# Northern Wellington SATURN Model Update

## MODEL CALIBRATION AND VALIDATION REPORT

- Rev 01a
- 14 May 2013

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# 1. Executive Summary

This report documents the NWSM (Northern Wellington SATURN Model) calibration process and outlines the goodness of fit of model outputs to observed data.

The chapters of this report outline the:

- Data inputs
- Calibration process
- Time slicing process
- Model convergence
- Pre estimation validation
- Post estimation calibration
- Model sensitivity tests

This report also highlights discrepancies between survey and modelled data and these should be taken into consideration for any potential use of the model.

The purpose of NWSM is to provide an improved representation of network performance than within the regional WTSM (Wellington Transport Strategic Model) for specific use for the economic assessment of the proposed Petone to Grenada link road to scheme assessment level, and a number of additional proposed roading upgrades to PFR level, including the Cross Valley Link and SH58 improvements.

The NWSM is intended to be used in conjunction with WTSM, with WTSM required to establish likely changes in traffic distribution and mode choice and provide an input initial estimate of travel demands for a given land-use scenario. This is particularly important in the discussion of changes that have been made to the initial estimate of 2011 traffic demands taken from the WTSM model. The development of the NWSM seeks to balance replication of existing traffic conditions whilst maintaining sufficient linkage with WTSM to provide forecasting robustness.

The development of future year networks and demands is not covered in this model calibration report, instead being covered in project specific reporting. However, the following points will be common to all future year schemes modelled using the NWSM:

- Matrices will be disaggregated using the same factors developed in the 2011 base models. Where future year meshblock data exists to update these factors, these will be used. This will include the application of sector to sector adjustment, and sector specific time slice factors.
- An additive calibration correction matrix will be applied, calculated as the difference between the pre-estimated and post-estimated matrices.

- Future year networks will be coded in line with the code book developed for this model to ensure consistency of approach and confidence in the robustness of assumptions made.

The full NWSM area is shown in **Figure 1-1** with road colouring reflecting road hierarchy in the core model area. The shaded area between Ngauranga, MacKays Crossing and Upper Hutt are modelled with 'simulation' coding (fairly detailed intersection modelling and all roads modelled as links with speed-flow relationships, shown in **Figure 1-1**) with the remainder of the area modelled in 'buffer' coding (no detailed intersection coding but all roads modelled as links with speed-flow relationships shown in **Figure 1-2**). The full model area is consistent with the area covered by WTSM.

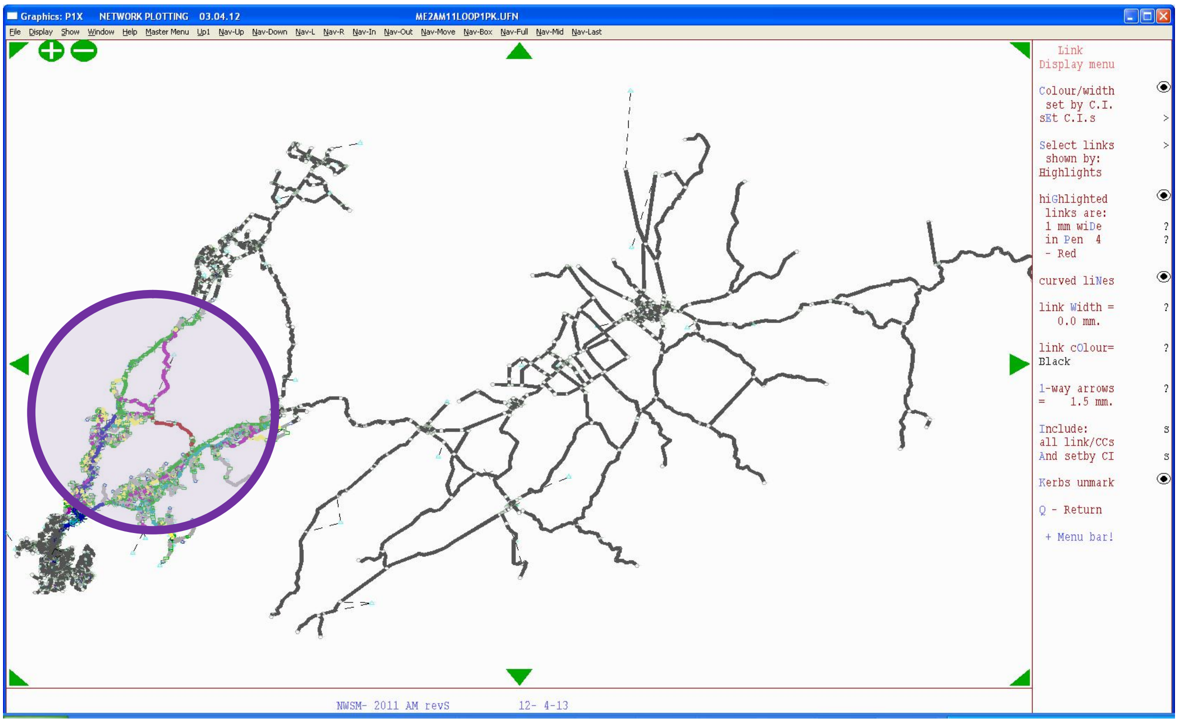
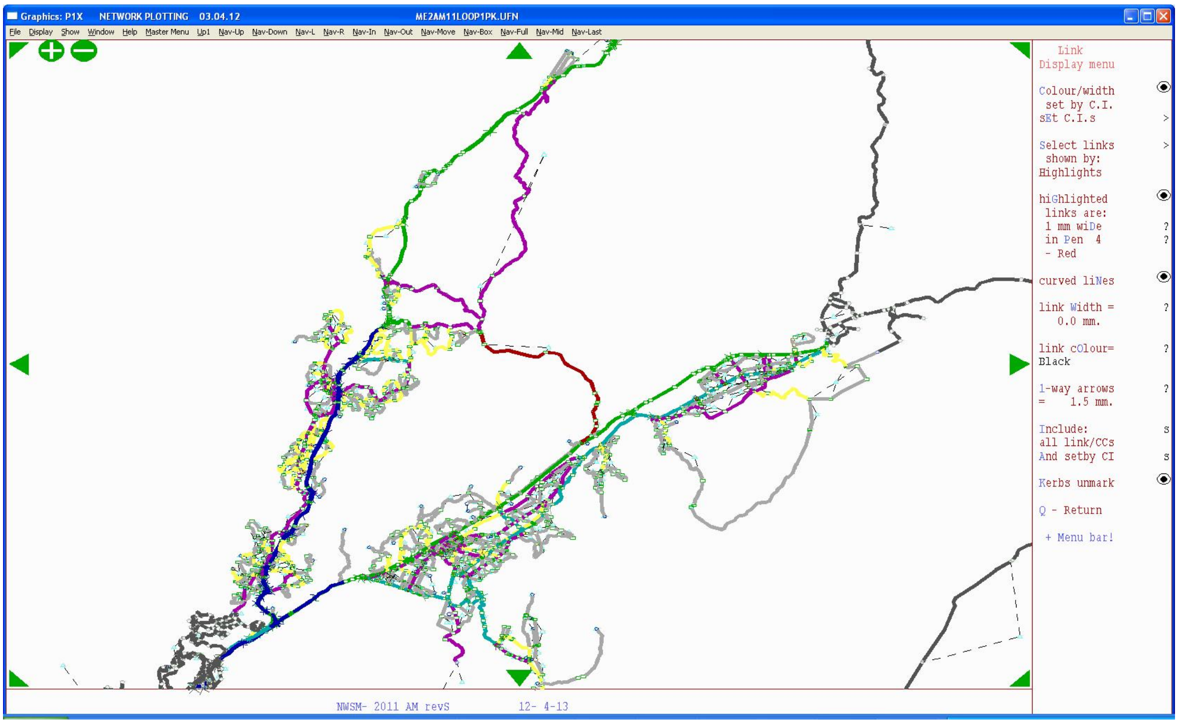



**Figure 1-1 The NWSM Full Network**




- **Figure 1-2 The NWSM Simulation Network**

It is considered that the outputs provided in this document demonstrate that the NWSM reflects observed 2011 traffic conditions to an appropriate level of accuracy across the model simulation area. Further, the relatively fine-grained network and demand resolution employed, and the sophisticated simulation capability of the SATURN software, combined with calibration of travel demands at a turning level of detail, have been successful in delivering a model that provides a significantly improved representation of network conditions (flows and travel times) than within the regional WTSM model. This will enable the model outputs to be used with confidence for the Petone to Grenada, Cross Valley Link and SH58 assessments. As with any model of this size, the application of the model in additional studies would require confirmation of the goodness of fit (and associated risks) in these study areas. This may require both model refinements and additional data collection.

# 2. Data Inputs

## 2.1. WTSM

The 2011 WTSM model without any modifications from the “as delivered” model has been used to provide information with regards to:

- Network coverage: buffer area coding
- Matrices: disaggregated to produce Northern Wellington SATURN model matrices

No version or revision identifier for WTSM is available. 2006 land use inputs into the WTSM model, both at a WTSM zonal and meshblock level have been used as part of the disaggregation methodology. This information has been sourced from Greater Wellington Regional Council, the owners of the WTSM model.

## 2.2. Traffic Counts

The raw data for the NWSM has come from various sources and as a combination of link and turn counts. The following sources provided the raw data for the traffic count processing:

- TEAM Traffic surveys: traffic counts undertaken 6th and 7th of March 2013.
- WTSM traffic counts: provided via email by GWRC in November 2012. Spreadsheets received are:
  - Batch1.xlsx
  - Batch2.xlsx
  - Batch3.xlsx
- Only the counts located in and around the simulation area of the model were used.
- HCC tube counts (hourly) and intersection counts on The Esplanade received via email on 19th November 2012 from GHD
- NZTA / Wellington City Council / Hutt City Council / Porirua City Council traffic counts received via email 2nd December 2012 from BECA. This information was resourced as part of BECA’s Freight Matrix Project.
- Porirua City Council traffic counts received 9th and 10th of January 2013
- Wellington City Council: counts for the Grenada area received 21st December 2012.
- Freight Speed Surveys from BECA: The following spreadsheets were received:
  - eRUC HCV matrices:
    ”EROAD Matrix_Mar2012Data_v2-Client_Copy_051212.xlsx” spreadsheet received 4th December 2012
  - eRUC speed data:
    “eRUC HCV Speed Data_v1.xlsx” spreadsheet received 5th December 2012
  - Bluetooth data:

"NG to AQ Bluetooth Data March 2012.xlsx" spreadsheet received 7th December 2012

- SKM Hutt City counts as part of the Hutt City SATURN model. Counts undertaken 17th June 2009
- UHCC counts received on 14th December 2012 from HTS group.

There was a significant amount of data cleaning required due to a number of issues:

- Camera malfunctions during the surveys.
- Misrepresentation of HCVs (inconsistent with adjacent counts)
- Where only hourly data was available (peak hour proportions of peak period vary significantly across the model area as demonstrated in the time slicing by sector discussed in Section 5.3)
- Where classified data was unavailable, total volumes only were used for validation, noting that total observed vehicle flows are compared with total PCU flows in NWSM.
- Where directional flows were counter intuitive and inconsistent with adjacent counts

The eliminated counts were all checked for consistency and sensibility checks were carried out during the model build. In areas where there was conflicting data, the TMS database and local knowledge was used to establish the reasonability of counts and eliminate faulty or incorrect counts.

### 2.3. Count processing

The WTSM link counts were consolidated and summarised to extract light and heavy vehicle counts in 15 minute resolution for counts undertaken Tuesdays to Thursdays. This count set, consisting of link counts only, provides a good spread of counts throughout the NWSM.

The identified peak hours and periods are as follows:

- AM peak: 07.30-08.30 AM period: 07.00-09.00
- Inter peak: average 11.00-13.00
- PM peak: 16.30-17.30 PM period: 16.00-18.00

Given the level of validation of the pre-estimated NWSM (see Section 7 and 8) it was decided to utilise all classified counts in the matrix estimation process. However journey times and total vehicle count data, including at the period level provides a useful validation.

- The AM peak and period uses 351 counts overall of these 94 counts are link counts with the remaining 257 counts being turn counts.
- Inter peak counts used are 305 in total with 91 of these being link counts and the remaining 214 counts are turn counts.
- PM peak and period has 353 counts overall. 91 counts are link counts and the remaining 262 counts are turn counts.

## 2.4. Signal Timings and Phasings

Signal timings and phasings have been received for the following areas:

- Wellington City received 3rd December 2012
- Porirua City received 25th February 2013
- Hutt City received 4th December 2012
- Upper Hutt City received 14th December 2012
- Signals operated on SCATS for all 4 jurisdictions received 19th December 2012

The signal timings and phasings were averaged out over the peak hour and these average times were included into the NWSM. Where signals operate in groups, such as at the Melling interchange, common cycle times have been used to ensure appropriate simulation of delays between the signals. Average signal times have been used across the peak hours. This may reflect phases that are only called once every 3 cycles (for example) with a phase that is called every cycle for 1/3 of the length to ensure appropriate reflection of signal capacity.

## 2.5. Journey Times

The following two sources provided journey times:

WTSM journey times were received via email on 13th December 2012. Spreadsheet received:

- Beca NZTA Wellington Congestion Monitoring - Corridor Results March 2011.xlsx

The WTSM journey times comprises 13 strategic travel routes with 6 of these routes being processed for model validation. In general the travel journeys are undertaken in the inbound and outbound direction for all 3 peak periods except for Porirua where the route is a circle. The travel time surveys were recorded during March 2011. These surveys have been undertaken on behalf of NZTA as part of their ongoing congestion monitoring surveys. The routes within the NWSM simulation area are as follows:

- Route 1 – Wellington Airport and Waikanae Rail Station
- Route 2 – Wellington Rail Station and Upper Hutt Rail Station
- Route 3 – SH58 between SH1 and SH2
- Route 6 – Wainuiomata and Hutt Road

The journey times were recorded for Monday to Friday with each strategic route being recorded for one run per peak each day. For the purpose of the NWSM model build the travel times from Tuesday to Thursday were processed. It is noted that the single survey run each day may or may not be representative of "typical peak hour" conditions. Further discussion of the implications of this is provided in Chapter 13.

Also, the Porirua journey times along Kenepuru Drive has not been considered in the validation of the NWSM model. Routes 3S and 3N have not been used in the travel journey validation as more detailed surveys were undertaken in March 2013 and are described below in more detail.

TEAM Traffic undertook surveys on SH58 and The Esplanade on Wednesday 6th of March 2013. The following two spreadsheets were received via email on 15th march 2013:

- SH 1 to SH 2 Journey times.xlsx
- The Esplanade Journey times.xlsx

The number of runs per direction and peak for the journey time surveys undertaken by TEAM Traffic is provided in **Table 2-1**. Due to time and budget constraints as many runs as possible within the AM, IP and PM peaks were conducted. The journey times were undertaken on Wednesday, 6th of March 2013.

**Table 2-1 Journey Time information**

| Peak | Route | Direction | Number of Runs |
|---|---|---|---|
| AM | Paremata to Lower Hutt | SE | 4 |
| AM | Lower Hutt to Paremata | NW | 4 |
| IP | Paremata to Lower Hutt | SE | 6 |
| IP | Lower Hutt to Paremata | NW | 6 |
| PM | Paremata to Lower Hutt | SE | 4 |
| PM | Lower Hutt to Paremata | NW | 4 |
| AM | Hutt Rd to Randwick Rd | E | 6 |
| AM | Randwick Rd to Hutt Rd | W | 7 |
| IP | Hutt Rd to Randwick Rd | E | 18 |
| IP | Randwick Rd to Hutt Rd | W | 17 |
| PM | Hutt Rd to Randwick Rd | E | 9 |
| PM | Randwick Rd to Hutt Rd | W | 8 |

For the purpose of the NWSM model build the minimum, maximum and average travel times have been extracted out of the data and are compared to the model outputs to evaluate how well the model replicates the current conditions.

# 3. Network construction

## 3.1. Extent of Simulation Coding

SATURN offers two levels of coding detail:

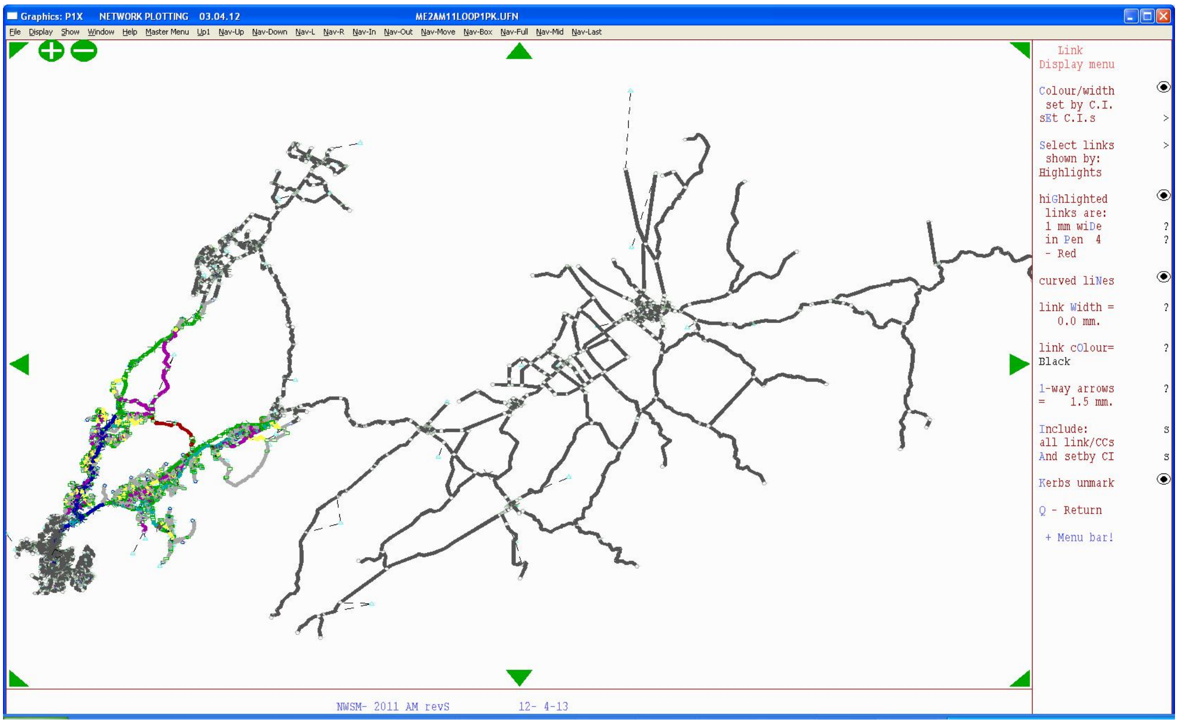
- ‘Simulation’ – including intersection detail, typically used in urban areas
- ‘Buffer’ – uses only link speed / flow relationships, typically used in rural areas

The simulation coding of the NWSM base year model extents to the following points:

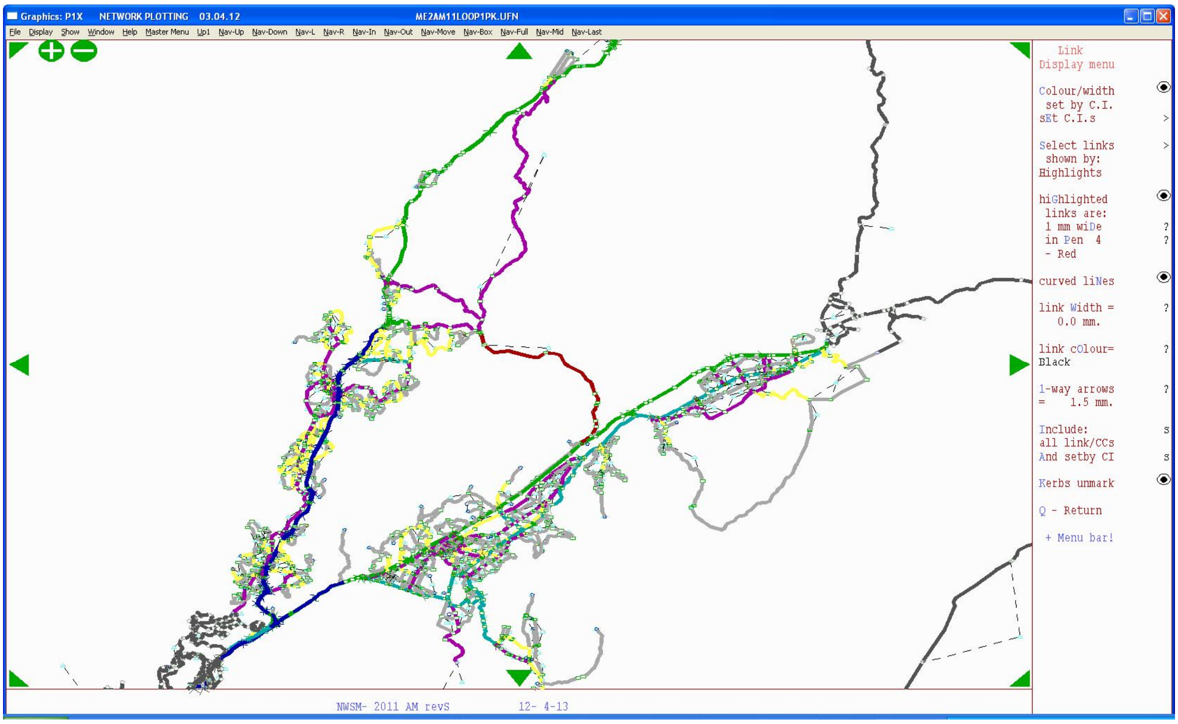
- SH2 at Mangaroa Hill Road/Fergusson Drive/River Road in the North-East
- SH1 at MacKays Crossing in the North
- SH1 at Aotea Quay in the South

The remainder of the WTSM model area has been coded as buffer network, with speed-flow relationship defined for all links modelled. This methodology allows trips from beyond the urban area to re-assign to their appropriate route under different network modelling scenarios. This approach will ensure that all links within the WTSM are modelled within the NWSM, but that capacity restraint is not applied in areas beyond Northern Wellington area and the Wellington CBD. This approach ensures that capacity constraints applied through intersection coding are incorporated within the area of interest. The limitation of simulation coding to the Northern Wellington area will also avoid unnecessarily high model run times through the reduction in simulation nodes required.

The full model area is shown in **Figure 3-1** with the simulation area shown in **Figure 3-2**.




■ **Figure 3-1 The NWSM Full Network**




■ **Figure 3-2 The NWSM Simulation Network**

### 3.2. Intersection Coding Assumptions

It is considered important to reiterate at this stage that there are two key drivers in the network coding for the NWSM:

- Production of an accurate representation of the 2011 road network that appropriately reflects the network capacity and travel times / distances
- A transparent methodology for updating the model and managing the model in the future.

A 'code book' has been produced (SATURN Modelling in Wellington: A Consistent Approach, v01c, 11th October 2011) by QTP and SKM which was referred to in the model scoping exercise as part of the model documentation. The purpose of this code book was to ensure consistency in coding practices between the sectors of the model being developed by different consultants. The code book also enables future year option models to be coded in a manner consistent with the base model. It also serves as a log of all initial saturation flow and gap acceptance assumptions for different types of intersection (signals, give-ways, roundabouts). The initial saturation flows have been developed based on the model build team's experience and with reference to TRL Research Report 67 and TRRL Supplementary Report 582. These network wide assumptions may be subject to change on an intersection by intersection basis to better reflect observed capacities and delays.

### 3.3. Link Speed-flow curves

Speed flow curves have been applied to all links, with the exception of short links coded for intersection approaches. The role of the speed flow curve is twofold:

- To account for side friction and other non intersection based delays to traffic; and
- To apply a mid link capacity restriction where the intersection capacity at either end of the link exceeds the link capacity.

Speed flow curves have been applied on a capacity index basis by road class in a manner consistent with the usage of the Greater Wellington Road network. These are based on a modified combination of DfT and Akcelik curves to allow for PCUs. Speed flow curves in the buffer area have slightly reduced

In the buffer area, speed flow curves were selected that replicated as closely as possible the volume delay functions in WTSM, with lower powers applied to links where an intersection delay was tagged in WTSM.

### 3.4. Bus Lanes and HOV lanes

HOV lanes have not been explicitly coded in the NWSM, with the HOV lanes through Mana reflected through a 25% increase in mid link capacity with intersections flaring out to two lanes as normal. This mid link capacity increase reflects the fact that both HOVs and non-compliant SOVs will be using the HOV lane, although no data specifying the precise use of these lanes is known. It is noted that should the NWSM be used for a study which requires accurate reflection of the speed and capacity of both HOV and adjacent general traffic lanes be required, then this capacity approximation would require refinement. Bus lanes have been coded as “B” coding for a peak specific bus lane on The Esplanade in Petone. The majority of bus lanes are in the buffer area of the model in Wellington CBD.

### 3.5. Network Coding Practices

Roundabouts are typically coded using SATURN type 5 (with U-turn). It is acknowledged that there are limitations to the roundabout modelling in SATURN with regards to varying turn capacities for each approach, as capacities are defined for a given approach road, rather than a specific turn. However, this is consistent with standard empirical formulae developed in the UK for assessing roundabout capacity and the coding book provides greater detail on the use of the empirical formulae for calculating approach capacities and setting appropriate minimum gap and maximum roundabout capacities in the NWSM.

At the Paremata roundabout where circulating capacity varies between 1 lane and 4 lanes with lane utilisation significantly impacting the roundabout performance, and the roundabout being of large diameter, this has been coded as a series of one way links and priority intersections. Similarly, the Mungavin roundabout spans SH1 and is considered sufficiently large enough to operate as a series of priority intersections. At the Petone off ramp, the alternate priorities at the “roundabout” have also been coded as a priority intersection.

Bottleneck nodes on motorways have been incorporated using the SATURN “Q” coding downstream of the motorway merge. This enables the delays on motorway mainlines and on-ramps to be modelled more realistically. Merge capacities at “Q” coded nodes have been consistently coded with a 10% capacity reduction over continuous lanes to account for the increased friction and vehicles merge.

Nodes are typically be coded at intersections **and** where the road characteristics change (for example at the point at which the number of lanes increase on approach to signals). This methodology results in improved simulation and representation of queues. The stacking capacity on a particular link is calculated automatically by SATURN rather than relying on a manual specification of stacking capacity which can be overlooked in option coding. We refer to such nodes as ‘pre-nodes’.

Link distances are calculated from node co-ordinates including allowing for curved links through the specification of additional co-ordinates of points along a curved link via a ‘GIS’ curve file.

As part of the model build process it became evident that many of the shorter links in the network, either inherited from the WTSM network, or introduced as pre and post nodes were resulting in simulation convergence issues with significant observed queuing blocking back through these short links resulting in unstable levels of delay. Manual overwrites of larger stacking capacities have been introduced to alleviate this issue, including the breaking of link chains by insertion of a negative stacking capacity.

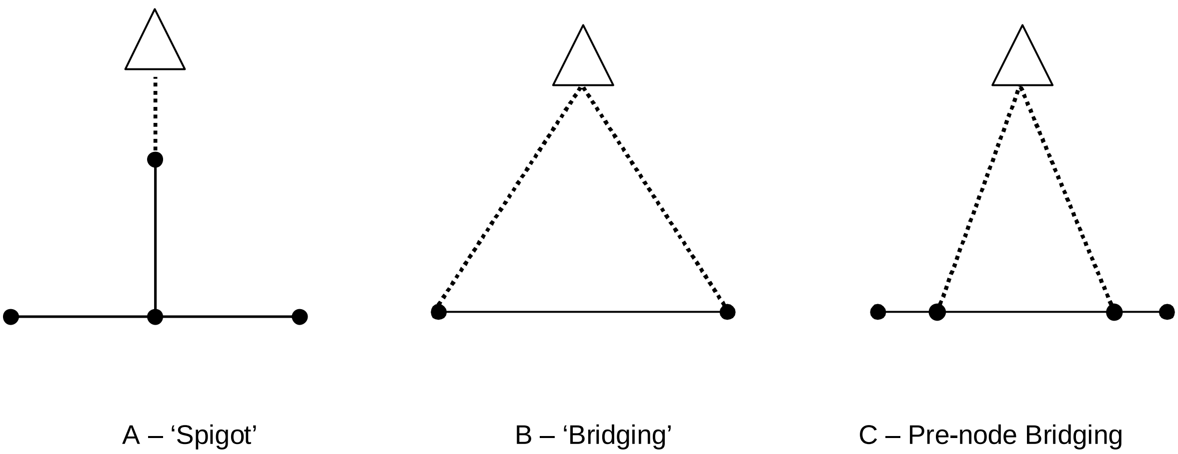
A single network “DAT” file is provided as opposed to using “$INCLUDE” files.  This has been found to be the most transparent way of ensuring that all coding alterations are managed centrally to help minimise any introduced errors in coding.

Peak period “DAT” files are all generated from a “Master” “DAT” file with all peak specific coding in the “Master” file preceded with a *AM, *IP or *PM so that the appropriate peak can be selected using a text editor.  The “preamble” of the master file also requires updating depending on whether the network is peak hour (LTP and LRTP set to 60), pre or post load (LTP and LRTP set to 30). For the SATTPX runs, matrices are specified in the “DAT” file, whereas for PASSQ runs both the matrices and the PASSQ file are defined in the batch process.

All signal timings have been set with an initial estimate based on collated SCATS data but with optimisation constraints generally placed at a ±2 second tolerance when SIGOPT is invoked.

## 3.6. Zone Loading Coding Practices

Different modellers employ different zone coding techniques for a variety of reasons.  The choice of zone loading coding is a trade-off between improving model accuracy and transparency locally and the additional effort in introducing additional simulation nodes and the implications this has on model run times and size of licence required. Three different practices in coding zone loading are illustrated below:




- **Figure 3-3: Zone Loading Coding Practices**

Method A, the ‘spigot’ method, implies greater precision of zone loading location, but more importantly, does not lead to an under-reporting of link flows, as occurs with method B.  However, the method requires an additional two simulation nodes over method B, which has significant implications on model run times and size of model software required.  It is also important that the capacity at the node where traffic joins the full network is appropriately coded if the spigot represents a number of loading locations (such as multiple driveways) which would not receive the same delays as if they joined the network at a single point.

Method B is quick to implement and minimises the number of nodes required but leads to an under-reporting of link flows as all volumes to and from the zone do not pass through the link being bridged. In the CBD, where most links currently have connections to zones, this would lead to a significant under-reporting of link flows and leads to ambiguity where traffic counts used in model calibration / validation are specified for bridged links.

Method C is a useful compromise where pre-nodes are available (e.g. at signalised intersections) as it requires no additional simulation nodes and link counts may be specified on the short links either side of the link being bridged.

The model build team have agreed a hierarchical approach to zone loading coding:

1) Where car-parks or areas with a single point of access (large cul-de-sacs) are modelled as a zone, method A, 'spigots' is preferred.
2) Where zones do not represent well defined 'point' loads, method C, 'pre-node bridging' is preferred.
3) In other cases, method C 'bridging' will be applied, but only where two-way zonal demands do not exceed 20% of the two-way link volume and the link being bridged is not a link with an observed count being used for model calibration or validation.

## 3.7. Assignment and Simulation Parameters

During the SATURN network build, assignment and simulation process a large number of network parameters are used.  Parameters which remain unspecified retain their default values whereas parameters with values specified in the DAT file (whether these are default values or not) are listed below:

**Table 3-1: Network Parameters**

| Use | Parameter | Description | Notes |
|---|---|---|---|
| **Error suppression** | ERRYES(25)=F | An input distance of zero is replaced by the crow-fly value | These warnings are inconsequential and a result of the use of capacity indices and SHANDY. |
| | ERRYES(102)=F | Speed/time set to zero but the distance is non-zero | |
| | ERRYES(170)=F | An input simulation link time/speed 0.0 replaced by speed flow curve value | |
| | WRIGHT = F | Upgrades some warnings to semi fatal errors (these are checked manually) | |
| **Time-Slice Demand Parameters** | TIJFIL(1) = 'AM1hr_fct_Prior3_prepre.UFM' | SATTPX input trip matrices, matrices for PASSQ runs are defined in the batch file. | Note that the "prepre" matrix is only required in the AM peak. |
| | TIJFIL(2) = | | |

| Use | Parameter | Description | Notes |
|---|---|---|---|
| | 'AM1hr_fct_Prior3 _pre.UFM' | | |
| | TIJFIL(3) = 'AM1hr_fct_Prior3 _pk.UFM' | | |
| | TIJFIL(4) = 'AM1hr_fct_Prior3 _post.UFM' | | |
| | LTP(1) = 15 | Length of time period simulated (noting all inputs and outputs are provided as hourly equivalents) | |
| | LTP(2) = 30 | | This is period 1 in the PM peak |
| | LTP(3) = 60 | | This is period 2 in the PM peak |
| | LTP(4) = 30 | | This is period 3 in the PM peak |
| | LTP = 60/30 | Length of time period simulated, peak hour and pre/post loads respectively | Only used in PASSQ runs |
| | LRTP = 60 | Length of the "random" time period as used for calculating random delays at traffic signals and/or major arms at priority junctions | |
| **User Class and Count Files** | NOMADS = 2 | Number of separate user classes assigned | |
| | MCCS = 3 | Number of count fields (total PCUs, light vehicles and HCVs, in PCUs) | |
| | BUSPCU = 3 | PCU equivalent of a bus | |
| **Gap parameters** | GAP=4 | Gap acceptance at priority intersections | |
| | GAPR=2 | Gap acceptance at roundabouts (overwritten at individual intersections. | |
| | GAPM=2 | Gap acceptance at merges | |
| | APRESV=0.25 | Propensity for mainline vehicles to "move over" to accommodate merging traffic. | |
| **Assignment Options** | KOMBI = 5 | After "KOMBI" assignment/simulation loops the assigned flows are. averaged with those from the previous assignment in order to avoid | |

| Use | Parameter | Description | Notes |
|---|---|---|---|
| | | oscillations | |
| | AUTOK = F | KOMBI is fixed rather than invoked by SATURN | |
| | SPIDER = T | Aggregated network is used within the assignment | |
| **Simulation Options** | QUEEN = T | Blocking back is based on the queue at the end of the time period (not the average) | In the IP peak QUEEN = F |
| | BB109 = T | Blocking back is calculated using a link chain stacking capacity | |
| | BBKING = 0.70 | Blocking back is introduced when Q/S reach 0.7 (rather than 1) | |
| | PMAX = 5 | The maximum power used in the simulation flow delay curves at intersections | |
| | ALEX = 609 | Length of a queued vehicles (including spacing) | |
| | SIGOPT = T | Signal optimisation is invoked | Not invoked during matrix estimation process |
| | SATOFF = T | Offset optimisation is invoked | Not invoked during matrix estimation process |
| | NIPS = 1 | Number of interactions of signal optimisation | Not invoked during matrix estimation process |
| | MANOFF = 10526 | The reference node for all offsets | Not invoked during matrix estimation process |
| | MYTVV = 5 | SATURN Equi-saturation Mark 2 signal optimisation algorithm is used | Not invoked during matrix estimation process |
| | FREDDY = F | No output RGS file of signal settings is produced | Not invoked during matrix estimation process |
| **General Network Parameters** | ATLAS = F | Nodes for which co-ordinates are specified but that are not linked to others are not included | |
| | SPEEDS = T | Speeds input in node coding rather than | |

| Use | Parameter | Description | Notes |
|---|---|---|---|
| | | travel times | |
| | AUTOX = T | External nodes are coded automatically if not coded explicitly | |
| | NOTUK = 1 | Opposite right-turning vehicles, for example at traffic signals do not interfere with one another | |
| | SHANDY = T | Crow fly distances are used for buffer and simulation links rather than being input in the coding (this includes distances along curves defined in GIS file) | |
| | CROWCC = T | Crow fly distances are used for centroid connectors if not input directly | |
| **Bus Routes** | EZBUS = T | Free format permitted in bus route coding (66666s) | |
| | FOZZY = T | SATNET will interpolate un connected nodes in bus routes, use with caution and check routing! | |
| | UPBUS = T | Bus routes start at first node specified | |
| **Gap Acceptance** | GAP = 4 | Default give way gap acceptance (note this can be overwritten at individual nodes or turns) | |
| | GAPM = 3 | Default merge gap acceptance (note this can be overwritten at individual nodes) | |
| | GAPR = 2 | Default roundabout gap acceptance (note this can be overwritten at individual nodes) | |
| | *XFILE | No turn specific gaps defined 'GAPS.Dat' | |
| **Convergence Criteria** | KONSTP = 1 | Stopping criteria based on percentage gap value | |
| | STPGAP = 0.1 | Critical gap used in stopping criteria | |
| | NITA = 20 | Maximum number of assignment iterations | |
| | NITS = 30 | Maximum number of simulation iterations | |
| | NITA_M = 4 | Minimum number of assignment iterations | |
| | NITA_S = 100 | Maximum number of assignment iterations in post convergence assignment | |

| Use | Parameter | Description | Notes |
|---|---|---|---|
| | MASL = 40 | Maximum number of assignment simulation loops | |
| | PCNEAR = 1.0 | Percentage change in flows judged to be "near" in successive assignments. | Note that with KNSTP=1 these parameters are not used but have been retained should the user choose to alter KONSTP in the future. |
| | ISTOP = 99 | The loops stop automatically if ISTOP % of the link flows change by less than "PCNEAR" percent from one assignment to the next for "NISTOP" successive loops. | |
| | NISTOP = 3 | See ISTOP | |
| **Post 108 recommended defaults** | UFC109 = T | UFC files are constructed from the final assignment rather than the SAVEIT assignment | |
| | RTP108 = T | Length of random delays are set by "estuary" (all turns use all available lanes) | |
| | MONACO = T | The number of pcus which are required to "sit at the head of a blocked queue" is set to TAX + 1 | |
| | AUTNUC = T | Number of time-units into which the cycle is divided in the simulation is calculated automatically | |
| **Generalised Cost** | PPM = 1.0 | Time weighting in generalised cost | Overwritten in 88888s section, set per user class |
| | PPK = 0.5 | Distance weighting in generalised cost | Overwritten in 88888s section, set per user class |

# 4. Zone Structure

## 4.1. General Principals of Zone Disaggregation

The 2011 WTSM contains 228 zones. A more refined demand matrix, with smaller vehicular zone loadings is one of the key elements for the NWSM model. An average zonal flow of around 100 vehicles per hour has been identified as a pragmatic target for the 'simulation' area covering the Northern Wellington area, given the aspiration to be able to model network flows with around this accuracy in the majority of cases. Therefore, WTSM zones have been split, or 'disaggregated' to approximately this resolution, leaving a total of 650 zones within the NWSM model. The following principals for disaggregation have been used:

- Of the 110 WTSM zones that lie within the NWSM simulation area, disaggregate to the Wellington Public Transport Model (WPTM) zone system as a minimum.
- Using 100 vehicles/hour as a guide, zones were then further spilt to result in 521 zones within the simulation area. Note that 100 vehicles per hour was a guide only, with some large traffic generators (Johnsonville Mall for example not being required to be split due to the minimal number of entrances/exits to the mall).
- Meshblock boundaries were typically used except where there was sufficient traffic generation/attraction in combination with multiple zone access/egress point to cover with a meshblock correspondence. Areas where meshblocks were split include Hutt city area (4 zones), Mana Esplanade (1 zone), at the Paremata roundabout (1 zone), adjacent to the Dowse interchange (1 zone), Paekakariki (1 zone) and the High Street Hospital and radiology department (1 zone) (discussed further in Section 5).
- The WTSM zoning system (and connectors) was retained in the buffer area with the exception of WTSM zone 39 (Aotea Quay) which was split 50/50 to include an additional zone (and associated connectors) to reflect the Inter-islander ferry terminal. This was done to help improve the split between SH1 and Hutt Road south of Ngauranga.
- Zone are named consistently with the following process:
  - WTSM zone and 1 in buffer area, so WTSM zone XX becomes NWSM zone XX1 etc.
  - WPTM zone naming in the simulation where not split further in NWSM, which extends the same convention as above, i.e. WTSM zone YY becomes WPTM zone YY1 and YY2
  - Extension of the WPTM convention where WPTM zones are split, i.e. WTSM zone ZZ becomes WPTM zones ZZ1 and ZZ2 and NWSM zones ZZ1, ZZ2, ZZ3, ZZ4 and ZZ5.

The adopted one structure is included in **Appendix A**.

# 5. Demand Disaggregation

## 5.1. Disaggregation Process

The process of 'disaggregating' (or splitting) of Regional model demands to sub-regional models is well established in New Zealand, having been applied to the Auckland , Christchurch and previous revisions of the Wellington Regional Models for refinement of demands as inputs into local SATURN models.

The WTSM zones align with Statistics New Zealand meshblock boundaries and comprise of one or more meshblocks. The zone splitting process identifies the desired number of NWSM model zones that each WTSM model is to be split to, based on the principals described within the previous Chapter.

The process of identifying the proportions by which the vehicle trip ends for the WTSM zones are split to the NWSM zones is based on simplistic trip generation models which estimate the vehicle trip ends from land-use data for each of the NWSM sub-zones and is summarised as follows:

- Obtain WTSM model demands, by trip purpose and vehicle type, for each of the model periods within the model simulation area (AM Peak, Interpeak, PM Peak). The simulation area was used to exclude anomalous generators such as the CBD (multiple car parks) and airport which are not generally consistent with the type of trip generation in the simulation area.
- Identify land use data (households and jobs) for each WTSM model zone. Additional land use categories such as educational role and employment and household by type were initially considered but these provided little additional accuracy to just these two categories. There were also issues with the availability of education data at a meshblock level generated for the WTSM build.
- Determine linear regression models which closely replicate demands to and from WTSM (trip ends) by purpose, period and direction based on this land-use data (households, jobs) as described further below
- Identify land use data (households and jobs) for each NWSM zone as a summation of the meshblocks within that zone. Note that for the NWSM zones that were smaller than a meshblock (shown in **Table 5-1**) manual splits were calculated based upon site walkovers.

- **Table 5-1 Split Zones**

| | | | Light | | | | | | HCV | | | | | | How splits derived |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | AM | | IP | | PM | | AM | | IP | | PM | | |
| WTSM zone | Current NWSM | NWSM | O | D | O | D | O | D | O | D | O | D | O | D | |
| 178 | 1786 | 1786 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | area size |
| | | 1787 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | |
| 182 | 1821 | 1821 | 0.20 | 0.57 | 0.80 | 0.80 | 0.57 | 0.20 | 0.57 | 0.20 | 0.20 | 0.20 | 0.57 | 0.20 | site walkover |
| | | 1825 | 0.80 | 0.43 | 0.20 | 0.20 | 0.43 | 0.80 | 0.43 | 0.80 | 0.80 | 0.80 | 0.43 | 0.80 | |
| 179 | 1792 | 1792 | 0.23 | 0.63 | 0.56 | 0.56 | 0.50 | 0.13 | 0.23 | 0.63 | 0.14 | 0.14 | 0.50 | 0.13 | site walkover |
| | | 1793 | 0.77 | 0.38 | 0.44 | 0.44 | 0.50 | 0.87 | 0.77 | 0.38 | 0.86 | 0.86 | 0.50 | 0.87 | |
| 181 | 1811 | 1812 | 0.25 | 0.15 | 0.15 | 0.15 | 0.25 | 0.20 | 0.25 | 0.15 | 0.15 | 0.15 | 0.25 | 0.20 | site walkover |
| | | 1811 | 0.15 | 0.25 | 0.25 | 0.25 | 0.25 | 0.20 | 0.15 | 0.25 | 0.25 | 0.25 | 0.25 | 0.20 | |
| | | 1813 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | |
| | | 1814 | 0.25 | 0.40 | 0.40 | 0.40 | 0.35 | 0.30 | 0.25 | 0.40 | 0.40 | 0.40 | 0.35 | 0.30 | |
| | | 1815 | 0.25 | 0.10 | 0.10 | 0.10 | 0.05 | 0.20 | 0.25 | 0.10 | 0.10 | 0.10 | 0.05 | 0.20 | |
| 110 | 1102 | 1102 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | area size |
| | | 1107 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | |
| 115 | 1152 | 1152 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | area size |
| | | 1155 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | |
| 193 | 1934 | 1934 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | carpark assumption |
| | | 1938 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | |
| 105 | 1054 | 1054 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | carpark assumption |
| | | 1057 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | |
| 170 | 1705 | 1705 | 0.50 | 0.67 | 0.60 | 0.67 | 0.67 | 0.75 | 0.50 | 0.67 | 0.67 | 0.67 | 0.60 | 0.75 | site walkover |
| | | 1708 | 0.50 | 0.33 | 0.40 | 0.33 | 0.33 | 0.25 | 0.50 | 0.33 | 0.33 | 0.33 | 0.40 | 0.25 | |

- Apply linear regression models by peak, purpose, and direction to estimate trip ends for each NWSM zone
- Calculate the contribution of each NWSM zone to the total trip ends for each WTSM zone (as a fraction of the total trip ends based on summing each of the NWSM zones trip ends that belong to a parent WTSM zone)
- Apply the calculated fractions for each NWSM zone to the WTSM zone to yield the disaggregated NWSM model vehicle demand matrices.

We note that the total number of trips within the 'parent' WTSM zone is unchanged by this process (i.e. the sum of the disaggregated 'child' NWSM trips for each WTSM zone is equal to the trips to/from the parent WTSM zone, prior to any processing). It also follows, therefore, that the total number of trips in the disaggregated NWSM matrices will be the same as the total number of trips within the WTSM matrices. Note that this disaggregation process will transform a significant number of WTSM intra zonal trips into inter zonal trips. This will implicitly produce a not insignificant number of short trips that previously had zero length in the WTSM model.

Disaggregation of future year demands will use exactly the same process if land use forecasts are available at meshblock level. In the absence of meshblock level data, disaggregation factors calculated in 2011 will be used.

## 5.2. Deriving The Trip End Regression Equations

The land-use data used in the regression analysis is:

- Total households
- Total employment

Compared to the segmentation of data used within the WTSM trip generation model, the above categories are highly simplified. However, this simplistic approach ensures ease of analysis and transparency of process, which the disaggregation process easily implemented within a standard spreadsheet package and all inputs clearly visible.

## 5.3. Time-Slicing

The AM and PM peak two-hour peak period demands have been split to a number of time-slices. The two-hour periods have been split to represent a one-hour peak-hour model, with pre-peak and post-peak periods either side. In the calibration process, the inclusion of a 15 minute “pre-pre” peak to reflect the build up of queues on SH2 at Petone prior to 7.00am was required. The derivation of such factors to split the two-hour peak period demands is described within Chapter 8.

# 6. Calibration and Validation Process

## 6.1. Outline

The NWSM was calibrated through parallel adjustment of both vehicular demands and model network. The initial construction of the model network using guidance set out in the NWSM code book ensured that links and intersections throughout the model area were coded in a consistent manner.

The stages of model demands calibration and validation are set out below which occurred in parallel to the network calibration. Note that the one-hour matrices generated at each stage of the calibration process are given an identifier which is referenced throughout this document:

1) Disaggregation of WTSM demands to the NWSM zone system creating average hourly demands (to create **Prior1**)
2) Comparison of vehicular demand flows in the average AM, PM and inter peak hours across screenlines dividing the sectors illustrated in **Figure 6-1** using **Prior1** assignments using the following screenlines:
    a. Northern screenline across SH1 and Paekakariki Hill Road
    b. Southern Screenline across Hutt Road and SH1 south of Ngauranga
    c. P2G screenline across SH58 and SH2 east of Ngauranga
    d. Hutt River screenline between Waione Bridge and Kennedy Good Bridge.
    e. North east screenline across SH2 and Eastern Hutt Road north of SH58
3) Factoring of **Prior1** demands at a sector to sector level to create average hourly demands adjusted for differences across the screenlines between sectors (see **Section** 7). Note that since many sector to sector movements involve the crossing of more than one screenline, judgement has been used to average (or otherwise) sector to sector factors to account for the discrepancies on individual screenlines. The output average hourly matrices produced at this stage are labelled **Prior2**.
4) Peak hour factors were developed at a sector level by assessing the traffic profiles across the screenlines used in the global sector factoring. Peak hour demands as a proportion of average hourly demands were then generated for the AM and PM peak hours (labelled **Prior3,** see **Section 8**). Factors to create pre peak and post peak hour matrices from the peak hour were also created at this stage.
5) The final step was automated matrix adjustment through the use of SATME2 to create **ME2Loop5** (denoting 5 loops of matrix estimation, outlined in **Section 9**).

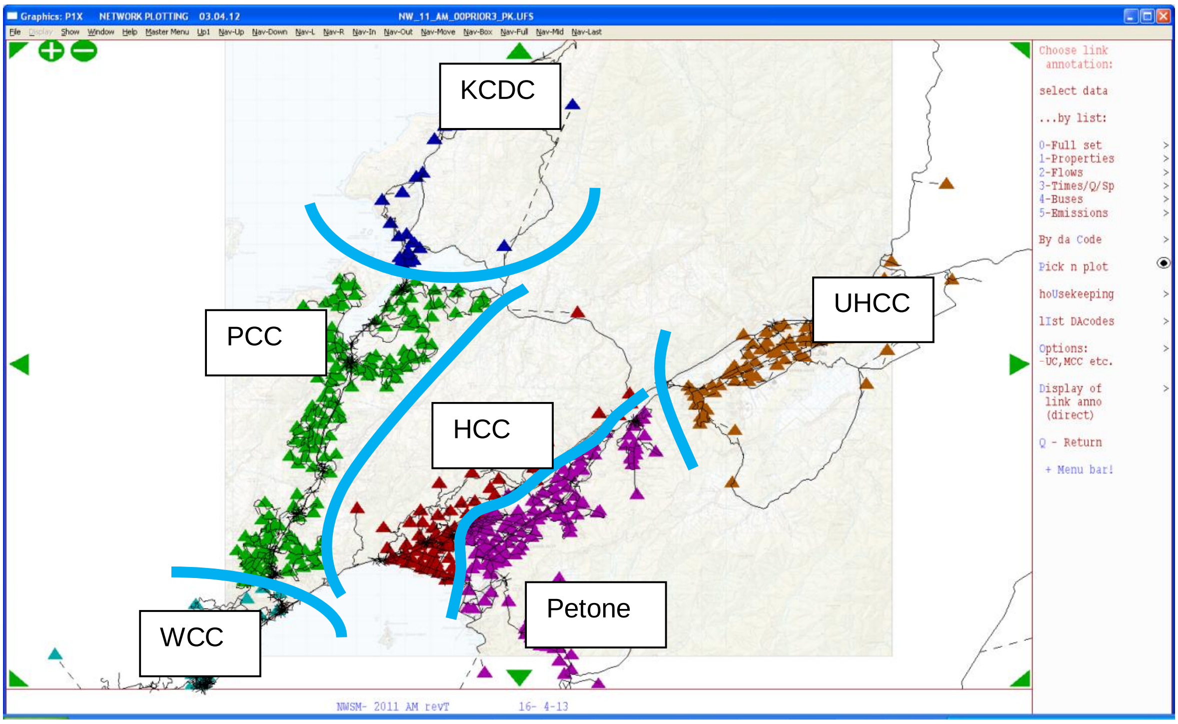



Figure 6-1: NWSM Sectorisation

## 6.2. Calibration and Validation

As discussed in Section 2, there were significant issues with count consistency as may be expected with data from multiple sources collected over an extended period. Whilst the initial intention had been to retain counts for model validation, it was not considered that there were sufficient counts available to enable this to occur. All counts have therefore been used in the matrix estimation process. Whilst a significant amount of data cleaning has been undertaken, it is acknowledged that there will still be some areas where the model appears to not reflect observed counts well will be due to count inconsistencies.

# 7. WTSM Demand Adjustment

## 7.1. NWSM Sector and Screenline Design

Prior to applying matrix estimation to 'correct' discrepancies between modelled and observed traffic volumes on a count-by-count basis, it is good modelling practice to identify any underlying trends contributing to discrepancies at a more regional or global level. For this reason, a new set of 'sectors' and 'screenlines' were developed for the NWSM build that segregate the modelled area into a number of distinct regions.

It was considered necessary to develop these screenlines to capture a number of features of Wellington trip making patterns identified at the scoping stage:

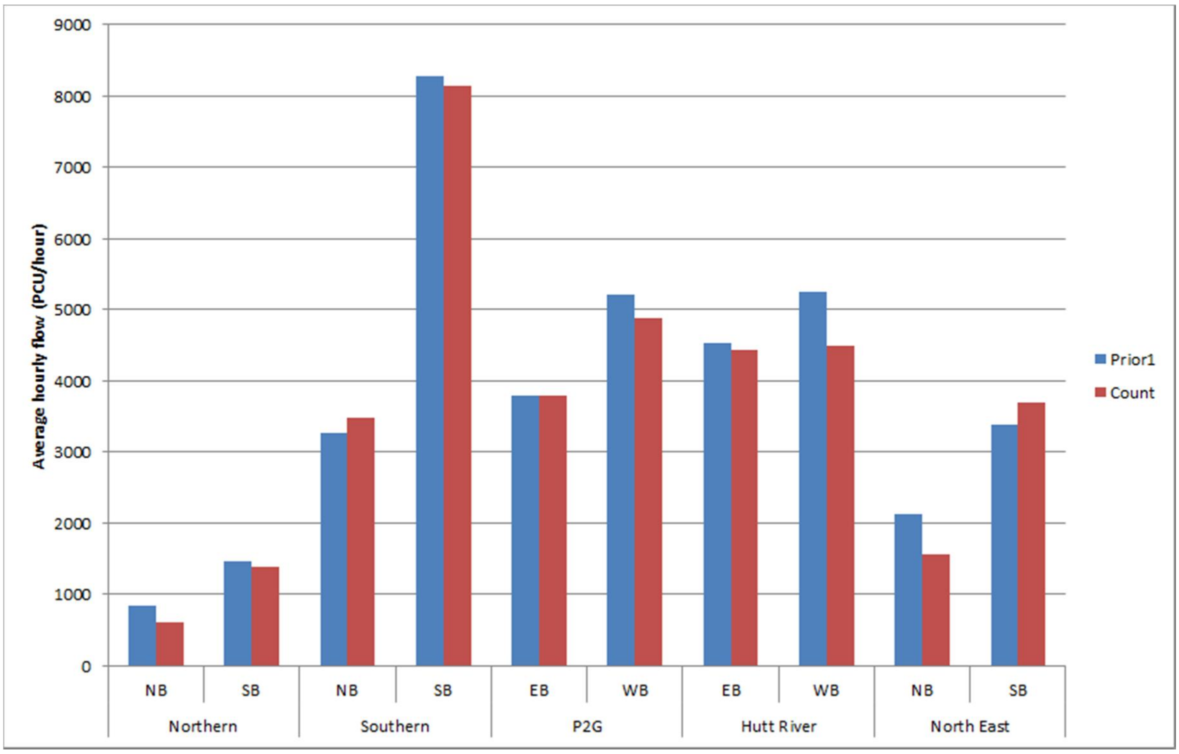
- Both the previous Transmission Gully SATURN model build and the Wellington Transport Model (SATURN) had highlighted the poorer reflection of WTSM of turn counts at the Ngauranga interchange, including the critical Petone to Grenada movements. It was therefore important to include an east-west screenline.
- Due to the size of the NWSM, with significant tidality of flows to and from Wellington City, earlier peaks in traffic exist for longer distance trips.
- A simplified sector system was desirable for the purpose of factoring demands, following strong linear features wherever possible
- The significant delays around the Petone interchange begin at the start of the AM peak hour (7.30am) so having a sector to the east of the Hutt River enabled appropriate scaling of the pre-peak demands here.

The resulting sector and screenlines are illustrated in **Figure 6-1**. The count locations forming the screenlines largely duplicate those from WTSM but the counts are grouped together slightly differently and supplemented with additional data where required

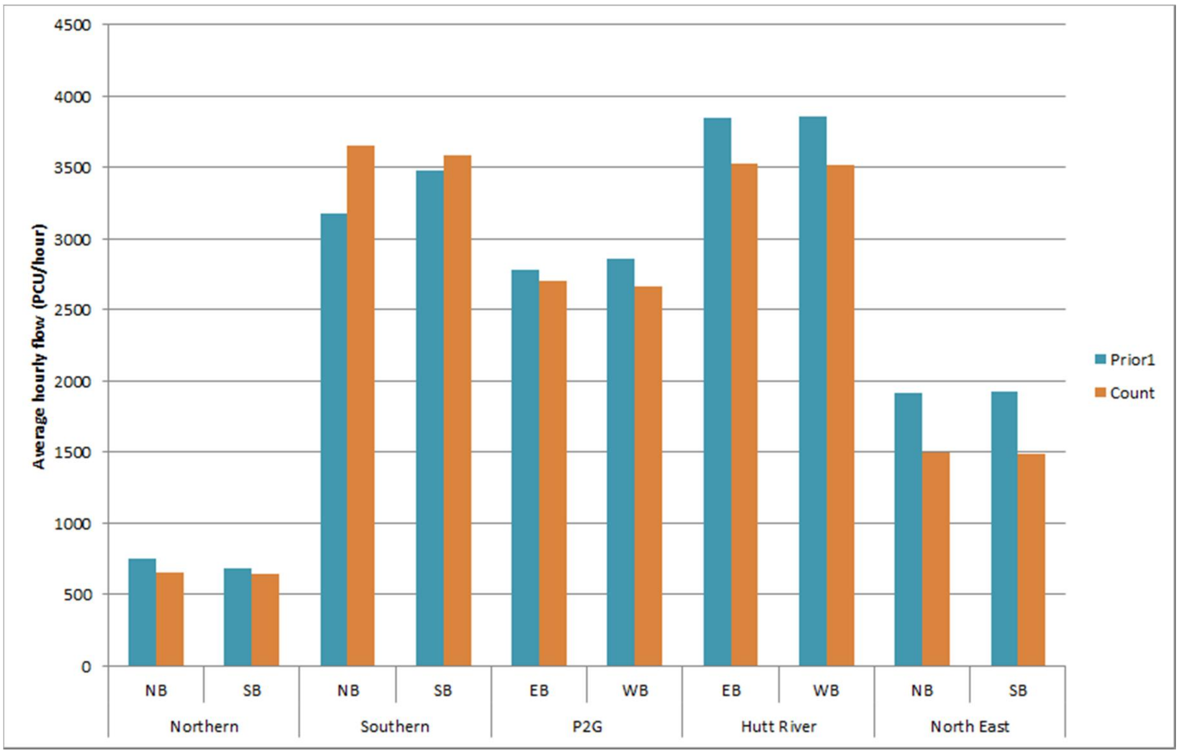
## 7.2. 'Raw' WTSM Demand Screenline Count Comparison

As introduced in the previous chapter, the first step in refining WTSM demands was to compare 'raw' WTSM demands assigned in the NWSM to the NWSM screenline counts. The 'raw' NWSM demands are an average hour and so demand flows are used to ensure that bottlenecks in the peak hour do not influence the flows between sectors. Factoring to develop peak hour and peak shoulder demands is discussed in **Section** 8).

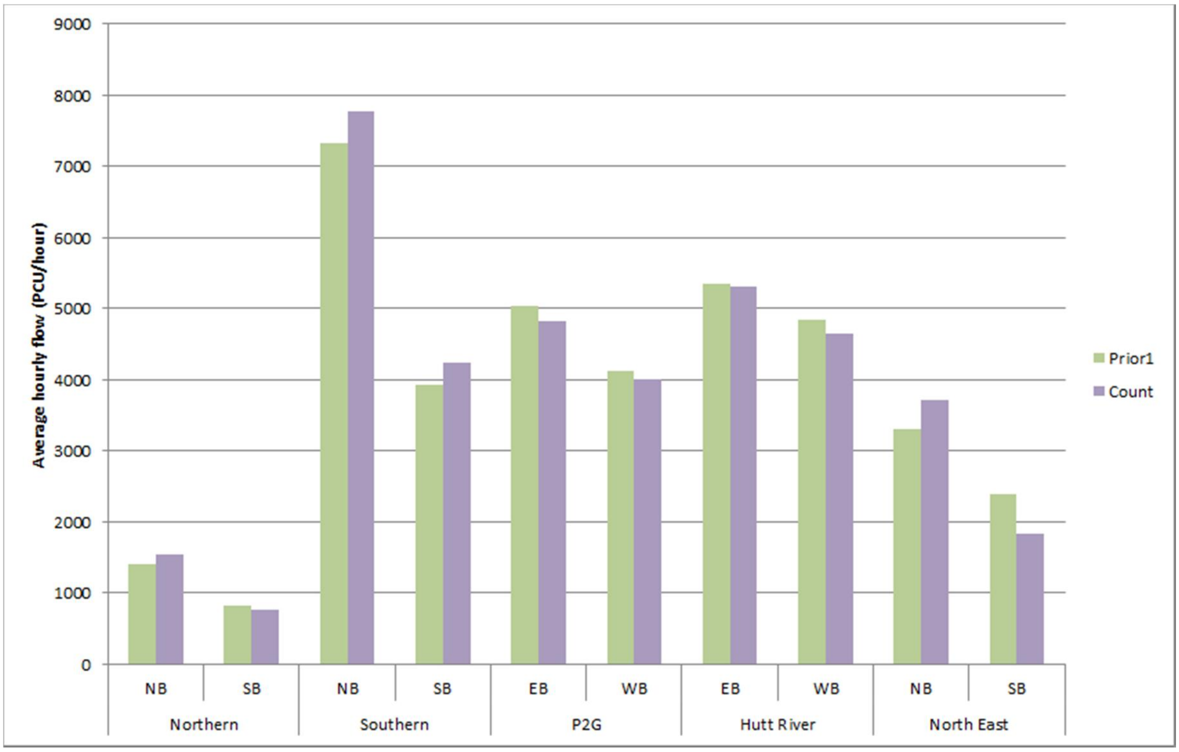
The following figures illustrate the goodness of fit of modelled traffic volumes to the observed NWSM screenline counts, prior to any adjustment.




- **Figure 7-1: NWSM Screenline Count Comparison with Prior1 Demands - AM Peak Period**



- **Figure 7-2: NWSM Screenline Count Comparison with Prior1 Demands - Interpeak Period**




- **Figure 7-3 NWSM Screenline Count Comparison with Prior1 Demands - PM Peak Period**

These graphs illustrate generally a very good level of correlation between the Prior1 modelled demands and the observed data at the screenline (and average hourly) level. There is no overarching over or underestimation of modelled flows compared to observed which indicates likely value in sector to sector factoring rather than at a global level.

Key discrepancies for adjustment at the screenline level prior to undertaking matrix estimation are:

- Both P2G and Hutt River westbound in the AM peak are overestimated by the model
- The Hutt River screenline is overestimated in both directions in the inter peak.
- There is underestimation of the northbound flow south of Ngauranga in the inter peak.
- Northbound flows are underestimated in the PM peak at both the southern and northwest screenlines.
- Southbound flows are overestimated in the PM peak at the northeast screenline.

The presentation of the correlation between modelled and observed traffic volumes on the NWSM screenlines provided here is to illustrate the likely benefit of factoring demands at the sector level as the first stage of the demand calibration process.

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## 7.3. Screenline Adjustment Factors

Screenline adjustment factors were developed and applied to bring average hourly modelled flows to within about 5% of observed volumes. These factors were developed by first attempting to make consistent adjustments to sector to sector movements which logically cross a particular screenline, but only for the movements that wouldn't adversely affect another screenline.

The point to note with this process is that it is a high-level adjustment of demand patterns of relatively small scale to correct for trends in screenline errors inherited from the regional model. It is a logical, more transparent process than sector changes arising purely from matrix estimation alone. Both the SATURN manual and the Project Team agree that logical, more global adjustment to demands as input to the matrix estimation process is preferable to potentially greater changes in demands being affected by the matrix estimation process if no adjustment were made to the disaggregated WTSM demands.

The resulting factors from this process which have been applied are provided in the following tables:

- **Table 7-1: Sector Demand Adjustment Factors - AM Peak Period**

| Sectors | KCDC | PCC | WCC | Petone | HCC | UHCC |
|---|---|---|---|---|---|---|
| KCDC | 1.0000 | 0.9500 | 0.9500 | 0.9500 | 0.9500 | 0.7400 |
| PCC | 0.7200 | 1.0000 | 1.1000 | 1.0000 | 1.0000 | 0.7400 |
| WCC | 0.8950 | 1.0700 | 1.0000 | 1.0700 | 1.0700 | 0.9050 |
| Petone | 0.7200 | 0.9400 | 1.1000 | 1.0000 | 0.7500 | 0.7400 |
| HCC | 0.7200 | 0.8500 | 1.1000 | 0.8500 | 1.0000 | 0.7400 |
| UHCC | 0.7200 | 1.0900 | 1.0900 | 1.0900 | 1.0900 | 1.0000 |

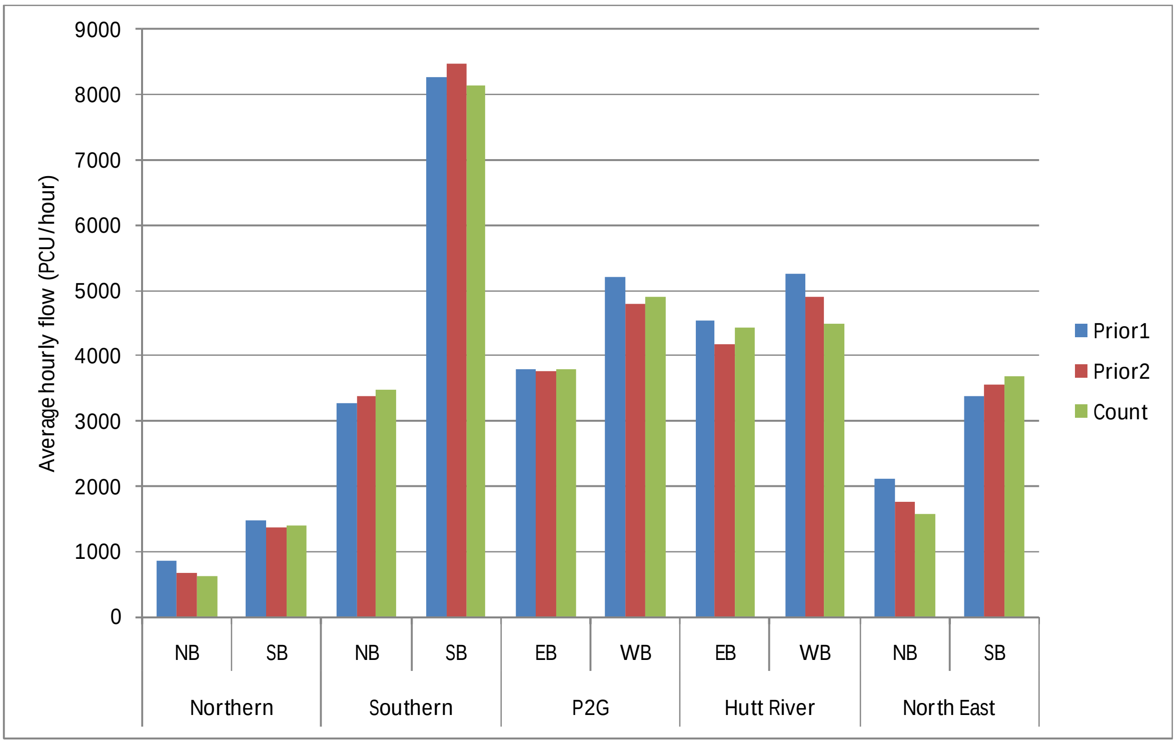
- **Table 7-2: Sector Demand Adjustment Factors - Interpeak Period**

| Sectors | KCDC | PCC | WCC | Petone | HCC | UHCC |
|---|---|---|---|---|---|---|
| KCDC | 1.0000 | 0.9400 | 0.9400 | 0.9400 | 0.9400 | 0.7800 |
| PCC | 0.8700 | 1.0000 | 1.0300 | 0.9700 | 0.9700 | 0.7800 |
| WCC | 1.0100 | 1.1500 | 1.0000 | 1.1500 | 1.1500 | 0.9650 |
| Petone | 0.8700 | 0.9300 | 1.0300 | 1.0000 | 0.9200 | 0.7800 |
| HCC | 0.8700 | 0.9100 | 1.0300 | 0.9100 | 1.0000 | 0.7800 |
| UHCC | 0.8200 | 0.7700 | 0.7700 | 0.7700 | 0.7700 | 1.0000 |

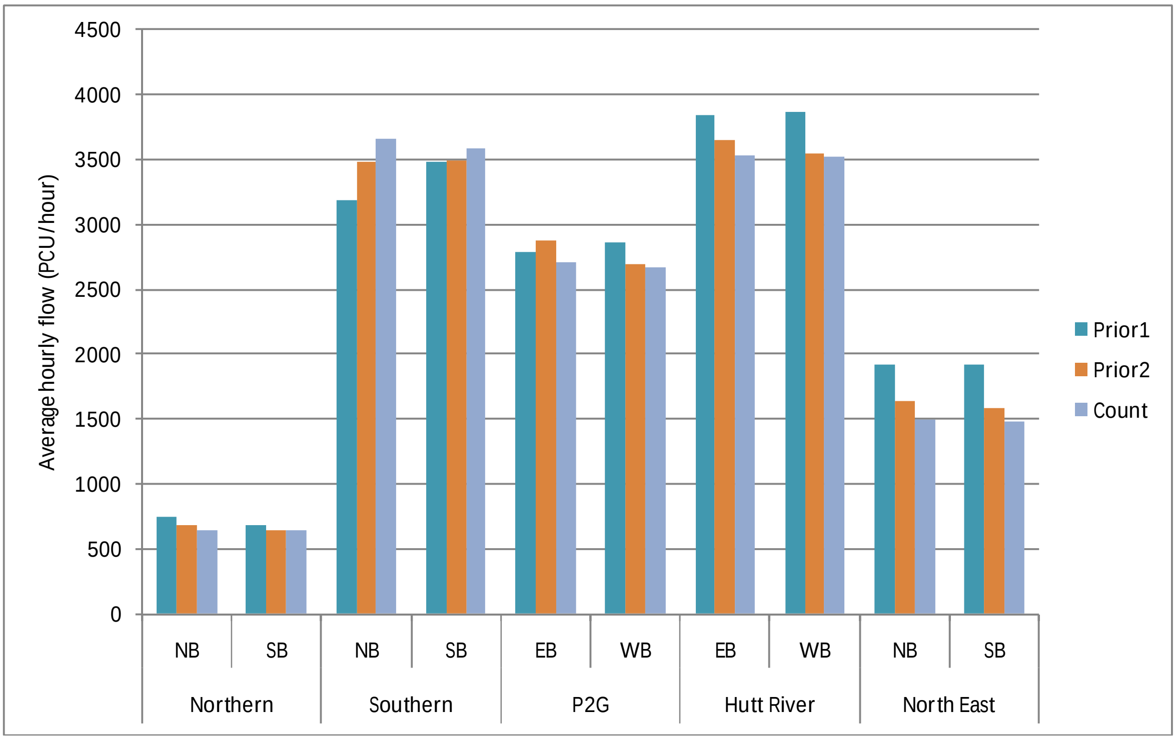
### Table 7-3: Sector Demand Adjustment Factors - PM Peak Period

| Sectors | KCDC | PCC | WCC | Petone | HCC | UHCC |
|---|---|---|---|---|---|---|
| KCDC | 1.0000 | 0.9400 | 1.0100 | 0.9400 | 0.9400 | 1.1200 |
| PCC | 1.1100 | 1.0000 | 1.0800 | 0.9600 | 0.9600 | 1.1200 |
| WCC | 1.1100 | 1.0600 | 1.0000 | 1.0600 | 1.0600 | 1.1200 |
| Petone | 1.1100 | 0.9700 | 1.0800 | 1.0000 | 0.9900 | 1.1200 |
| HCC | 1.1100 | 0.9600 | 1.0800 | 0.9600 | 1.0000 | 1.1200 |
| UHCC | 0.9400 | 0.7700 | 0.7700 | 0.7700 | 0.7700 | 1.0000 |

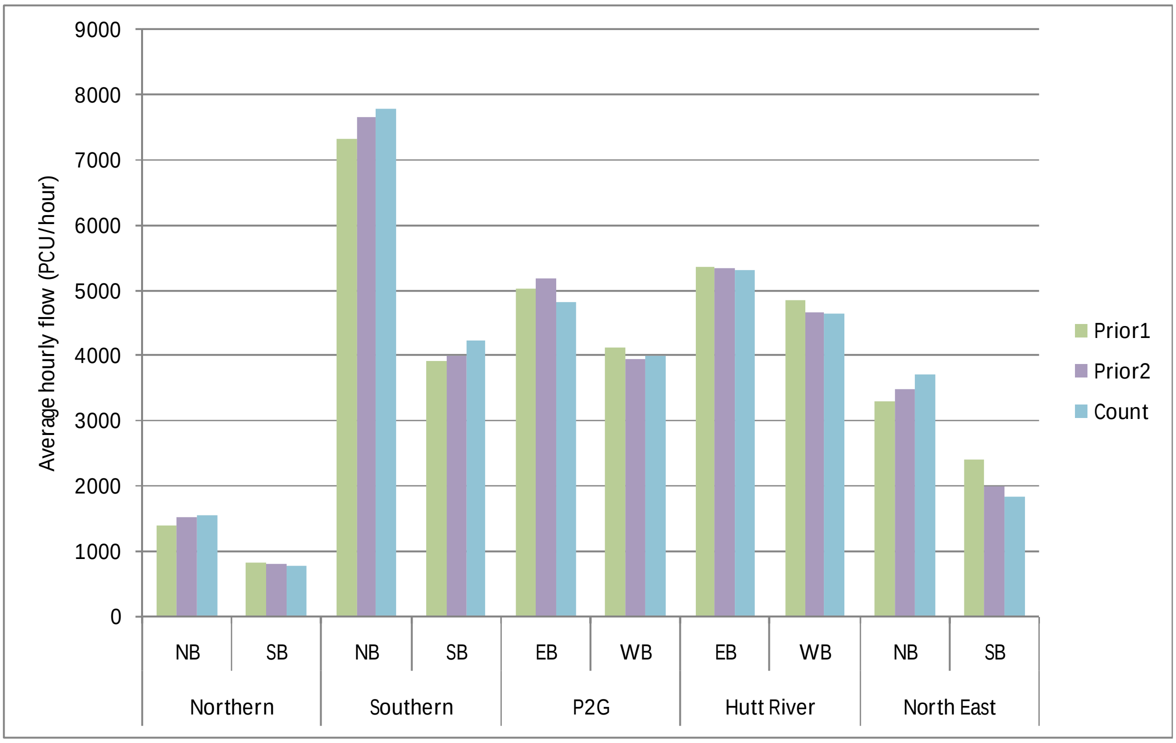
The above adjustment factors were implemented in the model calibration process and yield the following screenline comparison graphs for the model assignments based on the adjusted demands:




### Figure 7-4: NWSM Screenline Count Comparison with Sector-Factored WTSM Demands - AM Peak Period




- **Figure 7-5: NWSM Screenline Count Comparison with Sector-Factored WTSM Demands - Interpeak Period**




- **Figure 7-6: NWSM Screenline Count Comparison with Sector-Factored WTSM Demands - PM Peak Period**

The above graphs illustrate the resulting improved correlation between NWSM flows and observed flows on the NWSM screenlines. These demands are considered to be a better starting point for implementing matrix estimation at a detailed intersection level than with the 'raw' (disaggregated) WTSM demands. The demands are, however, at the average hourly level. The next chapter describes the development of time-slice factors for the purpose of improving the peak-hour assignments prior to applying matrix estimation.

The traffic profiles across the same screenlines were used for these sector adjustments. The outcomes of the combination of the sector factoring and matrix estimation has resulted in improvements in both the replication of screenline validation as well as full dataset count calibration, indicating consistency between the two datasets.

# 8. Demand Time-Slicing

## 8.1. Process

The final NWSM periods are:

- AM SH2 pre loading 06.45-07.00
- AM pre peak half hour 07.00-07.30
- AM peak hour 07.30-08.30
- AM post peak half hour 08.30-09.00
- IP peak average hour 09.00-16.00
- PM pre peak half hour 16.00-16.30
- PM peak hour 16.30-17.30
- PM post peak half hour 17.30-18.00

The SH2 preloading is discussed in Section8.2. In order to generate pre peak, peak and post peak demands in the AM and PM peak periods, the profiles at the screenlines used for the calculation of global factors were assessed. Firstly factors were developed to move from average hourly demands to peak hour demands (this was carried out for the AM and PM peak periods only, the inter peak period is already an average hour). These factors are at a sector level are shown in **Table 8-1** and **Table 8-2** for the AM and PM peaks respectively.

**Table 8-1: AM Peak Hour Time-Slice Factors**

| Sectors | KCDC | PCC | WCC | Petone | HCC | UHCC |
|---|---|---|---|---|---|---|
| KCDC | 1.000 | 1.021 | 1.021 | 1.021 | 1.021 | 1.021 |
| PCC | 1.104 | 1.000 | 1.071 | 1.112 | 1.109 | 1.106 |
| WCC | 1.094 | 1.094 | 1.000 | 1.094 | 1.094 | 1.100 |
| Petone | 1.104 | 1.029 | 0.988 | 1.000 | 0.988 | 1.106 |
| HCC | 1.012 | 1.012 | 1.000 | 1.000 | 1.000 | 1.012 |
| UHCC | 1.076 | 1.076 | 1.076 | 1.076 | 1.076 | 1.000 |

**Table 8-2: PM Peak Hour Time-Slice Factors**

| Sectors | KCDC | PCC | WCC | Petone | HCC | UHCC |
|---|---|---|---|---|---|---|
| KCDC | 1.000 | 1.047 | 1.047 | 1.047 | 1.047 | 1.047 |
| PCC | 1.095 | 1.000 | 1.074 | 1.012 | 1.052 | 1.095 |
| WCC | 1.023 | 1.023 | 1.000 | 1.023 | 1.023 | 1.059 |
| Petone | 1.095 | 1.096 | 1.000 | 1.000 | 1.031 | 1.095 |
| HCC | 1.062 | 1.062 | 1.031 | 1.031 | 1.000 | 1.062 |
| UHCC | 1.072 | 1.072 | 1.072 | 1.072 | 1.072 | 1.000 |

As would be expected, the majority of these factors are greater than one, indicating a slight peak within the peak period. The exception to this is between Petone (east of the Hutt River) and Hutt west of the river in the AM peak. Whilst the Hutt River screenline was well reflected across the whole screenline, there was a significant bias in demands to towards Melling Bridge, with much of this demand being for movements between Petone and Hutt (note that the naming is demonstrative only, with Hutt CBD actually sitting in the sector labelled Petone). The factoring down of this movement consistent with the 25% reduction in this sector to sector movement evident in the factoring outlined in **Section** 8.

As part of the matrix estimation process (described in **Section** 9), it is only the peak hour matrices that are adjusted, with pre peak demands being generate from the peak hour matrices using a sector factoring process. This is important due to the requirement to pre load the peak hour networks with both queues and traffic volumes from the pre peak which make up peak hour traffic volumes, and also influence vehicle routing.

The post peak matrices are also generated using a similar process, but these are not required in the matrix estimation process and purely provide demands to be used in the period assignments using SATTPX. The factors to generate pre and post peak demands (noting that all demands are put in hourly terms even though the pre and post peak periods are only 30 minutes long) are shown in **Figure 8-1** to **Figure 8-4**.

- **Figure 8-1 AM peak to pre peak factors**

| Sectors | KCDC | PCC | WCC | Petone | HCC | UHCC |
|---|---|---|---|---|---|---|
| KCDC | 1.000 | 1.090 | 1.090 | 1.090 | 1.090 | 1.090 |
| PCC | 0.595 | 1.000 | 0.908 | 0.781 | 0.558 | 0.666 |
| WCC | 0.698 | 0.698 | 1.000 | 0.698 | 0.698 | 0.682 |
| Petone | 0.595 | 1.000 | 1.080 | 1.000 | 1.080 | 0.666 |
| HCC | 0.914 | 0.914 | 0.997 | 0.997 | 1.000 | 0.914 |
| UHCC | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 1.000 |

- **Figure 8-2 AM peak to post peak factors**

| Sectors | KCDC | PCC | WCC | Petone | HCC | UHCC |
|---|---|---|---|---|---|---|
| KCDC | 1.000 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 |
| PCC | 1.029 | 1.000 | 0.828 | 0.817 | 1.050 | 0.951 |
| WCC | 0.957 | 0.957 | 1.000 | 0.957 | 0.957 | 0.954 |
| Petone | 1.029 | 0.887 | 0.969 | 1.000 | 0.969 | 0.951 |
| HCC | 1.039 | 1.039 | 1.004 | 1.004 | 1.000 | 1.039 |
| UHCC | 0.737 | 0.737 | 0.737 | 0.737 | 0.737 | 1.000 |

- **Figure 8-3 PM peak to pre peak factors**

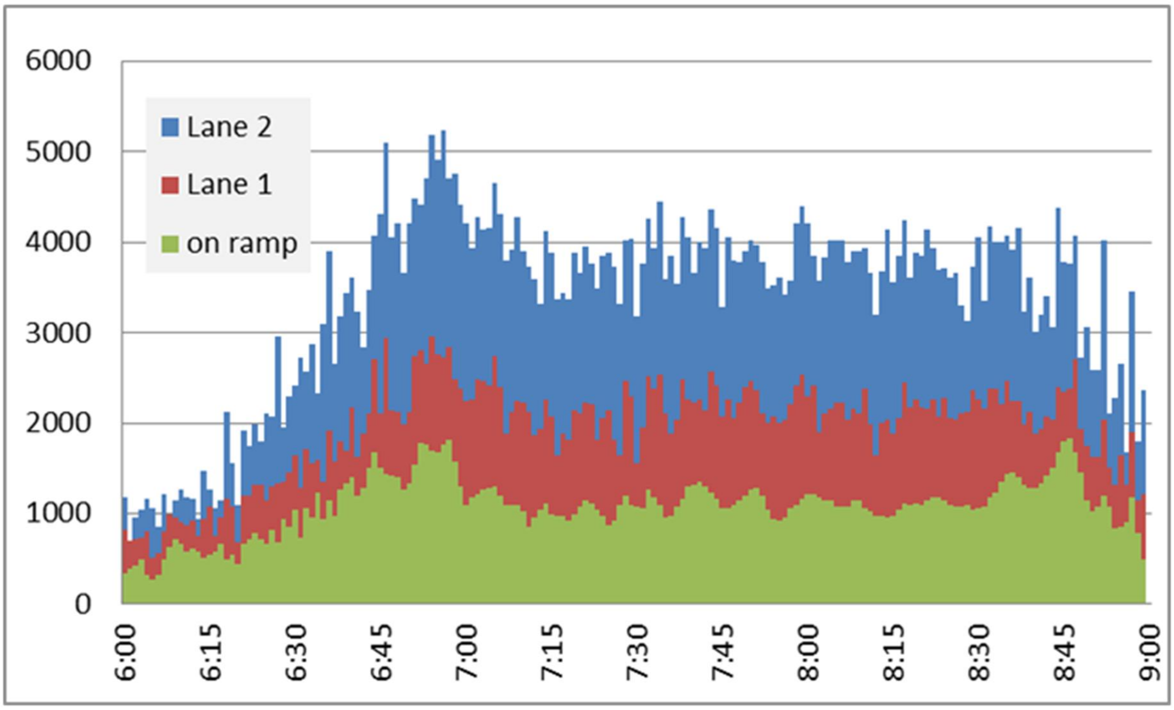
| Sectors | KCDC | PCC | WCC | Petone | HCC | UHCC |
|---|---|---|---|---|---|---|
| KCDC | 1.000 | 0.962 | 0.962 | 0.962 | 0.962 | 0.962 |
| PCC | 0.774 | 1.000 | 0.851 | 1.001 | 0.932 | 0.820 |
| WCC | 0.895 | 0.895 | 1.000 | 0.895 | 0.895 | 0.858 |
| Petone | 0.774 | 0.804 | 1.068 | 1.000 | 0.985 | 0.820 |
| HCC | 0.887 | 0.887 | 0.978 | 0.978 | 1.000 | 0.887 |
| UHCC | 0.898 | 0.898 | 0.898 | 0.898 | 0.898 | 1.000 |

- **Figure 8-4 PM peak to post peak factors**

| Sectors | KCDC | PCC | WCC | Petone | HCC | UHCC |
|---|---|---|---|---|---|---|
| KCDC | 1.000 | 0.861 | 0.861 | 0.861 | 0.861 | 0.861 |
| PCC | 0.880 | 1.000 | 0.874 | 0.952 | 0.871 | 0.834 |
| WCC | 1.016 | 1.016 | 1.000 | 1.016 | 1.016 | 0.925 |
| Petone | 0.880 | 0.847 | 0.932 | 1.000 | 0.896 | 0.834 |
| HCC | 0.879 | 0.879 | 0.905 | 0.905 | 1.000 | 0.879 |
| UHCC | 0.832 | 0.832 | 0.832 | 0.832 | 0.832 | 1.000 |

## 8.2. SH2 Preloading

A significant issue in the AM peak is the blocking back of a queue from SH2 onto the Esplanade in Petone. An analysis provided by NZTA[1] in draft format included data on the demands at the Petone interchange and is replicated in **Figure 8-5**.




- **Figure 8-5 Petone on ramp flows**

This data shows a peak in demand prior to the AM peak period, with a flow spike of 5,000vph (noting that the flow is given at an hourly level even though this level of flow lasts for a shorter time period) at approximately 6.50 which takes this interchange to capacity by 7.00am. Anecdotally, this demand spike causes queues to propagate up SH2 and along the Esplanade which do not recover until beyond the end of the peak hour of 07.30-08.30.

[1] Report for NZTA - State Highway 2 - Petone to Ngauranga, GHD ref 51/31371/LH

This demand spike and consequent queuing is replicated in the model through preloading of the AM model period (which begins at 7.00am) with queues generated through the assignment of a select link analysis of SH2 between Petone and Ngauranga. This preloading of the network essentially puts queues on SH2 and the Esplanade which are retained throughout the AM preload half hour and peak hour (07.30-08.30am) as demonstrated in **Section 13**. The preload matrix was generated through a factor of the peak hour matrix (which has been generated through the process outlined in **Sections** 7 and **8.1**). Given that this preload is specifically to address the queue on the Esplanade at 7.00am, the only sectors for which demands use SH2 southbound between Petone and Ngauranga. Based on **Figure 8-5**, it appears as if the volumes on the on ramp are approximately 60% greater than during the peak period, and flows on SH2 are slightly higher so the sector factors shown in **Table 8-3**.

- **Table 8-3 06.45-07.00 sector factors**

| Sectors | KCDC | PCC | WCC | Petone | HCC | UHCC |
|---|---|---|---|---|---|---|
| KCDC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| PCC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| WCC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Petone | 0.000 | 1.600 | 1.600 | 0.000 | 0.000 | 0.000 |
| HCC | 0.000 | 1.100 | 1.100 | 0.000 | 0.000 | 0.000 |
| UHCC | 0.000 | 1.100 | 1.100 | 0.000 | 0.000 | 0.000 |

This “pre-pre” load factoring provided a queue that extended into the peak hour, resulting in observed westbound travel times on the Esplanade and southbound travel times on SH2 being more closely reflected than without this queuing passing over.

# 9. Matrix Estimation

## 9.1. Process

Matrix estimation has been applied to estimate peak-hour demands. Heavy vehicles and light vehicle demands have been estimated from the input traffic counts. The process has been applied in a looping manner, initially with 9 loops set-up and convergence of assigned traffic volumes monitored statistically and graphically. For the matrix estimation process, it is not possible to model automated time-slice modelling through implementation of the SATTPX module. Instead, only the peak-hour demands have been estimated (consistent with the count data used for the process), but with a pre-peak time-slice assignment specified for each loop of the matrix estimation, using the PASSQ option. On each loop, the pre-peak time-slice matrix was updated such that the original ratio between the pre-peak and peak-hour 'prior' demands was preserved.

Matrix Estimation has been run with the default value of the parameter XAMAX reduced from 5 to 2. This means that any single link count may factor a single matrix cell within the limits of half to double its original value (as opposed to 1/5 or 5 times its original value by default). This limit is considered appropriate in that it allows the required changes to the matrix to satisfy the majority of turning counts (see Chapter 11) whilst limiting excessive changes to the prior matrix.

## 9.2. Monitoring Convergence

Monitoring of the convergence of the matrix estimation process through examination of flow difference plots on a loop-by-loop basis indicated that the process was yielding a stable set of traffic volumes after 4 to 5 loops of matrix estimation and so 5 loops were used in the refinement process.

## 9.3. Effects of Matrix Estimation

The application of automated matrix estimation resulted in the calculation of the demand matrix **DemandsME**. The prior and estimated matrices, together with changes and absolute changes to the prior matrix are presented on a sector to sector level within **Appendix A**.

The largest absolute changes generally appear to have occurred within the NWSM model sectors, rather than on a sector to sector basis (for example Sector 2 to Sector 2, Sector 3 to Sector 3 etc.). This is intuitive given that a reasonably high level of validation has already been achieved on a screenline basis, at the interface of the sectors (albeit to a different set of count data). Some change to intra-sector demands would be anticipated given that calibration / validation of WTSM, upon which the NWSM prior demands are based, has not compared modelled flows to observed counts within the NWSM sectors (only on the sector borders, defined by the count screenlines).

The largest changes in inter-sector demands occurs

# 10. Peak Period Calibration

## 10.1. Model Form

As discussed in **Section** 8, the full NWSM model is made up of the following modelled periods:

- AM pre-pre peak fifteen minutes 06.45-07.00
- AM pre peak half hour 07.00-07.30
- AM peak hour 07.30-08.30
- AM post peak half hour 08.30-09.00
- IP peak average hour 09.00-16.00
- PM pre peak half hour 16.00-16.30
- PM peak hour 16.30-17.30
- PM post peak half hour 17.30-18.00

In order to generate full AM (two hours and fifteen minutes), interpeak (seven hours) and PM (two hours) periods the above modelled periods are combined such that the AM and PM period models (pre peak, peak and post peak) are run using the SATURN module SATTPX. This process automatically runs all time-slices specified, passing any residual queues from one period to the next and then combines the period outputs using SATSUMA to create a period assignment for analysis in module P1X ( a .UFT file), in addition to time-slice assignments (.UFS files). It is noted that the UFT file for the AM peak specifically reflects the queuing and delay at Petone rather than in the wider model area. Whilst it may be possible to produce appropriate factors to reflect traffic volumes outside of the WTSM AM peak period, it is likely that distribution patterns are likely to alter away from those generated in WTSM and therefore provide less forecasting robustness. It is unlikely that there will be significant benefits for any scheme other than those for which the model is intended to be used in the period 06.45-07.00 and so it is still considered appropriate to use the UFT file for economic appraisal in the AM peak.

Interpeak assignments are typically used for economic appraisal, with operational assessment focusing on the peak hours of demand. For the seven-hour interpeak period, the level of queue transfer from one period to the next is not significant, so an interpeak assignment is simply run based on average demands over the seven-hour periods, with model outputs such as travel time and travel distance simply multiplied by seven to represent the whole of the interpeak period.

## 10.2. NWSM Sectors

As described in **Chapter** 7, a simplified screenline and sector system has been designed for NWSM for the purpose of adjusting and analysing travel demands. The effects of disaggregating the WTSM matrices to the NWSM zone system and applying uniform sector factors for the average AM, inter and PM peak hours are shown in **Section 7.3**.

A comparison of period NWSM sector screenline flows for the disaggregated (Prior1 factored to period level), sector factored (Prior2 factored to period level), time sliced (Prior3 run through SATTPX) and matrix estimated (ME run through SATTPX) matrix assignments are shown in

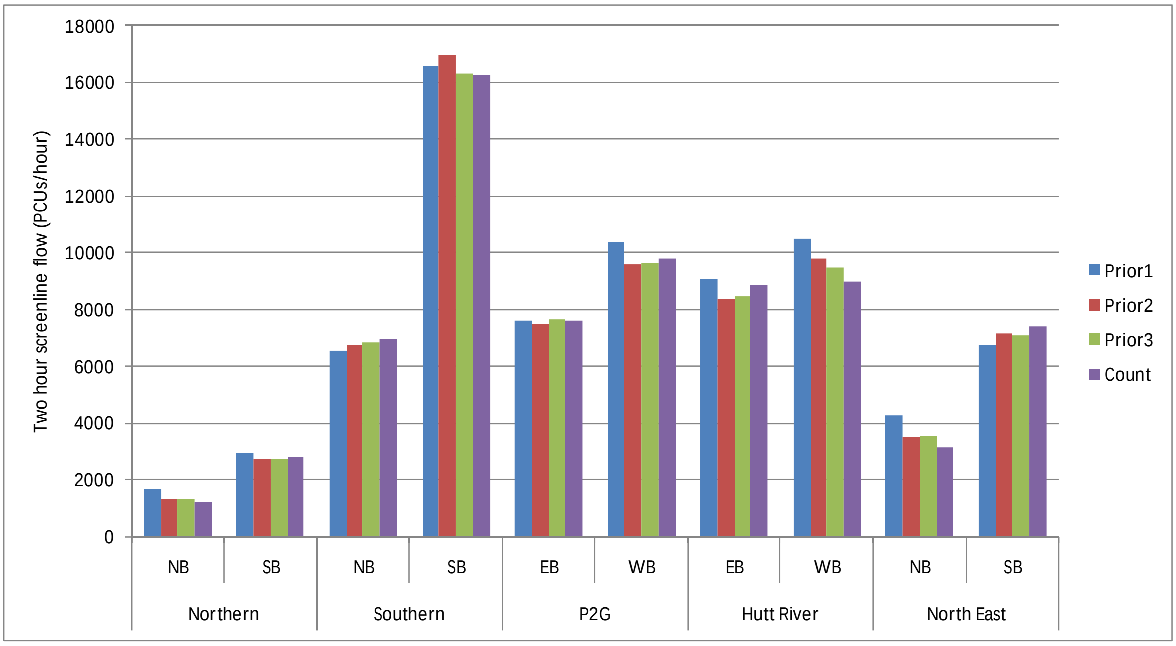
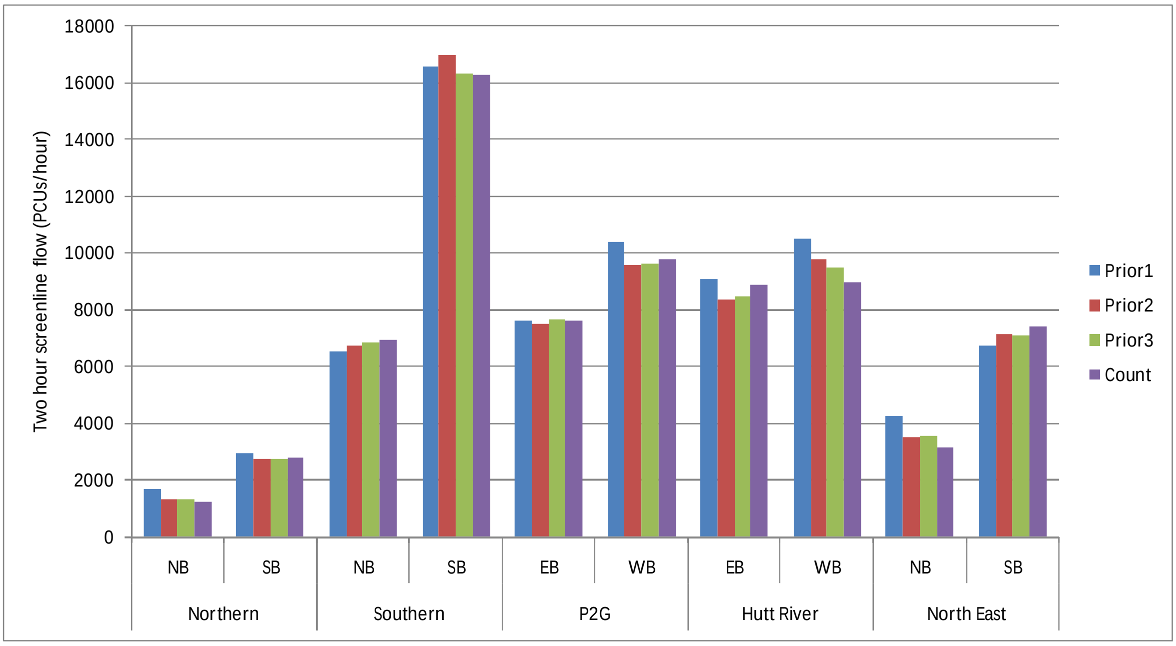
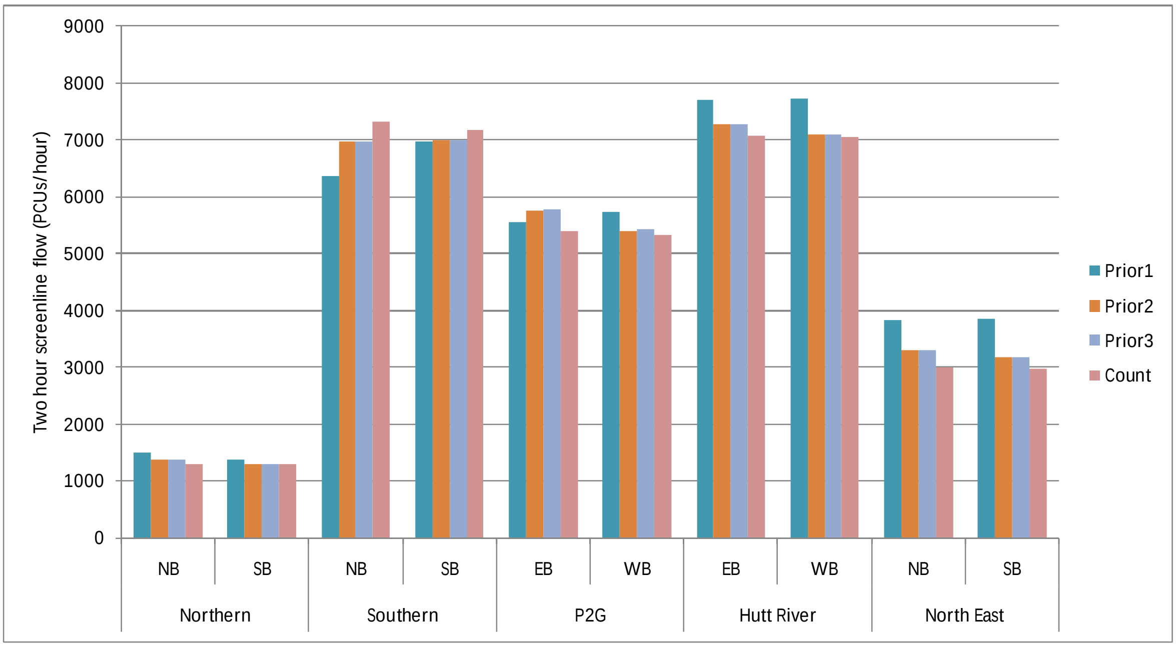



**Figure** 10-1, **Figure 10-2** and **Figure 10-3.**




▪ **Figure 10-1: AM NWSM Screenline Flows With Matrix Adjustments**




▪ **Figure 10-2: Interpeak NWSM Sector Screenline Flows with Matrix Adjustments**

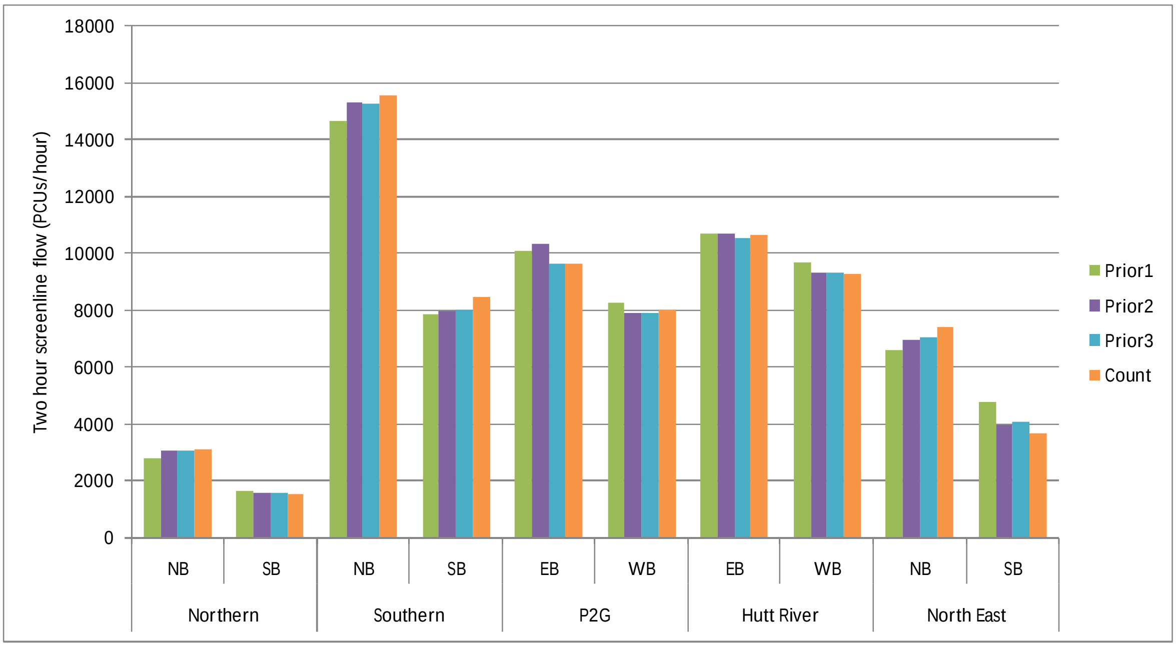



**Figure 10-3: PM NWSM Sector Screenline Flows with Matrix Adjustments**

**Figure 10-1**, **Figure 10-2** and **Figure 10-3** show that at a period level, the sector factoring has significantly improved the replication of the observed screenline volumes.

After additional peak hour sector specific adjustments and matrix estimation, the total sector screenline flow changes are relatively minor. The above plots provide confidence that the matrix estimation process, does not significantly adversely affect calibration at the screenline level. Some minor adjustment of volumes across the screenlines is inevitable given that classified turning counts within close proximity to the screenline link counts will record volumes that vary from the links counts, such discrepancies being due to daily or seasonal variations and / or relatively minor errors in the count data set.

# 11. Peak Hour Count Calibration

## 11.1. SATME2 Process

SATPIJA and SATME2, SATURN's automated matrix estimation modules have been used for the fine tuning of the sector specific time sliced matrices (Prior3), the process being described in Chapter 9.

The time-sliced peak hour matrices (Prior3) were estimated using all counts available from a variety of sources (outlined in Section 2). This resulted in approximately 350 counts in the AM and PM peak hours and 300 counts in the inter peak

## 11.2. Calibration Process

With approximately 1,000 counts specified in the matrix estimation process, investigation of outliers has focussed on those counts with the largest absolute discrepancies between observed and modelled flows. All counts with difference in modelled flows greater than 200 vehicles per hour have been investigated. During this investigation process, for counts yielding the largest differences to modelled flows, most discrepancies could clearly be attributed to errors in the count data or inconsistencies between counts at a single site over several years of data. As this process continued, with count errors at around 200 vehicles per hour, very few genuine cases of faulty data were being discovered and discrepancies were becoming almost exclusively attributable to differences between adjacent counts and / or variations between counts conducted over multiple years.

Within the time and budgets available for the NWSM build, further investigation of discrepancies of counts with errors of less than 200 vehicles per hour was not considered viable, or to add any great value. The effects of removing such counts from the matrix estimation process would have very little effect on assigned flows as by virtue of the presence of the discrepancy between modelled and assigned flows, other counts are pulling the traffic volumes in other directions that prevent the erroneous flows from eventuating.

## 11.3. Calibration Outputs

The full turn count calibration output sheets are provided in "Count Comparison_ME_RevU.xlsx" in **Appendix C** and so only a summary is provided here. **Table 11-1:** shows a summary of the GEH statistics for each peak for both pre (SF) and post estimated (ME) matrix assignments.

**Table 11-1: GEH summary**

| Peak | Class | Matrix | Counts | GEH<5 | GEH<10 | GEH<12 |
|---|---|---|---|---|---|---|
| TARGET | | | | 60% | 95% | 100% |
| AM | Total | Prior3 | 351 | 55% | 87% | 92% |
| | | Post ME | | 77% | 95% | 97% |
| | | Improvement | | 22% | 7% | 5% |
| | Lights | Prior3 | 345 | 54% | 86% | 91% |
| | | Post ME | | 78% | 94% | 95% |
| | | Improvement | | 25% | 8% | 4% |
| | HCVs | Prior3 | 345 | 70% | 93% | 96% |
| | | Post ME | | 88% | 96% | 97% |
| | | Improvement | | 18% | 3% | 1% |
| IP | Total | Prior3 | 305 | 53% | 87% | 92% |
| | | Post ME | | 86% | 97% | 98% |
| | | Improvement | | 33% | 10% | 6% |
| | Lights | Prior3 | 303 | 56% | 86% | 91% |
| | | Post ME | | 88% | 97% | 98% |
| | | Improvement | | 32% | 11% | 7% |
| | HCVs | Prior3 | 300 | 78% | 96% | 98% |
| | | Post ME | | 90% | 99% | 100% |
| | | Improvement | | 12% | 4% | 2% |
| PM | Total | Prior3 | 353 | 58% | 88% | 93% |
| | | Post ME | | 80% | 95% | 97% |
| | | Improvement | | 22% | 7% | 4% |
| | Lights | Prior3 | 347 | 56% | 86% | 91% |
| | | Post ME | | 80% | 95% | 97% |
| | | Improvement | | 24% | 9% | 6% |
| | HCVs | Prior3 | 346 | 72% | 94% | 96% |
| | | Post ME | | 89% | 97% | 99% |
| | | Improvement | | 16% | 3% | 3% |

Prior to applying matrix estimation, none of the EEM criteria are met. After matrix estimation, the EEM criteria for GEH<5 are met and for GEH<10 in the inter and PM peaks. There is significant improvement in the level of fit between observed and modelled data for GEH<12 but there are still 11, 5 and 10 counts with GEH values greater than 12 in the AM, interpeak and PM peaks respectively.

The $R^2$ values for total vehicles, light vehicles and heavy vehicles are shown in **Table 11-2:** for both the pre estimated and estimated matrix assignments. For the pre-estimated model, the slope of the line of best fit of the data has been provided (and the corresponding $R^2$) whilst in the final model, the correlation with y=x has been provided in line with EEM requirements.

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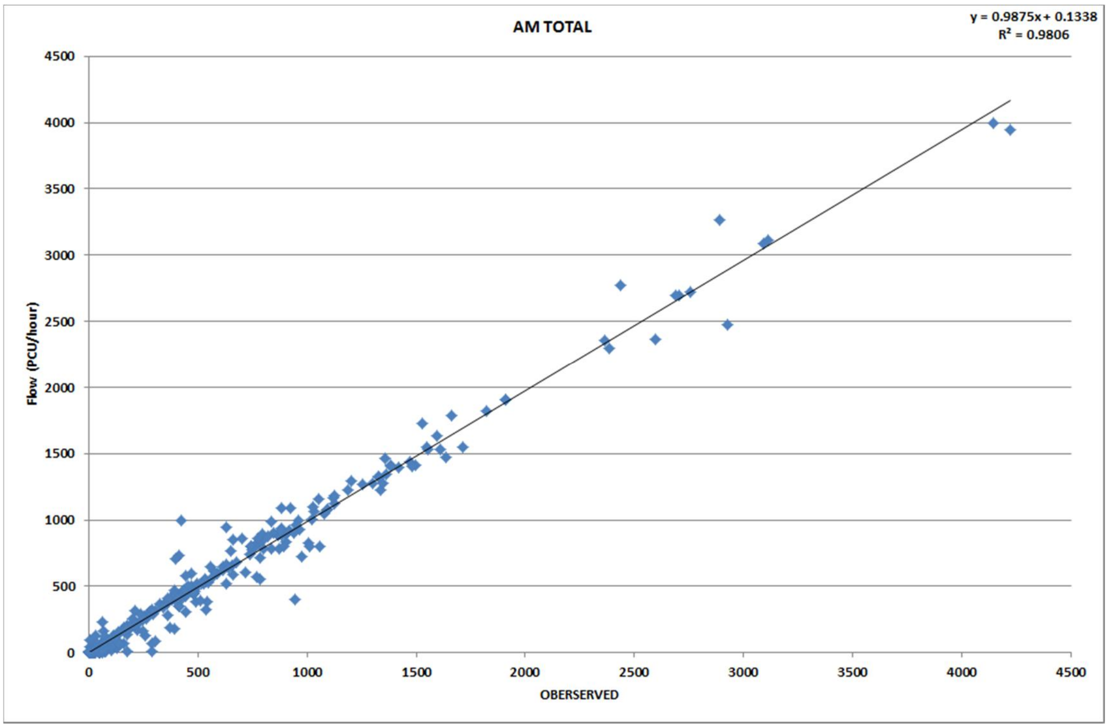
- **Table 11-2: $R^2$ Summary**

| Peak | Class | Matrix | Slope | $R^2$ |
|---|---|---|---|---|
| TARGET | | | 1.00 | 0.95 |
| AM | Total | Prior3 | 0.98 | 0.94 |
| | | Post ME | 0.99 | 0.98 |
| | | Improvement | | 0.04 |
| | Lights | Prior3 | 0.95 | 0.92 |
| | | Post ME | 0.99 | 0.97 |
| | | Improvement | | 0.05 |
| | HCVs | Prior3 | 0.69 | 0.62 |
| | | Post ME | 0.61 | 0.84 |
| | | Improvement | | 0.22 |
| IP | Total | Prior3 | 1.00 | 0.90 |
| | | Post ME | 0.97 | 0.98 |
| | | Improvement | | 0.09 |
| | Lights | Prior3 | 0.98 | 0.85 |
| | | Post ME | 0.97 | 0.97 |
| | | Improvement | | 0.13 |
| | HCVs | Prior3 | 0.83 | 0.71 |
| | | Post ME | 0.85 | 0.92 |
| | | Improvement | | 0.21 |
| PM | Total | Prior3 | 0.92 | 0.96 |
| | | Post ME | 0.98 | 0.99 |
| | | Improvement | | 0.03 |
| | Lights | Prior3 | 0.88 | 0.94 |
| | | Post ME | 1.01 | 0.99 |
| | | Improvement | | 0.05 |
| | HCVs | Prior3 | 0.72 | 0.53 |
| | | Post ME | 0.48 | 0.71 |
| | | Improvement | | 0.19 |

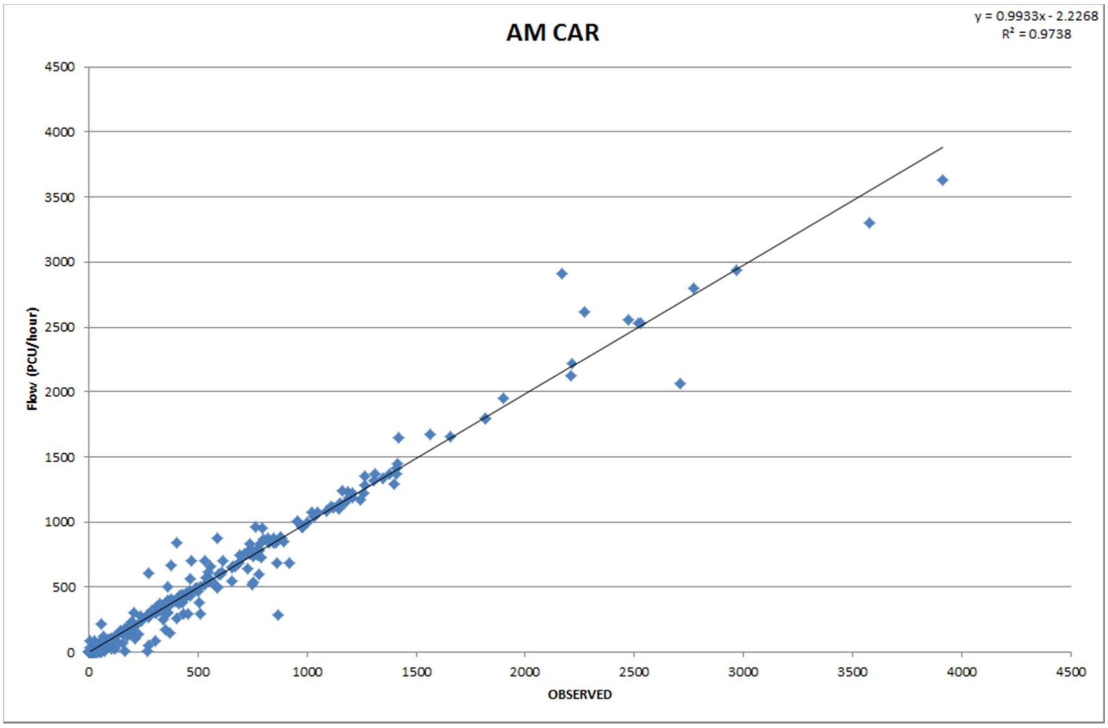
In all three peak hour models with a pre-estimated matrix assignment, whilst the slopes of the trend lines are close to one, the $R^2$ values are less than 0.95 (the EEM criteria). Matrix estimation improves the line of best, particularly for total PCUs and light vehicles.

## 11.4. Calibration Outputs: AM Peak

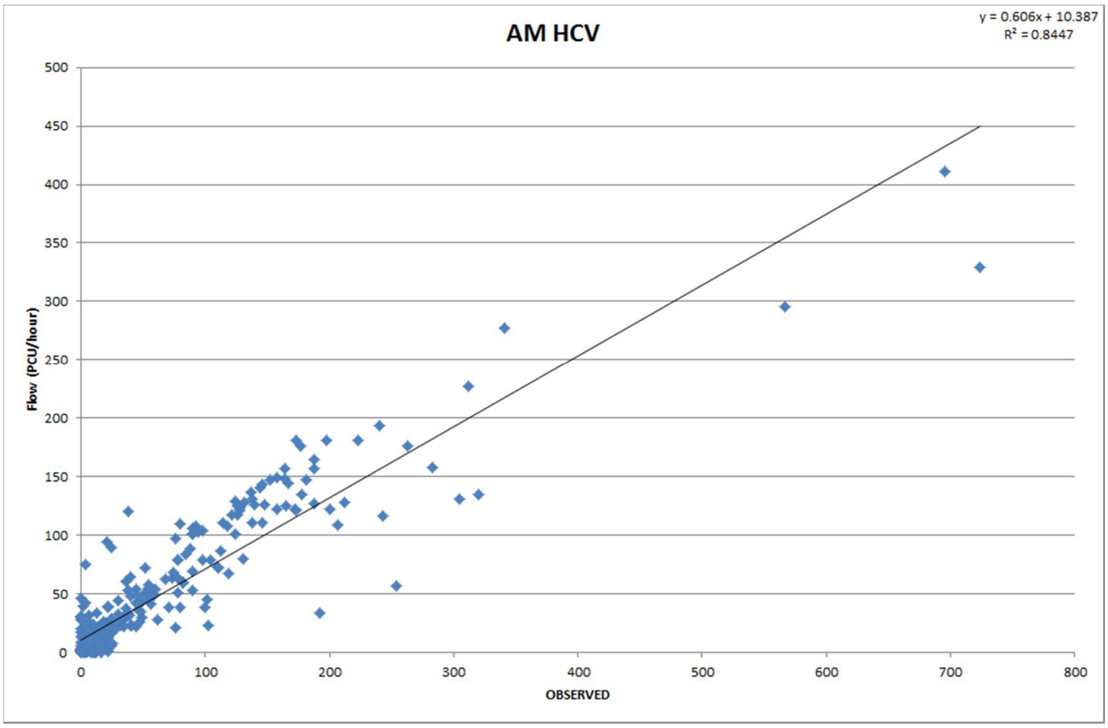
Graphs showing the correlation between observed and modelled hourly PCU flows for all vehicles, light vehicles only and heavy vehicles only are shown in **Figure 11-1**, **Figure 11-2** and **Figure 11-3** respectively.




■ **Figure 11-1: AM Peak Hour Flow Comparison (All Vehicles)**

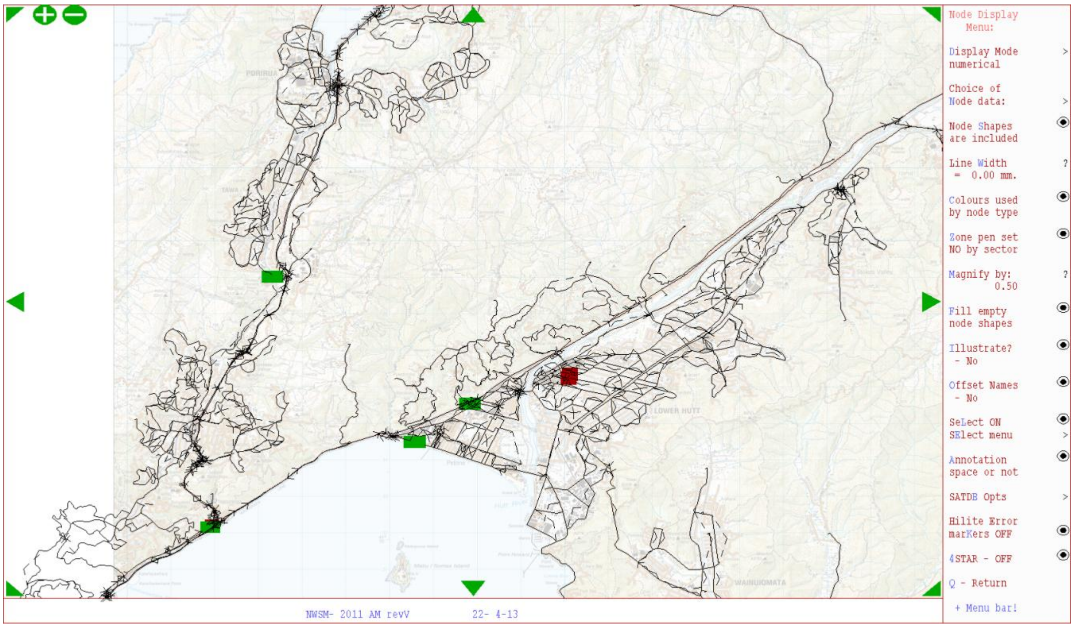



■ **Figure 11-2: AM Peak Hour Flow Comparison (Light Vehicles)**




■ **Figure 11-3: AM Peak Hour Flow Comparison (Heavy Vehicles)**

The locations of the eight sites where there are all vehicle flow differences greater than 200 PCUs/hour with a GEH>12 are highlighted in **Figure 11-4**.




■ **Figure 11-4: AM Peak Count Outlier Locations**

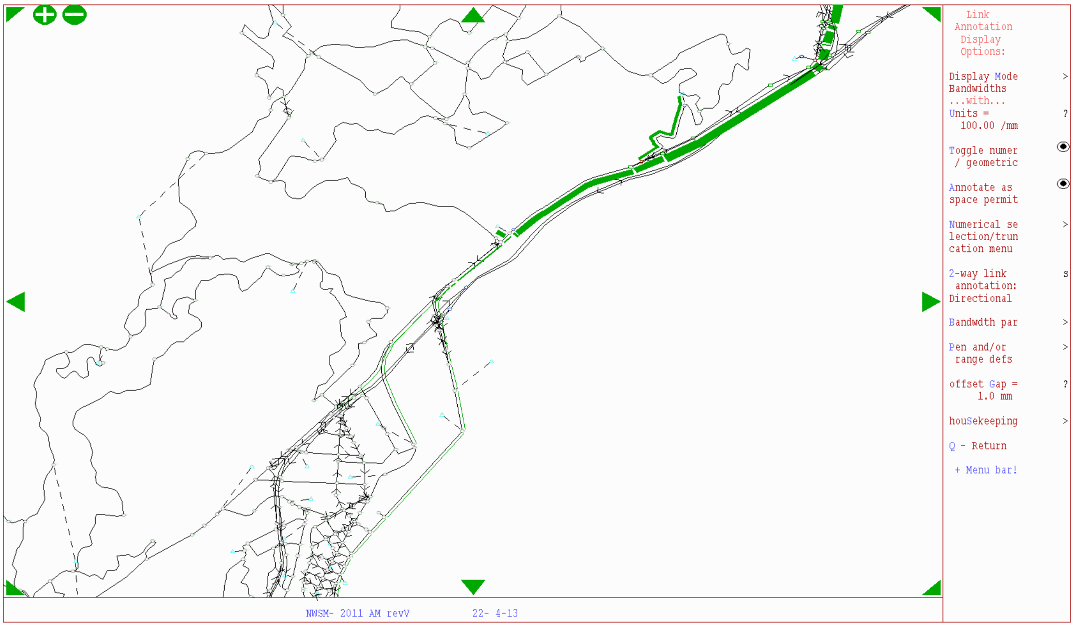
These eight sites are effectively in four areas:

1) Ngauranga interchange.
2) Petone
3) Eastern Hutt
4) Willowbank Road

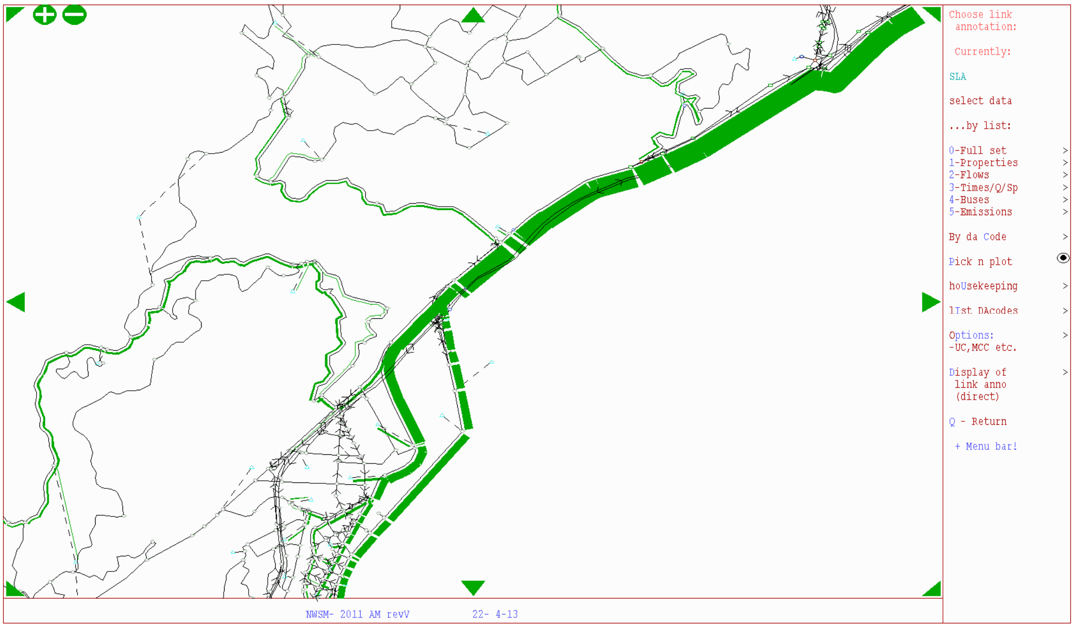
### 11.4.1. Ngauranga interchange

There appears to be an underestimation of traffic from SH1 onto Hutt Road, and an equivalent overestimation of traffic from SH2 onto Hutt Road. The Jardin Mile signals are operating well within capacity for the SH1 to Hutt Road movement with less than 30 seconds delay for the southbound movement.

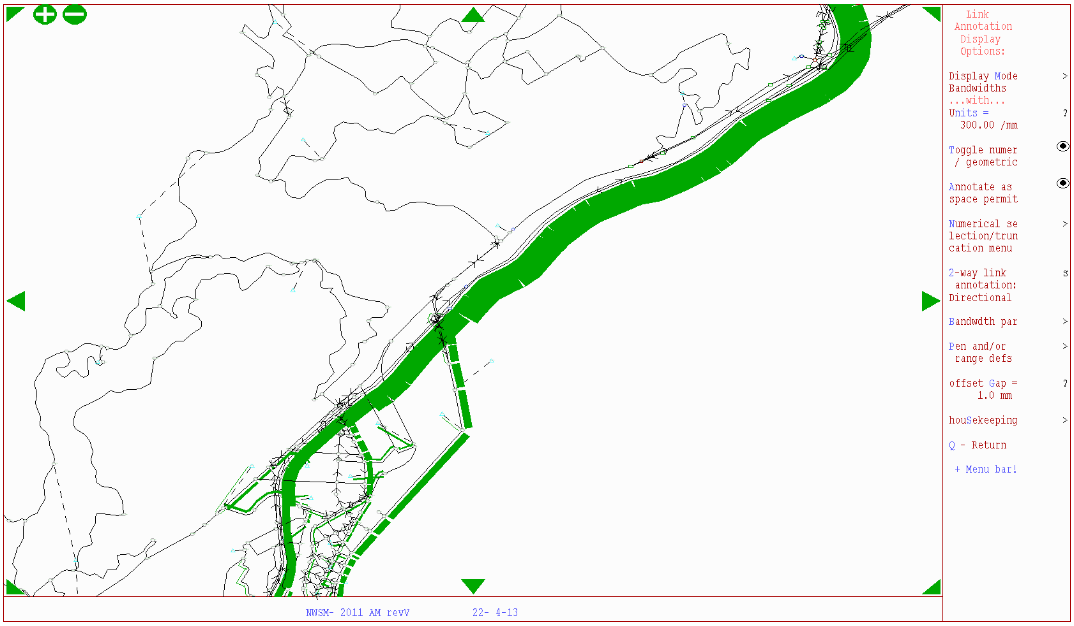
**Figure 11-5** to **Figure 11-8** show select link analyses for each of the movements to SH1 and Hutt Road south of Ngauranga. It is of note that trips from SH1 to Hutt Road appear to have a local catchment only (north of Aotea Quay) whereas the catchment from SH2 includes trips travelling to the northern CBD. All of these northern CDB bound trips from SH1 use SH1 in preference to Hutt Road.



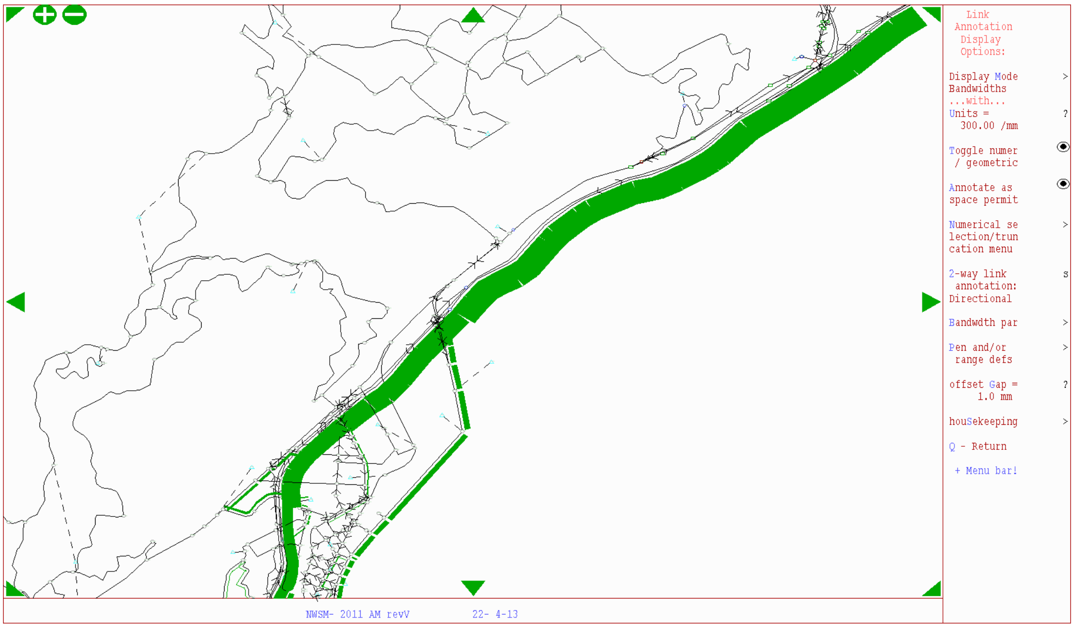

▪ **Figure 11-5 SH1 to Hutt Road**




■ **Figure 11-6 SH2 to Hutt Road**




■ **Figure 11-7 SH1 to SH1**



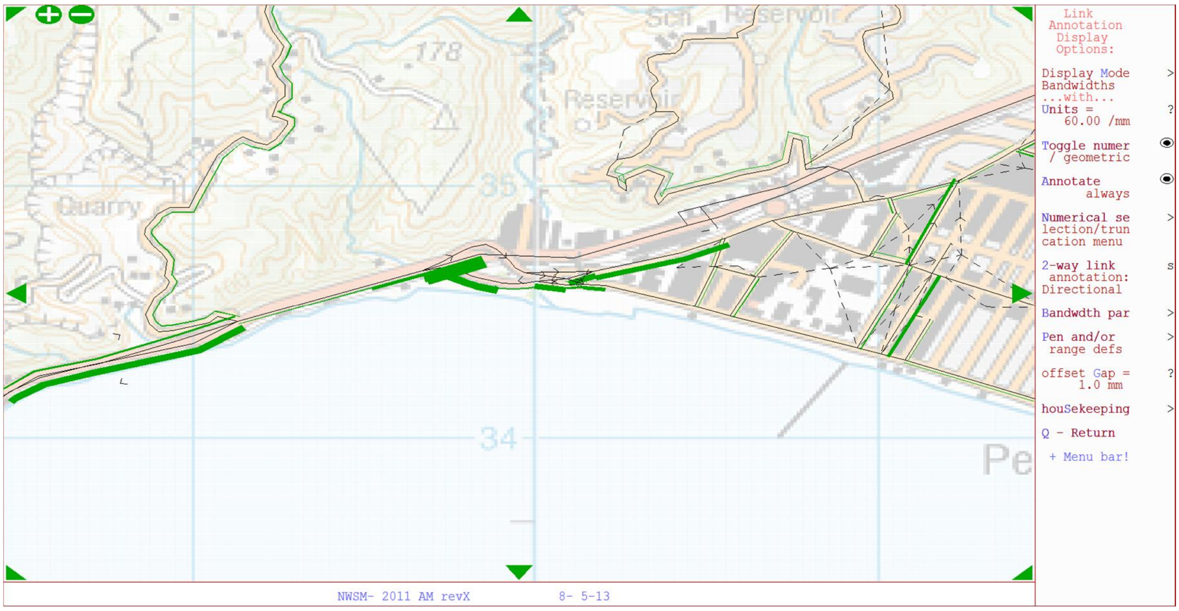

- **Figure 11-8 SH2 to SH1**

Whilst the key movements between SH1 and SH2 north of Ngauranga are well reflected in the model, this issue with routing between Hutt Road and SH1 south of Ngauranga should be taken into consideration when assessing options where this split is likely to change significantly

### 11.4.2. Petone

A significant amount of work has gone into ensuring that delays and queuing to southbound on SH2 from both SH2 north of Petone and on the Esplanade are well reflected in the model. This has included the development of a 15 minute preload from 06.45-07.00 (outlined in **Section 8.2**). Whilst there is significant queuing and delays incorporated into the peak hour model (07.30am-08.30am), this is present at the western end of the Esplanade, with the observed slow moving queue further east on the Esplanade reflected by a speed flow curve slowing traffic on links on the Esplanade with intersection queuing only at the western end. Testing with increased levels of demands to reflect observed queue lengths more closely resulted in overestimation of the delay at the western end of the Esplanade and on SH2. It was decided to more closely reflect the overall journey for traffic using SH2 south of Petone rather than overestimate delays at the interchange itself and have queuing further back along the Esplanade.

The resultant links with delays on are shown in **Figure 11-9**. Note that there are also delays southbound on Hutt Road on approach to the Petone roundabout. Again, there has been a balance here between having sufficient capacity at the roundabout to enable observed volumes to get through the roundabout (implying a higher capacity than coded), with generating the significant observed delays (implying a lower capacity than coded).




- **Figure 11-9 Petone Delays**

### 11.4.3. Eastern Hutt

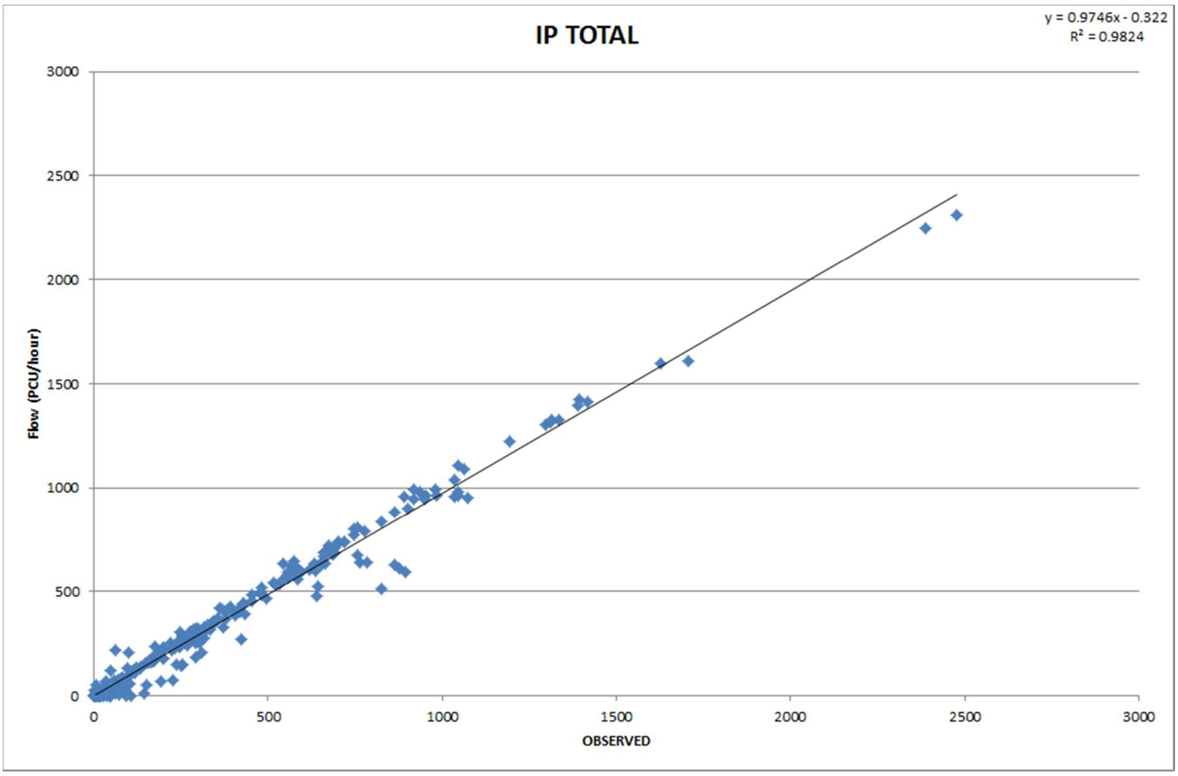
The tidality of the counts at Cornwall Street and Waterloo Road does not appear to match surrounding intersections. The raw data has been re-examined and confirmed that the data has been processed accurately but it is considered that this data is unlikely to be accurate. Given this uncertainty (it is not clear whether east and west have been swapped, or if the entire intersection has been rotated), no alterations have been made to the counts, and this should simply be considered when assessing traffic volumes in this area.

### 11.4.4. Willowbank Road

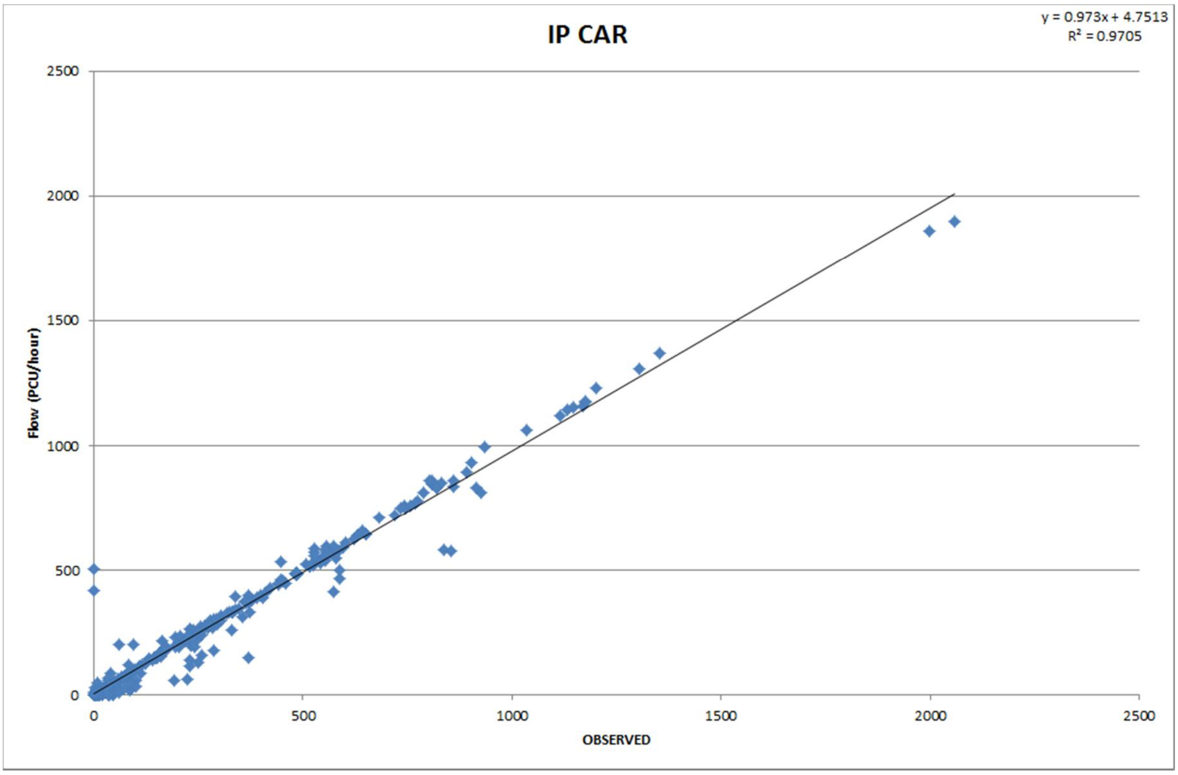
There is very limited traffic using Willowbank Road in the morning peak running parallel to SH1. There are limited attractors of traffic here so the observed ~300vph using this link are likely to be vehicles avoiding SH1 to access northern Johnsonville. The posted speed limit on Willowbank Road is 50kph and with the applied speed flow curve, the modelled cruise speed is approximately 48kph. On SH1 parallel to Willowbank Road, the modelled speeds still exceed 80kph and therefore provide a more logical route choice. The speed on SH1 is determined by motorwat speed flow curves developed that most closely replicate a variety of motorway flow conditions and as such so not exactly replicate any one condition. These are discussed in more detail in **Section 13**.

## 11.5. Calibration Outputs: Interpeak

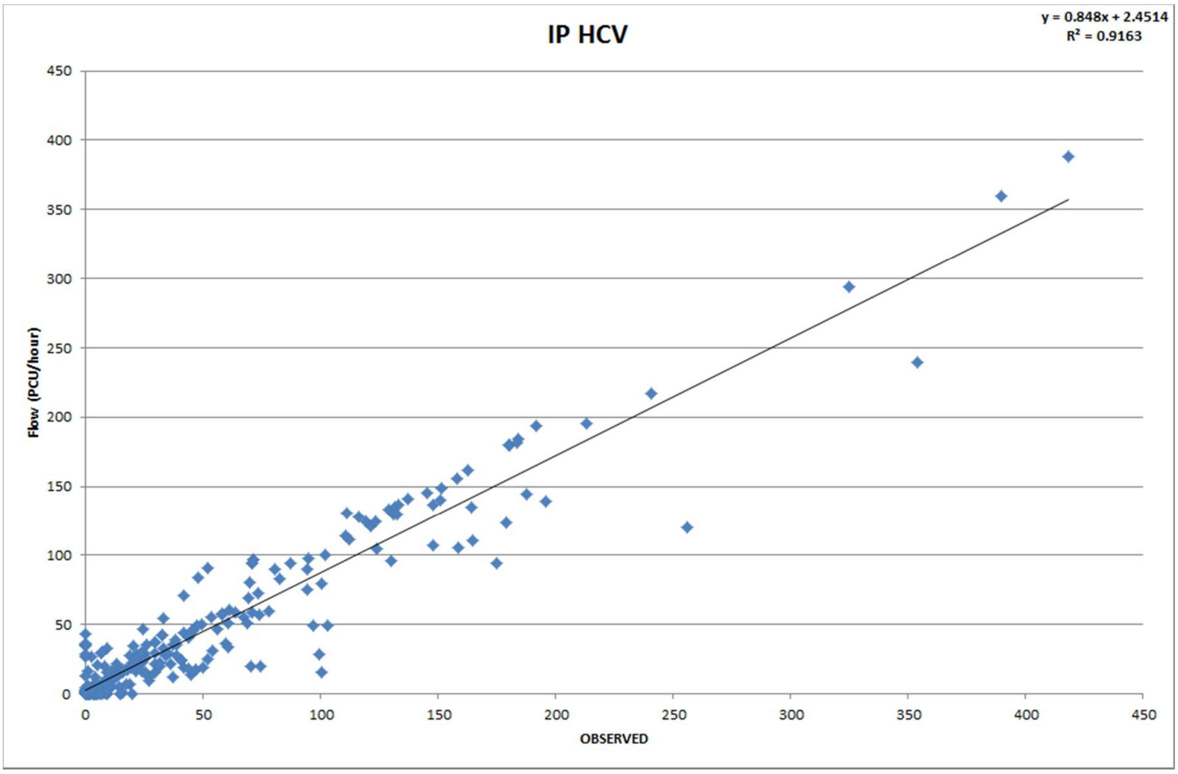
Graphs showing the correlation between observed and modelled hourly vehicular flows for all vehicles, light vehicles only and heavy vehicles only are shown in **Figure 11-10**, **Figure 11-11** and **Figure 11-12** respectively.




- **Figure 11-10: Interpeak Hour Flow Comparison (All Vehicles)**



- **Figure 11-11: Interpeak Hour Flow Comparison (Light Vehicles)**

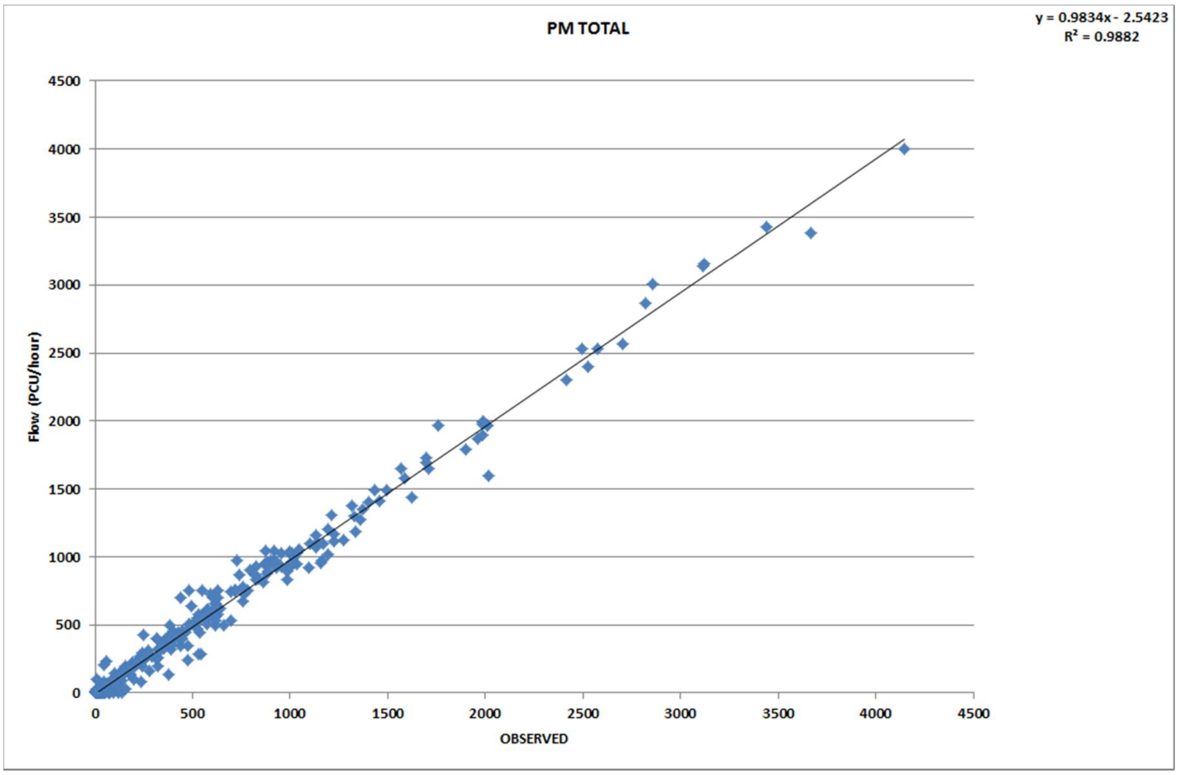



- **Figure 11-12: Interpeak Hour Flow Comparison (Heavy Vehicles)**

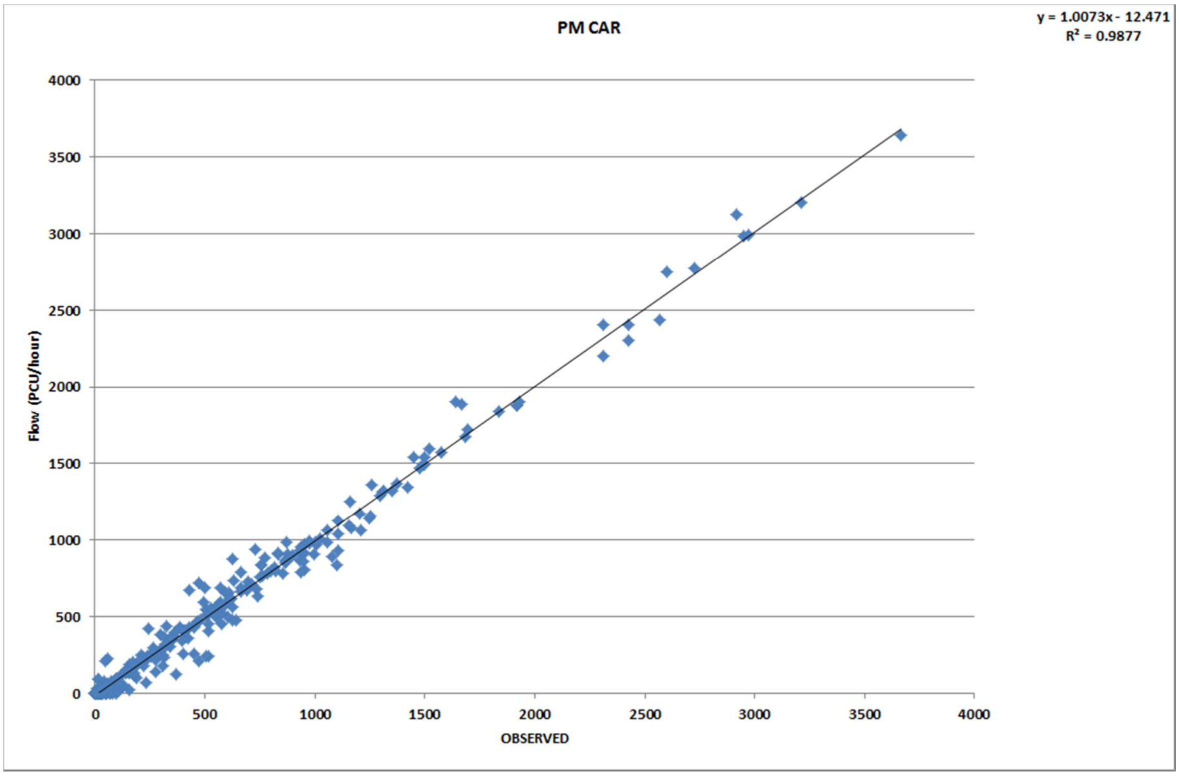
There are no count locations with a GEH>12 and flow differences greater than 200 PCUs/hour.

## 11.6. Calibration Outputs: PM Peak

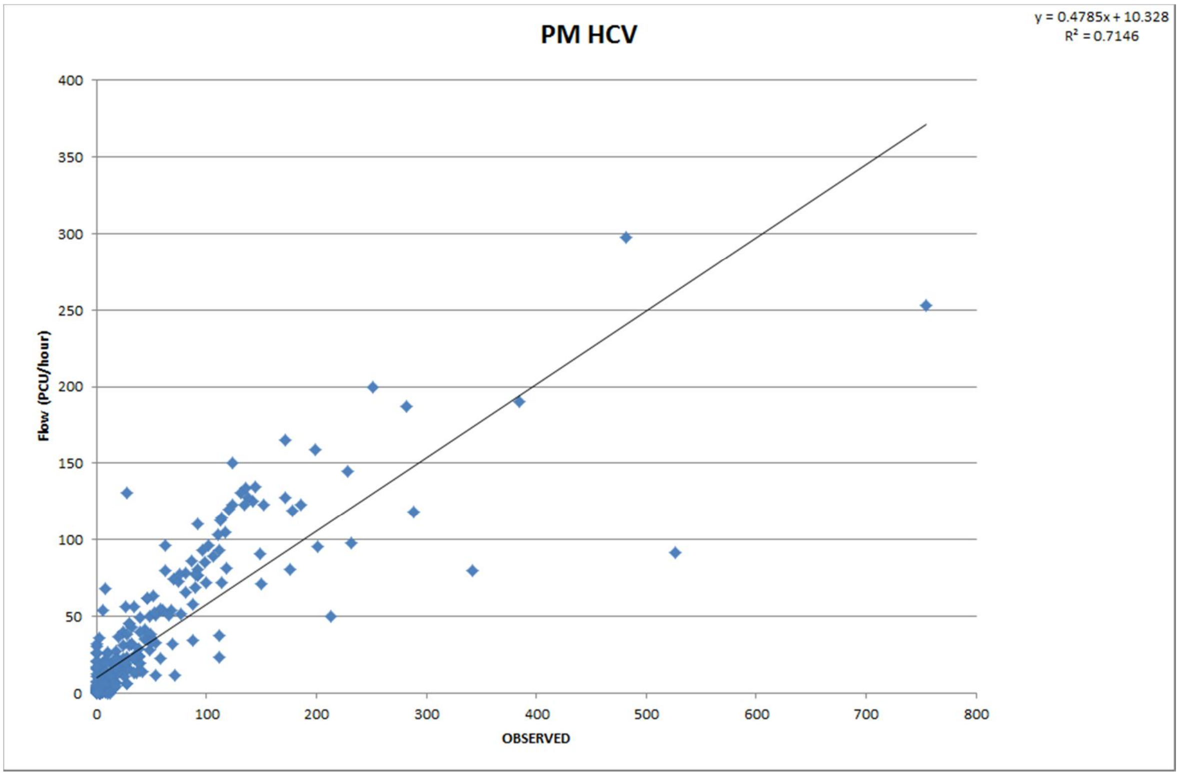
Graphs showing the correlation between observed and modelled hourly vehicular flows for all vehicles, light vehicles only and heavy vehicles only are shown in **Figure 11-13**, **Figure 11-14** and **Figure 11-15** respectively.



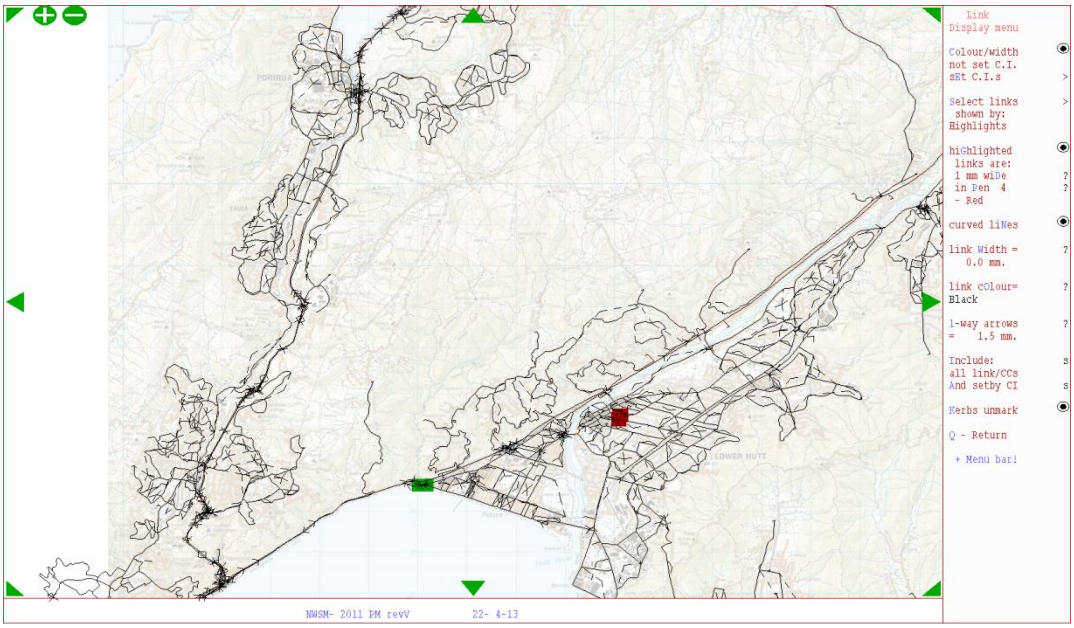

■ **Figure 11-13: PM Peak Hour Flow Comparison (All Vehicles)**



## Figure 11-14: PM Peak Hour Flow Comparison (Light Vehicles)




## Figure 11-15: PM Peak Hour Flow Comparison (Heavy Vehicles)



- **Figure 11-16: PM Peak Turn Count Outlier Locations**

In the PM peak, the three outlier counts are at Cornwall Street – Waterloo Road which has been discussed in for the AM peak model (see **Section 11.4.3**) and at the Petone roundabout (see **Section 11.4.2**).

# 12. Model Convergence

## 12.1. Peak Hours

The convergence parameters utilised for NWSM are set out below:

- KONSTP = 1 (stopping criteria based on the gap function rather than on percentage changes in link flows)
- STPGAP = 0.1%
- NITA = 20
- NITS = 30
- NITA_S = 100
- MASL = 40

The convergence parameters taken from the final loop of the peak hour AM peak, interpeak and PM peak models are provided in **Table 12-1**.

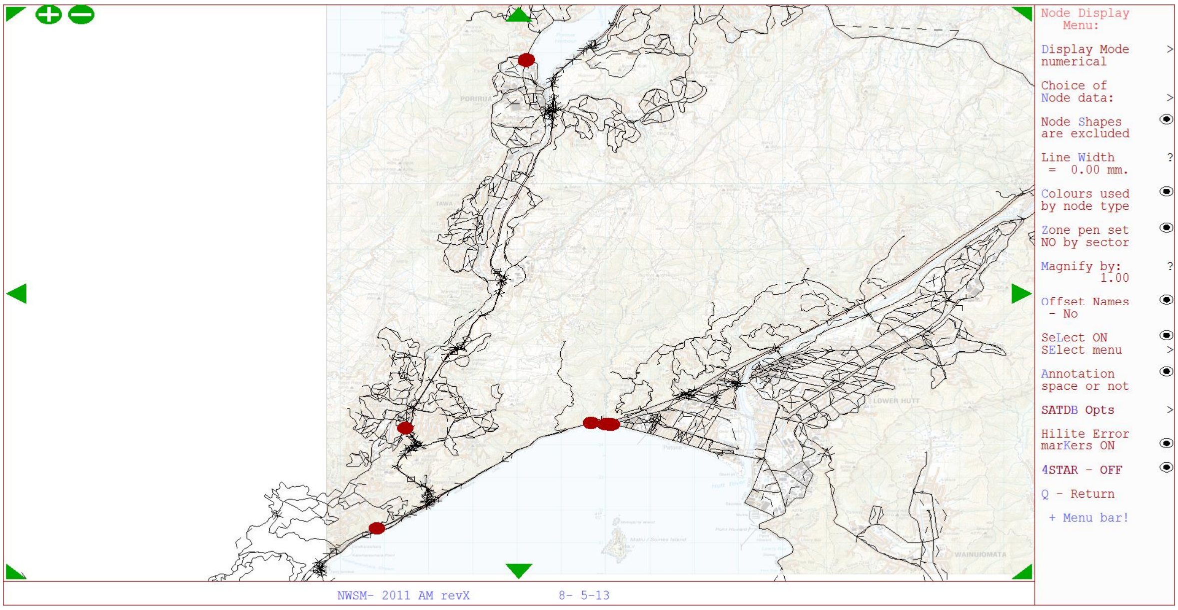
**Table 12-1 Model convergence outputs**

| LPT | Loop | Delta function | Link flows Changing by <1% Between Ass/Sim Loops | Turn delays Changing by <1% Between Assignment and Simulation | Wardrop Equilibrium Gap Function Post Simulation |
|---|---|---|---|---|---|
| ME2AM11Loop6_645_900C | 13 | 0.0847% | 98.8% | 99.8% | 0.064% |
| ME2IP11Loop5 | 5 | 0.0381% | 94.9% | 99.9% | 0.025% |
| ME2PM11Loop5B | 15 | 0.0462% | 98.9% | 99.7% | 0.094% |

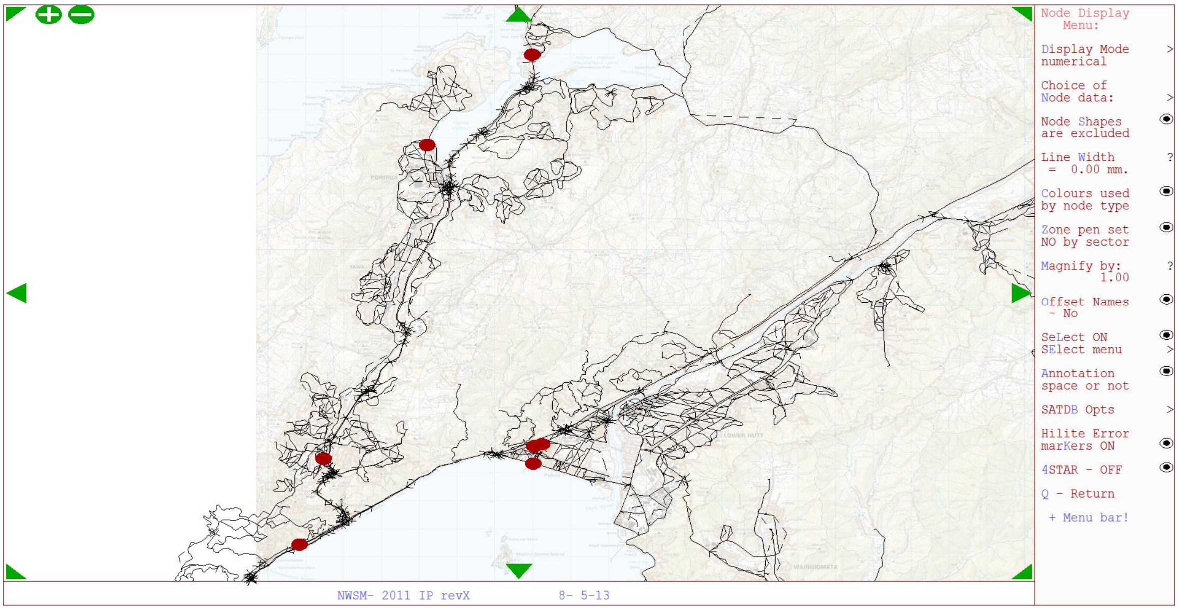
The above table indicates that the base year model is well converged against standard industry practice. For example, default convergence criteria in SATURN are set at 95% of links within 5% of previous assignment / simulation loop flows. The use of KONSTP=1, basing convergence on the gap function has resulted in highly converged models. This is a measure of how close the model is, on average, at assigning trips to their actual minimum cost route, with SATURN manual guidance indicating that models with a GAP of less than 1% are generally considered to be well converged.

As with any model, whilst the flows and delays are changing very little from one iteration to the next (demonstrated in **Table 12-1**), the stability of the NWSM should be checked in areas where KPIs are being extracted for a particular scheme. This will ensure that any changes in flows and delays are genuine effects of a scheme rather than as a result of the model running an additional simulation or assignment loop.

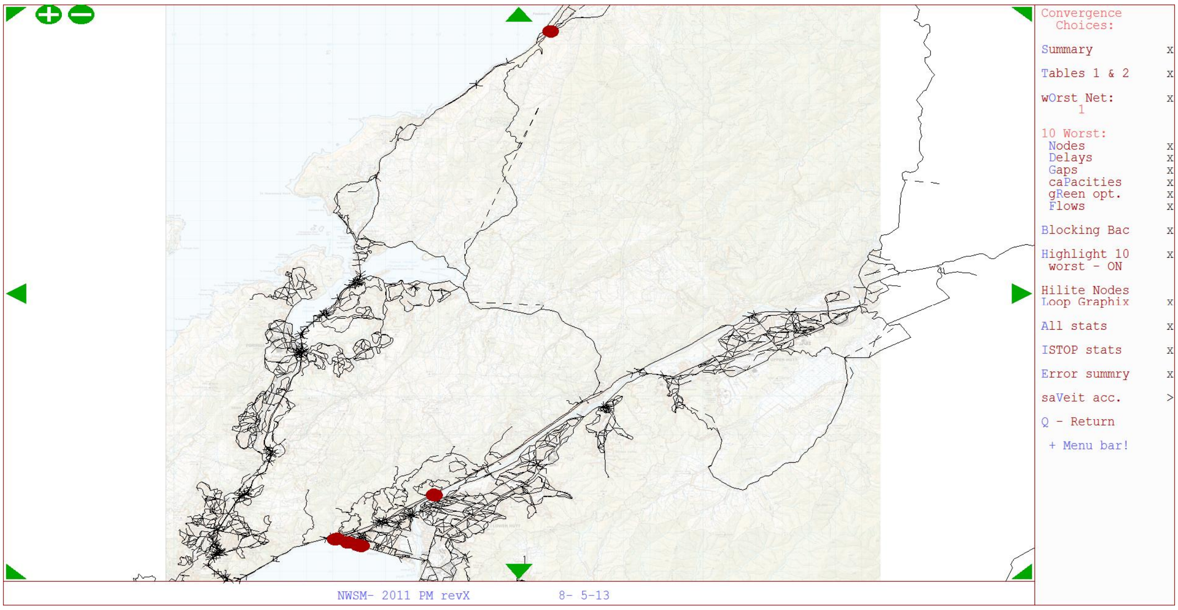
The 10 worst converged nodes (with respect to delay) for the AM, IP and PM peak hour models are shown in **Figure 12-1**, **Figure 12-2** and **Figure 12-3** respectively.




- **Figure 12-1 AM peak 10 worst converged nodes**




- **Figure 12-2 IP 10 worst converged nodes**




- **Figure 12-3 PM peak 10 worst converged nodes**

The only nodes where there are differences in delay between the final assignment and simulation loops greater than 5 seconds are:

- AM peak: Corlett Street, 6 seconds
- IP: Onslow Road, 14 seconds
- PM peak: Hutt Road roundabout, 117 seconds
- PM peak: Melling interchange, 17 seconds
- PM peak: Sydney Street, 15 seconds
- PM peak: Victoria Street, 11 seconds
- PM peak: Fitzherbert Street, 7 seconds
- PM peak: Sydney street, 6 seconds
- PM peak: Paekakariki Hill Road, 5 seconds

Whilst the overall level of model convergence is excellent in all three peaks, if turn specific delays are to be used at the above locations, it is recommended that the models be run with tighter convergence criteria, noting that this increases model run times significantly.  A test using the convergence parameters below has been undertaken:

- STPGAP = 0.01%
- NITA   = 30
- NITS   = 60
- NITA_S = 100
- MASL = 100

This results in the changes in flow of less than 10vph, and more typically 1vph.  The only significant change in delay is at the northern approach to the Hutt Road roundabout as a result of blocking intermittent blocking back on the approach link.

# 13. Travel Time Data

## 13.1. Data

Of the routes surveyed as part of the WTSM model build, three are used for the NWSM validation supplemented by two additional routes. These routes are described in **Table 13-1:** and illustrated **Figure 13-1**.

**Table 13-1: Travel Time Route Descriptions**

| Route ID | Description |
|---|---|
| 1 | SH1 Between MacKays Crossing and Aotea Quay |
| 2 | SH2 Between Upper Hutt and Aotea Quay using Hutt Road south of Ngauranga |
| 6 | Dowse interchange to Wainuiomata via the Esplanade |
| SH58 | SH58 between SH1 and SH2 |
| Esplanade | Between SH2 and Randwick Road |

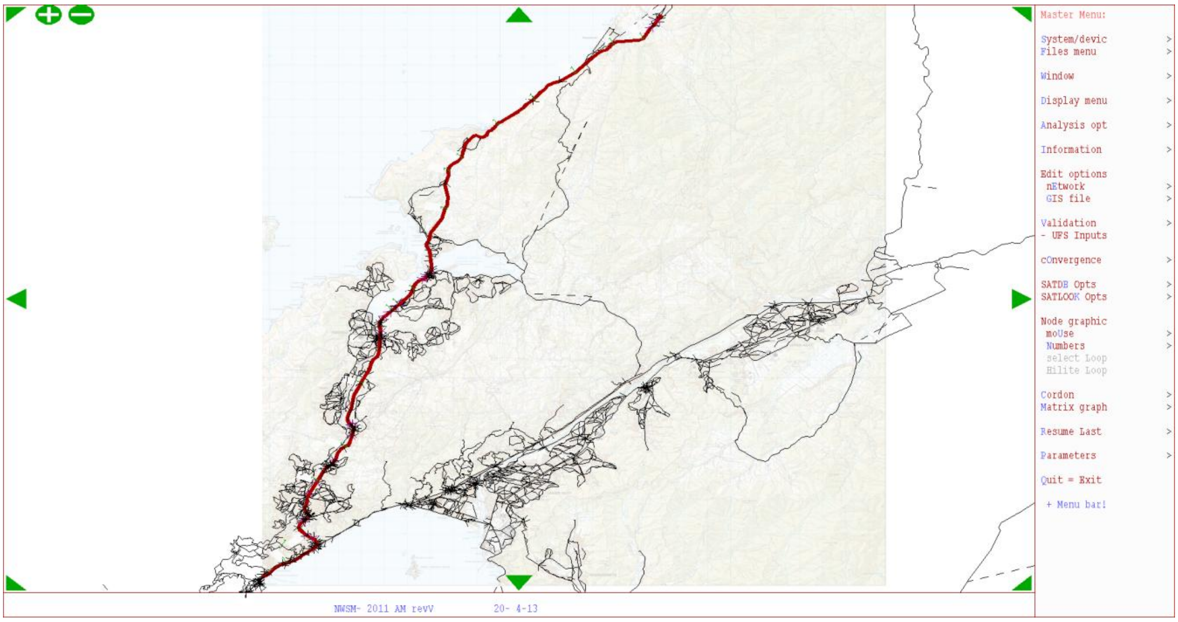
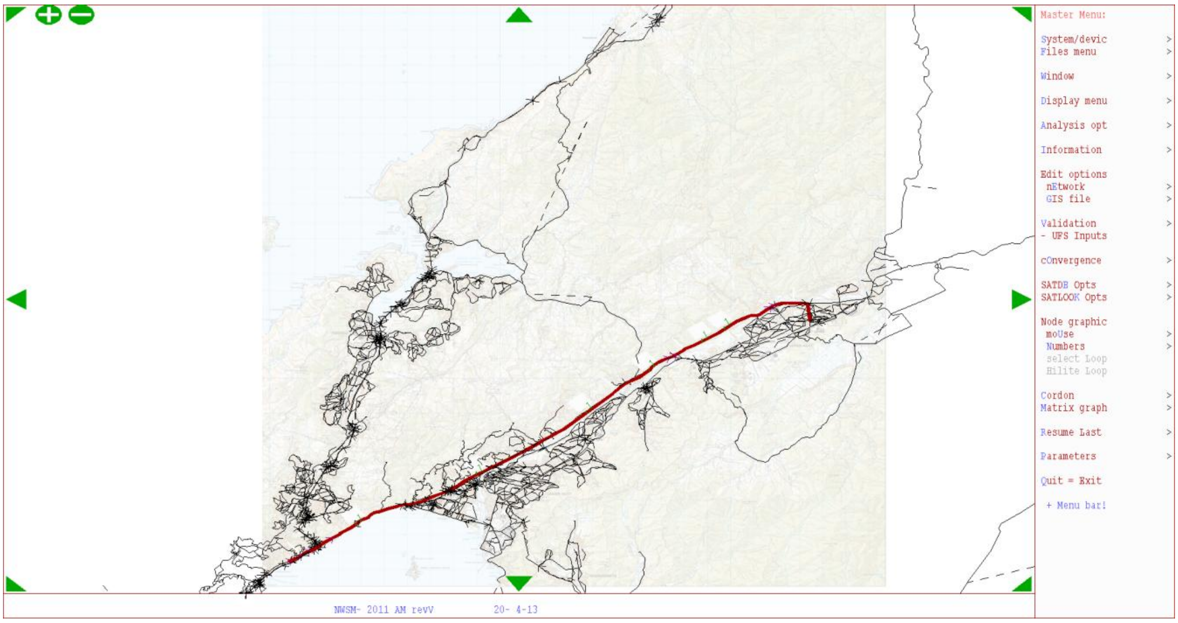
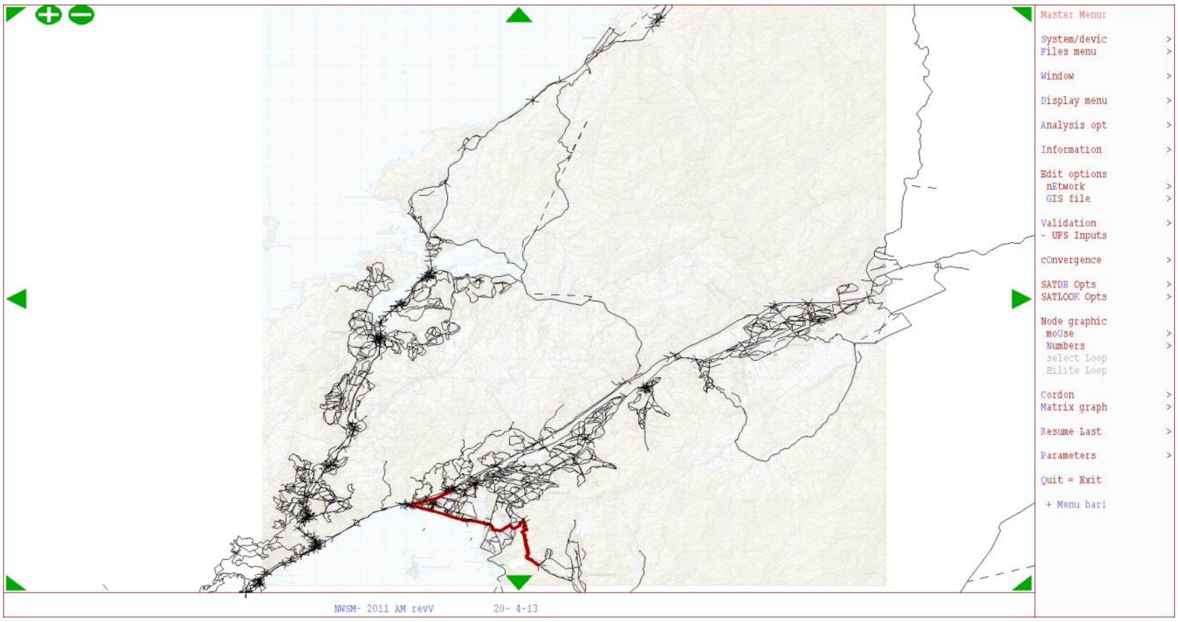



**Figure 13-1: Travel Time Route 1N/1S**

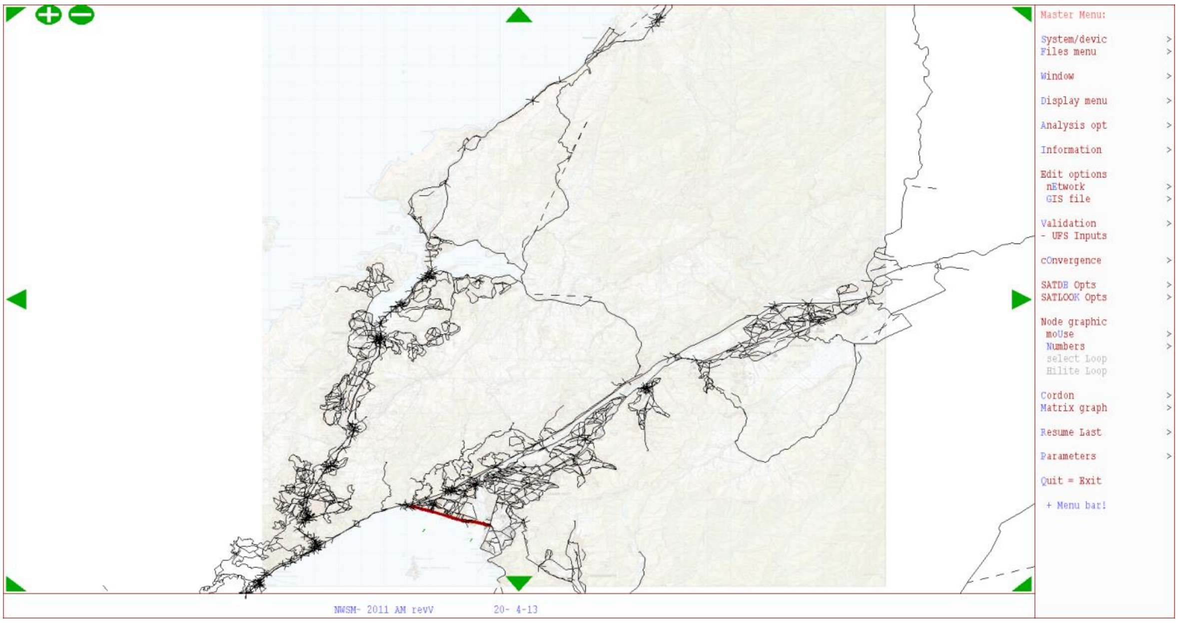
SINCLAIR KNIGHT MERZ SKM



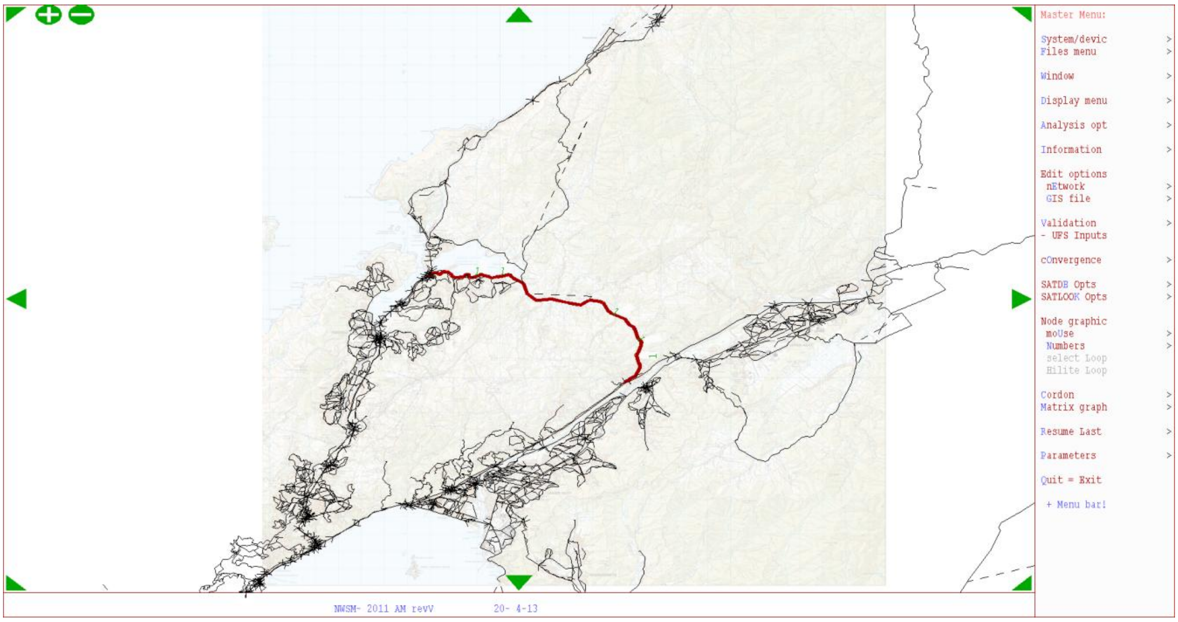

- **Figure 13-2: Travel Time Route 2N/2S**




- **Figure 13-3: Travel Time Route 6N/6S**




- **Figure 13-4: Travel Time Route Esplanade E/W**




- **Figure 13-5: Travel Time Route SH58 E/W**

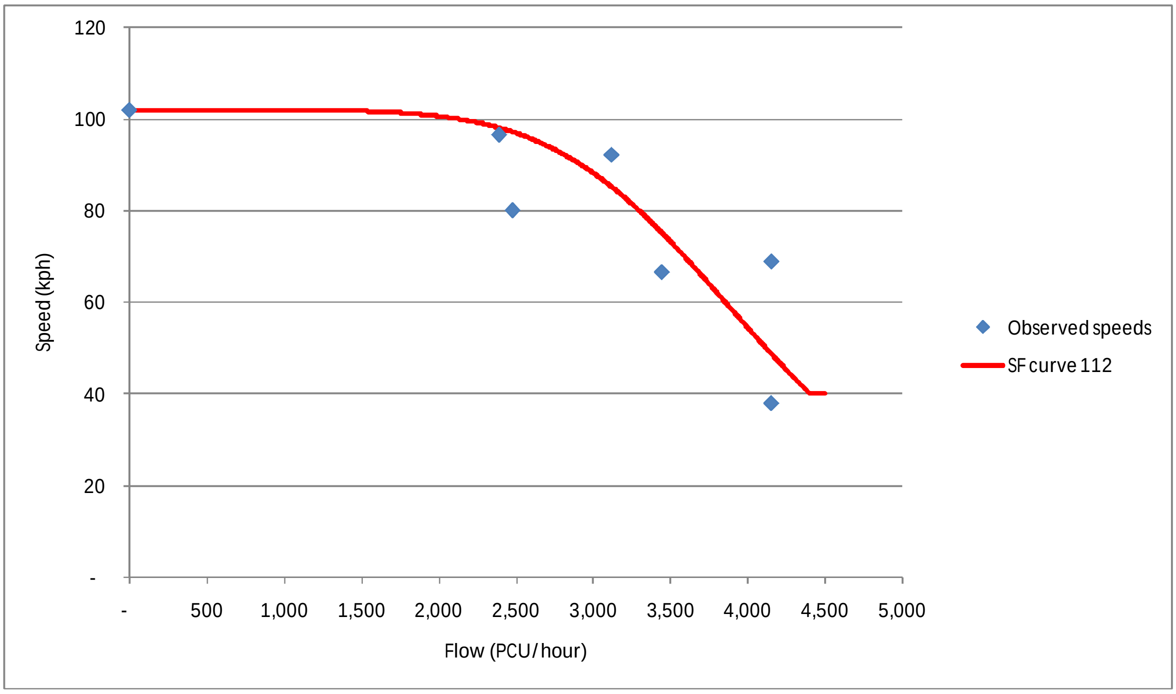
A full set of travel time plots (time versus distance) for each of these routes by direction is provided in **Appendix E**

In the following sections, a commentary on the travel time plots is provided with a summary of the performance on each total route provided in **Table 13-2:** Differences have been highlighted red where the total route modelled time is not within 20% of the observed average time. Further commentary on these outliers is provided in **Sections 13.2** to **13.6**. A detailed breakdown of the travel time routes is provided in Appendix E.

### Table 13-2: Travel Time Comparison Summary

| Route Name and location | | Observed Cummulative Travel Times (min) | | | | | | | | | Modelled Cumulative Travel Times | | | Difference Mod-Obs (min) | | | Difference Mod-Obs (%age) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | AM | | | IP | | | PM | | | AM | IP | PM | AM | IP | PM | AM | IP | PM |
| | | Min | Ave | Max | Min | Ave | Max | Min | Ave | Max | | | | | | | | | |
| 1S | Waikanae Railway Station to Wellington Airport | 46 | 55 | 68 | 30 | 31 | 33 | 29 | 33 | 37 | 42 | 32 | 34 | -12.7 | 0.4 | 1.0 | -23% | 1% | 3% |
| 1N | Wellington Airport to Waikanae Railway Station | 28 | 29 | 30 | 27 | 28 | 30 | 30 | 33 | 39 | 28 | 28 | 43 | -1.3 | -0.4 | 9.7 | -5% | -1% | 29% |
| 2S | Upper Hutt Rail Station to WLG Rail Station via Old Hutt Rd | 30 | 40 | 54 | 17 | 19 | 21 | 21 | 23 | 27 | 33 | 20 | 23 | -7.1 | 1.0 | -0.5 | -18% | 5% | -2% |
| 2N | WLG Rail Station to Upper Hutt Rail Station via Old Hutt Rd | 20 | 23 | 26 | 24 | 26 | 28 | 23 | 30 | 38 | 23 | 22 | 37 | 0.0 | -4.5 | 6.7 | 0% | -17% | 22% |
| 6N | Wainuiomata Rd to Hutt Rd Northbound | 16 | 18 | 19 | 12 | 12 | 13 | 13 | 13 | 14 | 17 | 14 | 16 | -1.0 | 1.1 | 2.4 | -6% | 9% | 18% |
| 6S | Hutt Rd to Wainuiomata Rd Southbound | 25 | 28 | 32 | 13 | 14 | 14 | 13 | 17 | 21 | 17 | 14 | 17 | -11.0 | 0.7 | -0.1 | -39% | 5% | -1% |
| The Esplanade E | Hutt Rd to Randwick Rd | 4 | 5 | 6 | 4 | 5 | 7 | 5 | 9 | 12 | 6 | 6 | 7 | 0.8 | 0.4 | -1.4 | 16% | 8% | -16% |
| The Esplanade W | Randwick Rd to Hutt Rd | 4 | 9 | 16 | 4 | 4 | 5 | 4 | 4 | 5 | 7 | 5 | 6 | -2.1 | 0.6 | 1.5 | -22% | 14% | 34% |
| SH58 E | SH1 to SH2 | 13 | 14 | 15 | 12 | 14 | 15 | 13 | 14 | 14 | 14 | 12 | 13 | 0.5 | -1.5 | -0.3 | 3% | -11% | -2% |
| SH58 W | SH2 to SH1 | 13 | 14 | 16 | 13 | 15 | 17 | 13 | 14 | 15 | 14 | 13 | 13 | 0.1 | -2.0 | -0.5 | 1% | -14% | -4% |

**Figure 13-6** shows average travel speeds on SH2 south of Petone for various flows (measured as northbound and southbound in the AM, inter and PM peaks). As can be seen in **Figure 13-6** there are reasonable differences in travel speeds for very small changes in flows. As with any model build, there is a balance between making “site specific” adjustments to more closely reflect observed conditions, and retaining sufficient generality as to enable forecasting to be undertaken in a robust manner. It is considered that the speed flow curve applied for a two lane motorway (SFcurve 112) provides an appropriate reflection of the observed data.




▪ **Figure 13-6 Travel speeds on SH2**

## 13.2. Route 1: State Highway 1

There is excellent correlation along the length of the SH1 route northbound in the AM and inter peaks. The PM model is running slightly slower than observed data suggests (19% slower). This is in line with observed speeds in the PM peak being slightly quicker than modelled speeds for the equivalent flow in the AM and inter peaks.

Southbound the inter and PM peaks are well reflected with the AM peak running approximately 28% quicker than observed data. This is predominantly due to the "moving queue" from Tawa to Ngauranga with the speeds south of Ngauranga well reflected. It is noted that there is anecdotally significant variation in travel speeds on this section of SH1. The speed flow curve on SH1 has been altered to have a maximum speed of 82kph and minimum of 20kph to reflect the fact that there are variable speed limits applied southbound in the AM peak and northbound in the PM peak. This has resulted in southbound modelled speeds of between 10kph (at the merging of SH1 and SH2 south of Ngauranga, including merge delay) to 37kph between Newlands and Ngauranga and 43kph at Johnsonville. Speeds are only slightly higher in the pre and post peak periods due to the relatively flat peak. In order to maintain consistency of coding with the PM peak, it is not considered appropriate to further restrict the speed on this section, acknowledging that this may underestimate the congestion relief that the Petone to Grenada link may bring.

The travel time surveys undertaken have speeds varying between 17kph and 34kph on the same section for the three survey days used with the time the vehicle reaching Ngauranga varying between 08.00 and 09.00.

## 13.3. Route 2: State Highway 2

As on SH1, the PM peak is running slightly slower than observed data due to the speed flow curves developed to reflect speeds in all three peaks slightly underestimating speeds in the PM peak.

Travel times southbound on SH2 are well reflected in the inter and PM peaks, with the AM peak running slightly faster than observed for the section at Korokoro Road, with the delay in the model occurring at the Petone on ramp so that overall the travel time is well reflected.

## 13.4. Route 6: Dowse to Wainuiomata Road

Eastbound the queue back from the Petone roundabout up Hutt Road is resulting in a 2 minute delay north of the eastbound slip to the Esplanade and a further 2 minutes between this diverge and the roundabout itself. The traffic travelling onto the Esplanade therefore only incurs a 2 minute delay rather than the total 4 minutes to the roundabout. It is of note that the observed travel time data indicates delays in excess of 15 minutes on this section of Hutt Road even though the parallel section of SH2 is significantly quicker. Any attempts in the model to increase the traffic on Hutt Road (and therefore the delay at this intersection) results in this traffic diverting onto SH2. It is not clear why vehicles do not use this route choice in reality. It is noted that the observed travel times are spread between 07.30 and 08.30 with consistent observed speeds less than 10kph (despite SH2 running parallel to Hutt Road at 20kph at the same time).

Westbound travel times are well reflected in all peaks. It is of note that this route incorporates the Esplanade westbound route discussed in Section 13.6 and has significantly lower delays than the Esplanade survey data suggests.

## 13.5. Route SH58: State Highway 58

The travel times both eastbound and westbound are well reflected in the model.

## 13.6. Route Esplanade: The Esplanade

Eastbound the model is reflecting observed travel times well with speeds slightly lower than observed in the AM peak and slightly higher in the PM peak.

Westbound, the delay at the western end of the Esplanade onto SH2 is significant with a total of approximately 8 minutes delay from the merge point on SH2. Only two minutes of this delay is borne on the Esplanade prior to the right slip to the roundabout developing which results in the modelled travel time to the roundabout being under reflected.

Significant testing has occurred to assess the effects of increased queuing from SH2, but this has resulted in unrealistically high delays on SH2 and the on ramps themselves. It is considered that the models produced provide a reasonable compromise in balancing queuing and delays in the model.

## 13.7. Travel Time Summary

It is considered that the model network and demands produced provide a reasonable reflection of congestion on the Northern Wellington network, balancing traffic demands, location of queues and delays appropriately for assessing the proposed Petone to Grenada link road. The consistency of the coding approach provides confidence that any differences in the base year replication of delays will be offset by improved consistency in future year and option forecasting.

## 13.8. HCV speed validation

Beca Infrastructure Ltd (Beca) provided freight speed profiles using the EROAD data stored in the FMD database. Speeds for spot reference points were provided by Beca. The information provided was used to verify that the speeds are in the right ballpark range. Only the speeds for the congested peak hours were used in the comparison as only in highly congested situations the speeds will be the similar for both user classes (HCVs and Lights). The net speed (km/hr) was looked at to determine the differences. The ned speed incorporates queue delays.

The speed comparison was undertaken southbound in the AM peak and northbound in the PM peak for the following three locations:

- SH1 south of Tawa
- SH1 north of Ngauranga
- SH2 north of Ngauranga

The reference point located on SH2 south of Melling has not been used in the validation as the acceleration and deceleration of HCVs is considerably different to light vehicles and therefore the speed cannot be compared.

**Table 13-3 HCV observed speed versus modelled net speed**

| | Model speed (km/hr) | | EROAD (km/hr) | | Diff (km/hr) | |
|---|---|---|---|---|---|---|
| Location | AM | PM | AM | PM | AM | PM |
| SH1 south of Tawa | 41 | 66 | 31 | 61 | 10 | 5 |
| SH1 north of Ngauranga | 36 | 42 | 24 | 41 | 12 | 1 |
| SH2 north of Ngauranga | 48 | 50 | 39 | 41 | 9 | 9 |

The comparison showed that the differences between the observed HCV speeds and the modelled net speeds are on the order of ≤10 km/hr. For all peaks and all directions the model is running slightly quicker than the observed speeds indicate. However this could be an artefact of comparing HCV speeds to model speeds comprising both Lights and HCVs. Only one reference point is approximately 12km/hr quicker than the observed. This occurs on SH1 north of Ngauranga in the AM peak. However the speed at the merge at Newlands is approximately 6km/hr slower than this figure and the variability is greater when speeds drop that significantly from free flowing conditions.

Overall, the modelled speeds are considered in an acceptable range.

# 14. Sensitivity and Sensibility Testing

## 14.1. Effect of Generalised Cost on Assignment

The following approximations to perceived generalised cost have been retained for the NWSM:

- Light vehicles: PPM = 1, PPK = 0.3
- MCV/HCV: PPM = 1, PPK = 0.6

Sensitivity testing of the following alternate generalised cost components has been undertaken:

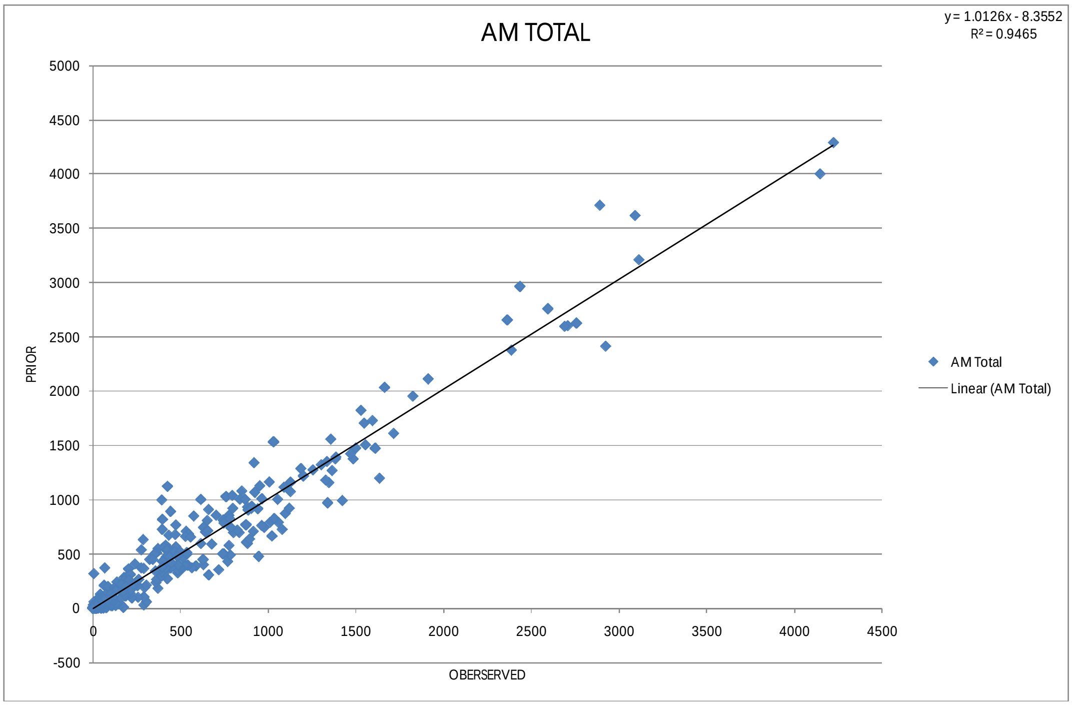
- **Test A (reduced perceived VOC)**
  - Light vehicles: PPM = 1, PPK = 0.15
  - MCV/HCV: PPM = 1, PPK = 0.3
- **Test B (increased perceived VOC)**
  - Light vehicles: PPM = 1, PPK = 1
  - MCV/HCV: PPM = 1, PPK = 2

This testing has been carried out assigning the non-estimated matrices to establish the sensitivity of the goodness of fit of modelled flows to traffic counts.

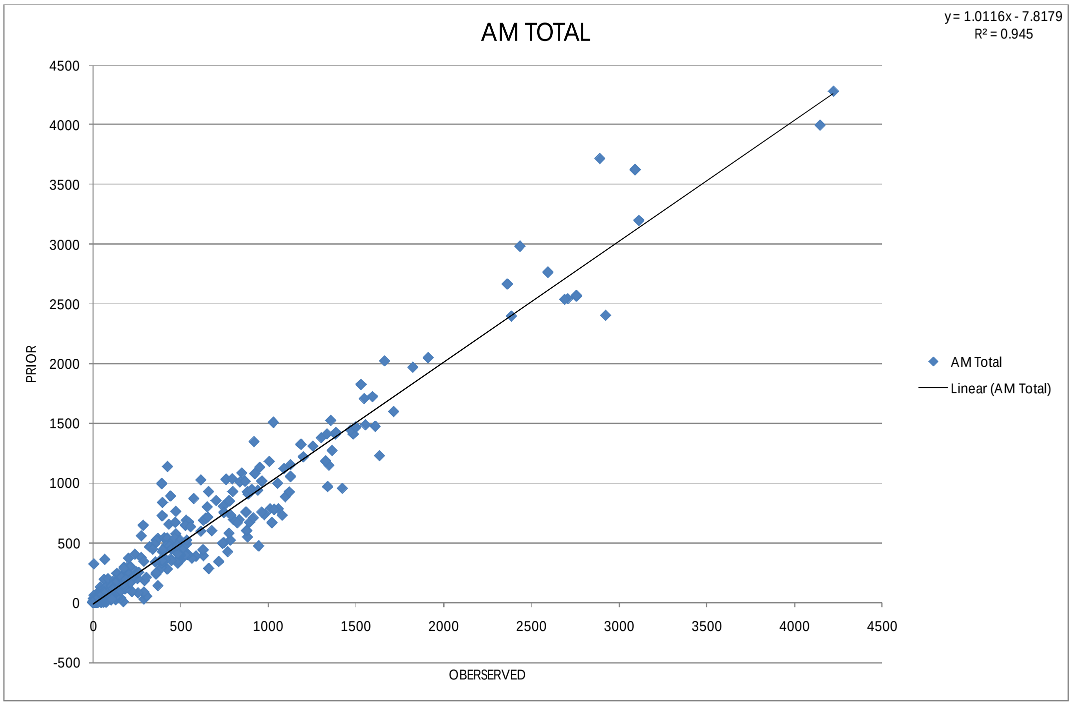
**Figure 14-1** to **Figure 14-9** show the overall goodness of fit of total vehicle flows to the entire count data set (link and turn counts), for the adopted components of generalised cost and the two sensitivity tests.

It is of note that the level of correlation between the adopted generalised cost values and the sensitivity tests is very similar. In the AM peak, there is no change for the reduced dependence on distance in the cost function and slight deterioration in correlation when the distance dependence is increased (although the line of best fit moves closer to 1). In the interpeak, there is deterioration in the gradient for the line of best fit for both sensitivity tests. In the PM peak the gradient of the line of best fit improves slightly with a reduced dependence on distance and worsens with an increased dependence on distance.

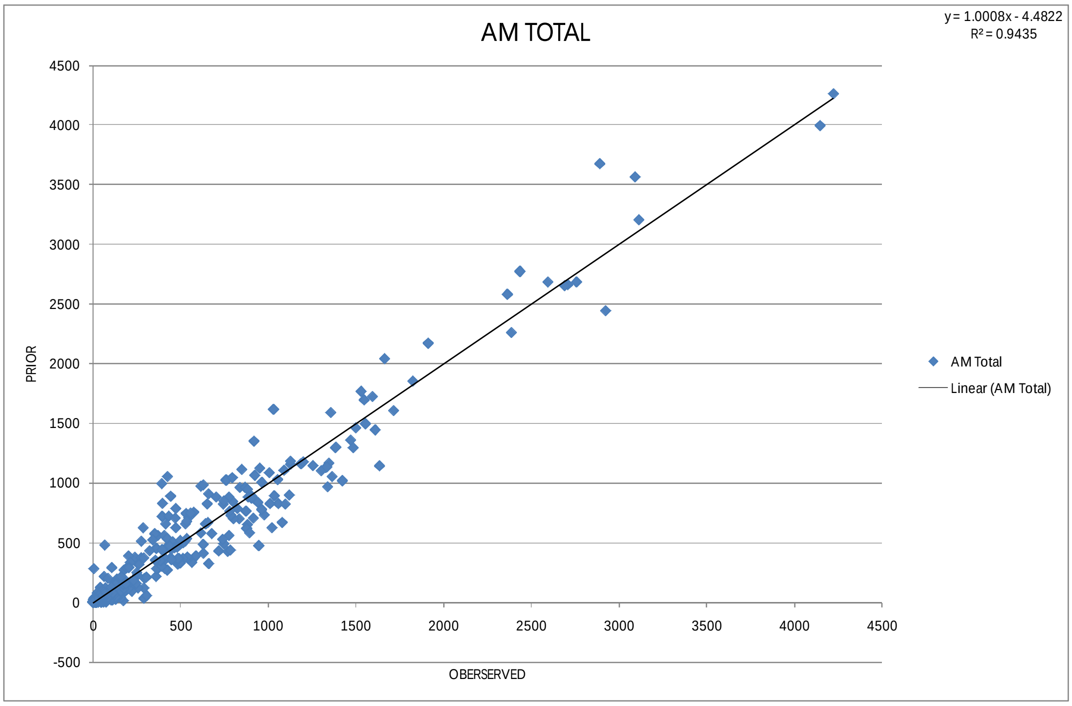
In summary, the increased dependence on distance worsens the correlation in all three peaks, and the reduced dependence on distance improves the correlation in the PM peak, but worsens in the inter peak. It is considered that these small changes in correlation do not provide sufficient evidence to warrant changing the generalised cost function.



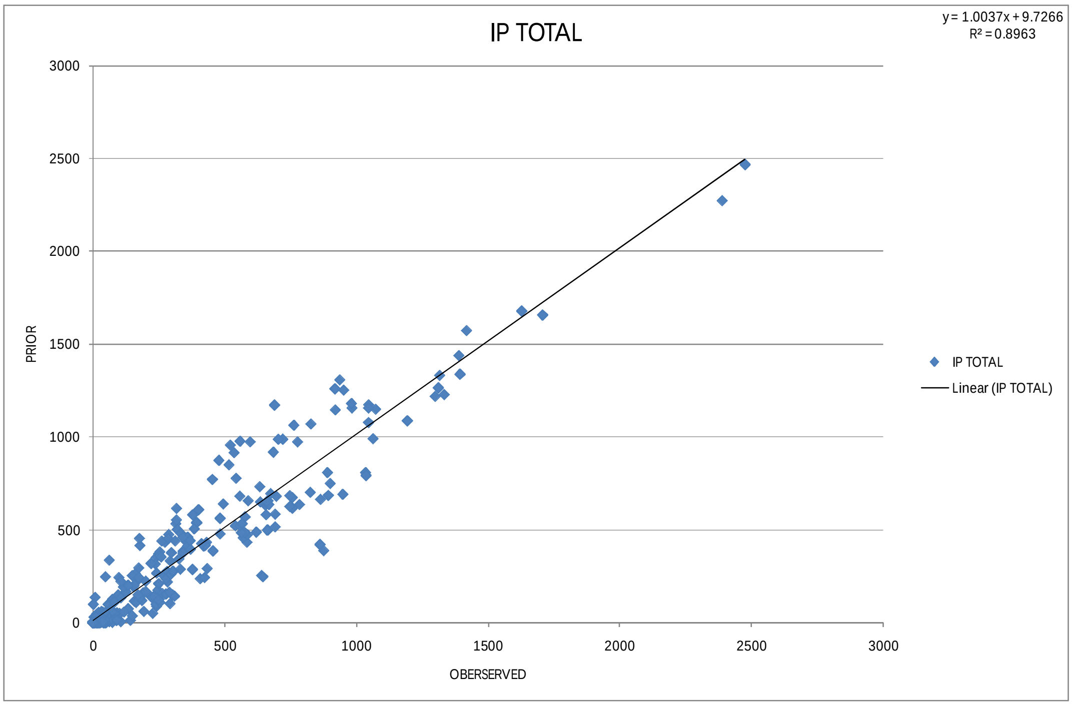

■ **Figure 14-1: Modelled v All Counts, Adopted Generalised Cost Components, AM Peak Hour**



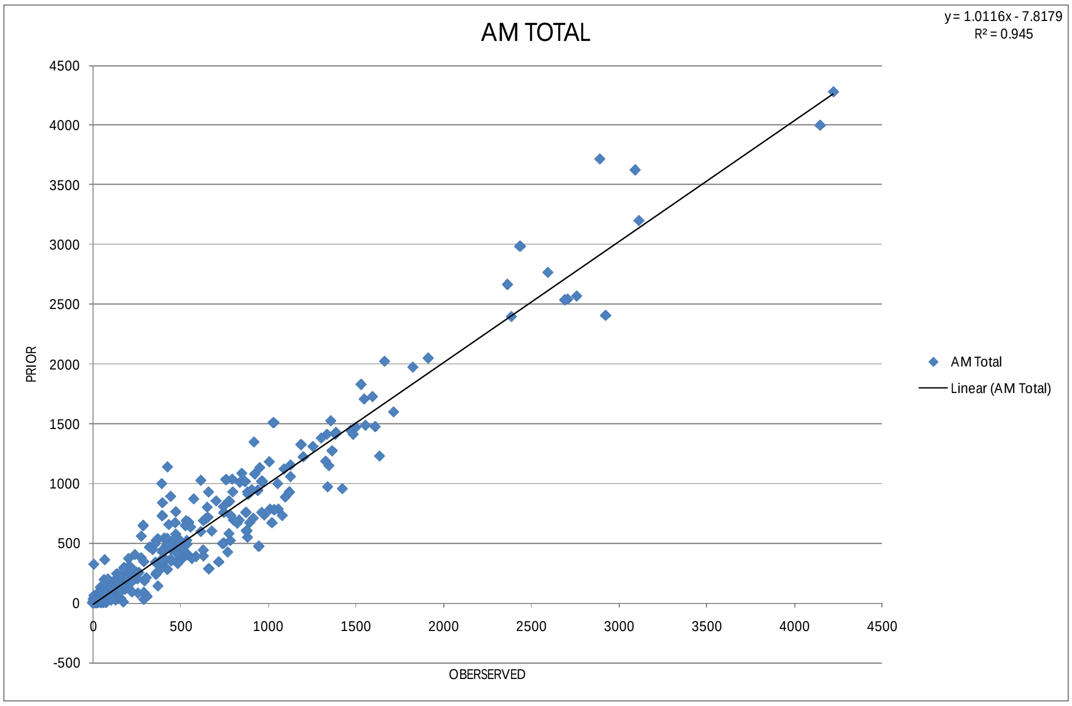

■ **Figure 14-2: Modelled v All Counts, Reduced VOCs, AM Peak Hour**



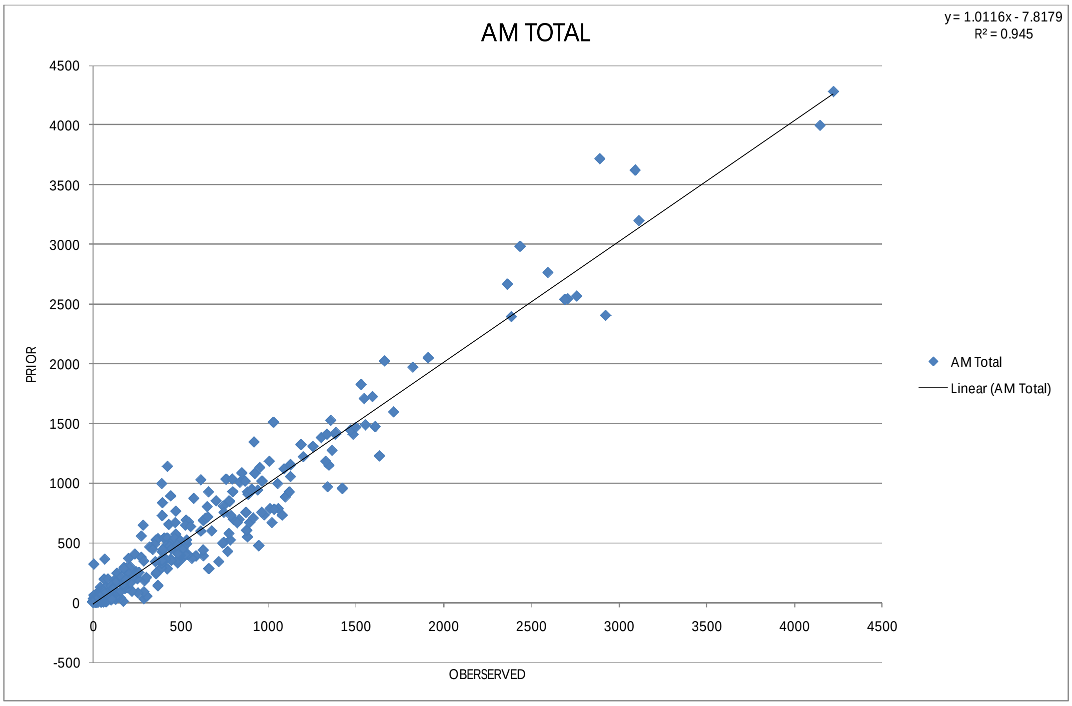

- **Figure 14-3: Modelled v All Counts, Increased VOCs, AM Peak Hour**



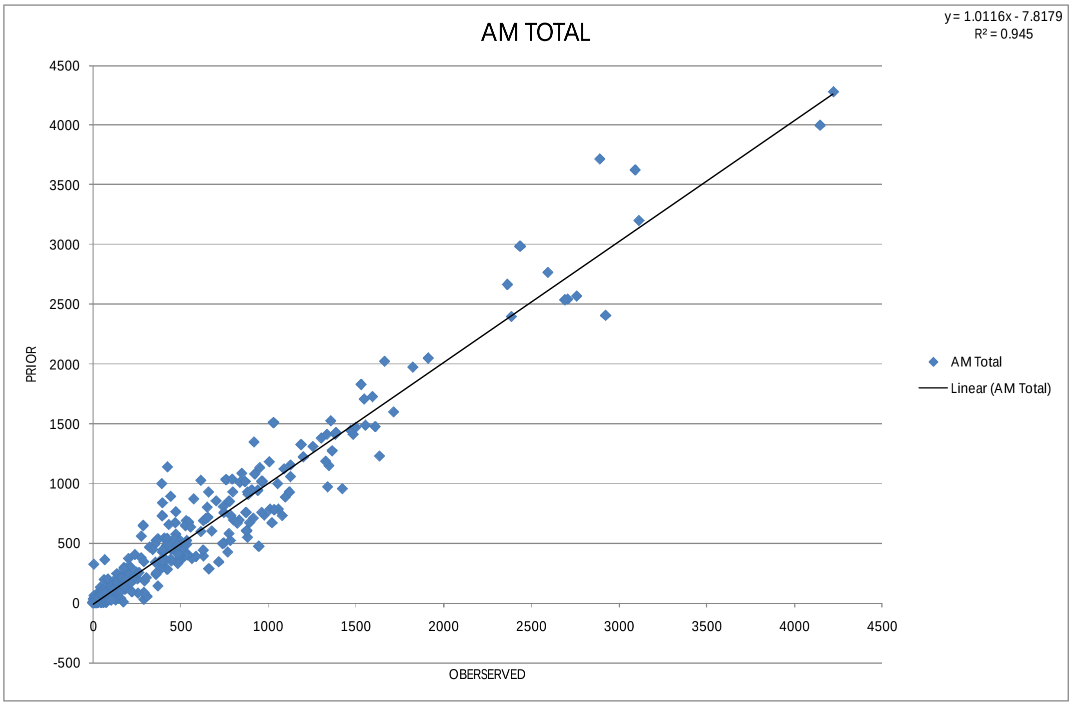

- **Figure 14-4: Modelled v All Counts, Adopted Generalised Cost Components, Interpeak**



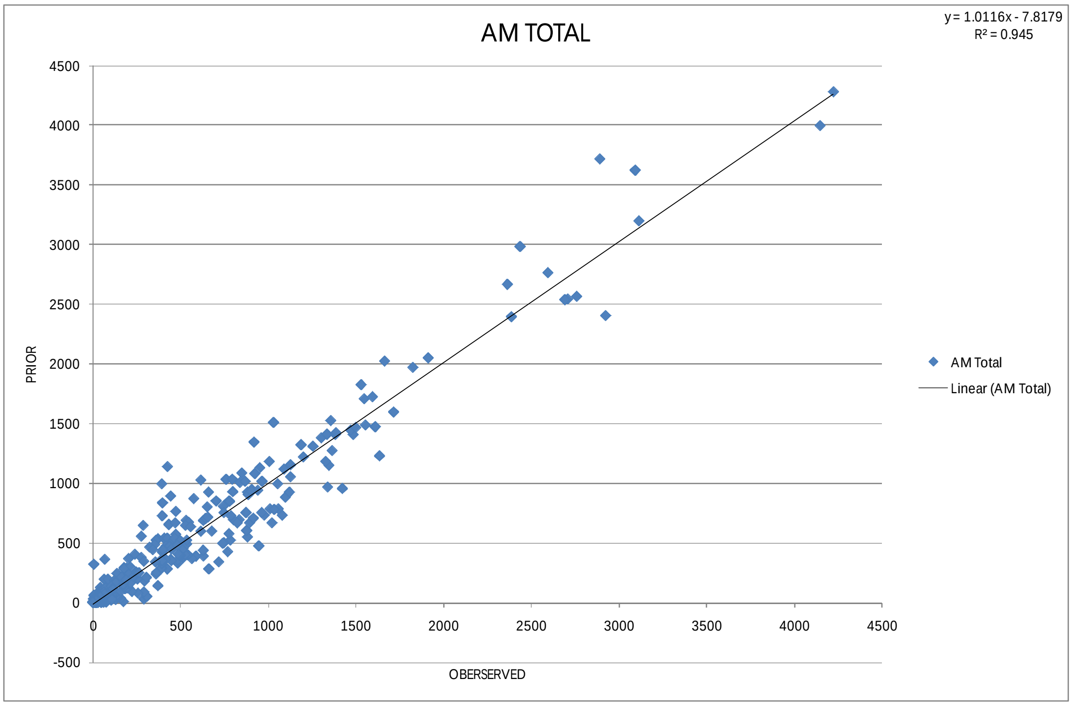

- **Figure 14-5: Modelled v All Counts, Reduced VOCs, Interpeak Average Hour**



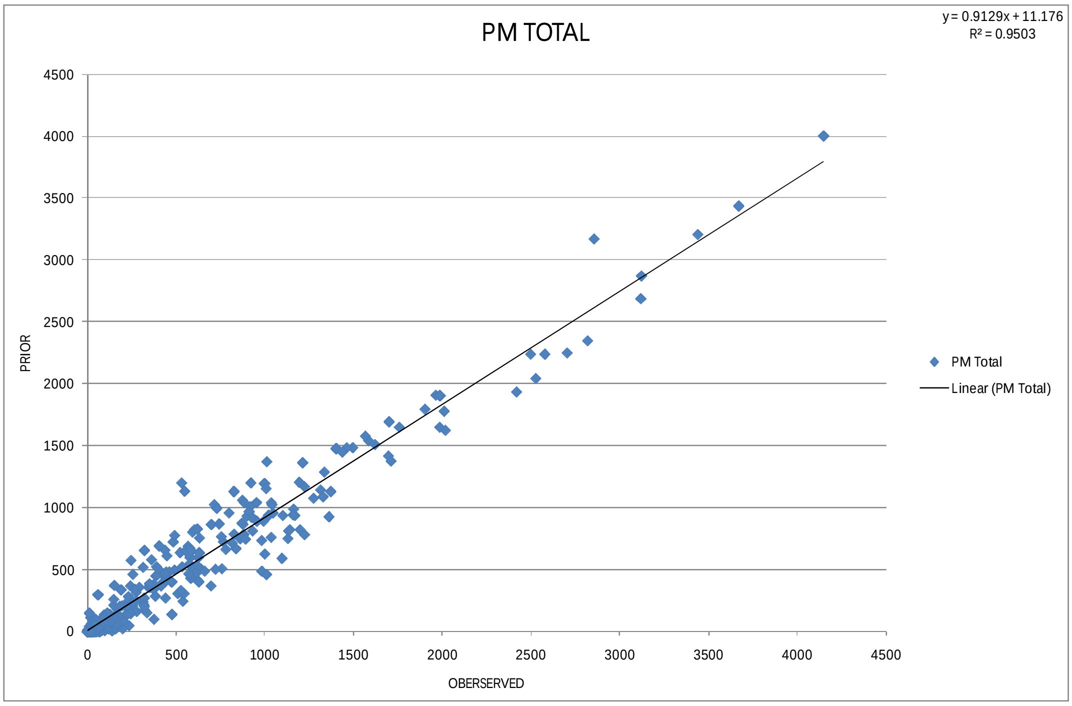

- **Figure 14-6: Modelled v All Counts, Increased VOCs, Interpeak Average Hour**




- **Figure 14-7: Modelled v All Counts, Adopted Generalised Cost Components, PM Peak Hour**




- **Figure 14-8: Modelled v All Counts, Reduced VOCs, PM Peak Hour**




- **Figure 14-9: Modelled v All Counts, Increased VOCs, PM Peak Hour**

## 14.2. Routing Issues and Checks

Count outlier investigations have indicated some route choices in the model at a very limited number of locations where the assignments based on generalised cost are inaccurate. However, this is not necessarily consistent with road hierarchy and therefore would be very difficult to replicate systematically in a robust way that could be carried forward into forecasting.

Whilst no specific data exists on vehicle route choice, as part of the calibration process and indentifying areas where counts are not well reflected in the model, vehicle routing has been investigated and found to be consistent with local anecdotal observations.

## 14.3. Software Error Checks

The SATURN LPN file has been interrogated to ensure that serious warnings and non-fatal errors have been rationalised. Network serious warnings are documented in **Table 14-1** with explanation provided.

- **Table 14-1: LPN file checks**

| Error ID | Description | Explanation |
|---|---|---|
| 109 | SOME OF YOUR IN-LINKS MAY NOT HAVE BEEN DEFINED IN STRICT CLOCKWISE ORDER. | This occurs as a result of over bridges. |

| Error ID | Description | Explanation |
|---|---|---|
| 112 | A ZONE HAS ONE OR MORE CENTROID CONNECTORS CONNECTED TO EXTERNAL SIMULATION | Connectors used to appropriately reflect loading points. Counts around these connectors may not be well reflected |
| 113 | SIMULATION ARMS NOT IN (COUNTER-)CLOCKWISE ORDER ACCORDING THE CO-ORDINATES OF THE A-NODES | As per 109 |
| 117 | TWO PRIORITY MOVEMENTS CROSS AT A PRIORITY JUNCTION BUT NEITHER HAS A TURN PRIORITY MARKER | Lane gains |
| 129 | BLANK RECORD READ IN - AND SKIPPED | |
| 135 | MORE THAN ONE GIVE WAY TURN SHARING THE SINGLE LANE: MAJOR ARM AT A PRIORITY JUNCTION; | Shared lanes at priority intersections. Additional lanes have been coded where there's room to pass. |
| 137 | THE TURN SATURATION FLOWS PER LANE DIFFER WIDELY | Occurs where geometry isn't replicated. Turn saturation flows are consistent with Wellington Coding manual. |
| 147 | A POSITIVE INTERGREEN SEPARATES TWO IDENTICAL STAGES | Linked signals where a single set of signals has been coded with two nodes |
| 150 | A NEARSIDE MERGE INTO A TURN NOT IN ITS INSIDE LANE | Checked as merging into first lane. |
| 152 | A SINGLE-LANE ARM AT SIGNALS WHICH INCLUDES AN X-MARKED TURN | No room for two vehicles to pass, consistent with operation. |
| 154 | X-TURN SHARES IDENTICAL LANES WITH THE TURN INSIDE IT BUT THAT TURN USE LANES FURTHER INSIDE TO AVOID BEING BLOCKED BY THE X-TURN | As per 152 |
| 156 | THE EXIT LINK FROM A MERGE HAS EQUAL/MORE LANES THAN THE SUM OF THE TWO MERGING TURNS | Capacity of the link is throttled using a capacity index where link flares out at downstream intersection |
| 157 | MID-LINK CAPACITY EITHER >> OR << STOP-LINE SATURATION FLOWS | Capacity index used to reflect mid link capacity |
| 161 | AN X-TURN AT A PRIORITY JUNCTION HAS NO MAJOR TURNS OPPOSING IT | As per 111 |
| 168 | A TURN HAS BEEN BANNED BUT OTHER TURNS AT THE ROUNDABOUT USE THE SAME EXIT ARM | Roundabout slip lanes have removed left lane from roundabout coding |
| **210** | ZERO FLOW DEFINED | Zero counts in database |
| **222** | A BUS ROUTE "STUTTERS | No impact |
| **273** | A SIMULATION LINK HAS DOWNSTREAM EXITS BUT NO UPSTREAM ENTRIES | Zone is loaded on downstream link |
| **275** | A BUFFER LINK HAS NO POSSIBLE ENTRIES APART FROM ITS U-TURN | Buffer coding consistent with WTSM |

## 14.4. Average Queue Lengths

As described in the model scoping document, whilst the NWSM replication of observed congestion is captured in the travel time validation (see Chapter 13), queue lengths provide another useful measure. Due to the size and complexity of the NWSM, it is not practical to provide plots of this information in this report. Queue lengths have been checked and areas of significant queuing are consistent with site observations.

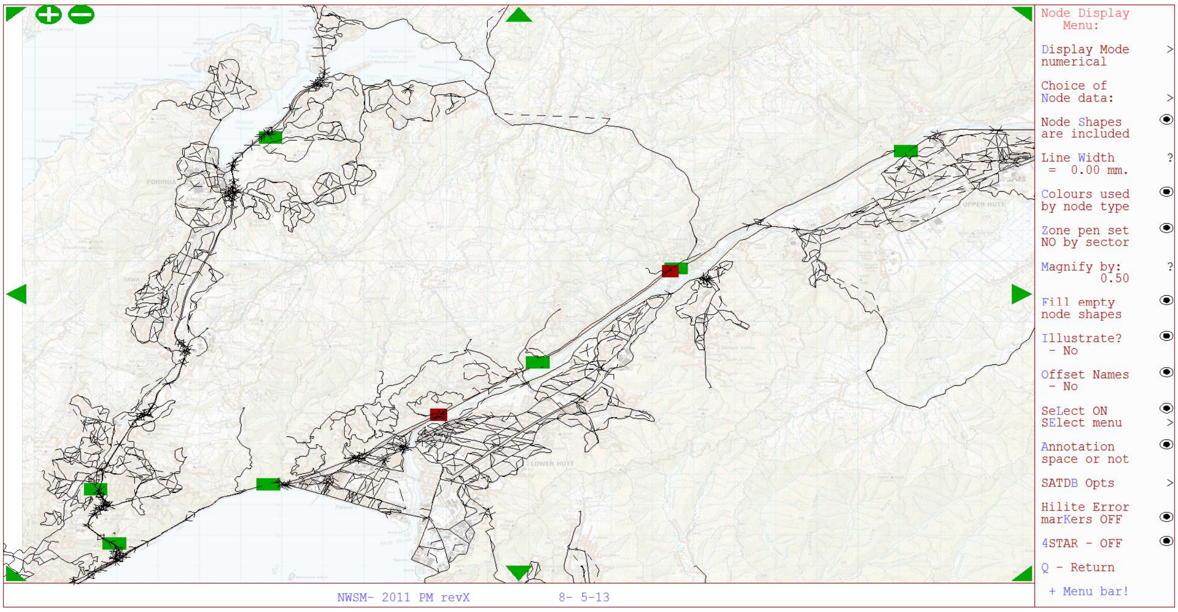
It should be noted here that through a combination of the automated coding of link lengths, and the insertion of signalised intersection pre and post node, blocking back of queues and the impact on the capacity of upstream links is captured within the NWSM.

### 14.5. Volume to Capacity Ratios

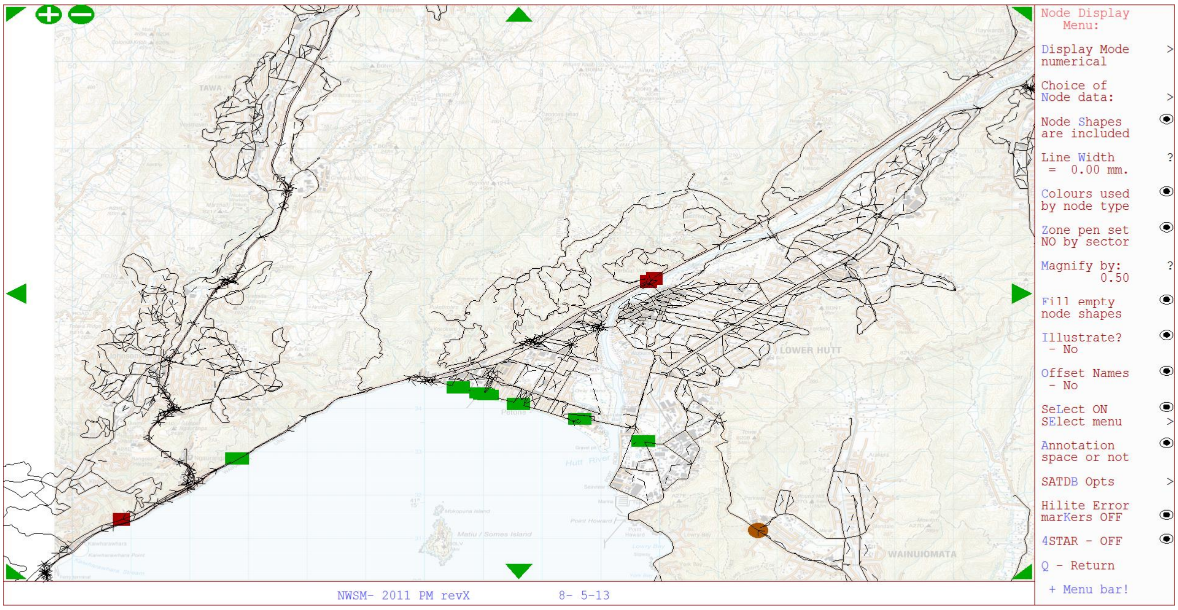
Another measure of congestion is the volume to capacity (V/C) ratio at all nodes in the model. The effects that this has on network speeds are captured both in link delays (through application of a speed flow curve) and intersection delays. Typically, once V/C ratios reach approximately 85% there is a rapid deterioration in network performance, displayed through the steeper section of speed flow curves where small changes in flow can result in larger changes in speed, and the equivalent volume delay functions at intersections. In order to demonstrate areas of the network which are at this "tipping point" where small increases in would result in large increases in delay, areas of the network that have a V/C>85% are shown have been checked and are consistent with known areas of congestion.

### 14.6. Areas of high delay

The intersections where there are modelled turn delays greater than 3 minutes are highlighted for the AM and PM peaks in **Figure 14-10** and **Figure 14-11**. The areas of high delay coincide with the known congested SH2 and SH1 corridors in the AM peak, and SH2 and along the Esplanade in the PM peak.




- **Figure 14-10 AM areas of high delay**




- **Figure 14-11 PM areas of high delay**

## 14.7. Data Variability

Development of the NWSM has involved comparison of modelled flows with large sets of traffic count data, as reported in Chapters 10 and 11. With the availability of turning counts at adjacent intersections, undertaken on different days, or with multiple counts at the same intersection, there will always be a degree of variability of observed data. This variability is due to daily and seasonal variations in observed traffic volumes and also includes errors in recording and processing count data. A consequence of the variability in observed traffic data is that there will always be some variation between observed data and modelled traffic volumes.

## 14.8. Key Model and Data Discrepancies

This chapter identifies key discrepancies between surveyed data and modelled flows which are due to the three effects described above which we summarise as:

- Inconsistencies in count data
- Inherent errors in the input demands from the regional model
- Limitations of the NWSM assignment and simulation process

As described in Chapters 10 and 11 the NWSM model generally provides excellent correlation between observed and modelled flows for the hundreds of count locations used. There are however inevitably some discrepancies between data and modelled flows as described above and we stress that these are not simply model 'errors'. The key discrepancies are identified and an explanation provided in Section 11. These explanations should provide a useful point of reference for future application of the model such that modellers are aware of potential issues and are able to interpret model outputs appropriately.

# Appendix A MB, NWSM and WTSM zone boundaries

# Appendix B Effects of Matrix Estimation on Sector Demands

# Appendix C Count Comparison_ME_RevV.xlsx

# Appendix D JourneyTimeJoyRideDataRevV.xlsx