flow calibration reflects the robustness of the profiles used in the model. During the flow calibration process the peak hour the modelled flow data indicated either over or under-estimation of traffic flows along some sections along SH16. This was noted in the westbound direction in particular, in both AM and PM models. The 'City- Further' and 'City to St Lukes' profiles in the AM model and 'City – Further' profiles in the PM model were considered to particularly affect the release of vehicles along SH16. This was because a high percentage of westbound vehicles entered SH16 from the zones that were assigned this profile. Additional analysis and modification of this profiles as well as City to St Lukes profile (in AM mode) resulted in more robust calibration results that confirmed this alteration in these two profiles.

8. Calibration/Validation Results

The summary results for the flow and travel time calibration for the AM and PM period models against the DMRB criteria are shown in **Tables 8.1 and 8.2**. Tables showing the full comparison of all observed and modelled link flows, from which these summaries are derived, are listed in **Appendix F.**

8.1 Flow Validation Results

The traffic flow validation was undertaken with the ATMS mainline (SH16) link flow counts that were not used in the matrix estimation process (that is using the independent ATMS data set). The validation was carried out for the average hour (from modelled 3.5 hour period) and peak one hour periods for the AM and PM models. These results are based on average of five runs undertaken with random seed. The random seed ensures that the arrival of vehicles and their behaviour and interactions within the model network differ to a certain degree between each model run.

Table 8.1 – Validation Results – GEH Statistics

		AM Peak Period (6:15-9:45am)		AM Peak Hour (7:30-8:30am)		PM Peak Period (14:45-18:45)		PM Peak Hour (16:15-17:15)	
GEH	**Target %**	**Achieved %**	**Result**	**Achieved %**	**Result**	**Achieved %**	**Result**	**Achieved %**	**Result**
< 5	> 85%	96.8%	**Pass**	89.3%	**Pass**	90.3%	**Pass**	89.3%	**Pass**
< 10	> 95%	100%	**Pass**	100%	**Pass**	100%	**Pass**	100%	**Pass**
< 12	100%	100%	**Pass**	100%	**Pass**	100%	**Pass**	100%	**Pass**

Table 8.2 – Validation Results – Individual Link Flow Flows

Flow Target & Range	Target %	AM Peak Period		AM Peak Hour		PM Peak Period		PM Peak Hour	
		Achieved %	Result	Achieved %	Result	Achieved %	Result	Achieved %	Result
+/- 100 for flows < 700	> 85%	98.9%	**Pass**	95.7%	**Pass**	97.9%	**Pass**	97.9%	**Pass**
+/- 15% for 700 < flows < 2700	> 85%	100%	**Pass**	93.6%	**Pass**	92.5%	**Pass**	94.6%	**Pass**
+/- 400 for flows > 2700	> 85%	100	**Pass**	97.9%	**Pass**	100%	**Pass**	100%	**Pass**

The results detailed in **Tables 8.1** and **8.2** show that both AM and PM peak period and peak hour validation results are well within the required ranges and therefore satisfy the validation criteria. The calibration of the link flows on the on/off ramps and on arterial/local roads were also undertaken for the AM and PM models. The calibration results for the independent plus the link counts used in matrix estimation is presented in Appendix E.

8.1.1 Observed versus Modelled SH16 Mainline Link Flows

Comparison between the observed count and modelled SH16 mainline flows were undertaken for the peak period (average hour of the 3.5hour modelled period) as well as peak hours, for the AM and PM models. **Figures 8.1** to **8.4** show the results of the flow comparisons of the independent counts on the mainline.

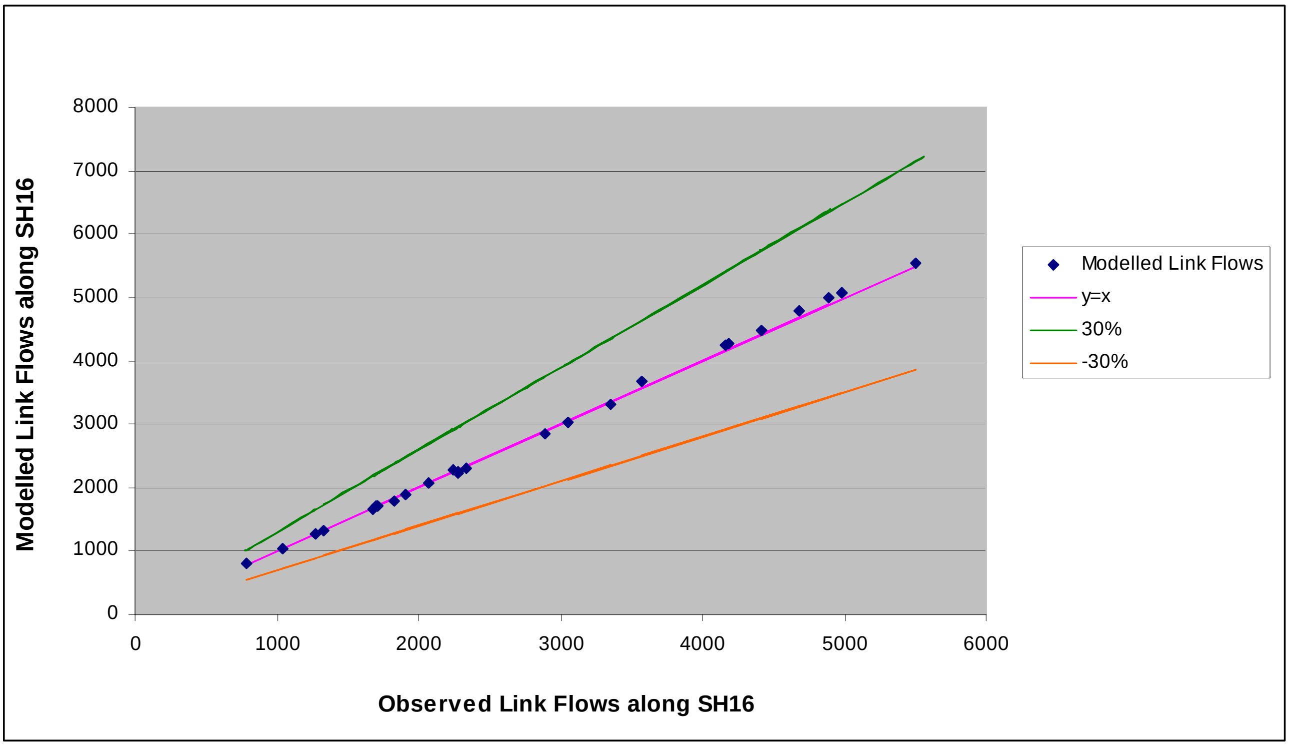


Figure 8.1 – AM Peak Period Link Flow Comparison (Average 1 Hour) – Observed vs Modelled SH16 MainlineFlows

Figure 8.1 shows the comparison between observed and modelled link flows for the AM peak period. The results are based on an average one hour flows of the total 3.5 hours modelled period. This confirms the accuracy of the demand matrix for the SH16 mainline flows in both eastbound and westbound directions.

The difference between the sum of all observed and modelled SH16 (eastbound and westbound) flows is approximately -1.0%. There is slightly more traffic modelled within the AM peak period hour than was observed. The difference is not considered to be significant given the small scale of the difference when compared to the total sum of flows (which is greater than 85,000 vehicular observations).

The R^2 value for this peak hour is 1.00 which indicates that the line of best fit is straight through the y=x axis.

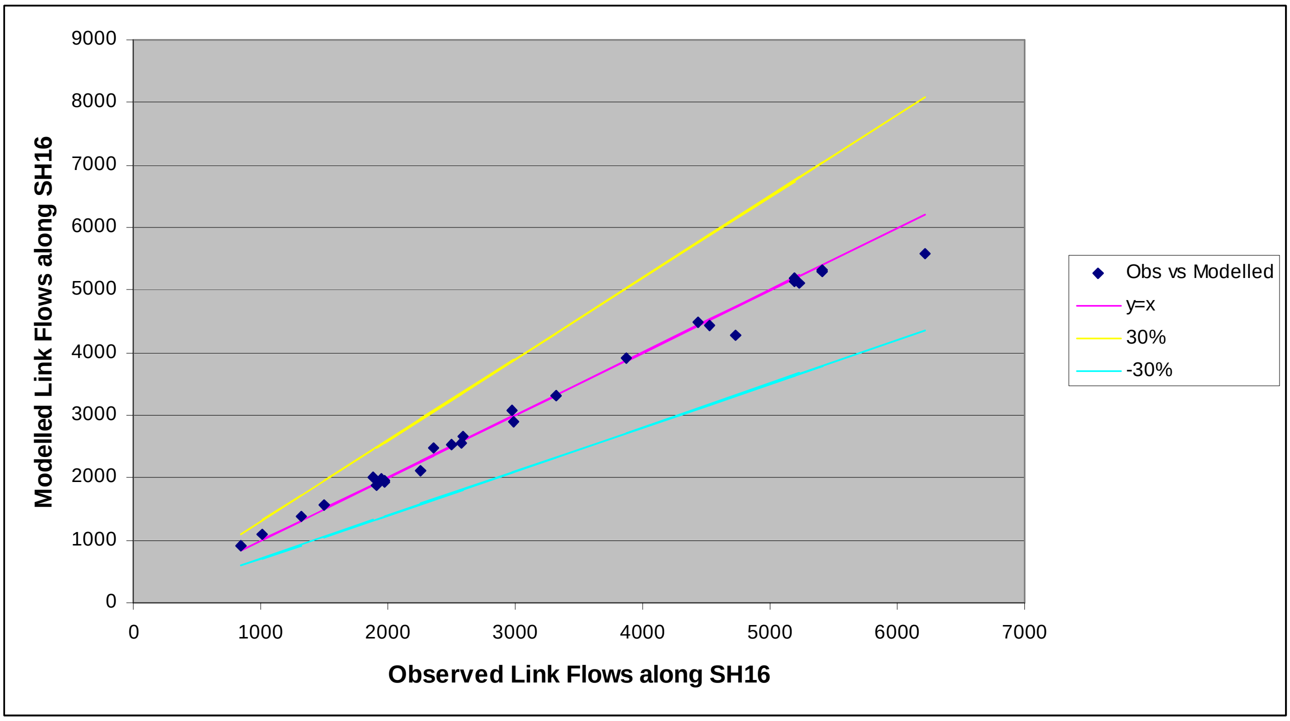


Figure 8.2 – AM Peak Hour Link Flow Comparison (7:30-8:30am) – Observed vs Modelled SH16 Mainline Flows

Figure 8.2 shows the observed versus modelled link flows comparison for the AM peak hour (7:30-8:30am). The figure indicates a good fit between the observed and modelled flows. The level of correlation is lesser than that for the AM peak period (average one hour of the 3.5hour period), however all links flows are well within the +/- 30% range. The difference between the sum of all observed and modelled SH16 (eastbound and westbound) flows is approximately 1.2%. This thus indicates that there is slightly less traffic modelled within the AM peak hour than was observed. Again the difference is not considered to be significant given the small scale of the difference when compared to the total sum of flows.

The R^2 value for this peak hour is 0.99 which again indicates a strong linear correlation between the modelled and observed flows.

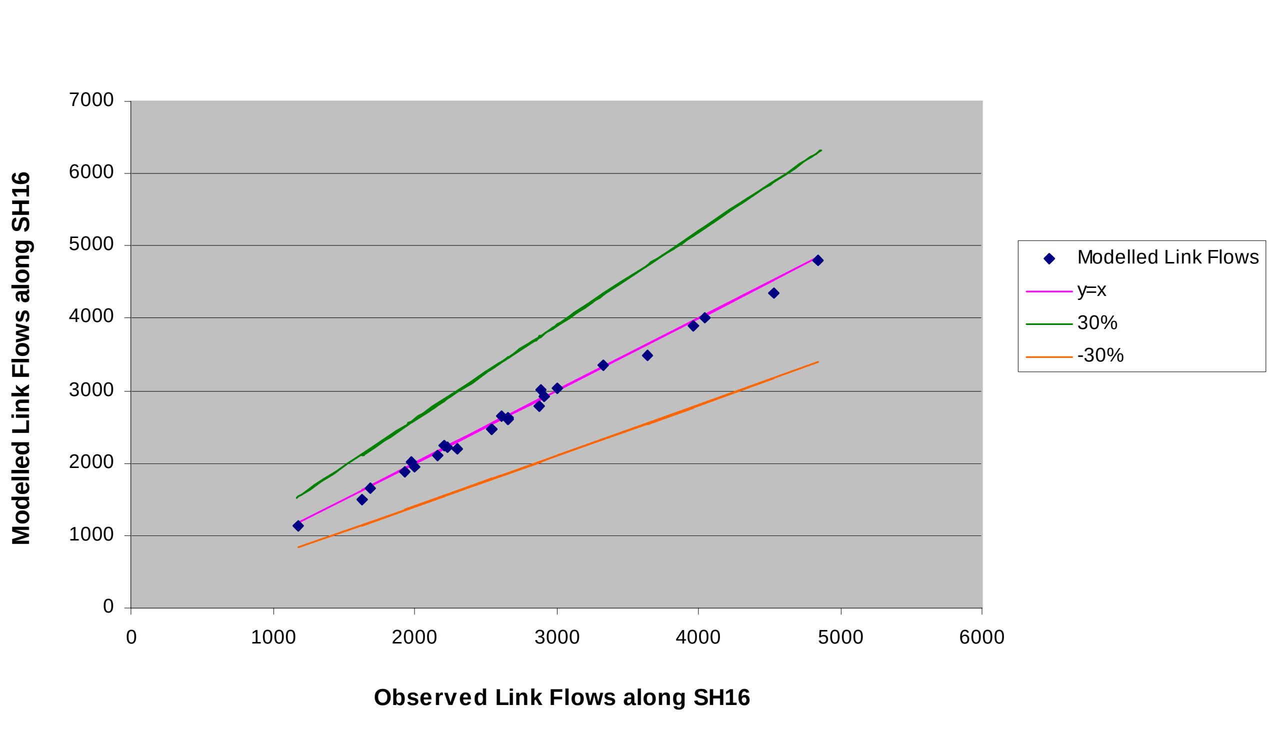


Figure 8.3 – PM Peak Period Link Flow Comparison (Average 1 Hour) – Observed vs Modelled SH16 Mainline Flows

Figure 8.3 shows the high correlation between the observed and modelled link flows for the PM peak period. None of the modelled link flows are outside the +/- 30% range. This confirms the accuracy of the demand matrix for the SH16 mainline flows in both eastbound and westbound directions, in the PM peak period.

The difference between the sum of all observed and modelled SH16 flows is approximately 1.5%. This indicates slightly less modelled traffic within the PM peak hour when compared to the observed. The R^2 value however for this peak period is 0.99 which indicates a strong linear correlation between the modelled and observed PM period flows.

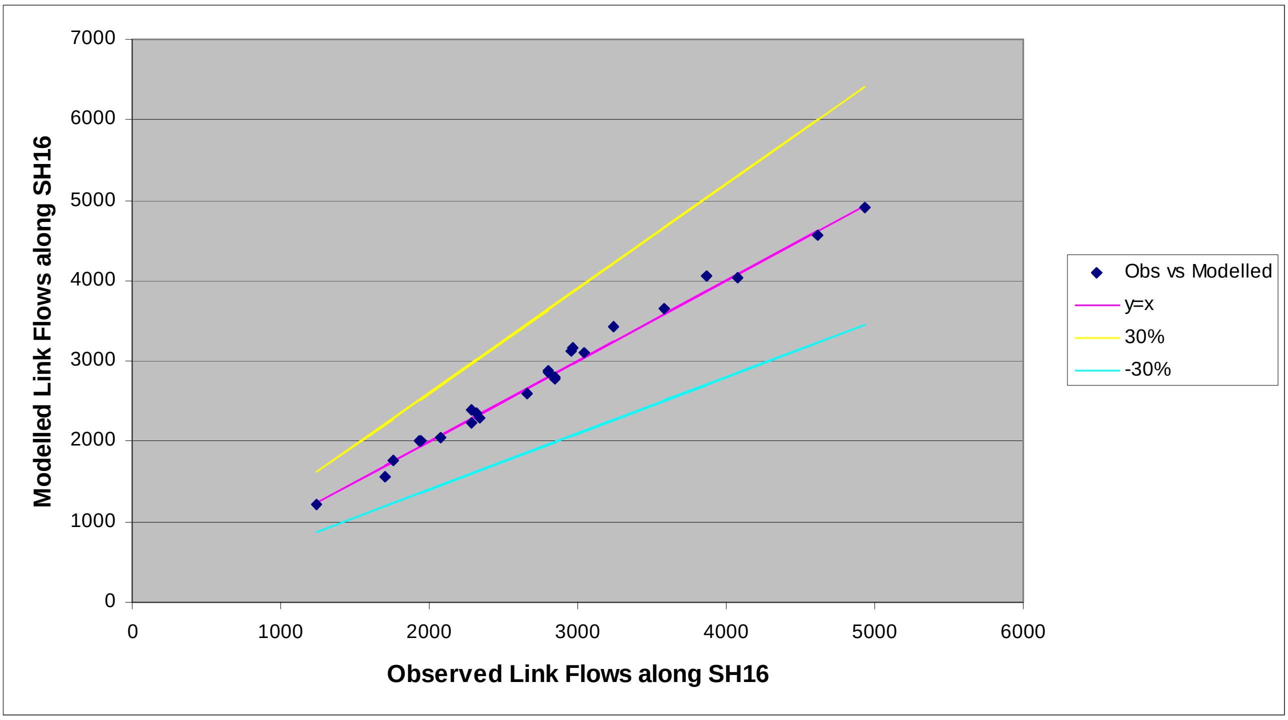


Figure 8.4 – PM Peak Hour Link Flow Comparison (7:30-8:30am) – Observed vs Modelled SH16 Mainline Flows

Figure 8.4 shows the observed versus modelled link flows comparison for the PM peak hour (4:15-5:15pm). The figure indicates a good fit between the observed and modelled flows. The difference between the sum of all observed and modelled SH16 (eastbound and westbound) flows is approximately -0.6%. This indicates that there is slightly greater traffic modelled within the PM peak hour than was observed. The difference is not considered to be significant given the small scale of the difference when compared to the total sum of flows (which is greater than 74,000 vehicular trips). Again it is also noted that these flows were not included in the matrix estimator and therefore are independent values.

The R^2 value for this peak hour is 0.99 which again indicates a strong linear correlation between the modelled and observed flows.

The comparison of the observed and modelled flows was also undertaken for the calibrated links flows on the on/off ramps and arterial and local roads. The total results for the validated link flows (independent mainline flows) and the calibrated link flows are attached in **Appendix E**. The comparison results showed a higher deviation from the y=x linear axis for the AM and PM peak hour and peak period flows for arterial/local roads. This thus indicated lower correlation between the observed and modelled flows for the arterial and local roads in the model network. A small percentage of flows were outside the +/- 30% range, however this was only for low volume flows along the links. However, the results indicates a high correlation between the modelled and observed flows with the R^2 falling in the 0.90 -1.00 range for both peak periods and peak hours, in the AM and PM models.

8.1.2 Model Stability

The use of different random seeds to collect the modelled results is undertaken to taken to replicate the day-to-day variation inherent in traffic movements. However, this variation needs to be within an acceptable range to demonstrate the robustness of the modelled results. Results of the five model runs for AM and PM models are shown in **Table 8.3** below.

Table 8.3 – Model Stability Results

Model Run	Total Distance (km)		Total Time (hour)		Total Vehicles	
	AM	PM	AM	PM	AM	PM
Run 1	478,500	458,600	14,000	14,000	86,700	80,100
Run 2	476,800	457,500	14,800	14,500	86,800	80,000
Run 3	470,600	459,900	15,500	13,400	86,700	80,100
Run 4	475,900	458,200	14,900	14,000	86,700	80,100
Run 5	472,200	457,200	15,600	14,400	86,800	80,100

Tables 8.3 and Figures 8.1-8.4 indicate consistency across the five different modelled runs, for all three measures, for the AM and PM peak periods. The total distance travelled by all vehicles completing their trips within the 3.5hr modelled period is consistent between the model runs which, is expected due to the lack of alternative routing options for vehicles travelling between each origin and destination pair.

The differences in the total number of vehicles and the distance travelled is less than 2% in both AM and PM models. The total time in the network for all vehicles completing their trips within the modelled period is more variable; however this is expected due to the congested nature of the road network and changes in traffic in conditions on a daily basis.

The variability between the maximum and minimum values for all measures is not considered significant given the high number of vehicles travelling in the network during these peak periods as well as the long distances travelled.

It is therefore considered that the model results retrieved from the five runs have provided stable results and the variations represented in the tables and graphs above only represent the normal day-to-day fluctuations in the traffic behaviours and network conditions in a congested traffic environment.

The difference in these results between each run is illustrated in **Figures 8.5 – 8.7**.

Further analysis of model stability will be undertaken as part of the future year model reporting.

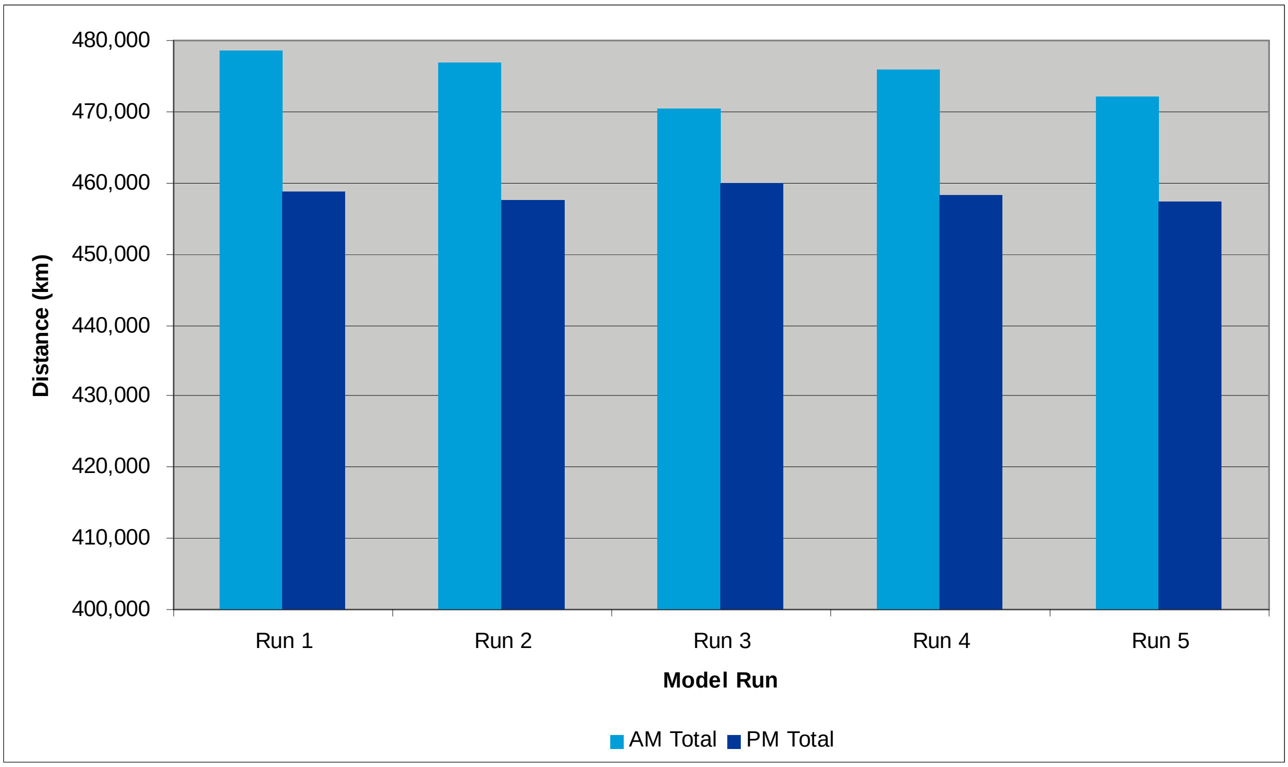


Figure 8.5 – Difference in Distance Travelled (km) between the Five Modelled Runs

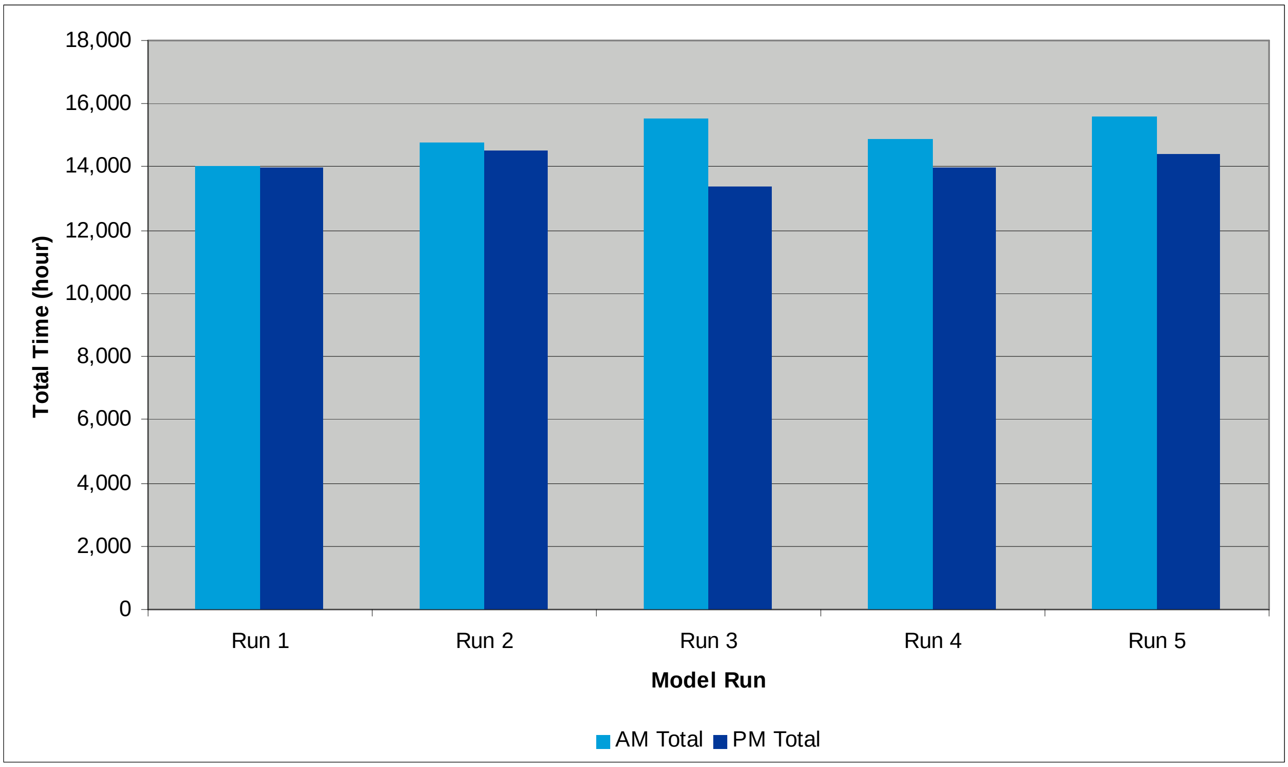


Figure 8.6 – Difference in Time (Hour) between the Five Modelled Runs

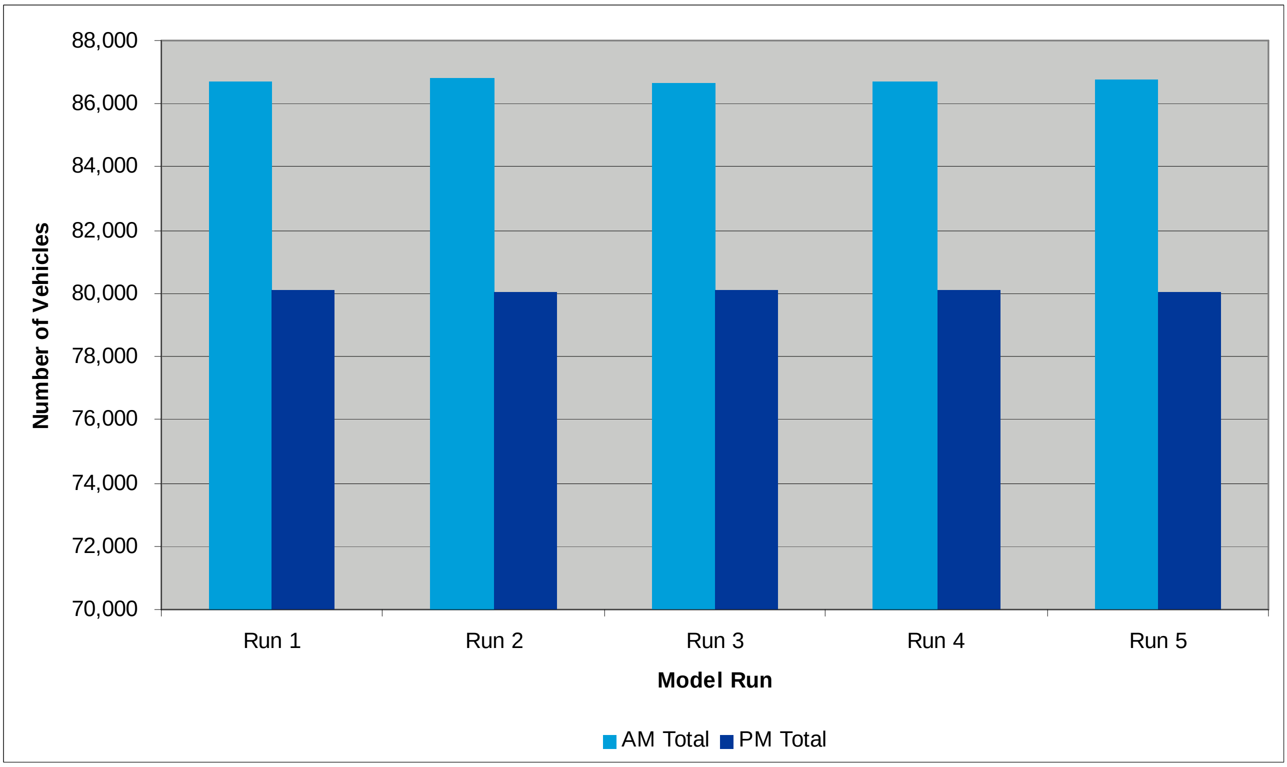


Figure 8.7 – Difference in Number of Vehicles between the Five Modelled Runs

8.1.3 Flow Validation

The results discussed in **Sections 8.1** and **8.1.1** indicate the AM and PM peak period models satisfy the required and recommended calibration criteria. The emphasis of the calibration process was placed on SH16 mainline flows. However, the calibration process also ensured that the flows along the arterial and local roads also satisfied the flow calibration criteria. The accuracy of the flow profiles used in the models are confirmed by the high level of correlation between the observed and modelled link flows along SH16, in the peak hours, as well as arterial and local roads. The calibration results also confirm the traffic demands for the AM and PM peak periods.

The AM and PM peak period models are appropriately calibrated to represent the demands and movements of trips through the network in both peak periods.

8.2 Travel Time Validation

The travel time calibration was undertaken by comparing the modelled travel time along SH16 corridor in eastbound and westbound directions against the surveyed travel times. As discussed in **Section 7.4.2** the model travel times were collected for the entire study length of the SH16. The travel time path was also broken down into seven sections for the purpose of comparing the travel times between the highway interchanges and determining sections where the travel times were too fast or slow.

It is noted that the surveyed travel times covered the period 7:00-9:00am and 4:00-6:00pm and these travel times represented the average times over these two-hour periods. The model travel time results were therefore collected and averaged over these two-hour periods.

It is also noted that the exact number of travel time floating car surveys undertaken to collect these observed results is unknown. However, it is understood that the sample size of both AM and PM peak surveys were small hence it has been taken into accounts that the surveyed data may not accurately reflect the variability in the range of travel times that was observed along SH16 in 2006. The floating car survey methodology provides a snapshot of network performance only at times when vehicles are travelling on the intermediate sections. However, the modelled results include all vehicles travelling along SH16 corridor. Therefore, it is likely that the maximum travel times will be higher than that observed.

8.2.1 AM Model Results

The AM period travel time calibration results are shown in **Table 8.4** for the five individual modelled runs. The table shows the travel times along the seven segmented sections along SH16 as well along the entire state highway corridor.

Table 8.4– Travel Time Comparison for AM Peak Period (7:00-9:00am) – Eastbound Direction

EB	Observed			Ave of 5 average modelled runs		
	Max	Min	Ave	Max	Min	Ave
Hob to Royal	1.60	1.35	1.43	1.79	1.05	1.21
Royal to Lincoln	2.00	1.40	1.70	3.87	1.28	1.80
Lincoln to Te Atatu	4.10	1.30	2.03	4.92	1.24	2.41
Te Atatu to Patiki	4.40	1.65	3.10	3.69	1.17	2.04
Patiki to Waterview	6.10	2.70	3.86	14.59	2.19	4.80
Waterview to St Lukes	6.85	4.05	5.18	9.55	1.66	4.98
St Lukes to Newton	2.80	2.75	2.88	5.73	1.05	3.76
SH16 EB	27.85	15.20	**20.18**	**44.15**	**9.63**	**21.00**

Table 8.5 – Travel Time Comparison for AM Peak Period (7:00-9:00am) – Westbound Direction

WB	Observed			Ave of 5 average modelled runs		
	Max	Min	Ave	Max	Min	Ave
Newton to St Lukes	1.65	1.50	1.53	1.48	1.18	1.25
St Lukes to Waterview	1.80	1.60	1.66	2.17	1.76	1.86
Waterview to Patiki	1.80	1.65	1.73	2.44	1.82	1.99

Patiki to Te Atatu	2.10	1.75	1.92	1.93	1.39	1.52
Te Atatu to Lincoln	1.60	1.35	1.44	1.47	1.06	1.14
Lincoln to Royal	1.00	0.90	0.93	2.50	1.37	1.66
Royal to Hob	2.50	1.70	2.24	1.19	0.79	0.96
SH16 WB	12.45	10.45	**11.44**	**13.18**	**9.36**	**10.38**

In the AM peak period the modelled average travel times satisfy the DMRB criteria for both eastbound and westbound direction of travel. In the eastbound direction is the difference between the observed and modelled travel times is less than a minute. The travel time difference in the westbound direction is slightly higher than one minute however, the percentage difference between the observed and modelled travel times is well within the minimum requirement of 15%.

Figure 8.8 shows how the results from each of the runs compare against the observed average travel times along entire SH16 corridor and over the seven sections along the highway (see **Figure 7.2**).

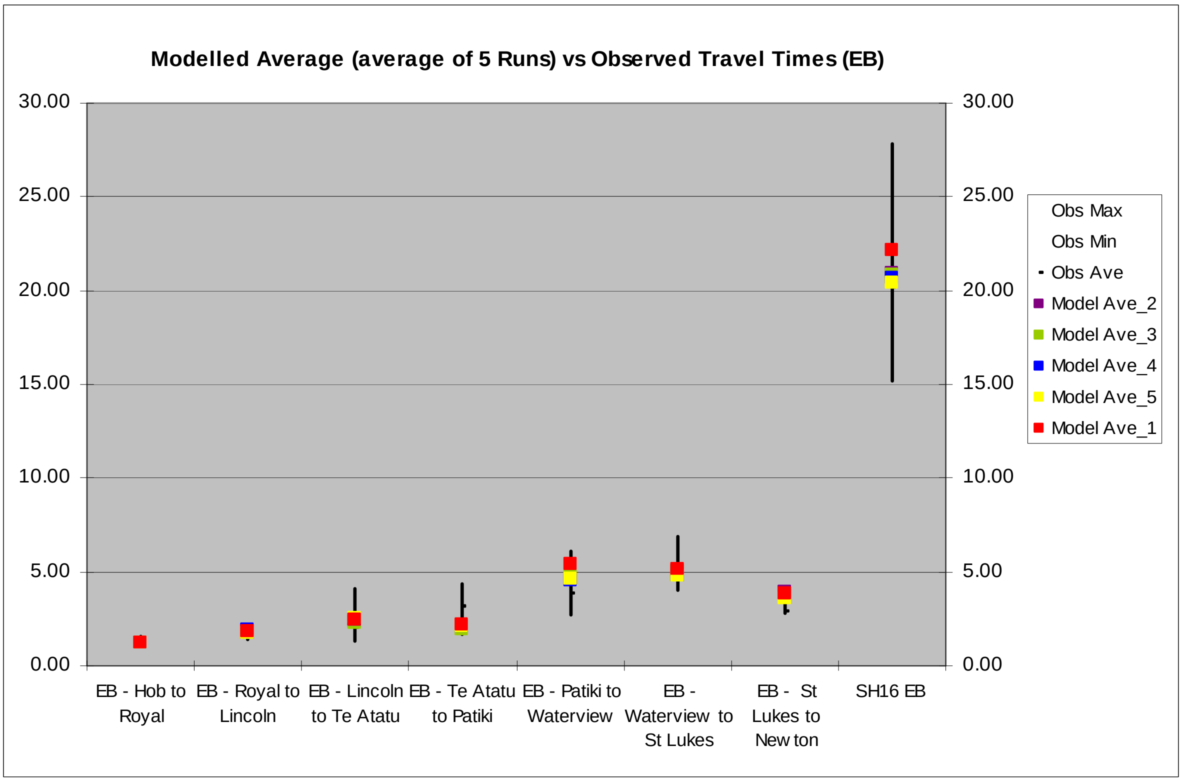


Figure 8.8 – Modelled Average Travel Times vs Observed Average Travel Times (EB) – AM

Figure 8-8 indicates that there is a high variability between the observed minimum and maximum travel times. The difference between the maximum and minimum travel time along the entire state highway is approximately 12 minutes. The five individual modelled run results indicate that the modelled averages are very close to the observed average travel times. The percentage difference between the observed average and modelled average travel times along the corridor is in the order of 4%.

The results also indicate there is a high variation in observed travel times in the section between Rosebank/Patiki Road interchange to Waterview in the eastbound direction. The maximum journey times along this section was in the order of 15 minutes whilst the maximum observed travel times are approximately 6 minutes. The travel times of individual eastbound vehicles travelling along this section was plotted over the peak hour (7:30-8:30am) period to determine the percentage of traffic travelling at this higher travel times along this section. This information is shown in **Figure 8.9** below. The travel times indicated in **Figure 8.9** are based average values based on the modelled five runs.

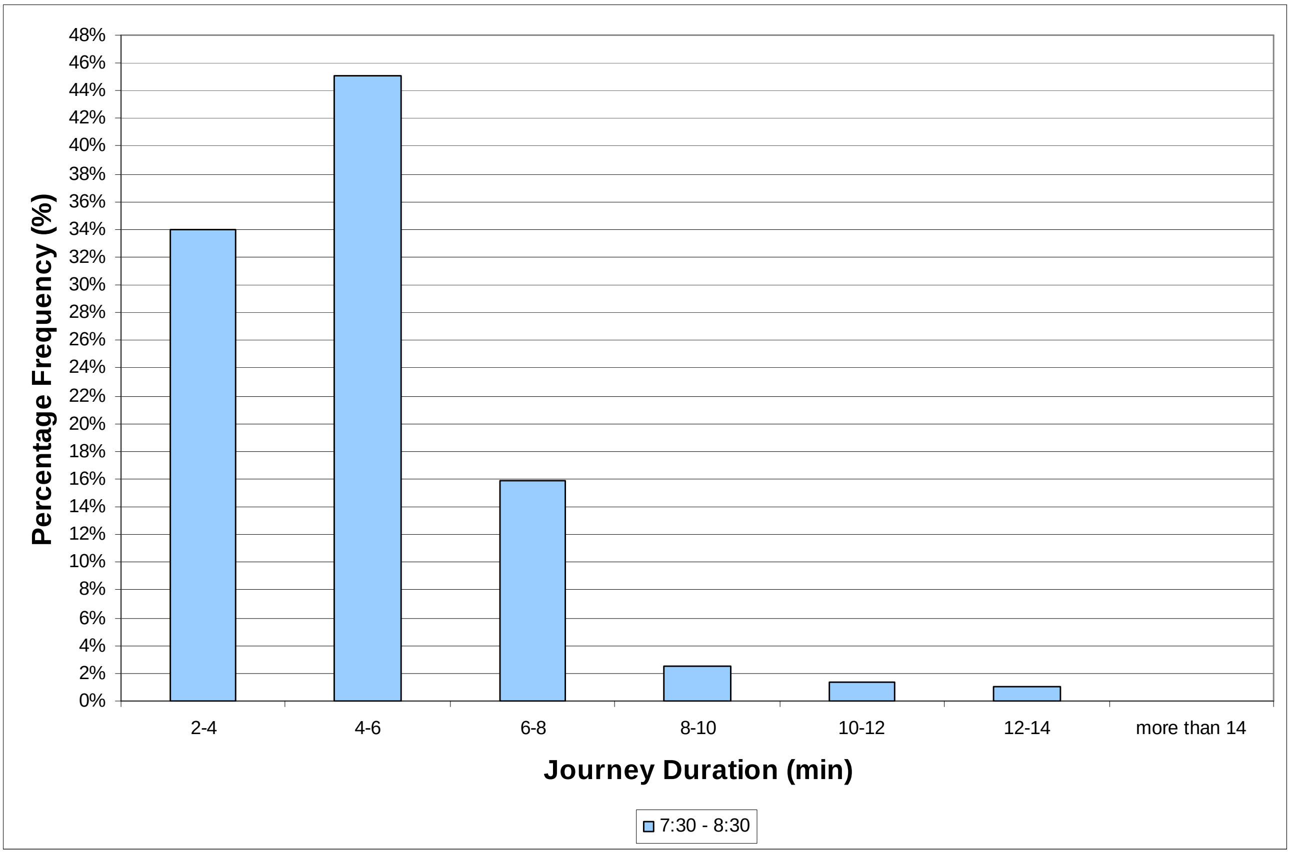


Figure 8.9 – AM Peak Hour Average Observed Travel Times (Rosebank/Patiki to Waterview) – EB

Figure 8.9 confirms that a high percentage of vehicles travelled within the 4-6 minute range of travel times over this section in the peak hour period. Whilst some percentage of traffic did travel over this section at slower travel times (>8 minutes), the total numbers are considered low especially when compared to the total number of vehicles travelling along this section, during the peak hour.

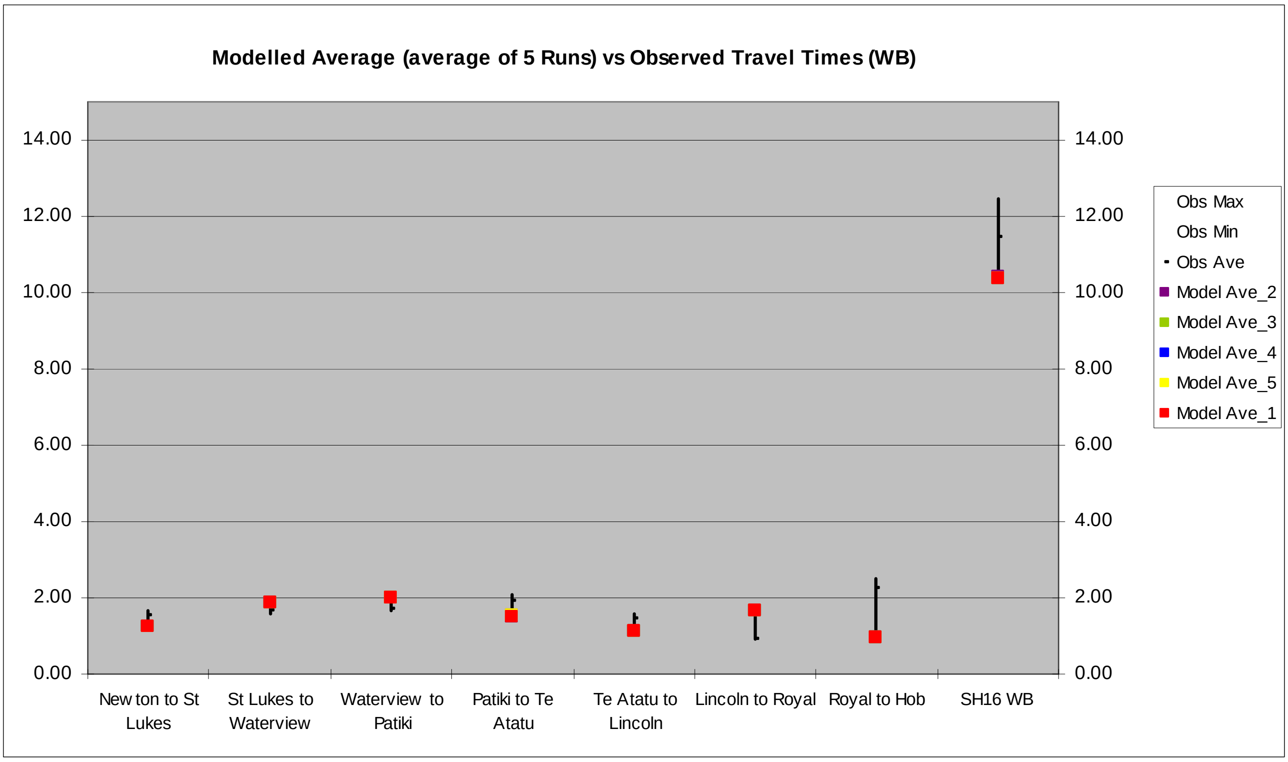


Figure 8.10 – Modelled Average Travel Times vs Observed Average Travel Times (WB) – AM

Figure 8.10 indicates that all individual modelled run averages for all seven sections as well as for the entire SH16 corridor is approximately the same. This is due to westbound vehicles not being affected by congested conditions and where any queuing experienced along the state highway would be transient. The variability in the maximum and minimum modelled and observed travel times are also small due to free flowing conditions in this non-peak direction of travel.

Figure 8.10 also indicates that the travel times over the end section Royal Road to Hobsonville is faster than that observed in reality. It is noted that the modelled network does not include the Hobsonville intersection as the SH16 links terminate at this point. Hence, the difference in travel times could be due to the model not realistically replicating the queuing and congestion created by the Hobsonville interchange.

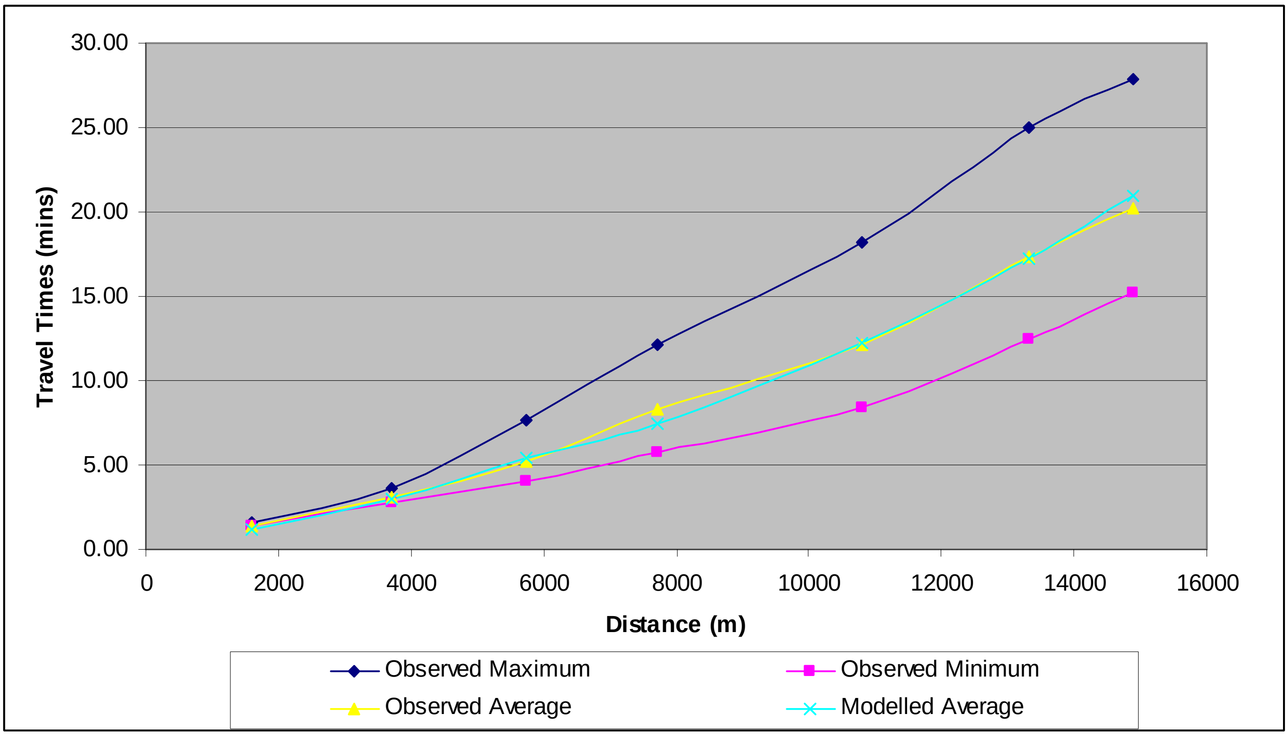


Figure 8.11 – Modelled Average Travel Times vs Observed Travel Times (EB) – AM

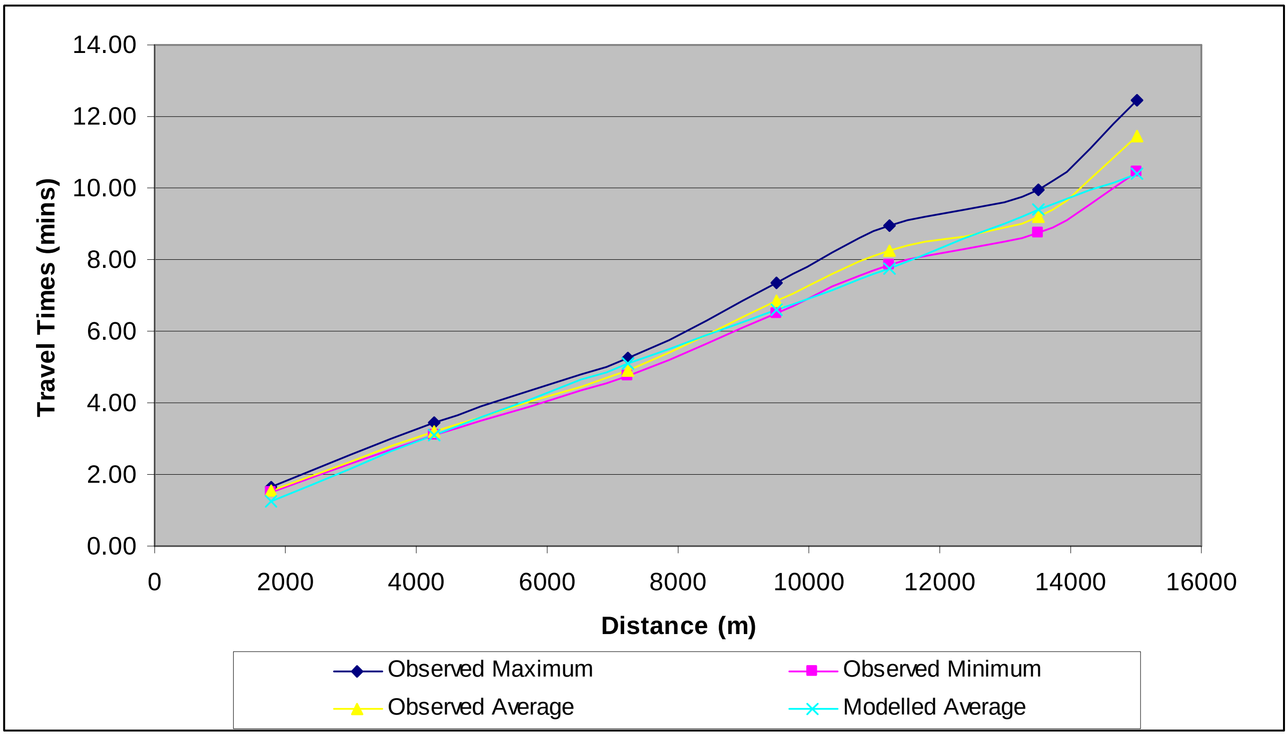


Figure 8.12 – Modelled Average Travel Times vs Observed Travel Times (WB) – AM

Figures 8.11 – 8.12 show the cumulative travel times along the SH16 corridor. These figures indicates that the modelled averages along the corridor fit very closely to the observed average values especially in the eastbound peak direction of travel.

8.2.2 PM Model Results

Table 8.6 – Travel Time Comparison for PM Peak Period (4:00-6:00pm) – Eastbound Direction

EB	Observed			Ave of 5 modelled average runs		
	Max	Min	Ave	Max	Min	Ave
Hob to Royal	1.50	1.30	1.39	1.76	1.05	1.18
Royal to Lincoln	1.75	1.45	1.60	1.58	1.27	1.35

Lincoln to Te Atatu	1.55	1.35	1.47	1.81	1.23	1.35
Te Atatu to Patiki	1.60	1.40	1.49	1.80	1.15	1.37
Patiki to Waterview	1.80	1.70	1.77	2.52	1.92	2.13
Waterview to St Lukes	1.95	1.85	1.88	2.23	1.66	1.82
St Lukes to Newton	2.00	1.65	1.79	1.26	0.93	1.01
SH16 EB	**12.15**	**10.70**	**11.39**	**12.96**	**9.21**	**10.22**

Table 8.7– Travel Time Comparison for PM Peak Period (4:00-6:00pm) – Westbound Direction

WB	Observed			Ave of modelled 5 average runs		
	Max	Min	Ave	Max	Min	Ave
Newton to St Lukes	1.75	1.25	1.54	6.59	2.53	4.14
St Lukes to Waterview	7.65	1.55	4.05	6.65	1.79	2.57
Waterview to Patiki	7.35	4.95	6.99	10.91	1.87	3.65
Patiki to Te Atatu	6.90	4.60	5.82	8.91	1.43	3.52
Te Atatu to Lincoln	3.50	2.05	2.28	5.10	1.09	2.30
Lincoln to Royal	1.45	1.13	1.24	3.31	1.38	1.98
Royal to Hob	1.28	1.15	1.24	1.20	0.77	0.94
SH16 WB	29.88	16.68	**23.16**	**42.67**	**10.86**	**19.10**

In the PM peak period the eastbound modelled average travel times satisfy the DMRB criteria however the westbound modelled travel times is faster than the observed by approximately 4 minutes (18%). The sections along SH16 where the travel times are particularly faster are between Waterview and Rosebank/Patiki interchange. The average modelled travel time is faster by over three minutes. In reality, queuing along SH16 in the westbound direction was observed to extend east from Lincoln Road off-ramp. The model does replicate this condition however, the faster modelled travel times along the Waterview and Patiki section in particular, creates an overall faster travel times along the entire corridor.

The headway factors altered along the westbound SH16 links was kept consistent with that included in the AM model. By increasing the headway factors for westbound vehicles the congestion level also increased along the state highway which in effect increased the westbound travel times by a small percentage. However, this reduced the throughput of vehicles along the state highway and therefore compromised the link flow calibration.

Therefore, it was considered to keep the headway factors at 1.25s which kept the alteration in the headway factors between the two peak models consistent. This faster travel time for the westbound traffic will be noted and taken into consideration when developing and reporting on the future models. Any travel time saving hence estimated in the future option models will take the 4 minute difference in travel time into consideration. This was agreed following discussions with the peer reviewer.

Figure 8.13 shows how the results from each of the runs compare against the observed average travel times along entire SH16 corridor and over the seven sections along the highway.

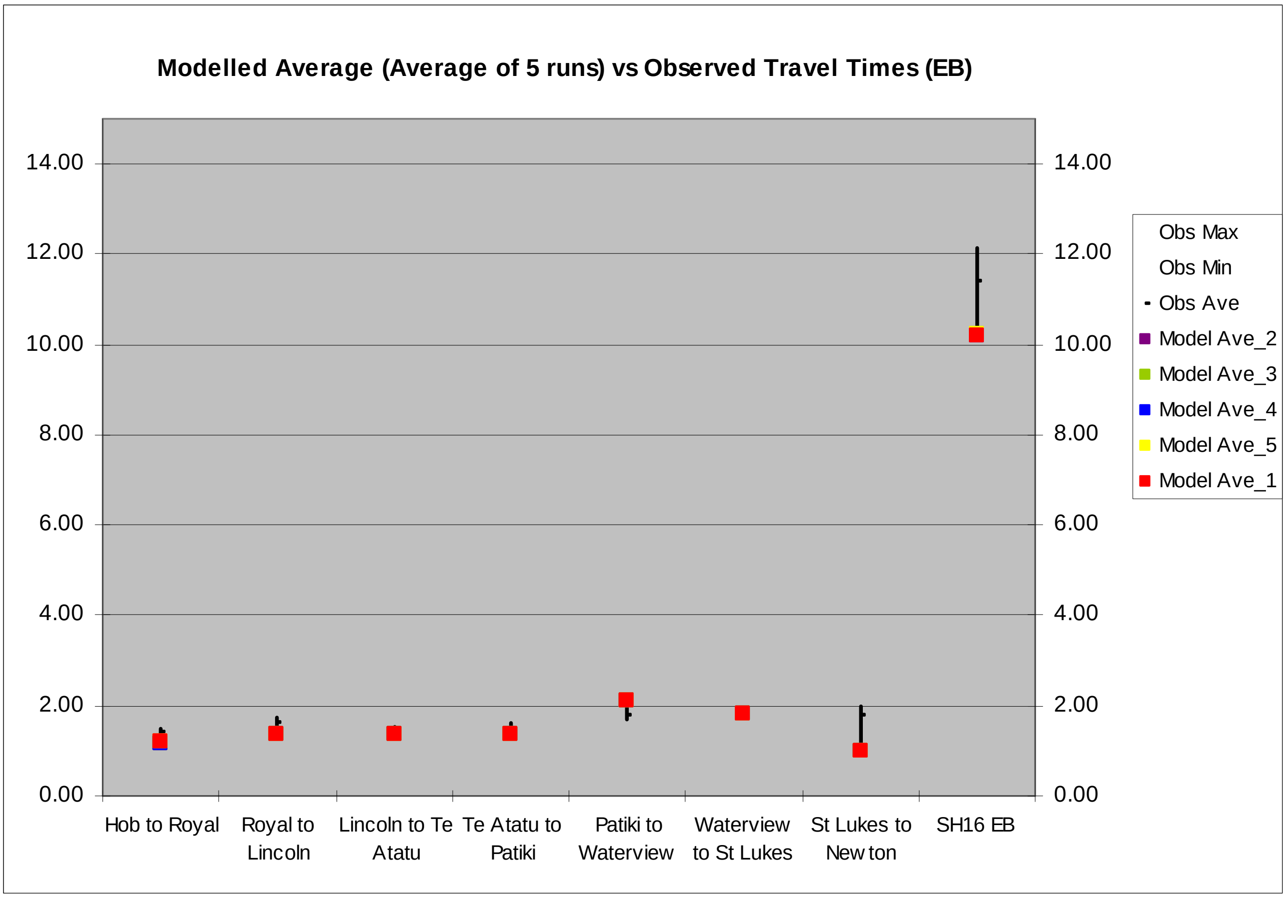


Figure 8.13 – Modelled Average Travel Times vs Observed Average Travel Times (EB) – PM

Figure 8.13 also indicates that the travel times over the end section St Lukes to Newton is faster than that observed in reality. It is noted that the modelled network does not include the Newton Road on/off ramps and the City end section where the southern motorway traffic queuing did extend onto the SH16, in 2006. Hence, the difference in travel times could be due to the model not realistically replicating the queuing and congestion created by the Hobsonville interchange.

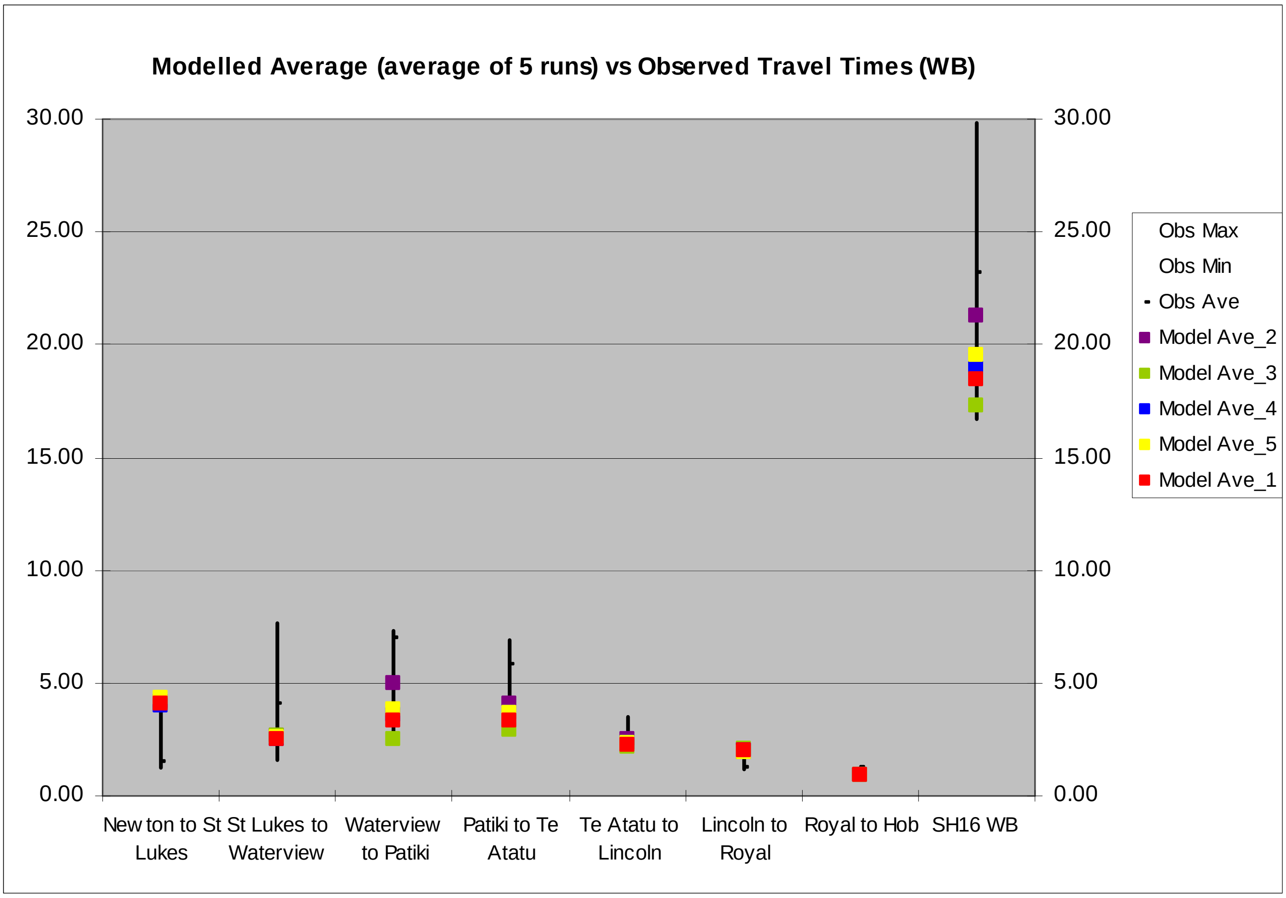


Figure 8.14– Modelled Average Travel Times vs Observed Average Travel Times (WB) – PM

As discussed previously, the eastbound travel times meet the DMRB criteria for travel time calibration/validation. **Figure 8.13** indicates consistent average travel times along the SH16 sections and over the entire SH16 corridor which is considered accurate for vehicles travelling in non-peak direction along the state highway, in 2006.

Figure 8.14 indicates that over the section between the eastern end of the model and St Lukes interchange the modelled travelled times are higher than the observed travel times. However, vehicles travelling further along SH16 generally travel faster past St Lukes interchange. The overall average travel times for each run varies by more than a minute.

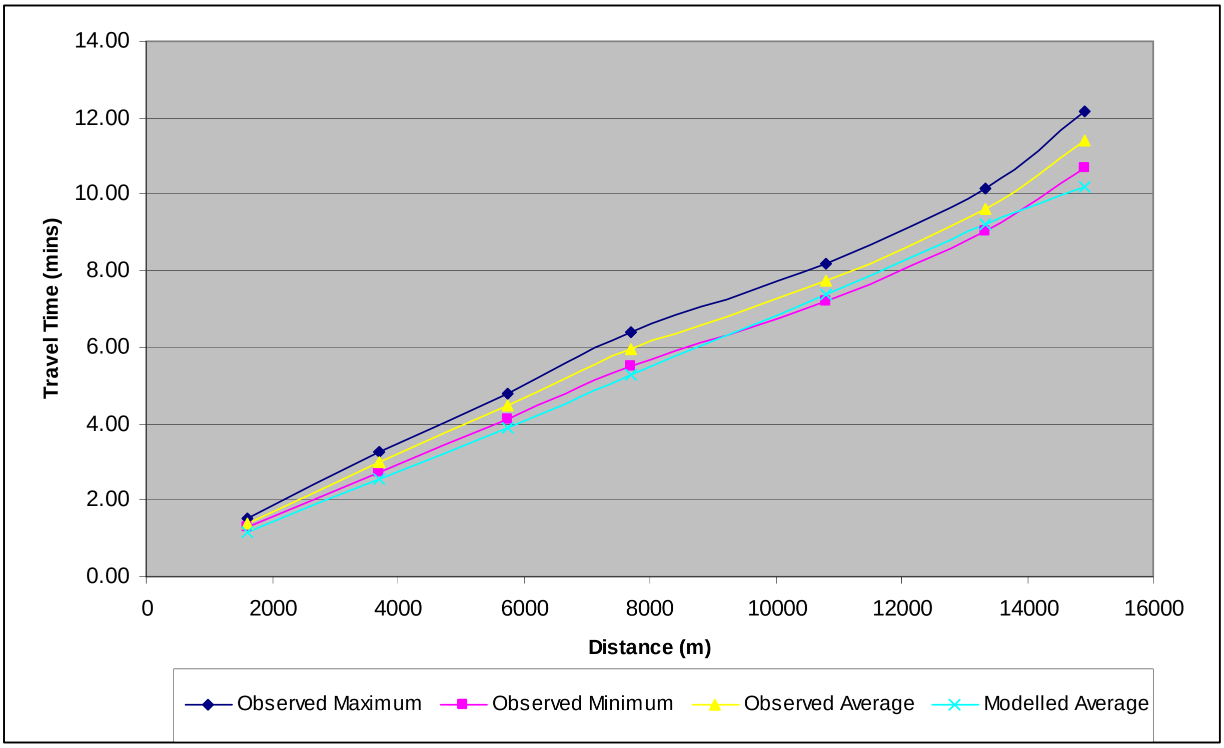


Figure 8.15 – Modelled Average Travel Times vs Observed Travel Times (EB) – PM

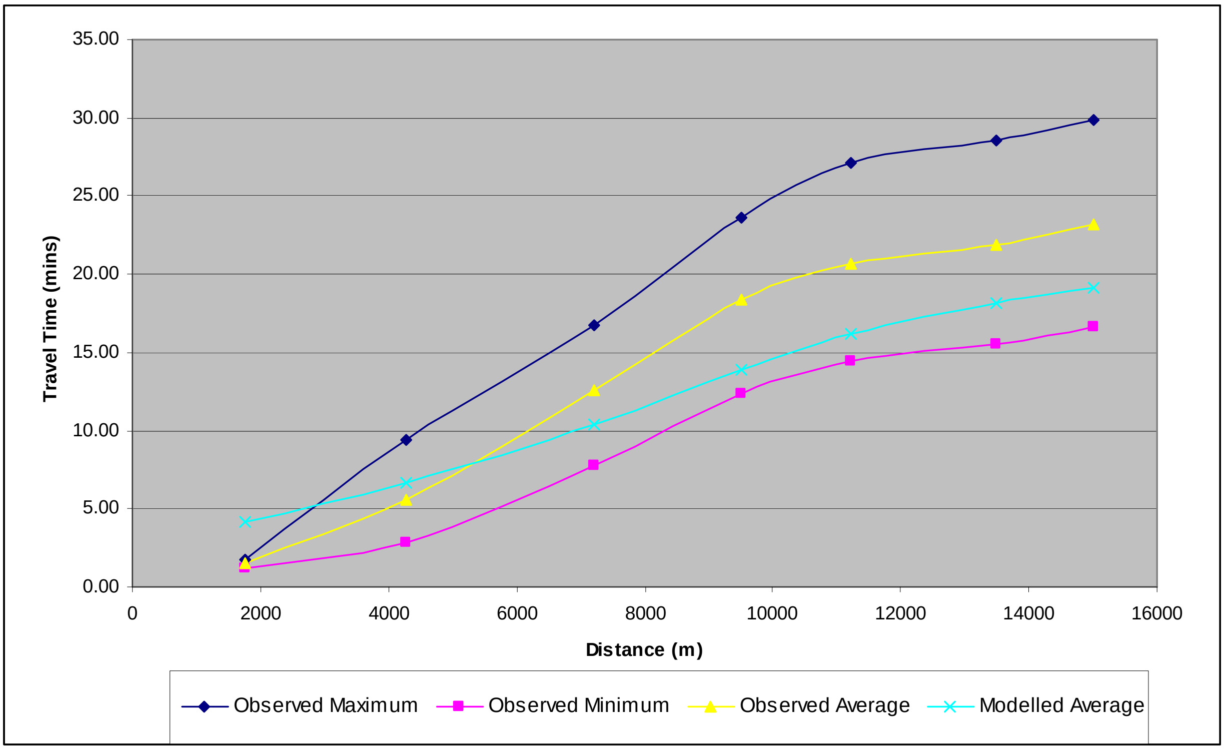


Figure 8.16 – Modelled Average Travel Times vs Observed Travel Times (WB) – PM

Figure 8.15 indicates a low variation between the maximum and minimum observed travel times along the length of SH16. The modelled travel times as indicated previously comply with the assessment criteria of maximum difference in travel time of one minute or 15%, between the modelled and observed survey times. The maximum difference in travel time for the eastbound traffic is a slightly over one minute however, it is well within the maximum requirement of 15%.

Figure 8.16 indicates that the modelled average travel times are greater than the minimum observed travel times along the length of the SH16 corridor. However, as discussed above, the difference in the modelled and observed travel times is approximately 4 minutes.

8.3 Other Travel Time Data

As discussed in previous sections, the travel time calibration and validation of the operational models has concentrated on the SH16 mainline.
A 'sensibility check' has been undertaken on other data relating to the surrounding arterial routes – namely Great North Road, Te Atatu Road and Lincoln Road. The average of five model runs was compared against observed data from 2006 to check the performance of the model. It should be noted the surevy data was extracted from much longer routes and given the relatively low sample size may not be fully representative over such short distances. Hence, this was a high level comparison to 'check' the performance of the model rather than a full scale validation of the travel times on these routes. **Tables 8.8** and **8.9** contain the results of this analysis.

Table 8.7– Travel Time Comparison for AM Peak – Arterial Routes

Road	From	To	Dir	Observed (Min)	Model (min)	Difference	% Diff
Lincoln Road	Universal Drive	SH16 westbound off-ramp	S/B	2.09	1.60	-0.49	-23%
			N/B	7.90	7.81	-0.09	-1%
Te Atatu Road	Edmonton Road	SH16 westbound off-ramp	S/B	1.72	1.65	-0.07	-4%
			N/B	2.77	5.16	2.39	86%
Great North Road	Blockhouse Bay Road	SH16 westbound off-ramp	S/B	2.73	2.03	-0.70	-26%
			N/B	3.07	6.16	3.09	100%

From **Table 8.8** the following summaries can be reached:

- Northbound on these arterial routes is the peak direction of travel in the morning and this is clearly seen in both the observed and modelled data;

- On Lincoln Road, the northbound data form the model correlates closely with the observed data, with both showing an average speed of 6.7kph. Anecdotal information from Waitakere City Council (WCC) officers suggests that on an average day in the AM peak, the queue on Lincoln Road is from the SH16 interchange to the intersection with universal Drive. Observations from the model on Lincoln road show a queue from the interchange to the intersection with Universal Drive is formed by 7am;

- On Te Atatu Road, the observed northbound travel time is shown to be 2.77 minutes in the AM peak, with the model being slower at 5.16 minutes to travel from the intersection with Edmonton Road to the SH16 interchange. The observed data appears to be questionable as it is seemingly too fast, with an average speed for that section of 19kph, compared to model average speed of 10kph. Again, anecdotal evidence from WCC suggests that the queues on an average day in the AM peak stretch from the interchange to Edmonton Road, which would be more representative of the operational model travel times rather than the observed travel times. Observations made from the model support this, as by 7am there is a queue back to the intersection with Edmonton Road;

- On Great North Road, the observed travel time again appears to be highly questionable, with a travel time from the Blockhouse Bay intersection to the SH16 interchange of some 3.07 minutes (average speed of 31kph), whereas the operational model suggests 6.16 minutes (15.5kph), which is thought to be more in line with the extensive queues observed every morning extending beyond Blockhouse Bay Road. The operational model shows slow moving queues along Great North Road, with these reaching the intersection with Blockhouse Bay road by 7.30am, although these are thought to be driven by the signals at Oakley Avenue. By 8am however, the queue is form the interchange to Blockhouse Bay Road; and

- The southbound direction for the AM peak travel times show a reasonable level of correlation against the observed travel times especially given the short distances involved, with the model being faster in all cases.

Table 8.9 – Travel Time Comparison for PM Peak – Arterial Routes

Road	From	To	Dir	Observed (Min)	Model (min)	Difference	% Diff
Lincoln Road	Universal Drive	SH16 westbound off-ramp	S/B	2.14	1.8	-0.31	-14%
			N/B	2.33	5.7	3.40	146%
Te Atatu Road	Edmonton Road	SH16 westbound off-ramp	S/B	2.14	1.9	-0.25	-12%
			N/B	2.16	2.3	0.18	8%
Great North Road	Blockhouse Bay Road	SH16 westbound off-ramp	S/B	2.94	2.1	-0.80	-27%
			N/B	2.45	2.7	0.27	11%

From **Table 8.9** the following summaries can be reached:

- On Lincoln Road, the southbound modelled travel time correlates well with the observed journey time, although the model is slightly faster, suggesting an average speed for the section of 28.8kph, compared to an observed average speed of 24.7kph;

- On Lincoln Road in the northbound direction, again, the observed data is considered questionable. The observed data suggests a travel time of 2.33 minutes (22.71 kph average speed), with the model suggests a slower 5.7 minutes (9.23kph average speed). Anecdotal information from Waitakere City Council (WCC) officers suggests that on an average day in the PM peak, the queue on Lincoln Road is from the SH16 interchange to the intersection with Universal Drive, which would support the higher travel time shown in the operational model. Observations from the model on Lincoln road show a queue from the interchange to the intersection with Universal Drive is formed by 5pm;

- On Te Atatu Road, the PM peak matched well against the observed data in both the northbound and southbound direction. In the southbound direction, the model is slightly (12%) faster than the observed data, and in the northbound direction it is slightly slower (8%). The observations from the model show relatively free flowing conditions which match with anecdotal evidence from WCC;

- On Great North Road, the PM peak matched well against the observed data in both the northbound and southbound direction. In the southbound direction, the model is faster (27%) than the observed data, and in the northbound direction it is slightly slower (11%). The observations from the model show relatively free flowing conditions which match with anecdotal evidence form the use of Great North Road.

Overall, the models appear to underestimate travel times for traffic leaving the models (southbound direction), but match the observed data within acceptable tolerances. In the northbound direction, the model appears higher than observed, although for the largest differences, the models appear more representative than the observed data.

9. Peer Review

This section describes the peer review process that has been undertaken.

9.1 Process

As discussed in **Chapter 1** SKM were appointed by NZTA as independent peer reviewers of the operational model. Due to the time constraints relating to the model development, calibration, validation and subsequent forecasting, an interactive approach was adopted with the peer reviewers being involved form the commencement of the model development, rather than at the end of the model development process.

Regular meetings, telephone conferences and e-mail communications were held between Beca and SKM to discuss the progress of the modelling and to discuss any issues arising during the validation and forecasting process.

10. Summary

In 2009 the NZ Transport Agency (NZTA) confirmed its intention that the 'Waterview Connection Project' would be lodged with the Environmental Protection Authority as a Proposal of National Significance. The Project includes works previously investigated and developed as two separate projects: being the SH16 Causeway Project and the SH20 Waterview Connection. The key elements of the Waterview Connection Project are:

- Completing the Western Ring Route (which extends from Manukau to Albany via Waitakere);
- Improving resilience of the SH16 causeway between the Great North Road and Rosebank Interchanges to correct historic subsidence and "future proof" it against sea level rise;
- Providing increased capacity on the SH16 corridor (between the St Lukes and Te Atatu Interchanges);
- Providing a new section of SH20 (through a combination of surface and tunnelled road) between the Great North Road and Maioro Street Interchanges; and
- Providing a cycleway throughout the surface road elements of the Waterview Connection Project corridor.

This report details the development and validation of the updated operational model developed for the assessment of the Waterview Connection project. The model is part of a hierarchy of models used for the project, comprising of the Auckland Regional Council's (ARC) multi-modal strategic demand model, a detailed traffic assignment model (reported separately), and a localised operational model for more detailed consideration of design and operational issues (the subject of this report).

The scale of this project requires assessment of both the strategic, long-term multi-modal effects over the wider Auckland region, and detailed operational issues within this specific corridor. It is not feasible to capture this range of strategic and detailed functionality in a single model, and as such this hierarchy of models was adopted. This is a commonly used approach for such projects, and has been used for most major transport projects in the Auckland region for the last 15 years.

The model documented in this report is similar in structure to the previous models used for the analysis of this project, separately covering the weekday morning and evening 4-hour peak periods, being developed in the S-Paramics software and being linked to the project assignment model which is in turn linked to the regional multi-model model. The key driver to update the modelling system was the desire to link the traffic models to the comprehensively updated regional multi-model model recently completed by the ARC (ART3).

The base year operational traffic model covers the SH16 corridor, from the Royal Road interchange in the West to the Newton Road interchange in the east, and a number of arterial roads which feed onto the State Highway. Traffic demands in the form of origin-to-destination trip matrices were obtained form the project assignment model then calibrated to match known and observed traffic patterns, then validated against independent traffic observations. This report describes the specification, calibration and validation of that base year 2006 model. The use of the models for future forecasting will be reported separately in the Technical Report G.25: *Traffic Modelling Report*, and result summarised in the Transport Assessment report.

The approach to the update of the model was first developed in a Model Scoping workshop, which was agreed NZTA, and also with the appointed independent peer review team. Throughout the development of the base year model, the study team worked interactively with the independent peer review team to discuss issues arising and agree detailed elements of the methodology and outcomes.

The model update consisted of development of a new network, derived from the previous Traffic Design Group model for SH16, development of a new model zoning system, creation of a new interface with the project assignment model and calibration and validation of the model to an extensive set of observed traffic count and travel time surveys.

The fit of the model to observed 2006 data was measured by standard statistical tests used in NZ and overseas, and especially the NZTA's Economic Evaluation Manual. These tests showed a high level of correlation against observed data and hence an acceptable level of model validation.

As such, the operational model developed for this project is deemed appropriate for evaluating the Waterview Connection project.