OPUS INTERNATIONAL CONSULTANTS AND ARUP

# WELLINGTON TRANSPORT MODELS

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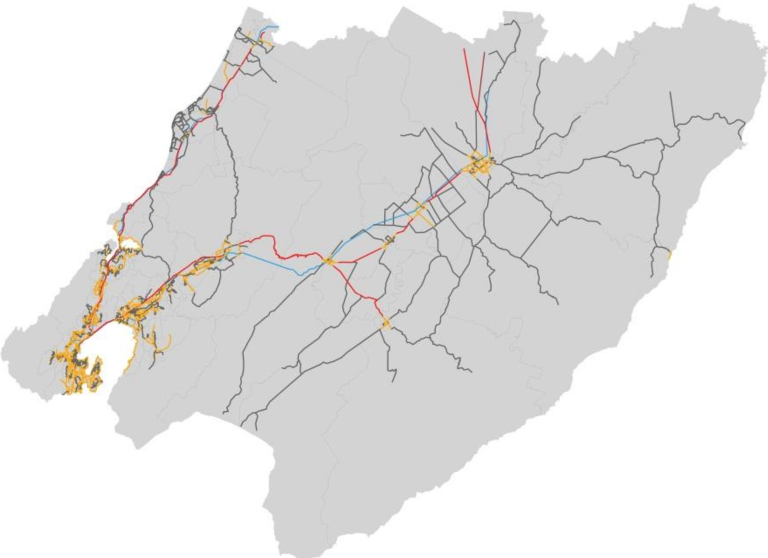

# TN18 WTSM Calibration and Validation

**Date: December 2012**

ARUP OPUS

# Wellington Transport Models

# TN18 WTSM Calibration & Validation

## prepared for

## Greater Wellington Regional Council


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This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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# Contents


**1 Introduction ........ 4**

**2 Recalibration Process – Issues and Opportunities ........ 5**
2.1 Introduction ........ 5
2.2 Aggregate Demand Issue ........ 6
2.3 2011 HCV Matrix Adjustment ........ 7
2.4 Mode Choice Model Issue ........ 8
2.5 Assignment Routing Issues ........ 10
2.6 Software Opportunities ........ 11
2.7 Summary Results ........ 12

**3 Vehicle Count Validation ........ 13**
3.1 Introduction ........ 13
3.2 Car Screenline Validation ........ 14
3.3 Individual Counts Summary ........ 17
3.4 HCV Validation ........ 20

**4 Vehicle Journey Time Validation ........ 22**
4.1 Introduction ........ 22
4.2 Summary Results ........ 22
4.3 Journey Time Analysis ........ 24

**5 Bus Count Validation ........ 25**
5.1 Passenger Count Screenline Validation ........ 25

**6 Rail Count Validation ........ 27**
6.1 Passenger Validation ........ 27
6.2 Boarding and Alighting ........ 27

**7 Trip Length Distribution Comparison 2006-2011 ........ 30**
7.1 Introduction ........ 30
7.2 Car Matrices ........ 30
7.3 HCV Matrices ........ 31
7.4 Public Transport Matrices ........ 32

**8 Demand and Assignment Model Convergence ........ 34**
8.1 Demand Model Convergence ........ 34
8.2 Highway Assignment Model Convergence ........ 34
8.3 Link Volume Convergence ........ 35

**9 Model Sensitivity Tests ........ 37**

9.1 Introduction .......... 37
9.2 Results and Analysis .......... 37

**10 Conclusion .......... 38**

**Appendix A – Update of WTSM to 2011 Base Year – 2011 HCV Model .......... 40**

**Appendix B – Car Screenlines with TDG Counts (1 hour) .......... 46**

**Appendix C – Screenlines Comparison against 2001/2006 Reports .......... 47**

**Appendix D – Highway Travel Time Validation .......... 50**

**Appendix E – Highway and Transit Assignment Path Analysis .......... 63**

**Appendix F – 2001 and 2006 Demand and Highway Assignment Convergence .......... 88**

**Appendix G – Transit Assignment with Variants Flow Chart .......... 92**

# 1 Introduction

Opus International Consultants Limited (Opus) and Arup Australia (Arup) were commissioned by Greater Wellington Regional Council (GWRC) to rebase the existing 2006 Wellington Transport Strategy Model (WTSM) to a new base year of 2011. Opus updated the WTSM while Arup developed a Wellington Public Transport Model (WPTM) based on networks from WTSM and detailed public transport surveys. The whole process of model updates and development is complex and involves several steps which have each been individually reported in a series of technical notes. This technical note describes the calibration and validation procedures carried out on the 2011 WTSM model update. This note covers:

- **The calibration process in Section 2.** A number of key themes developed early in the model update process that affected how the project proceeded and the type of analysis undertaken. Whilst a number of these investigations are documented in TN1 and TN15, this chapter describes some of the more significant investigations.
- **Vehicle screenline validation process in Section 3.** Validation of vehicle trips has been carried out using a similar method to that used for the 2006 WTSM validation therefore; comparison can be made between the two models. Vehicle assignment has been compared against observed data and 2006 values using GEH statistical values for private vehicles and HCVs separately. Additionally, individual counts have been presented as scatterplots for the calculation of the coefficient of determination ($R^2$) and root mean square error (RMSE).
- **Vehicle journey time validation in Section 4.** The team used travel time surveys carried out on behalf of NZTA along strategic routes within the Wellington region across the AM, inter peak (IP) and PM periods. Summary tables comparing observed averages against modelled times are presented in the main body along with notes providing further explanation where required.
- **Bus passenger count validation in Section 5.** Observed values were sourced from the WPTM bus assignment which assigned observed ETM records. Validation of bus patronage has been carried out in a similar method to vehicle screenline validation. They differ in terms of the period reported (data was only collected for AM and IP periods) and in the measures they are assessed against (GEH and percent difference in line with international best practice).
- **Rail count validation in Section 6.** Observed values were obtained from rail counts at the end of 2011. Rail count validation has been reported as a comparison of observed and modelled cumulative loading profiles down the Kapiti and Hutt lines for the AM, IP, and PM Peak periods.
- **Demand and assignment model convergence in Section 7**. Demand model convergence has been measured by calculating the RMSE for each final demand matrix (car and public transport for each period - i.e. 6 matrices). Highway assignment convergence has been measured using relative gaps of total vehicle kilometres and vehicle minutes travelled between successive updates of intersection capacities during the highway assignment.
- **Sensitivity tests in Section 8.** Tests were run to establish whether the overall sensitivity of the model to changes in network level-of-service are reasonable. These tests included changes to public transport fares, public transport in-vehicle times, public transport frequencies, car operating costs or fuel costs, car in-vehicle times and CBD parking charges.

# 2 Recalibration Process – Issues and Opportunities

## 2.1 Introduction

A number of key themes developed early in the model update process that affected how the project proceeded and the type of analysis undertaken. The issues presented the team with opportunities and challenges:

- **New networks and services.** A major new component of the updated model was the replacement of the entire network. The purpose was to take advantage of a growing pool of data on public transport movements through collection of ETM data and the automatic generation of transit lines files from the online General Transit Feed Specification. Much of this has been documented in TN1 but the calibration and validation of this work is reported in this document. For example, with such significant changes to the network a substantial amount of highway assignment and public transport (PT) path checking has been undertaken and documented within this chapter (and in Appendix E – Highway and Transit Assignment Path Analysis).
- **Estimated landuse (and cancellation of the 2011 NZ Census).** A major earthquake struck Christchurch in September 2010 causing the 2011 NZ census to be postponed. As a result, landuse and demographic inputs to the model for 2011 had to be estimated from statistics NZ projections.
- **Economic recession and government policy changes.** At the time of the model update the New Zealand Economy was still emerging from the Global Financial Crisis. This issue was compounded in Wellington with change in government policy from 2008 relating to public service staff numbers and government expenditure.
  There was concern that there may have been a fundamental change in not just the landuse and demographic inputs into the model but also decision making behaviour of households and businesses with regards to transportation decisions. Indications from the earliest datasets appeared to support these concerns as time series data for traffic counts showed a very obvious flattening out of traffic and PT patronage growth in the region.
- **Disruption to data collection programmes.** Firstly there was a winter storm that deposited snow in parts of the region that hadn't seen it in a generation. This seriously affected planned origin / destination (O-D) and count surveys on trains and several tube traffic count sites. Secondly, there was a major international sporting competition (the Rugby World Cup) running during part of the survey period.
- **Better public transport data availability.** Previous versions of the model did not have the same level of public transport data available as the 2011 update. Also, the public transport components of the model were opened to a level of scrutiny that they had not been exposed to before due to the influence of the PT Spine Study.
  While this is undoubtedly a good thing for model accuracy it can (and did) create issues in terms of calibration – i.e. perhaps PT surveys undertaken in 2001 and 2006, being sample data only, did not reflect 'real' PT demand as accurately as the new PT surveys (which used actual ETM data collected over a longer period).
- **New PT assignment module in EMME software.** In 2011 INRO (EMME software developers) released an updated version of the EMME software. The new Transit Strategy Assignment with Variants provides consistency of results with the EMME Standard Transit Strategy Assignment, plus additional flexibility.

- **Undocumented model run macros and updates to macros.** It can be challenging to pick up models where a large number of modellers have been working on model run macros. Understandably, over time modellers have wanted to test their own fixes and conduct their own investigations into model outputs, inputs and processes. This model was no exception and during the course of the project many minor (and some major) investigations were undertaken.
  One such example was discovered during the investigation of an assignment routing issue. The team discovered major differences in the assignment macros used in the select link macros and in the main assignment algorithms. While the team was able to resolve the conflict by aligning the macros it resulted in significant investigation into model convergence.
  Other examples, such as lack of documentation surrounding rail access modelling (along p-connectors) and source data for the calculation and calibration of the CBD parking costs were also issues but are described elsewhere in the technical documentation (parking costs in TN15 and rail access modelling in TN1).
  The main solution to avoid these problems in the future is to provide thorough documentation of the investigations and findings. Hence it is the purpose of the following sections to summarise some of the larger issues faced and addressed during the course of the model calibration process.

The following sections describe some of the main investigations before finishing with the Summary Results which briefly documents results of the initial testing. These investigations and results then formed the basis for detailed calibration to take place and subsequently documented in Chapters 3 to 8.

## 2.2 Aggregate Demand Issue

The team began assigning highway and PT demand onto the new networks and services towards the end of 2011. Initial transport demand flows across screenlines showed aggregate demand was too high across the board when compared with observed data. This proved to be a major obstacle to network calibration early in the process as the high level of demand was saturating the network i.e. network calibration moved demand from one overused route to another overused route – there was no way to balance flows across a screenline.

The team considered the likely causes to be one of five issues:

- **Trip generation.** Firstly, the team thought that the issue may have been related to economic conditions i.e. there may have been some form of suppression to trip generation not relating directly to the demographic inputs. For example, income is not an explanatory variable in the trip generation functions but perhaps its proxy (number of employed persons) was not satisfactorily explaining all trip-making behaviour relating to economic activity.
  Due to the delay it was causing team members working on network calibration a decision was made to factor demand down to observed levels. This enabled the team to carry on a sensible level of network calibration in parallel to an investigation of other causes to the problem which are described below. The demand suppression was

progressively abandoned as the true causes for the demand issue were uncovered and resolved.

- **Peak spreading.** Secondly, it was thought that the peak spreading macro may have failed to adequately spread traffic onto the shoulders of the peak traffic movement. However, it was concluded after investigation of traffic growth profiles that traffic growth between 2008 and 2011 had been too flat to cause any peak spreading.
- **Trip length distribution changes.** Thirdly, with new networks and input parameters there was concern that demand hadn't responded correctly to generalised costs and that this was feeding through into longer trip lengths. However, it was concluded after investigation of generalised cost trip distributions for PT and car movements that they had increased sensibly. Sample sector to sector and zone to zone movement Generalised Costs were also checked and these were also confirmed as sensible.
- **Employment rates.** Next the team examined the initial 2011 demographic estimates prepared by Russell Jones. The purpose was to confirm the full impact of both the recession and drop in number of government employees had translated into the demographic inputs. The investigation confirmed that initial demographic assumptions had been to hold employed persons per household constant at 2006 levels. Secondly the team checked Statistic NZ data for employed people per household and found that the employed persons per household in Wellington Region had declined from 1.49 in 2006 to 1.42 in 2011, a reduction of 5%. It was then decided to adjust 2011 demographic input by transferring 5% employed adults to non-employed adults.
- **Traffic count errors.** Finally, the team went back to the traffic counts collected for the Wellington CBD screenline (W1) during the collection period in August 2011 and compared them against counts from Wellington City Council (WCC) that had also been collected in 2011. The investigation concluded by replacing 3 counts along the CBD screenline with the WCC counts as they appeared to be more consistent with upstream counts on screenline W4. More detail on the count consistency issue between W1 and W4 is provided in Note 1 of Section 3.2. For completeness, the original TDG count has been reported in Appendix B – Car Screenlines with TDG Counts (1 hour). As can be seen the TDG counts were considerably higher on W1 than modelled while the upstream validation at W4 appeared to be fine.

Combining both the reduction in employed persons per household with the re-sourcing of traffic counts helped overall levels of modelled demand decrease to observed levels.

## 2.3 2011 HCV Matrix Adjustment

In WTSM the Heavy Commercial Vehicle (HCV) matrices are fixed for a particular modelled year and are developed from factoring the base year (2001) 24-hour matrix and then applying time period factors. For the 2006 update, counts were available for the 2-hour assignment periods only and not for 24 hours, so a process was developed within a spreadsheet for adjusting the HCV trips by sectoring the zone system (matrix) according to screenlines and using HCV screenline counts.

The same approach has been adopted for the 2011 update. The procedures and initial adjustment factors are described in a memo by David Young Consulting (which has been included in Appendix A – Update of WTSM to 2011 Base Year – 2011 HCV Model) while the final adjustment factors have been listed below. The resulting level of HCV validation is reported in Section 3.4.

**Table 2-1: AM Peak HCV Sector to Sector Demand Adjustment Factors**

| | A | B | C | D | E | F | G | H | I | J | K | E1 | E2 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A** | 0.65 | 0.77 | 1.00 | 0.30 | 0.75 | 0.83 | 0.74 | 0.52 | 0.98 | 1.07 | 0.56 | 1.20 | 1.20 | 0.62 |
| **B** | 2.15 | 1.46 | 1.00 | 0.30 | 0.75 | 0.83 | 0.74 | 0.52 | 0.98 | 1.07 | 0.56 | 1.20 | 1.20 | 1.47 |
| **C** | 0.30 | 0.30 | 0.95 | 0.30 | 0.23 | 0.25 | 0.22 | 0.16 | 0.29 | 0.32 | 0.17 | 1.20 | 1.20 | 0.52 |
| **D** | 1.00 | 1.00 | 1.00 | 0.65 | 0.75 | 0.83 | 0.74 | 0.52 | 0.98 | 1.07 | 0.56 | 1.20 | 1.20 | 0.87 |
| **E** | 0.60 | 0.60 | 0.60 | 0.60 | 1.91 | 1.10 | 0.99 | 0.69 | 1.30 | 1.43 | 0.74 | 1.20 | 1.20 | 0.93 |
| **F** | 3.12 | 3.12 | 3.12 | 3.12 | 5.20 | 1.93 | 0.90 | 0.63 | 6.76 | 1.43 | 0.74 | 1.20 | 1.20 | 2.11 |
| **G** | 1.56 | 1.56 | 1.56 | 1.56 | 2.60 | 0.50 | 0.76 | 0.70 | 3.38 | 0.72 | 0.37 | 1.20 | 1.20 | 0.82 |
| **H** | 1.48 | 1.48 | 1.48 | 1.48 | 2.47 | 0.48 | 0.95 | 0.25 | 6.42 | 1.05 | 0.54 | 1.20 | 1.20 | 0.40 |
| **I** | 1.80 | 1.80 | 1.80 | 1.80 | 3.00 | 1.10 | 0.99 | 0.77 | 1.20 | 1.10 | 0.57 | 1.20 | 1.20 | 1.24 |
| **J** | 1.53 | 1.53 | 1.53 | 1.53 | 2.55 | 2.55 | 2.30 | 0.77 | 0.85 | 0.92 | 0.52 | 1.20 | 1.20 | 0.90 |
| **K** | 1.84 | 1.84 | 1.84 | 1.84 | 3.06 | 3.06 | 2.75 | 0.71 | 1.02 | 1.20 | 0.86 | 1.20 | 1.20 | 0.96 |
| **E1** | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 |
| **E2** | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 |
| **Average** | 0.93 | 0.98 | 0.99 | 0.59 | 1.67 | 1.10 | 0.80 | 0.32 | 1.21 | 0.98 | 0.82 | 1.20 | 1.20 | 0.85 |

**Table 2-2: Inter Peak HCV Sector to Sector Demand Adjustment Factors**

| | A | B | C | D | E | F | G | H | I | J | K | E1 | E2 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A** | 0.53 | 0.85 | 0.55 | 0.50 | 1.00 | 1.50 | 1.28 | 0.96 | 1.10 | 0.61 | 0.48 | 1.20 | 1.20 | 0.62 |
| **B** | 1.30 | 1.08 | 0.55 | 0.50 | 1.00 | 1.50 | 1.28 | 0.96 | 1.10 | 0.61 | 0.48 | 1.20 | 1.20 | 1.01 |
| **C** | 0.50 | 0.50 | 0.74 | 0.50 | 0.50 | 0.75 | 0.64 | 0.48 | 0.55 | 0.30 | 0.24 | 1.20 | 1.20 | 0.58 |
| **D** | 0.55 | 0.55 | 0.55 | 0.53 | 1.00 | 1.50 | 1.28 | 0.96 | 1.10 | 0.61 | 0.48 | 1.20 | 1.20 | 0.60 |
| **E** | 1.50 | 1.50 | 0.83 | 1.50 | 1.28 | 1.50 | 1.28 | 0.96 | 1.10 | 0.61 | 0.48 | 1.20 | 1.20 | 1.27 |
| **F** | 1.65 | 1.65 | 0.91 | 1.65 | 1.10 | 1.10 | 0.85 | 0.64 | 1.21 | 0.61 | 0.48 | 1.20 | 1.20 | 1.08 |
| **G** | 1.57 | 1.57 | 0.86 | 1.57 | 1.05 | 0.95 | 0.84 | 0.75 | 1.15 | 0.57 | 0.46 | 1.20 | 1.20 | 0.87 |
| **H** | 1.25 | 1.25 | 0.69 | 1.25 | 0.84 | 0.76 | 0.80 | 0.28 | 0.97 | 0.44 | 0.35 | 1.20 | 1.20 | 0.36 |
| **I** | 2.10 | 2.10 | 1.16 | 2.10 | 1.40 | 1.50 | 1.28 | 1.13 | 1.15 | 0.55 | 0.44 | 1.20 | 1.20 | 1.12 |
| **J** | 1.16 | 1.16 | 0.64 | 1.16 | 0.77 | 0.77 | 0.65 | 1.13 | 0.55 | 0.78 | 0.80 | 1.20 | 1.20 | 0.75 |
| **K** | 1.39 | 1.39 | 0.76 | 1.39 | 0.92 | 0.92 | 0.79 | 0.50 | 0.66 | 1.20 | 1.00 | 1.20 | 1.20 | 0.99 |
| **E1** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **E2** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Average** | 0.66 | 0.87 | 0.62 | 0.66 | 1.13 | 1.15 | 0.87 | 0.36 | 1.09 | 0.78 | 0.92 | 1.20 | 1.20 | 0.77 |

**Table 2-3: PM Peak HCV Sector to Sector Demand Adjustment Factors**

| | A | B | C | D | E | F | G | H | I | J | K | E1 | E2 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A** | 0.60 | 1.19 | 0.45 | 0.75 | 0.60 | 3.30 | 1.65 | 1.73 | 1.50 | 2.10 | 2.10 | 0.90 | 0.90 | 0.79 |
| **B** | 0.88 | 1.03 | 0.45 | 0.75 | 0.60 | 3.30 | 1.65 | 1.73 | 1.50 | 2.10 | 2.10 | 0.90 | 0.90 | 0.90 |
| **C** | 0.75 | 0.75 | 0.91 | 0.75 | 0.45 | 2.48 | 1.24 | 1.30 | 1.13 | 1.58 | 1.58 | 0.90 | 0.90 | 0.81 |
| **D** | 0.45 | 0.45 | 0.45 | 0.60 | 0.60 | 3.30 | 1.65 | 1.73 | 1.50 | 2.10 | 2.10 | 0.90 | 0.90 | 0.63 |
| **E** | 1.00 | 1.00 | 0.45 | 1.00 | 2.23 | 5.50 | 2.75 | 2.89 | 2.50 | 3.50 | 3.50 | 0.90 | 0.90 | 1.79 |
| **F** | 1.80 | 1.80 | 0.81 | 1.80 | 1.80 | 2.13 | 0.50 | 0.53 | 4.50 | 3.50 | 3.50 | 0.90 | 0.90 | 1.54 |
| **G** | 1.26 | 1.26 | 0.57 | 1.26 | 1.26 | 0.70 | 0.76 | 1.05 | 3.15 | 2.45 | 2.45 | 0.90 | 0.90 | 0.82 |
| **H** | 1.01 | 1.01 | 0.45 | 1.01 | 1.01 | 0.56 | 0.80 | 0.21 | 3.60 | 1.12 | 1.12 | 0.90 | 0.90 | 0.30 |
| **I** | 0.90 | 0.90 | 0.41 | 0.90 | 0.90 | 5.50 | 2.75 | 5.78 | 1.09 | 1.40 | 1.40 | 0.90 | 0.90 | 1.20 |
| **J** | 0.90 | 0.90 | 0.41 | 0.90 | 0.90 | 0.90 | 0.45 | 5.78 | 1.00 | 1.10 | 1.00 | 0.90 | 0.90 | 1.12 |
| **K** | 0.90 | 0.90 | 0.41 | 0.90 | 0.90 | 0.90 | 0.45 | 1.05 | 1.00 | 1.00 | 1.00 | 0.90 | 0.90 | 1.00 |
| **E1** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **E2** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Average** | 0.64 | 0.97 | 0.62 | 0.74 | 1.02 | 2.32 | 0.84 | 0.43 | 1.18 | 1.16 | 1.06 | 0.90 | 0.90 | 0.84 |

## 2.4 Mode Choice Model Issue

Once the aggregate demand issue was resolved the team moved onto the next major issue which was mode split across major cordons. The team narrowed the investigation to new input parameters for the 2011 model and transit lines files created as part of the General Transit Feed Specification (GTFS) to EMME transit line conversion process. The investigations have been summarised below:

- **Input parameter investigation.** The approach taken to input parameters is covered in detail in TN15 but summarised below to the extent that it relates to the mode split issues. In the 2006 model nominal values for vehicle operating cost (VoC), value of time (VoT), parking costs, and PT fares were incorporated into the model. Some doubt was expressed over the suitability of this approach as there was concern that the 2001 model was calibrated in 2001 prices so a decision was made to adjust the 2011 updated values for inflation back to 2001 dollars.

It was thought the inflation adjustment in particular would help with the mode split issue as VoC had increased at a faster nominal rate than PT fares over the past ten years i.e. using the nominal values further exacerbated the mode split issue by shifting more demand onto PT.

Concerns also arose during the update process over how the Car and PT demand were responding to input parking costs. The team were unable to locate any guidance or information relating to the calculation of the 2001 parking costs. The initial approach for the 2011 update was to collect commuter parking price information from Wilsons parking website for Wellington CBD. However, as the team converted these new costs into the model it became clear they were excessive, even when allowing for inflation adjustment and reduction factors relating to the proportion of parkers that pay for parking. When combined with the fact that it was clearly affecting mode choice into the Wellington CBD a decision was taken to revert to the 2006 approach to updating parking costs (which has been documented in TN15).

- **PT service provision investigation.** There was concern that the update of PT services from the GTFS had fundamentally changed the model responses. The team made a comparison of the level of PT service provision and this has been summarised in the table below.

**Table 2-4: Comparison Total Transit Vehicle Capacity kms 2006-2011**

| Model | 2006 | 2011 | Diff | % Diff |
|---|---|---|---|---|
| Rail | 549,911 | 577,748 | 27,836 | 5% |
| Ferry | 26,232 | 29,169 | 2,937 | 11% |
| Bus | 536,123 | 684,468 | 148,345 | 28% |

Public transport officers from GWRC were sent the analysis above and they concluded that the ferry and rail changes looked realistic but they confirmed there definitely hadn't been an increase of 28% in terms of bus service provision. Given the detailed work that went into proving the 2011 transit lines files were generating correct services (documented in TN1) the team concluded that it was more likely that either:

- The uplifts applied as part of the 2006 update were incorrect; or
- The original 2001 bus transit lines were over simplified.

As a test 2011 bus frequencies were factored down by 28% to match 2006 levels. This enabled the team to assess whether this might be playing a role in the popularity of PT. Results indicated a limited change in PT demand. The reason for the lack of response was investigated and is summarised in the points below:

- A large proportion of public transport demand already experience low wait times making the effect marginal; and
- The effect was amplified by the fact that the model is calibrated to maximum wait times of 0.25 x headway.

In summary, the team concluded that while part of the mode choice issue was resolved by the calibration of input parameters the issue remained unresolved. As a last resort a decision was therefore taken to add a ‘mode constant’ to the public transport generalised cost matrices during the mode choice stage of the model. Several ‘mode constant’ values were applied before settling on a factor of 1.2. The testing of various combinations of input parameters and mode constants has been summarised in Section 2.7.

## 2.5 Assignment Routing Issues

Reasonably early in the update process the team discovered issues with the select link macros. The team was concerned with convergence at a link level between assignment iterations and this prompted the investigations summarised below:

- **Convergence Investigation.** The team conducted a thorough investigation of the model convergence as a way of resolving issues around select link analysis and stability of the assignment model. The background on the convergence process is summarised in Appendix F – 2001 and 2006 Demand and Highway Assignment Convergence. The investigation resulted in fixes for the select link macros, reporting of 2011 convergence measures for demand and assignment convergence (documented in Section 7), and the addition of a new, link-based, measure for convergence. The team subsequently confirmed that both the 2006 and 2011 versions of the models were converging satisfactorily.
- **Path Analysis Investigation.** While path analysis is recommended for most revalidation exercises it is especially true for the WTSM update where the entire network and all PT services have been replaced. The network and PT service development process is documented in more detail in TN1 and it is the purpose of this section to summarise results of the path analysis. Path analysis in both highway and PT assignments were checked between the following origins and destinations:

    1. Petone to Wellington CBD
    2. Wellington CBD to Seatoun
    3. Karori to Seatoun
    4. Berhampore to Johnsonville
    5. Berhampore to Paraparaumu
    6. Upper Hutt to Waikanae
    7. Porirua to Lower Hutt
    8. Porirua to Upper Hutt
    9. Airport to Wellington Railway Station

    Results indicated that an overwhelming majority of paths generated the intuitively correct route (using local knowledge). However, there were a number of minor exceptions and these are summarised below:

    - Results of the **Berhampore to Johnsonville** route show slight variations between periods. In all periods vehicles turn right into Hall Street, avoiding the Adelaide / John Street signals and the Basin Reserve. From there the AM route continues onto the Terrace Tunnel via Wallace Street and Webb Street, joining the motorway at the SH1 / Willis Street signals. In the IP period the journey continues from Hall Street onto Tasman Street and accesses the SH1 motorway at the Tasman / SH1 lights. In the PM period, from Hall street, the route joins the motorway at the Taranaki / SH1 signalised intersection travelling via Wallace Street.

- Significant variation in route choice between the **Airport to Wellington Railway Station** depending on the period. In particular there appears to be a preference to use Tory Street in the AM peak as opposed to more intuitively correct routes of Taranaki Street or Kent Terrace.

Illustrations and descriptions of the remaining routes have been included in Appendix E – Highway and Transit Assignment Path Analysis.

### 2.6 Software Opportunities

In 2011 INRO released an update of the software that included more advanced transit assignment and analysis modules. INRO summarised the changes as providing *"consistency of results with the EMME Standard Transit Strategy Assignment, plus the added flexibility to model the spatial distribution of demand within a zone; uneven demand distribution in large zones; competition between parallel services, including express lines; amenities at transit stops, such as benches, shelters, posted schedules, and services; the perceived cost of walk links due to the presence/lack of sidewalks, adjacent traffic volume, and public safety."*

The 2011 WTSM offered the possibility to incorporate these features but not before the software was tested through the following investigations:

- **Transit assignment procedure investigation.** Despite the enthusiasm to adopt the new assignment procedures there were concerns over its ability to replicate "Standard Transit Assignment" procedures (given WTSM 2001 and 2006 had been calibrated using these procedures in Module 5.11). To resolve these concerns the team ran comparison of the "Standard Transit Assignment" and "Transit Assignment with Variants - <u>optimal assignment</u>". For clarity a flow chart illustrating the different transit assignment procedures has been developed and provided in Appendix G – Transit Assignment with Variants Flow Chart.
- **Investigation into added functionality.** There was strong motivation by the team to move to the new assignment procedure for the added functionality it gave to analysts once assignments are run. Provided the output files produced by the "Transit Assignment with Variants' (STRAT_*scenario*) is retained with the relevant databank then it is possible to obtain various results and perform user-defined analyses.

After confirming both the usefulness of the added functionality and that the 'standard' and 'variants' assignment results were indistinguishable from one another the team updated the transit assignment procedures in:

- **WTSM** with the Transit Assignment with Variants - <u>optimal assignment</u> option; and
- **WPTM** with the Transit Assignment with Variants – <u>with variants</u> option.

Both assignment versions generate the (STRAT_*scenario)* outputs file making it much easier to compare WTSM and WPTM results. It also reduces the need to produce duplicate macros which call the new analysis module (6.27) and this was particularly useful for TN16 (which compares transit times for a sample of origins and destinations).

## 2.7 Summary Results

The following table represents a sample of sensitivity tests undertaken as part of the process described in Sections 2.1 to 2.6.

**Table 2-5: Comparison of Modelled and Observed Trips Under Different Assumptions***

| Test No. | Demand Reduction | HBW Parking costs | PT Mode Constant | Car | | | Bus | | Rail | | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | AM | IP | PM | AM | IP | AM | IP | |
| **1** | -4% | 2006 costs x1.5 | 1.2 | 0% | -6% | -6% | -3% | 6% | -12% | 15% | Note 1 |
| **2** | 0% | Nominal 2011 estimated | 1.2 | 3% | -2% | -4% | 6% | 12% | -11% | 3% | Note 2 |
| **3** | 0% | 2006 costs x1.5 | 1.2 | 2% | -4% | -5% | 1% | 10% | -15% | -1% | Note 3 |
| **4** | 0% | 2006 costs x1.5 | 1.2 | 7% | 3% | -1% | 2% | 13% | -15% | -1% | Note 4 |
| **5** | 0% | 2006 costs x1.5 | 1.2 | 7% | 3% | -1% | -5% | 18% | -15% | -9% | Note 5 |
| **6** | 0% | 2006 costs x1.5 | 1.2 | 8% | 3% | 0% | -9% | 18% | -17% | -9% | Note 6 |
| **7** | 0% | 2006 costs x1.5 | 1.1 | 6% | 2% | -1% | 1% | 32% | -6% | 6% | Note 7 |

* %'s reported as modelled compared to observed e.g. In Test 1 in the inter peak modelled car flows were 6% less than observed.

Explanations for Notes 1 – 7 are listed below:

- **Note 1**: Total Trip generation suppressed by 4% to help with network calibration.
- **Note 2**: Trip suppression removed but nominal estimated 2011 parking charges applied (which were subsequently discarded as being too high).
- **Note 3**: Trip suppression removed and parking costs adjustment aligned with 2006 Model update process.
- **Note 4**: 5% adjustment to employment discussed in section 2.2, adjustments to CBD capacity coding errors, and update of airport demand inputs (from 2006 to 2011 daily passengers).
- **Note 5**: New bus travel time functions incorporated (documented in TN1).
- **Note 6**: TDM adjustment factors had been included for 2011 (as it was originally a forecast adjustment). Decision made to remove it from 2011 base calculations.
- **Note 7**: Mode adjustment factor reduced to 1.1 as the previous test had resulted in excessive car demand but not enough bus demand.

The final large scale change to 2011 inputs (before moving onto detailed calibration) was to inflation adjust 2011 nominal PT fares to 2001 dollar values. This caused PT demand to increase above acceptable levels. The PT mode constant was then adjusted to 1.2 resulting in the final demand levels reported in Section 5.

# 3 Vehicle Count Validation

## 3.1 Introduction

Validation of vehicle trips has been carried out in a similar method to that used for the 2006 WTSM validation meaning comparison can be made between the two models. Vehicle assignment has been compared against observed data and 2006 values using GEH statistical values.

GEH is an empirical statistical measure used to compare modelled hourly counts against observed. The lower the GEH value, the better the modelled flow compares with that observed. A GEH value of 5 or less on an individual link is a very good, a value between 5 and 10 is good and 10 to 12 is reasonable.

The Economic Evaluation Manual (EEM) states that:

- At least 60% of individual link flows should have GEH less than 5.0;
- At least 95% of individual link flows should have GEH less than 10.0;
- All individual link flows should have GEH of less than 12.0; and
- Screenline flows should have GEH less than 4.0 in most cases.

However, the GEH targets set out in the EEM are designed for project specific models rather than multi-modal strategic models such as WTSM so they have only been referred to as guidelines. Observed traffic counts were undertaken by TDG during late August and early September using the methodology outlined in TN2.

Another validation measure outlined in the EEM is the percentage root mean square error (RMSE). Unlike the GEH statistic, the RMSE applies to the whole network and not just individual links. The RMSE should give a value of less than 30% for each modelled period. The EEM guidance for scattergrams of observed vs. modelled flows is that the R2 (coefficient of determination) should be greater than 0.85 in general.

All GEH statistics presented in TN18 have been calculated using 1 hour flows. To achieve this modelled and observed flows have been divided by two to generate an 'average hour flow'. The method employed in the 2006 update for the reporting of GEHs was to tabulate 2 hour observed and modelled flows, then divide these flows by two in the GEH calculation.

While guidelines don't explicitly state that GEH statistics require one-hour flows the team decided that the same approach used in the 2006 update would be used for the 2011 update. This ensured that the 2006 reported validation statistics could be compared directly with results published in TN18.

### 3.2 Car Screenline Validation

The following section illustrates the performance of the 2011 updated modelled car screenlines and individual car counts against modelled volumes. The figure below illustrates the location of screenlines (represented as pink lines) and individual counts represented as small blue dots).

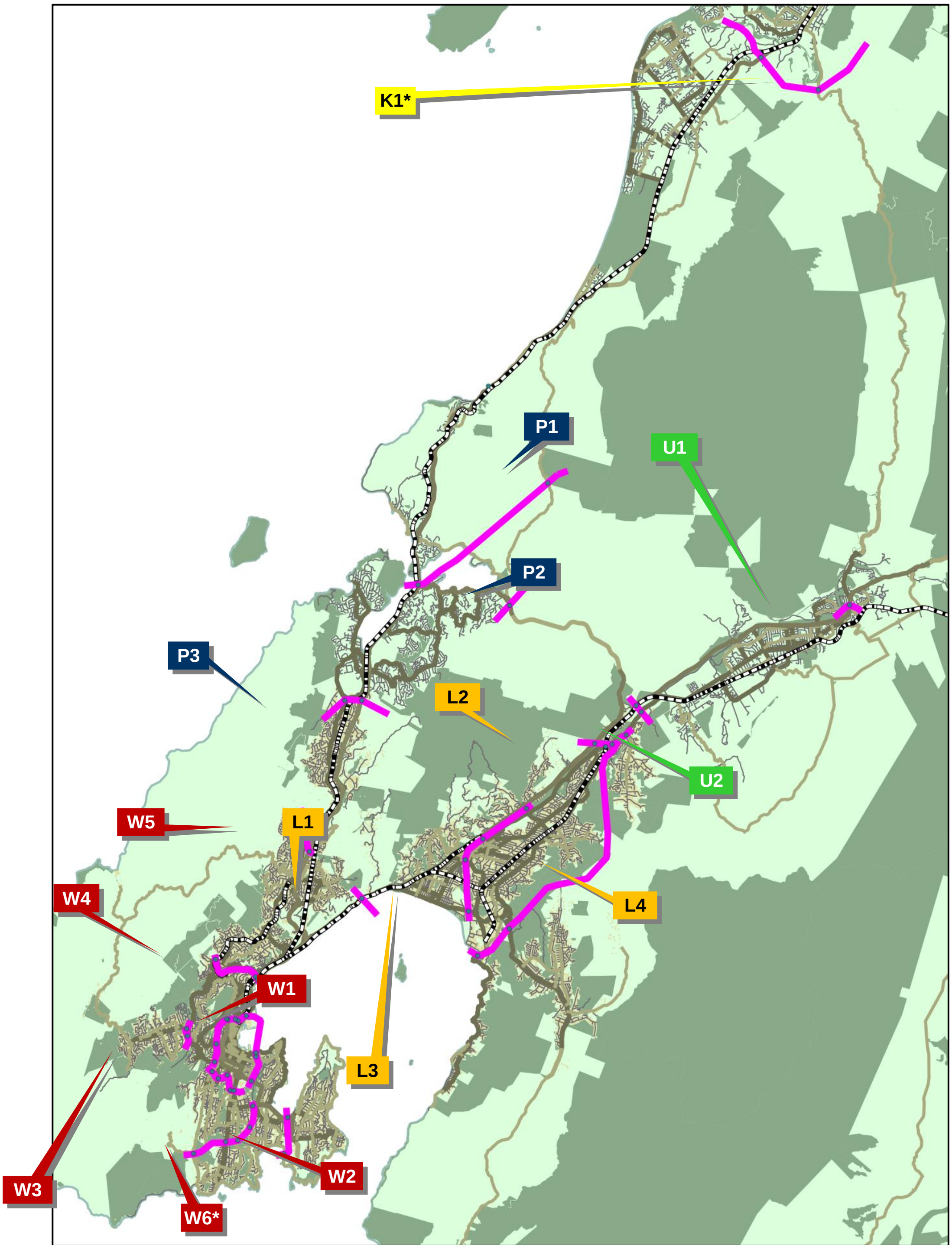



**Figure 3-1: Screenlines for 2011 WTSM Update**

The project added two new screenlines – one in Kapiti (K1) south of Waikanae and one in Wellington (W6) between the CBD and Newtown - Island Bay. Performance of these screenlines has been reported in Appendix B – Car Screenlines with TDG Counts (1 hour). The table below shows the same screenlines as reported in 2006.

**Table 3-1: Car Screenlines (1-hour flows)**

| | AM | | | | IP | | | | PM | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Description** | **Obs** | **Mod** | **Diff** | **GEH** | **Obs** | **Mod** | **Diff** | **GEH** | **Obs** | **Mod** | **Diff** | **GEH** | |
| **W1-CBD in** | 12,714 | 13,935 | 1,221 | 10.6 | 7,320 | 7,461 | 141 | 1.6 | 9,005 | 8,964 | -41 | 0.4 | **Note 1** |
| **W1-CBD out** | 6,992 | 7,240 | 248 | 2.9 | 7,141 | 7,229 | 88 | 1.0 | 12,692 | 13,361 | 669 | 5.9 | |
| **W2-Miramar In** | 1,931 | 1,938 | 7 | 0.2 | 1,354 | 1,287 | -68 | 1.9 | 1,524 | 1,544 | 20 | 0.5 | |
| **W2-Miramar Out** | 1,555 | 1,324 | -231 | 6.1 | 1,529 | 1,232 | -298 | 8.0 | 2,142 | 1,897 | -244 | 5.4 | |
| **W3-Karori out** | 353 | 497 | 144 | 7.0 | 493 | 595 | 102 | 4.4 | 1,023 | 1,141 | 118 | 3.6 | |
| **W3-Karori in** | 1,168 | 1,248 | 80 | 2.3 | 523 | 613 | 91 | 3.8 | 637 | 727 | 90 | 3.4 | |
| **W4-Thorndon out** | 3,141 | 3,073 | -68 | 1.2 | 3,288 | 2,917 | -371 | 6.7 | 7,568 | 6,767 | -801 | 9.5 | |
| **W4-Thorndon in** | 7,751 | 7,411 | -340 | 3.9 | 3,383 | 3,108 | -275 | 4.8 | 4,162 | 3,790 | -372 | 5.9 | |
| **W5-Churton P out** | 1,485 | 1,419 | -66 | 1.7 | 1,429 | 1,291 | -138 | 3.8 | 3,165 | 2,885 | -280 | 5.1 | |
| **W5-Churton P in** | 2,905 | 3,146 | 241 | 4.4 | 1,415 | 1,381 | -34 | 0.9 | 1,844 | 1,748 | -96 | 2.3 | |
| **L1-Nga to Pet out** | 2,396 | 2,635 | 239 | 4.8 | 1,875 | 1,904 | 29 | 0.7 | 3,611 | 3,857 | 246 | 4.0 | |
| **L1-Nga to Pet in** | 3,641 | 3,800 | 158 | 2.6 | 1,877 | 1,975 | 98 | 2.2 | 2,840 | 2,988 | 148 | 2.7 | |
| **L2-L to U Hutt out** | 1,373 | 1,441 | 68 | 1.8 | 1,238 | 1,320 | 82 | 2.3 | 3,544 | 2,592 | -952 | 17.2 | **Note 2** |
| **L2-L to U Hutt in** | 3,695 | 2,691 | -1,004 | 17.8 | 1,310 | 1,316 | 5 | 0.2 | 1,767 | 1,684 | -83 | 2.0 | |
| **L3-L Hutt in** | 4,208 | 4,020 | -188 | 2.9 | 3,147 | 2,847 | -300 | 5.5 | 4,277 | 3,948 | -328 | 5.1 | |
| **L3-L Hutt out** | 3,434 | 3,512 | 78 | 1.3 | 3,165 | 2,821 | -343 | 6.3 | 4,901 | 4,427 | -473 | 6.9 | |
| **L4-Wainui-Stoke in** | 2,839 | 3,174 | 336 | 6.1 | 1,122 | 1,419 | 297 | 8.3 | 1,231 | 1,525 | 294 | 7.9 | |
| **L4-Wainui-Stoke out** | 728 | 1,122 | 394 | 13.0 | 1,151 | 1,386 | 235 | 6.6 | 2,914 | 3,135 | 221 | 4.0 | **Note 3** |
| **U1-U Hutt N in** | 990 | 1,077 | 87 | 2.7 | 404 | 656 | 252 | 10.9 | 494 | 834 | 340 | 13.2 | **Note 4** |
| **U1-U Hutt N out** | 272 | 716 | 444 | 20.0 | 416 | 657 | 242 | 10.4 | 1,068 | 1,065 | -3 | 0.1 | |
| **U2-U Hutt S out** | 1,445 | 1,593 | 148 | 3.8 | 1,101 | 1,277 | 176 | 5.1 | 2,771 | 2,080 | -692 | 14.0 | **Note 5** |
| **U2-U Hutt S in** | 2,649 | 2,185 | -464 | 9.4 | 1,116 | 1,298 | 182 | 5.2 | 1,560 | 1,761 | 202 | 4.9 | |
| **P1-Porirua N out** | 591 | 679 | 88 | 3.5 | 819 | 666 | -153 | 5.6 | 1,638 | 1,484 | -154 | 3.9 | |
| **P1-Porirua N in** | 1,493 | 1,586 | 93 | 2.4 | 835 | 693 | -142 | 5.1 | 961 | 850 | -111 | 3.7 | |
| **P2-SH58 west** | 613 | 716 | 103 | 4.0 | 304 | 455 | 151 | 7.8 | 801 | 726 | -75 | 2.7 | |
| **P2-SH58 east** | 833 | 732 | -101 | 3.6 | 305 | 420 | 115 | 6.0 | 618 | 615 | -3 | 0.1 | |
| **P3-Porirua S out** | 1,579 | 1,304 | -275 | 7.2 | 1,559 | 1,075 | -484 | 13.3 | 3,320 | 2,382 | -938 | 17.6 | **Note 6** |
| **P3-Porirua S in** | 3,041 | 2,569 | -471 | 8.9 | 1,615 | 1,150 | -465 | 12.5 | 2,125 | 1,603 | -522 | 12.1 | |
| | 75,814 | 76,781 | 1% | | 51,235 | 50,449 | -2% | | 84,201 | 80,381 | -5% | | |

A number of the screenlines across all periods experienced very high GEHs. While guidance indicates screenlines should be below GEH of 4, the model is a strategic four stage model which tends to be afforded greater lee-way against guiding criteria. In the WTSM update the team has generally adopted the following approach:

- Achieve a comparable level of validation as achieved in the 2001 and 2006 versions of the model; and
- Achieve comparable level of validation against similar sized 4-stage models in Christchurch and Auckland.

Significant variations from observed volumes are explained further. The list below corresponds to the ‘Note’ listed in the most right hand column in the above table:

- **Note 1.** Screenline W1 (which relates to the CBD) inbound in the AM Peak has a GEH of 10.7. This relates to the fact that there are 1200 more vehicles modelled entering the CBD than what was observed. In 2006 the GEH value was 11.2 and while this was for the combined car and HCV movement, the level of variation between the modelled and observed volumes was similar to that achieved in 2011 (1300). Various attempts were made to calibrate the model to address the issue but it proved too difficult without unbalancing many of the other related counts.

For example, a breakdown of the flows across W1 revealed the largest divergence between observed and modelled flows occurred across the northern part of the screenline. The team investigated a number of measures to help address this issue including CBD parking charge adjustments, application of mode split constants to shift demand onto bus or rail, and re-examination of the traffic counts themselves.

Unfortunately there is another screenline (W4) just to the north of W1 and the level of validation achieved here was very good (GEH of 1.3 inbound). Given the level of landuse activity between W1 and W4 the team considered it highly unlikely that it would generate a further 1200 vehicles that would cross into the CBD.

Ultimately the team decided not to pursue GEH any better than 10.2 because:

- It was better than what was achieved in 2006; and
- Further adjustment resulted in severe disruption to related vehicle and public transport screenlines.

- **Note 2, Note 4, and Note 5.** Screenline L2 (between Lower Hutt and Upper Hutt but south of SH58) experienced a GEH of 17.7 in the southbound direction of the AM Peak and 17.3 in the northbound direction of the PM Peak. What follows is a discussion of the AM peak issues as the PM is a mirror of the AM Peak.

  The team investigated the issue and concluded it was related to the issue in Screenline U2 which covered the same roads but was just north of SH58. The movement in question was the peak demand pulse coming down from the Hutt Valley and into Wellington – Lower Hutt.

  Tracing the demand back up to Upper Hutt it was clear that the demand was 460 light at U2 and became even worse by the time the traffic passed L2 (-1,000). The first place the team checked was SH58 (P2) but the validation on that screenline was fine. It was also unlikely to be related to demand destined for Wellington as L1 in the southbound direction was okay.

  When compared against 2006 validation the team found that the lack of demand southbound across U2 was repeated but the demand across L2 was not. In fact L2 validated well, as did P2 (across SH58). The team thought this was suspicious as counts across these three locations (L2, U2, and P2) didn't add up.

  Ultimately, the team concluded that the most likely cause of the problem was:

  - A traffic count issue at L2 in 2011; and
  - A trip distribution issue with a lack of demand from Upper Hutt to Lower Hutt but too much demand northbound across U1 to the Wairarapa. With no new data in the form of Household Travel Survey to justify any recalibration there was little the team could do to prevent this from happening. Also the maximum redistribution from Upper Hutt that could have been supplied was 400 car trips and L2 was short by 1000.

- **Note 3.** The L4 screenline separating eastern Hutt (Eastbourne and Wainuiomata) from Hutt central experiences excessive contra flow modelled demand when compared to the observed in the AM and PM peak periods. This produced GEH's of 13.0 and 7.9, respectively, exceeding the performance of the 2006 validation which achieved GEH's of 14 in the contra flow direction of both AM and PM peak periods. Given the 2011 model was able to outperform the 2006 GEH on this screenline, the team decided to move on to other calibration issues i.e. given that is likely an issue that has also been in the model as a result of trip generation, trip distribution or Production/Attraction (PA) to

Origin/Destination (OD) period conversion, there was little the team could do without major recalibration.

- **Note 6.** The P3 screenline, which separates Porirua and Tawa, experiences low levels of demand in both directions across all periods. This pattern is repeated, to a limited degree, in the 2006 update validation, the main difference being the lack of demand occurring mostly in the peak flow direction. The team noted that the observed PM Peak flows in both directions were considerably higher than the AM Peak. The team found this difficult to explain given that most AM-PM demand patterns observed in Wellington tend to mirror each other. Given performance of related screenlines (W5 to the south and P1 to the north) perform relatively well the team found that:
    - In the AM peak there was too little demand exiting Tawa and travelling north to Porirua in the morning peak and too little demand travelling south from Porirua to Tawa; and
    - In the PM Peak the reverse was true.

  Ultimately the team concluded that:

    - Tawa was not generating enough trips; and
    - On the balance of probabilities, there appeared to be a higher level of attraction between Tawa and Porirua than inferred by the Gravity model.

The following table shows the level of car screenline validation achieved for both the 2011 and 2006 updates.

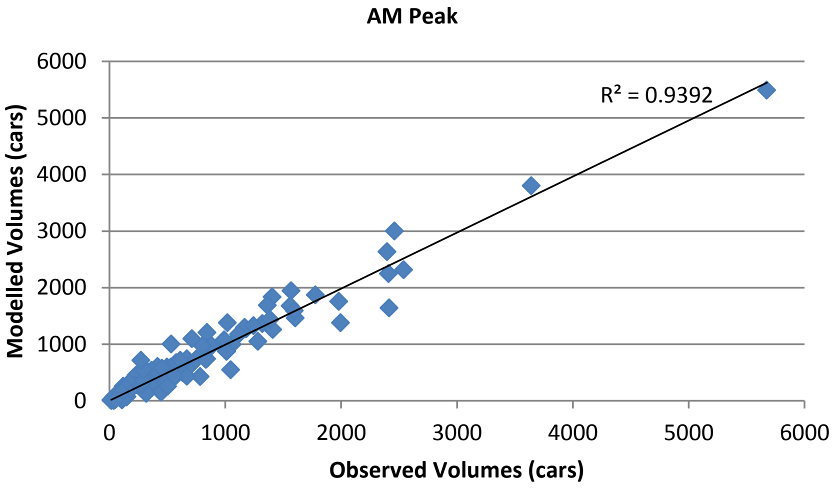
**Table 3-2: Car Screenlines Summary Comparison – 2006/2011***

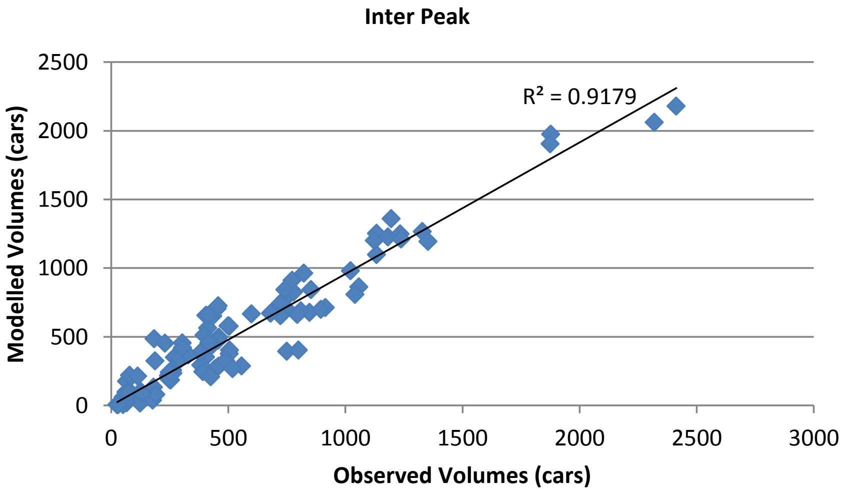
| | 2011 | | | 2006 | | |
|---|---|---|---|---|---|---|
| | AM | IP | PM | AM | IP | PM |
| GEH<5 | 64% | 43% | 54% | 64% | 57% | 57% |
| GEH<10 | 86% | 86% | 82% | 86% | 79% | 75% |
| GEH<12 | 89% | 93% | 82% | 96% | 89% | 96% |

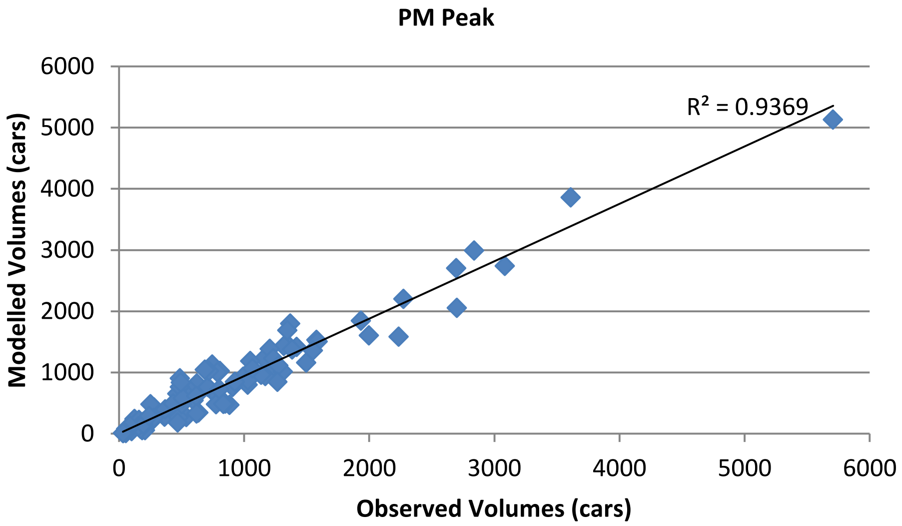
*Excludes W6 and K1

## 3.3 Individual Counts Summary

The graphs below plot individual counts and modelled flows against each other in scattergrams. EEM recommends achievement of $R^2$ values in excess of 0.85. The final $R^2$ values achieved range from 0.9179 to 0.9392.


AM Peak
Modelled Volumes (cars)
Observed Volumes (cars)
R² = 0.9392
0
1000
2000
3000
4000
5000
6000


Inter Peak
Modelled Volumes (cars)
Observed Volumes (cars)
R² = 0.9179
0
500
1000
1500
2000
2500
3000


PM Peak
Modelled Volumes (cars)
Observed Volumes (cars)
R² = 0.9369
0
1000
2000
3000
4000
5000
6000

The following table shows summary results for individual counts for all three time periods. Results show that all modelled periods meet RMSE EEM guidelines of <30% ranging from 23% in the IP and PM Peak periods to 26% in the AM Peak period.

**Table 3-3: Individual Count Summaries**

| | 2011 | | | 2006 | | |
|---|---|---|---|---|---|---|
| | **AM** | **IP** | **PM** | **AM** | **IP** | **PM** |
| Proportion of Counts with GEH<5 | 52% | 60% | 49% | 53% | 49% | 45% |
| Proportion of Counts with GEH<10 | 80% | 85% | 79% | 84% | 78% | 78% |
| Proportion of Counts with GEH<12 | 88% | 93% | 86% | 89% | 86% | 87% |
| R2 | 0.94 | 0.92 | 0.94 | 0.94 | 0.90 | 0.94 |
| RMSE | 26% | 23% | 23% | 25% | 29% | 24% |

The figure below compares relative performance of Auckland Regional Transport Model (ART3), Canterbury Transport Model (CTM) and Wellington Transport Strategy Model (WTSM). More specifically it compares the proportion of links which experience GEHs of less than 5, less than 10 and less than 12. Overall Wellington experiences performance in between that achieved by ART3 and CTM in all three periods with CTM clearly outperforming all three models in the AM and IP Periods and ART3 out performing all three models in the PM Peak Period[1].

[1] It should be noted that the GEHs from ART3 and CTM were combined car+HCV whereas WTSM was for light vehicles only. That being said the analysis remains highly indicative of the relative performance of all three models.

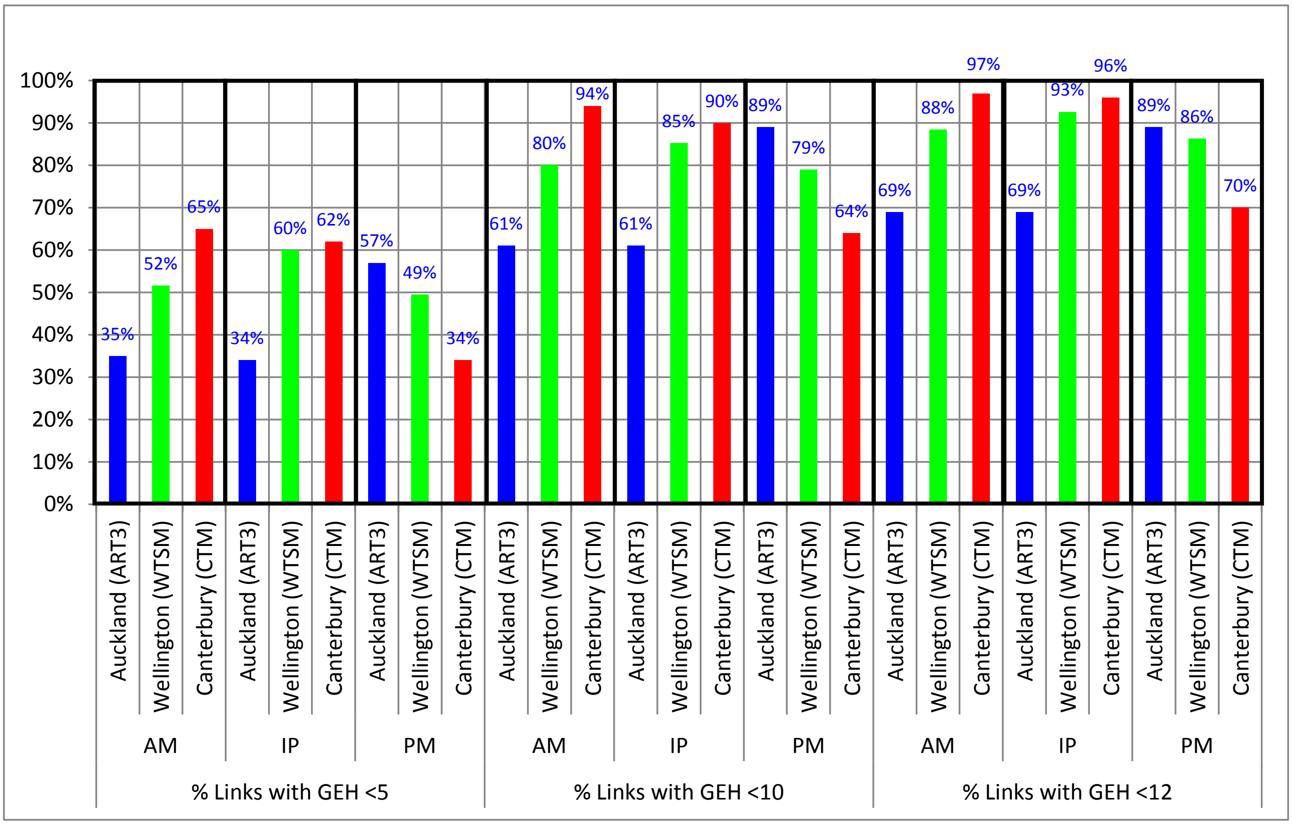



**Figure 3-2: Individual Count Summaries WTSM compared to ART3 and CTM**

The team concluded from this investigation that the 2011 updated WTSM was performing at a level comparable with other major 4-stage models in NZ.

## 3.4 HCV Validation

The HCV matrices used in the model were developed by David Young Consulting.

The following table compares the modelled HCV outputs across screenlines against surveyed data.

**Table 3-4: HCV Screenlines (1-hour flows)**

| Description | AM | | | | IP | | | | PM | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Obs | Mod | Diff | GEH | Obs | Mod | Diff | GEH | Obs | Mod | Diff | GEH | |
| W1-CBD in | 1,093 | 975 | -118 | 3.7 | 585 | 580 | -5 | 0.2 | 536 | 513 | -23 | 1.0 | |
| W1-CBD out | 534 | 535 | 1 | 0.1 | 572 | 545 | -27 | 1.2 | 907 | 800 | -107 | 3.7 | |
| W2-Miramar Out | 148 | 37 | -111 | 11.5 | 132 | 49 | -82 | 8.7 | 125 | 84 | -41 | 4.0 | Note 1 |
| W2-Miramar In | 86 | 92 | 6 | 0.6 | 76 | 60 | -16 | 1.9 | 76 | 44 | -32 | 4.2 | |
| W3-Karori in | 38 | 15 | -23 | 4.5 | 33 | 17 | -15 | 3.1 | 42 | 27 | -15 | 2.6 | |
| W3-Karori out | 80 | 25 | -56 | 7.7 | 37 | 17 | -20 | 3.8 | 38 | 14 | -24 | 4.7 | |
| W4-Thorndon out | 190 | 185 | -5 | 0.4 | 236 | 230 | -6 | 0.4 | 313 | 442 | 130 | 6.7 | |
| W4-Thorndon in | 459 | 540 | 81 | 3.6 | 246 | 264 | 18 | 1.1 | 194 | 226 | 32 | 2.2 | |
| W5-Churton P out | 147 | 104 | -43 | 3.9 | 190 | 155 | -35 | 2.6 | 354 | 298 | -56 | 3.1 | |
| W5-Churton P in | 368 | 292 | -76 | 4.2 | 171 | 177 | 6 | 0.4 | 160 | 118 | -41 | 3.5 | |
| L1-Nga to Pet out | 159 | 154 | -6 | 0.4 | 209 | 180 | -29 | 2.1 | 233 | 198 | -35 | 2.4 | |
| L1-Nga to Pet in | 270 | 244 | -25 | 1.6 | 190 | 152 | -38 | 2.9 | 123 | 107 | -16 | 1.5 | |
| L2-L to U Hutt out | 119 | 104 | -15 | 1.5 | 106 | 91 | -16 | 1.6 | 164 | 150 | -14 | 1.1 | |
| L2-L to U Hutt in | 213 | 143 | -70 | 5.3 | 116 | 81 | -35 | 3.5 | 103 | 63 | -40 | 4.4 | |
| L3-L Hutt in | 269 | 249 | -19 | 1.2 | 225 | 210 | -15 | 1.0 | 223 | 188 | -36 | 2.5 | |
| L3-L Hutt out | 220 | 204 | -16 | 1.1 | 219 | 194 | -25 | 1.7 | 245 | 167 | -78 | 5.4 | |
| L4-Wainui-Stoke in | 188 | 72 | -116 | 10.2 | 98 | 58 | -40 | 4.6 | 88 | 50 | -37 | 4.5 | Note 2 |
| L4-Wainui-Stoke out | 89 | 57 | -32 | 3.8 | 86 | 53 | -33 | 4.0 | 163 | 51 | -112 | 10.9 | |
| U1-U Hutt N out | 40 | 108 | 67 | 7.8 | 41 | 80 | 39 | 5.0 | 35 | 38 | 3 | 0.5 | |
| U1-U Hutt N in | 43 | 24 | -19 | 3.2 | 45 | 46 | 1 | 0.2 | 37 | 58 | 22 | 3.1 | |
| U2-U Hutt S out | 84 | 78 | -6 | 0.7 | 69 | 61 | -8 | 1.0 | 130 | 108 | -22 | 2.0 | |
| U2-U Hutt S in | 149 | 137 | -12 | 1.0 | 74 | 80 | 7 | 0.8 | 80 | 75 | -6 | 0.6 | |
| P1-Porirua N out | 75 | 89 | 15 | 1.6 | 93 | 116 | 23 | 2.3 | 164 | 146 | -18 | 1.4 | |
| P1-Porirua N in | 154 | 141 | -13 | 1.1 | 68 | 91 | 23 | 2.6 | 68 | 75 | 7 | 0.8 | |
| P2-SH58 east | 49 | 40 | -9 | 1.4 | 29 | 39 | 10 | 1.8 | 30 | 66 | 36 | 5.2 | |
| P2-SH58 west | 48 | 37 | -11 | 1.6 | 29 | 25 | -5 | 0.9 | 38 | 23 | -15 | 2.7 | |
| P3-Porirua S out | 104 | 105 | 1 | 0.1 | 135 | 150 | 14 | 1.2 | 114 | 159 | 45 | 3.9 | |
| P3-Porirua S in | 134 | 182 | 48 | 3.8 | 128 | 139 | 11 | 1.0 | 79 | 90 | 11 | 1.2 | |
| Total | 5,549 | 4,966 | -11% | | 4,239 | 3,942 | -7% | | 4,861 | 4,378 | -10% | | |

The following table shows the level of HCV screenline validation achieved for both the 2011 and 2006 updates.

**Table 3-5: HCV Screenlines Summary Comparison – 2006/2011**

| | 2011 | | | 2006 | | |
|---|---|---|---|---|---|---|
| | AM | IP | PM | AM | IP | PM |
| GEH<5 | 82% | 96% | 86% | 89% | 100% | 86% |
| GEH<10 | 93% | 100% | 96% | 100% | 100% | 100% |
| GEH<12 | 100% | 100% | 100% | 100% | 100% | 100% |

# 4 Vehicle Journey Time Validation

## 4.1 Introduction

Annually travel time surveys are carried out on behalf of NZTA along strategic routes within the Wellington region across the AM IP and PM periods. These surveyed routes are:

- Route 1 – Between Wellington Airport and Waikanae Rail Station
- Route 2 – Between Wellington Rail Station and Upper Hutt Rail Station
- Route 3 – Along SH58
- Route 4 – Between Karori and Courtenay Place
- Route 5 – Between Island Bay and Wellington Rail Station
- Route 6 – Between Wainuiomata and Hutt Road

## 4.2 Summary Results

The following sections compare the recorded travel times observed along the various routes to those produced in the WTSM model. Charts for each section showing the mean, minimum and maximum observed values produced in the surveys and maps of the routes are provided in Appendix D – Highway Travel Time Validation. The modelled values should aim to sit close to the mean travel time and not outside the envelope between the maximum and minimum values.

**Table 4-1: Observed and modelled travel times**

| Route | Direction | Distance (km) | AM Average Observed Minutes | AM Modelled Minutes | AM % Diff | IP Average Observed Minutes | IP Modelled Minutes | IP % Diff | PM Average Observed Minutes | PM Modelled Minutes | PM % Diff | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Route 1 - Between Wellington Airport and Waikanae Rail Station | North | 64.3 | 57.0 | 60.6 | 6% | 54.0 | 55.0 | 2% | 70.7 | 61.6 | -13% | Note 1 |
| | South | 64.2 | 80.4 | 63.9 | -21% | 55.0 | 54.6 | -1% | 61.7 | 61.8 | 0% | Note 1 |
| Route 2 - Between Wellington Rail Station and Upper Hutt Rail Station | North | 32.8 | 30.2 | 34.1 | 13% | 31.6 | 29.9 | -6% | 34.7 | 39.7 | 14% | Note 2 |
| | South | 32.7 | 44.2 | 40.9 | -7% | 26.8 | 29.3 | 9% | 31.5 | 34.3 | 9% | |
| Route 3 - Along SH58 | West | 15.1 | 14.1 | 14.1 | 0% | 13.1 | 13.4 | 2% | 13.2 | 13.8 | 5% | |
| | East | 15.1 | 15.1 | 13.5 | -10% | 13.4 | 13.2 | -2% | 14.0 | 13.7 | -3% | Note 3 |
| Route 4 - Between Karori and Courtenay Place | North | 9.2 | 22.1 | 22.4 | 2% | 19.7 | 19.5 | -1% | 23.5 | 21.9 | -7% | |
| | South | 9.1 | 22.9 | 23.2 | 1% | 19.2 | 19.9 | 4% | 24.2 | 22.4 | -8% | |
| Route 5 - Between Island Bay and Wellington Rail Station | North | 7.3 | 15.0 | 16.9 | 12% | 14.0 | 14.5 | 3% | 19.2 | 16.0 | -16% | Note 4 |
| | South | 9.1 | 17.2 | 16.4 | -4% | 14.7 | 14.9 | 1% | 17.8 | 17.4 | -2% | |
| Route 6 - Between Wainuiomata and Hutt Road | North | 10.7 | 20.0 | 14.4 | -28% | 13.1 | 14.4 | 10% | 14.2 | 13.5 | -5% | Note 5 |
| | South | 11.0 | 20.9 | 13.5 | -36% | 13.5 | 13.1 | -3% | 17.1 | 14.7 | -14% | Note 6 |

### 4.3 Journey Time Analysis

Explanation and interpretation of the summary journey time results are included in this section. The list below corresponds to the 'Note' listed in the most right hand column in Table 4-1:

- **Note 1:** Modelled journey times are 13% faster than the observed average in the PM peak northbound and 23% faster in the AM Peak in the southbound direction. Examination of the journey time profiles showed the issue to be a lack of delay in both directions along the Ngauranga Gorge section of SH1. The team looked into:
  - Using new merge macros developed by Beca but concluded these would not be used due to the minor impact the macro had; and
  - Adjusting capacities (@q).

  Ultimately, it was decided to leave capacities unchanged as:
  - Reduction of the capacities adversely impacted on the journey times along this Ngauranga section of the route for other periods;
  - The modelled time remained within the minimum and maximum observed journey time; and
  - The model is a 2 hour average highway assignment and the observed average was skewed by adverse runs undertaken in peak traffic conditions.
- **Note 2:** Modelled journey times are between 13% and 14% slower in the northbound direction. These sections coincide with signalised intersections around Melling.
- **Note 3:** Modelled journey times are 10% faster in the eastbound direction (towards the Hutt Valley from Porirua) in the AM Peak. However modelled times are still above minimum surveyed times.
- **Note 4:** Modelled journey times are 12% slower northbound between Island Bay and Wellington Railway Station in the AM peak and 16% faster northbound in the PM Peak. Modelled times are still above minimum surveyed times.
- **Note 5:** Modelled journey times are 28% faster in the AM Peak in the northbound direction between Wainuiomata and Hutt Rd. This is clearly an area of substantial congestion and delay with very large variation over a single survey period. The team believes that severe queuing is causing delays to back up through the length of the route. The assignment algorithms in EMME do not model blocking back i.e. delays/congestion of this magnitude are best modelled using highway simulation software such as SATURN.
- **Note 6:** Modelled journey times are 36% faster in the PM Peak in the southbound direction between Wainuiomata and Hutt Rd. As with the AM there is large variation between minimum and maximum journey times. As with Note 5, the team believes that severe queuing is causing delays to back up through the length of the route. The assignment algorithms in EMME do not model blocking back i.e. delays/congestion of this magnitude are best modelled using highway simulation software such as SATURN.

# 5 Bus Count Validation

## 5.1 Passenger Count Screenline Validation

Validation of bus patronage has been carried out in a similar method as vehicle screenline validation. There are very few international guidelines directing modellers in the calibration of PT trips. However, the Department for Transport (DfT) in the UK suggests a measure of +/-25% of flows across screenlines as a general guide. For this report a mixture of both percent difference and GEH are used due to the low flows across some of the screenlines.

The screenlines reported in the table below correspond to the screenlines used in the vehicle validation chapter. There are two reasons for this:

- The original model has been calibrated in this way (i.e. they're the same screenlines used in 2001 and 2006). If we were to redefine screenlines so that they focused on major PT route (or other business district cordons) it is likely trip generation and mode choice models would need to be recalibrated.
- Having common screenlines with the vehicles helps understand total demand and mode choice across screenlines. If they are separate it becomes difficult to understand how mode choice is changing.

**Table 5-1: Bus Passengers Screenlines (1-hour volumes)**

| Description | AM | | | | | IP | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Observed | Modelled | Diff | | GEH | Observed | Modelled | Diff | | GEH |
| W1-CBD in | 4,297 | 4,189 | -109 | -2.5% | 1.7 | 986 | 643 | -342 | -34.7% | 12.0 |
| W1-CBD out | 1,296 | 1,199 | -97 | -7.5% | 2.8 | 717 | 855 | 138 | 19.3% | 4.9 |
| W2-Miramar In | 602 | 772 | 170 | 28.3% | 6.5 | 133 | 120 | -13 | * | 1.1 |
| W2-Miramar Out | 78 | 116 | 37 | * | 3.8 | 85 | 151 | 67 | * | 6.1 |
| W3-Karori out | 58 | 87 | 29 | * | 3.4 | 62 | 96 | 34 | * | 3.8 |
| W3-Karori in | 538 | 581 | 43 | 8.0% | 1.8 | 101 | 76 | -25 | * | 2.6 |
| W4-Thorndon out | 151 | 232 | 82 | * | 5.9 | 172 | 313 | 141 | * | 9.0 |
| W4-Thorndon in | 1,517 | 1,058 | -459 | -30.2% | 12.8 | 269 | 135 | -134 | -49.7% | 9.4 |
| W5-Churton P out | 20 | 71 | 51 | * | 7.6 | 12 | 33 | 20 | * | 4.3 |
| W5-Churton P in | 55 | 93 | 38 | * | 4.4 | 14 | 25 | 11 | * | 2.6 |
| L1-Nga to Pet out | 107 | 100 | -7 | * | 0.7 | 93 | 162 | 68 | * | 6.1 |
| L1-Nga to Pet in | 308 | 174 | -135 | -43.7% | 8.7 | 132 | 49 | -83 | * | 8.7 |
| L2-L to U Hutt out | 57 | 42 | -15 | * | 2.1 | 47 | 93 | 45 | * | 5.4 |
| L2-L to U Hutt in | 203 | 180 | -23 | -11.2% | 1.6 | 63 | 30 | -33 | * | 4.8 |
| L3-L Hutt in | 253 | 243 | -11 | -4.1% | 0.7 | 157 | 94 | -63 | * | 5.6 |
| L3-L Hutt out | 196 | 163 | -33 | * | 2.5 | 139 | 193 | 54 | * | 4.2 |
| L4-Wainui-Stoke in | 631 | 520 | -112 | -17.7% | 4.7 | 166 | 128 | -37 | * | 3.1 |
| L4-Wainui-Stoke out | 306 | 306 | 1 | 0.2% | 0.0 | 164 | 230 | 66 | * | 4.7 |
| U2-U Hutt S out | 66 | 34 | -32 | * | 4.5 | 30 | 38 | 8 | * | 1.4 |
| U2-U Hutt S in | 73 | 79 | 6 | * | 0.7 | 38 | 13 | -26 | * | 5.1 |
| P1-Porirua N out | 0 | 0 | 0 | * | 0.0 | 0 | 0 | 0 | * | 0.0 |
| P1-Porirua N in | 3 | 0 | -3 | * | 2.6 | 0 | 0 | 0 | * | 0.0 |
| P2-SH58 west | 0 | 1 | 1 | * | 1.0 | 0 | 0 | 0 | * | 0.0 |
| P2-SH58 east | 0 | 0 | 0 | * | 0.0 | 0 | 0 | 0 | * | 0.0 |
| P3-Porirua S out | 39 | 50 | 12 | * | 1.8 | 21 | 19 | -2 | * | 0.5 |
| P3-Porirua S in | 20 | 13 | -7 | * | 1.6 | 13 | 10 | -3 | * | 0.7 |
| Total | 10,874 | 10,302 | | -5% | | 3,614 | 3,506 | | -3% | |

The list below corresponds to the 'note' listed in the most right hand column in the above table:

- **Note 1.** In the IP period there is 35% less modelled bus demand than observed entering Wellington CBD.

- **Note 2.** Too few modelled bus trips heading into town across the W4 screenline in both the AM and Inter peak periods.
- **Note 3.** Too few modelled trips travelling across the L1 Screenline from Lower Hutt to Wellington in both the AM and IP periods.

Given that the overall level of bus screenline validation exceed that achieved in 2006 the team did not pursue further improvements in bus validation.

Table 5-2 below shows the level of bus passenger screenline validation achieved for both the 2011 and 2006 updates.

**Table 5-2: Bus Patronage Screenlines Summary Comparison – 2006/2011**

| | 2011 | | 2006 | |
|---|---|---|---|---|
| | **AM** | **IP** | **AM** | **IP** |
| GEH<5 | 81% | 65% | 73% | 77% |
| GEH<10 | 96% | 96% | 92% | 88% |
| GEH<12 | 96% | 100% | 96% | 88% |

As described in TN1, transit lines have been prepared based on the General Transit Feed (GTF) for the Wellington Region, which originates from the GWRC public transport database. A GTF to EMME (G2E) converter was developed to generate EMME Transit lines from the GTF automatically for each period.

Refer to Appendix A of TN1 for a comparison of modelled vehicle frequencies against observed bus and rail service frequencies.

# 6 Rail Count Validation

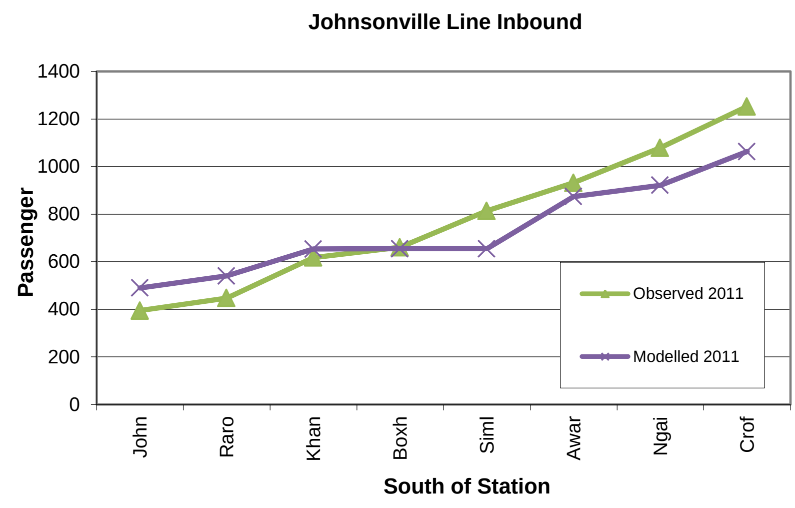
## 6.1 Passenger Validation

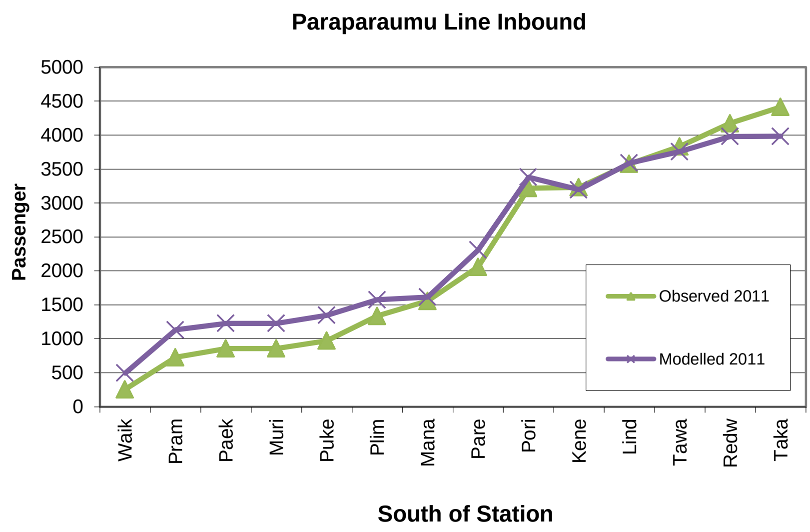
Passenger validation in the 2006 model was carried out against passenger survey counts carried out for the 2001 model. These 2001 counts had growth factors of 10% and 14% applied to the AM and IP counts respectively. It's noted that the 2006 WTSM validation report states that these growth rates were generated from *"analysis of available existing data"* but doesn't show the actual data or calculations.

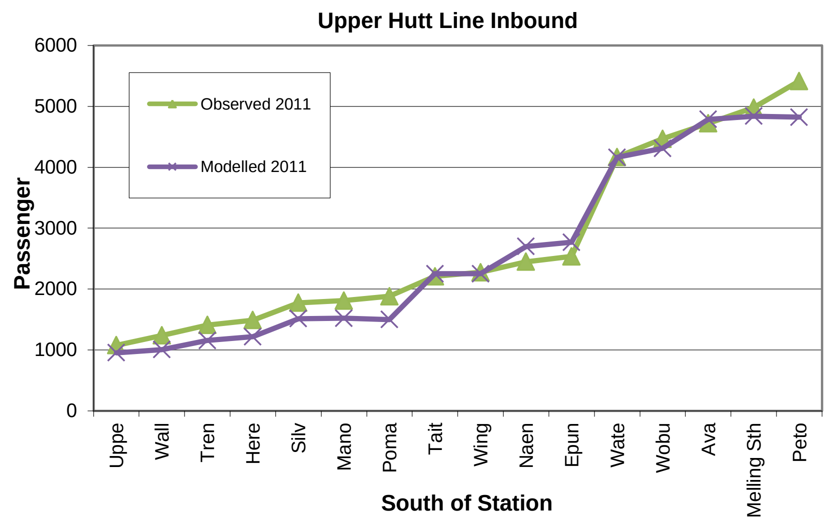
## 6.2 Boarding and Alighting

Rail loading profiles have been produced as was submitted for the 2006 WTSM update. The following charts compare modelled and observed data from 2011. The values shown are passenger volumes on the link past the rail station node.

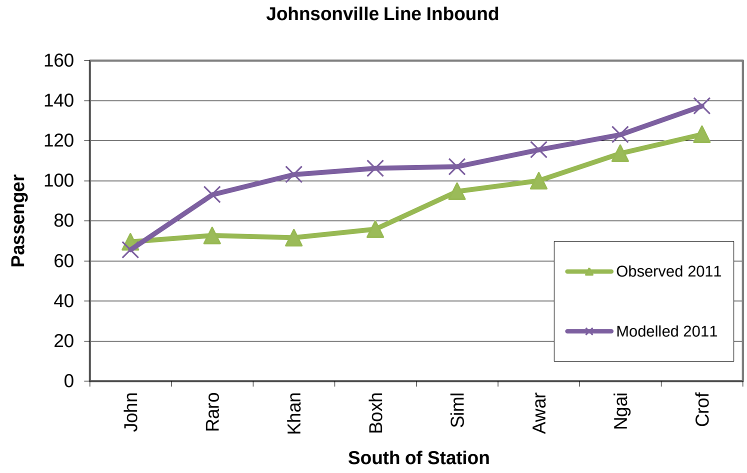
## Rail Loading Profiles – AM Peak Inbound (2-hour volumes)

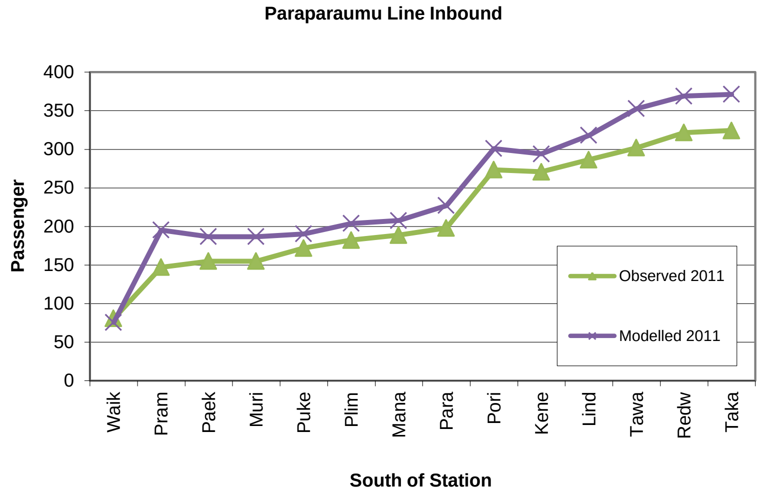


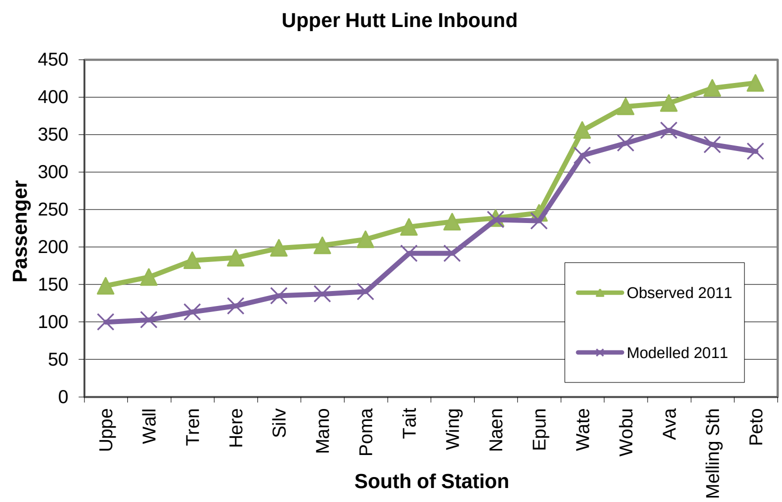



## Rail Loading Profiles – IP Peak Inbound (2-hour volumes)



# 7 Trip Length Distribution Comparison 2006-2011

## 7.1 Introduction

While the Trip Distribution Model was not recalibrated there were significant changes to the network and some changes made to the mode choice model. Those changes and implications are summarised below:

- Network replaced;
- Transit services replaced;
- HCV matrices re-estimated; and
- Mode choice model adjusted.

## 7.2 Car Matrices

The figure below compares AM Peak period trip length distribution for car trips in minutes between the 2006 and 2011 models. What it shows is that there has been a slight increase in trips travelling between 2.5 and 7.5 minutes.

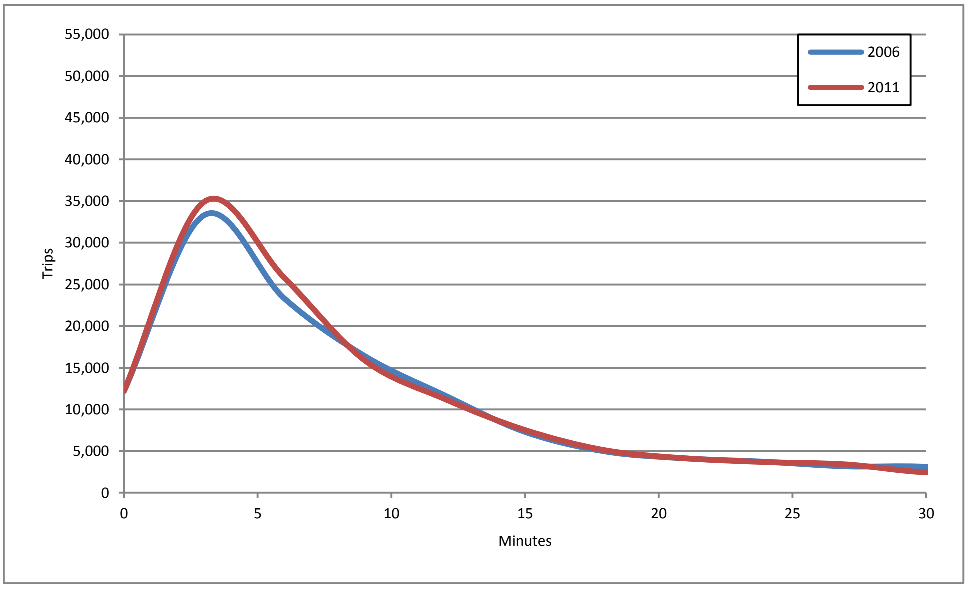



**Figure 7-1: AM Peak Car Trip Length Distribution 2006-2011 (time)**

The figure below compares AM Peak period trip length distribution for car trips in kms between the 2006 and 2011 models. What it shows is that there has been a substantial increase trips shorter than 5kms but a decrease in trips 6km and 11km.

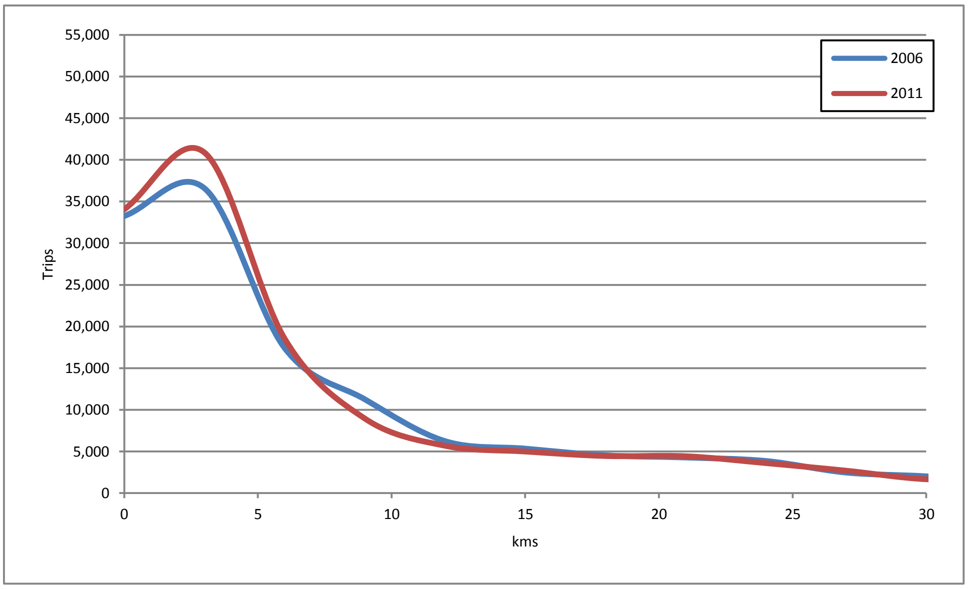



**Figure 7-2: AM Peak Car Trip Length Distribution 2006-2011 (distance)**

Taken together, the change in distribution illustrated in the graphs above indicate a marked shortening of trip lengths between the two versions of the model. Analysis of traffic growth between 2006 and 2011 show it is unlikely to be caused by increasing congestion levels. It is more likely that the change in trip distribution is caused by increasing real costs of fuel (documented in Section 3.8 of TN15 Input Parameters).

## 7.3 HCV Matrices

The figure below compares AM Peak period trip length distribution for HCV trips in minutes between the 2006 and 2011 models. What it shows is that there has been a significant decrease in trips travelling between 2.5 and 7.5 minutes.

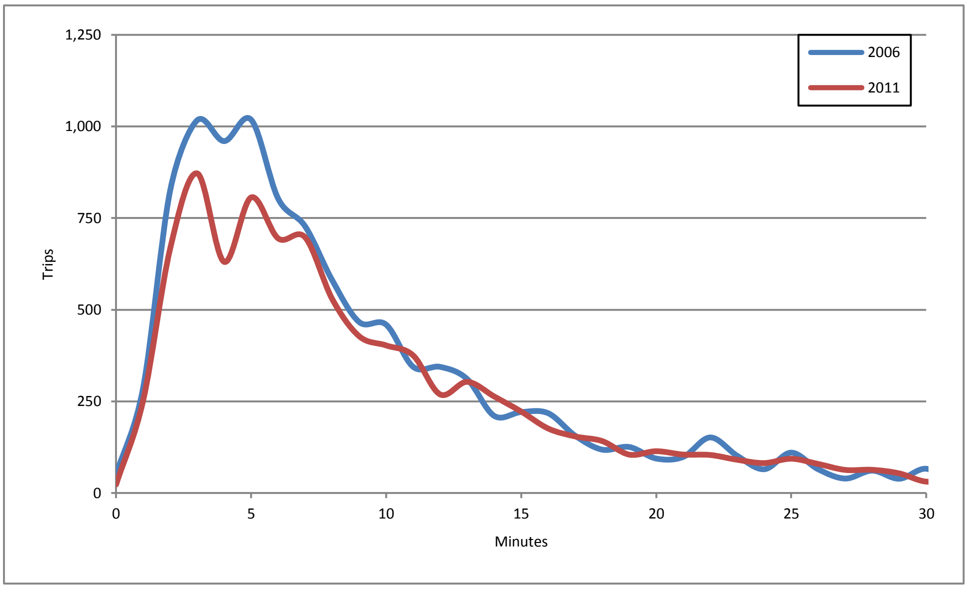



**Figure 7-3: AM Peak HCV Trip Length Distribution 2006-2011 (time)**

The figure below compares AM Peak period trip length distribution for HCV trips in kms between the 2006 and 2011 models. What it shows is that there has been a substantial increase trips between:

- 1km and 5km; and
- Between 7km and 12km.

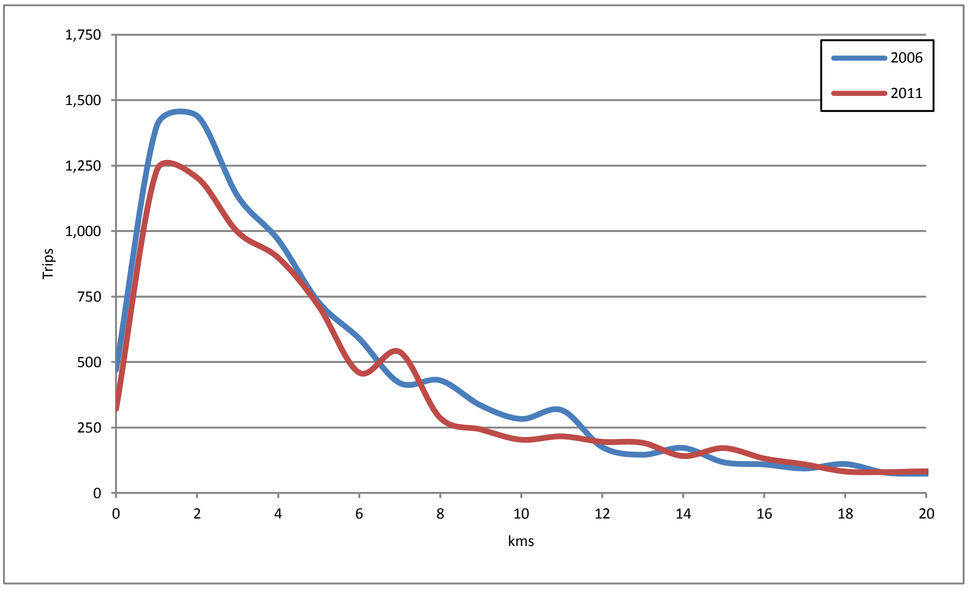



**Figure 7-4: AM Peak HCV Trip Length Distribution 2006-2011 (distance)**

As with the car trip distributions above the HCV distribution has demonstrated a degree of change between 2006 and 2011. The reasons for these changes relate to the additional sector to sector factoring undertaken for the 2011 update. These changes are described in more detail in Section 3.4 and Appendix A.

## 7.4 Public Transport Matrices

The figure below compares AM Peak period trip length distribution for trips in minutes for the synthetic 2006, synthetic 2011 and "observed" WPTM public transport demands. What it shows is that there has been a significant decrease in synthetic PT trip lengths between 2006 and 2011. This is demonstrated by the decrease in trips in the 70 minute to 100 minute range and increase in trips in the 40 minute to 70 minute range.

As indicated in the Model Investigation report, the team also took the opportunity to compare the Synthetic trip length distribution from the 2011 update against the "observed" distribution from WPTM (shown in green in the graph). The Synthetic 2011 demand matches the WPTM demand fairly closely for trips greater than 55 minutes but the 2011 WTSM PT demand are significantly higher than WPTM under 50 minutes.

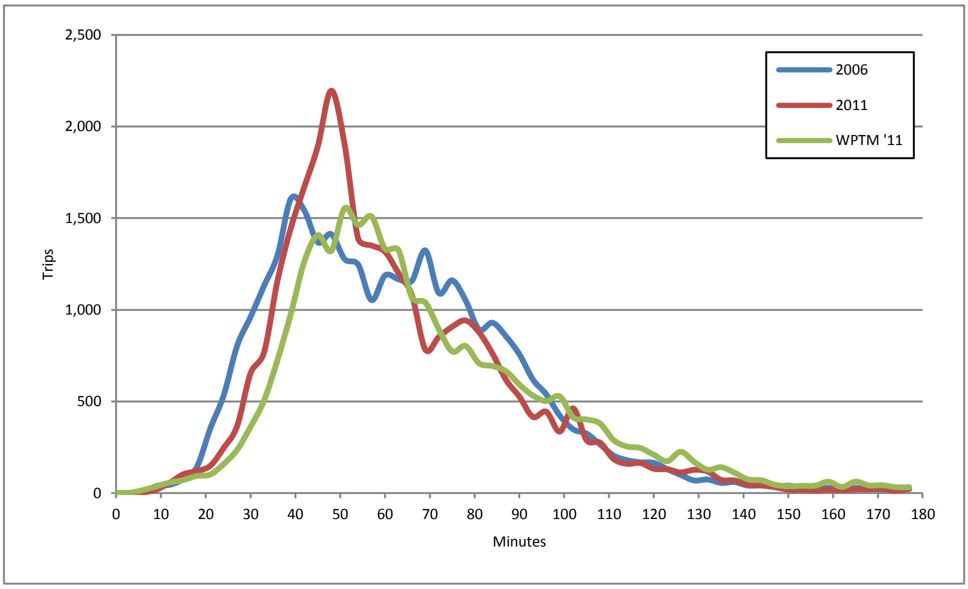



**Figure 7-5: AM Peak Period PT Trip Length Distribution (generalised minutes)**

The figure below compares AM Peak period trip length distribution for trips in kms for the 2006 and 2011 PT demands. It shows relatively similar distributions up to 18km but significant variation thereafter:

- There are more trips in 2011 than 2006 between 18km and 23km; and
- substantially less trips in 2011 than 2006 greater than 23km.

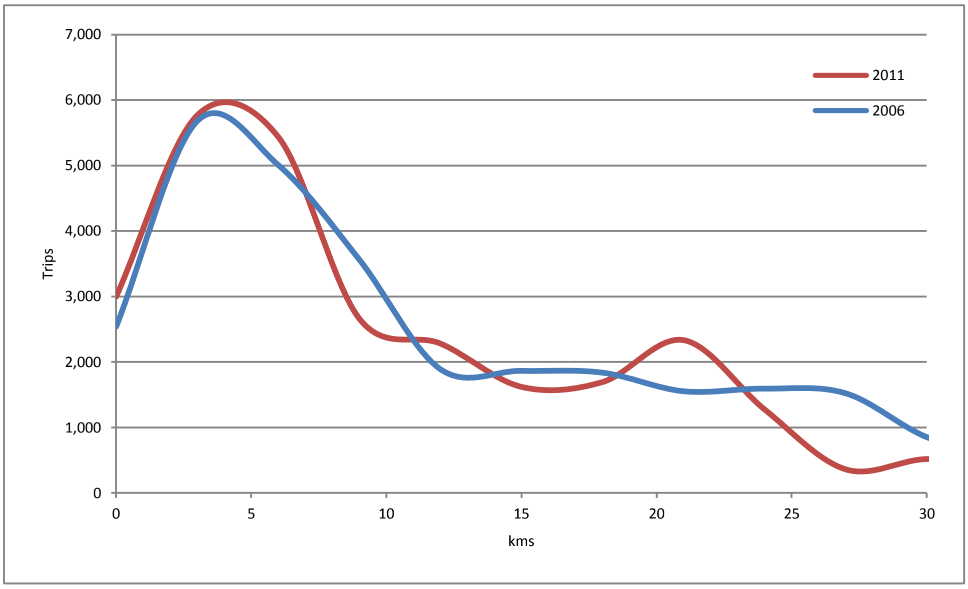



**Figure 7-6: AM Peak PT Trip Length Distribution 2006-2011 (distance)**

# 8 Demand and Assignment Model Convergence

## 8.1 Demand Model Convergence

The following figure shows the level of demand convergence achieved in the 2011 update. The result achieved similar level of convergence to that delivered in 2001.

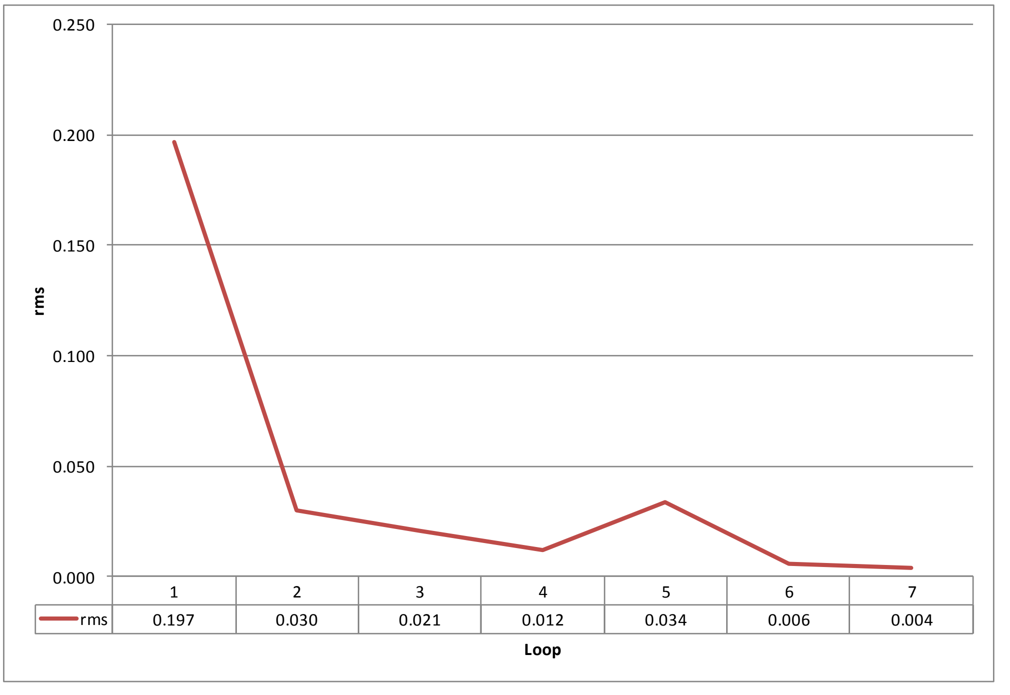



**Figure 8-1: 2011 WTSM Demand Model Convergence**

## 8.2 Highway Assignment Model Convergence

The table below shows statistics for the 2011 WTSM Highway Assignment Model Convergence for all three periods against vehicle kilometres travelled (veh.km) and vehicle minutes travelled (veh.min). The AM and IP periods achieve convergence (0.1% difference) by the 2$^{nd}$ and 3$^{rd}$ iterations whereas the PM does not achieve convergence for both veh.km and veh.min until the 7$^{th}$ iteration of the intersection capacities.

**Table 8-1: 2011 Highway Assignment Convergence Statistics**

| Intersection Update Iterations | AM Peak | | Inter Peak | | PM Peak | |
|---|---|---|---|---|---|---|
| | veh.km | veh.min | veh.km | veh.min | veh.km | veh.min |
| 0 | 1,556,089 | 2,005,066 | 1,098,762 | 1,259,226 | 1,624,176 | 2,048,950 |
| 1 | 1,554,298 | 1,955,458 | 1,098,620 | 1,255,907 | 1,623,437 | 2,031,337 |
| | -0.12% | -2.47% | -0.01% | -0.26% | -0.05% | -0.86% |
| 2 | 1,553,594 | 1,944,467 | 1,098,587 | 1,255,750 | 1,623,470 | 2,030,038 |
| | -0.05% | -0.56% | -0.003% | -0.01% | 0.002% | -0.06% |
| 3 | 1,553,605 | 1,945,242 | 1,098,611 | 1,256,084 | 1,623,531 | 2,036,397 |
| | 0.001% | 0.04% | 0.002% | 0.03% | 0.004% | 0.31% |
| 4 | 1,553,584 | 1,946,000 | 1,098,635 | 1,256,412 | 1,623,627 | 2,044,659 |
| | -0.001% | 0.04% | 0.002% | 0.03% | 0.01% | 0.41% |
| 5 | 1,553,618 | 1,948,615 | 1,098,673 | 1,256,895 | 1,623,963 | 2,049,637 |
| | 0.002% | 0.13% | 0.003% | 0.04% | 0.02% | 0.24% |
| 6 | 1,553,689 | 1,949,592 | 1,098,688 | 1,257,014 | 1,624,192 | 2,053,532 |
| | 0.005% | 0.05% | 0.001% | 0.01% | 0.01% | 0.19% |
| 7 | 1,553,769 | 1,950,515 | 1,098,708 | 1,257,138 | 1,624,397 | 2,055,176 |
| | 0.01% | 0.05% | 0.00% | 0.01% | 0.01% | 0.08% |

## 8.3 Link Volume Convergence

Link Volume Convergence was not assessed in 2001 or 2006 models. The following section is based on an approximation of convergence statistics used in SATURN highway assignment modelling. Section 9.1.2 of the SATURN Manual states that:

> "In order to deal with the interactions [the assignment] loops between **assignment** and **simulation** until (reasonably) steady flows are obtained, at which point the model is judged to be "self-consistent" or "in equilibrium"; i.e., the flows that go into the simulation produce delays which in turn produces the same flows on assignment. (Technically this approach is known as the "diagonalisation method").
>
> The (main) parameter used to monitor the rate of convergence is the percentage of link flows which vary by less than, say, **5%** between loop n and loop n-1. If this exceeds the (integer) parameter then the process is judged to have converged satisfactorily. If the criteria is satisfied on successive loops then the process is terminated" **Default: 95 %**

To draw parallels between the WTSM highway assignment algorithm and the SATURN highway assignment algorithms mentioned in the 1st sentence of the quote above:

- **SATURN Assignment** is the equivalent of **"equilibrium assignment"** stage in the Highway Assignment Algorithm flow chart provided in Appendix F; and
- **SATURN "Simulation"** is the equivalent of the **"calculate approach capacities"** stage in the Highway Assignment Algorithm flow chart provided in Appendix F.

The table below shows the percentage of assigned links with changes in flows over successive iterations of greater than 5% for the 2011 WTSM. In this table n is the final iteration.

**Table 8-2: Link Volume Convergence Statistics**

| | AM Peak | Inter Peak | PM Peak |
|---|---|---|---|
| n-4 iteration | 6.7% | 3.0% | 7.3% |
| n-3 iteration | 5.9% | 1.9% | 6.0% |
| n-2 iteration | 4.1% | 1.7% | 4.4% |
| n-1 iteration | 3.1% | 1.6% | 3.2% |
| n iteration | 3.0% | 1.3% | 3.0% |

# 9 Model Sensitivity Tests

## 9.1 Introduction

Tests have been run to establish whether the overall sensitivity of the model to changes in network level-of-service are reasonable. These tests were:

- Public transport fares: +20% changes in all PT fares;
- Public transport in-vehicle times: +20% changes in all PT times;
- Public transport frequencies: +20% changes for all PT;
- Car operating costs or fuel costs: +20%; and
- Car in-vehicle times: +20%.

For information we have also tested:

- CBD parking charges: 100% increase on average CBD charges; and
- CBD pricing cordon: $2 peak, $1 off peak.

## 9.2 Results and Analysis

The table below details the elasticity results/model responses for the above tests. For all sensitivity tests the results are in line with expectations drawn from local and international evidence. The results for the parking charge increase and cordon charges do not seem to be of an unreasonable magnitude.

**Table 9-1: Elasticity Results**

| | | 2011 Model | 2001 Model | Comparative Values |
|---|---|---|---|---|
| PT Fares +20% | ∑ PT Trips | -0.21 | -0.20 | Original model: -0.22 (trips) International range: -0.1 to –0.6 (PDFH*: short & medium distance urban rail: -0.3 to –0.6) Transfund patronage funding work: -0.2 to –0.45 |
| | ∑ Pass.km | -0.38 | -0.29 | |
| PT In-Vehicle Time +20% | ∑ PT Trips | -0.21 | -0.20 | Original model - rail only: -0.46 (rail only trips) PDFH rail: -0.2 to –0.8 (inferred) |
| | ∑ Pass.km | -0.40 | -0.39 | |
| PT Frequency +20% | ∑ PT Trips | 0.11 | 0.10 | Original model: +0.085 (trips); Transfund patronage funding work: +0.2 to +0.7 PDFH rail: +0.15 to +0.6 (inferred) |
| | ∑ Pass.km | 0.19 | 0.16 | |
| Car VOC +20% (Fuel Increase) | ∑ Car Trips | -0.07 | -0.05 | Original model: -0.1 (car driver trips), Typical international fuel price elasticities: -0.1 to –0.3 |
| | ∑ veh.km | -0.40 | -0.26 | |
| Car Journey Time +20% | ∑ Car Trips | -0.07 | -0.07 | Transfund PEM: -0.2 to –0.25 |
| | ∑ veh.km | -0.29 | -0.28 | |
| CBD Parking Charge +100% | Car Trips | -0.01 | -0.01 | |
| | CBD Car Trips | -0.05 | -0.04 | |
| CBD Cordon Charge ($2 Peak, $1 Off-Peak) | Car Trips | -0.05 | -0.02 | |
| | CBD Car Trips | -0.09 | -0.08 | |

*PDFH = Passenger Demand Forecasting Handbook

# 10 Conclusion

TN18 reported the results of the WTSM model validation across a range of performance measures including car, HCV and bus screenline data along with highway journey times, rail loading profiles and sensitivity tests.

> Being an update as opposed to a full model recalibration, the team set the goal of achieving validation comparable with both the 2001 / 2006 versions of the models and the 4 stage models in Auckland and Christchurch.

A number of key themes developed early in the model update process that affected how the project proceeded and the type of analysis undertaken. The issues presented the team with the following opportunities and challenges:

- New networks and services;
- Estimated landuse (and cancellation of the 2011 NZ Census);
- Economic recession and government policy changes;
- Disruption to data collection programmes;
- Better public transport data availability;
- New PT assignment module in EMME software; and
- Undocumented model run macros and updates to macros.

The team met these challenges through a series of thorough investigations which benefited substantially from input from the peer reviewer via weekly update meetings. Those investigations included:

- Trip generation & aggregate demand;
- HCV demand re-estimation;
- Network and matrix model convergence;
- Mode choice model adjustments;
- Assignment routing issues; and
- Testing and implementation of new Transit Assignment EMME Module.

The specific validation criteria were informed by both the 2001 and 2006 validation reports completed by SKM and Beca and agreement with the model Peer Reviewer. The validation categories and relative performance are summarised below:

- **Vehicle screenline counts and individual counts.** Most screenlines and count sites met EEM criteria and where there were variations explanations were provided. Most explanations related to the 2001 and 2006 models and could only really be addressed with substantial local recalibration or through recalibration of the entire model with a new Household Travel Survey and census.
- **Vehicle journey time validation.** Most journey times validated well within the minimum and maximum survey envelopes. The team encountered significant difficulties in validating journey times along the most severely congested parts of the network (Ngauranga Gorge and Petone Esplanade). The poor performance on these routes was

attributed to the fact that EMME highway assignment algorithms struggled to deal with severe queuing.

- **Bus screenlines count validation.** While included in the 2006 Model Validation Report the 2006 Peer Reviewer had expressed concern of the reliability of the observed estimates. The 2011 WTSM update however was able to take advantage of the newly collated bus ETM data and WPTM assignment to generate more enhanced and reliable screenlines. The morning peak performed particularly well with the Wellington CBD cordon achieving GEHs of between 1.7 and 2.8. However, the Inter peak did not fare as well with GEH of 12 on CBD inbound trips.
- **Bus journey time validation.** This was reported separately in TN1 so it could be kept together with the development of the bus transit lines.
- **Rail count validation.** As with the bus screenline data the team was able to take advantage of much more reliable observed data through WPTM. All modelled loading profiles performed well against observed data in both the AM and PM peaks.
- **Sensitivity tests.** For all sensitivity tests the results were in line with expectations drawn from local and international evidence. The results for the parking charge increase and cordon charges do not seem to be of an unreasonable magnitude.

Lastly, the team recognised that while a comprehensive recalibration process was not possible due to the lack of a census and household travel survey that trip length distributions for the 2006 and 2011 model should be reported. The purpose was to either confirm that the model had changed very little or, that where there was change, the model users were aware of it. Overall, trip length distributions appeared to have decreased slightly between 2006 and 2011. These changes have been attributed to the increasing costs of travel (in the case of car trips).

A recurring theme of the past three model validations (2001, 2006 and 2011) was the lack of suitability of the EEM criteria for 4 stage models developed from Household Travel Surveys. To help address this issue the team compared updated 2011 validation against findings from the Christchurch and Auckland demand models. Overall the Wellington model experiences performance in between that achieved by ART3 and CTM in all three periods with CTM clearly outperforming all three models in the AM and IP periods and ART3 outperforming all three models in the PM peak period.

The 2011 model update process concluded with a model that achieved validation goals and, as such, is considered suitable for the purpose of policy studies, strategy studies, corridors studies and providing demand to project models in the Wellington Region. However, as with any strategic model, local area validation may be required if it is to be used for project studies where WTSM is the sole source of economic evaluation data.

# Appendix A – Update of WTSM to 2011 Base Year – 2011 HCV Model

David Young Consulting

## 1 Introduction

This section describes the procedure for developing 2011 base year CV matrices.

In WTSM the CV (HCV and MCV) matrices are fixed for a particular modelled year and are developed from factoring the base year (2001) 24-hour matrix and then applying time period factors.

The 2001 24-hour matrix was developed from matrix estimation on screenlines using MVESTM in TRIPS. For the 2006 update counts were available for the 2-hour assignment periods only and not for 24 hours, so a process was developed within a spreadsheet for adjusting the CV trips by sectoring the zone system (matrix) according to screenlines and using CV screenline counts.

## 2 Procedure

The same procedure as developed for 2006 has been undertaken for the 2011 update.

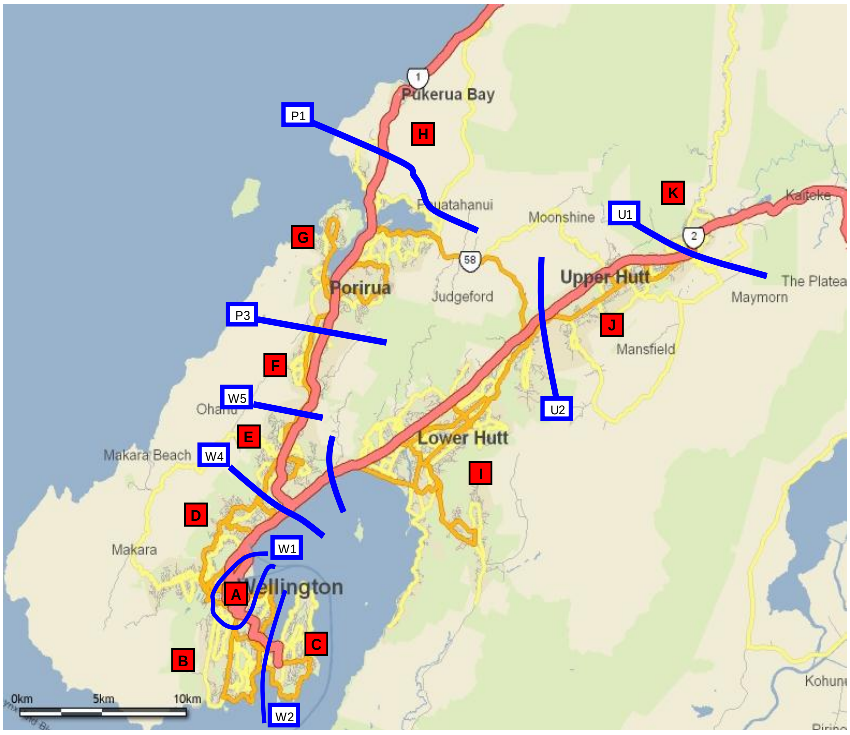
The forecast 2011 matrices for the three time periods are used as the starting matrices and are adjusted on a sector basis so that the screenline counts are matched as far as possible, while attempting to minimise the change from the initial matrix. In doing so, the adjustments take account of trips that cross more than one screenline, and the resulting adjustment factors for each sector are the product of those made across each relevant screenline.

Intra-sector flows are adjusted using the average of adjacent inter-sector factors.

The result is a set of multiplicative factors between and within each sector.

The sectors and screenlines used are given in Figure 0-1, noting that there were no 2011 CV counts on U1 so the factors from the 2006 adjustments were used.

- **Figure 0-1 CV Sectors and Screenlines**



The sets of adjustment factors are given in Table 0-1, Table 0-2, and Table 0-3, including the row, column and overall averages (these are weighted by the number of trips in each case).

- **Table 0-1 AM Peak CV Adjustment Factors**

| | A | B | C | D | E | F | G | H | I | J | K | E1 | E2 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 0.65 | 0.65 | 1.00 | 0.30 | 0.75 | 0.83 | 0.74 | 0.52 | 0.98 | 1.07 | 0.56 | 1.20 | 1.20 | 0.60 |
| B | 0.65 | 0.65 | 1.00 | 0.30 | 0.75 | 0.83 | 0.74 | 0.52 | 0.98 | 1.07 | 0.56 | 1.20 | 1.20 | 0.66 |
| C | 0.30 | 0.30 | 0.95 | 0.30 | 0.23 | 0.25 | 0.22 | 0.16 | 0.29 | 0.32 | 0.17 | 1.20 | 1.20 | 0.52 |
| D | 1.00 | 1.00 | 1.00 | 0.65 | 0.75 | 0.83 | 0.74 | 0.52 | 0.98 | 1.07 | 0.56 | 1.20 | 1.20 | 0.87 |
| E | 0.60 | 0.60 | 0.60 | 0.60 | 1.91 | 1.10 | 0.99 | 0.69 | 1.30 | 1.43 | 0.74 | 1.20 | 1.20 | 0.93 |
| F | 3.12 | 3.12 | 3.12 | 3.12 | 5.20 | 1.93 | 0.90 | 0.63 | 6.76 | 1.43 | 0.74 | 1.20 | 1.20 | 2.11 |
| G | 1.56 | 1.56 | 1.56 | 1.56 | 2.60 | 0.50 | 0.76 | 0.70 | 3.38 | 0.72 | 0.37 | 1.20 | 1.20 | 0.82 |
| H | 1.48 | 1.48 | 1.48 | 1.48 | 2.47 | 0.48 | 0.95 | 2.21 | 6.42 | 1.05 | 0.54 | 1.20 | 1.20 | 2.09 |
| I | 1.80 | 1.80 | 1.80 | 1.80 | 3.00 | 1.10 | 0.99 | 0.77 | 1.20 | 1.10 | 0.57 | 1.20 | 1.20 | 1.24 |
| J | 1.53 | 1.53 | 1.53 | 1.53 | 2.55 | 2.55 | 2.30 | 0.77 | 0.85 | 0.92 | 0.52 | 1.20 | 1.20 | 0.90 |
| K | 1.84 | 1.84 | 1.84 | 1.84 | 3.06 | 3.06 | 2.75 | 0.71 | 1.02 | 1.20 | 0.86 | 1.20 | 1.20 | 0.96 |
| E1 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 |
| E2 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 |
| Average | 0.80 | 0.71 | 0.99 | 0.59 | 1.67 | 1.10 | 0.80 | 2.00 | 1.21 | 0.98 | 0.82 | 1.20 | 1.20 | 1.08 |

- **Table 0-2 Inter peak CV Adjustment Factors**

| | A | B | C | D | E | F | G | H | I | J | K | E1 | E2 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 0.53 | 0.53 | 0.55 | 0.50 | 1.00 | 1.50 | 1.28 | 0.96 | 1.10 | 0.61 | 0.48 | 1.20 | 1.20 | 0.57 |
| B | 0.53 | 0.53 | 0.55 | 0.50 | 1.00 | 1.50 | 1.28 | 0.96 | 1.10 | 0.61 | 0.48 | 1.20 | 1.20 | 0.55 |
| C | 0.50 | 0.50 | 0.74 | 0.50 | 0.50 | 0.75 | 0.64 | 0.48 | 0.55 | 0.30 | 0.24 | 1.20 | 1.20 | 0.58 |
| D | 0.55 | 0.55 | 0.55 | 0.53 | 1.00 | 1.50 | 1.28 | 0.96 | 1.10 | 0.61 | 0.48 | 1.20 | 1.20 | 0.60 |
| E | 1.50 | 1.50 | 0.83 | 1.50 | 1.28 | 1.50 | 1.28 | 0.96 | 1.10 | 0.61 | 0.48 | 1.20 | 1.20 | 1.27 |
| F | 1.65 | 1.65 | 0.91 | 1.65 | 1.10 | 1.10 | 0.85 | 0.64 | 1.21 | 0.61 | 0.48 | 1.20 | 1.20 | 1.08 |
| G | 1.57 | 1.57 | 0.86 | 1.57 | 1.05 | 0.95 | 0.84 | 0.75 | 1.15 | 0.57 | 0.46 | 1.20 | 1.20 | 0.87 |
| H | 1.25 | 1.25 | 0.69 | 1.25 | 0.84 | 0.76 | 0.80 | 0.91 | 0.97 | 0.44 | 0.35 | 1.20 | 1.20 | 0.92 |
| I | 2.10 | 2.10 | 1.16 | 2.10 | 1.40 | 1.50 | 1.28 | 1.13 | 1.15 | 0.55 | 0.44 | 1.20 | 1.20 | 1.12 |
| J | 1.16 | 1.16 | 0.64 | 1.16 | 0.77 | 0.77 | 0.65 | 1.13 | 0.55 | 0.78 | 0.80 | 1.20 | 1.20 | 0.75 |
| K | 1.39 | 1.39 | 0.76 | 1.39 | 0.92 | 0.92 | 0.79 | 0.50 | 0.66 | 1.20 | 1.00 | 1.20 | 1.20 | 0.99 |
| E1 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| E2 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Average | 0.58 | 0.58 | 0.62 | 0.66 | 1.13 | 1.15 | 0.87 | 0.91 | 1.09 | 0.78 | 0.92 | 1.20 | 1.20 | 0.83 |

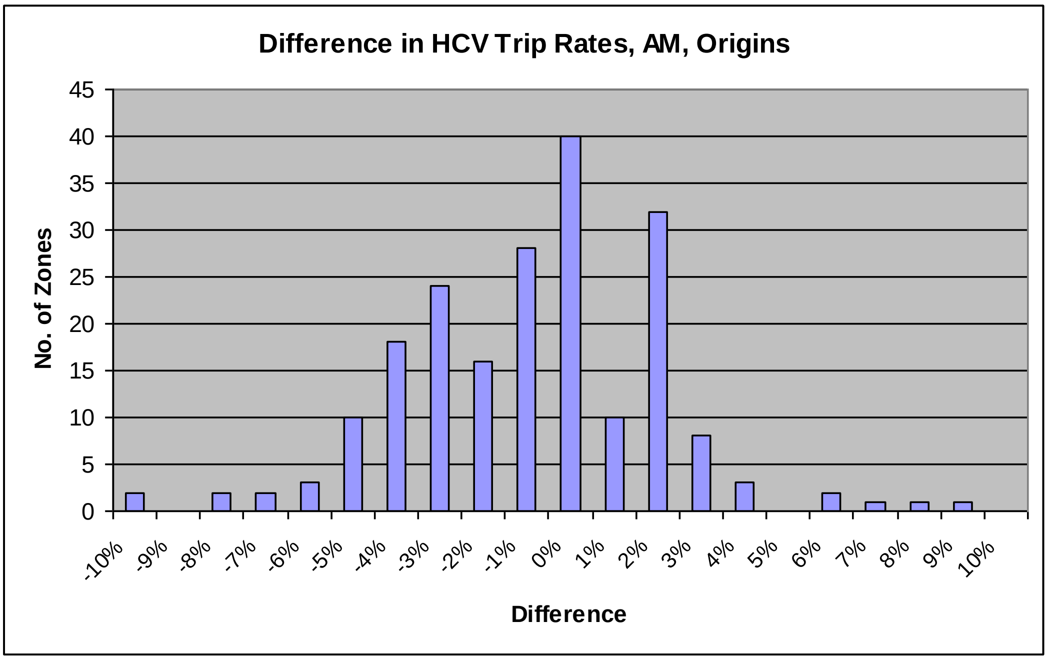
- **Table 0-3 PM Peak CV Adjustment Factors**

| | A | B | C | D | E | F | G | H | I | J | K | E1 | E2 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 0.60 | 0.60 | 0.45 | 0.75 | 0.60 | 3.30 | 1.65 | 1.73 | 1.50 | 2.10 | 2.10 | 0.90 | 0.90 | 0.72 |
| B | 0.60 | 0.60 | 0.45 | 0.75 | 0.60 | 3.30 | 1.65 | 1.73 | 1.50 | 2.10 | 2.10 | 0.90 | 0.90 | 0.65 |
| C | 0.75 | 0.75 | 0.91 | 0.75 | 0.45 | 2.48 | 1.24 | 1.30 | 1.13 | 1.58 | 1.58 | 0.90 | 0.90 | 0.81 |
| D | 0.45 | 0.45 | 0.45 | 0.60 | 0.60 | 3.30 | 1.65 | 1.73 | 1.50 | 2.10 | 2.10 | 0.90 | 0.90 | 0.63 |
| E | 1.00 | 1.00 | 0.45 | 1.00 | 2.23 | 5.50 | 2.75 | 2.89 | 2.50 | 3.50 | 3.50 | 0.90 | 0.90 | 1.79 |
| F | 1.80 | 1.80 | 0.81 | 1.80 | 1.80 | 2.13 | 0.50 | 0.53 | 4.50 | 3.50 | 3.50 | 0.90 | 0.90 | 1.54 |
| G | 1.26 | 1.26 | 0.57 | 1.26 | 1.26 | 0.70 | 0.76 | 1.05 | 3.15 | 2.45 | 2.45 | 0.90 | 0.90 | 0.82 |
| H | 1.01 | 1.01 | 0.45 | 1.01 | 1.01 | 0.56 | 0.80 | 2.81 | 3.60 | 1.12 | 1.12 | 0.90 | 0.90 | 2.58 |
| I | 0.90 | 0.90 | 0.41 | 0.90 | 0.90 | 5.50 | 2.75 | 5.78 | 1.09 | 1.40 | 1.40 | 0.90 | 0.90 | 1.20 |
| J | 0.90 | 0.90 | 0.41 | 0.90 | 0.90 | 0.90 | 0.45 | 5.78 | 1.00 | 1.10 | 1.00 | 0.90 | 0.90 | 1.12 |
| K | 0.90 | 0.90 | 0.41 | 0.90 | 0.90 | 0.90 | 0.45 | 1.05 | 1.00 | 1.00 | 1.00 | 0.90 | 0.90 | 1.00 |
| E1 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| E2 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Average | 0.61 | 0.62 | 0.62 | 0.74 | 1.02 | 2.32 | 0.84 | 2.62 | 1.18 | 1.16 | 1.06 | 0.90 | 0.90 | 1.14 |

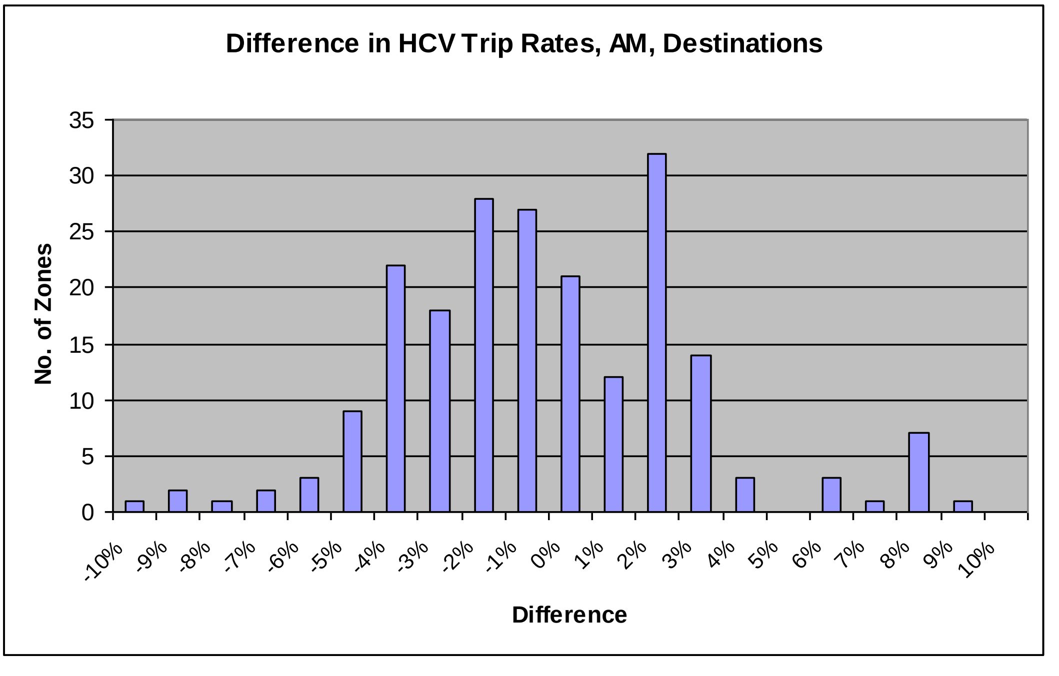
The final HCV trip ends have been checked against the 2011 land use data in terms of frequency distributions of the differences in HCV trip rates between the initial and final matrices. In this case the trip rates are defined as trip ends (origins or destinations) over the sum of land use weighted by the HCV rates for each category as given in the 2001 HCV report.

These are shown in Figure 0-2 to Figure 0-7, and indicate that for the great majority of zones the adjustment of the matrices has resulted in less than 3% change in the trip rates.

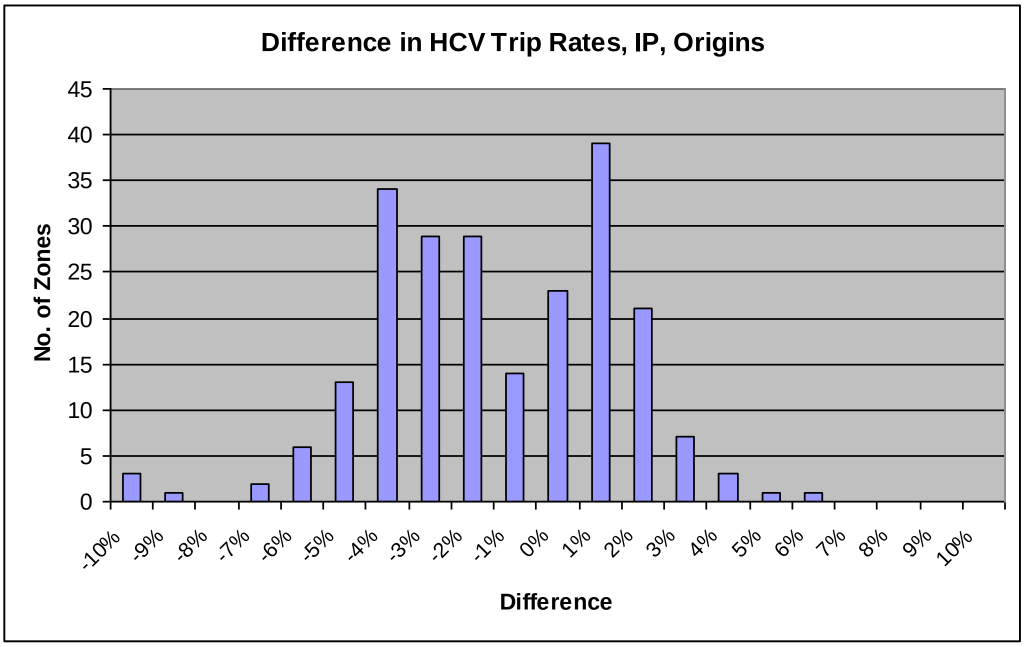
- **Figure 0-2 Difference in HCV Trip Rates, AM, Origins**



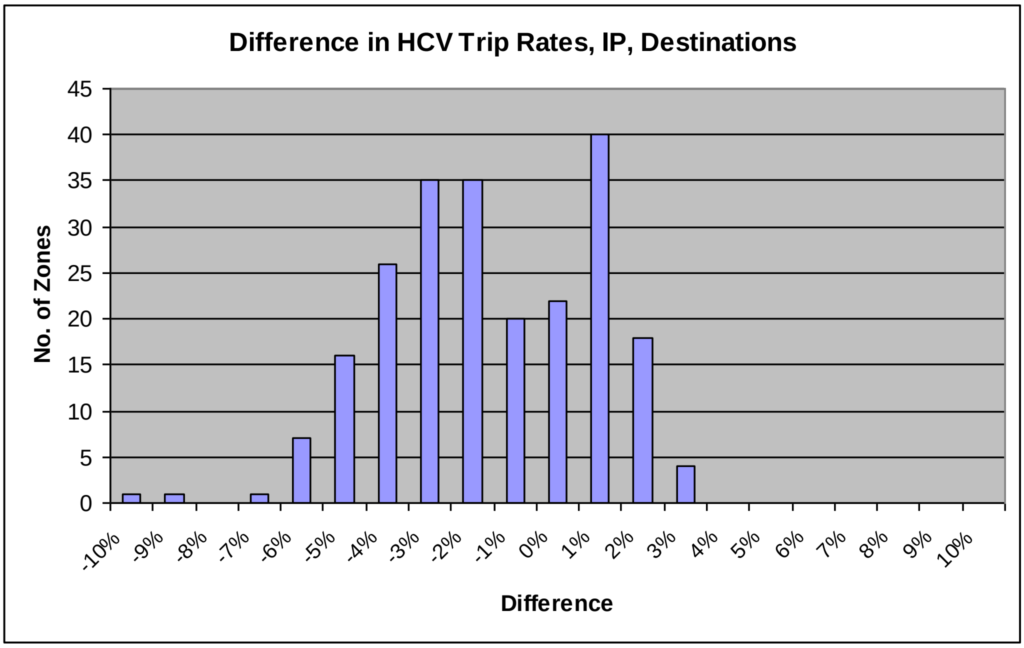

- **Figure 0-3 Difference in HCV Trip Rates, AM, Destinations**



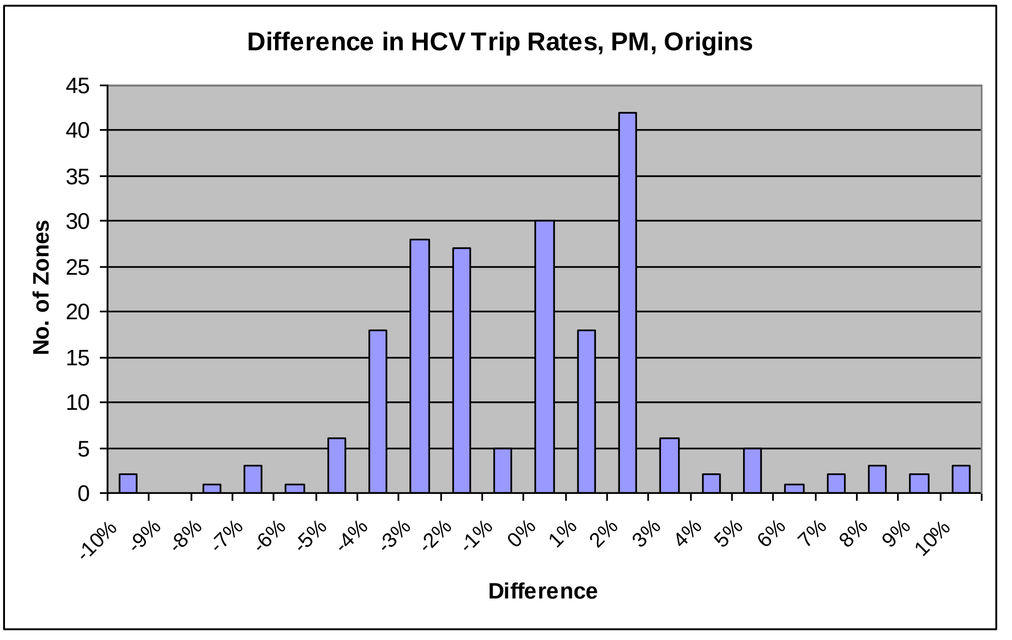
- **Figure 0-4 Difference in HCV Trip Rates, IP, Origins**



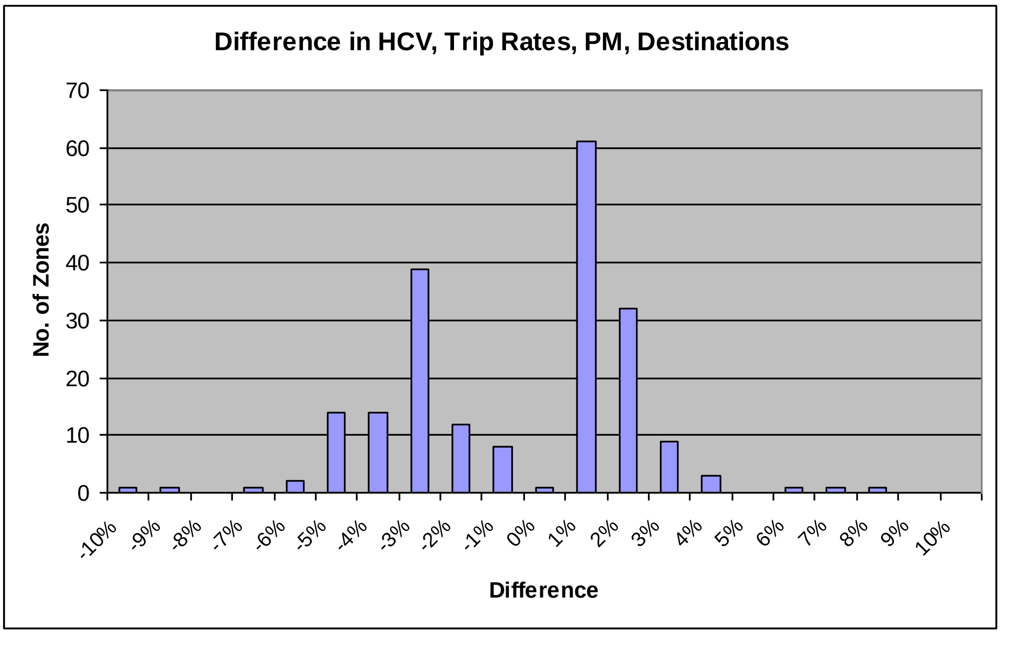

- **Figure 0-5 Difference in HCV Trip Rates, AM, Destinations**



- **Figure 0-6 Difference in HCV Trip Rates, PM, Origins**




- **Figure 0-7 Difference in HCV Trip Rates, PM, Destinations**



## 3 Implementation

The 2011 CV model is implemented as follows:

- Base Year, 2011:
  - The 2011 2-hour time period matrices were produced as per the 2006-based model, that is by forecasting from the 2006 matrices,
  - The adjustment factors were applied (multiplicatively) to each time period matrix to give the final 2011 CV matrices,
  - These matrices were exported from EMME and stored in the "311" folders as HCV11.311.
- Forecasting:
  - In forecasting from 2011, the change in synthesised future trip ends from 2011 as produced by the HCV component of the WTSM trip generation model are applied to the final 2011 matrices. (Note: the HCV trip generation model, HCV.XLS needs to be modified so that the change factors are between the future year and 2011, rather than 2006)

The trips in the initial and final (adjusted) 2011 HCV matrices are given in Table 0-4. The adjustments to better fit with counts results in increases in the AM and PM matrices and a decrease in the IP matrix.

- **Table 0-4 CV Trips**

| | AM | IP | PM |
|---|---|---|---|
| 2011 initial | 12,708 | 12,772 | 11,065 |
| 2011 final | 13,663 | 10,571 | 12,623 |
| % Difference | 8% | -17% | 14% |

David Young

3 March 2012

# Appendix B – Car Screenlines with TDG Counts (1 hour)

| Description | AM | | | | IP | | | | PM | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Obs | Mod | Diff | **GEH** | Obs | Mod | Diff | **GEH** | Obs | Mod | Diff | **GEH** |
| W1-CBD in | 11,869 | 13,951 | 2,083 | **18.3** | 7,066 | 7,464 | 399 | **4.7** | 8,752 | 8,957 | 206 | **2.2** |
| W1-CBD out | 6,830 | 7,239 | 409 | **4.9** | 7,109 | 7,233 | 123 | **1.5** | 12,323 | 13,355 | 1,032 | **9.1** |
| W2-Miramar In | 1,555 | 1,316 | -239 | **6.3** | 1,529 | 1,232 | -298 | **8.0** | 2,142 | 1,896 | -246 | **5.5** |
| W2-Miramar Out | 1,931 | 1,945 | 14 | **0.3** | 1,354 | 1,287 | -68 | **1.9** | 1,524 | 1,543 | 19 | **0.5** |
| W3-Karori out | 353 | 496 | 144 | **7.0** | 493 | 595 | 102 | **4.4** | 1,023 | 1,141 | 118 | **3.6** |
| W3-Karori in | 1,168 | 1,248 | 80 | **2.3** | 523 | 613 | 91 | **3.8** | 637 | 727 | 89 | **3.4** |
| W4-Thorndon out | 3,141 | 3,069 | -72 | **1.3** | 3,288 | 2,919 | -369 | **6.6** | 7,568 | 6,765 | -804 | **9.5** |
| W4-Thorndon in | 7,751 | 7,426 | -325 | **3.7** | 3,383 | 3,110 | -273 | **4.8** | 4,162 | 3,784 | -378 | **6.0** |
| W5-Churton P out | 1,485 | 1,417 | -69 | **1.8** | 1,429 | 1,292 | -137 | **3.7** | 3,165 | 2,886 | -279 | **5.1** |
| W5-Churton P in | 2,905 | 3,156 | 251 | **4.6** | 1,415 | 1,382 | -33 | **0.9** | 1,844 | 1,747 | -97 | **2.3** |
| W6-Island Bay in | 1,629 | 2,227 | 598 | **13.6** | 1,065 | 1,191 | 126 | **3.8** | 1,396 | 1,774 | 378 | **9.5** |
| W6-Island Bay out | 747 | 1,105 | 357 | **11.7** | 1,069 | 1,170 | 101 | **3.0** | 1,823 | 2,129 | 306 | **6.9** |
| L1-Nga to Pet out | 2,396 | 2,632 | 236 | **4.7** | 1,875 | 1,905 | 30 | **0.7** | 3,611 | 3,851 | 240 | **3.9** |
| L1-Nga to Pet in | 3,641 | 3,804 | 163 | **2.7** | 1,877 | 1,976 | 99 | **2.2** | 2,840 | 2,982 | 142 | **2.6** |
| L2-L to U Hutt out | 1,373 | 1,441 | 68 | **1.8** | 1,238 | 1,321 | 83 | **2.3** | 3,544 | 2,589 | -955 | **17.3** |
| L2-L to U Hutt in | 3,695 | 2,693 | -1,002 | **17.7** | 1,310 | 1,316 | 6 | **0.2** | 1,767 | 1,680 | -86 | **2.1** |
| L3-L Hutt in | 4,208 | 4,023 | -185 | **2.9** | 3,147 | 2,848 | -300 | **5.5** | 4,277 | 3,945 | -332 | **5.2** |
| L3-L Hutt out | 3,434 | 3,510 | 76 | **1.3** | 3,165 | 2,822 | -343 | **6.3** | 4,901 | 4,425 | -476 | **7.0** |
| L4-Wainui-Stoke in | 2,839 | 3,171 | 332 | **6.1** | 1,122 | 1,420 | 298 | **8.3** | 1,231 | 1,525 | 294 | **7.9** |
| L4-Wainui-Stoke out | 728 | 1,122 | 394 | **13.0** | 1,151 | 1,386 | 235 | **6.6** | 2,914 | 3,128 | 214 | **3.9** |
| U1-U Hutt N in | 990 | 1,077 | 87 | **2.7** | 404 | 656 | 252 | **11.0** | 494 | 834 | 339 | **13.2** |
| U1-U Hutt N out | 272 | 716 | 444 | **20.0** | 416 | 657 | 242 | **10.4** | 1,068 | 1,063 | -5 | **0.1** |
| U2-U Hutt S out | 1,445 | 1,594 | 149 | **3.8** | 1,101 | 1,278 | 177 | **5.1** | 2,771 | 2,075 | -696 | **14.1** |
| U2-U Hutt S in | 2,649 | 2,187 | -462 | **9.4** | 1,116 | 1,299 | 183 | **5.3** | 1,560 | 1,759 | 200 | **4.9** |
| P1-Porirua N out | 591 | 678 | 88 | **3.5** | 819 | 667 | -152 | **5.6** | 1,638 | 1,485 | -154 | **3.9** |
| P1-Porirua N in | 1,493 | 1,596 | 103 | **2.6** | 835 | 694 | -141 | **5.1** | 961 | 849 | -112 | **3.7** |
| P2-SH58 west | 613 | 717 | 104 | **4.0** | 304 | 455 | 152 | **7.8** | 801 | 725 | -75 | **2.7** |
| P2-SH58 east | 833 | 733 | -99 | **3.6** | 305 | 420 | 115 | **6.1** | 618 | 611 | -7 | **0.3** |
| P3-Porirua S out | 1,579 | 1,303 | -276 | **7.3** | 1,559 | 1,076 | -483 | **13.3** | 3,320 | 2,383 | -937 | **17.5** |
| P3-Porirua S in | 3,041 | 2,578 | -463 | **8.7** | 1,615 | 1,151 | -464 | **12.5** | 2,125 | 1,603 | -522 | **12.1** |
| K1-Kapiti out | 612 | 449 | -163 | **7.1** | 830 | 407 | -423 | **17.0** | 1,297 | 854 | -443 | **13.5** |
| K1-Kapiti in | 1,026 | 883 | -143 | **4.6** | 778 | 399 | -379 | **15.6** | 887 | 492 | -396 | **15.1** |
| Total | 78,821 | 81,503 | 3% | | 54,691 | 53,641 | -2% | | 88,981 | 85,561 | -4% | |
| | | | GEH<5 | 59% | | | GEH<5 | 44% | | | GEH<5 | 47% |
| | | | GEH<10 | 81% | | | GEH<10 | 81% | | | GEH<10 | 78% |
| | | | GEH<12 | 84% | | | GEH<12 | 88% | | | GEH<12 | 78% |

# Appendix C – Screenlines Comparison against 2001/2006 Reports

## 2001 Reported Screenlines (Car + HCV, 1-hour Volumes)

| | AM | | | | IP | | | | PM | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Description | Observed | Modelled | Diff | **GEH** | Observed | Modelled | Diff | **GEH** | Observed | Modelled | Diff | **GEH** |
| W1 - In | 10,005 | 10,617 | 612 | **6.0** | 6,576 | 6,979 | 403 | **4.9** | 7,694 | 8,480 | 786 | **8.7** |
| W1 - Out | 6,454 | 6,634 | 180 | **2.2** | 6,761 | 6,823 | 62 | **0.8** | 10,239 | 10,782 | 543 | **5.3** |
| W2 - East | 1,239 | 1,336 | 98 | **2.7** | 1,322 | 1,434 | 113 | **3.0** | 1,842 | 1,989 | 147 | **3.4** |
| W2 - West | 1,922 | 1,930 | 9 | **0.2** | 1,359 | 1,445 | 87 | **2.3** | 1,314 | 1,623 | 309 | **8.1** |
| W3 - East | 1,000 | 1,455 | 455 | **13.0** | 583 | 877 | 294 | **10.9** | 602 | 1,028 | 427 | **14.9** |
| W3 - West | 588 | 805 | 217 | **8.2** | 697 | 853 | 156 | **5.6** | 1,154 | 1,453 | 300 | **8.3** |
| W4 - North | 3,276 | 3,568 | 293 | **5.0** | 3,751 | 3,675 | -76 | **1.2** | 6,934 | 7,163 | 229 | **2.7** |
| W4 - South | 7,921 | 7,485 | -436 | **5.0** | 4,021 | 3,864 | -157 | **2.5** | 4,276 | 4,602 | 326 | **4.9** |
| W5 - North | 1,627 | 1,720 | 93 | **2.3** | 1,664 | 1,648 | -16 | **0.4** | 3,192 | 3,603 | 411 | **7.1** |
| W5 - South | 3,376 | 3,608 | 232 | **3.9** | 1,604 | 1,726 | 122 | **3.0** | 1,963 | 2,243 | 280 | **6.1** |
| L1 - North | 2,517 | 2,759 | 242 | **4.7** | 2,194 | 2,338 | 144 | **3.0** | 3,742 | 3,994 | 252 | **4.0** |
| L1 - South | 3,755 | 3,948 | 193 | **3.1** | 2,248 | 2,422 | 175 | **3.6** | 2,857 | 3,275 | 418 | **7.5** |
| L2 - North | 2,330 | 1,623 | -707 | **15.9** | 1,447 | 1,638 | 192 | **4.9** | 2,823 | 2,691 | -132 | **2.5** |
| L2 - South | 2,623 | 2,734 | 111 | **2.1** | 1,468 | 1,666 | 199 | **5.0** | 2,300 | 2,024 | -276 | **5.9** |
| L3 - In | 3,784 | 4,169 | 385 | **6.1** | 3,981 | 3,559 | -422 | **6.9** | 5,496 | 5,185 | -311 | **4.2** |
| L3 - Out | 4,135 | 4,670 | 535 | **8.1** | 4,066 | 3,602 | -464 | **7.5** | 5,466 | 4,742 | -725 | **10.1** |
| L4 - North | 2,781 | 2,829 | 48 | **0.9** | 1,148 | 1,582 | 434 | **11.7** | 1,171 | 1,701 | 531 | **14.0** |
| L4 - South | 795 | 1,244 | 449 | **14.1** | 1,205 | 1,554 | 350 | **9.4** | 2,773 | 2,884 | 111 | **2.1** |
| U1 - North | 307 | 606 | 299 | **14.0** | 452 | 719 | 267 | **11.0** | 938 | 1,148 | 210 | **6.5** |
| U1 - South | 886 | 1,041 | 155 | **5.0** | 437 | 718 | 282 | **11.7** | 519 | 795 | 276 | **10.8** |
| U2 - North | 2,192 | 1,805 | -388 | **8.7** | 1,266 | 1,550 | 285 | **7.6** | 2,136 | 2,293 | 158 | **3.3** |
| U2 - South | 1,856 | 2,138 | 282 | **6.3** | 1,255 | 1,579 | 324 | **8.6** | 2,074 | 2,065 | -10 | **0.2** |
| P1 - North | 530 | 719 | 189 | **7.6** | 738 | 715 | -23 | **0.9** | 1,437 | 1,159 | -278 | **7.7** |
| P1 - South | 1,305 | 1,153 | -152 | **4.3** | 695 | 712 | 18 | **0.7** | 730 | 899 | 169 | **5.9** |
| P2 - East | 523 | 870 | 347 | **13.1** | 329 | 529 | 200 | **9.6** | 760 | 806 | 47 | **1.7** |
| P2 - West | 769 | 624 | -145 | **5.5** | 314 | 538 | 224 | **10.9** | 491 | 858 | 367 | **14.1** |
| P3 - North | 1,818 | 1,230 | -588 | **15.1** | 1,646 | 1,279 | -367 | **9.6** | 2,589 | 2,668 | 79 | **1.5** |
| P3 - South | 2,574 | 2,764 | 190 | **3.7** | 1,668 | 1,355 | -313 | **8.1** | 2,280 | 1,617 | -663 | **15.0** |
| Total | 72,881 | 76,075 | 4% | | 54,887 | 57,375 | 5% | | 79,785 | 83,764 | 5% | |
| | | | GEH<5 | 46% | | | GEH<5 | 46% | | | GEH<5 | 39% |
| | | | GEH<10 | 79% | | | GEH<10 | 82% | | | GEH<10 | 79% |
| | | | GEH<12 | 79% | | | GEH<12 | 100% | | | GEH<12 | 86% |

## 2006 Reported Screenlines (Car + HCV, 1-hour Volumes)

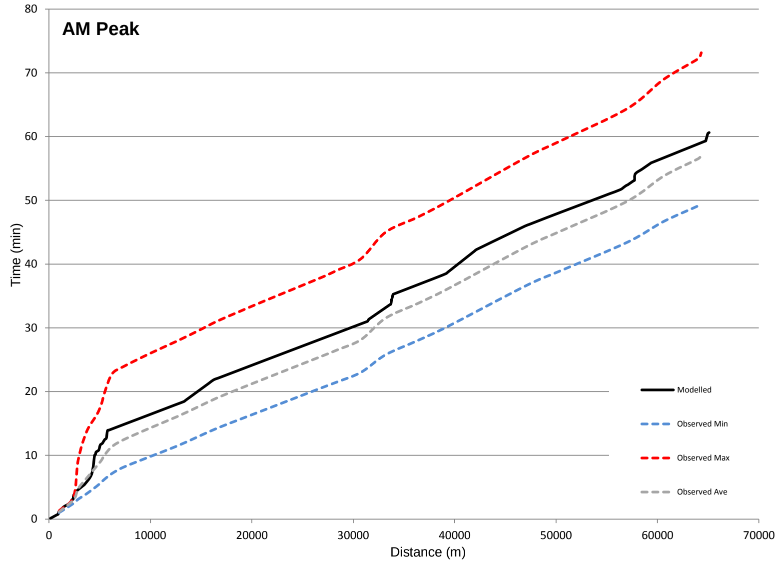
| Description | AM | | | | IP | | | | PM | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Observed | Modelled | Diff | **GEH** | Observed | Modelled | Diff | **GEH** | Observed | Modelled | Diff | **GEH** |
| W1 - In | 13,859 | 15,208 | 1,349 | **11.2** | 8,194 | 8,447 | 253 | **2.8** | 8,967 | 9,975 | 1,008 | **10.4** |
| W1 - Out | 7,722 | 8,364 | 642 | **7.2** | 7,911 | 8,197 | 286 | **3.2** | 13,332 | 14,432 | 1,100 | **9.3** |
| W2 - East | 1,467 | 1,457 | -10 | **0.3** | 1,499 | 1,488 | -11 | **0.3** | 1,935 | 2,201 | 266 | **5.9** |
| W2 - West | 1,817 | 2,103 | 286 | **6.5** | 1,399 | 1,487 | 88 | **2.3** | 1,445 | 1,748 | 304 | **7.6** |
| W3 - East | 1,211 | 1,551 | 340 | **9.2** | 667 | 906 | 239 | **8.5** | 774 | 1,072 | 299 | **9.8** |
| W3 - West | 551 | 848 | 297 | **11.2** | 658 | 882 | 224 | **8.1** | 1,130 | 1,498 | 368 | **10.1** |
| W4 - North | 3,095 | 3,179 | 84 | **1.5** | 3,030 | 2,936 | -93 | **1.7** | 6,556 | 6,363 | -192 | **2.4** |
| W4 - South | 7,097 | 6,800 | -298 | **3.6** | 2,869 | 3,047 | 178 | **3.3** | 3,788 | 3,886 | 98 | **1.6** |
| W5 - North | 1,916 | 1,997 | 81 | **1.8** | 1,906 | 1,598 | -308 | **7.4** | 3,756 | 3,462 | -294 | **4.9** |
| W5 - South | 3,737 | 3,635 | -102 | **1.7** | 1,829 | 1,681 | -148 | **3.5** | 2,245 | 2,296 | 51 | **1.1** |
| L1 - North | 2,666 | 2,792 | 126 | **2.4** | 2,408 | 2,233 | -174 | **3.6** | 3,742 | 3,927 | 185 | **3.0** |
| L1 - South | 3,755 | 3,988 | 233 | **3.7** | 2,159 | 2,264 | 105 | **2.2** | 3,026 | 3,216 | 191 | **3.4** |
| L2 - North | 1,626 | 1,679 | 52 | **1.3** | 1,393 | 1,569 | 176 | **4.6** | 3,081 | 2,685 | -397 | **7.4** |
| L2 - South | 2,974 | 2,872 | -102 | **1.9** | 1,374 | 1,577 | 203 | **5.3** | 1,839 | 1,974 | 136 | **3.1** |
| L3 - In | 5,182 | 4,883 | -299 | **4.2** | 3,769 | 3,587 | -181 | **3.0** | 5,582 | 4,713 | -869 | **12.1** |
| L3 - Out | 4,716 | 4,228 | -488 | **7.3** | 3,455 | 3,528 | 73 | **1.2** | 5,557 | 5,249 | -308 | **4.2** |
| L4 - North | 3,057 | 2,976 | -81 | **1.5** | 1,147 | 1,581 | 434 | **11.7** | 1,294 | 1,680 | 386 | **10.0** |
| L4 - South | 1,060 | 1,251 | 192 | **5.6** | 1,188 | 1,546 | 358 | **9.7** | 2,969 | 2,922 | -47 | **0.9** |
| U1 - North | 333 | 751 | 418 | **17.9** | 472 | 746 | 275 | **11.1** | 1,044 | 1,092 | 49 | **1.5** |
| U1 - South | 950 | 1,073 | 123 | **3.9** | 460 | 746 | 287 | **11.7** | 513 | 893 | 380 | **14.3** |
| U2 - North | 1,627 | 1,735 | 108 | **2.6** | 1,362 | 1,476 | 114 | **3.0** | 2,437 | 2,266 | -172 | **3.5** |
| U2 - South | 2,620 | 2,285 | -336 | **6.8** | 1,322 | 1,497 | 175 | **4.7** | 1,866 | 1,963 | 96 | **2.2** |
| P1 - North | 584 | 699 | 115 | **4.5** | 657 | 717 | 59 | **2.3** | 1,375 | 1,264 | -110 | **3.0** |
| P1 - South | 1,375 | 1,337 | -38 | **1.0** | 684 | 695 | 11 | **0.4** | 770 | 861 | 91 | **3.2** |
| P2 - East | 842 | 789 | -52 | **1.8** | 344 | 479 | 135 | **6.7** | 663 | 767 | 103 | **3.9** |
| P2 - West | 708 | 716 | 8 | **0.3** | 372 | 485 | 114 | **5.5** | 871 | 751 | -120 | **4.2** |
| P3 - North | 1,871 | 1,482 | -389 | **9.5** | 1,826 | 1,324 | -502 | **12.6** | 2,958 | 2,626 | -331 | **6.3** |
| P3 - South | 2,771 | 2,764 | -7 | **0.1** | 1,793 | 1,370 | -423 | **10.6** | 2,217 | 1,791 | -426 | **9.5** |
| Total | 81,188 | 83,440 | 3% | | 56,143 | 58,089 | 3% | | 85,728 | 87,570 | 2% | |
| | | | GEH<5 | 64% | | | GEH<5 | 57% | | | GEH<5 | 57% |
| | | | GEH<10 | 89% | | | GEH<10 | 82% | | | GEH<10 | 86% |
| | | | GEH<12 | 96% | | | GEH<12 | 96% | | | GEH<12 | 93% |

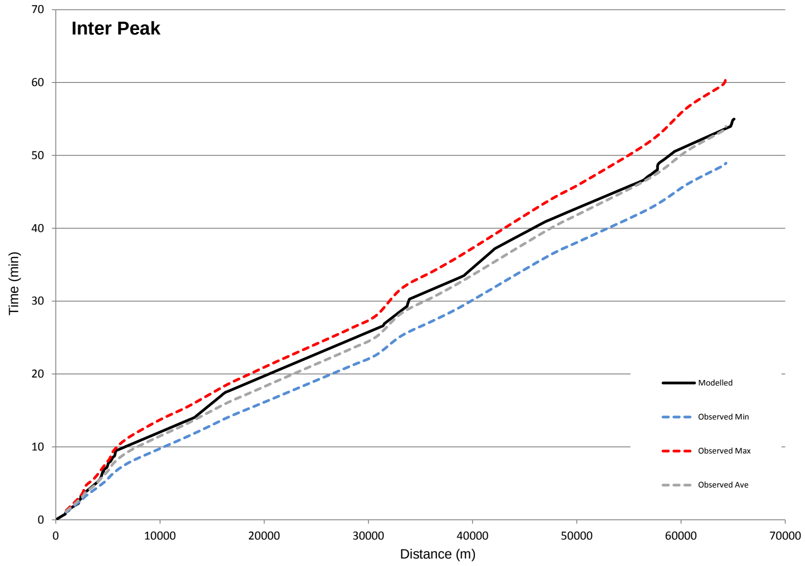
## 2011 Reported Screenlines (Car + HCV, 1-hour Volumes)

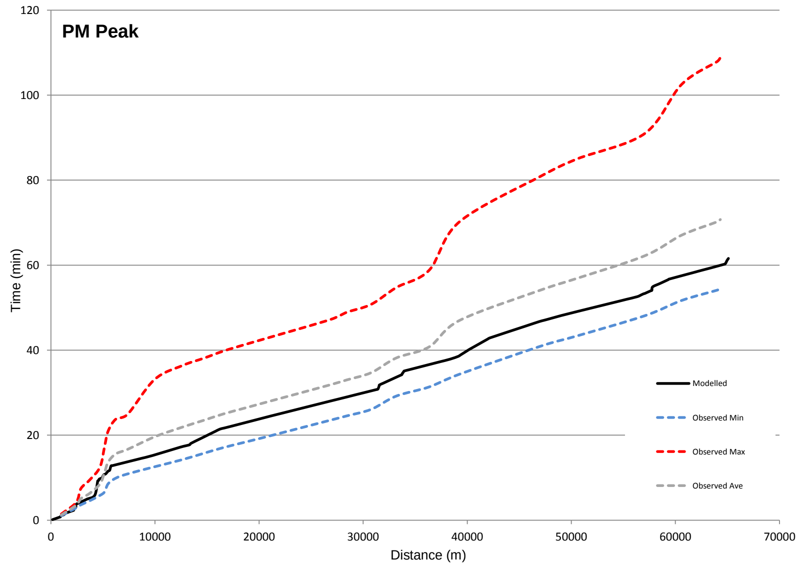
| Description | AM | | | | IP | | | | PM | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Obs | Mod | Diff | **GEH** | Obs | Mod | Diff | **GEH** | Obs | Mod | Diff | **GEH** |
| W1-CBD in | 14,095 | 15,136 | 1,040 | **8.6** | 8,063 | 8,181 | 118 | **1.3** | 9,666 | 9,601 | -65 | **0.7** |
| W1-CBD out | 7,654 | 7,930 | 276 | **3.1** | 7,853 | 7,917 | 65 | **0.7** | 13,784 | 14,315 | 531 | **4.5** |
| W2-Miramar In | 2,079 | 1,982 | -97 | **2.2** | 1,486 | 1,336 | -150 | **4.0** | 1,649 | 1,627 | -22 | **0.5** |
| W2-Miramar Out | 1,641 | 1,408 | -233 | **6.0** | 1,606 | 1,292 | -314 | **8.2** | 2,218 | 1,939 | -278 | **6.1** |
| W3-Karori out | 1,248 | 1,273 | 24 | **0.7** | 560 | 631 | 71 | **2.9** | 675 | 740 | 65 | **2.5** |
| W3-Karori in | 391 | 511 | 121 | **5.7** | 526 | 612 | 86 | **3.6** | 1,064 | 1,167 | 103 | **3.1** |
| W4-Thorndon out | 3,331 | 3,254 | -77 | **1.3** | 3,524 | 3,149 | -375 | **6.5** | 7,881 | 7,207 | -674 | **7.8** |
| W4-Thorndon in | 8,210 | 7,966 | -244 | **2.7** | 3,629 | 3,374 | -255 | **4.3** | 4,356 | 4,010 | -346 | **5.3** |
| W5-Churton P out | 1,632 | 1,520 | -112 | **2.8** | 1,619 | 1,447 | -172 | **4.4** | 3,519 | 3,185 | -334 | **5.8** |
| W5-Churton P in | 3,273 | 3,448 | 175 | **3.0** | 1,586 | 1,559 | -27 | **0.7** | 2,004 | 1,865 | -138 | **3.1** |
| L1-Nga to Pet out | 2,556 | 2,786 | 231 | **4.5** | 2,084 | 2,085 | 1 | **0.0** | 3,843 | 4,049 | 205 | **3.3** |
| L1-Nga to Pet in | 3,911 | 4,048 | 137 | **2.2** | 2,067 | 2,128 | 61 | **1.3** | 2,963 | 3,089 | 126 | **2.3** |
| L2-L to U Hutt out | 1,493 | 1,545 | 53 | **1.3** | 1,344 | 1,412 | 67 | **1.8** | 3,709 | 2,739 | -969 | **17.1** |
| L2-L to U Hutt in | 3,908 | 2,836 | -1,072 | **18.5** | 1,426 | 1,397 | -29 | **0.8** | 1,870 | 1,743 | -127 | **3.0** |
| L3-L Hutt in | 4,477 | 4,272 | -204 | **3.1** | 3,372 | 3,058 | -314 | **5.5** | 4,500 | 4,133 | -367 | **5.6** |
| L3-L Hutt out | 3,654 | 3,714 | 60 | **1.0** | 3,384 | 3,016 | -368 | **6.5** | 5,146 | 4,592 | -554 | **7.9** |
| L4-Wainui-Stoke in | 3,027 | 3,243 | 216 | **3.9** | 1,220 | 1,477 | 257 | **7.0** | 1,319 | 1,575 | 256 | **6.7** |
| L4-Wainui-Stoke out | 817 | 1,179 | 362 | **11.4** | 1,237 | 1,439 | 202 | **5.5** | 3,077 | 3,179 | 102 | **1.8** |
| U1-U Hutt N in | 315 | 740 | 426 | **18.5** | 461 | 704 | 243 | **10.1** | 1,105 | 1,122 | 17 | **0.5** |
| U1-U Hutt N out | 1,031 | 1,185 | 154 | **4.6** | 446 | 736 | 291 | **12.0** | 529 | 871 | 342 | **12.9** |
| U2-U Hutt S out | 1,529 | 1,672 | 143 | **3.6** | 1,170 | 1,339 | 169 | **4.8** | 2,901 | 2,183 | -718 | **14.2** |
| U2-U Hutt S in | 2,797 | 2,323 | -474 | **9.4** | 1,190 | 1,379 | 189 | **5.3** | 1,640 | 1,834 | 194 | **4.7** |
| P1-Porirua N out | 665 | 768 | 103 | **3.8** | 912 | 783 | -129 | **4.4** | 1,802 | 1,631 | -171 | **4.1** |
| P1-Porirua N in | 1,647 | 1,736 | 89 | **2.2** | 903 | 785 | -118 | **4.1** | 1,029 | 924 | -105 | **3.4** |
| P2-SH58 west | 881 | 770 | -110 | **3.8** | 334 | 445 | 111 | **5.6** | 656 | 634 | -22 | **0.9** |
| P2-SH58 east | 662 | 757 | 95 | **3.6** | 332 | 494 | 162 | **8.0** | 831 | 792 | -39 | **1.4** |
| P3-Porirua S out | 1,683 | 1,407 | -275 | **7.0** | 1,695 | 1,225 | -469 | **12.3** | 3,434 | 2,542 | -892 | **16.3** |
| P3-Porirua S in | 3,175 | 2,760 | -415 | **7.6** | 1,743 | 1,290 | -452 | **11.6** | 2,204 | 1,693 | -511 | **11.6** |
| Total | 81,780 | 82,170 | 0% | | 55,772 | 54,692 | -2% | | 89,372 | 84,980 | -5% | |
| | | | GEH<5 | 68% | | | GEH<5 | 54% | | | GEH<5 | 57% |
| | | | GEH<10 | 89% | | | GEH<10 | 86% | | | GEH<10 | 82% |
| | | | GEH<12 | 93% | | | GEH<12 | 96% | | | GEH<12 | 86% |

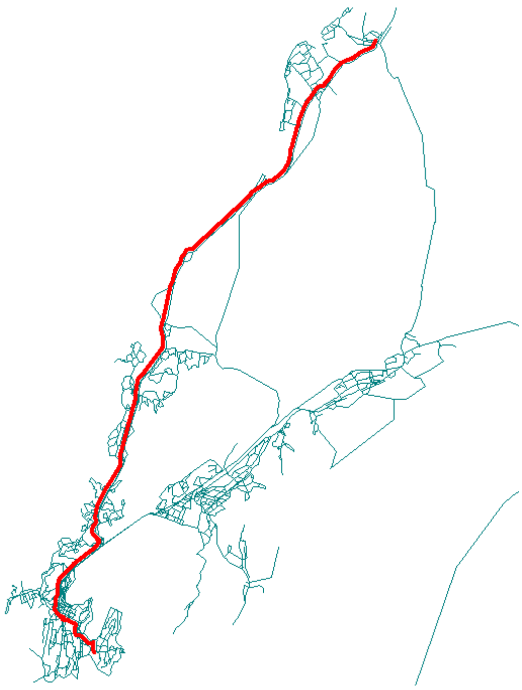
# Appendix D – Highway Travel Time Validation

Route 1 Northbound – Wellington Airport to Waikanae Railway Station

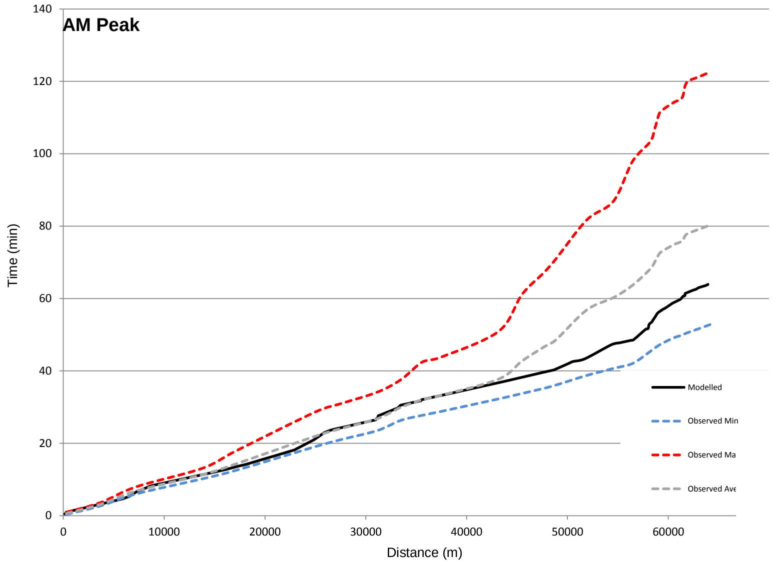


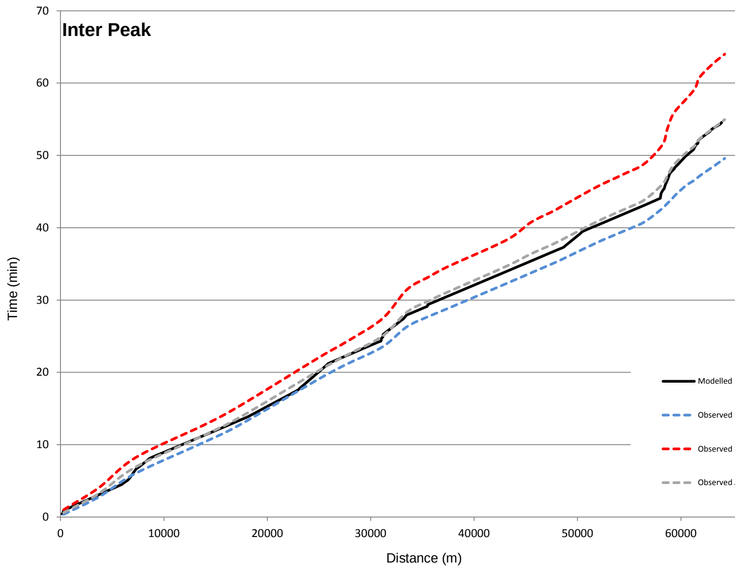



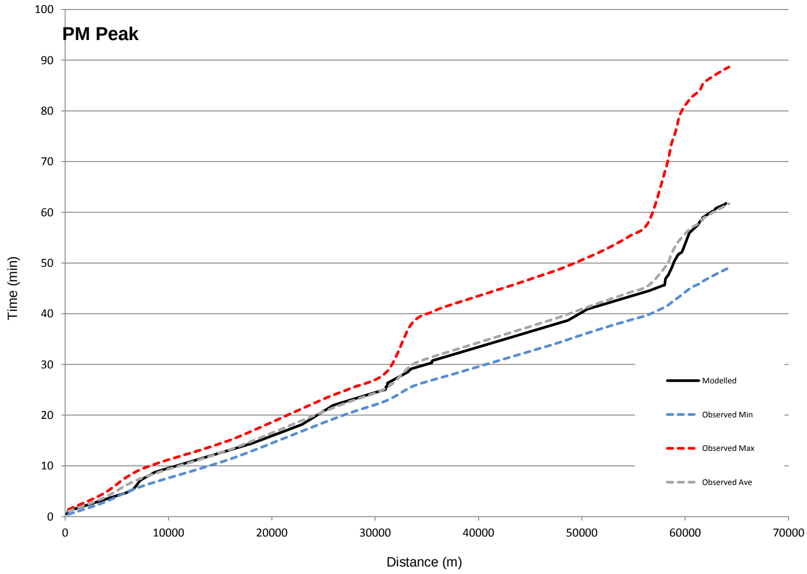



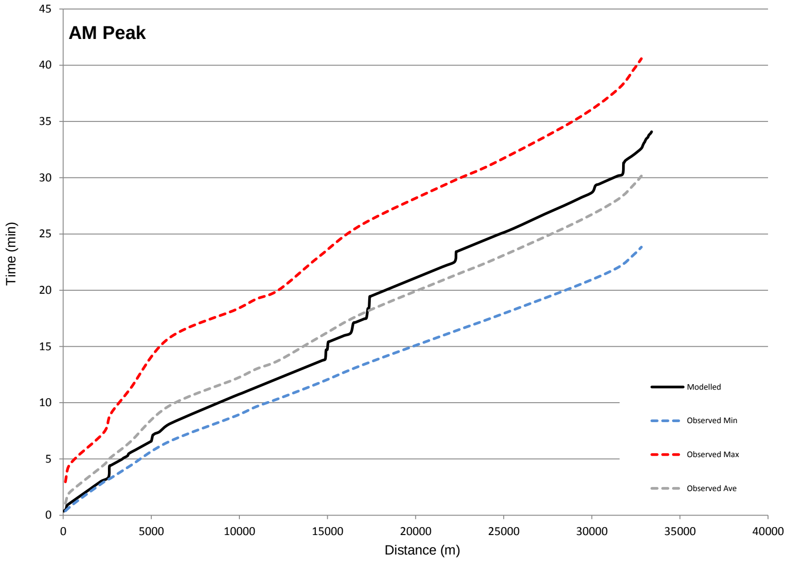
## Route 1 Southbound – Waikanae Railway Station to Wellington Airport

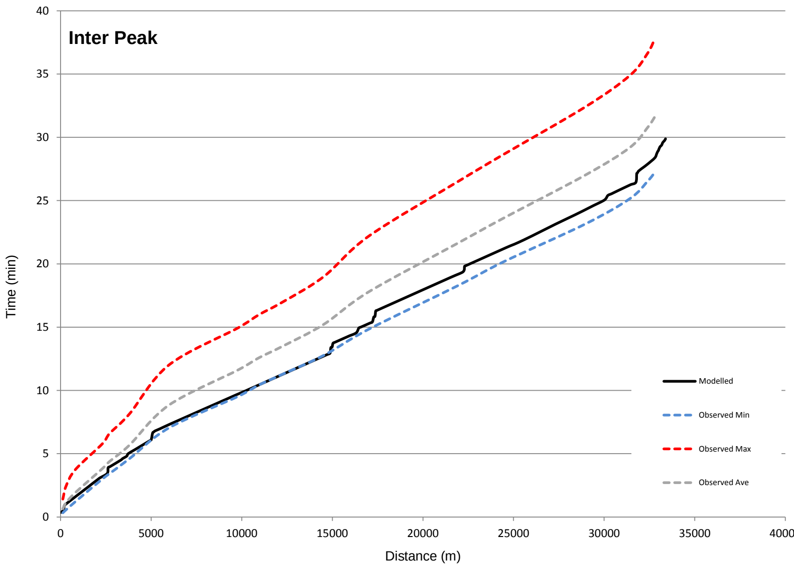


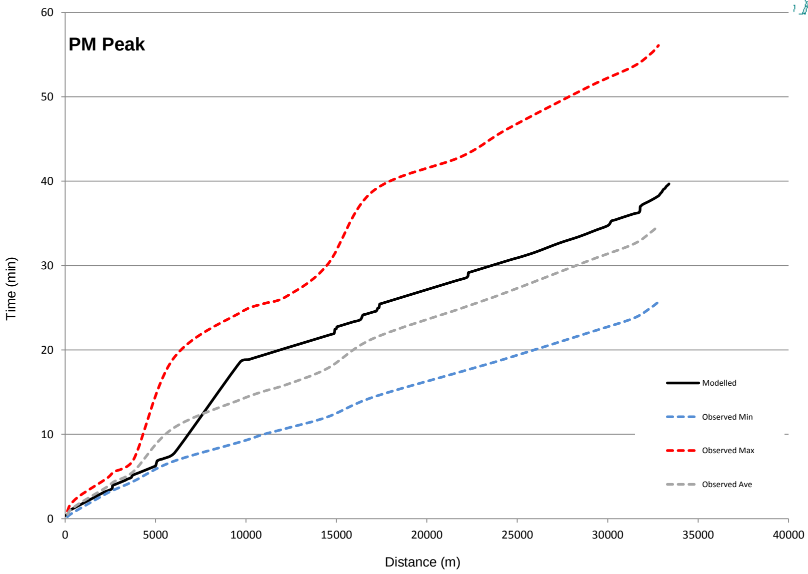



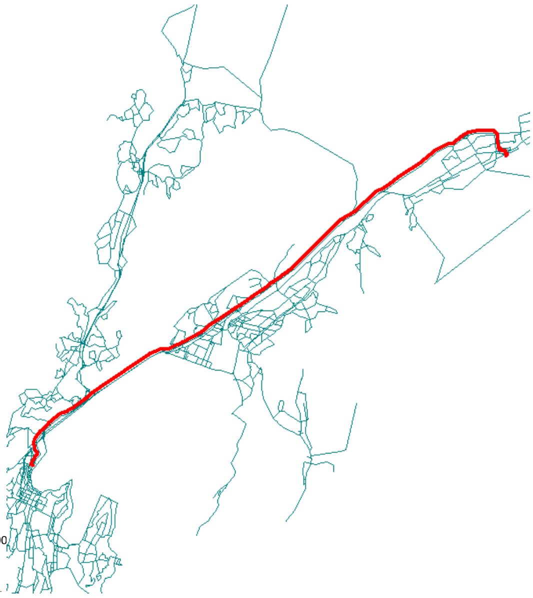




## Route 2 Northbound – Wellington Rail Station to Upper Hutt Rail Station

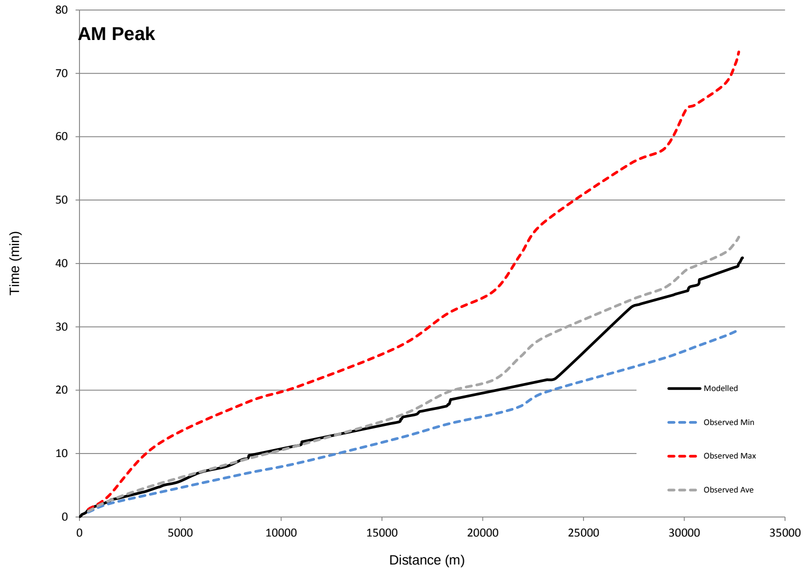


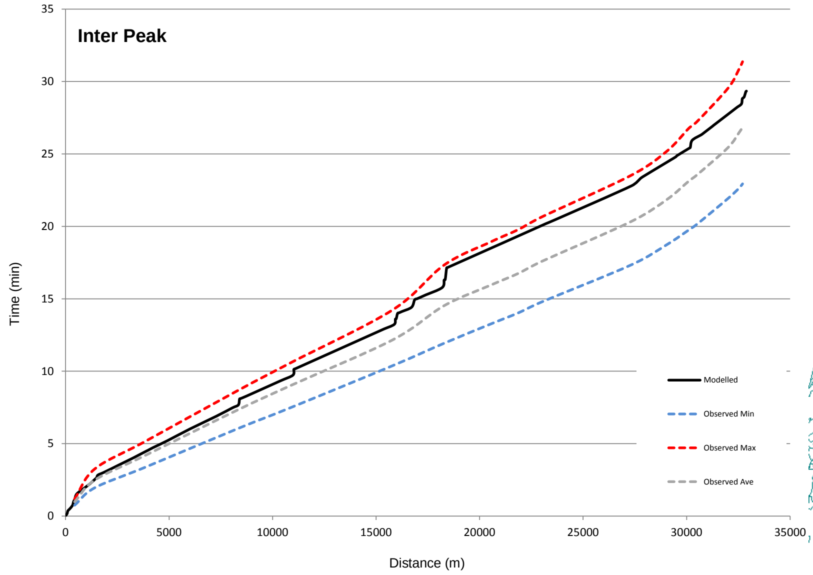



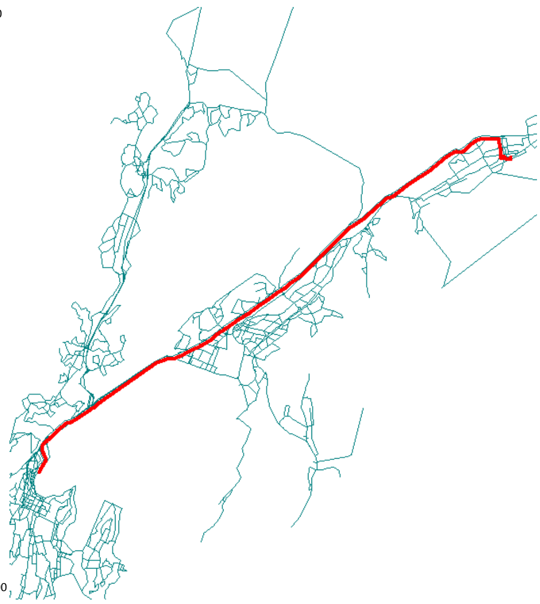



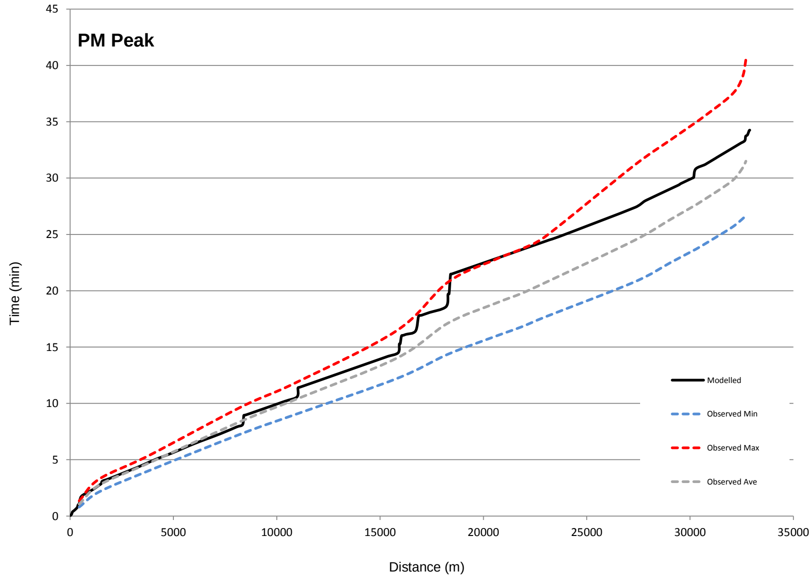



## Route 2 Southbound - Upper Hutt Rail Station to Wellington Rail Station

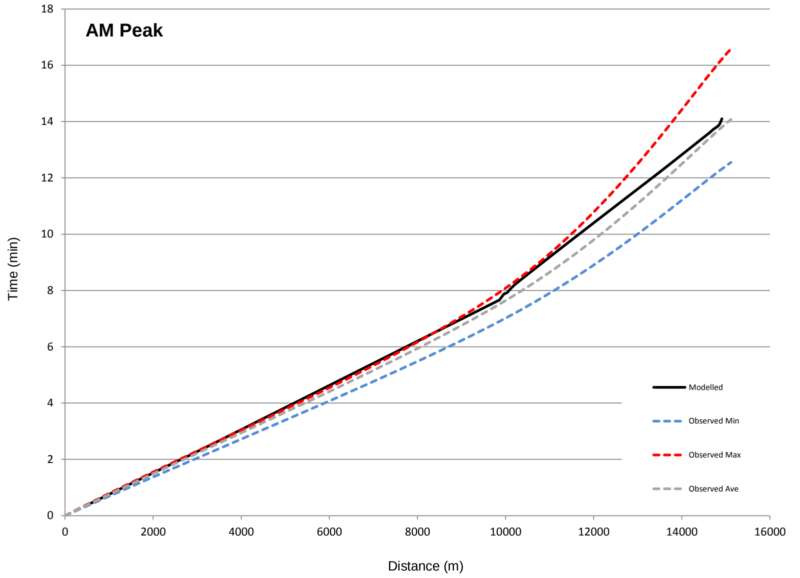


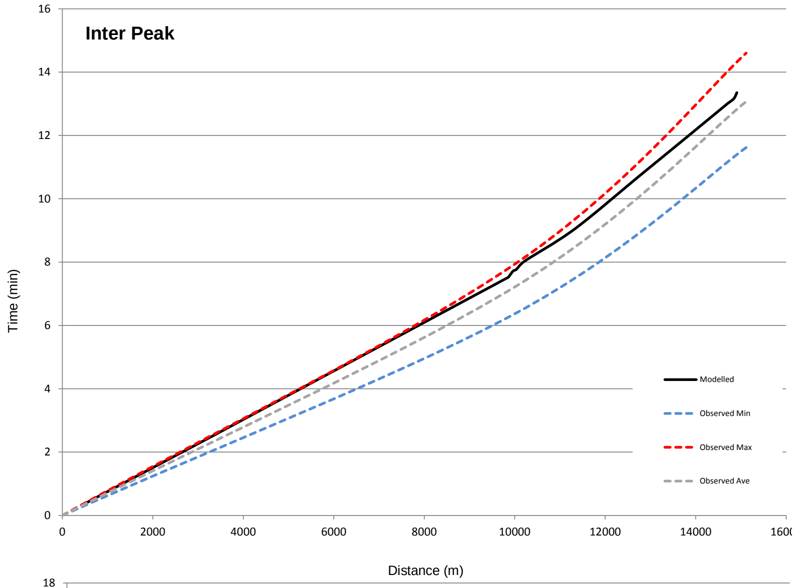



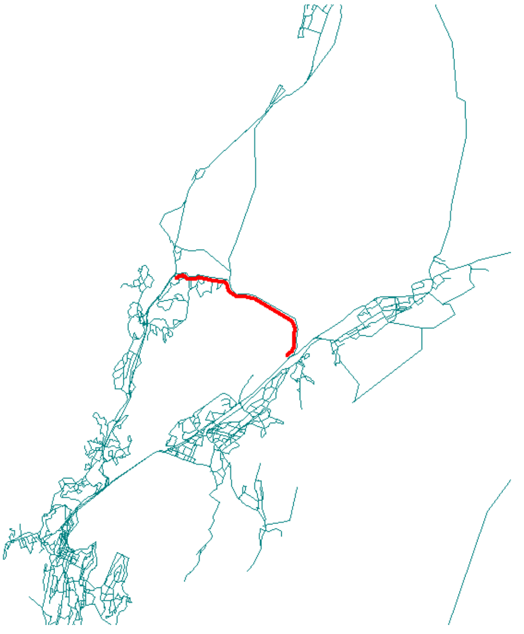



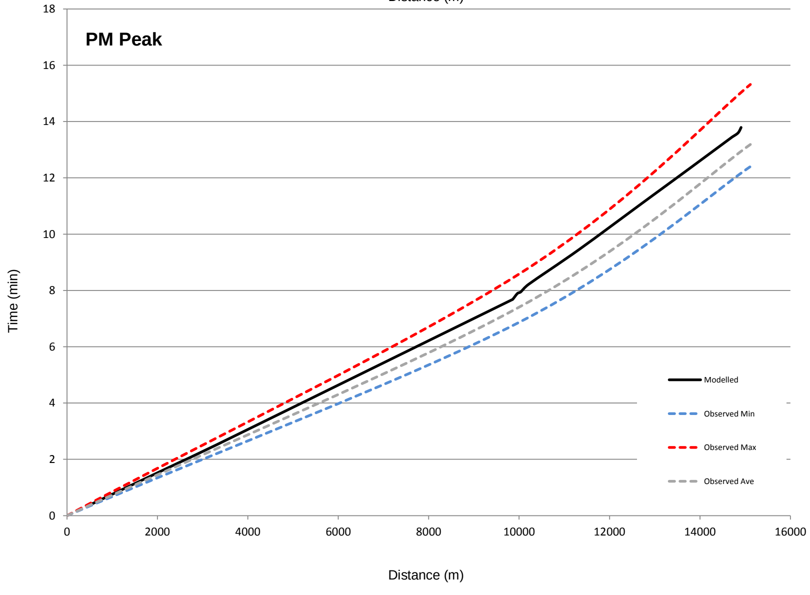


## Route 3 Westbound – SH58 Haywards Rd Paremata

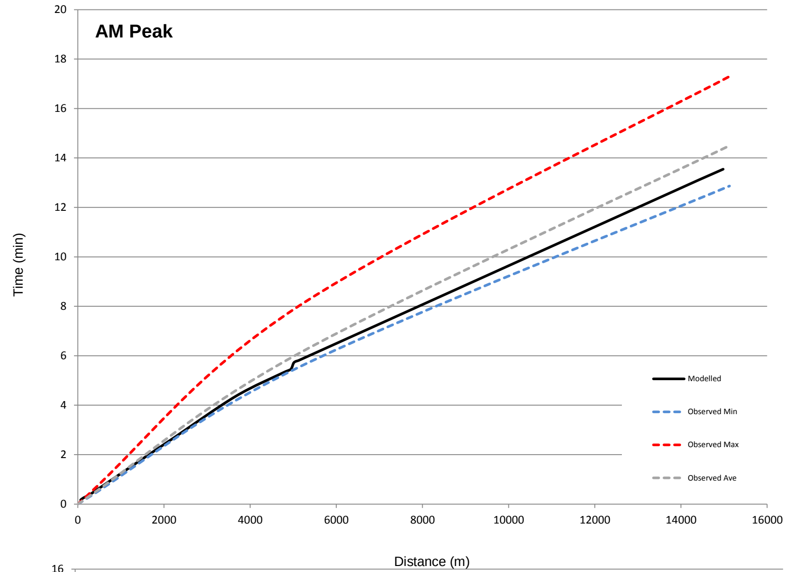


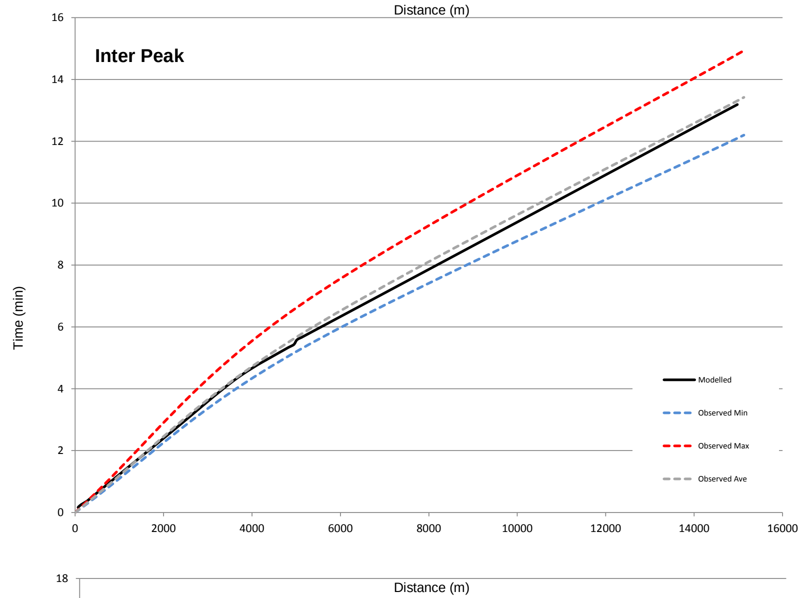



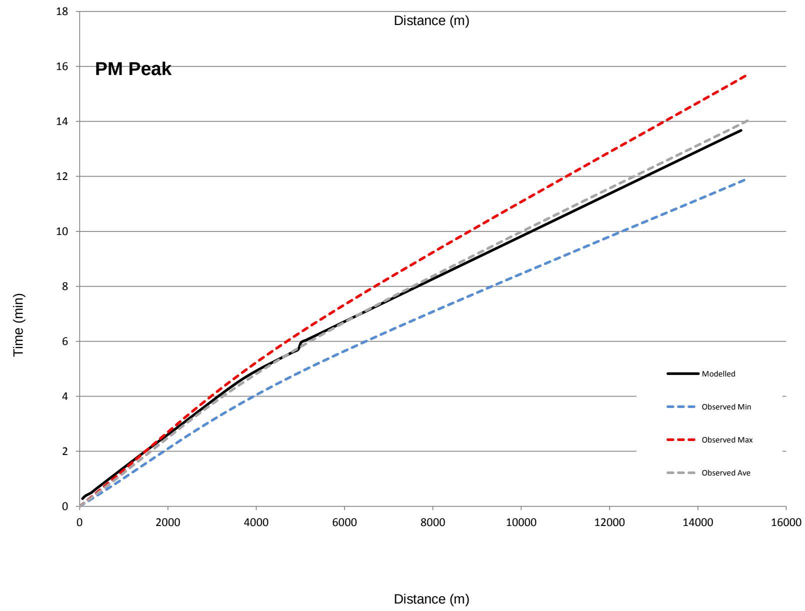



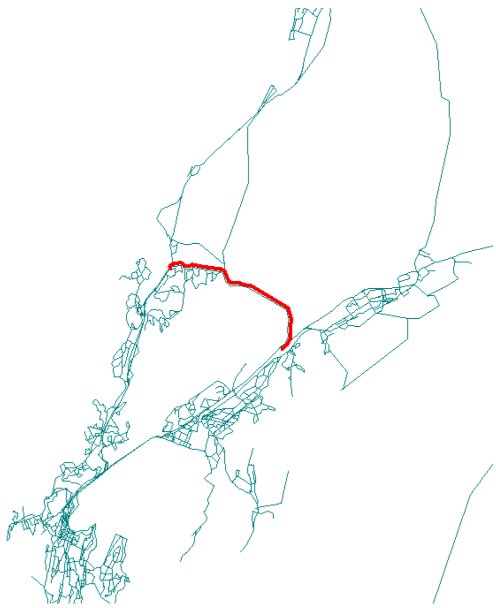


## Route 3 Eastbound – SH58 Paremata Haywards Rd

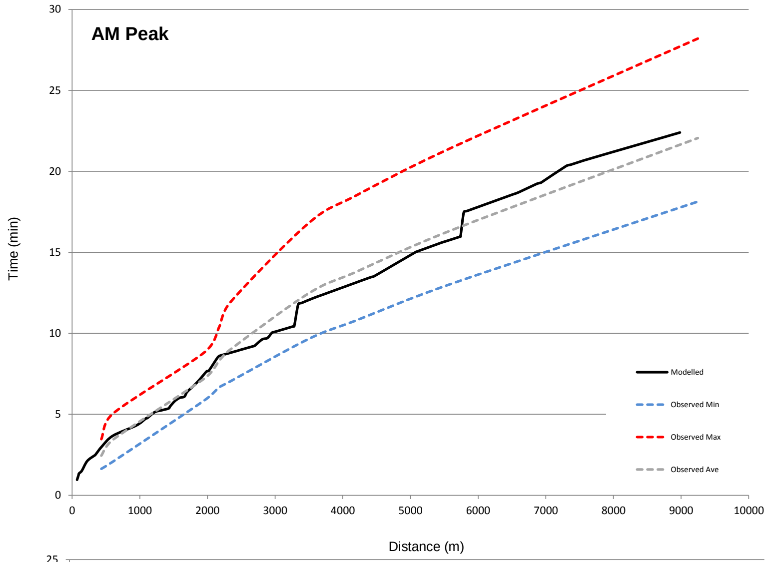


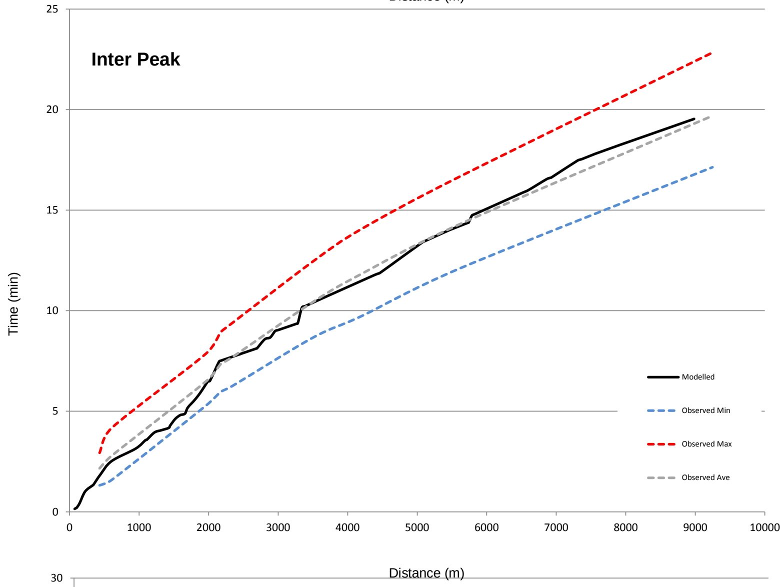



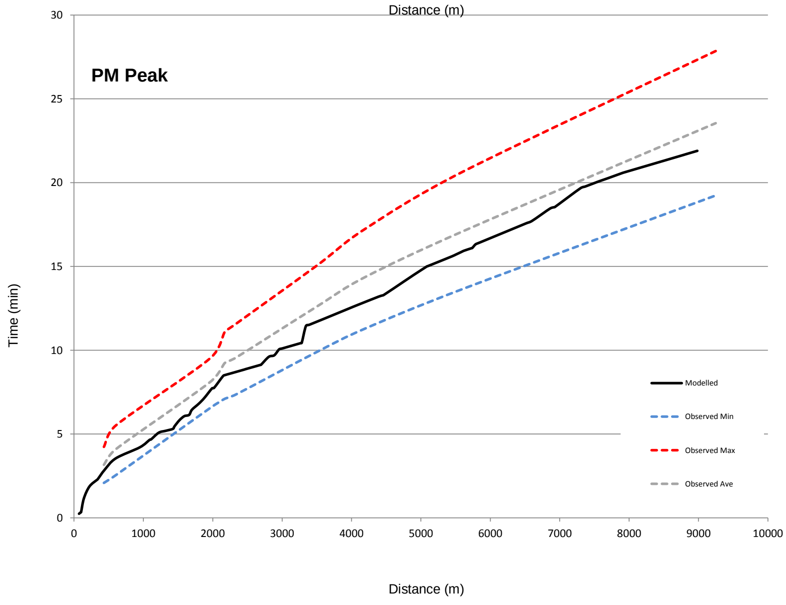



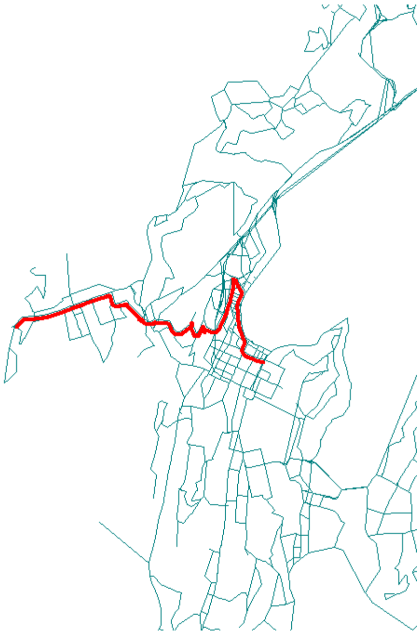



## Route 4 Northbound – Courtenay Place to Karori

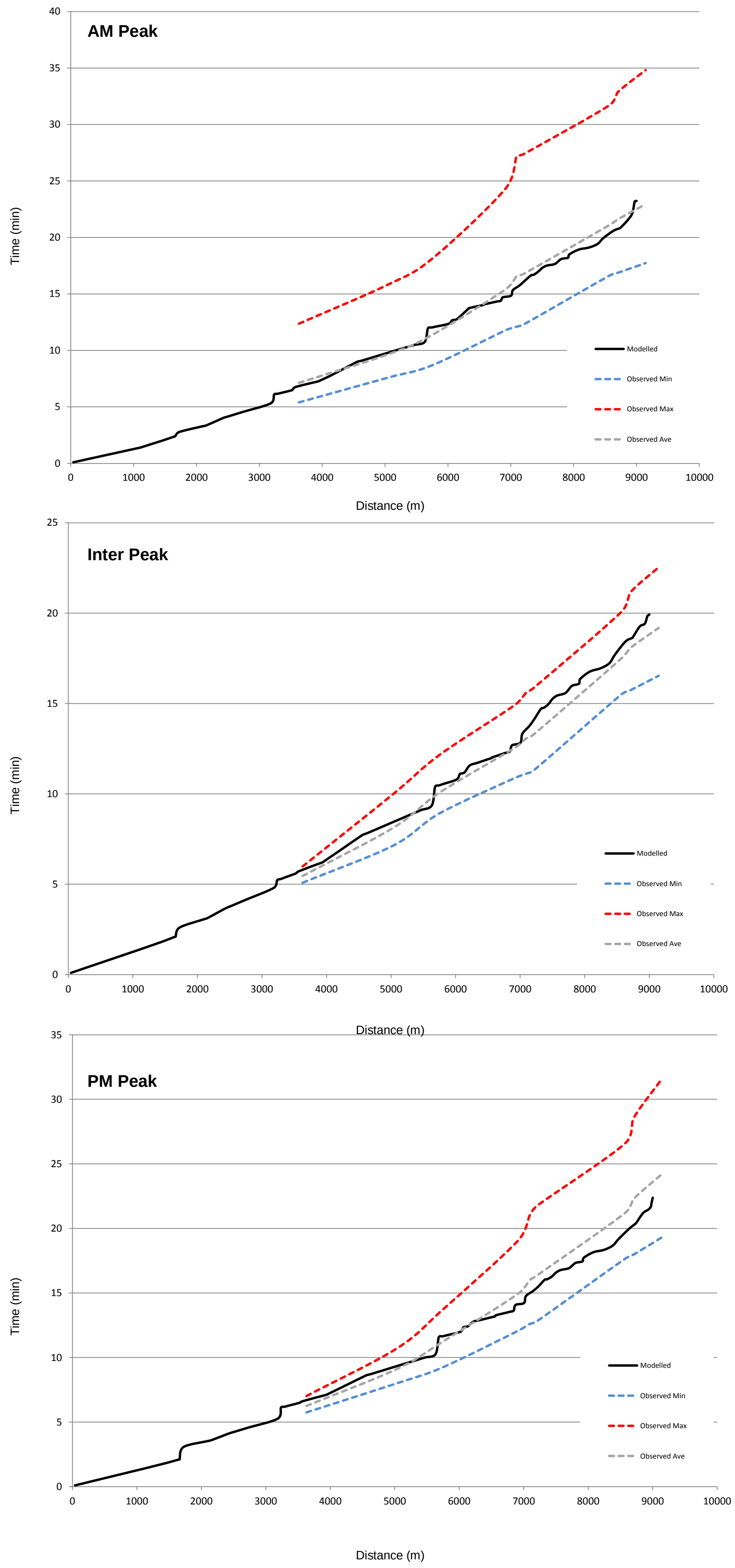


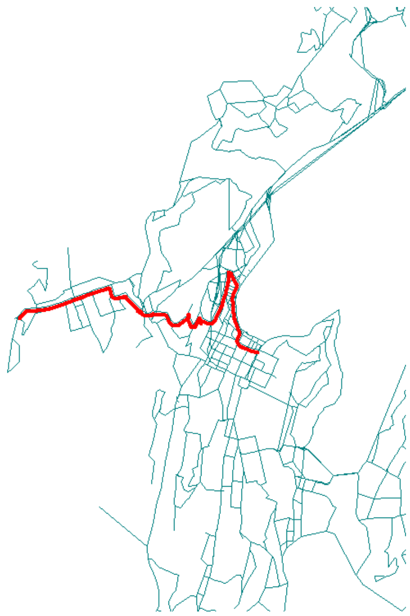



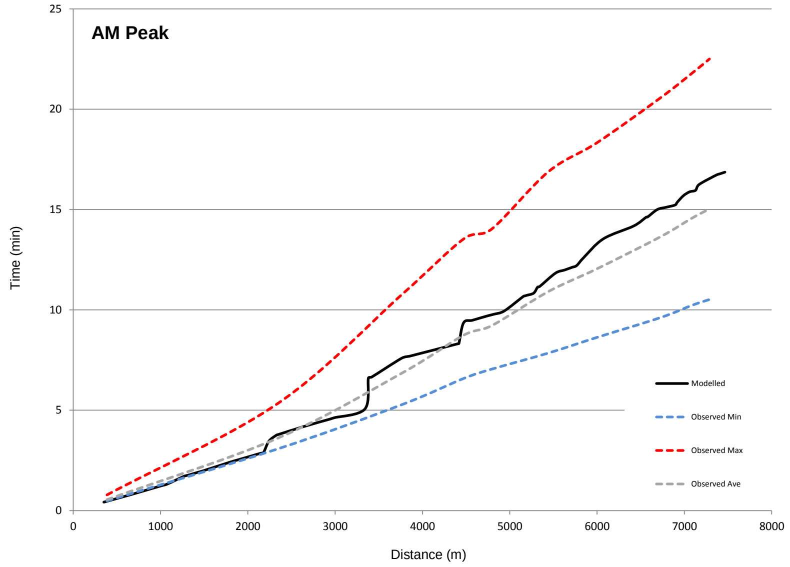



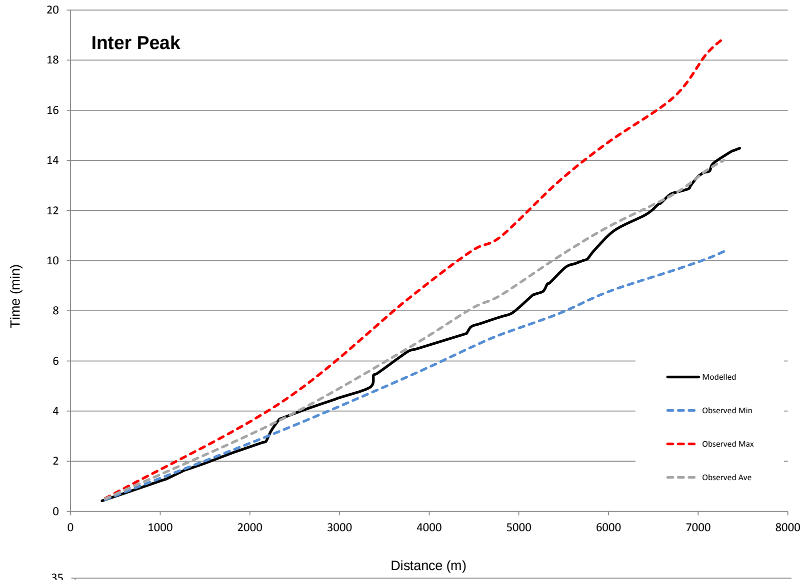
## Route 4 Southbound – Karori to Courtenay Place

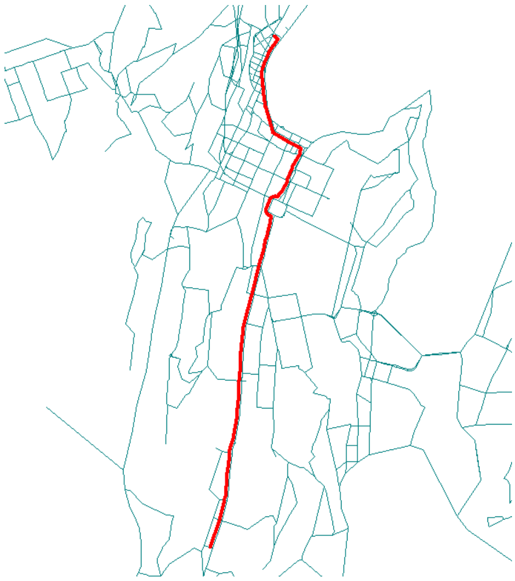


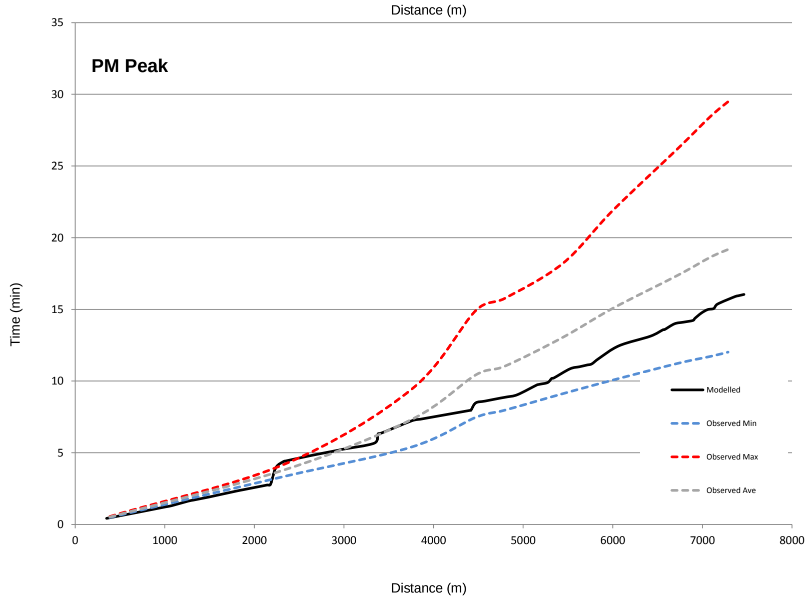



Route 5 Northbound – Island Bay to Wellington Railway Station

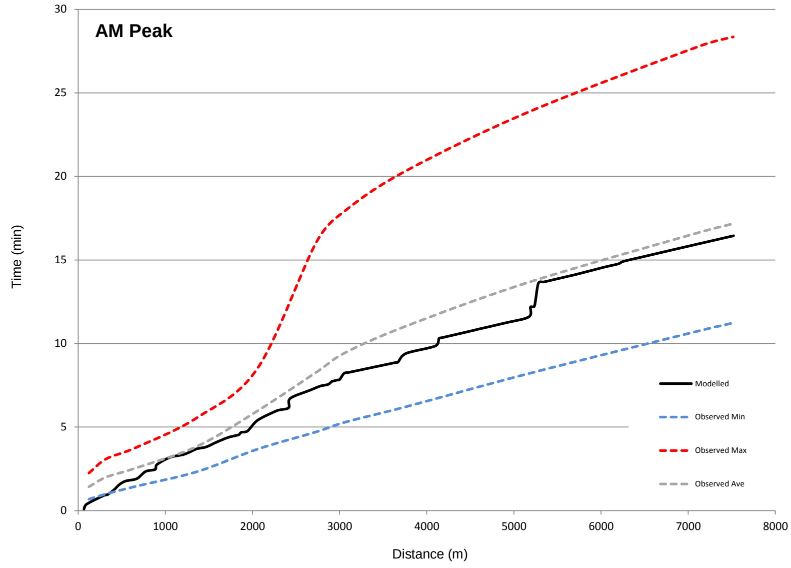


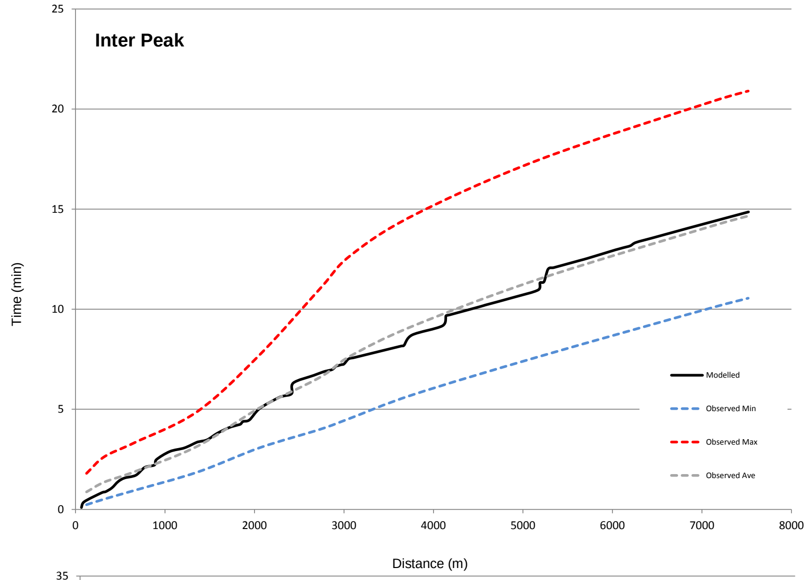



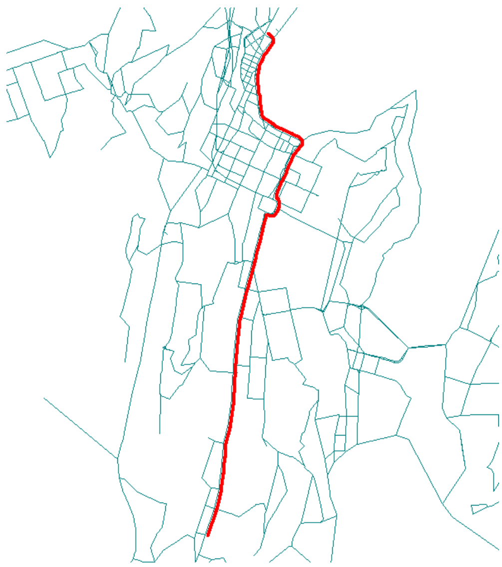



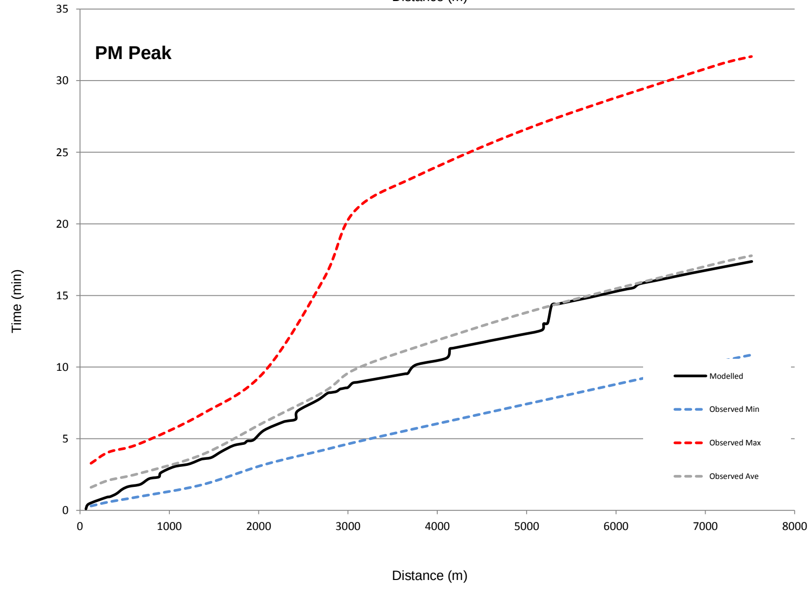


## Route 5 Southbound – Wellington Railway Station to Island Bay

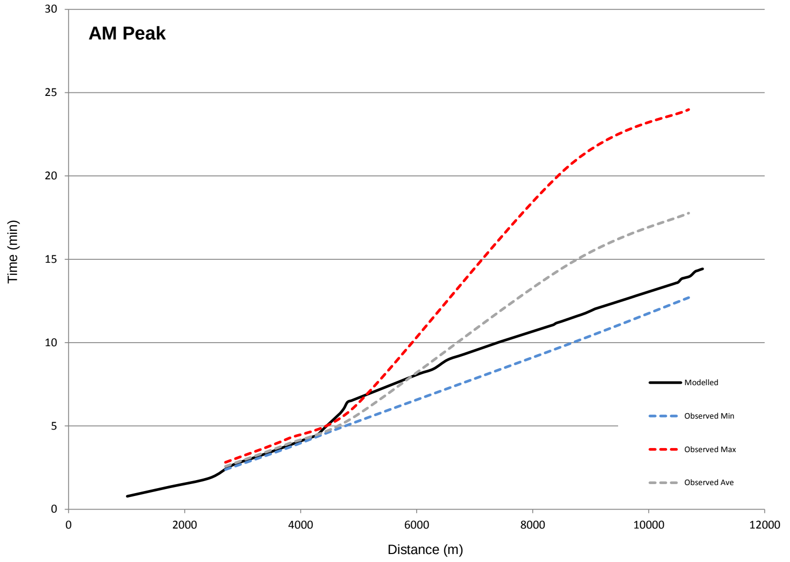


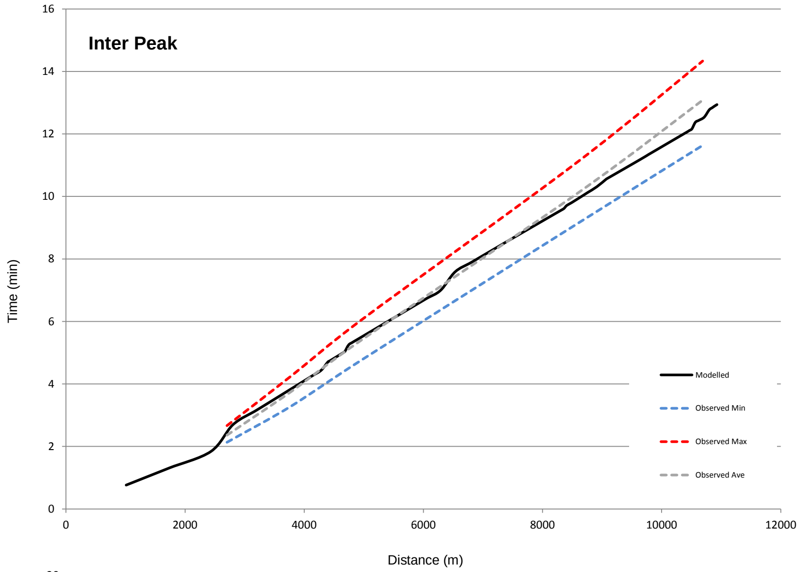



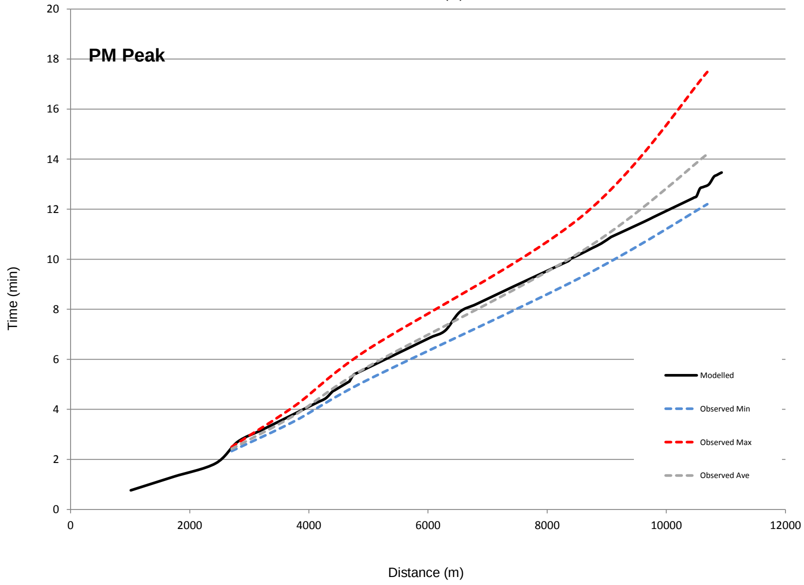



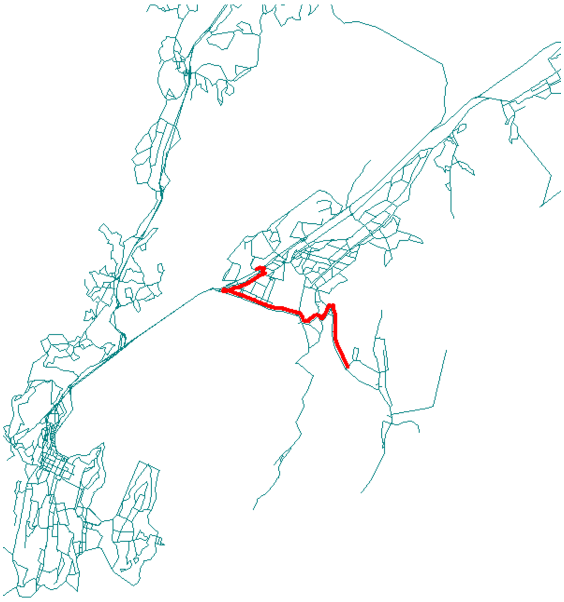


Route 6 Northbound - Wainuiomata Rd to Hutt Rd

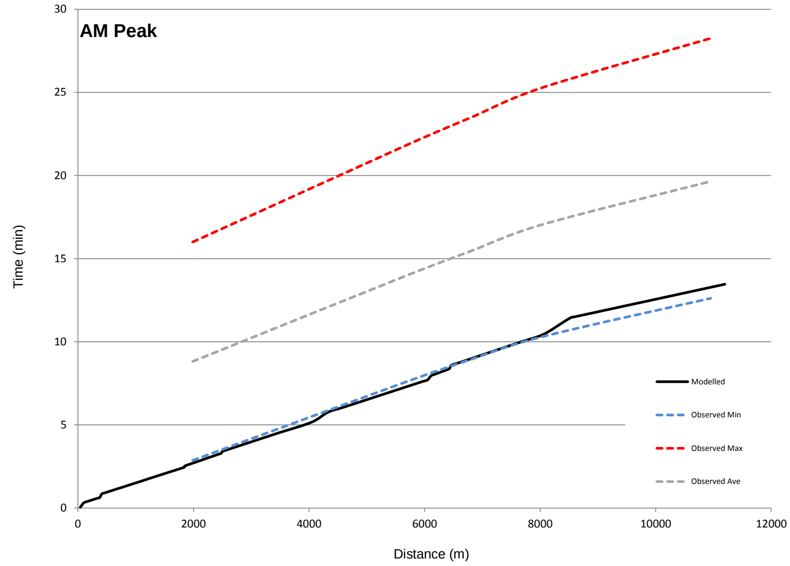


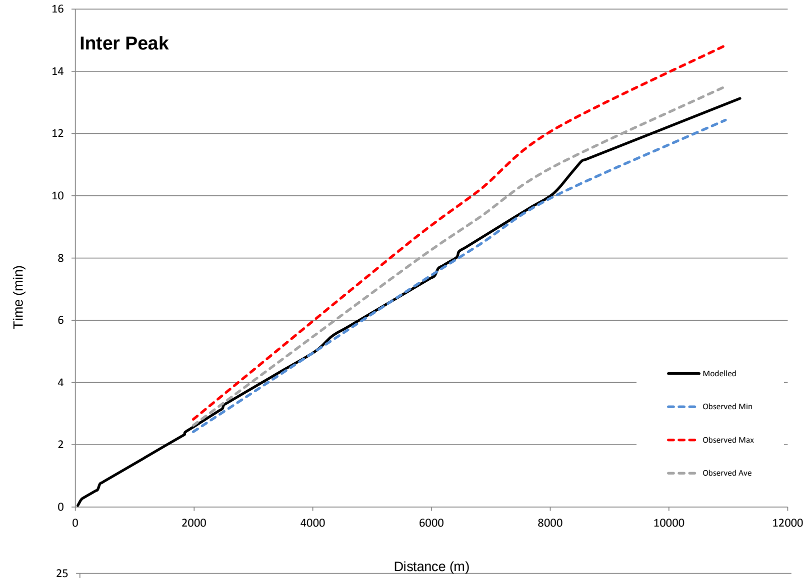



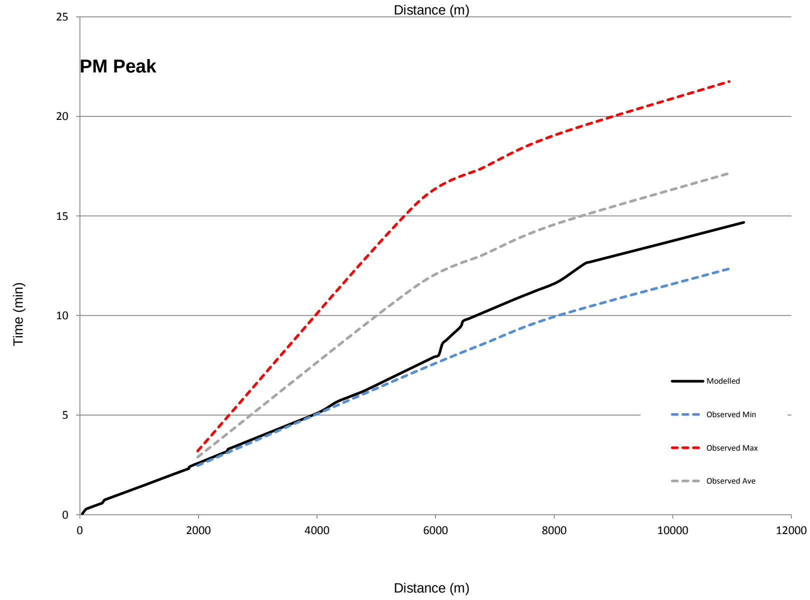



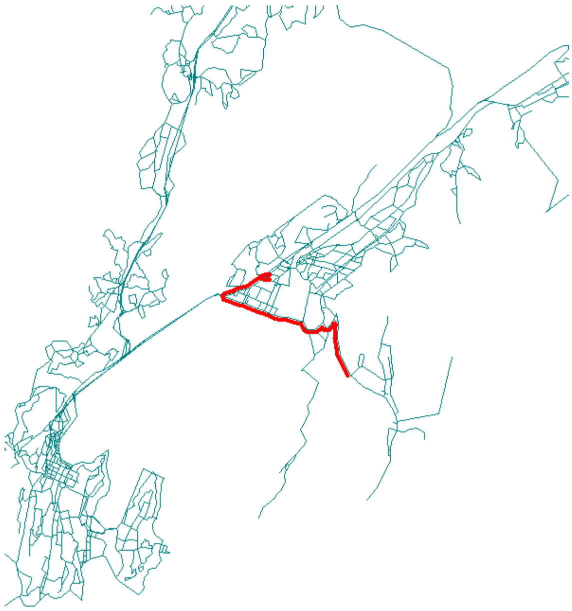



Route 6 Southbound - Hutt Rd to Wainuiomata Rd



# Appendix E – Highway and Transit Assignment Path Analysis

Route choice testing has been undertaken on the WTSM 2011 update to determine the validity of the model. This is especially important with this update as the model now contains an increased number of links, thus there is greater potential for rat running to occur.

Auto paths have been generated using the EMME standard worksheet "Shortest paths – Isochrones" and the generalised cost equation. The generalised cost equation used in the model is as follows:

$$Generalised\ Cost = (6.3 * @fcost) + timau$$

Where @fcost is the fixed link cost (in minutes), timau is the link auto travel time and 6.3 is a constant applied to the equation.

There is currently no equivalent shortest paths worksheet for public transport assignments. Public transport route choice testing has therefore been carried out by assigning 100 PT trips between the selected origin and destination zones. Transit and auxiliary transit volumes are then included in the voltr and volau attribute respectively and indicate the percentage of people using these in the model.

The table below describes the routes and zone O-D pairs selected for route choice testing.

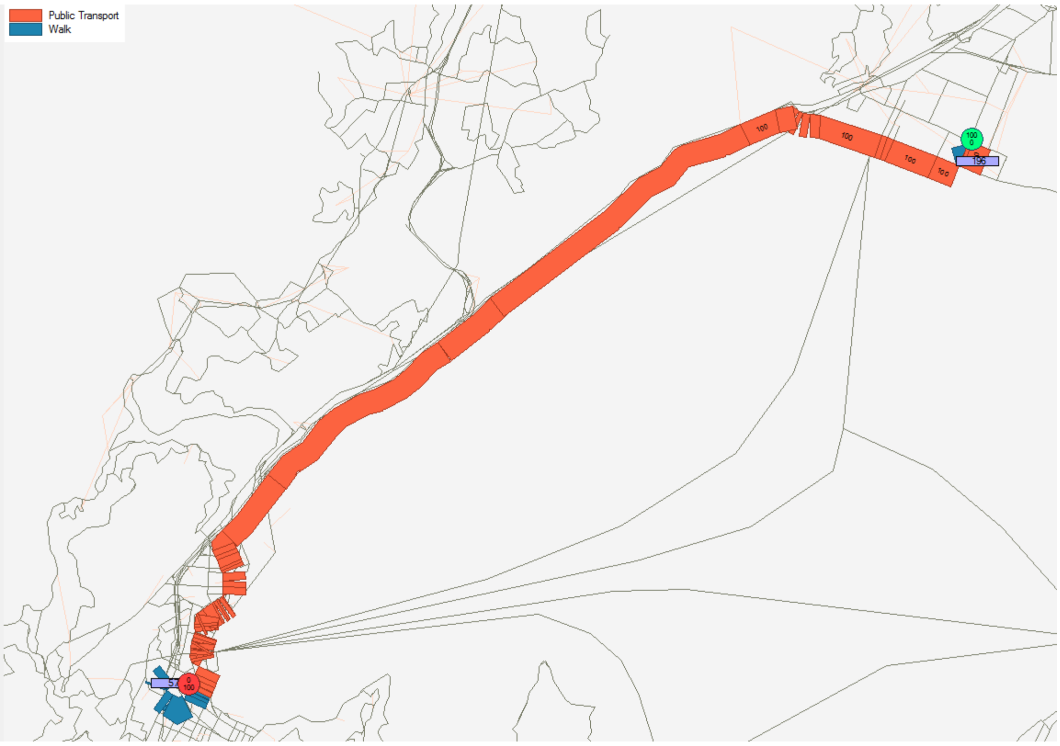
| Route | Origin Zone | Destination Zone |
|---|---|---|
| 1. Petone to Wellington CBD | 196 | 57 |
| 2. Wellington CBD to Seatoun | 57 | 5 |
| 3. Karori to Seatoun | 33 | 5 |
| 4. Berhampore to Johnsonville | 20 | 83 |
| 5. Berhampore to Paraparaumu | 20 | 120 |
| 6. Upper Hutt to Waikanae | 138 | 125 |
| 7. Porirua to Lower Hutt | 97 | 172 |
| 8. Porirua to Upper Hutt | 97 | 138 |
| 9. Airport to Wellington Station | 7 | 66 |

**Petone to CBD**

Vehicles travelling from Petone to the Wellington CBD are doing so by utilising SH1. The highway is being accessed from the Petone on-ramp and exit is via the Terrace off-ramp. This is consistent throughout all three modelled periods. The route followed is expected based on on-site observations.

Public transport use between Petone and the Wellington CBD is made via bus use in all three periods. This is consistent with on-site observations. The alternative is to use park and ride and travel in via rail.


Petone to CBD – Auto mode all periods



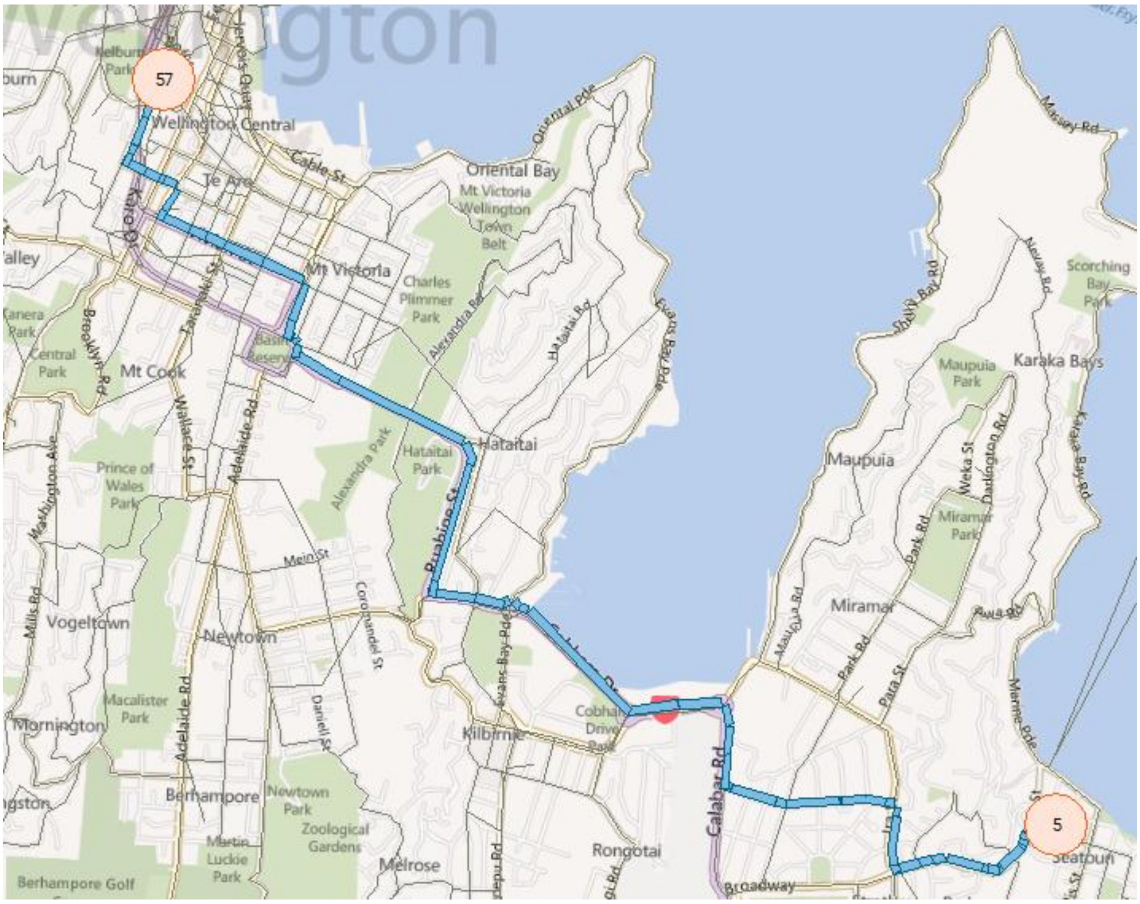

Petone to CBD – Public Transport AM period


Petone to CBD – Public Transport IP and PM periods

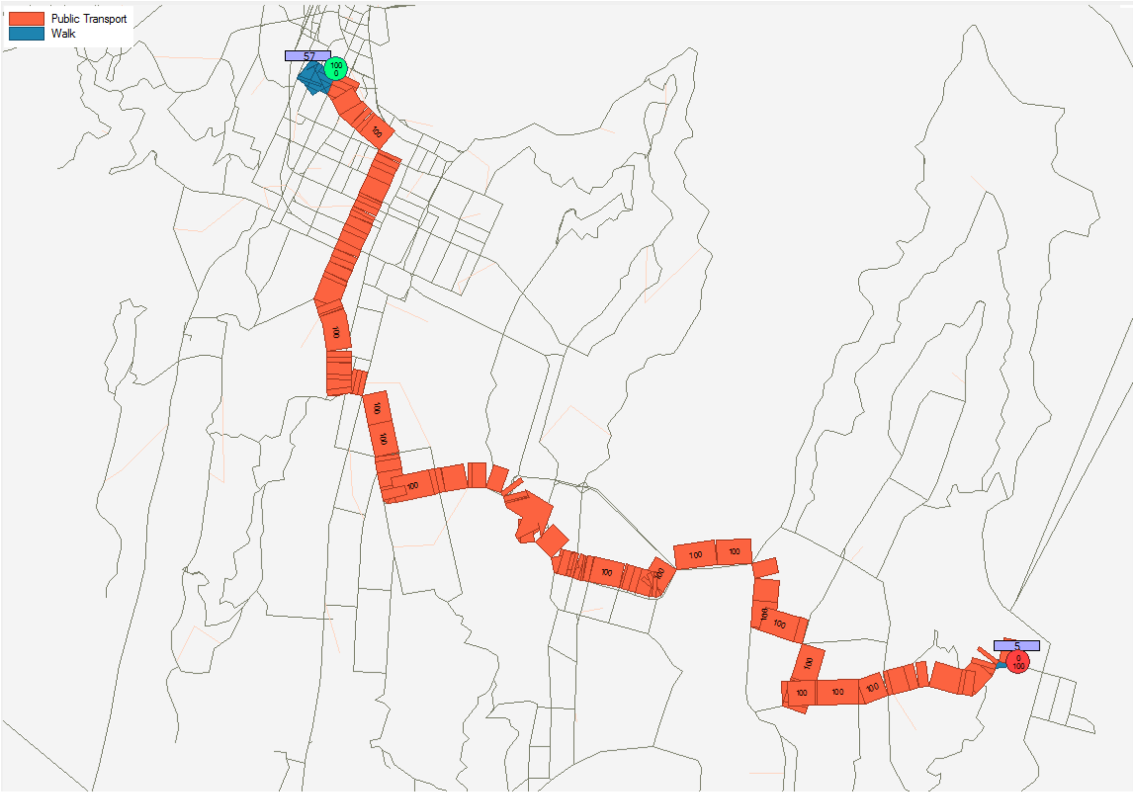
**CBD to Seatoun**

The vehicle network routing checks for the journey from the Wellington CBD to Seatoun shows vehicles choosing the expected route though the Mount Victoria Tunnel across all three periods. The final section is travelled via Caledonia St.

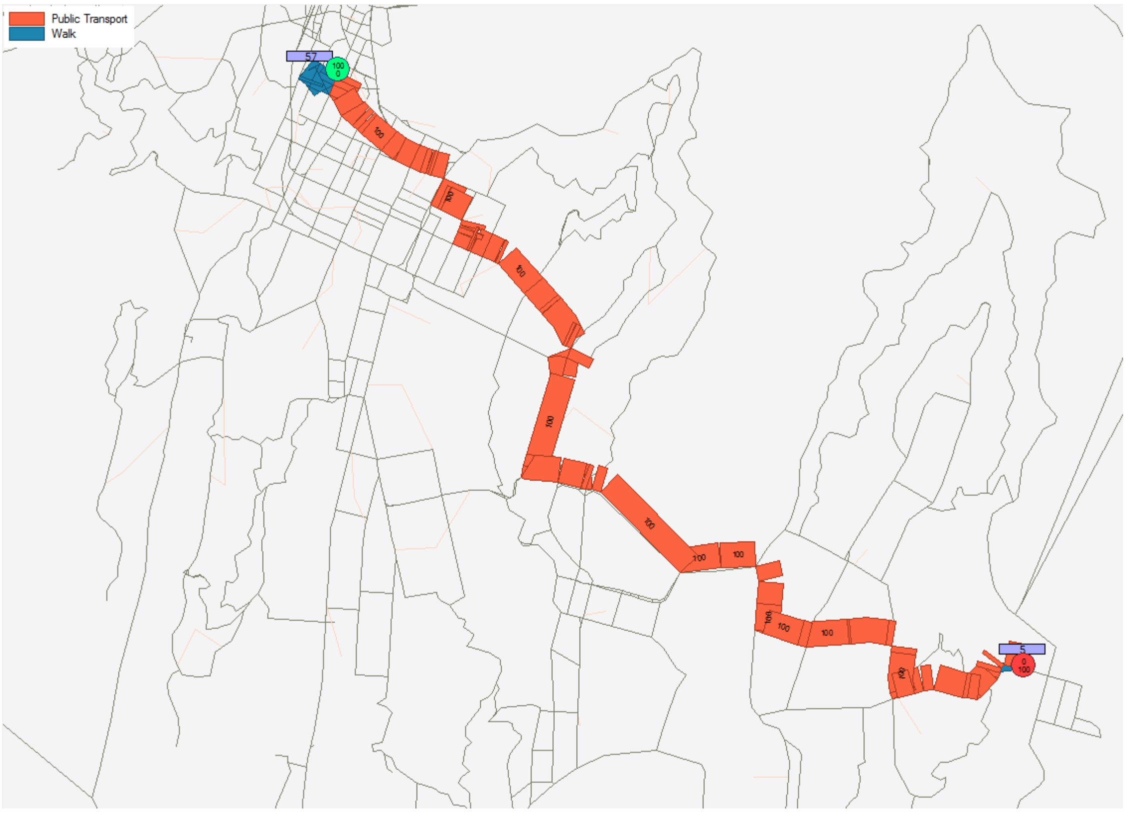
Public transport users are selecting non-stop bus service in all periods to travel between the CBD and Seatoun. AM and IP periods select identical routes and in the PM period a slightly alternative route is used.




CBD to Seatoun – Auto Mode All Periods




CBD to Seatoun – Public Transport AM and IP Periods




CBD to Seatoun – Public Transport PM Period

**Karori to Seatoun**

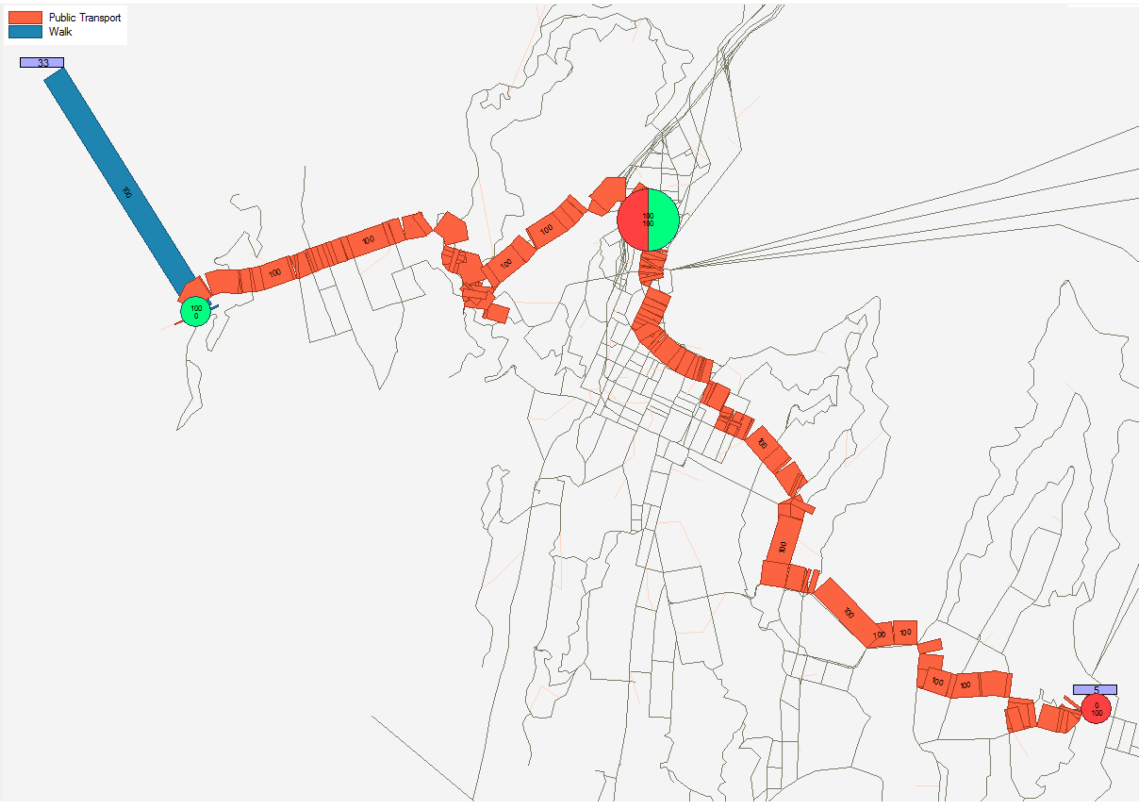
Vehicles travelling between Karori and Seatoun follow the same route throughout all three modelled periods. Vehicles begin by travelling along Karori Road. From here, they are travelling down the hill via Raroa Road and Aro Street to reach Vivian Street. From Vivian the route continues along SH1, through the Mount Victoria Tunnel before reaching the destination via Caledonia Street and Broadway.

The AM period has public transport users travelling between Karori and Seatoun using buses. A single transfer is made in this period with 24% of users making it at a Taranaki St stop and the remaining 76% making the transfer on Rongotai Road. The IP period users follow the same route as the AM user, but with all passengers transferring at the Taranaki Street bus stop. In the PM period users are travelling along Glenmore Street with all passengers transferring on Lambton Quay.


Karori to Seatoun – Auto Mode All Periods


Karori to Seatoun – Public Transport AM Period


Karori to Seatoun – Public Transport IP Period

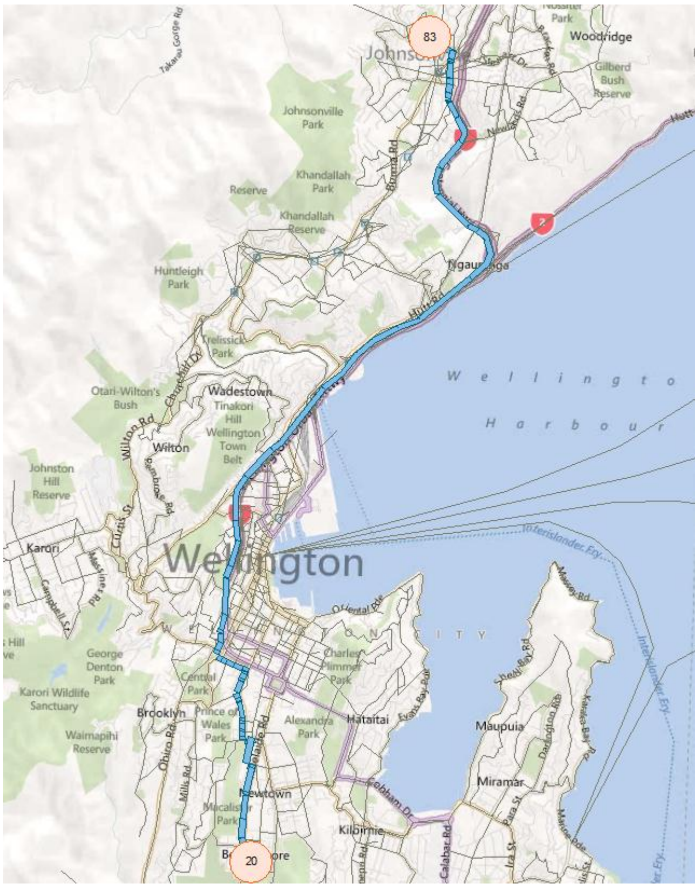



Karori to Seatoun – Public Transport PM Period

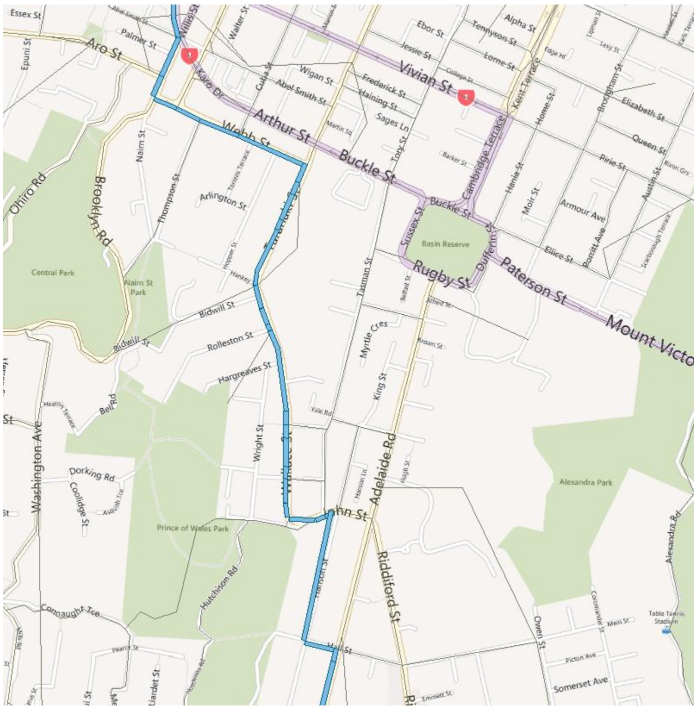
**Berhampore to Johnsonville**

Results of the Berhampore to Johnsonville route show slight variations between periods. In all periods vehicles turn right into Hall Street, avoiding the Adelaide / John Street signals and the Basin Reserve. From there the AM route continues onto the Terrace Tunnel via Wallace Street and Webb Street, joining the motorway at the SH1 / Willis Street signals. In the IP period the journey continues from Hall Street onto Tasman Street and accesses the SH1 motorway at the Tasman / SH1 lights. In the PM period, from Hall street, the route joins the motorway at the Taranaki / SH1 signalised intersection travelling via Wallace Street.

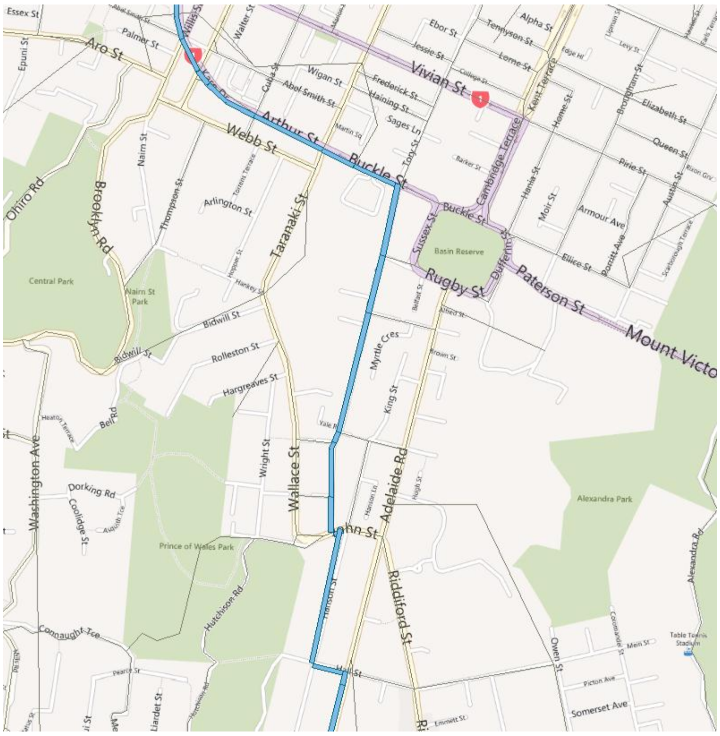
Public transport between Berhampore and Johnsonville in the AM period has people using buses services, making one transfer on Lambton Quay. The IP period is the same as the AM period, except that the bus service selected travels along a slightly different route. In the PM period, public transport users are bussing to the Wellington Rail Station, where they then transfer to reach their destination. The difference in the PM peak is likely due to the greater northbound delays.



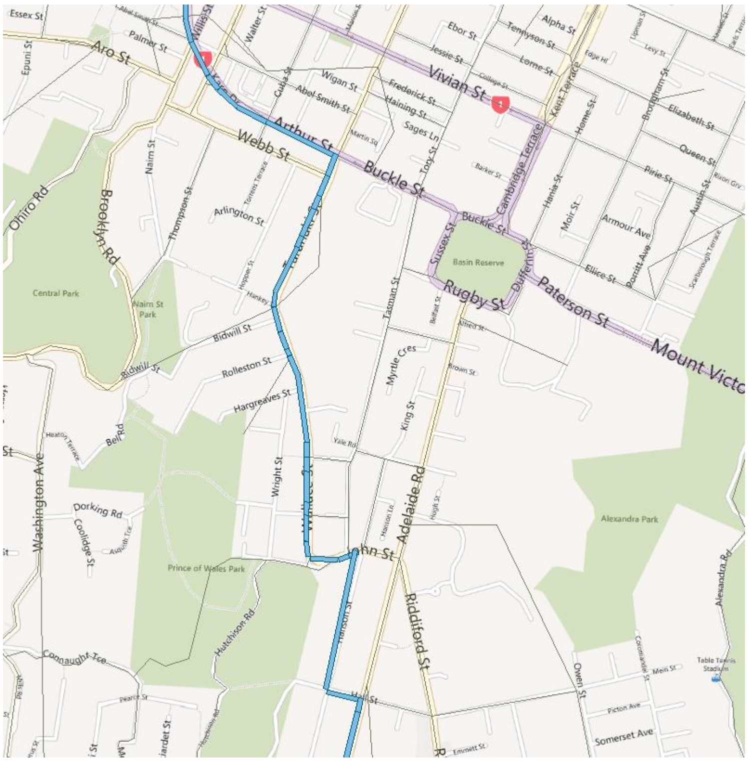

Berhampore to Johnsonville – Auto Trips Route Overview




Berhampore to Johnsonville – Auto Trips, AM Variation

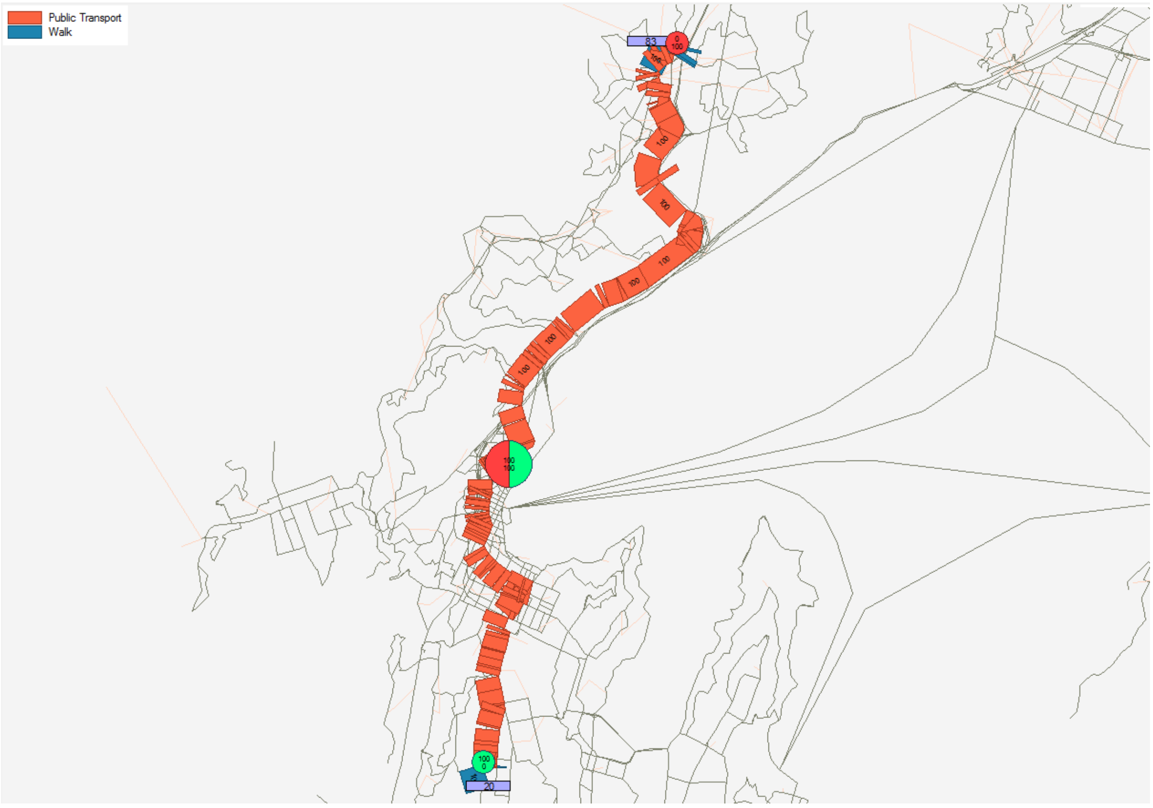



Berhampore to Johnsonville – Auto Trips IP Variation

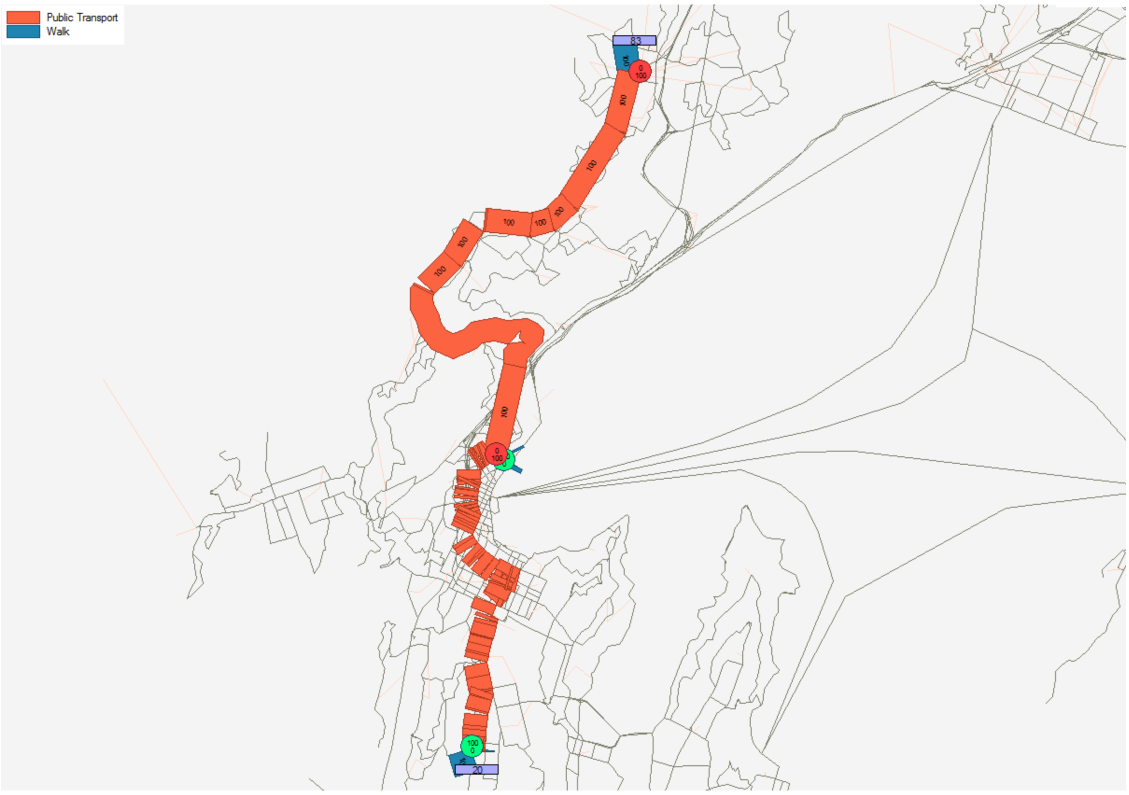



Berhampore to Johnsonville – Auto Trips PM Variation


Berhampore to Johnsonville – Public Transport AM Period




Berhampore to Johnsonville – Public Transport IP Period

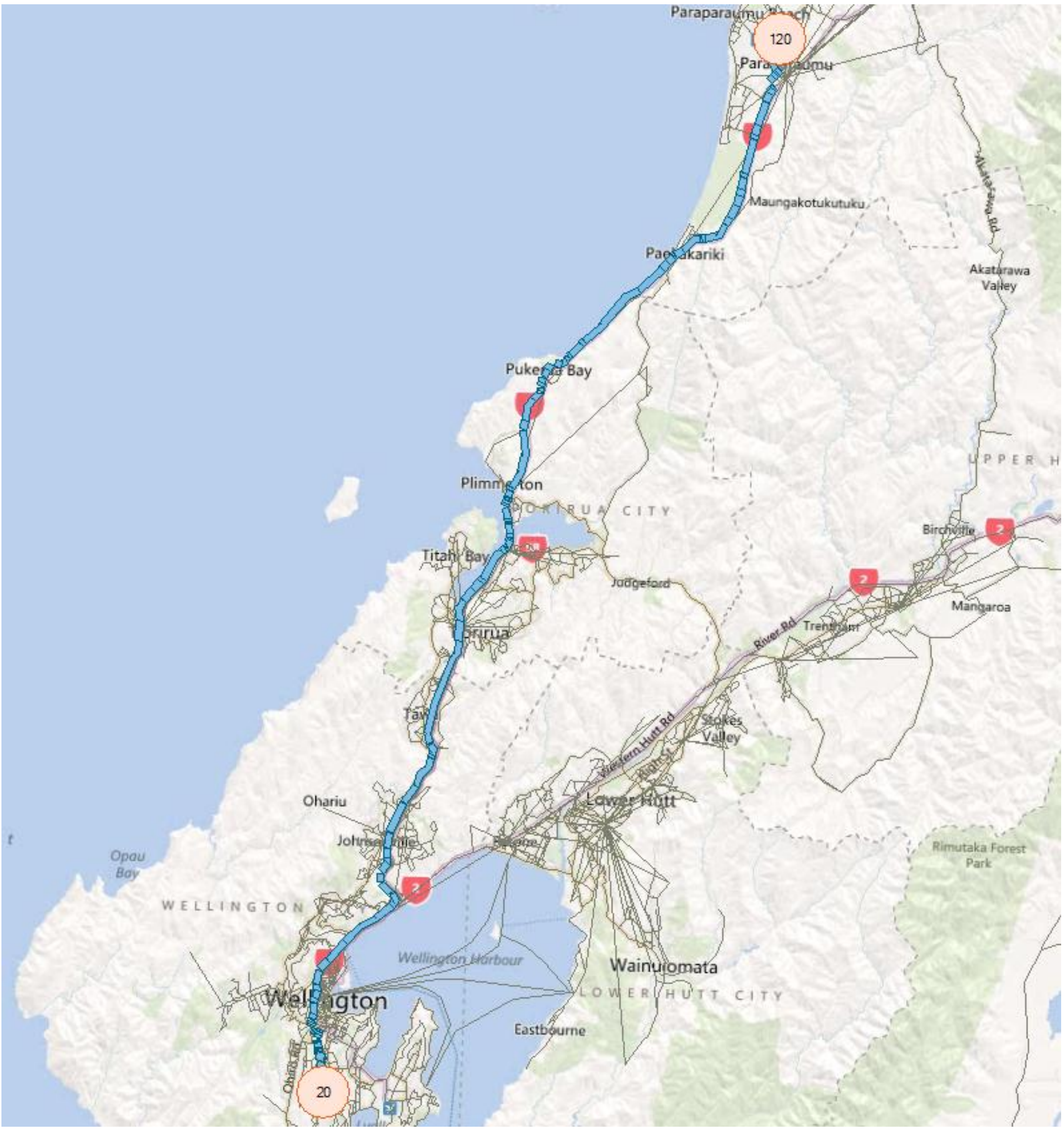



Berhampore to Johnsonville – Public Transport PM Period

**Berhampore to Paraparaumu**

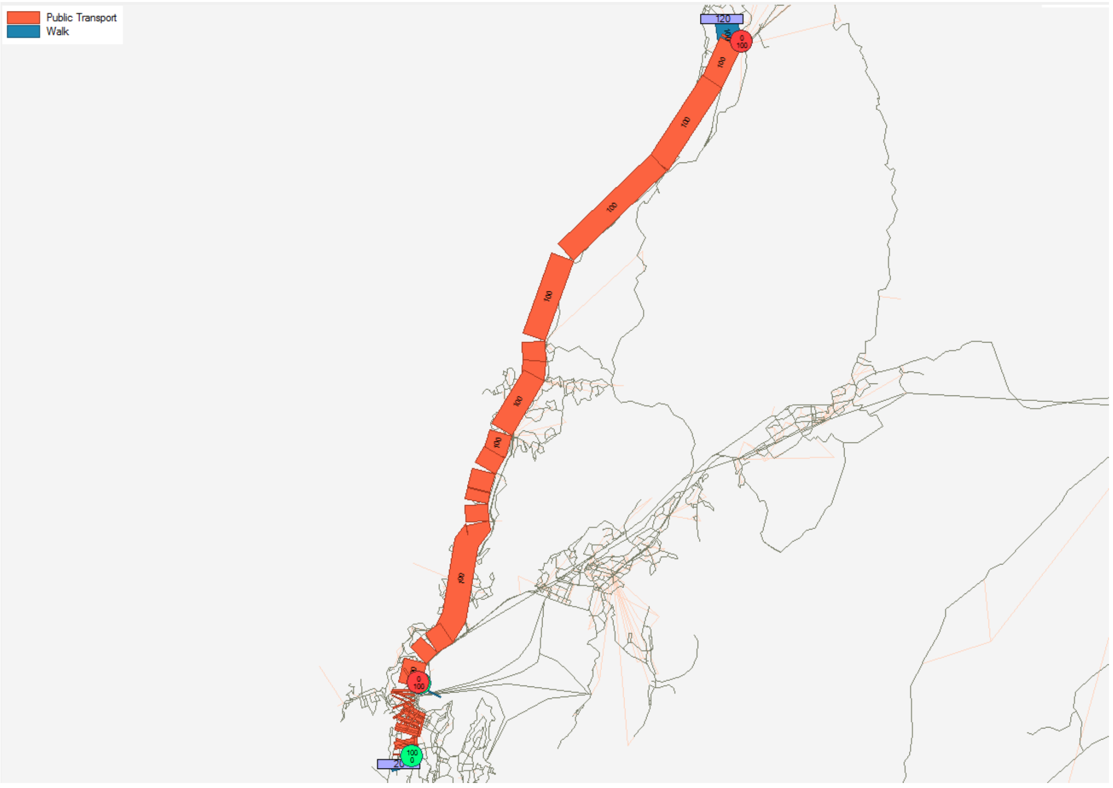
Between Berhampore and Paraparaumu the route largely and correctly follows the highway. There is some variation at the start of the journey, around the Basin Reserve area. This is the same variation as seen in previous tests.

Public transport users in the AM and IP periods both make two transfers: bus to station, rail to Paraparaumu, bus to destination. In reality people may walk to their final destination. In the PM period public transport users reach the Paraparaumu station using the same bus/rail combination as in the other periods, however for the final stage of the journey they use the p-connector instead of a bus.




Berhampore to Paraparaumu – Auto Trips Route Overview


Berhampore to Paraparaumu – Public Transport AM and IP Periods

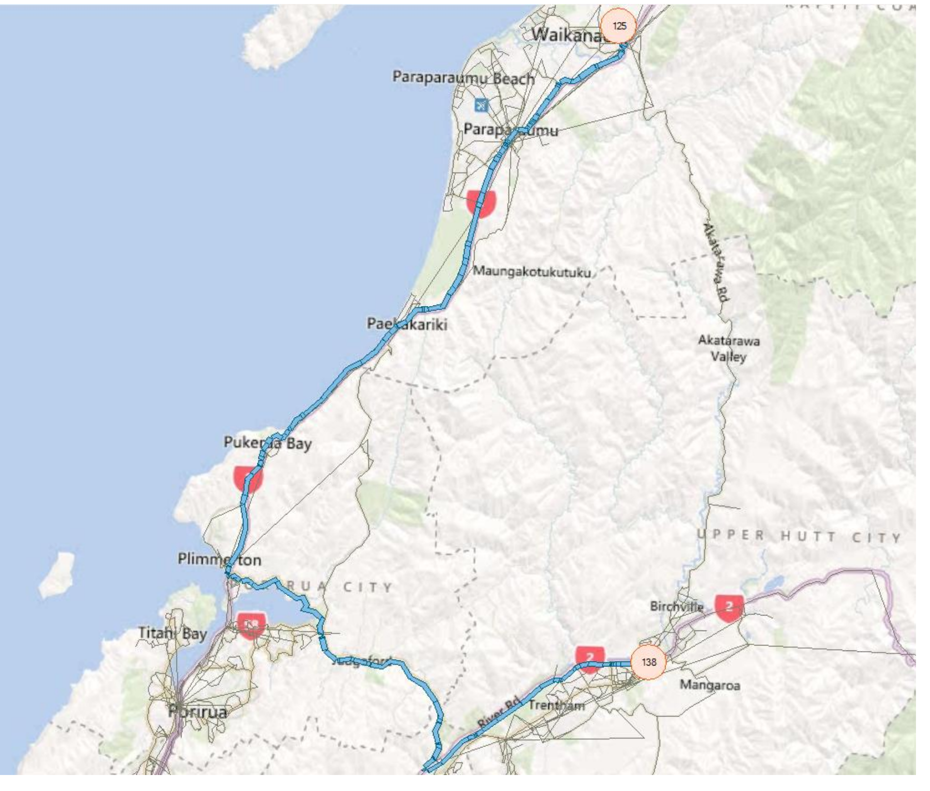



Berhampore to Paraparaumu – Public Transport PM Period

**Upper Hutt to Waikanae**

Vehicle users in the model, when travelling from Upper Hutt to Waikanae, are utilising the highways to do so. From Upper Hutt vehicles travel to SH58 via SH2 until reaching the Pauatahanui roundabout. From here, in the AM and IP periods, the journey travels onto SH1 via Grays Road, continuing onto the destination. In the PM period, vehicles are accessing SH1 via Paekakariki Hill Road, likely due to the significant congestion found on SH1 during this period. The main alternative to this route is via Akatarawa Road which, while shorter length-wise, is a low speed environment so results in a longer travel time.

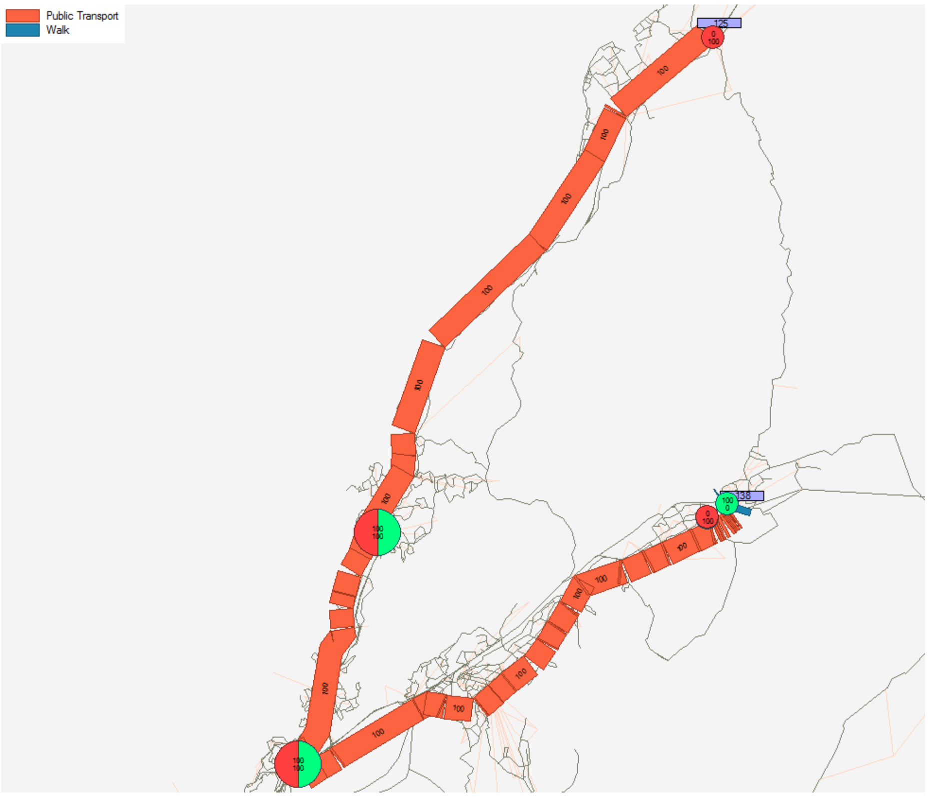
In the AM period, public transport users are using the rail service to make the journey, making one transfer from the Hutt Valley rail line to the Kapiti rail line. In the AM and IP periods users access the Upper Hutt station via a p-connector; in the PM period a bus service is used. In all periods a mid-journey rail transfer is made at the Wellington Rail Station. In the PM period an additional rail transfer is made at the Porirua Rail Station.




Upper Hutt to Waikanae – Auto Trips AM and IP periods


Upper Hutt to Waikanae – Auto Trips PM Period


Upper Hutt to Waikanae – Public Transport AM and IP Periods

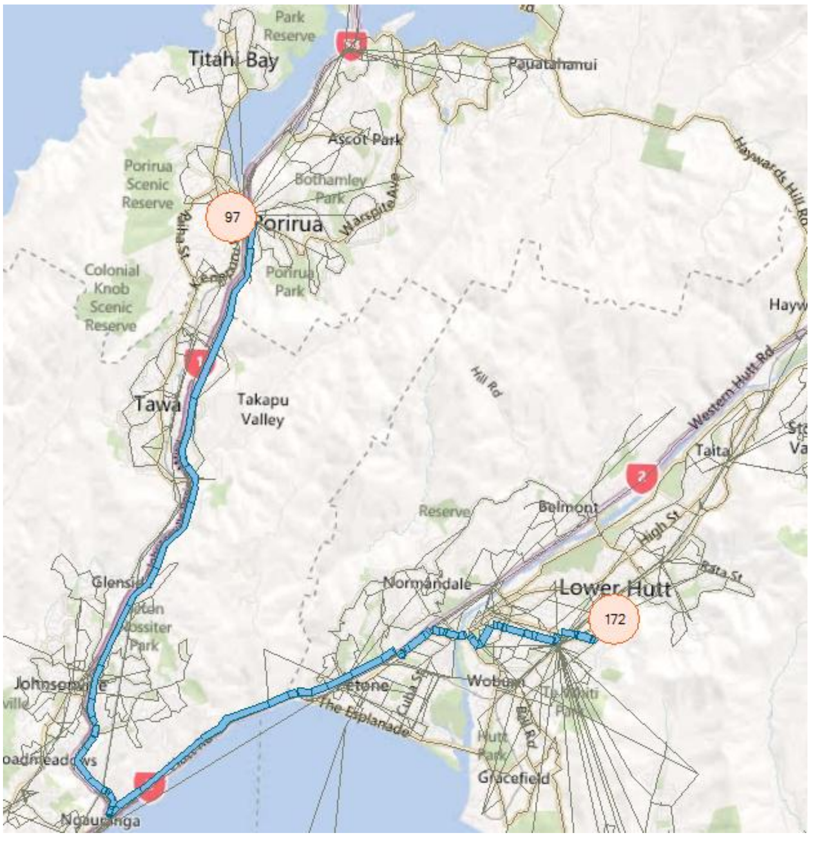



Upper Hutt to Waikanae – Public Transport PM Period

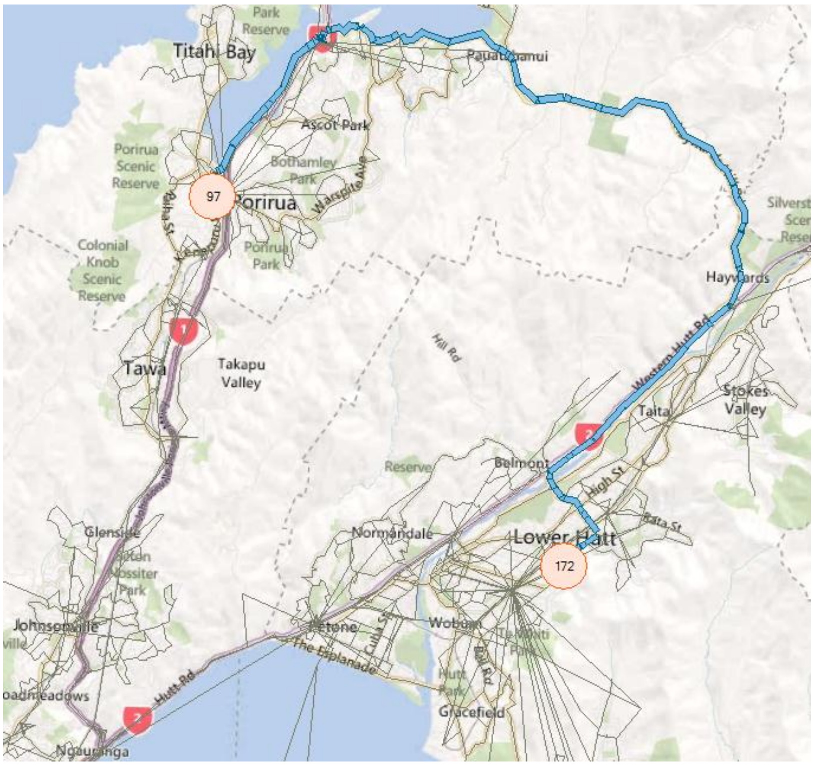
**Porirua to Lower Hutt**

Between Porirua and Lower Hutt there are two major routes, via Haywards and SH58 or via Ngauranga. In the AM and IP periods, the Ngauranga route is used and in the PM period the Haywards route is selected. The change in route choice during the PM period is likely due to increased traffic volumes on SH2 south of the Petone off-ramp during the PM periods which in turn reduces travel time along this section.

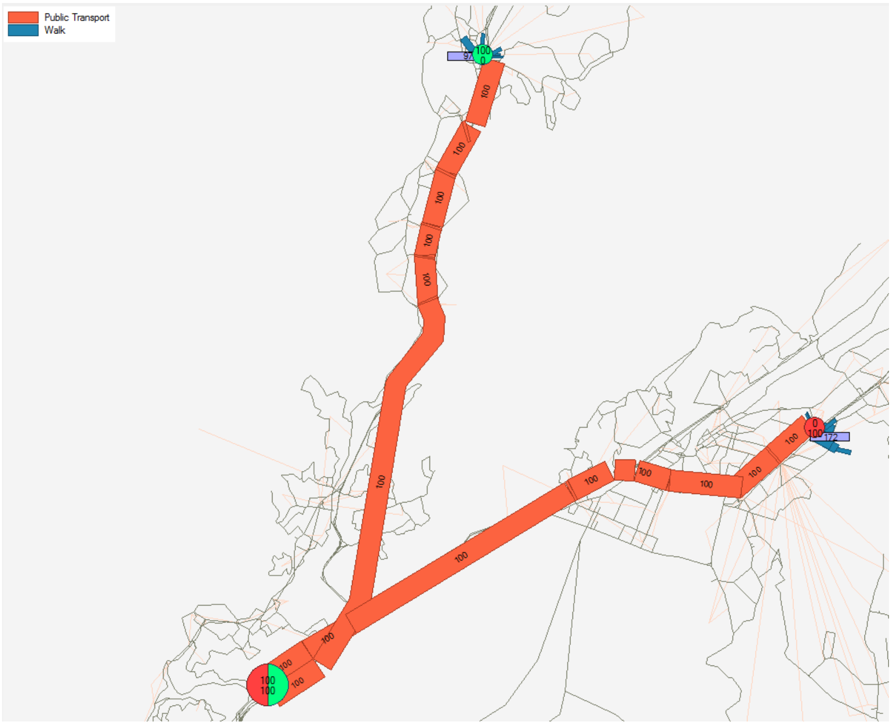
During the AM and IP, public transport users make the journey from Porirua to Lower Hutt using rail services. A single transfer is made at the Kaiwharawhara station and the access and egress legs of the journey are made using the walk mode. In the PM modelled period the rail is also used but with two rail transfers, the first at Kaiwharawhara (as with the other periods) and the second at the Petone station. The final egress leg of the PM peak uses a p-connector to reach the destination zone.



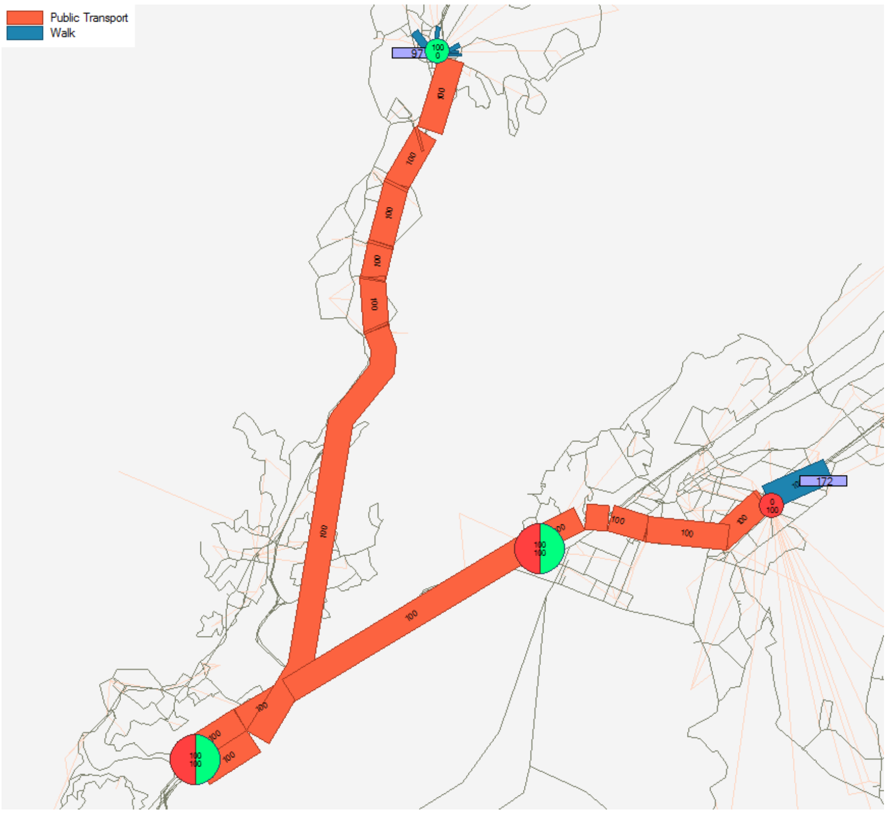

Porirua to Lower Hutt – Auto Trips AM and IP Periods




Porirua to Lower Hutt – Auto Trips PM Period




Porirua to Lower Hutt – Public Transport AM and IP Periods

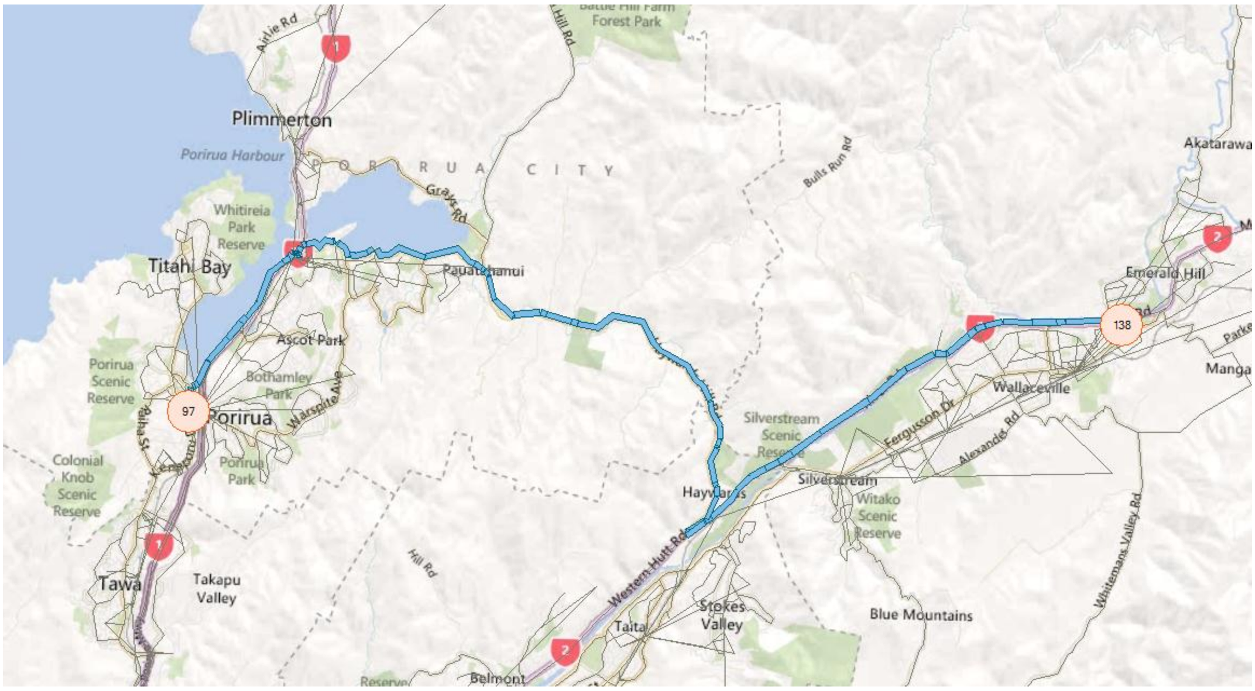



Porirua to Lower Hutt – Public Transport PM Period

**Porirua to Upper Hutt**

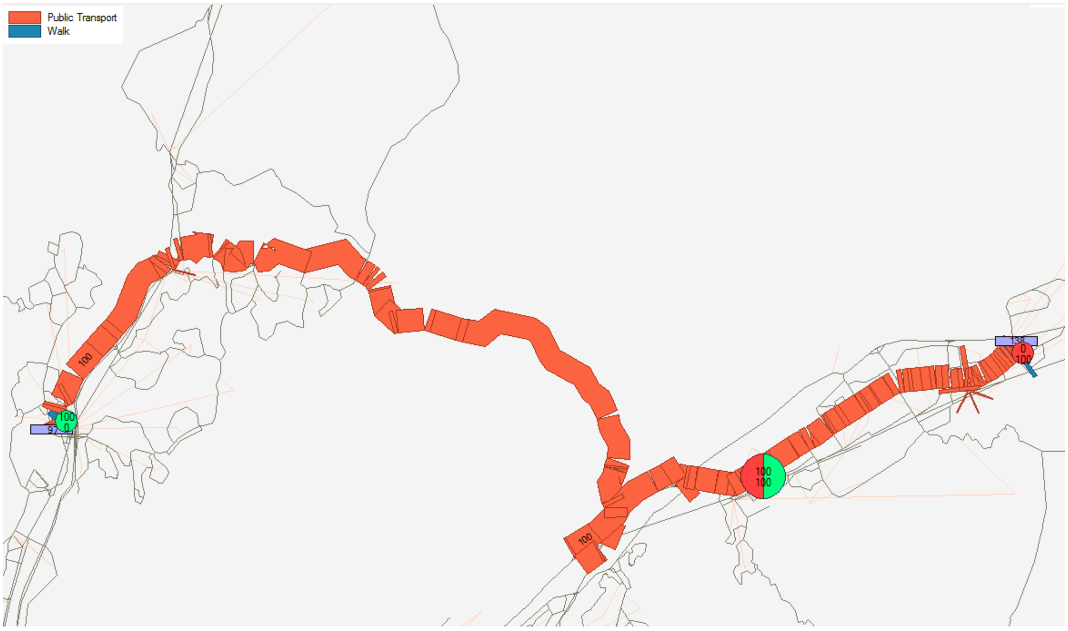
The journey from Porirua to Upper Hutt is made in the model via SH58. If this route had significant delays the traffic would likely reroute to travel via the Ngauranga interchange.

Public transport users in the AM and IP make the journey using rail, making a transfer at Kaiwharawhara station. In the PM period buses are used, a single transfer being made at a Fergusson Drive stop. This PM option, while having a greatly reduced travel time, only runs once during the period. The alternative to this would be to use the Kapiti rail line, transfer at Wellington Station onto the Upper Hutt rail line.




Porirua to Upper Hutt – Auto Trips All Periods


Porirua to Upper Hutt – Public Transport AM and IP Periods

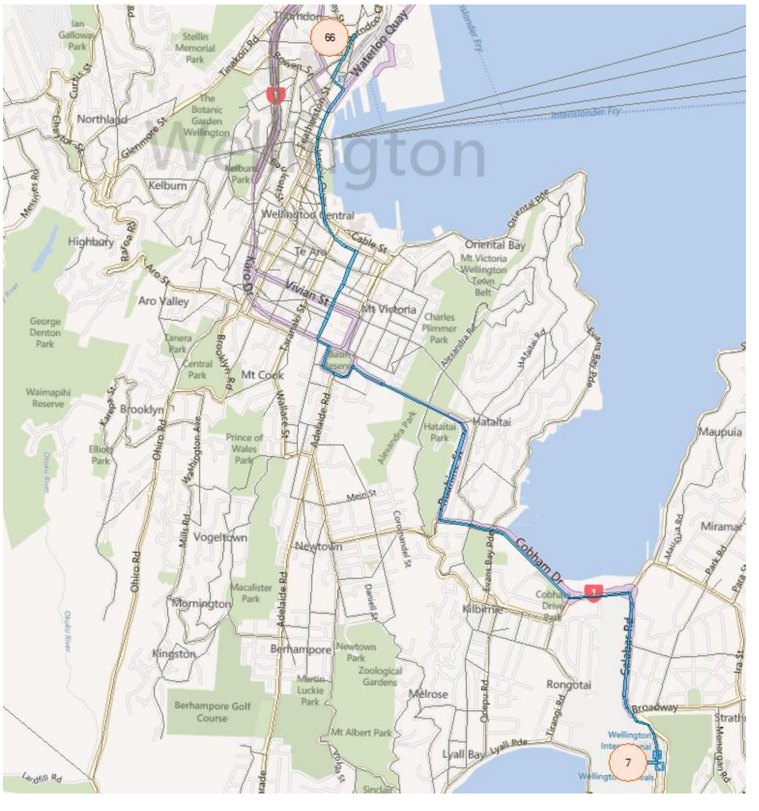



Porirua to Upper Hutt – Public Transport PM Periods

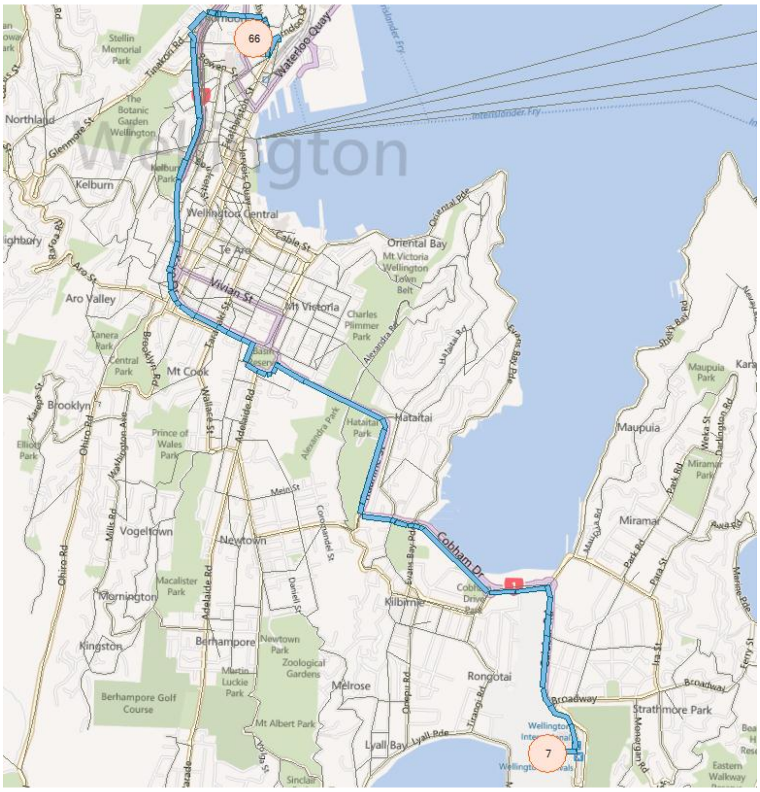
**Airport to Wellington Railway Station**

Route choice between the airport and the Wellington Railway Station shows vehicles selecting to use the Mount Victoria Tunnel across all periods. After the tunnel, variation is seen between each modelled period. In the AM period, vehicles travel around the Basin Reserve and onto Customhouse Quay via Wakefield Street and Tory Street. In the inter peak period, vehicles are using the motorway, exiting onto Tinikori Road and using the Hawkestone overbridge to reach the destination. Vehicles in the PM period follow a similar route to that used in the AM, except accessing Wakefield Street from Taranaki Street instead of Cambridge Terrace. The variation between periods is, as with previous route choice tests, due to varying traffic volumes, in this case along the motorway. The major alternative to Mount Victoria Tunnel is to travel around Evan's Bay.

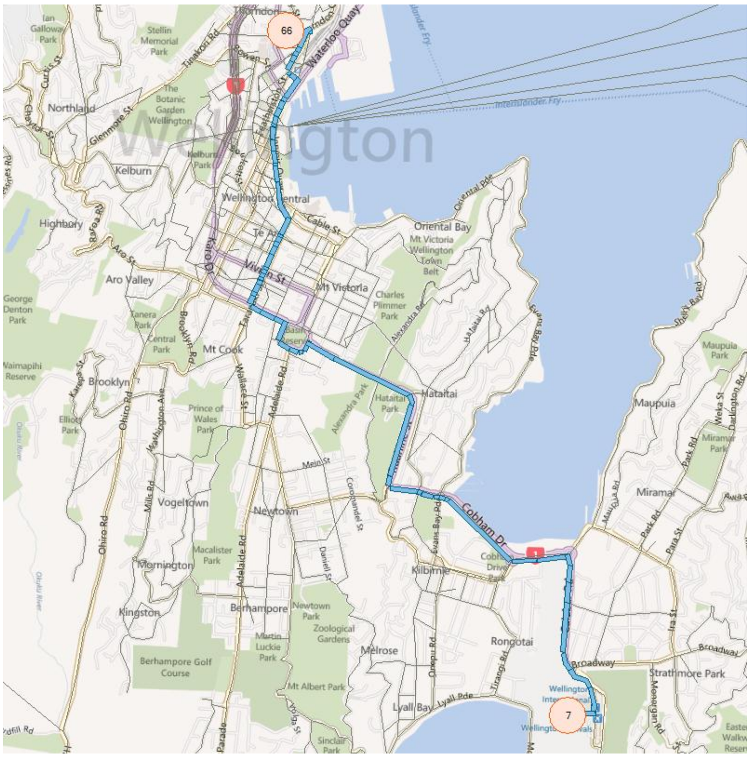
Public transport route choice is consistent across all periods, showing people using the airport flyer bus to travel directly to the destination.



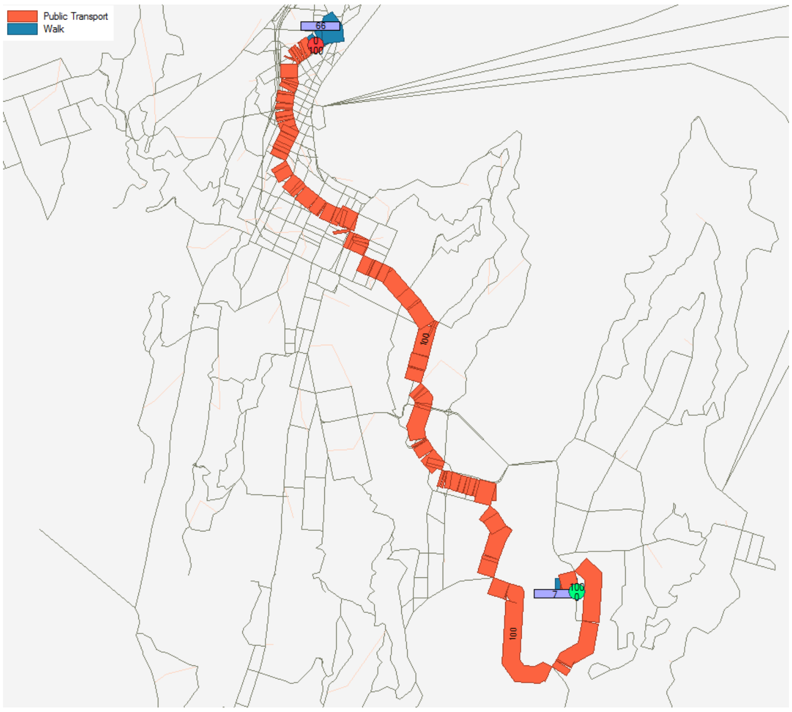
Airport to Wellington Station – Auto Trips AM Period




Airport to Wellington Station – Auto Trips IP Period




Airport to Wellington Station – Auto Trips PM Period




Airport to Wellington Station – Public Transport All Periods

# Appendix F – 2001 and 2006 Demand and Highway Assignment Convergence

The team were not only able to conclude the new networks were converging correctly but were also able to confirm the 2006 version model was converging using the new link based conversion measure described in Section 9. The following sections go on to specify:

- Guidance on model convergence;
- How the WTSM 2001 Demand Model was built to converge; and,
- How the Highway Assignment Model was built to converge.

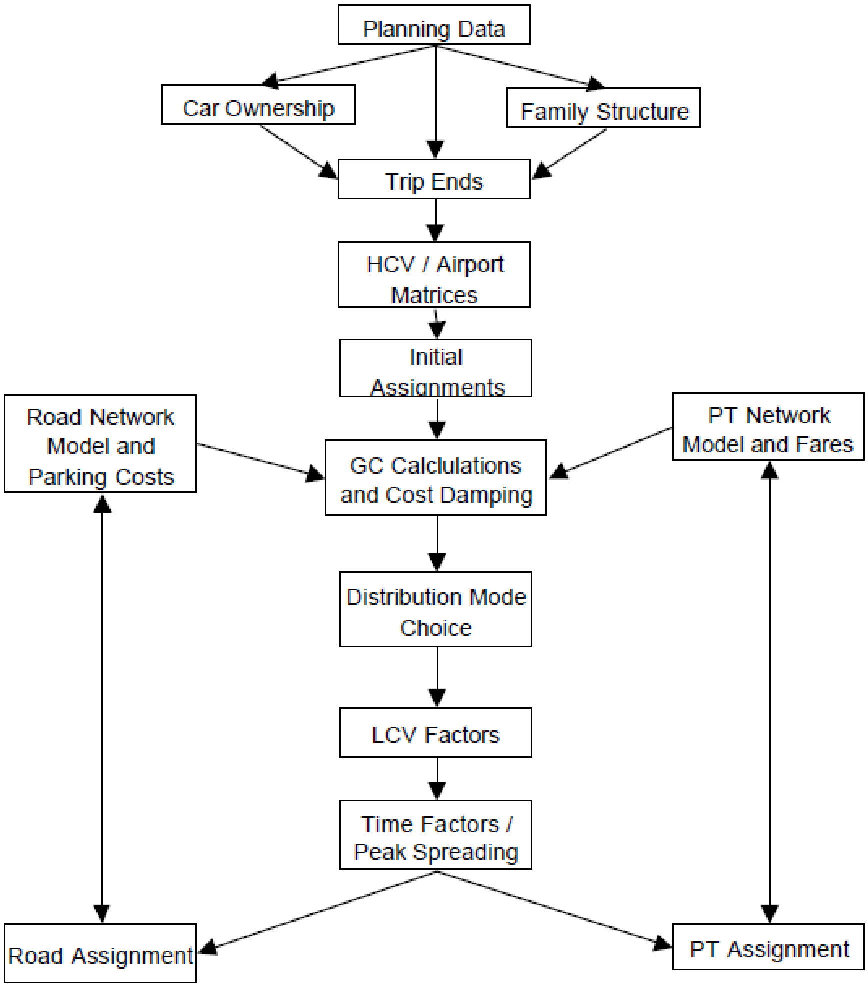
Guidance on how to measure and confirm highway model convergence is contained in The Economic Evaluation Manual (Volume 1). It advises that, as a general guideline, the degree of assignment convergence should be such that the difference in activity benefits computed from successive iterations is only a small fraction of the total activity benefit.

The following measures are suggested:

- The proportion of links in the entire network with flows changing less than five percent from the previous iteration;
- For stability there should be consecutive iterations with proportion greater than 95 percent;
- Where available, the 'normalised gap', δ, which expresses the flow–weighted difference between current total costs and the costs incurred if all traffic could use minimum cost routes, should be less than one percent for convergence; and,
- Other measures of stability and convergence provided by transportation modelling packages may also be included.

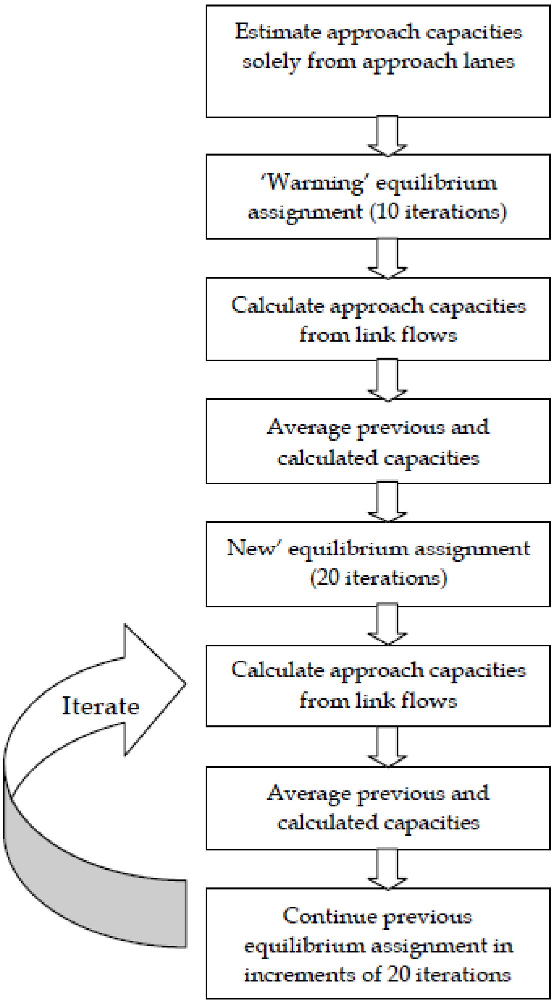
The mechanism for WTSM demand model convergence is documented in "*TN25.1 User Manual"* published by Beca in 2003. It states that:

> "the model looping process is run until convergence. The convergence test involves the calculation of the root mean square error (rmse) for each final demand matrix (car & PT for each period - i.e. 6 matrices). The model is considered converged when the rmse for each matrix is less than 0.01 for two consecutive iterations, with the base model converges in 7 iterations."




The Team have been unable to locate demand level convergence in the 2001 version of WTSM.

The way the highway assignment model converges was documented in *"TN14.1 Base Auto Networks"* published by Beca in 2003. It states that "intersections where the capacities are assessed as a function of the opposing and/or arrival flows will need to be updated as link flows change during the EMME equilibrium assignment process. Intersections with fixed approach capacities do not require any updates during the assignment process.




**2001 Highway Assignment Algorithm**

The 2001 model development process reported Total Vehicle Kilometres (TVK) and Vehicle Minutes Travelled (VMT) only i.e. link level convergence was not used. The criteria used were:

- Convergence gap criteria of 0.1% on the relative gap; and,
- 0.001 minutes for the normalised gap.

The graph below illustrates that convergence was achieved in the AM peak model after 6 updates of the intersection delays which translated into a normalised gap of 0.0318 minutes and a relative gap of 0.08%. No statistics were produced on link level convergence.

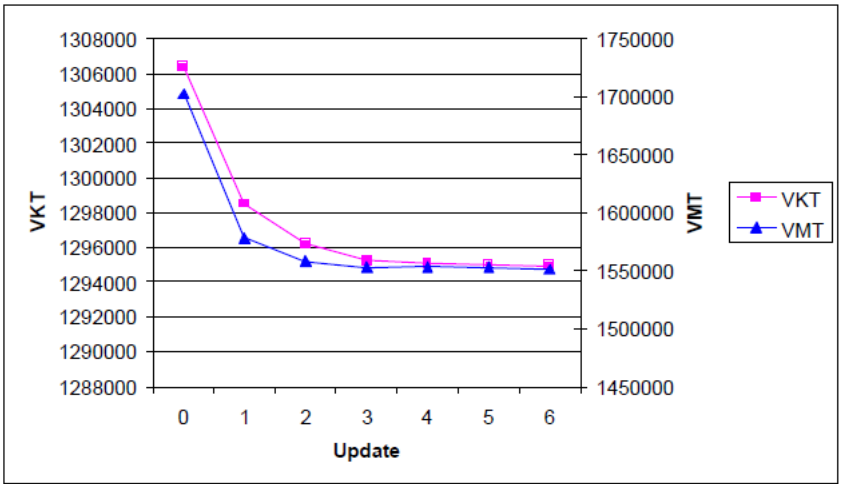



**Figure 0-1 2001 Highway AM Peak Assignment Convergence**

## Appendix G – Transit Assignment with Variants Flow Chart