Ngāmotu Strategic Transport Model

Model Development Report

Model Version 1.1

Prepared for New Plymouth District Council

Prepared by Beca Limited

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Contents

Appendices

Revision History

Revision Nº	Prepared By	Description	Date
1	Ali Danesh	First revision for client comment and peer review.	20/10/2023
2	Ali Danesh	Second revision to finalise the report following peer review, with no content changes.	14/11/2023

Document Acceptance

Action	Name	Signed	Date
Prepared by	Ali Danesh/ Subramanyam Uppuluri		14/11/2023
Reviewed by	Matt Hickson Caleb Deverell		14/11/2023
Approved by	Nyan Aung Lin		14/11/2023
on behalf of	Beca Limited		

Executive Summary

Purpose

This document describes the transport model developed for the New Plymouth urban area and the satellite towns (i.e., Waitara, Inglewood, Egmont and Oakura). The model is called as the Ngāmotu Strategic Transport Model, abbreviated as Ngāmotu STM. This report only relates to the base year model development and validation process. The future year model development and forecasting process will be documented in a separate report.

Model Specification

The model has a base year of 2018 and reflects average traffic and transport conditions of weekdays in 2018.

Three time periods are represented in Ngāmotu STM:

- Weekday AM peak: 7 am – 9 am.
- Weekday Inter peak (IP): 9 am – 4 pm.
- Weekday PM peak: 4 pm – 6 pm.

These periods are represented in Ngāmotu STM as an average hour of the period represented.

The model area is chosen to respond to the Council's requirement for the model to cover the New Plymouth City urban area and the satellite towns. The model consists of 434 internal, and 4 external zones, with the internal zones mostly aligning spatially to Statistical Area 1 (SA1) boundaries, as shown in **Figure A**.

Figure A Ngāmotu STM model area

The vast majority of roads in the modelled area are represented in the model. All strategic roads in the region are included. Minor roads are also included where they provide connectivity to the local land use. The modelled road network is illustrated in **Figure B**.

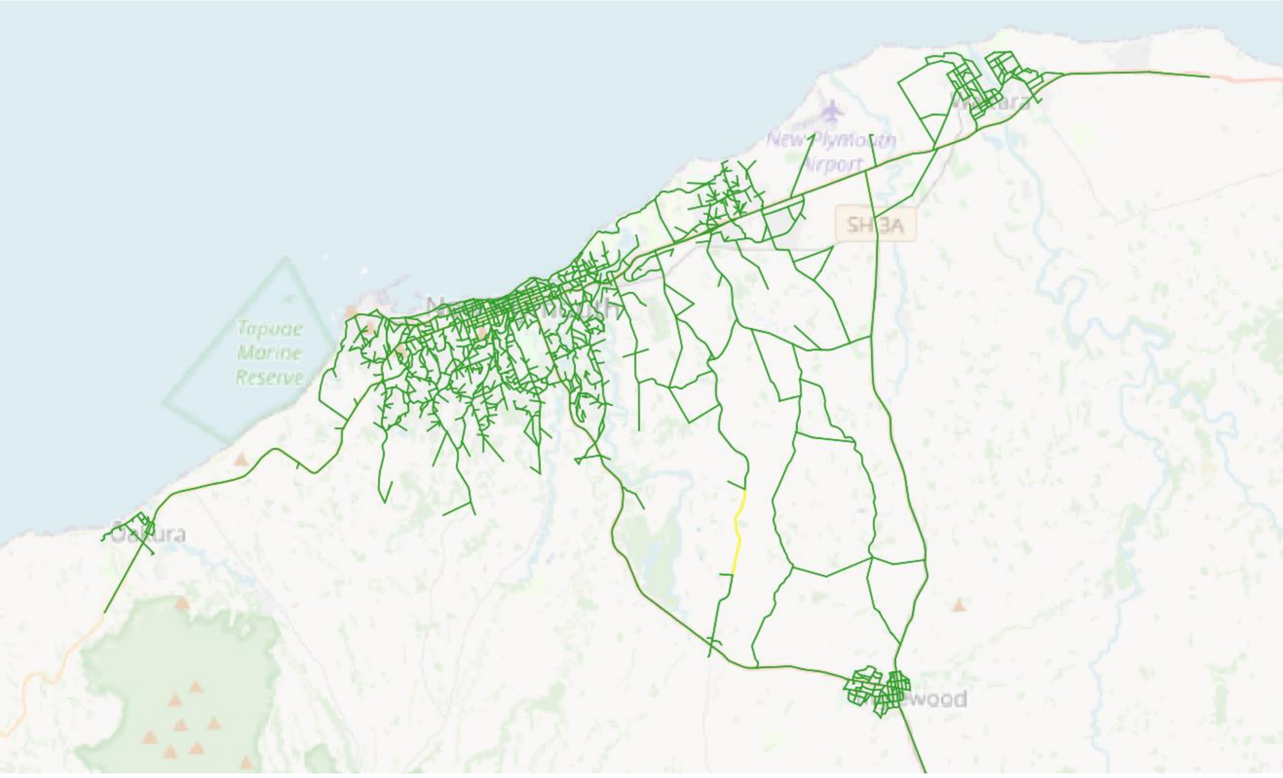


Figure B Ngāmotu STM modelled road network

Ngāmotu STM is a three and a half (3.5) stage transport model as presented in **Figure C** below. This is an alternative model structure to a form of full four-stage model. A four-stage model build requires more comprehensive data, a longer timeframe to build, and comes with higher technical risk. The 3.5-stage model is a good foundation for future model improvements and could be transitioned to a four-stage model or other model structures at a later date. Ngāmotu STM is modelled in CUBE Voyager transport modelling software.

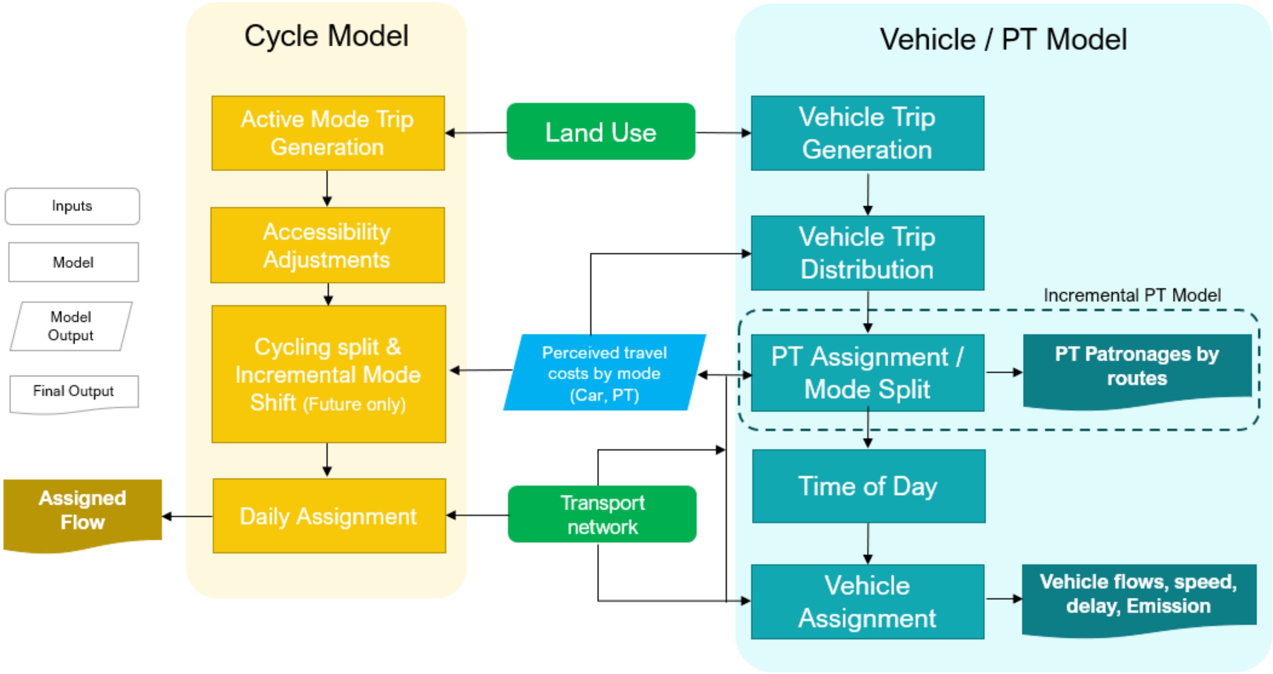


Figure C Ngāmotu STM model structure

Calibration and Validation

Calibration and validation process was undertaken for both light and heavy vehicles using count data. The result of validation is shown in **Table A** for link counts and **Table B** for journey times. Outputs from Ngāmotu STM are compared against the criteria provided in the Waka Kotahi Transport Model Development guidelines. In most cases, Ngāmotu STM meets or exceeds the validation criteria.

Table A Link count validation summary (All locations except CBD)

Measure	Criteria	Without ME		
		AM	IP	PM
GEH<5	>75%	71%	68%	66%
GEH<7.5	>85%	85%	86%	90%
GEH<10	>95%	96%	96%	96%
R Squared	>0.90	0.94	0.91	0.93
RMSE	<25%	29%	29%	26%

Table B Journey time validation summary

Measure	Criteria	Without ME		
		AM	IP	PM
Within 15% or 1 minute (if higher) (% of routes)	>85%	100%	100%	100%
Within 25% or 1.5 minute (if higher) (% of routes)	>90%	100%	100%	100%

The validation process has demonstrated that Ngāmotu STM is fit for purpose to assess future road network and land use changes within the model area.

Public Transport Model

The PT route and services information coded in the model are obtained from GTFS and Taranaki Regional Council website for the year 2022. The PT calibration was undertaken, and a marginal difference was observed between modelled daily trips and census data, as shown in **Table C**.

Table C PT daily trips - observed vs modelled

Component	Observed daily	Modelled daily	Difference
HBW	342	336	-6
HBE School Bus Students	1239	1295	56
HBE Public Students	640	609	-31
Other Trip Purposes	1119	1123	4

The comparison of modelled patronage versus observed patronage along individual PT routes is has shown less of a match. This is not unexpected for a strategic model of this nature, and we note this as a limitation of the model.

Cycle Model

The cycle model is coded in the model to estimate the cycle response to changes in infrastructure, land use or any other changes in other transport modes. The data is obtained from the 2018 census and GPS-tracked Strava journeys and a 4-stage model was developed. The validity of the model was checked by using the correlation coefficient (R^2) between observed and modelled daily cycle flows.

Model Limitations and Recommendations

The following sets out the list of model limitations:

- The model is strategic in nature, designed for a programme business case level study. The model outputs of individual road or intersection movements should not be relied on for more detailed planning and design.
- The model outputs of PT patronage on individual PT routes should not be relied on. Instead, it is recommended that the amount of change in patronage forecast by the model on individual PT routes is applied to base year observed levels of patronage.
- Although no toll road is expected in the Ngāmotu STM model, a toll component is included in the generalised cost. Any toll responses in future year scenarios should be treated as “very preliminary” as there is no validation undertaken for New Plymouth.
- Although no toll road is expected in the Ngāmotu STM model, a toll component is included in the generalised cost. Any toll responses in future year scenarios should be treated as “very preliminary” as there is no validation undertaken in base year. The model was developed using available local travel data and the model achieves reasonable calibration/validation outcomes and the model responses are within the expected ranges. Further improvements can be made if more local data (such as PT origin-destination data, household travel survey data) is available.

1 Introduction

1.1 Purpose

This report describes the structure, specification and validation of the New Plymouth Strategic Transport Model (Ngāmotu STM). The Ngāmotu STM has been developed to provide traffic, PT patronage and cycle demand predictions for the New Plymouth Urban Area and the nearby satellite towns for use in local and regional transport planning.

1.2 General Model Purpose and Type

The objectives of the model are:

- Assist in the development of the Integrated Transport Plan Programme Business Case
- Provide the platform to assess high-level strategic land use and transport options and provide outputs that inform the Council's strategic investment decisions
- Assist strategic decision-making for transport over a 30-year planning horizon

1.3 Functionality

We have assessed the key functional requirements of the model as follows:

- Provide a reliable replication of existing traffic patterns and network performance, suitable to the purpose of the model
- Relate traffic flows directly to input land use data
- Provide predictions of changes in traffic flows and patterns in future years, in response to changes in land use or the network
- Provide strong analysis and graphical output capabilities along with a good GIS interface (for both inputs and outputs)
- Provide a basis for more detailed models of specific projects

1.4 Guiding Principles

The model has been developed with consideration of some key guiding principles, including:

- Seek to be transparent and usable by other modellers (as much as is feasible for such models)
- Use common software and techniques where feasible
- Be based on common NZ modelling practice
- Keep it simple. This means a focus on the key functional requirements without overly complex model functionality, especially in areas not critical to this context
- Recognise that some judgement call will be required in the model design, but that these should be based on appropriate reasons and decided in consultation with the peer reviewer

1.5 Report Structure

The remainder of this report is structured as follows:

Chapter 2	Describes the data available for the model development
Chapter 3	Details the general specification and structure of the model
Chapter 4	Describes the Trip Generation Model
Chapter 5	Describes the Trip Distribution Model
Chapter 6	Describes the Time Period Model

Chapter 7	Describes the Assignment Model
Chapter 8	Describes the Calibration/Validation Methodology
Chapter 9	Describes the model validation results
Chapter 10	Describes the public transport model
Chapter 11	Describes the cycle model
Chapter 12	Conclusions and Model limitations

2 Data Sources

This chapter explains the data sources and data used as part of the model development.

2.1 Land Use/Demographic Data

2018 census data is a key input to the model. This data includes population, household, and employment data. The population and household data were augmented by similar data from NPDC. School roll data has been sourced from the school directory of the Ministry of Education website. For tertiary enrolment data, the only tertiary education facility within the study area is Western Institute of Technology at Taranaki (WITT) which also has a site campus outside of our study area. Its total full time equivalent student count is available from Ministry of Education, but the estimate for students within the study area is estimated from WITT provided split.

2.2 Origin/Destination (OD) Data

2.2.1 Journey to Work (JTW) and Journey to Education (JTE) - OD Data

The key source of origin-destination data was the census Journey to work (JTW) and Journey to Education (JTE) data. Statistics New Zealand typically supplies this at the statistical area 2 (SA2) level.

2.2.2 External Traffic Origin/Destination Data

An Automatic Number Plate Recognition (ANPR) survey was conducted to obtain external and port OD matrices. The survey was done over a 24-hour period on Tuesday 16 May 2023 near all 5 external zones. The locations of the sites is shown in **Figure 2-1**. The sites are as follows:

- Site A: SH3, East of Bayly Street, near zone 391
- Site B: SH45 West of Wairau Road, near zone 394
- Site C: SH3 South of Burgess Hill Road, near zone 393
- Site D: SH44, Breakwater Road, Northwest of Ngāmotu Road, near zone 390
- Site E: SH3A, Mountain Road, South of Manutahi Road, near zone 392

Figure 2-1 Site location of number plate survey

2.3 Network Data

2.3.1 Road Network

The main source of road network was from Waka Kotahi National Road Centreline GIS data. The model includes all strategic roads as identified by the Waka Kotahi ONRC system. A selection of the minor roads was also included where they provide connectivity to the local land use. Posted speed limits were sourced from Waka Kotahi and the number of lanes were cross-checked using Google aerial imagery. A model road classification system was developed based on the posted speed limits and other factors; this is described later in the report.

2.3.2 Intersection and Traffic Signal Phasing and Timing

A total number of 371 intersections including 20 traffic signals were included in the model. Google aerial imagery was used to identify lane configuration and intersection type. SCATS data for 2023 was sourced from the NPDC as records from 2018 were not available. A traffic volume comparison between 2018 and 2023 across 4 count locations were conducted. A slight growth in traffic volume was observed. The growth rates were within -1.34% to 14.80%. This slight difference indicates that the 2023 traffic is approximately at the 2018 levels. Therefore, 2023 SCATS data can be used in this model.

2.3.3 PT Network and Service

PT data of route and service headway were extracted from GTFS and Taranaki Regional Council website for the year 2022.

2.3.4 Cycle network

Cycle inputs were sourced from the 2018 census and GPS-tracked Strava journey data.

2.4 Traffic Count Data

RAMM and TMS traffic counts were the sources of traffic data for this model build. The location of counts used in the model calibration and validation is indicated in **Figure 2-2** below.

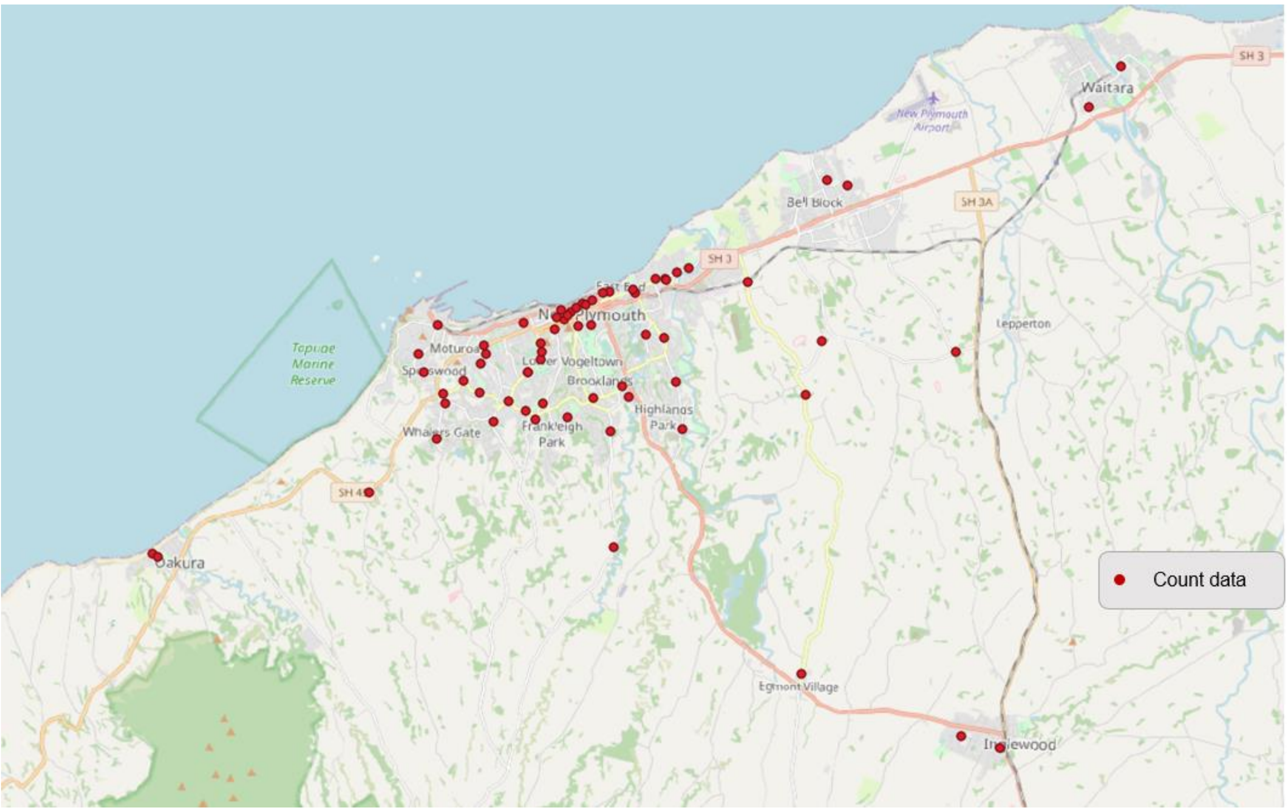


Figure 2-2 Traffic count locations in the model development

This data has been processed to identify sites with missing data or obvious errors or undertaken in December or January months. This check includes:

- Gap check: All weekday counts should be similar in magnitude. This check eliminates incomplete counts. Also, numbers of 'blank' or 'zero' were checked in raw data.
- Flow balance check: traffic flow should be balanced for both directions in all peaks.
- HCV % check: Percentage of HCV should be similar for both directions. If there was a discrepancy, a check was undertaken with the adjacent count.

All counts were loaded into the model and checked against flows from the initial model runs. If the discrepancies were noticeable, an investigation was made to identify whether it was count or model issue. If two or more counts were available within a close distance, the most recent count was retained with some sanity checks (e.g. flow balance and consistency with adjacent counts).

2.5 Travel Time Data

A total number of 28 routes were used to validate the modelled travel time. These routes are indicated in **Figure 2-3**. Access to 2018 travel time data was not available for the model development and so travel time data was collected for each route using Google Maps. Travel time for the majority of the routes was collected on 5 days from Monday 6 March 2023 to Friday 10 March 2023. After an initial analysis, three days from Tuesday to Thursday were selected. Travel time for routes 31-44, and the section from Koru Rd to Wairua Stream in Routes 30/31 were collected on Wednesday 18 October 2023. The median travel times of these days were reported as the observed travel time.

Figure 2-3 Travel time routes

3 Model Specification

3.1 Model Structure

The model structure is comprised of a core three and a half (3.5) stage traffic (light and heavy vehicle) model with incremental PT (bus) and active mode (cycle) modules.

The structure of the model is illustrated in **Figure 3-1** below. This is an alternative model structure to a form of full four-stage model. Normally, four-stage model development requires more comprehensive data, a longer timeframe, and comes with higher technical risk. The current low levels of PT use also limit the suitability of a four-stage model. The proposed three and half stage model is a good foundation for future model improvements and transition to a full four-stage model or other model structures at a later date.

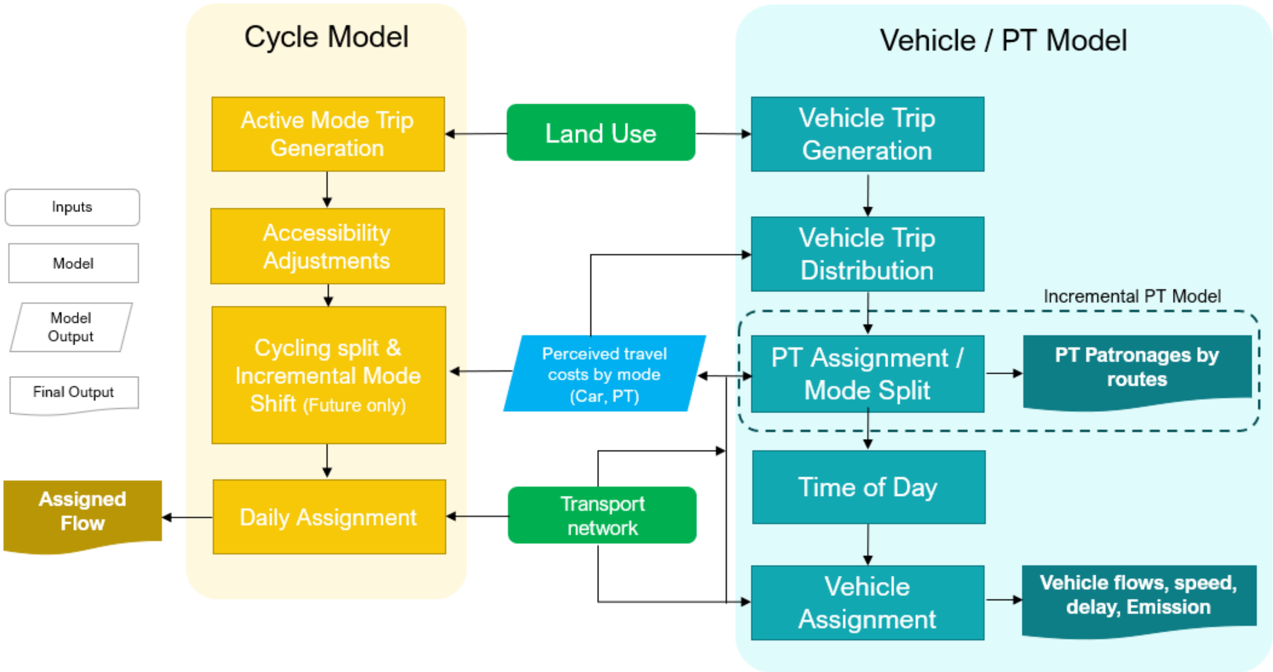


Figure 3-1 Model structure

3.2 Model Extent

The model area covers all of the New Plymouth urban area and the nearby satellite towns from Waitara in the east to Ōakura in the west to Inglewood in the south. The model area was chosen to respond to the NPDC requirement to cover the New Plymouth City urban area and the satellite towns. The extent of modelled area is shown in **Figure 3-2** along with the zone boundaries.

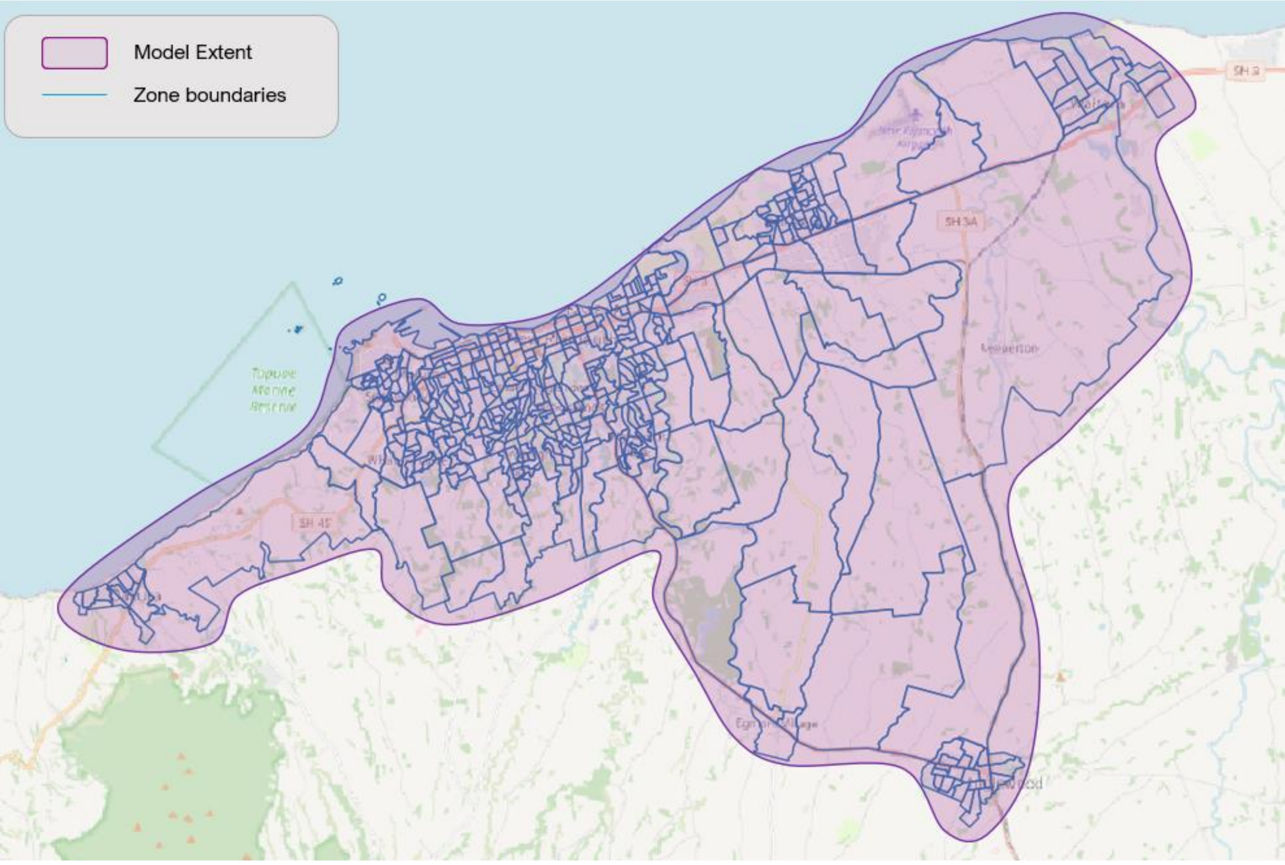


Figure 3-2 Ngāmotu STM model area and zone boundaries

The model includes 88% of the population in the New Plymouth District and 89% of the employment as set out in the table below.

Table 3-1 Proportion of land use in New Plymouth represented in Ngāmotu STM

	New Plymouth District	Modelled	Proportion modelled
2018 Population	83,180	72,899	88%
2018 Employment	30,672	27,447	89%

3.3 Zone System

The model consists of 438 zones. The zone system is based on existing SA1 boundaries and was made consistent with SA2 level boundaries to allow easy aggregation of data between SA1 and SA2 levels. Also, some refinements were done with the following criteria:

- If some zones could potentially generate high traffic volume (e.g. CBD area)
- Different land use activities (e.g. residential and industrial)

The model has 434 internal zones and 4 external zones. The traffic analysis zone (TAZ) map is illustrated in **Figure 3-3**.

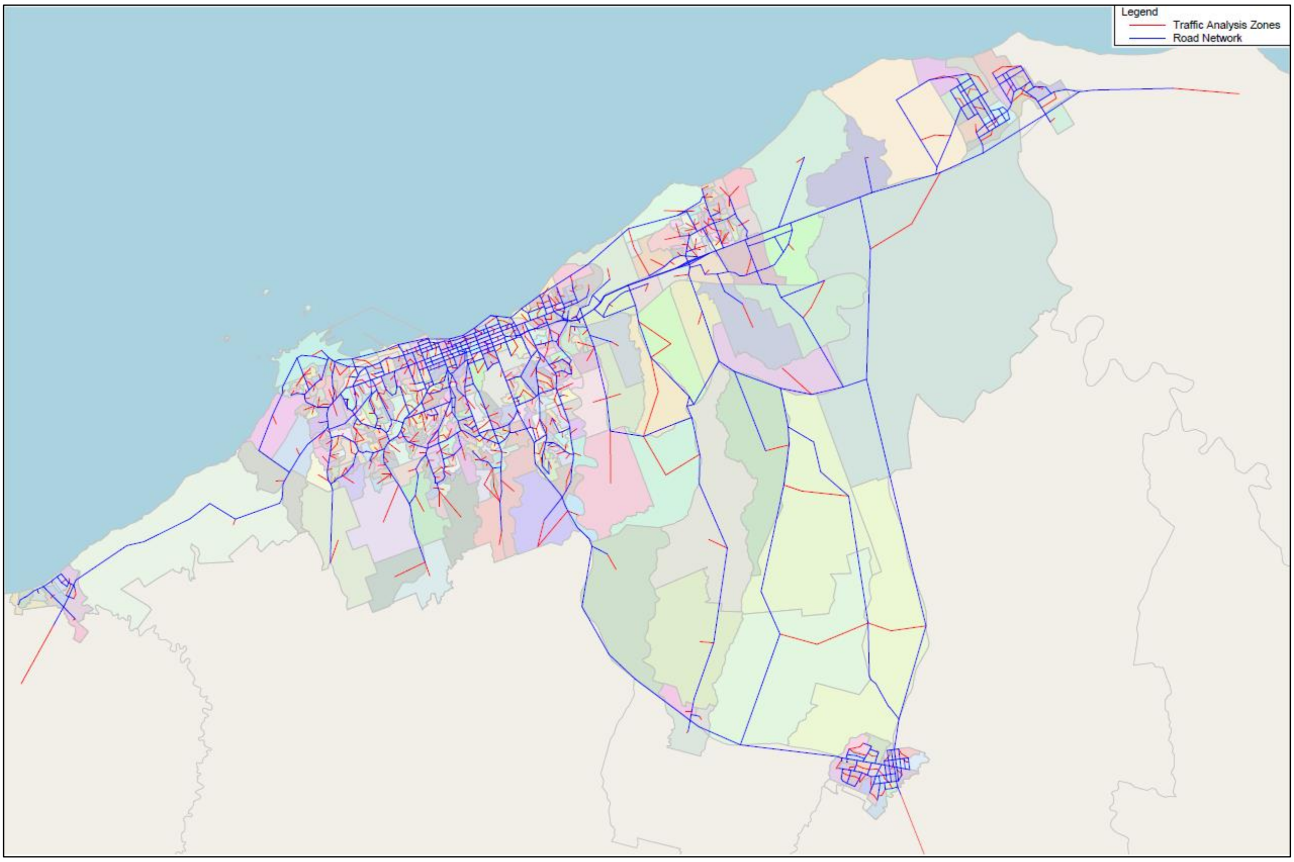


Figure 3-3 Modelled zones

3.4 Network Representation

The model represents network performance via speed-flow curves applied on links and with explicit, turn-level modelling of intersection delays. The model operates using flow units of vehicles rather than passenger-car unit (PCU). The link capacities were coded in vehicles per hour.

3.4.1 Link Types and Parameters

In order to provide consistent coding of similar sections of road, a link-type classification system was developed. All links were classified in terms of their road environment and given a relevant link type code. These link type classifications were used to allocate the parameters of the speed flow curves (e.g. free speed and capacity) and any relevant routing parameters (e.g. site specific weightings to reflect influences on route choice other than time and distance, such as signage, comfort etc).

The speed-flow functions require a 'free-speed' (typical speed with no other vehicles interrupting travel) rather than a speed limit. The free speeds were coded based on the speed limit, generally slightly higher for higher-standard roads and slightly lower for access or residential-type roads. Those relationships were adjusted during the model calibration process but a consistent approach using the link type classification was used rather than only adjusting the sample of roads for which travel time data is available.

3.4.2 Speed-Flow Curves

The speed-flow curves are based on the Akcelik speed-flow functions, as used in the Auckland, Christchurch, Wellington, Tauranga and Hibiscus Coast models. These were applied as a mathematical function in the model, rather than defined curves/lookup tables. This means that a single function can be used, with individual link parameters coded on each individual link. The function was implemented as a volume-delay function that predicts travel time, however these are readily equated to speed-flow curves.

The Akcelik function is as follows:

$$t = t_0 \left\{ 1 + 0.25 r_f \left[(x-1) + \sqrt{(x-1)^2 + \frac{8 J_A x}{Q t_0 r_f}} \right] \right\}$$

where : t= average travel time, in seconds per km;
t_0= minimum (zero-flow) travel time;
J_A = Curve Parameter;
x=q/Q = degree of saturation,
q = demand (arrival) Flow rate;
Q = capacity (veh/hr);
r_f=ratio of flow period T_f, to minimum travel time t_0 ($r_f=T_f/t_0$)
T_f = Analysis Flow Period, taken as 1 hour;

Each individual link therefore has the following three attributes coded:

- Number of lanes and the lane capacity (vehicles per hour per lane), which are multiplied to get the capacity (Q);
- Free speed, which gets converted to free-time (t0)
- Friction factor (JA), which was coded based on the road type and environment.

As noted above, consistency of link parameters was generally used for all roads within a defined link type. However, some deviations from those standard parameters were considered for specific environmental factors. For example, an arterial road might have a short section of tight radius curves for which a lower free speed is appropriate. This was still coded as an arterial link type (to avoid having too many link types which makes coding more complex), but with a free speed coded lower than the generic free speed for arterial roads.

Although implemented as a volume-delay function, the equivalent speed-flow curves are shown below in **Figure 3-4**.

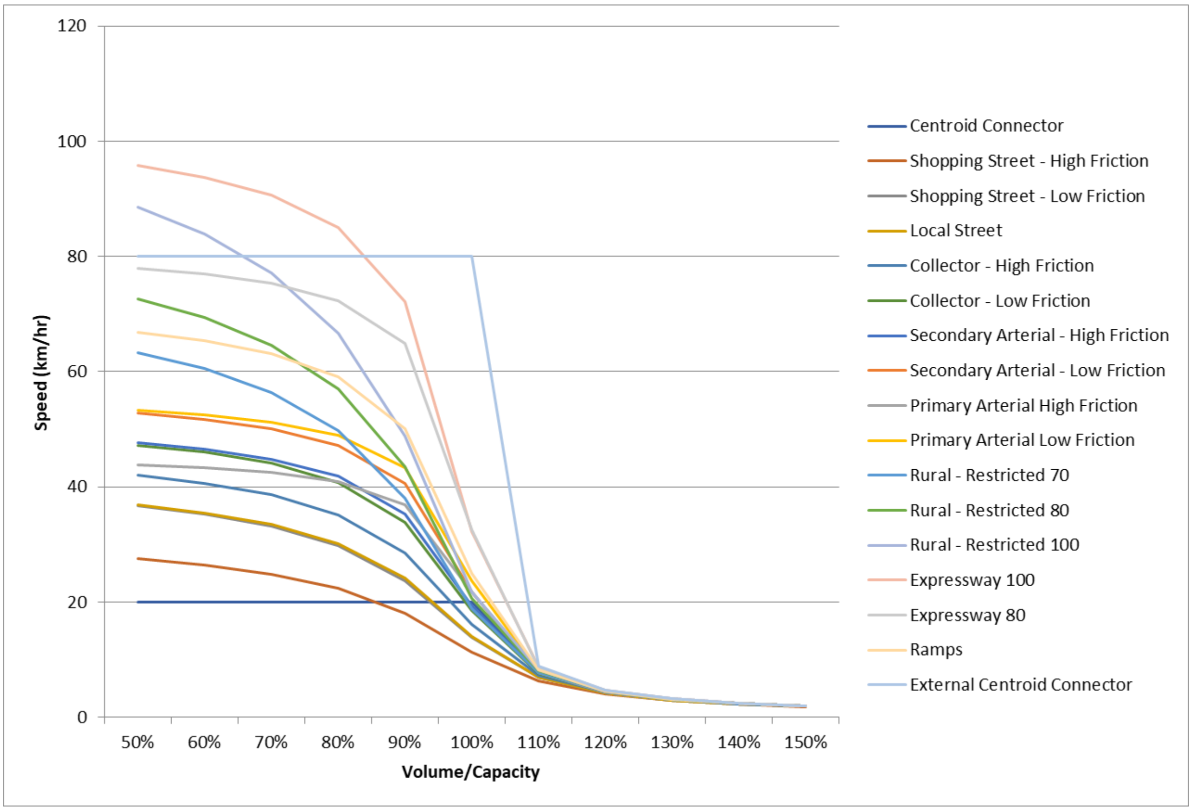


Figure 3-4 Example Speed-Flow curve

The generic link type categories[1], associated link parameters, and percentage of each link type in the modelled road network are represented in **Table 3-2**. The links are also shown in the **Figure 3-5.**

Table 3-2 Generic link type parameter

No	Type	Typical lane capacity, vph	Typical free speed, kph	Typical Friction Factor, J_A	% in the road network
1	Centroid Connector	5,000	40	0.0	-
2	Shopping Street - High Friction	600	30	1.8	2%
3	Shopping Street – Low Friction	800	40	1.8	0%
4	Local Street	800	40	1.7	4%
5	Collector - High Friction	1,000	45	1.6	5%
6	Collector - Low Friction	1,200	50	1.4	30%
7	Secondary Arterial - High Friction	1,200	45	1.2	2%
8	Secondary Arterial - Low Friction	1,300	50/60	1.0	13%
9	Primary Arterial High Friction	1,400	45	0.8	2%
10	Primary Arterial Low Friction	1,400	50/60	0.8	5%
11	Rural - Restricted 70	1,200	70	1.8	0%
12	Rural – Restricted 80	1,400	80	1.8	16%
13	Rural - Restricted 100	1,400	100	1.8	9%
14	Expressway 100	1,800	100	0.8	1%
15	Expressway 80	1,800	80	0.6	0.3%

[1] Link type 3 and 11 were not used in the model.

No	Type	Typical lane capacity, vph	Typical free speed, kph	Typical Friction Factor, J_A	% in the road network
16	Ramps	1,800	70	1.2	0.3%
17	External Centroid Connector	5,000	80	0.0	-
18	Cycle network	800	40	1.7	11%

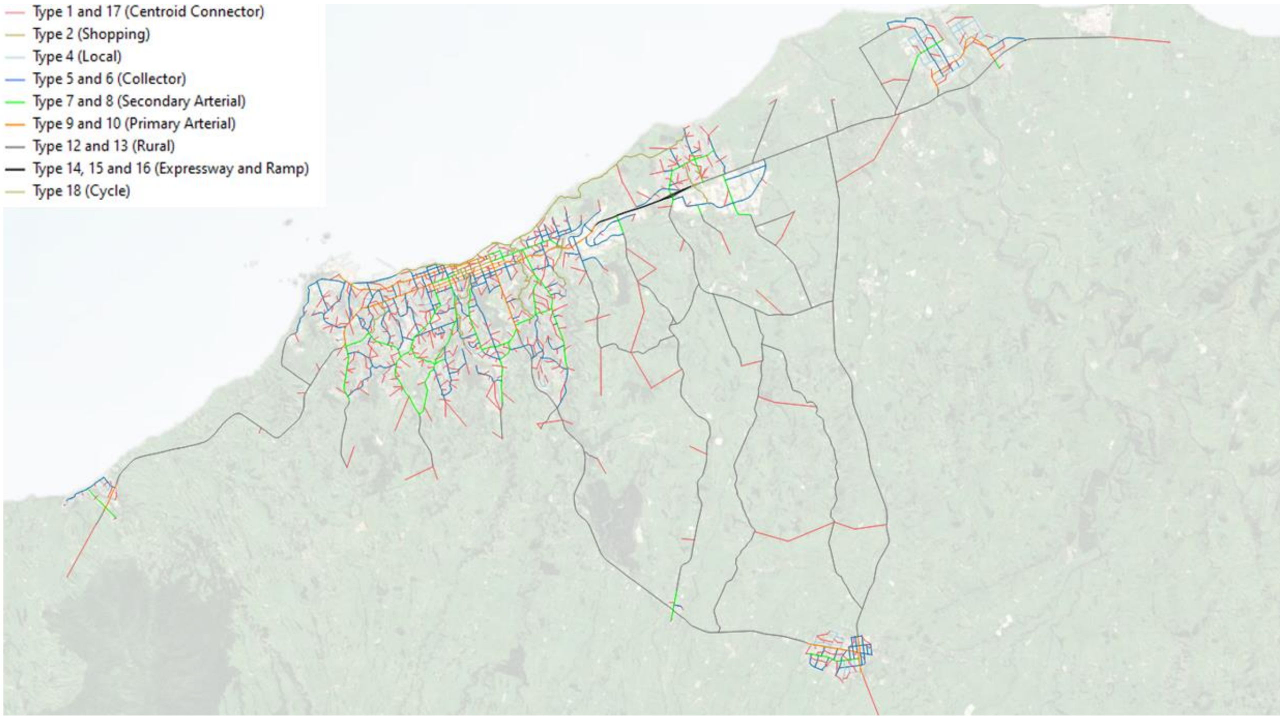


Figure 3-5 Link types in the network

3.4.3 Intersections

A total of 264 intersections including 20 traffic signals, 8 roundabouts and 236 priority controlled intersections in New Plymouth are represented in the model. Google aerial imagery was used to identify lane configuration and intersection type. As previously mentioned, SCATS data for 2023 was sourced from the NPDC as records from 2018 were not available. An adaptive signal model was used in CUBE to model the traffic signals. For each modelled time period, average cycle time, phasing plans, and minimum and maximum phase time were taken from SCATS data and input in the model. **Figure 3-6** displays the location of intersections by intersection type.

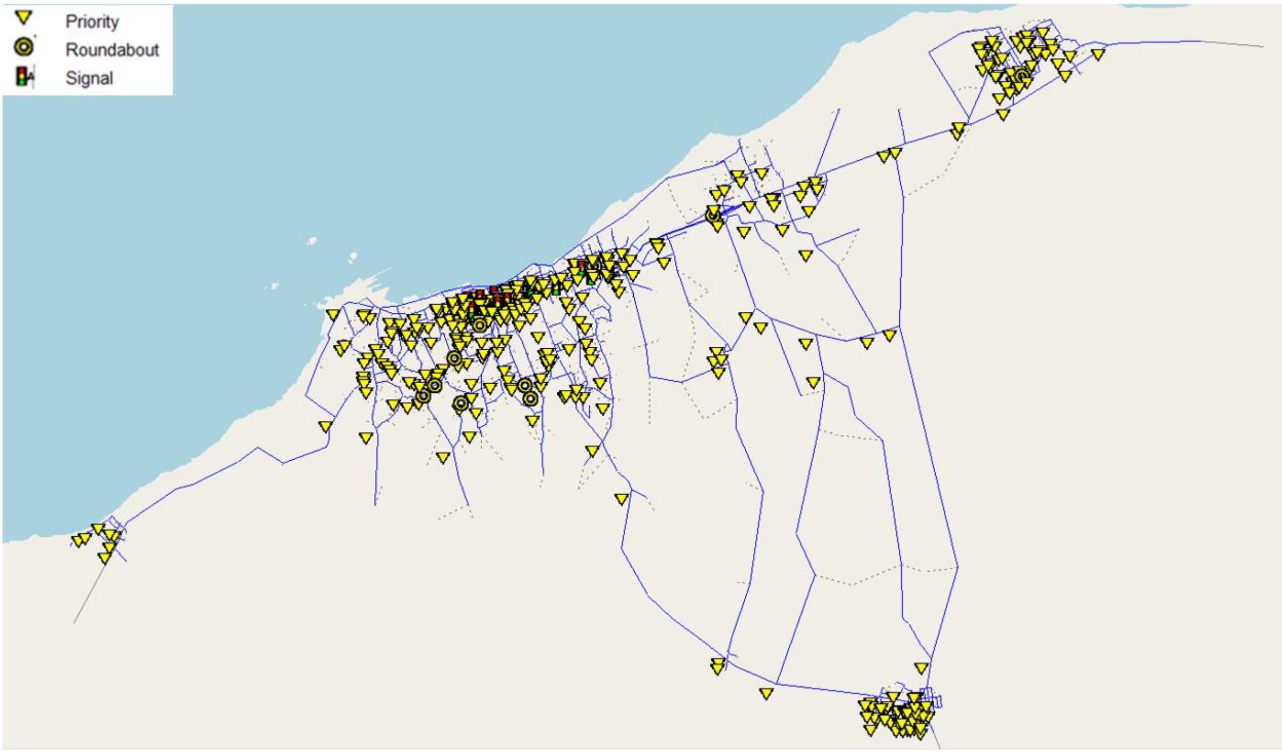


Figure 3-6 Location and type of intersections

3.4.4 Centroid Connectors

Centroid connectors have a generic link (e.g. 100m) in urban areas but longer distances for the larger, rural zones. Centroid connectors use fixed speeds rather than speed-flow functions because they do not represent real roads for which speed and capacities can be assessed.

3.5 Base Year and Time Periods

The time periods were selected by analysis of a selection of traffic count data. In total, 18 sites were selected across the study area and the 15-minute traffic profiles were analysed. **Figure 3-7** below shows the weekday profile of all 18 sites. This data indicates both large variations in the traffic flows but also variations in the shape of the peak profiles. In summary, the model periods are defined as follows:

- **AM**: An average hour for 7am-9am
- **PM**: An average hour for 4pm-6pm
- **Interpeak**: An average hour for 9am-4pm

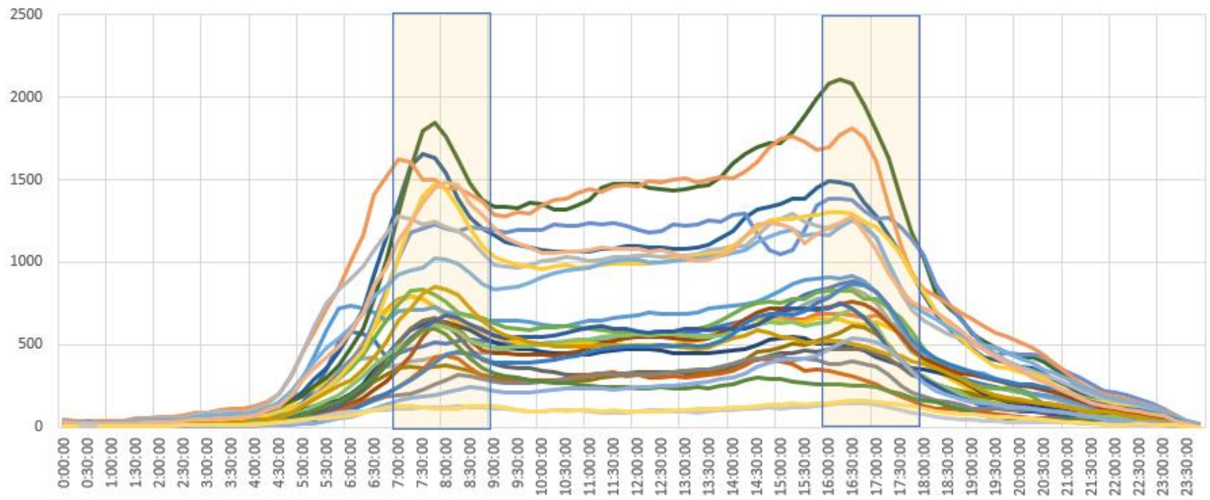


Figure 3-7 Weekday traffic profiles of selected sites

3.6 Expansion Factors

Model estimates of daily traffic flows were determined by expanding the three peak period flows to daily flows. Expansion factors were calculated for the 5 day ADT (ADT_5) using all available count data. ADT is calculated based on the following equation:

ADT_5 = 2.5 x AM + 8.63 x IP + 2.5 x PM

3.7 Trip Purposes

The selection of which trip purpose segmentation to use is based on the following considerations:

- The need for consistency with other models in NZ so the parameters (e.g. trip rates) can be compared;
- The desire to separate the trip patterns that are likely to be significantly different;
- The availability of data to support the segmentation; and
- The guiding principle of avoiding overly complex models.

Based on these considerations the following key segmentations are used:

- Home Based Work (**HBW**). These commuter trips are distinct from other trips and there is good information available through census Journey to Work data;
- Home Based Education (**HBE**). Again these trips are distinct in their destinations and timing of travel, and are especially important in regard to the influence of WITT;
- Heavy Commercial Vehicles (**HCV**). These are distinct in terms of the vehicle characteristics and there is a desire to be able to identify forecasts for such vehicles separately from light vehicles. Although it is a vehicle class rather than a trip purpose, the vast majority of truck movements are for commercial purposes;
- Employers Business (**EB**). Although these are not distinguishable in the traffic count data, it can be useful to estimate these trips separately for economic analysis and most other models include model parameters for this purpose. These are non-home based trips;
- Home Based Shopping Trips (**HBS**). These trips are distinguished by the time of travel and typical parameters can be sourced as most similar models include this segmentation;
- Home Based Other trips (**HBO**). This purpose is common to most models of this type and generally has the most number of trips as it is a kind of 'catch-all' of all other trips. These are normally modelled separately for home-based and non-home based; and
- Non-Home Based Other trips (**NHBO**).

3.8 Household Structure Model

The household structure model predicts numbers of households in each of the 16 household categories using the two input parameters, average people per household and average car ownership/household. The 16 household categories are based on four categories related to the number of people per household and four categories related to the number of vehicles per household. The categories are:

- Number of people per household (1, 2, 3 and 4+ people); and
- Number of vehicles per household (0, 1, 2 and 3+ vehicles)

The segmentation is illustrated in **Figure 3-8.**

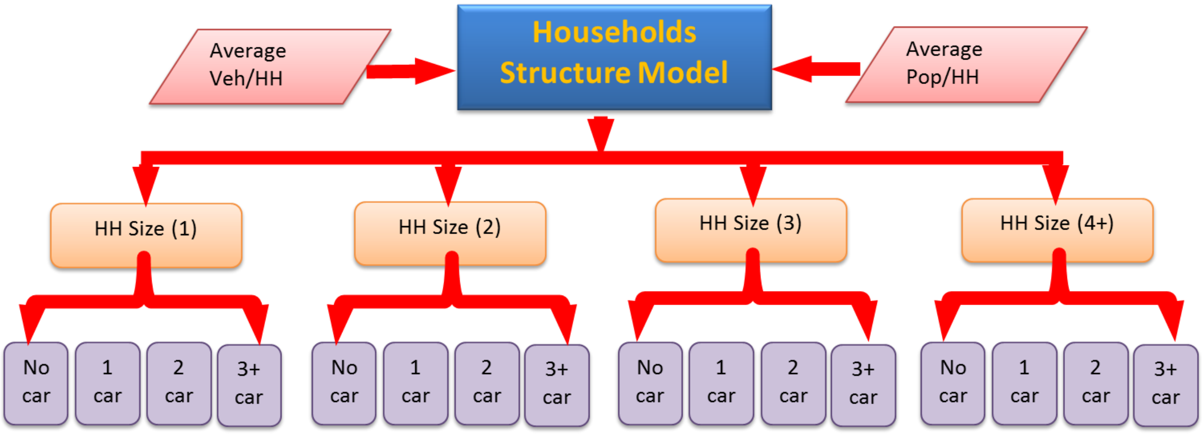


Figure 3-8 Household structure model

The household structure model was adopted from the similar models but recalibrated for Ngāmotu STM based on 2018 census data. The model works in two steps; first it estimates the total numbers for household for each household size category, then it splits into different level of car ownership within each household size. The model was calibrated using the 2018 Census data for New Plymouth and then the model parameters were adjusted in the calibration process to get a better match between modelled and observed datasets. It can be observed in **Table 3-3** and **Table 3-4** that the model can replicate the household categories very well.

Table 3-3 Household categories (based on vehicle ownership) comparison between model and census

Household Group	Model Estimate	Census	Difference
No motor vehicle	1,998	1,976	+23
1 motor vehicle	11,130	11,188	-58
2 motor vehicle	11,911	11,860	+51
3 motor vehicle or more	4,671	4,667	+4
Total	29,710	29,689	+20

Table 3-4 Household categories (based on size) between model and census

Household Group	Model Estimate	Census	Difference
1 member	7,852	7,919	-67
2 member	10,618	10,567	+52
3 member	4,553	4,556	-3
4 member or more	6,687	6,647	+40
Total	29,710	27,758	+21

4 Trip Generation Model

The primary data inputs for the trip generation model came from 2018 census land use data which includes population, households, employment, primary, secondary, and young adult age. Also, population and household data from New Plymouth District Council was used. Additionally, school roll information for primary, secondary and tertiary students was used in trip generation model development.

4.1 Base Year Land Use Data

The household data was obtained from NPDC and the employment data was obtained from the census. These data were used directly in the development of the base year model. The following processing was undertaken for the base demographic data:

- Household data was aggregated to SA2 level. The census provides the population and number of households in SA1 level. These values were multiplied by a factor to match the census with council data in SA2 level.
- Employment data (Retail, Agriculture, Industry, Education, and Services) was also generated from Census 2018 using ANZSIC06 classification. The proportion of each employment category was calculated at SA2 level and then the employment splits were applied to the model travel zones.
- The population of primary and secondary school age was determined from the census data. Due to privacy issue, a similar process as in the employment data was undertaken to estimate the school age for each model travel zones.
- The population and number of households for zone 364 was uplifted to take into account the extent of the zone boundary which includes more land use (i.e. Population and dwellings).

The land use data used for Ngāmotu STM in the base year is shown in **Table 4-1**.

Table 4-1 Land use data for 2018

Household information	Employment	School roll
Total population: 72,899	Retail: 3,424	Primary school: 6,854
Households: 26,689	Agriculture: 3,656	Secondary school: 6,636
Total number of cars: 50,900	Industrial: 7,644	Tertiary school: 1,009
Primary + Secondary age (5-17.5yr): 12,754 (17% of total population)	Education: 2,046	
Young Adult (17.5-24yr): 4,962 (7% of total population)	Service: 10,677	
	Total: 27,447	

4.2 Trip Production/Attraction Models

The trip generation model was built in a spreadsheet to have greater transparency and ability to manipulate the inputs. The model used the outputs from the household structure model and trip productions are function of 16 household categories. Trip rates were initially adopted from similar cities' models and then further recalibrated to local count and census data. The general form is as follows:

- The HBW, HBS and HBO production models were based on household data whereas the attraction model was based on employment data.
- The HCV model uses the same trip rates for production and attractions. These are based primarily on employment data but with a low trip rate also applied to household numbers (to represent home deliveries, tradespersons etc).
- The NHBO and EB models also use the same trip rates for production and attraction. These models are based on both employment and household data. The production models are based on household data, however these are only used to control the total number of such trips made. Then in the attraction model, employment data was used to estimate the trip then adjusted to match the total numbers of trips predicted by the production model.
- The HBE purpose is based on separate production/attraction models for primary, secondary and tertiary education. The productions are estimated from the population in each zone estimated to be of primary /secondary and tertiary age. Then attractions are based on the school rolls.

The trip generation models require the total number of productions to match the total number of attractions. Hence for the HBW, HBS, HBO and HBE trips, the initial attractions were based on the attraction trip rates, but these were adjusted so that the regional total matched the total for the productions. For the HCV, NHBO and EB trips the attraction and production models are the same so no factoring is required. The final calibrated production trip rates used in the model are as detailed in **Table 4-2** and illustrated in **Figure 4-1**.

Table 4-2 Adopted daily production rates

HH Size	Car Ownership	Category	Type	HBW	HBO	HBS	NHB	HBE	Total
1	0	F1C0	HH	0.15	1.44	0.36	0.45	-	2.40
	1	F1C1	HH	0.54	1.70	0.60	0.87	-	3.71
	2	F1C2	HH	0.56	1.70	0.60	0.92	-	3.78
	3+	F1C3	HH	0.59	1.70	0.60	0.96	-	3.85
2	0	F2C0	HH	0.16	1.44	0.58	0.77	-	2.95
	1	F2C1	HH	0.83	2.38	0.96	1.16	-	5.33
	2	F2C2	HH	1.63	2.50	0.96	1.47	-	6.56
	3+	F2C3	HH	1.88	2.52	0.96	1.69	-	7.05
3	0	F3C0	HH	0.16	1.44	0.58	0.77	-	2.95
	1	F3C1	HH	0.87	3.00	0.96	1.54	-	6.37
	2	F3C2	HH	2.01	3.06	0.98	1.81	-	7.86
	3+	F3C3	HH	2.18	3.07	1.01	2.00	-	8.26
4+	0	F4C0	HH	0.16	1.44	0.58	0.77	-	2.95
	1	F4C1	HH	0.93	3.20	0.95	1.77	-	6.85
	2	F4C2	HH	2.15	4.04	1.13	2.03	-	9.35
	3+	F4C3	HH	2.98	4.30	1.16	3.04	-	11.48
Age group (5 – 17.5 years)			Pop	-	-		-	0.78	-
Age group (17.5 – 24 years)			Pop	-	-		-	0.5	-
Retail Employees			E_R	-	-		0.8	-	-
Non-Retail Employees			E_{NR}	-	-		0.6	-	-

Where Types are:

HH = Number of households

Pop = Population

E_R = Number of Retail employment

E_{NR} = Number of Non-Retail employment

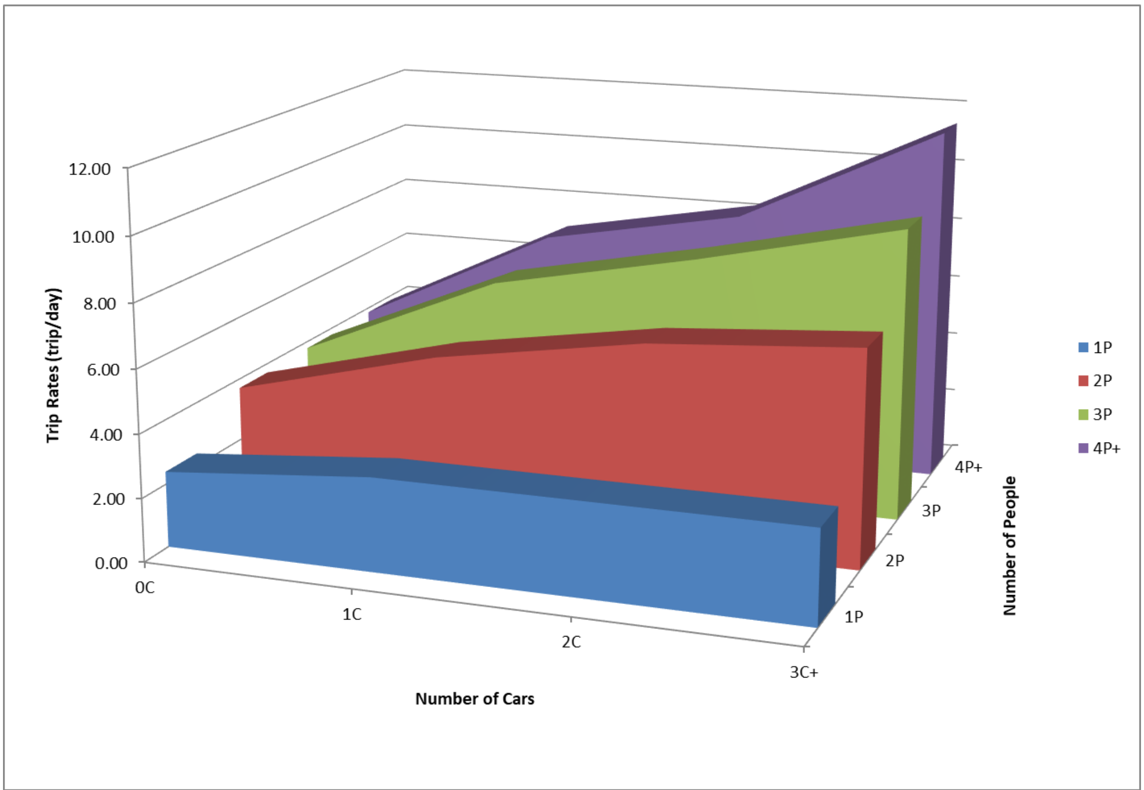


Figure 4-1 Adopted HH daily production rates (sum of all purposes except HBE and HCV)

Similar to the trip production model, the attraction trip rates were generally adopted from similar cities' models, but recalibrated to better match the local data. Trip attraction rates are further classified to the following categories and assigned to each zone to represent different trip rates based on the nature of the activities in that zone:

- Residential
- Commercial
- Industrial
- Rural
- CBD
- WITT
- External

The final attraction rates used in the model are shown in

Table 4-3 below.

Table 4-3 Adopted daily attraction rates

Purpose	Type	Residential	Commercial	Industrial	Rural	CBD	WITT
HBW	E_R	1.47	1.57	2.00	0.96	1.57	1.47
	E_{Ag}	0.60	0.60	0.60	0.39	0.60	0.60
	E_{Ind}	1.90	1.90	3.00	1.24	1.90	1.90
	E_{Ed}	1.16	1.16	1.16	0.75	1.16	1.16
	E_S	0.88	1.20	2.50	0.57	1.20	1.30
HBS	E_R	4.00	6.50	3.00	4.00	8.50	4.00
HBO	E_R	3.00	3.00	3.00	3.00	4.20	3.00

Purpose	Type	Residential	Commercial	Industrial	Rural	CBD	WITT
	E_{Ed}	1.60	1.60	1.60	1.60	1.60	0.45
	E_S	1.80	2.00	2.00	1.80	3.00	0.15
	H	1.40	1.40	1.40	1.40	1.40	1.40
HBE	SR_P	1.25	1.25	1.25	1.25	1.25	1.25
	SR_S	0.65	0.65	0.65	0.65	0.65	0.65
	SR_T	0.70	0.70	0.70	0.70	0.70	0.15
EB	E_R	1.50	1.50	1.50	1.50	1.50	1.50
	E_{Ag}	0.13	0.13	0.13	0.05	0.13	0.13
	E_{Ind}	0.36	0.45	0.36	0.36	0.36	0.36
	E_{Ed}	1.00	1.00	1.00	1.00	1.00	0.10
	E_S	0.54	0.60	0.60	0.54	0.54	0.10
NHBO	E_R	4.50	4.50	4.50	4.50	4.50	4.50
	E_{Ag}	0.21	0.21	0.21	0.10	0.21	0.21
	E_{Ind}	0.59	0.75	0.59	0.59	0.59	0.59
	E_{Ed}	1.91	1.91	1.91	1.91	1.91	0.20
	E_S	0.89	0.95	0.95	0.89	0.89	0.20
HCV	E_R	0.18	0.30	0.30	0.30	0.07	0.30
	E_{Ag}	0.09	0.15	0.15	0.15	0.15	0.15
	E_{Ind}	0.36	0.60	0.60	0.60	0.30	0.60
	E_S	0.06	0.10	0.10	0.10	0.02	0.10
	H	0.06	0.10	0.10	0.10	0.10	0.10

Where Types are:

ER	=	Retail employment for zone
EAg	=	Agriculture employment for zone
EInd	=	Industry employment for zone
EEd	=	Education employment for zone
ES	=	Service employment for zone
H	=	Total households for zone
SRP	=	Primary school rolls
SRS	=	Secondary school rolls

4.3 External Models

Two types of ‘external’ trips are used in the model as follows:

- External-to-external (‘through’) trips
- External-internal or internal-external trips

4.3.1 External to External

As described in section 2.2.2, an Automatic Number Plate Recognition (ANPR) survey was conducted on Tuesday 16 May 2023 near 4 external zones to develop an external to external matrix. The location for each point is shown in **Figure 4-2** and are:

- Site A: SH3, East of Bayly Street, near zone 391
- Site B: SH45 West of Wairau Road, near zone 394

- Site C: SH3 South of Burgess Hill Road, near zone 393
- Site D: SH44, Breakwater Road, Northwest of Ngāmotu Road, near zone 390
- Site E: SH3A, Mountain Road, South of Manutahi Road, near zone 392

Figure 4-2 Site Location of number plate survey

Data from the ANPR surveys was processed to determine vehicle demand (by light vehicles and heavy vehicles) between the site locations for a 24 hour period. **Table 4-4** to **Table 4-6** represent the external to external trips for light vehicle, heavy vehicle and total vehicles respectively. The location and description of each site was explained in section 2.2.2. From the tables below, it can be observed that most of the external to external trips are between point A (zone 391) and point B (zone 394).

Table 4-4 External to external trips- Light vehicles

	Destination	A	B	C	D	E	Total	Percentage Matched
Origin	Volume	2,918	2,831	5,959	4,83	2,576	14,767	
A	2,953		226	3	2	11	242	8.2%
B	2,762	238		5	8	5	256	9.3%
C	5,836	10	7		0	8	25	0.4%
D	4,74	6	2	1		9	18	3.8%
E	2,541	21	3	5	10		39	1.5%
Total	14,566	275	238	14	20	33	580	11.8%
Percentage Matched		9.4%	8.4%	0.2%	4.1%	1.3%	3.9%	

Table 4-5 External to external trips - Heavy vehicles

	Destination	A	B	C	D	E	Total	Percentage Matched
Origin	**Volume**	415	451	356	255	120	1,597	
A	404		35	2	3	1	41	10.1%
B	452	77		1	1	4	83	18.4%
C	348	1	0		0	0	1	0.3%
D	248	4	0	1		0	5	2.0%
E	115	1	1	1	2		5	4.3%
Total	1,567	83	36	5	6	5	135	14.2%
Percentage Matched		20.0%	8.0%	1.4%	2.4%	4.2%	8.5%	

Table 4-6 External to external trips- Total vehicles

	Destination	A	B	C	D	E	Total	Percentage Matched
Origin	Volume	3,333	3,282	6,315	738	2,696	16,364	
A	3,357	0	261	5	5	12	283	8.4%
B	3,214	315	0	6	9	9	339	10.5%
C	6,184	11	7	0	0	8	26	0.4%
D	722	10	2	2	0	9	23	3.2%
E	2,656	22	4	6	12	0	44	1.7%
Total	16,133	358	274	19	26	38	715	4.4%
Percentage Matched		10.7%	8.3%	0.3%	3.5%	1.4%	4.4%	

Note that the model was extended to the south to include Inglewood. The external locations C and E trips were combined and used in the expanded model.

4.3.2 External-Internal Trips

The external-internal (and reverse) trips were included directly in the generation/distribution models. Trip ends (in 24-hour production/attraction format) were developed by using the external count data. This gives trip ends at each external point by heavy and light vehicles. The external trip ends for the HBW purpose were derived from the census JTW data. The remaining trip purposes are segmented using the global model split factors.

The internal-external trips, which represent trips entering or leaving the model, were then included in the trip generation spreadsheet to produce trip ends for the distribution model.

4.4 Port Model

The initial analysis showed that there was very weak correlation between land use activities and trip generation. Hence the port was treated as one of the external zones and its tripends were developed based on the count. Not that the port is one of the external to external survey sites (Site D) as described in Section 4.3.1

5 Trip Distribution Model

5.1 Model Form

The distribution model allocates zonal trip productions to destination zones. A doubly-constrained gravity model was used for this purpose, operated at a 24-hour level, which is a typical model form. The model form is as follows:

$$T_{ij} = a_i b_j P_i A_j F(C_{ij}) K_{ij}$$

where: T_{ij} = Trips from zone I to zone j

P_i = Productions form zone I

A_j = Attractions to zone j

$F(C_{ij})$ = A cost deterrence (impedance) function

C_{ij} = the generalised cost between zone i and zone j

a_i, b_j = row and column balancing factors

K_{ij} = area-specific adjustment factors

5.2 Impedance Function

The impedance function controls the sensitivity to trip costs and was defined as follows:

$$F(C_{ij}) = e^{(xC_{ij})}$$

where: x is calibration constants and C is the generalised cost described above.

5.3 Generalised Cost

The defined generalised cost function included time, Vehicle Operating Costs (VOC) and toll costs. The VOC and toll monetary costs were converted to generalised minutes using Values of Time (VoT). The VoT was adopted form the HBC model. The generalised cost was hence:

$$GC_{ij} = T \times TIME_{ij} + D \times DIST_{ij} + TL \times TOLL_{ij}$$

Where:

GC_{ij} = generalised cost of travel from zone i to zone j, used in the distribution model

T = weight on time

$TIME_{ij}$ = travel time (minutes) between zone i and zone j

D = weight on travel distance, representing a vehicle operating cost

$DIST_{ij}$ = travel distance (km) between zone i and zone j

TL = weight applied to monetary toll

$TOLL_{ij}$ = toll cost (cents), between zone i and zone j

Although no toll road is expected in the Ngāmotu STM model, a toll component is included in the generalised cost. Any toll responses in future year scenarios should be treated as “very preliminary” as there is no validation undertaken for New Plymouth. Having a toll attribute in the cost function enables the quick test of a road closure scenario by putting a large toll without physically altering the network.

The cost parameters of the generalised cost are given in **Table 5-1** and are based on the following assumptions:

- Cost units of minutes, hence the weight on time, T, is 1.0.
- Distance weighting, D, based on perceived private light vehicle operating cost of 20c/km[2], 35c/km for heavy commercial vehicles. These costs were converted to time units using the mean VoT values (as indicated below);
- Toll weighting, TL, based on the VoT.

Table 5-1 Generalised cost parameters used in distribution model

Purpose	Time weight, T	VoT, $2018/hr	Toll weigh TL, min/c	VOC, c/km	Distance weight, D, min/km
HBW	1.0	$29.08	0.0206	20	0.413
HBE	1.0	$16.55	0.0363	20	0.725
HBS	1.0	$16.55	0.0363	20	0.725
HBO	1.0	$16.55	0.0363	20	0.725
EB	1.0	$69.70	0.0086	20	0.172
NHBO	1.0	$16.55	0.0363	20	0.725
CV	1.0	$49.46	0.0121	35	0.425

5.4 Time, Distance and Toll Skims

The time, distance and toll skims were extracted from two class assignments (Heavy and Light) of each peak period. As such they represent the average costs between each zone from the available routes. The AM, inter-peak and PM peak costs were then combined to create a composite 24-hour generalised cost. The peak period costs were weighted in accordance with the amount of travel expected to occur in each period. The peak skim weights used in this averaging process are indicated in **Table 5-2.**

Table 5-2 Period skim weight to develop 24-hr Generalised Cost

Trip Purpose	AM		IP		PM	
	From Home	To Home	From Home	To Home	From Home	To Home
HBW	0.45	0.01	0.25	0.21	0.03	0.47
HBE	0.64	0.08	0.19	0.66	0.04	0.10
HBO	0.13	0.03	0.51	0.47	0.13	0.21
HBS	0.07	0.02	0.65	0.56	0.12	0.23
EB	0.10		0.64		0.11	
NHBO	0.10		0.62		0.13	
HCV	0.16		0.56		0.12	

5.4.1 Access, Intra-Zonal and External Costs

Intra-zonal costs were set as 50% of the cost to the nearest neighbour zone. External-to-external costs were set to ‘999999’ to exclude any such trip making in the distribution models.

[2] Note these values of VOC were only used in the distribution modelling. Different values were used in the assignment modelling. 20c/km VOC is estimated from a fuel price of $2.1/L and fuel efficiency of less than 10km/L

5.5 Demand/Supply Convergence

The demand model requires updating of the travel costs as the trip demands are created. This requires iterations of the gravity and assignment models until satisfactory convergence is achieved. The maximum number of iterations was set to ten and a convergence criterion is 0.1% of changes in vehicle cost between current and previous iteration. A cost damping process is used between iterations to speed convergence.

5.6 Calibration of HBW and HBE Distribution Model

The impedance functions control distribution of the trips and they are unique based on the geographical layouts of the models. Impedance functions calibrated in other models may not be appropriate for the Ngāmotu STM. As such a local calibration was undertaken using the JTW and JTE census data which is a good data source for travel patterns of commuter (HBW) and education (HBE) trips.

It is noted that the JTW and JTE data is collected only for the census day and the data may not be a true representation of travel patterns. However, with the lack of other available data, the JTW and JTE census data was used for calibration of HBW and HBE travel patterns which is a common practice in other similar models.

5.6.1 Model Segmentation

Generally, the same impedance functions are set for areas where travel patterns are likely to be similar. Four segmentations were established for the following areas:

- Urban
- External
- Satellite
- Rural

5.6.2 Trip Length Distribution Comparison

Trip length distribution for modelled HBW and HBE against JTW and JTE census data will be covered in the following paragraphs. First, the comparisons have been done for each 4 segments of the model, namely urban, external, satellite towns and rural. Lastly, a total comparison is made.

5.6.2.1 HBW vs JTW

Figure 5-1 to **Figure 5-5** show the comparison of trip length frequency distribution between JTW data and HBW trip purpose for car trips. Also, **Figure 5-6** represents the trip length distribution for PT trips. Impedance parameters were adjusted to match HBW with JTW trip length distribution. The final impedance parameters are presented in Section 5.8. From the figures below it can be concluded that the modelled trip length distribution match very well with the census data.

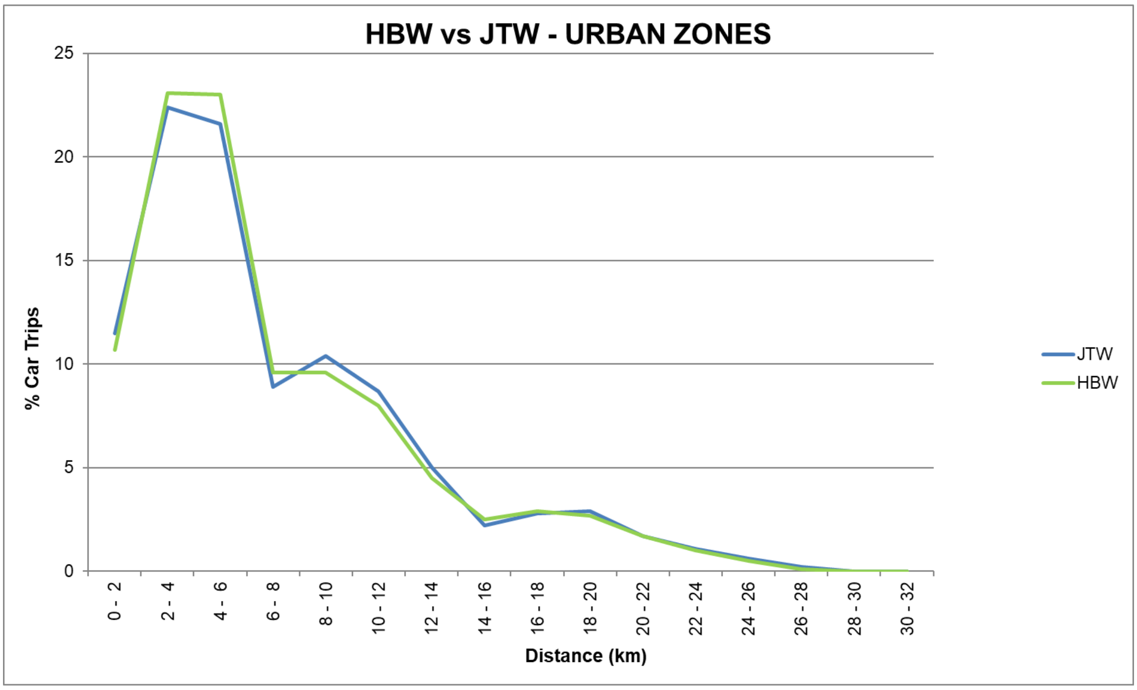


Figure 5-1 HBW vs JTW trip length comparison (Urban)

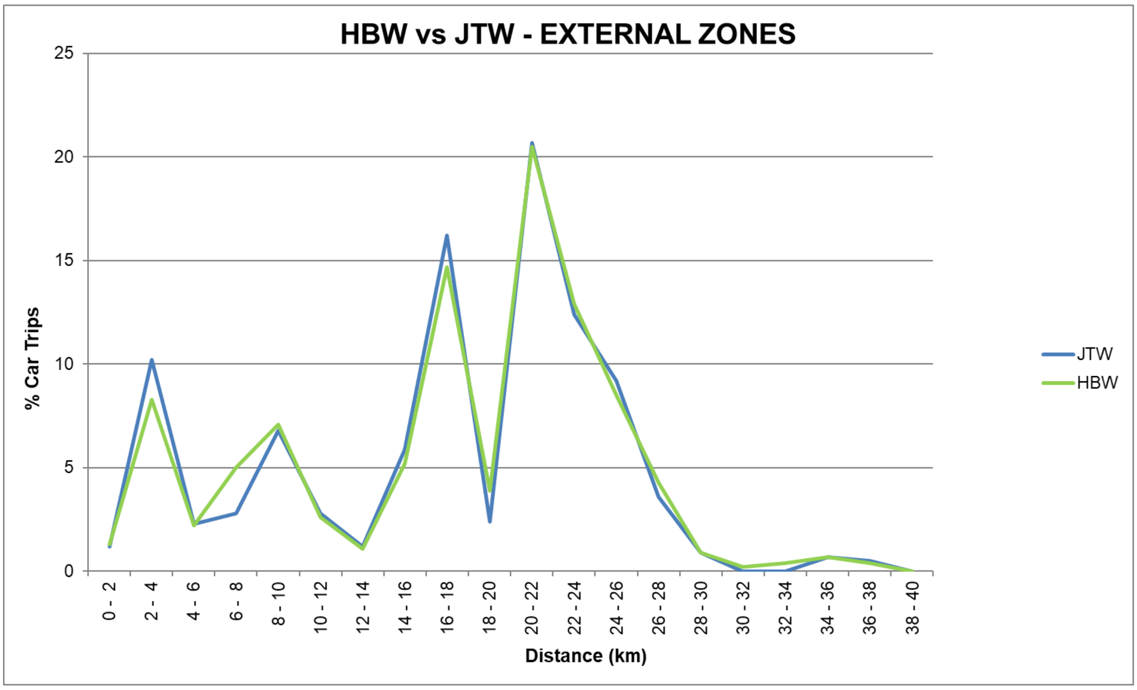


Figure 5-2 HBW vs JTW trip length comparison (External)

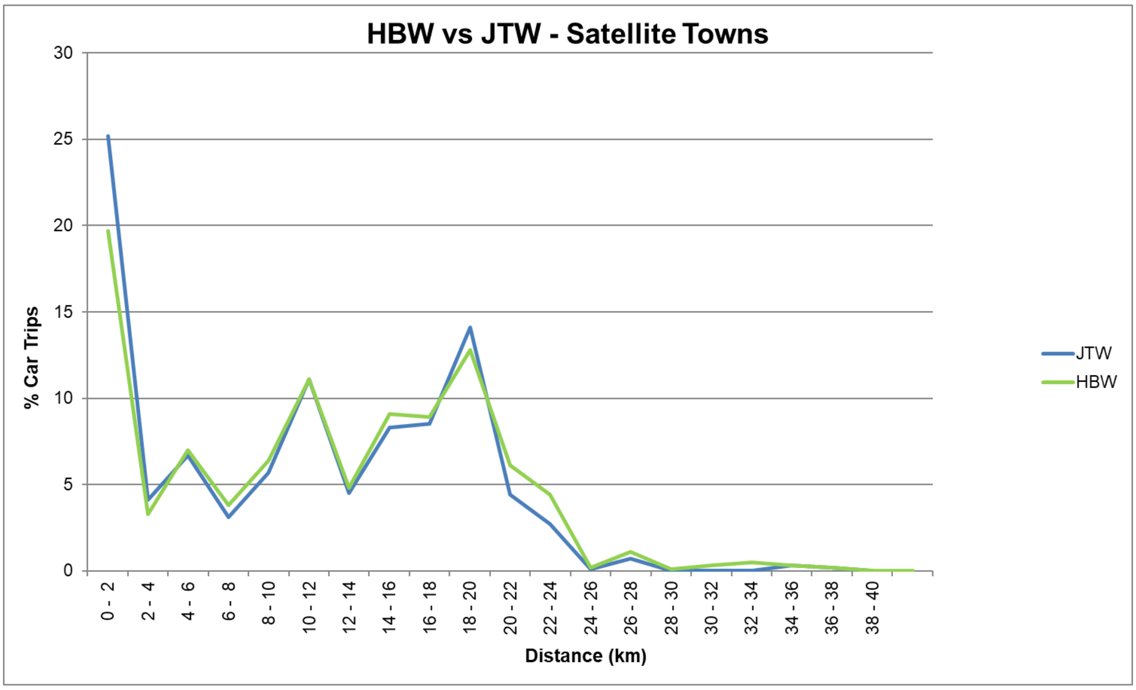


Figure 5-3 HBW vs JTW trip length comparison (Satellite)

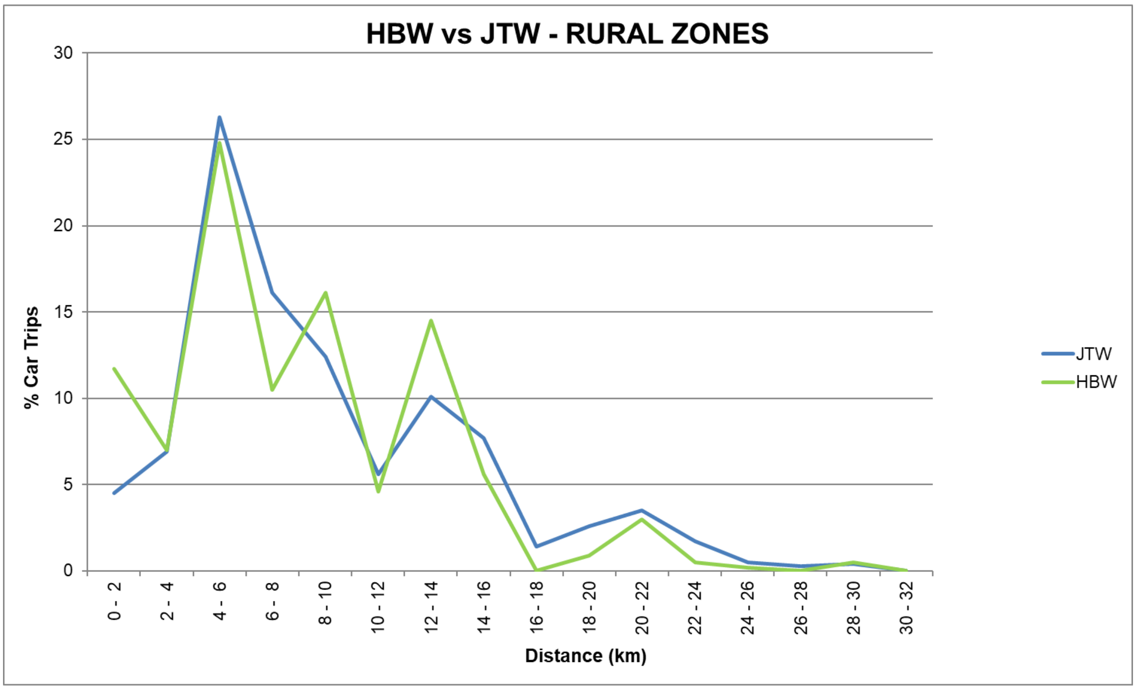


Figure 5-4 HBW vs JTW trip length comparison (Rural)

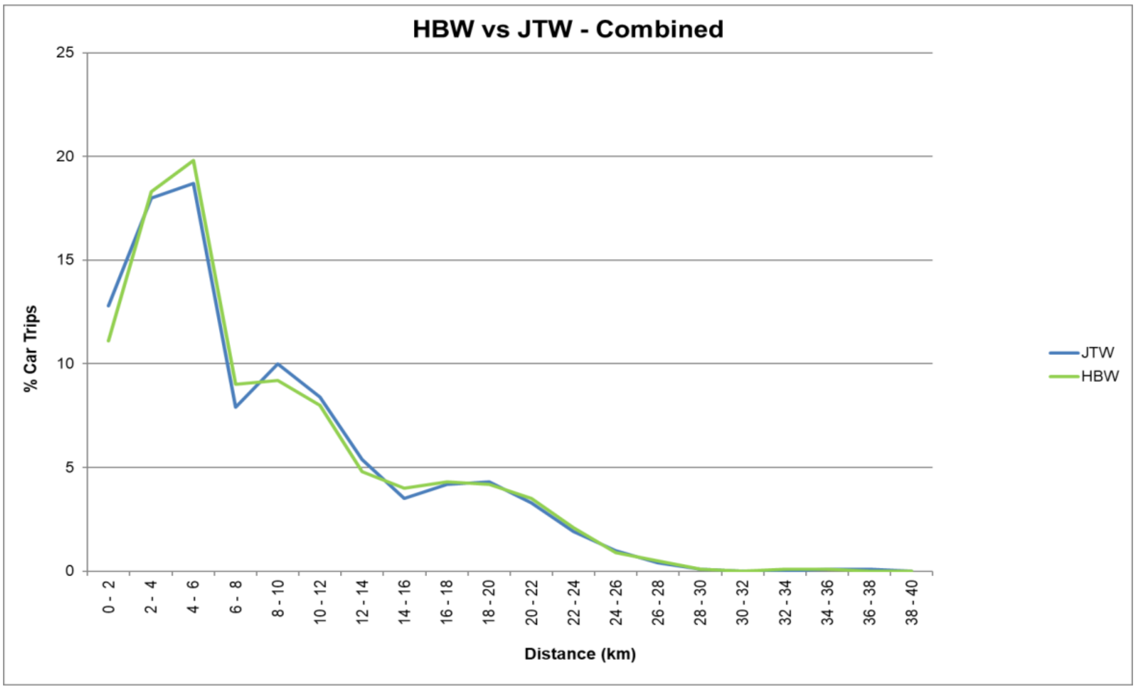


Figure 5-5 HBW vs JTW trip length comparison (Combined)

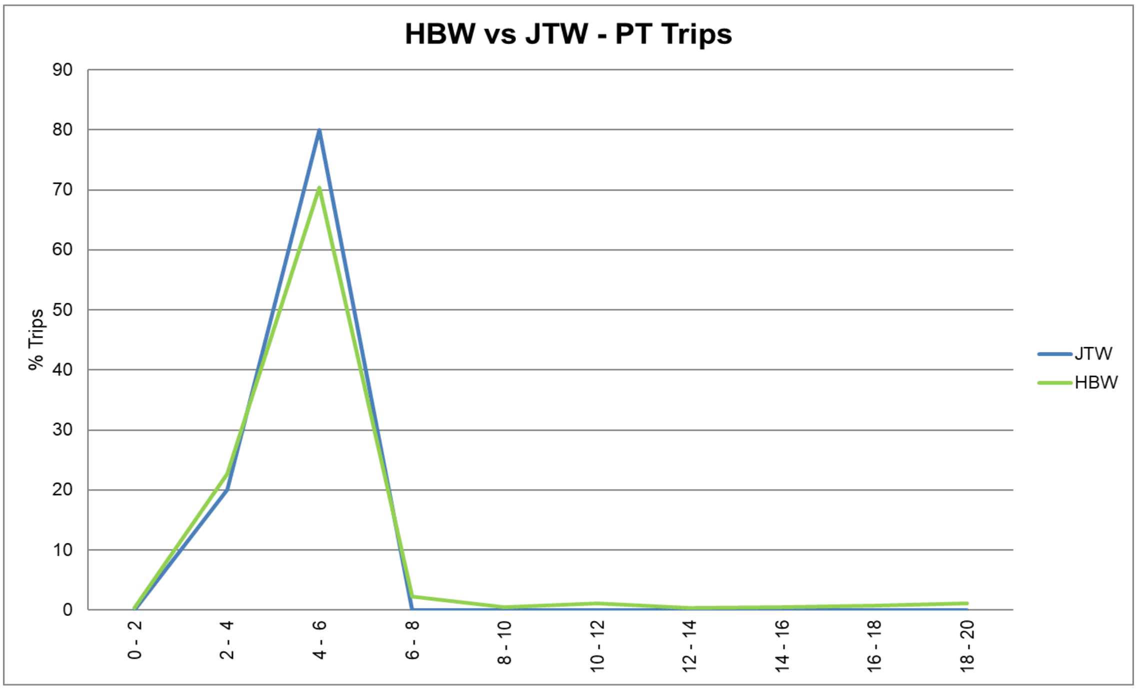


Figure 5-6 HBW vs JTW trip length distribution for PT trips

5.6.2.2 HBE vs JTE

Figure 5-7 to **Figure 5-10** represent the trip length frequency distribution comparison between JTE and HBE for car trips. However, a PT comparison at the zonal level is not reliable due to the low numbers of PT trips. This is because of the data confidentiality in the Census data obtained from the Stats NZ.

Impedance parameters were adjusted to match HBE with JTE trip length distribution. The final impedance parameters are given in Section 5.8. Generally, the figures show a very good match between modelled HBW and census JTW data. From the combined zones comparison (**Figure 5-10**), it can be inferred that the model has slightly lower short trips (0-4 km) than the census but it overestimates the longer trips.

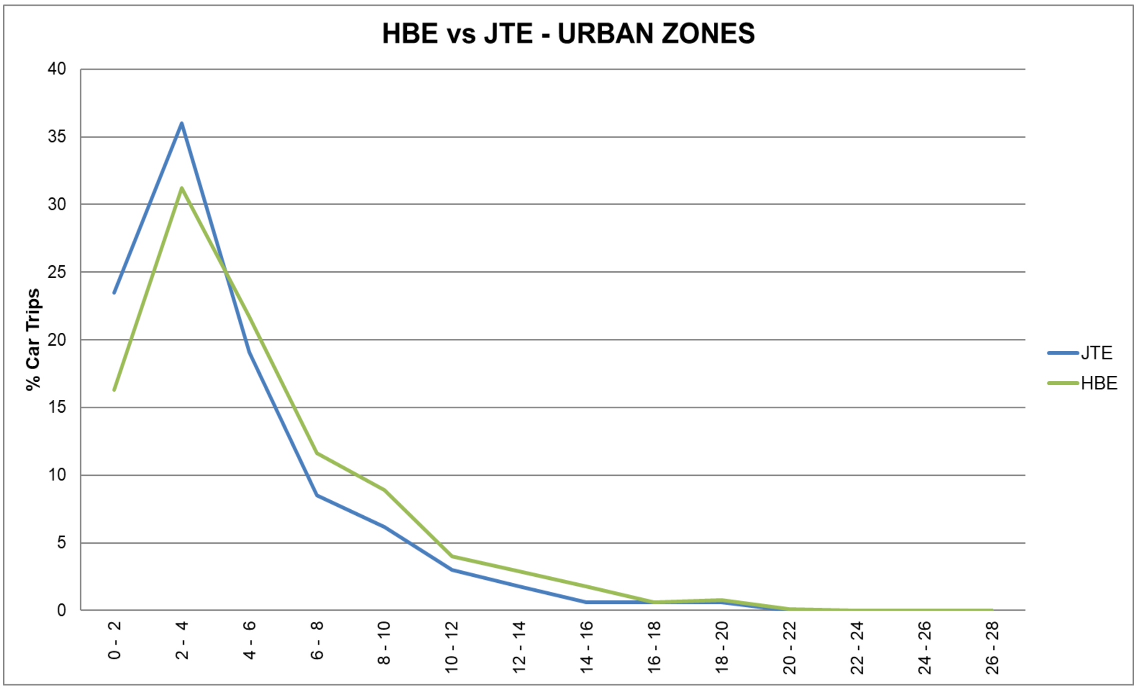


Figure 5-7 HBE vs JTE trip length comparison (Urban)

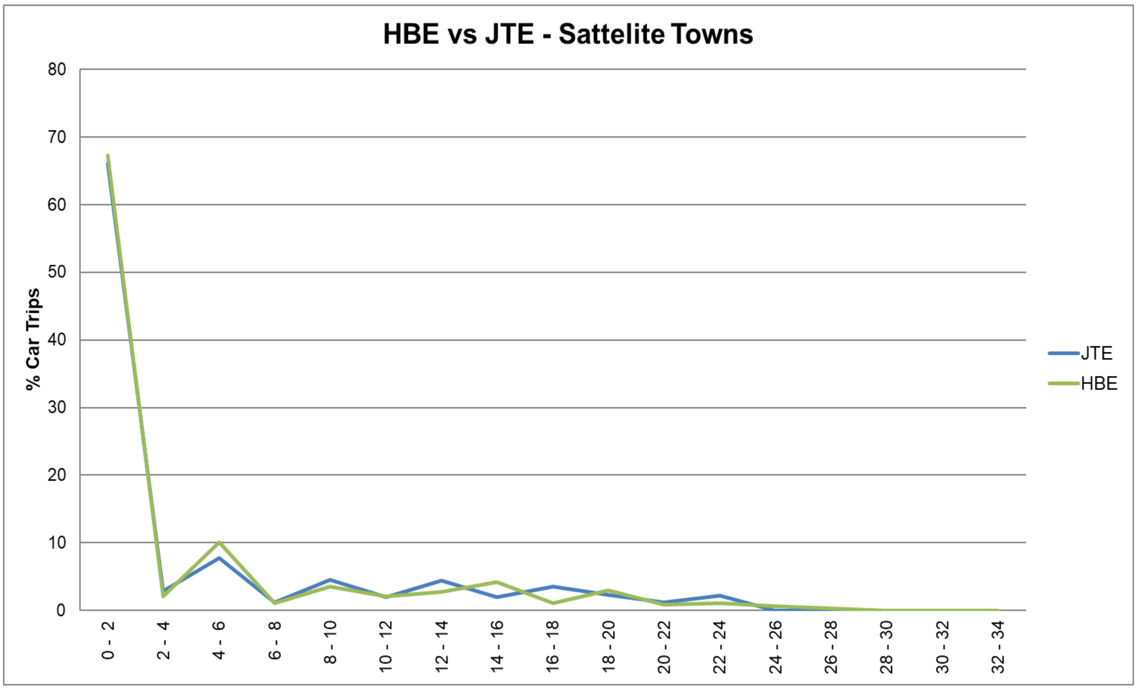


Figure 5-8 HBE vs JTE trip length comparison (Satellite)

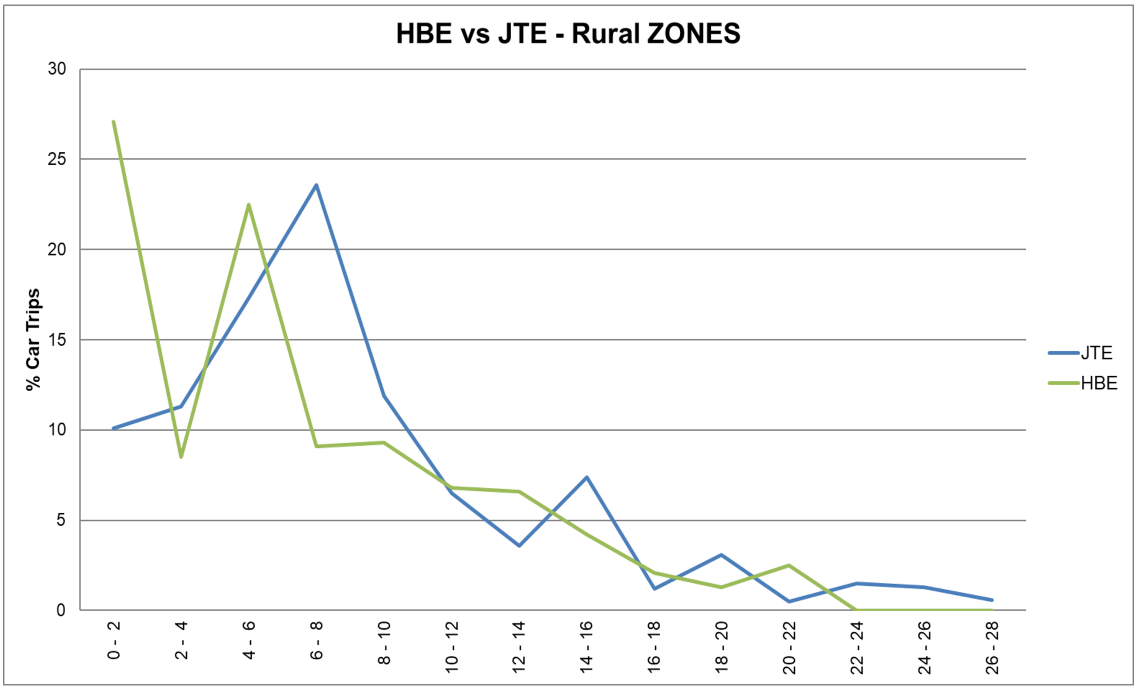


Figure 5-9 HBE vs JTE trip length comparison (Rural)

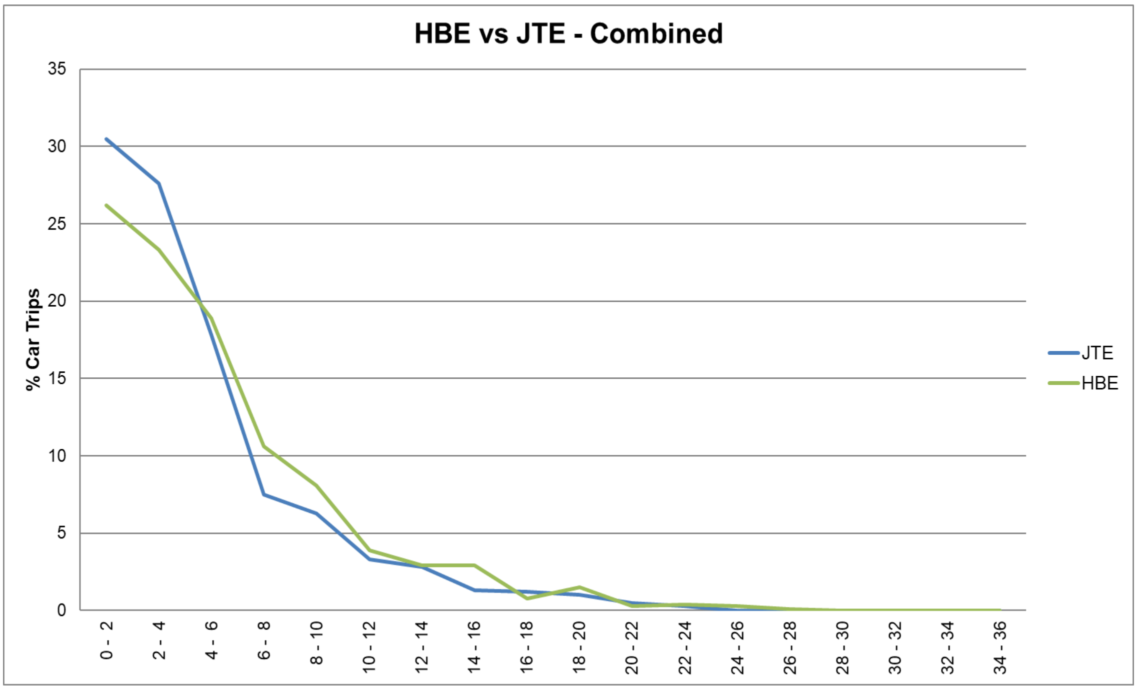
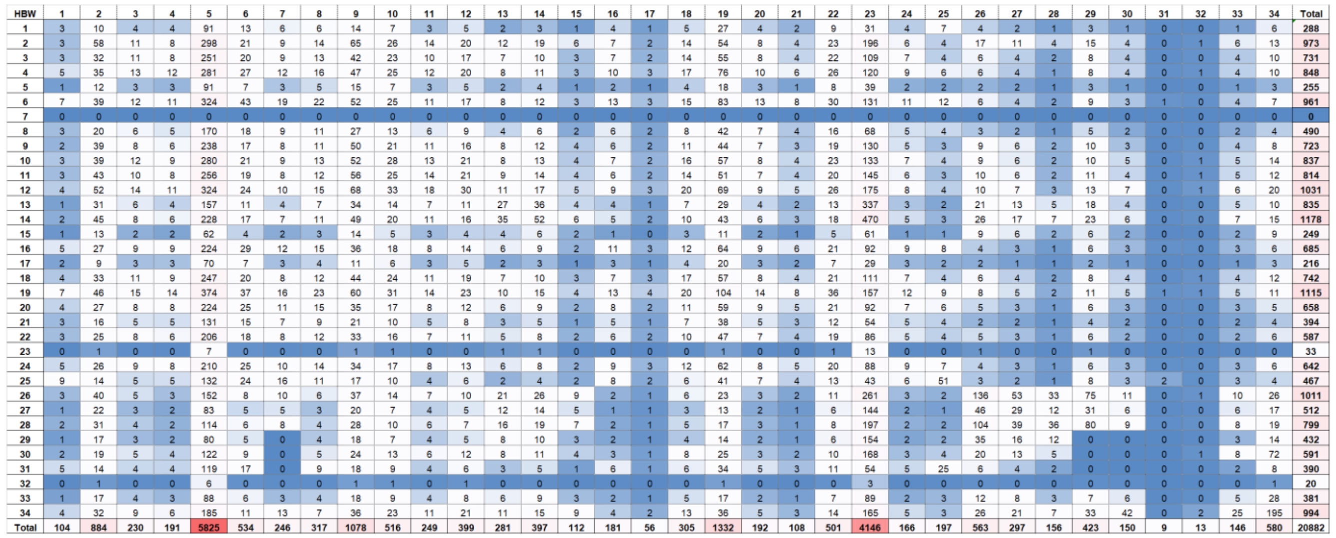


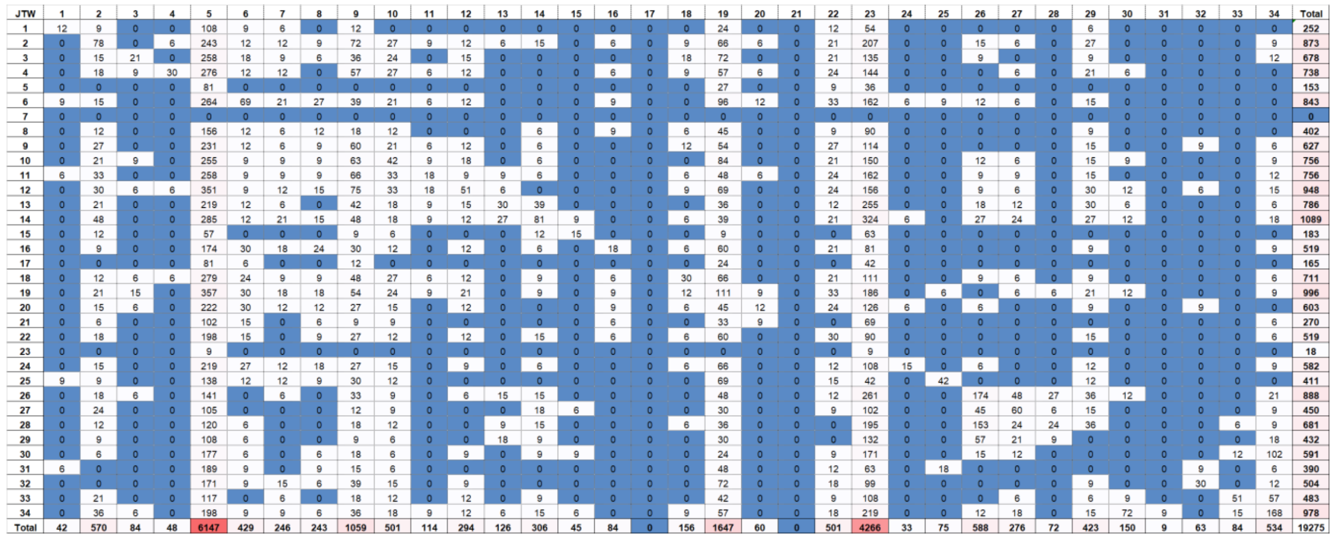
Figure 5-10 HBE vs JTE trip length comparison (Combined)

5.6.3 Sector to Sector Comparison

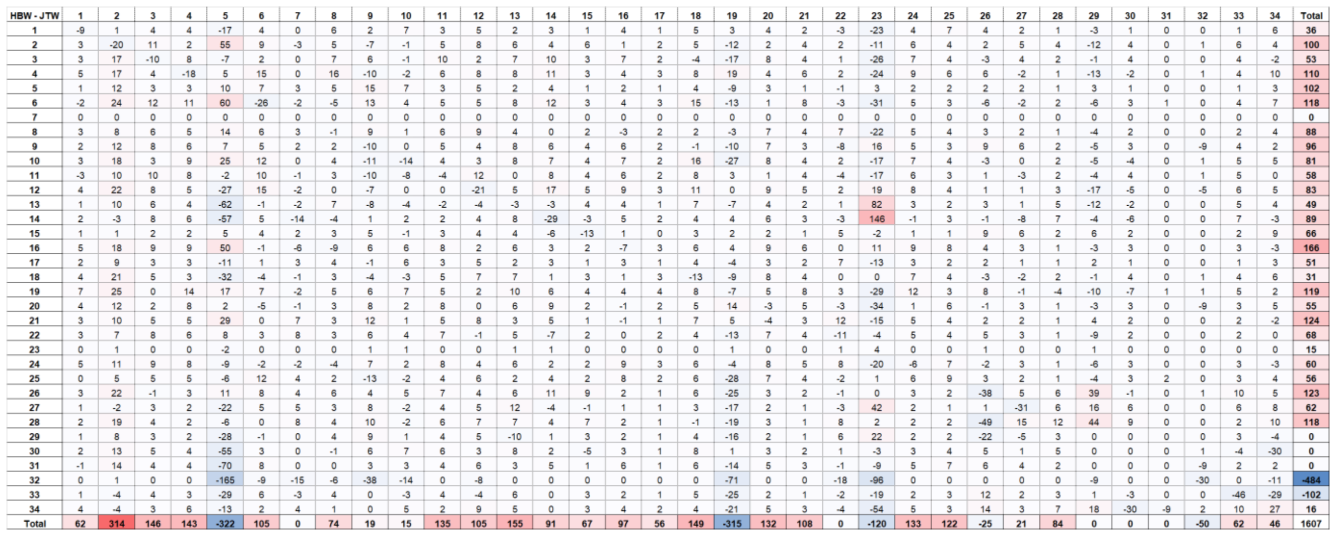
The sector to sector movements were compared between the modelled HBW and census JTW in **Figure 5-11** and between HBE trips and the census JTE trips in **Figure 5-12**. Sector map is shown in **Figure 5-13** in which sector 7, 27, 28 and 29 are external sectors.



(a) Modelled HBW Sector to sector movement

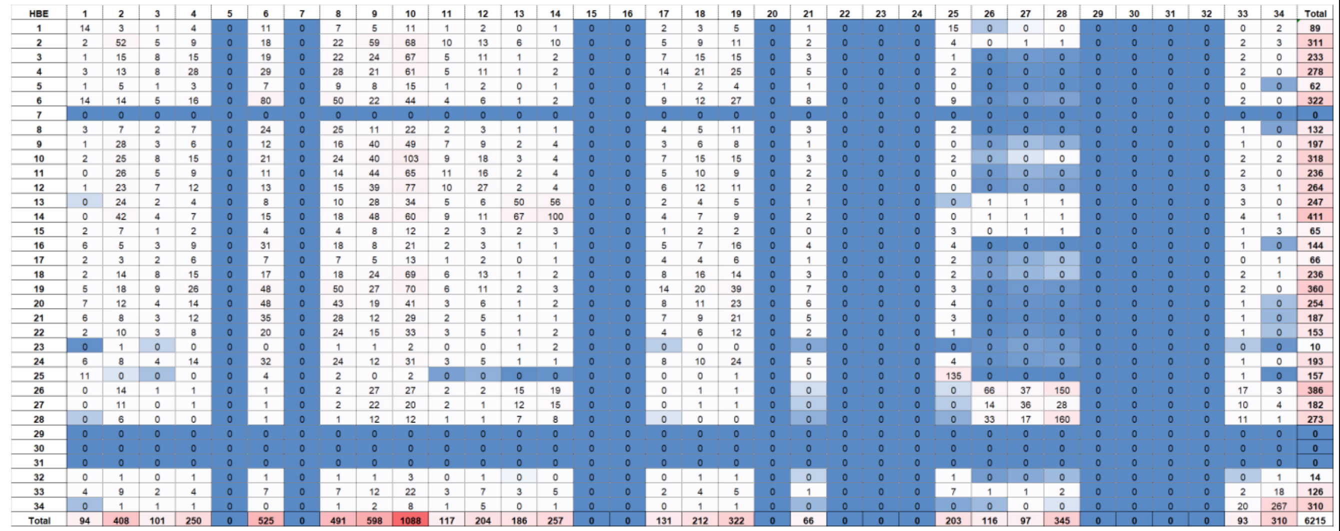


(b) Census JTW sector to sector movement

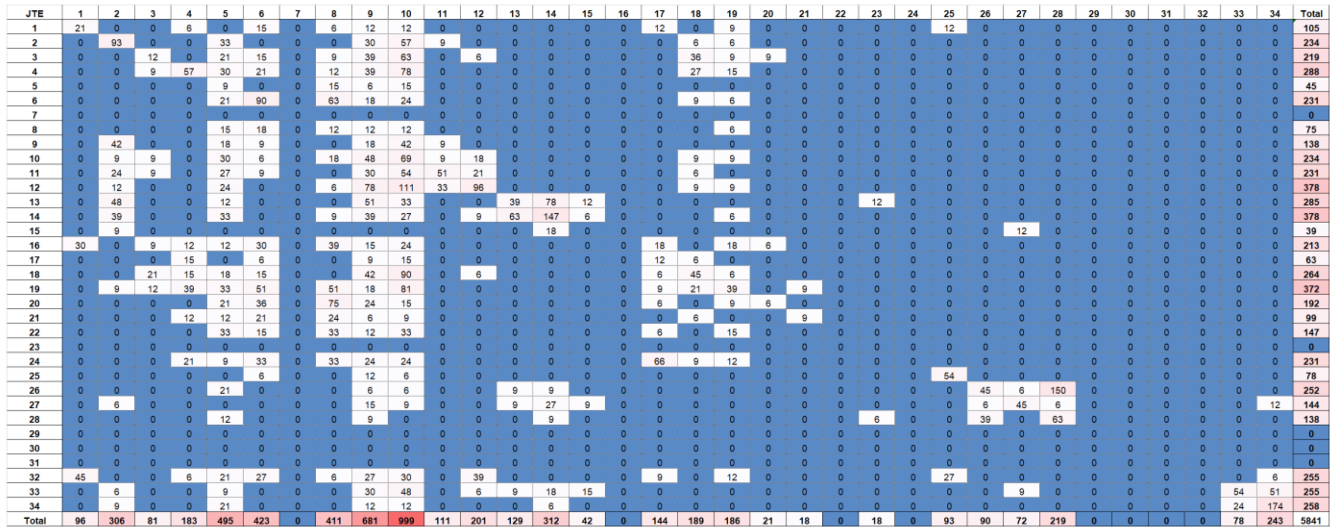


(c) Sector to sector comparison (HBW - JTW)

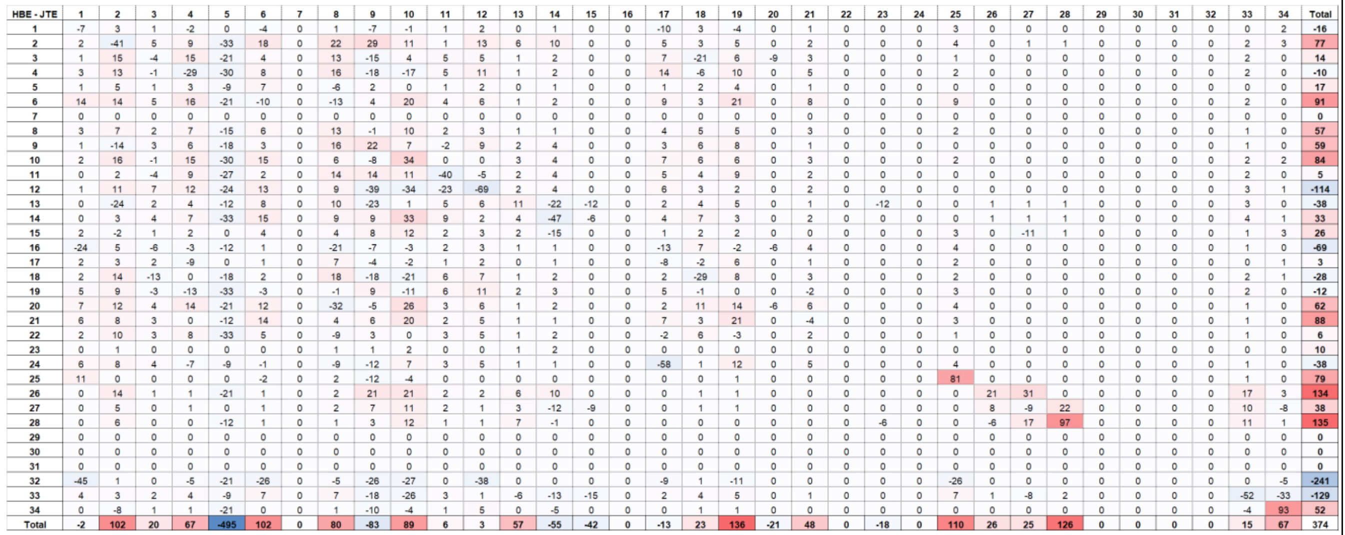
Figure 5-11 Sector to sector movement comparison (HBW vs JTW)



(a) Modelled HBE Sector to sector movement



(b) Census JTE sector to sector movement



(c) Sector to sector comparison (HBE - JTE)

Figure 5-12 Sector to sector movement comparison (HBE- JTW)

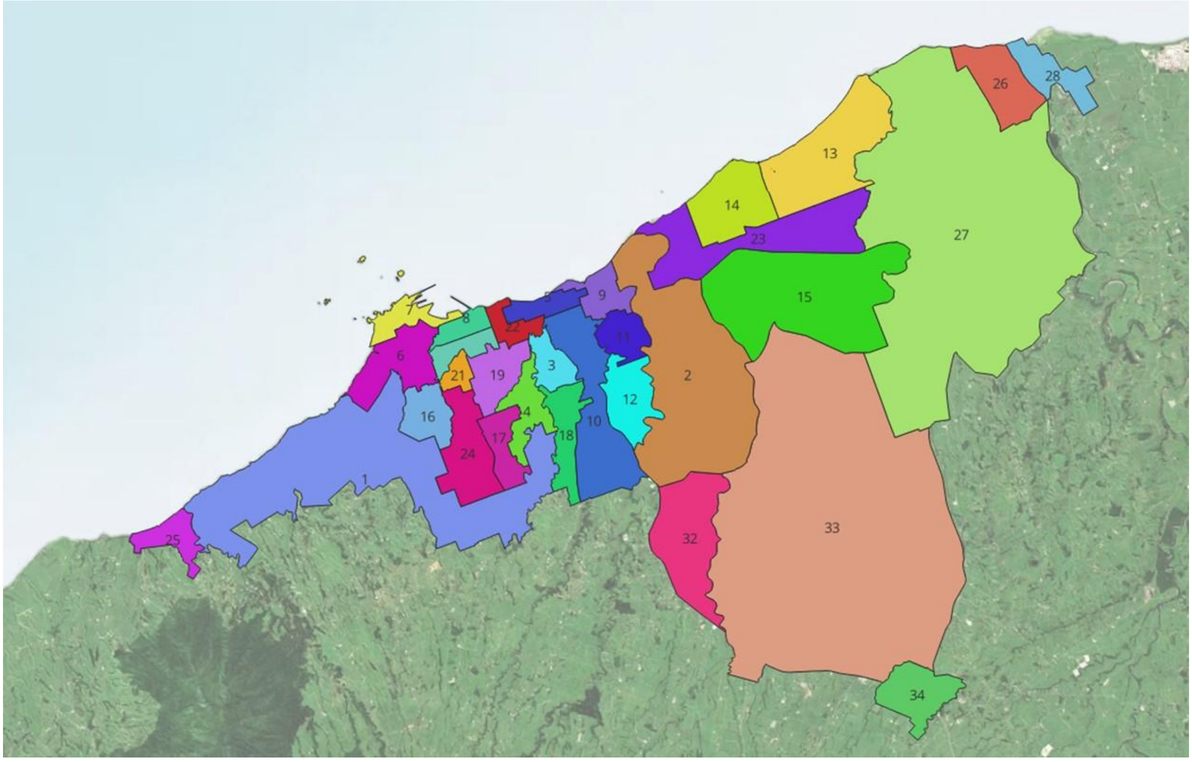


Figure 5-13 Sector map

5.7 Sector to Sector K Factor

Calibration of the distribution model includes altering trip rates, impedance parameters and K factors. Impedance functions are useful to adjust area-specific travel patterns (e.g. traffic originating from Rural, Urban and etc.). However, K factors are effective parameters to encourage more or less trip between certain sectors to reflect the observed Origin-Destination travel pattern.

A 32 sector[3] system was considered to develop K factors for this model is shown in **Figure 5-15**. Three different K factor matrices were created for different trip purposes for model calibration purpose. HBW, NHBEB, and HCV trip purpose trips use K-factor values in **Figure 5.14(a)**, HBE trip purpose trips use K-factor values in **Figure 5.14(b)**, and all other trips use K-factor values in **Figure 5.14(c)**.

[3] Sector 29 refers to Inlet Port Taranaki zone which is water area and does not represent any sector

K Fact Sector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
13	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.5	1.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.5	0.8	1	1	1	1	1	1	1	1
14	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.5	1.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.5	0.8	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
23	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.5	1.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.5	0.8	1	1	1.5	1.5	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.5	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.5	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

(a) Sector to sector K-factor for HBW, NHBEB, and HCV trip purpose

K Fact Sector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
13	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	2	2	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	2	0.8	1	1	1	1	1	1	1	1
14	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	2	2	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	2	0.8	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
23	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	2	2	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	2	0.8	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

(b) Sector to sector K-factor for HBE trip purpose

K Fact Sector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
13	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.5	1.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.5	0.8	1	1	1	1	1	1	1	1
14	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.5	1.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.5	0.8	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
23	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.5	1.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.5	0.8	1	1	1.5	1.5	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	1	1	1	1	1	1	1	1	0.8	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.5	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.5	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

(c) Sector to sector K-factor for all other trip purposes

Figure 5-14 Sector to sector K-factor for different trip purposes

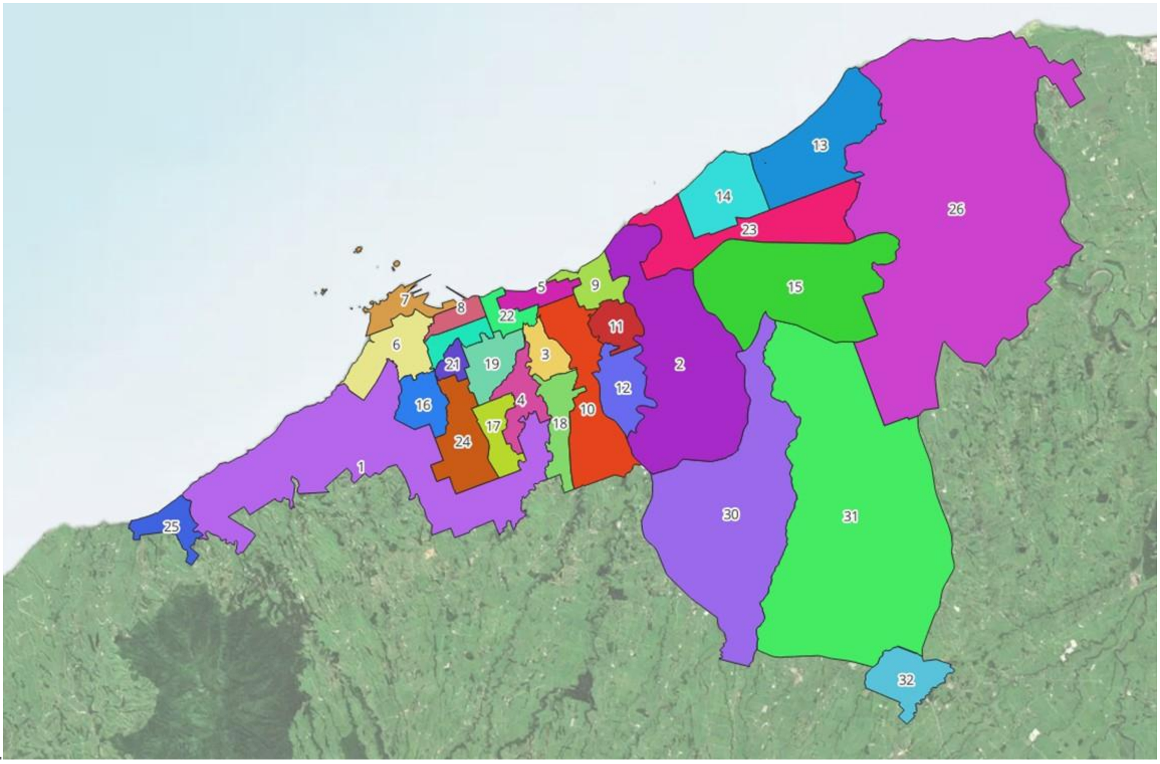


Figure 5-15 K Factor Sector Map

5.8 Adopted Distribution Parameters

The final impedance parameters used in Ngāmotu STM are listed in **Table 5-3** after the calibration of the JTW and HBW trips.

Table 5-3 Adopted impedance parameters

Purposes	Urban	Satellite	Rural	External
HBW	-0.04	-0.08	-0.05	-0.05
HBE	-0.1	-0.16	-0.05	-0.1
HBO	-0.08	-0.208	-0.1	-0.1
HBS	-0.072	-0.224	-0.09	-0.09
EB	-0.04	-0.112	-0.06	-0.06
NHBO	-0.064	-0.208	-0.08	-0.08
HCV	-0.04	-0.112	-0.06	-0.05

The HBW purpose trips have a good source of data (JTW) to calibrate their travel patterns and to calculate their impedance parameters. To estimate the impendence parameters for other purposes' trips, a factoring method was used as a base to HBW trips. For example, HBE purpose trips are supposed to have shorter trip lengths and hence a multiplication factor of 2.5 (urban areas) was used to estimate their impedance parameters. These factors are determined based on other similar models (e.g. Auckland, Christchurch, Tauranga and Wellington) and observed traffic counts across the model. There is no exact science and some modelling judgement was used in determining these factors (e.g. urban trip lengths were increased if most of the counts show under-estimation and if trip rates for general urban areas are considered appropriate). These multiplication factors for each purpose/segment are provided in **Table 5-4.**

Table 5-4 Factors for impedance parameters for other trip purposes

Purposes	Urban	Satellite	Rural	External
HBE	2.5	2.4	1	2
HBO	1.8	2.2	1.8	1.8
HBS	2	2	2	2
EB	1	1	1.2	1.2
NHBO	1.6	2	1.6	1.6
HCV	1	1	1.2	1

6 Time Period Model

6.1 Model Form

The gravity model outputs provide 24-hour Production-Attraction matrices which the Time Period Model converts to peak period Origin-Destination matrices. This is done using time period and direction factors adopted from other models and adjusted to match local count data.

The time period model has two components, firstly a process to determine the peak period demands from the 24-hour demands, and secondly to estimate peak-hour demands from the peak period demands.

The period demands are derived as follows:

24 hour trip matrix in P/A form is T_{ij}^{p}

From home trip matrix is $T_{ij}^{pf} = \frac{1}{2}T_{ij}^{p}$

To home trip matrix is $T_{ij}^{pr} = \frac{1}{2}T_{ji} = \frac{1}{2}T_{ij}^{p'}$

The matrix for any time period t, is constructed from the formula:

$$T_{ijt}^{p} = P_{t}^{pf} \times T_{ij}^{pf} + P_{t}^{pr} \times T_{ij}^{pr}$$

6.2 Period and Direction Factors

These factors are used to convert from 24 hour demand matrices to demand periods which are 2 hours for AM and PM and 7 hours for interpeak. Initial values were adopted from the Auckland, Tauranga, Palmerston North and Rodney models. Some adjustments were made during the calibration process. As described in the previous section, external to external matrices (or 'through') were developed using survey data. Then external to external trips were inserted as observed matrices after the trip distribution model.

The final factors used to convert 24hr demand matrices to demand periods are detailed in **Table 6-1** to **Table 6-6** along with time period factors used in other similar models.

Table 6-1 HBW time period/direction factors

Period	TTM		Auckland		Rodney		Ngāmotu STM	
	From	To	From	To	From	To	From	To
AM 2hr	0.45	0.01	0.63	0.02	0.44	0.02	0.45	0.01
IP 7hr	0.25	0.21	0.15	0.19	0.19	0.19	0.25	0.21
PM 2hr	0.03	0.47	0.02	0.50	0.03	0.45	0.03	0.47

Table 6-2 HBE time period/direction factors

Period	TTM		Auckland		Rodney		Ngāmotu STM	
	From	To	From	To	From	To	From	To
AM 2hr	0.64	0.08	0.77	0.01	0.64	0.09	0.64	0.08
IP 7hr	0.19	0.66	0.16	0.58	0.17	0.54	0.19	0.66
PM 2hr	0.04	0.1	0.04	0.21	0.01	0.17	0.04	0.10

Table 6-3 HBO time period/direction factors

Period	TTM		Auckland		Rodney		Ngāmotu STM	
	From	To	From	To	From	To	From	To
AM 2hr	0.13	0.03	0.25	0.08	0.14	0.04	0.13	0.03
IP 7hr	0.51	0.47	0.36	0.34	0.39	0.39	0.51	0.47
PM 2hr	0.13	0.21	0.14	0.22	0.11	0.18	0.13	0.21

Table 6-4 HBS time period/direction factors

Period	TTM		Auckland		Rodney[4]		Ngāmotu STM	
	From	To	From	To	From	To	From	To
AM 2hr	0.07	0.02	0.10	0.02	-	-	0.07	0.02
IP 7hr	0.65	0.56	0.59	0.53	-	-	0.65	0.56
PM 2hr	0.12	0.23	0.12	0.23	-	-	0.12	0.23

Table 6-5 EB and NHBO time period factors

Period	TTM		Auckland		Rodney[5]		Ngāmotu STM	
	EB	NHBO	EB	NHBO	EB	NHBO	EB	NHBO
AM 2hr	0.10	0.10	0.18	0.16	-	0.09	0.10	0.10
IP 7hr	0.64	0.62	0.55	0.54	-	0.54	0.64	0.62
PM 2hr	0.11	0.13	0.16	0.16	-	0.14	0.11	0.13

Table 6-6 HCV and External to External time period factors

Period	TTM	Auckland[6]	Rodney	Ngāmotu STM	
	HCV	HCV	HCV	HCV[7]	E to E[8]
AM 2hr	0.16	-	0.14	0.16	0.14
IP 7hr	0.56	-	0.46	0.56	0.49
PM 2hr	0.12	-	0.12	0.12	0.17

After application of these factors, the total Heavy and Light vehicle matrices were compared against the observed count data in terms of daily percentages for each period. Also total observed and modelled link flows were compared globally. If they did not match well, further adjustments were made until a good match was achieved.

[4] Rodney model does not have HBS trip purpose and HBS was combined with HBO

[5] Rodney model does not have EB trip purpose and EB was combined with NHBO

[6] HCV model for Auckland is built from observed matrices.

[7] HCV time period factors are determined from HCV counts

[8] External to External time period factors are determined from external counts

6.3 Average Hour Demands

The average-hour demands use in assignment are developed from the demand period and multiplied by the following factors to derive average hour demands. **Table 6-7** shows the factors for all trip purposes.

Table 6-7 Peak Hour Factors (From Demand Periods to Peak Periods)

	AM 2 hrs to 1 hr	IP 7 hrs to 1 hr	PM 2 hrs to 1 hr
All purposes	0.5	0.1429	0.5

7 Assignment Model

7.1 Model Form

Both assignment models in the demand creation and the final assignment module use two-class assignments for each period. Light vehicle and heavy vehicle matrices are assigned individually using differing path building parameters.

The assignment model applies the following iterative process:

- Least cost (All-or-Nothing) path building based on generalised cost
- Capacity restraint using explicit junction delay modelling, speed-flow curves and volume-averaging of flows

7.2 Generalised Cost for Path Building

The generalised cost function is similar to that used in the distribution model, albeit with different parameters:

$$GC_{ij} = T \times TIME_{ij} + D \times DIST_{ij} + TL \times TOLL_{ij}$$

The parameters are derived using the VoT provided in **Table 5-1** for each modelled time period (rather than for each trip purpose as in the demand model). A weighted average VoT ($/hr) was calculated for each modelled period then converted to toll weights (TL) in 'minute/cent' unit. Toll value should be in 'cent' and these toll weights would convert toll value (cents) to equivalent travel time (minute) value. As there are no toll roads in the model, these toll weights have no effect on the assignment results.

It is considered that vehicle operation cost effects on route choice decisions are less sensitive than that of destination choice in the demand model. Hence only 75% of VOC value was used in the route choice model (in comparison with values used in the demand model).

The distance component parameter is used to represent both the perceived vehicle operating costs and also any other environmental factors that could influence route choice. These environmental factors include a preference for higher-standard, high speed roads and an avoidance of lower standard, windy, narrow roads. The parameters used in the assignment model are as detailed in **Table 7-1.**

Table 7-1 Assignment model parameters

	Link Type	AM	IP	PM
Time Weight, T	All	1.0	1.0	1.0
Distance Weight, D (minute/km)	1	0.3386	0.3661	0.3821
	2	0.3386	0.3661	0.3821
	3	0.3386	0.3661	0.3821
	4	0.5418	0.5858	0.6113
	5	0.4740	0.5126	0.5349
	6	0.4402	0.4760	0.4967
	7	0.4063	0.4394	0.4585
	8	0.3725	0.4027	0.4203
	9	0.3386	0.3661	0.3821
	10	0.3047	0.3295	0.3439
	11	0.3386	0.3661	0.3821
	12	0.3386	0.3661	0.3821
	13	0.3386	0.3661	0.3821
	14	0.2709	0.2929	0.3057
	15	0.2709	0.2929	0.3057

	Link Type	AM	IP	PM
	16	0.2709	0.2929	0.3057
	17	0.3386	0.3661	0.3821
	18	0.3386	0.3661	0.3821
Toll Weight, TL (Light) (minute/cent)	All	0.0233	0.0254	0.0261
Toll Weight, TL (Heavy) (minute/cent)	All	0.0121	0.0121	0.0121

8 Model Calibration and Validation Methodology

This chapter discusses the approach to calibrate and validate the model. The initial stage in this process was to undertake an independent internal review of model network coding, and demand inputs. This was undertaken by an experienced modeller independent from the project team. Input parameters were also shared with the peer reviewer, Ian Clark from Flow Transportation Specialists.

In this context, model calibration refers to the process in which the network coding, delay parameters and demands were adjusted to match observed data. Validation is the process in which the resulting traffic flows, delays and speeds are compared to data not used in calibration.

8.1 Calibration Approach

The philosophy was to obtain satisfactory replication of base year (2018) conditions without excessive change to the demands. The main steps in the process were as follows:

- Start with the unmodified synthetic demands;
- Calibrate the network speeds/assignment;
- Make reasonable and realistic adjustments to the networks;
- Check of the network and intersection coding where there are large delays;
- Review of the locations of zone connectors and split of traffic (for multiple connectors); and
- Review network speed and assignment:

8.2 Key Validation Checks

The 'fit' of the model to observed data includes the following comparisons:

- Screenline vehicle flow totals by period and direction
- Individual link vehicle flow totals by period and direction
- HCV flows. Given the generally low proportion of HCV's, these comparisons focus on daily flows, however comparisons at peak period levels were also included
- Travel times on key routes

9 Model Validation Results

This chapter discusses the results of the validation that has been undertaken.

9.1 Statistical Tests

The statistical tests and measurements to compare the model against observed data are based on common practice in NZ as well as appropriate guidelines such as the draft guidelines produced by Waka Kotahi Transport Model Development Guidelines.

9.1.1 Link Flow Comparison

The comparison of the modelled and the observed flows was undertaken using the following statistical tests:

- Actual and percentage difference between the modelled and the observed flows
- RMSE (Root Mean Square Error)
- R^2 (correlation co-efficient)
- GEH is calculated for each link and screenlines

Waka Kotahi sets different criteria based on different types of model category. Ngāmotu STM falls in category B: Strategic Network. This category as per Waka Kotahi guidelines is defined as:

A strategic network assignment model is likely to be focused on strategic links such as motorway corridors, the state highway, and/or the arterial route network across a wider geographic area. These models are commonly used to assess major transport infrastructure changes, e.g. large-scale motorway schemes, bridges etc.

The model validation criteria for category B is summarized in **Table 9-1**.

Table 9-1 Validation criteria for link flow

Descriptions	*Category B: Strategic Network*
Total Directional Count Across Screenlines	
GEH < 5.0	>75%
GEH < 7.5	>85%
GEH < 10	>95%
Individual Directional Link Count	
GEH < 5.0	>80%
GEH < 7.5	>85%
GEH < 10	>90%
GEH < 12	>95%
XY Scatter Criteria	
R^2	>0.90
Line of Best Fit	Y=0.9x – 1.1x
RMSE	<25%

9.1.2 Travel Time Comparison

The criteria for travel time validation are obtained from Waka Kotahi Guidelines and shown in **Table 9-2**.

Table 9-2 Validation criteria for travel time

Criteria	Descriptions	Category B: Strategic Network
C1	Within 15% or 1 minute (if higher) (% of routes)	>85%
C2	Within 25% or 1.5 minute (if higher) (% of routes)	>90%

9.2 Flow Validation

Flow validation was undertaken across a number of screenlines and at spot count sites. This data was arranged into three 'sets' for the purposes of model validation process. These are:

- Set 1 – All available count data ("all data") (144 counts);
- Set 2 – Screenline total count ("SL") shown in **Figure 9-1** (13 screenlines and 43 counts);
- Set 3 - Count data outside CBD area (120 counts). We noted the zone system in the CBD is too crude (although further zones were split in the CBD from the SA1 unit) for the available count locations and it is not appropriate to use the count data in the CBD. Hence this dataset was developed and should be used as the main dataset to assess the performance of the model.

Figure 9-1 Screenline location map

The validation results are provided in **Table 9-3** below. It can be observed that in most of the cases, Ngāmotu STM meets or exceeds the validation criteria. The detailed flow validation results are provided in **Appendix A**.

Table 9-3 Summary of validation results

Set	Measure	Criteria	Without ME		
			AM	IP	PM
1 All	GEH<5	>75%	65%	66%	65%
	GEH<7.5	>85%	84%	84%	88%
	GEH<10	>95%	95%	91%	93%
	GEH<12		98%	94%	95%
	R^2	>0.90	0.93	0.90	0.92
	RMSE	<25%	32%	32%	30%
2 SL	GEH<5	>80%	74%	77%	74%
	GEH<7.5	>85%	86%	91%	95%
	GEH<10	>90%	98%	93%	100%
	GEH<12	>95%	100%	98%	100%
	R^2	>0.90	0.94	0.91	0.94
	RMSE	<25%	23%	26%	20%
3 Non-CBD (main dataset)	GEH<5	>75%	71%	68%	66%
	GEH<7.5	>85%	85%	86%	90%
	GEH<10	>95%	96%	96%	96%
	GEH<12		98%	98%	97%
	R2	>0.90	0.94	0.91	0.93
	RMSE	<25%	29%	29%	26%

Note that R^2 values reported in the table above are measured from the y=mx trendline (i.e., from the Excel scatterplot). There are other alternative methods to measure R^2 such as measured from y=x and this requires some additional calculations. However, there is no clear instruction from the guideline on what R^2 value to be used.

- For all locations, the validation results (Without ME) are slightly lower than the Waka Kotahi criteria and able to achieve 91% locations under GEH <10 measure.
- At screenlines sites, the validation results (Without ME) are slightly lower than the Waka Kotahi criteria for GEH <5 and exceed for Waka Kotahi criteria for other GEH measures.

Figure 9-2 to **Figure 9-4** show the comparison of observed and modelled flow for AM, Interpeak and PM peaks respectively, for All dataset.

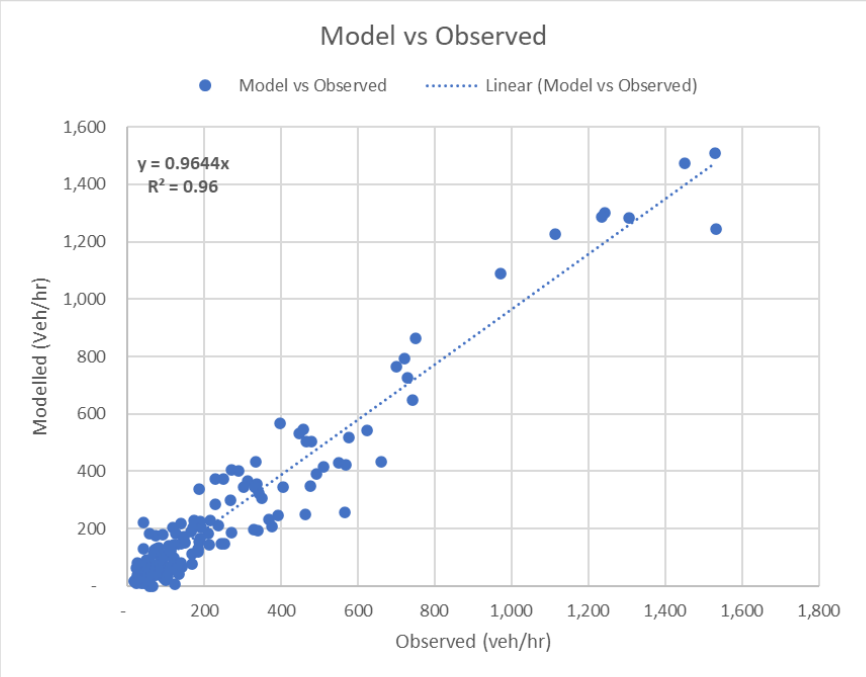


Figure 9-2 AM Peak scatterplot of modelled and observed flow

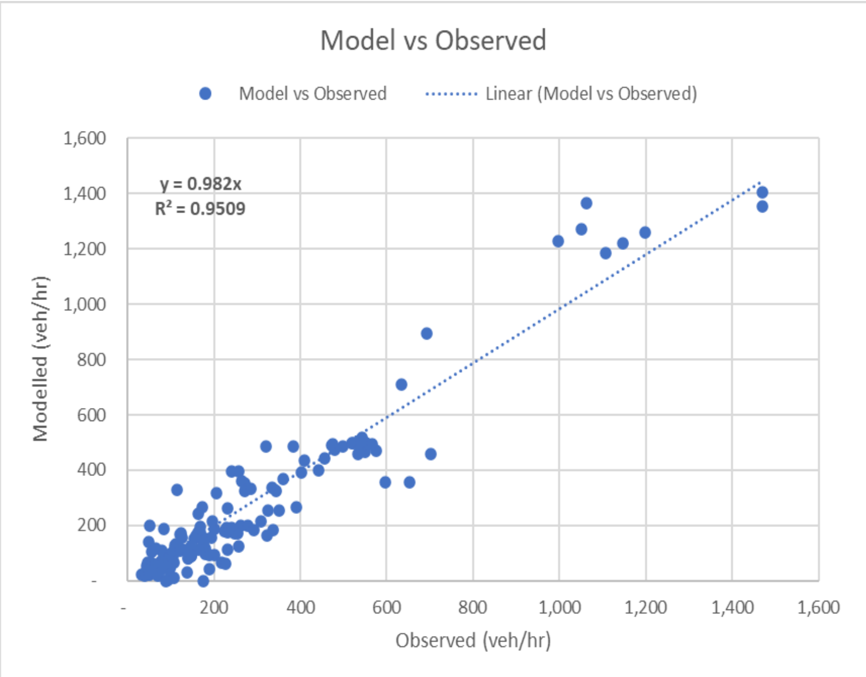


Figure 9-3 Inter Peak scatterplot of modelled and observed flow

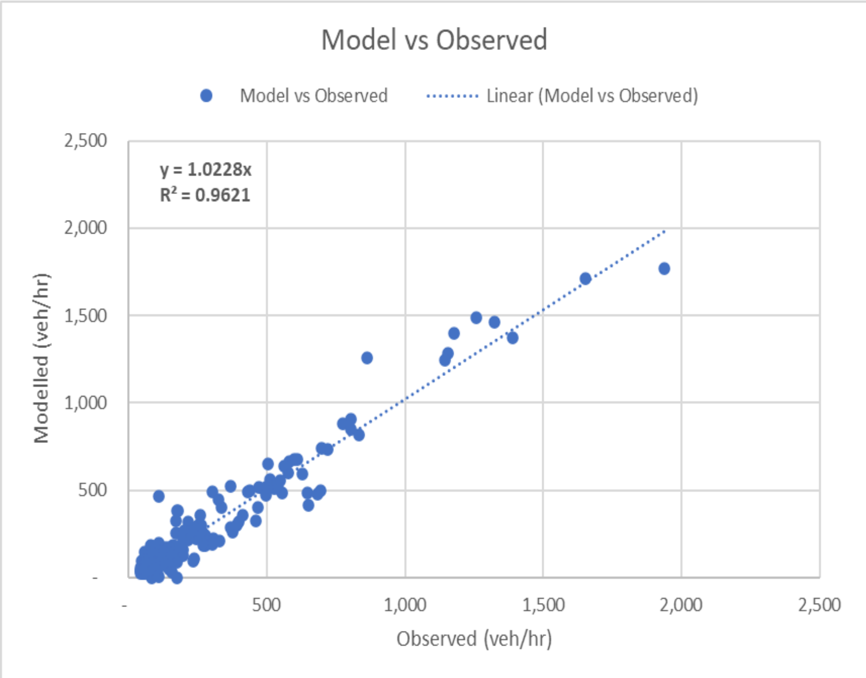


Figure 9-4 PM Peak scatterplot of modelled and observed flow

9.3 Travel Time Validation

Modelled and observed travel times were compared on 28 routes, as indicated in **Figure 9-5.** A comparison between observed (median) and modelled travel time for each peak was undertaken and provided in **Figure 9-6** to **Figure 9-8.**

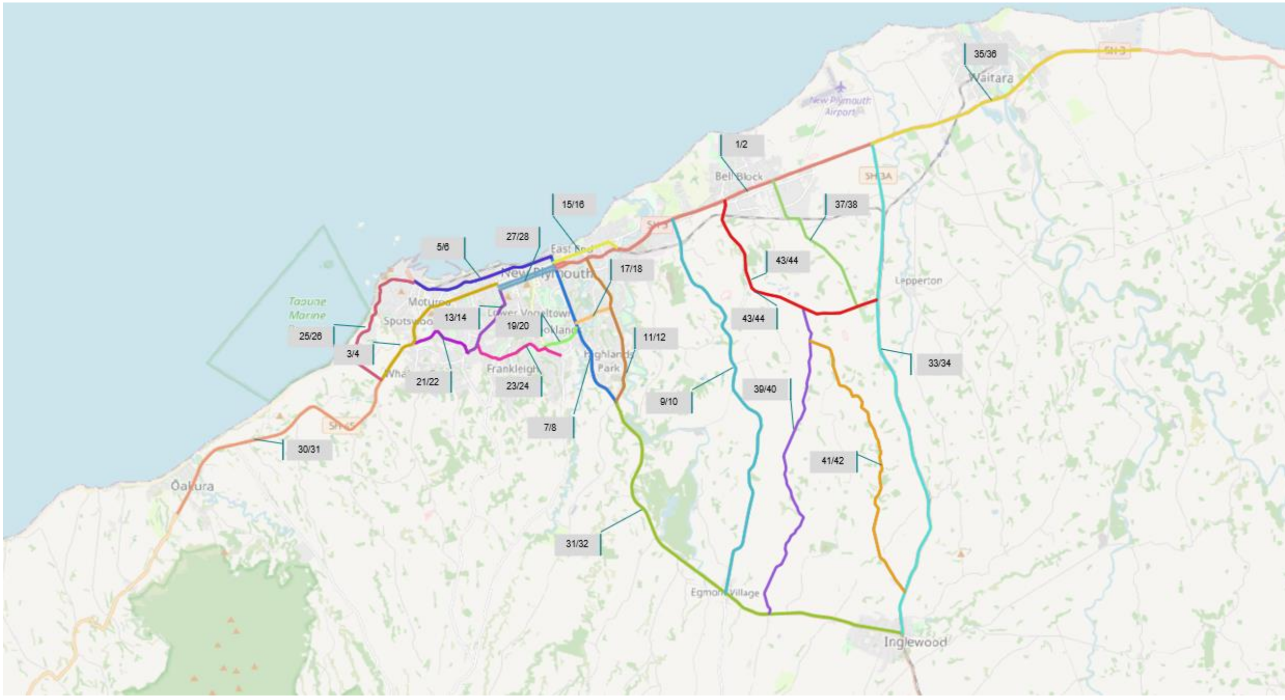


Figure 9-5 Location of Travel Time Routes

Route No.	Route Description	Direction	Observed Travel Time (minutes)			Modelled Travel Time (minutes)	Diff	C1	C2
			15th	Median	85th				
1	SH3 East - City_EB	EB	10.0	10.4	10.9	9.8	-6%	Yes	Yes
2	SH3 East - City_WB	WB	10.0	12.1	21.5	10.4	-14%	Yes	Yes
3	SH3 West - City_EB	EB	5.6	5.9	7.9	5.7	-3%	Yes	Yes
4	SH3 West - City_WB	WB	5.5	5.8	6.6	5.4	-6%	Yes	Yes
5	SH44 Port - Eliot St_EB	EB	6.1	6.8	7.1	6.6	-3%	Yes	Yes
6	SH44 Port - Eliot St_WB	WB	6.7	7.1	7.7	6.4	-10%	Yes	Yes
7	SH3 South - City_NB	NB	6.0	6.5	9.3	7.1	10%	Yes	Yes
8	SH3 South - City_SB	SB	6.3	7.0	8.4	6.4	-9%	Yes	Yes
9	Egmont Road_NB	NB	10.0	10.3	10.7	11.3	9%	Yes	Yes
10	Egmont Road_SB	SB	11.0	11.3	11.8	11.0	-2%	Yes	Yes
11	Mangorei Road_SB	SB	5.9	6.2	6.7	5.9	-4%	Yes	Yes
12	Mangorei Road_NB	NB	6.2	6.6	8.9	6.0	-9%	Yes	Yes
13	Tukapa Street / Morley St_SB	SB	3.5	3.7	3.8	3.2	-13%	Yes	Yes
14	Tukapa Street / Morley St_NB	NB	3.4	3.6	3.9	3.2	-11%	Yes	Yes
15	Devon St East_EB	EB	3.7	3.9	5.0	3.9	-1%	Yes	Yes
16	Devon St East_WB	WB	3.9	4.0	4.6	3.9	-3%	Yes	Yes
17	Cumberland St_EB	EB	1.4	1.5	1.7	1.6	5%	Yes	Yes
18	Cumberland St_WB	WB	1.5	1.6	1.9	1.8	13%	Yes	Yes
19	Upjohn St_EB	EB	1.7	1.9	4.8	1.9	-1%	Yes	Yes
20	Upjohn St_WB	WB	1.6	1.8	2.3	1.8	2%	Yes	Yes
21	Omata Road_EB	EB	2.7	2.8	3.2	2.6	-7%	Yes	Yes
22	Omata Road_WB	WB	2.6	2.7	2.7	2.6	-3%	Yes	Yes
23	Vogeltown - Tukapa St_EB	EB	4.2	4.8	5.9	4.6	-4%	Yes	Yes
24	Vogeltown - Tukapa St_WB	WB	4.0	4.2	5.2	4.4	4%	Yes	Yes
25	Centenial Dr_SB	SB	5.3	5.7	6.1	4.8	-17%	Yes	Yes
26	Centenial Dr_NB	NB	5.3	5.5	5.9	4.8	-13%	Yes	Yes
27	SH45 CBD_EB	EB	3.3	3.8	4.7	3.7	-3%	Yes	Yes
28	SH45 CBD_WB	WB	2.9	3.1	4.2	3.1	-1%	Yes	Yes
29	Beach Rd-Koru Rd_WB	WB	7.4	7.5	7.7	7.3	-3%	Yes	Yes
30	Beach Rd-Koru Rd_EB	EB	7.1	7.3	7.5	7.4	1%	Yes	Yes
31	Inglewood_Mangorei_NB	NB	10.6	10.7	11.0	9.6	-11%	Yes	Yes
32	Inglewood_Mangorei_SB	SB	10.6	10.9	11.1	9.4	-14%	Yes	Yes
33	SH3A/SH3-Inglewood_SB	SB	11.8	12.0	12.4	10.7	-11%	Yes	Yes
34	SH3A/SH3-Inglewood_NB	NB	11.0	11.3	11.4	10.7	-5%	Yes	Yes
35	SH3_SH3A_Methanol Plant_EB	EB	8.1	8.1	8.6	7.9	-3%	Yes	Yes
36	SH3_SH3A_Methanol Plant_WB	WB	8.2	8.2	8.2	8.2	0%	Yes	Yes
37	Corbett Rd_SH3_Manutahi Rd_SB	SB	5.4	5.6	5.8	5.2	-8%	Yes	Yes
38	Corbett Rd_SH3_Manutahi Rd_NB	NB	5.0	5.1	5.2	5.3	4%	Yes	Yes
39	Upland Rd_Manutahi Rd_SB	SB	9.3	9.3	9.3	9.6	4%	Yes	Yes
40	Upland Rd_Manutahi Rd_NB	NB	9.2	9.2	9.2	9.6	5%	Yes	Yes
41	Hursthouse Rd_Upland Rd_SB	SB	9.0	9.0	9.0	8.6	-4%	Yes	Yes
42	Hursthouse Rd_Upland Rd_NB	NB	8.9	8.9	8.9	8.6	-3%	Yes	Yes
43	Manutahi Rd_SH3_SH3A_EB	EB	6.2	6.3	6.4	5.6	-11%	Yes	Yes
44	Manutahi Rd_SH3A_SH3_WB	WB	5.8	5.9	5.9	5.5	-7%	Yes	Yes
							% OK	**100%**	**100%**

Figure 9-6 Travel time validation results (AM Peak)

Route No.	Route Description	Direction	Observed Travel Time (minutes)			Modelled Travel Time (minutes)	Diff	C1	C2
			15th	Median	85th				
1	SH3 East - City_EB	EB	10.0	10.3	10.8	10.0	-3%	Yes	Yes
2	SH3 East - City_WB	WB	10.4	11.0	12.8	10.2	-8%	Yes	Yes
3	SH3 West - City_EB	EB	5.6	5.8	6.1	5.7	-1%	Yes	Yes
4	SH3 West - City_WB	WB	5.6	5.7	5.9	5.5	-4%	Yes	Yes
5	SH44 Port - Eliot St_EB	EB	6.8	7.0	7.3	6.6	-7%	Yes	Yes
6	SH44 Port - Eliot St_WB	WB	7.1	7.5	8.0	6.4	-14%	Yes	Yes
7	SH3 South - City_NB	NB	6.2	6.5	7.1	7.1	10%	Yes	Yes
8	SH3 South - City_SB	SB	6.3	6.8	7.3	6.4	-5%	Yes	Yes
9	Egmont Road_NB	NB	10.2	10.6	10.9	11.2	6%	Yes	Yes
10	Egmont Road_SB	SB	10.4	10.9	11.2	11.0	1%	Yes	Yes
11	Mangorei Road_SB	SB	5.9	6.1	6.4	6.0	-2%	Yes	Yes
12	Mangorei Road_NB	NB	6.2	6.4	6.9	6.0	-7%	Yes	Yes
13	Tukapa Street / Morley St_SB	SB	3.7	3.8	3.9	3.3	-13%	Yes	Yes
14	Tukapa Street / Morley St_NB	NB	3.5	3.6	3.8	3.2	-11%	Yes	Yes
15	Devon St East_EB	EB	4.4	4.7	5.1	3.9	-16%	Yes	Yes
16	Devon St East_WB	WB	4.1	4.4	4.8	3.9	-11%	Yes	Yes
17	Cumberland St_EB	EB	1.5	1.6	1.7	1.6	4%	Yes	Yes
18	Cumberland St_WB	WB	1.5	1.6	1.8	1.8	12%	Yes	Yes
19	Upjohn St_EB	EB	1.8	1.8	2.1	1.8	0%	Yes	Yes
20	Upjohn St_WB	WB	1.8	1.8	1.9	1.8	2%	Yes	Yes
21	Omata Road_EB	EB	2.8	2.8	2.9	2.6	-7%	Yes	Yes
22	Omata Road_WB	WB	2.7	2.7	2.8	2.6	-5%	Yes	Yes
23	Vogeltown - Tukapa St_EB	EB	4.3	4.5	5.0	4.6	3%	Yes	Yes
24	Vogeltown - Tukapa St_WB	WB	4.2	4.3	4.6	4.4	1%	Yes	Yes
25	Centenial Dr_SB	SB	5.3	5.5	5.8	4.8	-14%	Yes	Yes
26	Centenial Dr_NB	NB	5.4	5.6	6.3	4.8	-14%	Yes	Yes
27	SH45 CBD_EB	EB	3.9	4.2	4.8	3.6	-14%	Yes	Yes
28	SH45 CBD_WB	WB	3.4	3.5	3.9	3.1	-10%	Yes	Yes
29	Beach Rd-Koru Rd_WB	WB	7.4	7.6	7.7	7.4	-3%	Yes	Yes
30	Beach Rd-Koru Rd_EB	EB	7.3	7.4	7.5	7.3	-1%	Yes	Yes
31	Inglewood_Mangorei_NB	NB	10.6	10.7	10.9	9.5	-11%	Yes	Yes
32	Inglewood_Mangorei_SB	SB	10.4	10.6	10.8	9.5	-10%	Yes	Yes
33	SH3A/SH3-Inglewood_SB	SB	11.6	11.8	12.0	10.7	-9%	Yes	Yes
34	SH3A/SH3-Inglewood_NB	NB	11.2	11.4	11.6	10.7	-6%	Yes	Yes
35	SH3_SH3A_Methanol Plant_EB	EB	8.0	8.2	8.5	8.0	-2%	Yes	Yes
36	SH3_SH3A_Methanol Plant_WB	WB	8.2	8.3	8.6	8.1	-3%	Yes	Yes
37	Corbett Rd_SH3_Manutahi Rd_SB	SB	5.2	5.5	5.6	5.2	-4%	Yes	Yes
38	Corbett Rd_SH3_Manutahi Rd_NB	NB	5.3	5.4	5.5	5.3	-2%	Yes	Yes
39	Upland Rd_Manutahi Rd_SB	SB	9.3	9.3	9.3	9.6	4%	Yes	Yes
40	Upland Rd_Manutahi Rd_NB	NB	9.2	9.2	9.2	9.6	5%	Yes	Yes
41	Hursthouse Rd_Upland Rd_SB	SB	9.0	9.0	9.0	8.6	-3%	Yes	Yes
42	Hursthouse Rd_Upland Rd_NB	NB	8.9	8.9	8.9	8.6	-3%	Yes	Yes
43	Manutahi Rd_SH3_SH3A_EB	EB	6.1	6.2	6.3	5.6	-9%	Yes	Yes
44	Manutahi Rd_SH3A_SH3_WB	WB	5.9	6.0	6.1	5.5	-10%	Yes	Yes
							% OK	**100%**	**100%**

Figure 9-7 Travel time validation results (IP)

Route No.	Route Description	Direction	Observed Travel Time (minutes) 15th	Median	85th	Modelled Travel Time (minutes)	Diff	C1	C2
1	SH3 East - City_EB	EB	9.5	9.9	10.3	10.9	10%	Yes	Yes
2	SH3 East - City_WB	WB	9.7	10.7	24.4	10.6	-1%	Yes	Yes
3	SH3 West - City_EB	EB	5.5	5.7	5.9	5.6	-1%	Yes	Yes
4	SH3 West - City_WB	WB	5.4	5.6	5.8	5.6	0%	Yes	Yes
5	SH44 Port - Eliot St_EB	EB	6.4	6.7	7.1	6.6	-2%	Yes	Yes
6	SH44 Port - Eliot St_WB	WB	6.6	7.1	8.1	6.6	-7%	Yes	Yes
7	SH3 South - City_NB	NB	5.9	6.2	6.6	7.2	16%	Yes	Yes
8	SH3 South - City_SB	SB	6.0	6.3	7.0	6.6	5%	Yes	Yes
9	Egmont Road_NB	NB	10.0	10.3	10.6	11.3	10%	Yes	Yes
10	Egmont Road_SB	SB	10.1	10.3	10.5	11.1	8%	Yes	Yes
11	Mangorei Road_SB	SB	5.9	6.2	6.4	6.0	-4%	Yes	Yes
12	Mangorei Road_NB	NB	5.9	6.2	6.5	6.0	-3%	Yes	Yes
13	Tukapa Street / Morley St_SB	SB	3.4	3.5	3.9	3.4	-4%	Yes	Yes
14	Tukapa Street / Morley St_NB	NB	3.2	3.3	3.5	3.2	-3%	Yes	Yes
15	Devon St East_EB	EB	3.7	3.9	4.5	4.0	1%	Yes	Yes
16	Devon St East_WB	WB	3.8	4.0	4.4	3.9	-3%	Yes	Yes
17	Cumberland St_EB	EB	1.5	1.5	1.7	1.7	10%	Yes	Yes
18	Cumberland St_WB	WB	1.5	1.6	1.8	1.9	16%	Yes	Yes
19	Upjohn St_EB	EB	1.7	1.8	2.0	1.8	1%	Yes	Yes
20	Upjohn St_WB	WB	1.7	1.8	1.9	1.9	5%	Yes	Yes
21	Omata Road_EB	EB	2.7	2.8	2.9	2.6	-5%	Yes	Yes
22	Omata Road_WB	WB	2.6	2.7	2.8	2.6	-5%	Yes	Yes
23	Vogeltown - Tukapa St_EB	EB	4.2	4.3	4.7	4.8	11%	Yes	Yes
24	Vogeltown - Tukapa St_WB	WB	4.1	4.2	4.2	4.4	7%	Yes	Yes
25	Centenial Dr_SB	SB	5.1	5.4	5.5	4.8	-12%	Yes	Yes
26	Centenial Dr_NB	NB	5.3	5.5	5.8	4.8	-12%	Yes	Yes
27	SH45 CBD_EB	EB	3.4	3.9	5.3	3.7	-6%	Yes	Yes
28	SH45 CBD_WB	WB	3.1	3.6	4.1	3.3	-10%	Yes	Yes
29	Beach Rd-Koru Rd_WB	WB	7.2	7.3	7.3	7.5	4%	Yes	Yes
30	Beach Rd-Koru Rd_EB	EB	7.2	7.3	7.4	7.3	0%	Yes	Yes
31	Inglewood_Mangorei_NB	NB	10.4	10.6	10.7	9.5	-10%	Yes	Yes
32	Inglewood_Mangorei_SB	SB	10.2	10.4	10.6	9.7	-6%	Yes	Yes
33	SH3A/SH3-Inglewood_SB	SB	11.3	11.5	11.8	10.8	-6%	Yes	Yes
34	SH3A/SH3-Inglewood_NB	NB	11.0	11.1	11.4	10.7	-4%	Yes	Yes
35	SH3_SH3A_Methanol Plant_EB	EB	7.8	7.9	8.0	8.2	4%	Yes	Yes
36	SH3_SH3A_Methanol Plant_WB	WB	8.0	8.1	8.5	8.1	0%	Yes	Yes
37	Corbett Rd_SH3_Manutahi Rd_SB	SB	4.8	4.8	4.9	5.2	7%	Yes	Yes
38	Corbett Rd_SH3_Manutahi Rd_NB	NB	4.8	5.1	5.4	5.4	5%	Yes	Yes
39	Upland Rd_Manutahi Rd_SB	SB	9.3	9.3	9.3	9.7	4%	Yes	Yes
40	Upland Rd_Manutahi Rd_NB	NB	9.2	9.2	9.2	9.6	5%	Yes	Yes
41	Hursthouse Rd_Upland Rd_SB	SB	9.0	9.0	9.0	8.6	-3%	Yes	Yes
42	Hursthouse Rd_Upland Rd_NB	NB	8.9	8.9	8.9	8.6	-3%	Yes	Yes
43	Manutahi Rd_SH3_SH3A_EB	EB	5.7	5.8	5.8	5.6	-2%	Yes	Yes
44	Manutahi Rd_SH3A_SH3_WB	WB	5.8	5.9	5.9	5.5	-7%	Yes	Yes
							% OK	**100%**	**100%**

Figure 9-8 Travel time validation results (PM Peak)

Table 9-4 provides a summary of travel time validation results. Detailed cumulative travel time information for each route for all three peaks is provided in **Appendix B**. The results indicate that the model meets the Waka Kotahi Guideline criteria for Category B.

Table 9-4 Summary of travel time validation results

Measure	Criteria	Without ME		
		AM	IP	PM
C1	>85%	100%	100%	100%
C2	>90%	100%	100%	100%

Figure 9-9 to **Figure 9-11** show scatterplots of modelled and observed travel time.

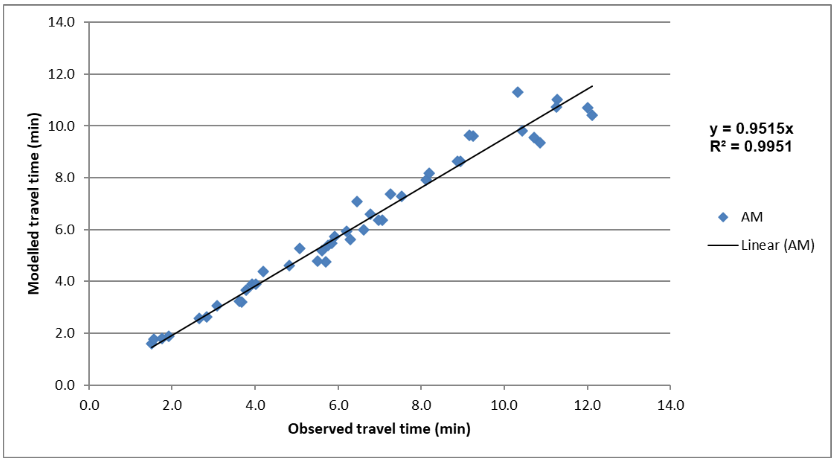


Figure 9-9 Scatterplot of Modelled and Observed Travel Time (AM Peak)

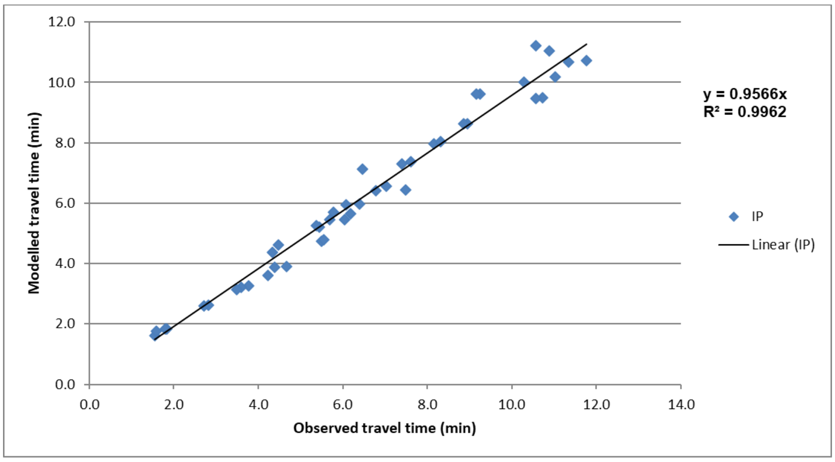


Figure 9-10 Scatterplot of Modelled and Observed Travel Time (Inter Peak)

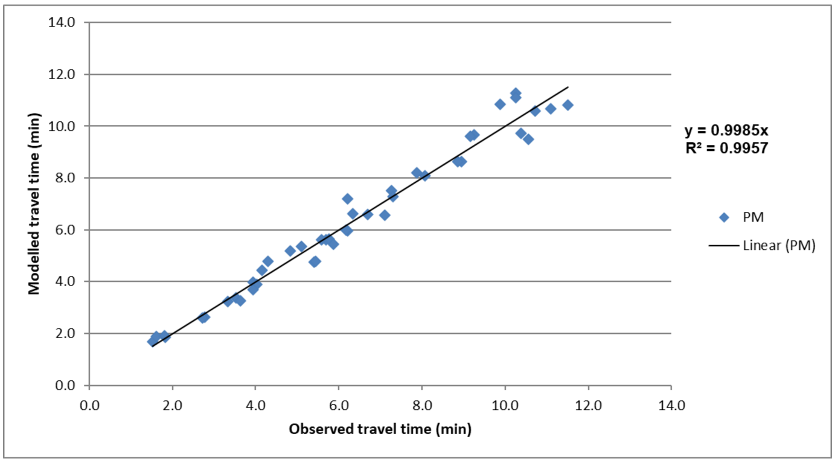


Figure 9-11 Scatterplot of Modelled and Observed Travel Time (PM Peak)

As previously described, the observed travel times are from March 2023 rather than 2018. As an additional step in the validation process a 2023 was prepared with 2023 land use inputs and model travel times rechecked against the 2023 observed travel times. The outcomes were similar, with the travel time validation meeting the stipulated criteria.

10 Public Transport Model Development

10.1 Introduction

This chapter describes the PT development process, including calibration and validation results. The Ngāmotu STM is a trip-based model with a PT module that estimates any changes in PT trips in forecast years (in comparison with the base year) and adjusts the forecast year car matrices in response to the predicted changes in PT trips.

10.2 PT Model Inputs Parameters

10.2.1 Time Periods

The PT assignment time periods are consistent with the Ngāmotu STM highway assignment time periods, which are average hour traffic volumes within the following peak periods:

- AM Peak: 7 am – 9 am
- Interpeak: 9 am – 4 pm
- PM peak: 4 pm – 6 pm

10.2.2 Walking Time

The walk access times between traffic analysis zones (TAZ) and the PT network are kept between 3 to 5 minutes, depending on the lengths of the centroid connectors.

10.2.3 Value of Time (VOT)

The PT VOT was derived from the traffic VOT ($2018), adjusted with the assumed occupancy factor of 1.2. The updated VOT for Home Based Work trip purpose is $24.16/hr, and the Other trip purpose is $13.80/hr.

10.2.4 PT Generalized/composite Cost

The PT generalised cost of public transport trips has three components:

1. In-vehicle time in minutes.
2. Out-of-vehicle time in minutes, which is a weighted sum of
    a. Access time (minutes)
    b. Egress time (minutes).
    c. Wait time (minutes).
    d. Transfer penalty (minutes).
3. Transit Fares (converted to minutes).

GC (perceived cost) = IVT + a*AET + b*WT + c*TP + FARE/VOT

where:

GC (perceived cost)	= Generalised time by public transport from zone i to j
IVT	= In-vehicle time for public transport
AET	= Public transport access/egress time in minutes
a	= Weight factor for access/egress time

WT	= Public transport waiting time
b	= Weight factor for wait time
TP	= Transfer penalty in minutes
c	= Weight factor for transfer penalty
FARE	= Public transport fare in $
VOT	= Value of time for public transport users

The consistent generalised cost is used in the assignment (i.e., path building) as well as in the mode split model.

10.2.5 Station Quality

Three levels of station quality are available in Ngāmotu STM, namely Normal, Medium and High. This represents the physical quality of the stations and is reflected in the model by different levels of the wait perception factors, transfer penalties, and perception factors, as shown in **Table 10-1.**

Table 10-1 PT station quality

	Normal	Medium	High
Initial wait time	As per the wait curve (see Figure 10-4)	As per the wait curve (see Figure 10-4)	As per the wait curve (see Figure 10-4)
Transfer wait time	As per the transfer wait curve	As per the transfer wait curve	As per the transfer wait curve
Wait perception factor	2	1.6	1
Transfer penalty	10 min	8 min	5 min
Transfer penalty perception factor	2	1.6	1

10.2.6 Parking Costs

In the mode split model, car parking costs were added to Car GC from the main three-stage model for the CBD zones, as shown in **Table 10-2**. The following assumptions were made to derive the parking costs for each period:

- Daily parking costs of $16 for the New Plymouth CBD area.
- Assumed 62.5% of CBD trips use paid parking for HBW trip purpose.
- A flat parking fee of $3 was considered for Other trip purposes.
- There is no parking cost for HBE trips as New Plymouth CBD does not have a school.

Table 10-2 Parking cost- HBW and Other trip purposes

Location	Zones	HBW	HBE	Others
CBD	152, 153, 356-358, 360	$10	$0	$3

Figure 10-1 shows the parking zones in the Ngāmotu STM CBD area.

Figure 10-1 Parking zones in New Plymouth CBD

10.3 Public and School Buses

The PT lines were coded based on GTFS 2022 received from the Taranaki Regional Council website. The data includes public and school bus services with scheduled bus route itineraries, service frequency, and bus fare. The school bus services cover the New Plymouth urban region.

Table 10-3 and **Table 10-4** shows the Public and School Buses PT services and headway coded in the model.

Table 10-3 Public Bus PT service and headways

Route No	Route Name	Inbound services			Outbound services		
		AM	IP	PM	AM	IP	PM
3101	Inglewood – New Plymouth	120	140	120	120	140	120
5001	City (Ariki St)- Moturoa	30	70	40	30	70	40
5002	Blagdon/Whalers Gate-Whalers Gate	30	70	40	30	70	40
5003	Lynmouth/Marfell-Lynmouth/Marfell	30	0	0	0	70	40
5004	Westown/Hurdon-Westown/Hurdon	30	70	40	30	70	40
5005	Frankleigh Park/Ferndale-Frankleigh Park/Ferndale	30	70	40	30	70	40
5006	Vogeltown/Brooklands-Vogeltown/Brooklands	30	70	40	30	70	40
5007	Welbourn/Highlands Park-Welbourn/Highlands Park	30	70	40	30	70	40
5008	Merrilands/Highlands Park-Merrilands/Highlands Park	30	70	40	30	70	40
5009	Fitzroy/The Valley/GlenAvon-Fitzroy/The Valley/GlenAvon	30	84	40	30	84	40
5020	Waitara (via Bell Block)-Waitara/Bell Block	120	140	120	120	140	120

Table 10-4 School Bus PT service and headways

Route No	Route Name	Inbound Services AM	Outbound Services IP
5012	Route12-Merrilands to Spotswood	60	60
5021	Route21-Waitara to Spotswood	60	60
5022	Route22-Waitara/Motunui to New Plymouth	60	60
5024	Route24-Waitara to Francis Douglas Memorial College	60	60
5030	Route30-Bell Block to Highlands Intermediate	60	60
5031	Route31-Lepperton/Bell Block to Highlands/Woodleigh Schools	60	60
5032	Route32-Bell Block to New Plymouth Girls' High School	60	60
5033	Route33-Bell Block to Francis Douglas Memorial College	60	60
5034	Route34-Bell Block to Francis Douglas Memorial College	60	60
5035	Route35-New Plymouth to Bell Block	60	60
5041	Route41-Omata to Highlands	60	60
5042	Route42-Oakura to Francis Douglas Memorial College	60	60
5043	Route43-Oakura to New Plymouth Girls' High School	60	60
5044	Route44-Oakura to Sacred Heart Girls' College	60	60
5045	Route45-DevonInt to Oakura	60	60
5051	Orbiter51-Orbiter51	60	60
5052	Orbiter52-Orbiter52	60	60
5053	Orbiter53-Orbiter53	60	60
5054	Orbiter54-Orbiter54	60	60
5055	Orbiter55-Orbiter55	60	60
5091	Route91-NPGHS to Ariki St(afternoon only)	-	60
5092	Route92-NPBHS to Ariki St(afternoon only)	-	60
5093	Route93-SHGC to Ariki St(afternoon only)	-	60
5095	Route95-Highlands Intermediate to Ariki St(afternoon only)	-	60
5097	Route97-NPBHS to Ariki St(afternoon only)	-	60
5098	Route98-Newplymouth-Inglewood	60	60

10.4 Cost Parameters

Ngāmotu STM uses short trip factor and mode-specific constant (MSC) parameters in the base year model calibration process to match the 2018 Census data. These adjustments were required to match observed and modelled PT trips.

10.4.1Short Trip Factor

The PT GCs from the assignment model require adjustments to prevent short trips which are typically represented by active mode trips. A set of multiplicative factors was developed based on the distance between zones. Different levels and combinations of factors were tested extensively in the model calibration process, and **Figure 10-2** shows the adopted factors. The blue line represents the factors adopted for HBW and Other trip purposes using public services, the grey lines for the HBE students using the public services and the orange lines for school services. **Table 10-5** shows the adopted distance factors in Ngāmotu STM.

Table 10-5 Short distance parameter

Component	Factor
HBW	10
Other trip purposes	10
HBE_School students	37.5
HBE_Public_students	15

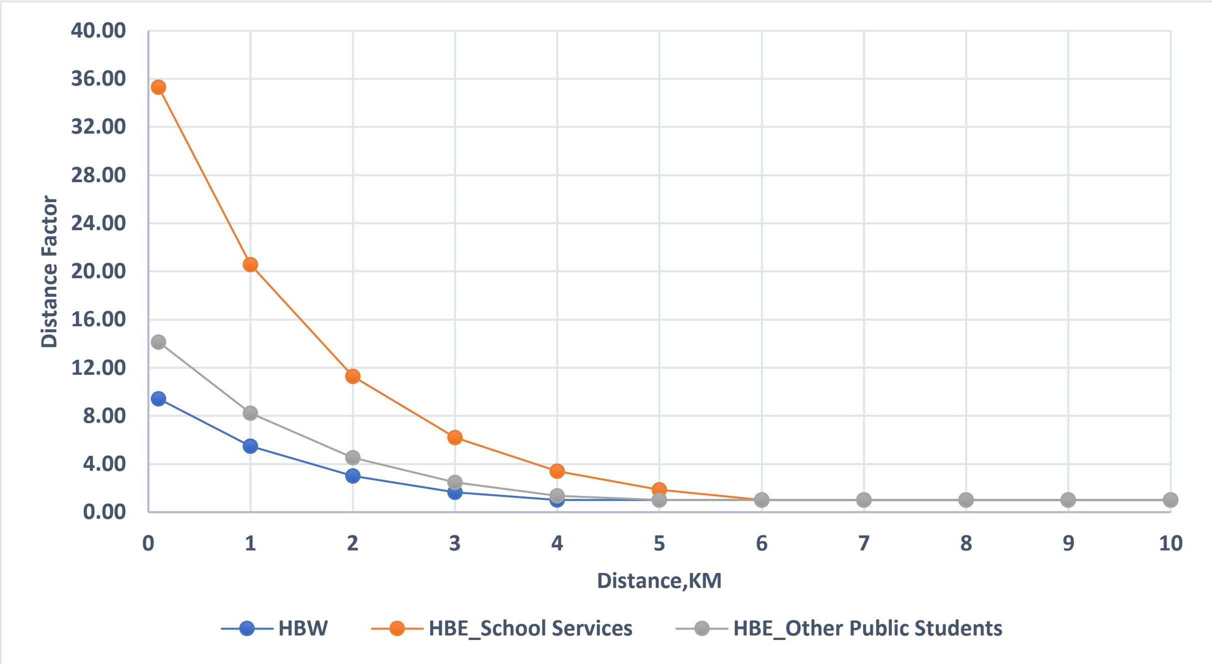


Figure 10-2 Multiplicative factor to PT GCs

10.4.2 Mode specific constants (MSCs)

The mode-specific constants (MSC) are used in the PT model calibration process to match the observed travel patterns.

- **HBW Trip Purpose**
  - A negative 10 (i.e., -10) minutes MSC was applied to overall Car GCs in the model calibration process.
- **HBE Trip Purpose**
  - A 17.5 minutes MSC was applied to the Car GCs. This is to represent that not all HBE trips are accessible by car.
  - A negative 10 (i.e., -10) minutes MSC was applied to School GCs to represent the safety/reliability effects of school buses compared to public buses.
  - A 10 minutes MSC was applied to HBE public bus students GCs to represent bus safety aspects of students.
- **Other Trip Purposes**
  - A negative 20 (i.e., -20) minutes MSC was applied to overall Car GCs in the mode split model.

Table 10-6 shows the other adopted MSCs in the model.

Table 10-6 Mode-Specific Constants (in mins)

Component	MSC (in minutes)
HBW (to cars)	-10
Other trip purposes (to cars)	-20
HBE (to cars)	17.5
HBE (to public services)	10
HBE (to school services)	-10

10.5 Fare System

Taranaki public transport systems cover the New Plymouth urban area, Inglewood, Stratford and Hawera, which consist of 4 fare zones as illustrated in **Figure 10-3**. However, the Ngāmotu STM model only covers the New Plymouth urban and Inglewood areas; hence, Fare zones ONE (1) and TWO (2) are used for the modelling purpose. The PT fare system consists of different ticket types, such as Cash and Bee Card users, as received from the NPDC and calculates the weighted average fare for adults and students.

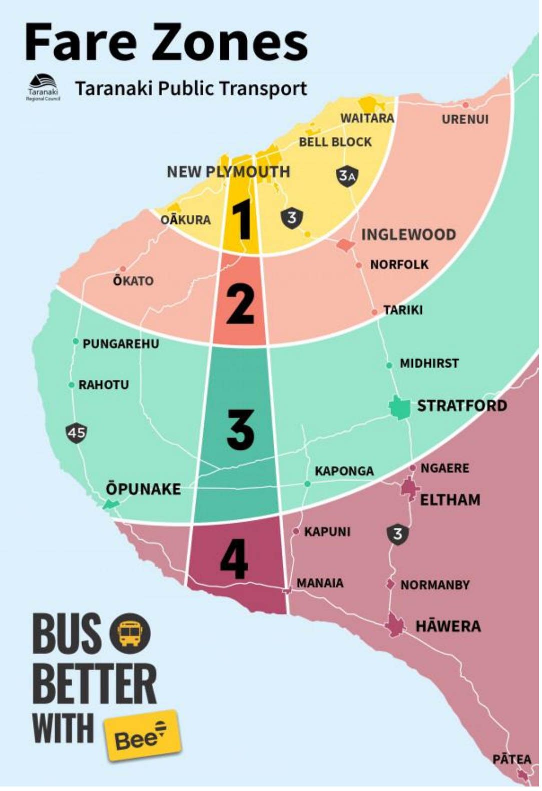


Figure 10-3 Taranaki public transport fare zones

10.5.1 Processing of Bee card data

NPDC has provided the PT service for the September 2022 transaction report for processing the Bee Card data. September 2022 weekdays PT transaction data was used for this task. The steps in processing the Bee Card data are discussed below:

- 2022 PT services are segregated into Public (i.e. Urban) and School buses
- Estimate the passengers who paid by Cash and Bee Card
- Remove duplicates or tags where there was insufficient data (i.e. no card number and location)
- Map tag ons to tag offs, based on card number, to get the origin and destination.

  - 22% of the data could not be mapped completely. Either the origin or destination did not contain data, or they were the same.
  - To overcome this, we instead calculated the number of journeys between each origin and destination stop for the completely mapped data and summed by day and peak. Then, divide this by the number of completely mapped users, the day and peak, to calculate average journeys per user. The total number of users, including insufficiently mapped, was then multiplied to get the total.
  - The data includes all PT users (i.e. Cash, Bee Card and SuperGold Card)
- Stops are geospatially mapped to zones, and patronage is summarised in time intervals, transit lines, and fare types based on the data used.

The Public and School bus services' fare areas are estimated separately, computed by weighted average fares for Adults and Students (Child + Tertiary) based on the proportion of passengers paying by cash and Bee Card for the Ngāmotu STM PT model input.

$$WeightedAvgFare_i = \frac{(Patronage_{i,Cash} * Fare_{Cash}) + (Patronage_{i,BeeCard} * Fare_{Beecard})}{Patronage_{i,Cash} + Patronage_{i,BeeCard}}$$

Where $i \in \{Adult\ and\ Students\ (Child + Tertiary)\}$ and $Fare_{Cash}$ and $Fare_{Beecard}$ were sourced from the NPDC bus website.

The weighted average PT fare matrices for adults, students and Other trip purposes (Adults) used in the Ngāmotu STM are provided in **Table 10-7** to **Table 10-9**.

Table 10-7 Fare Matrix – Adults

Fare Zone Name	Fare Zone No.	New Plymouth 1	Inglewood 2
New Plymouth	1	2.12	3.06
Inglewood	2	3.06	2.12

Table 10-8 Fare Matrix – Students

Fare Zone Name	Fare Zone No.	New Plymouth 1	Inglewood 2
New Plymouth	1	2.06	3.05
Inglewood	2	3.05	2.06

Table 10-9 Fare Matrix – Other Trip Purposes[9]

Fare Zone Name	Fare Zone No.	New Plymouth 1	Inglewood 2
New Plymouth	1	1.71	2.92
Inglewood	2	2.92	1.71

[9] The Other trip purposes fare includes both Adults and Senior Citizen users.

10.6 Model Validation/Calibration

10.6.1 Wait time curves

In the PT assignment, the wait times for different transit modes are based on the wait curves, as shown in **Figure 10-4**. The Initial and transfer wait curves are utilised for urban bus services, while the school buses use the school wait curve values.

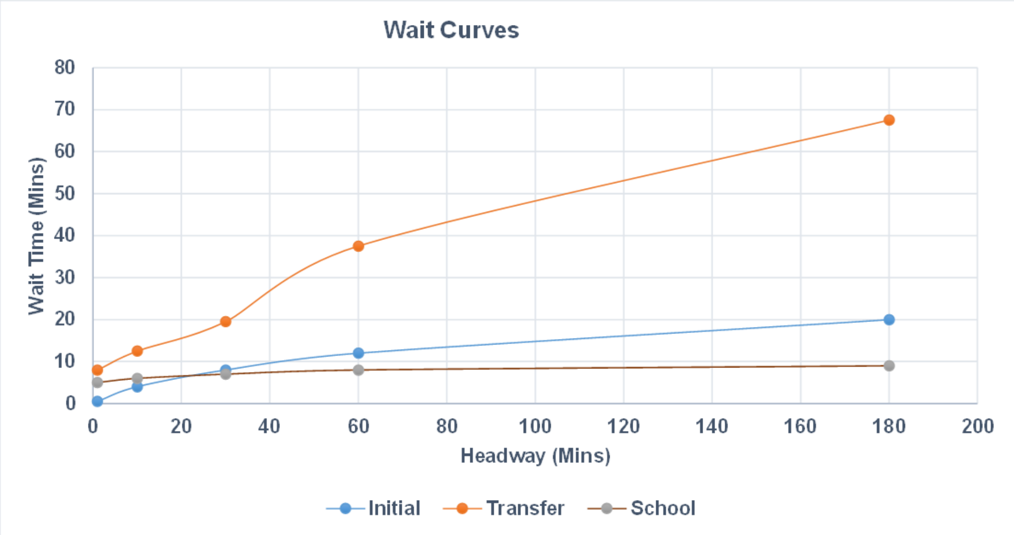


Figure 10-4 PT wait curves

10.6.2 Calibration of Mode Choice Logit Models for different trip purposes

New Plymouth has a very low PT mode share and PT trips represent about 1% of the mechanise mode trips. Hence any attempts to calibrate the PT mode share is a challenging task. In this model update, the focus is to better match the modelled and observed PT data as well as to achieve a better model response.

10.6.2.1 HBW mode choice model

The 2018 JTW total matrix (car+PT) was processed and input to the HBW mode choice model, which estimates the modelled PT matrix. The JTW PT trips census data is very low due to highly confidential information. Hence, the modelled PT trips are compared to JTW New Plymouth Ward PT trips at daily trips level. The Ngāmotu STM's distribution model is based on the daily (24-hr) level. Hence, the calibration was undertaken for different parameter sets at daily level to estimate PT demand. The car time period factors were already established in the Ngāmotu STM. The PT time period factors are assumed to be similar to the car time period factors for the HBW trip purpose.

The HBW mode split logit model development process is listed below:

- Use the JTW Total (24-hr PA) OD matrices
- Set up an absolute mode split model using car and PT costs at daily(24-hr) level
- Calibrate model split models until reasonable matches are achieved between synthetic and observed PT demands at daily level
- Obtain mode split parameters at daily level

The calibration process is illustrated in **Figure 10-5**.

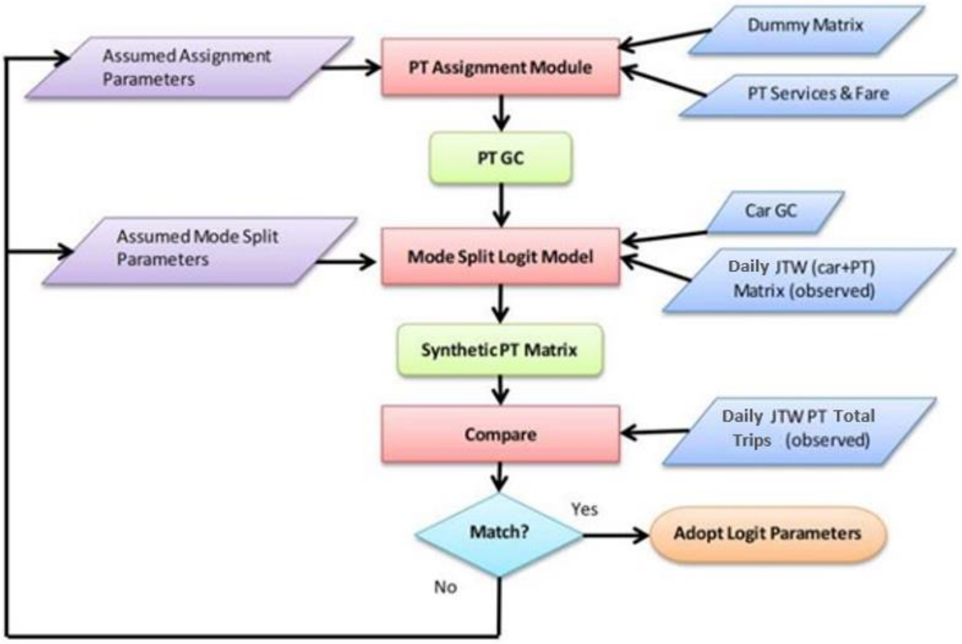


Figure 10-5 HBW mode split model calibration process

The HBW mode split model is a binary logit model structure as shown in **Figure 10-6**.

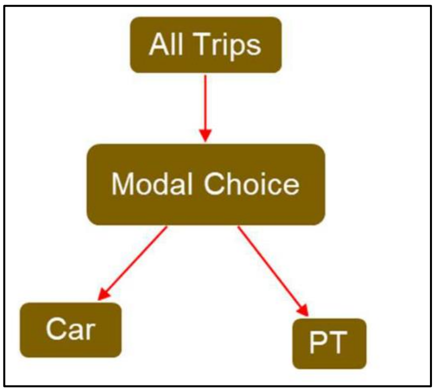


Figure 10-6 Binary logit model structure for HBW

The logit model formulation is provided below:

$$p_{ij}^{1} = \frac{\exp\left(-\mu * C_{ij}^{1}\right)}{\sum_k \exp\left(-\mu * C_{ij}^{k}\right)}$$

Where:

p_{ij}^{1} proportion of trips traveling from I to j via mode 1

μ scaling factor in mode choide model

C_{ij}^{1} cost of travelling between i to j via mode 1

C_{ij}^{k} cost of travelling between i to j for all modes

The car time period factors were already established in the Ngāmotu STM. The PT time period factors are assumed to be similar to the car time period factors for the HBW trip purpose. The daily JTW matrices are further split into three modelled peaks using the time period factors for the final PT assignment is shown in **Table 10-10.**

Table 10-10 Time period factors- HBW

Description	AM	IP	PM
Car- HBE from home	0.45	0.25	0.03
Car- HBE to home	0.01	0.21	0.47
PT- HBE from home	0.45	0.25	0.03
PT- HBE to home	0.01	0.21	0.47

Due to the very low PT mode share in New Plymouth Area, PT trips between sectors are generally quite small and it is hard to achieve good validation results, especially for low trips. **Table 10-11** gives a comparison of modelled and observed flows at the daily trips level.

From the calibration exercise, the final adopted scaling factor (μ) for HBW trips was 0.079.

Table 10-11 HBW Trip Purpose- Observed vs Modelled Daily Trips

Component	Observed Daily trips	Modelled Daily trips	Difference Daily Trips
HBW	342	336	-6

10.6.2.2 HBE mode choice model

The calibration of the HBE model is more challenging than the HBW model. This is due to

- The model only has public schools, and it does not have other types of schools (such as special needs or private schools).
- It was hard to establish accurate school bus route information as there were many public school bus services in New Plymouth. For example, the JTE information shows there are school trips between the sectors, but little or no school bus routes exist between these sectors from the available information.
- As discussed, the Ngāmotu STM is a trip-based model, and PT trips were estimated from car trips. Potentially the car and PT distribution patterns are different in New Plymouth. The HBE car trip lengths are generally short and hence it is hard to achieve long-distance PT trips.

With these challenges in mind, the calibration of the HBE model was undertaken and discussed below.

The 2018 JTE total matrix (Car+ HBE on Public+ School) was input to the mode choice model, which estimates the PT matrix. Then the modelled PT matrix was compared with the JTE PT (observed) matrix at daily trips level.

The daily JTE matrices are further split into three modelled peaks using the time period factors for the final PT assignment as shown in **Table 10-12**.

Table 10-12 Time period factors- HBE

Description	AM	IP	PM
Car- HBE from home	0.64	0.19	0.04
Car- HBE to home	0.08	0.66	0.1
PT- HBE from home	1	0	0
PT- HBE to home	0	1	0

Similar GC adjustments were made as in the HBE model. The HBE model is a Nested logit mode choice model, as shown in **Figure 10-7** below.

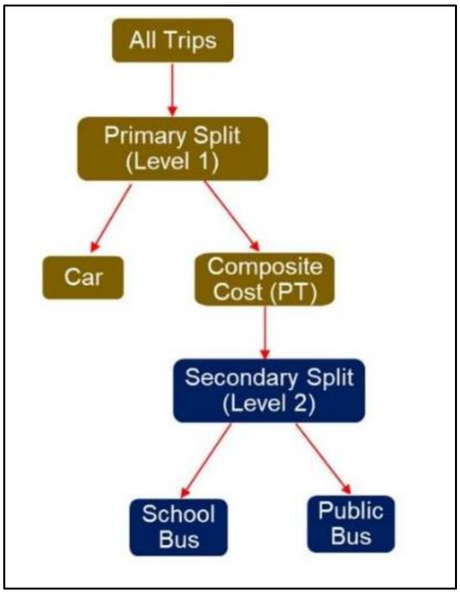


Figure 10-7 Nested logit model structure- HBE

From the calibration exercise, the final adopted scaling factor (µ) for HBE trip purpose is provided in **Table 10-13**.

Table 10-13 Mode choice model scale factor (µ) - HBE

Component	Car vs PT (Level 1)	SB vs PB (Level 2)
HBE	0.025	0.028

Due to very low PT mode share, trips between sectors are generally quite small and it is hard to achieve good validation results. **Table 10-14** gives a comparison of modelled and observed flows for HBE trip purpose at daily trips level.

Table 10-14 HBE Trip Purpose- Observed Vs Modelled Daily Trips

Component	Observed Daily Trips	Modelled Daily Trips	Difference Daily Trips
HBE_School Bus Students	1239	1295	56
HBE_Public Bus Students	640	609	-31

10.6.2.3 Other Trip Purposes

The Other trip purpose represents HBO, HBS, NHBEB, and NHBO. A logit model was developed to represent the Other trip purposes. The logit model structure is similar to the HBW model structure. The observed Other trip purpose was estimated by deducting the Census JTW and JTE (public students) data from the NPDC PT ticket passenger data.

For the model calibration, the predicted PT demands were compared against the observed Other trips estimated from the PT passengers' data. However, the parking and mode-specific constants are needed to achieve the target PT trips with reasonable scale factors in the mode split model.

The final adopted mode choice model scaling factor (µ) is assumed to be 0.055. The comparison of modelled and observed Other trip purpose demand is shown in **Table 10-15.**

Table 10-15 Others Trip Purposes- Observed vs Modelled Daily Trips

Component	Observed Daily Trips	Modelled Daily Trips	Difference Daily Trips
Other trip purposes	1119	1123	4

10.6.3 PT validation

10.6.3.1 Line by line boarding validation

Figure 10-8 to **Figure 10-10** represent the comparison of modelled and observed boarding data for all PT services for different peak periods. The detailed validation results are provided in **Appendix C**.

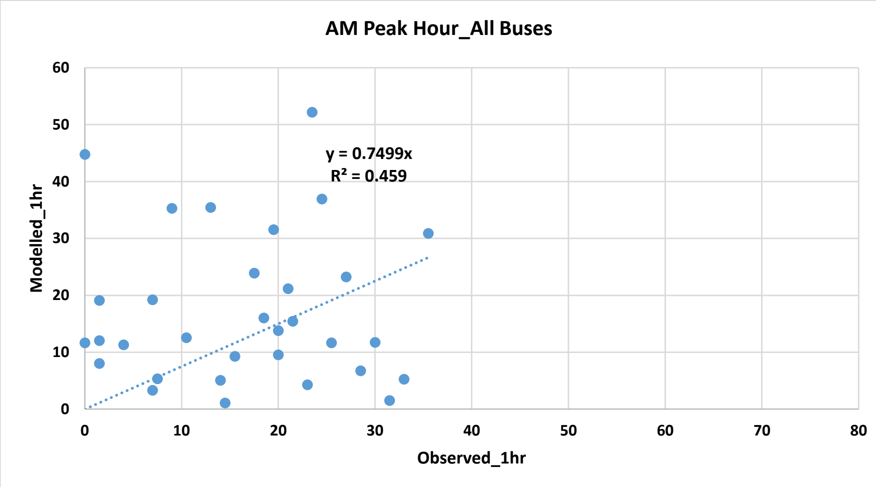


Figure 10-8 Scatterplot of modelled and observed PT boarding (line by line)- AM Peak Hour

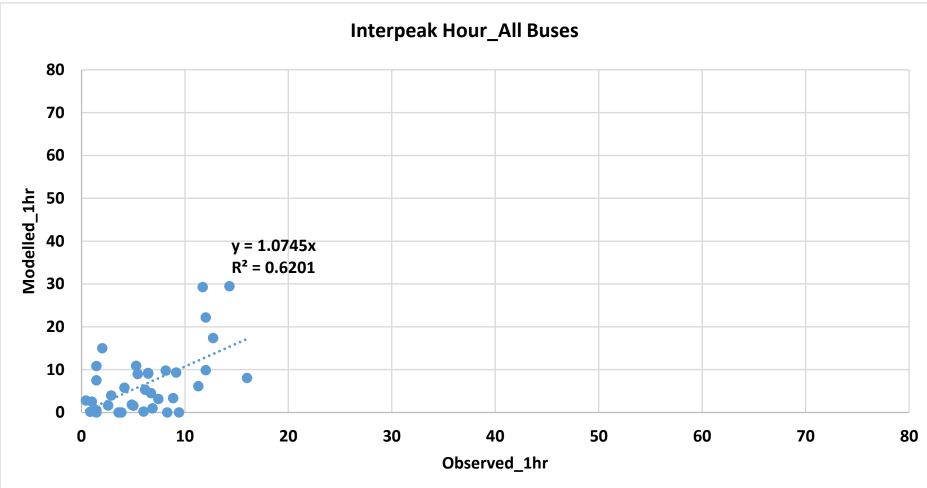


Figure 10-9 Scatterplot of modelled and observed PT boarding (line by line)- Interpeak Hour

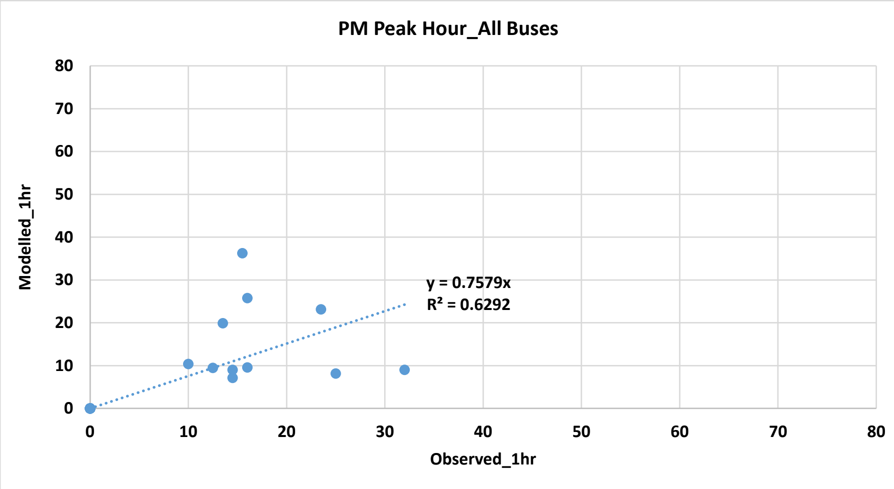


Figure 10-10 Scatterplot of modelled and observed PT boarding (line by line)- PM Peak Hour

The AM and IP plots have more data points due to inclusion of school bus services while the PM peak only covers the public bus services. The IP and PM peaks has the highest R^2 around 0.62 and 0.63, whereas AM peak hour is relatively smaller R^2 with around 0.45 respectively. The reason for low R^2 in AM and IP is the effect of school bus services. The Public bus services R^2 values for AM peak (0.78), IP (0.79) and PM peak (0.63) respectively.

10.6.4 Inclusion of Global PT modal constant

The global PT model constant parameter represents how PT users perceive the benefits or disbenefits of using the PT service. This component was included in the model via the "Global PT MSC" switch key. This component was added to the overall PT generalised cost (GC) equation in the mode split model. The purpose of this parameter is to enable a quick sensitivity test in future years to understand the effects of improved perception on the PT over time.

10.6.5 Model response checks against typical elasticity ranges

Sensitivity tests were carried out to assess the reasonability of the PT model response. The following sensitivity tests were undertaken:

- Public Transport (PT) Fares: 20% Increase in all PT fares (i.e., bus fares)
- Public Transport (PT) In-Vehicle Time: 20% Increase in all PT In-Vehicle Time (i.e., bus times)
- Public Transport (PT) Service Frequency: 20% Increase in all PT service frequency (i.e., buses)

Table 10-16 shows the elasticity results and model responses for the range of sensitivity tests along with expected values from NZTA EEM, Transfund Patronage Funding Work, Auckland Macro Strategic Model (MSM), Wellington Transport Strategic Model (WTSM) and International Values.

Table 10-16 Model Sensitivity Tests

Attribute	Component	AM	IP	PM	Comparative values
PT Fares+20%	Total PT Trips*	-0.22	-0.29	-0.37	International range: -0.1 to -0.6 MBCM: -0.2 to -0.6 Transfund -0.2 to -0.6 for short-run, long-run 1.5-2.5 times of short-run
	Total Public Trips**	-0.29	-0.35	-0.37	
PT IVT+20%	Total PT Trips*	-0.35	-0.47	-0.73	MBCM: -0.1 to -0.7 Transfund -0.1 to -0.5 for short-run, long-run 1.5-2.5 times of short-run
	Total Public Trips**	-0.57	-0.63	-0.73	
PT Service Frequency+20 %	Total PT Trips*	0.24	0.40	0.69	Transfund 0.2 to 0.5 for short-run, long-run 1.5-2.5 times of short-run
	Total Public Trips**	0.64	0.66	0.69	

**Total PT trips include HBE School Students Trips*

***Total Public Trips trips exclude HBE School Students Trips using School Bus Services*

From the table, the following can be concluded:

- PT fare responses are within the expected range.
- PT in-vehicle time responses are slightly higher than Transfund's shot-run elastics but well within the long-run range.
- PT service (frequency) responses are within the expected range for Transfund's shot-run elastics in AM and IP. The PM peak response is well within the long-run range.

11 Cycle Model Development

This chapter discusses the development of the cycle model. The purpose of this model is to estimate the cycle response to changes in infrastructure, land use or any changes in other transport modes. The main sources for the model development were:

- 2018 census
- Aggregated GPS-tracked Strava journeys

However, the following key issues influenced the model structure and development:

- Census data confidentiality limits
- Limited data on trip purposes other than HBW and HBE
- Count sites primarily on trails/shared paths

11.1 Model Structure

The structure of the model is shown in **Figure 11-1**, outlining the inputs and outputs from each of 4 steps namely trip generation, trip distribution, mode shift and assignment.

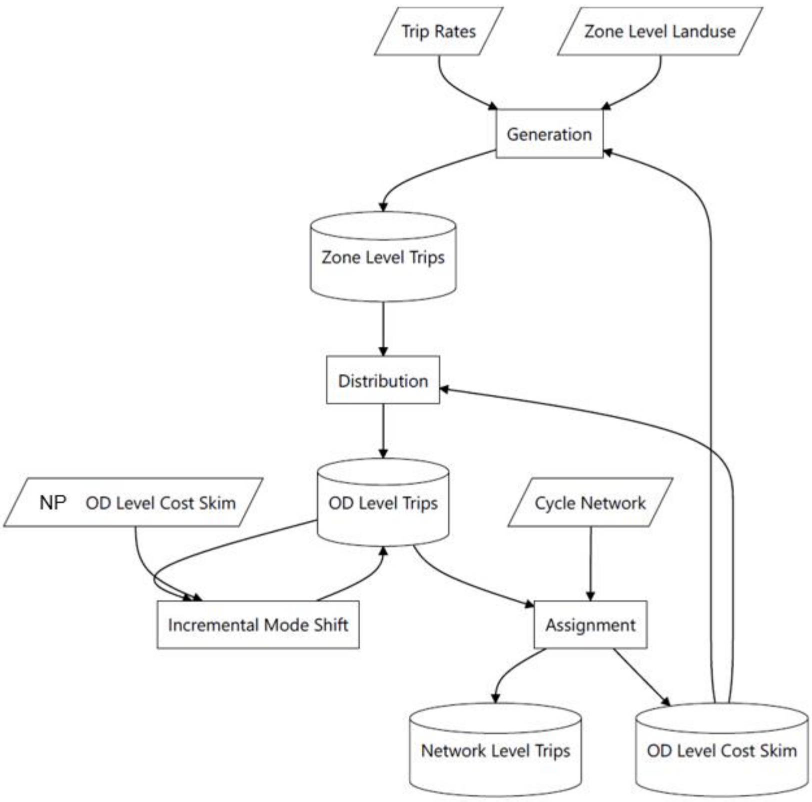


Figure 11-1 Cycle model structure

11.2 Cycle Trip Generation Model

11.2.1 Census Data

The 2018 census Journey to Work (JTW) and Journey to Education (JTE) was sourced for a range of SA2 and sector systems. Sparseness of the data has meant that the calibration has primarily been undertaken at more aggregate level (region-wide totals and sector level), rather than directly at a zonal level.

The 2018 census asked participants to provide information on the 'typical' mode of travel for journey to work and journey to education trips. Whilst it is difficult to determine for certain, evidence would suggest that the use of the term 'typical' has led to an over-representation of cycle trips. The evidence for this is based on cycle count data. The growth in cycle numbers between census 2013 and 2018 far exceeded the growth rate found by count data.

11.2.2 Travel Costs

Real and perceived cycle travel times (in minutes) were skimmed from the model network. The travel time and perception functions are detailed later in this report in regard to the assignment model, but include the following attributes:

- Average cycle cruise speeds based on the type of cycle facility on each link;
- Fixed delays added at major intersections;
- Perceived cycle travel times estimated by applying perception factors for each cycle facility type to the actual travel times;
- Additional factors applied to the perceived travel times to reflect routes with high amenity (e.g., coastal routes) and gradients;
- Intra-zonal costs were assumed to be 50% of the costs to the 'nearest-neighbour'; and
- The cycle assignment model segments each purpose demand into Low, Medium and High cyclists' 'confidence', each with different speeds and perception factors. The demand models use the Medium confidence costs

11.2.3 Model Form and Development Process

The cycle production and attraction models were developed as follows:

- Regression analysis of land use inputs to determine the significance of each variable;
- Sense check on the significant variables;
- Testing of various variable groupings and re-running regression analysis;
- Forcing a low weight applied to variables of little to no-significance where appropriate (observed data is somewhat limited and does not necessarily indicate no correlation in cycle trips to the variable of interest).

Judgement calls were made around the significance of variables and application of minimum weights, maintaining the model principles of being intuitive and easy to understand.

11.2.4 Production Accessibility Function

The initial cycle productions were adjusted based on a measurement of the accessibility to employment of each zone. The accessibility function included:

- An impedance function applied to the skim costs to reflect the observed trip length distribution. This adopted the same function as calibrated for the distribution model;
- A distance function applied to the skim costs to prevent overly long-distance trips occurring;
- The total employment of each destination zone;

- An S-Shaped function that adjusts the initial productions based on the relative accessibility of each zone. This function was calibrated to find the best fit of trip generation to the JTW data

The impedance function adopted was:

$$I = C^{X_1} e^{-X_2 C} \cdot (1 - \left(\frac{dist}{dist_{max}}\right)^3)$$

Where;

I	=	Impedance
C	=	Travel cost
x1	=	calibration parameter 1
x2	=	calibration parameter 2
d_f	=	distance factor
$dist$	=	travel distance
$dist_{max}$	=	Calibration parameter, representing maximum expected distance travelled by purpose

The accessibility function applied to each zone was:

$$PAF = \frac{F_{max} + (F_{min} - F_{max})}{1 + e^{(F_{shape} * (RA - F_x))}}$$

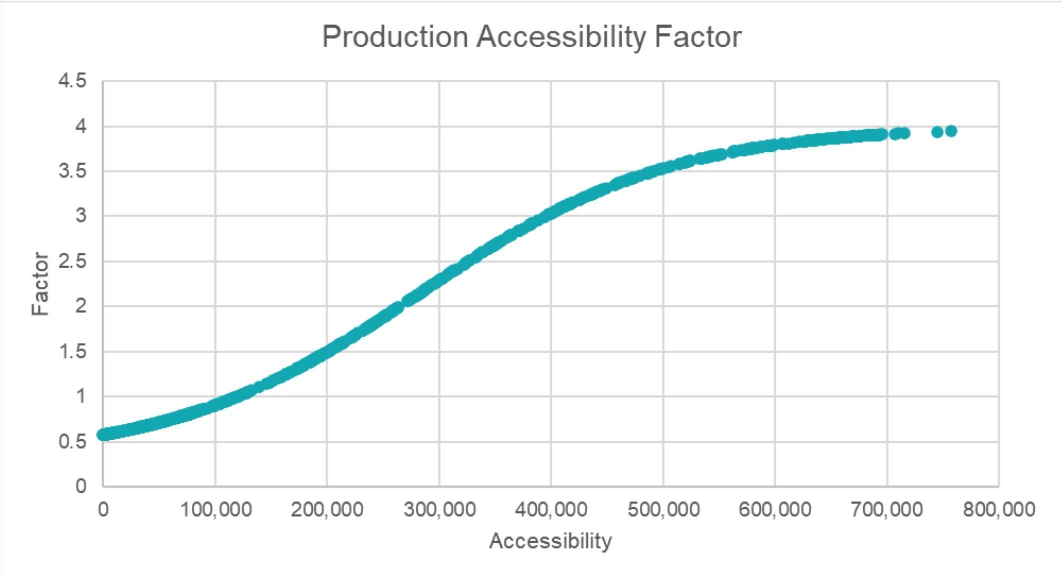


Figure 11-2 Production Accessibility Factor

11.2.5 Home-Based Work

11.2.5.1 Production

Following the initial regression analysis, the following trip production rates were adopted:

Table 11-1 HBW trip production rates

	Total Households
Trip rate	0.024

This provided a fit to the observed productions shown in **Figure 11-3** (grouped by the 32-sector system):

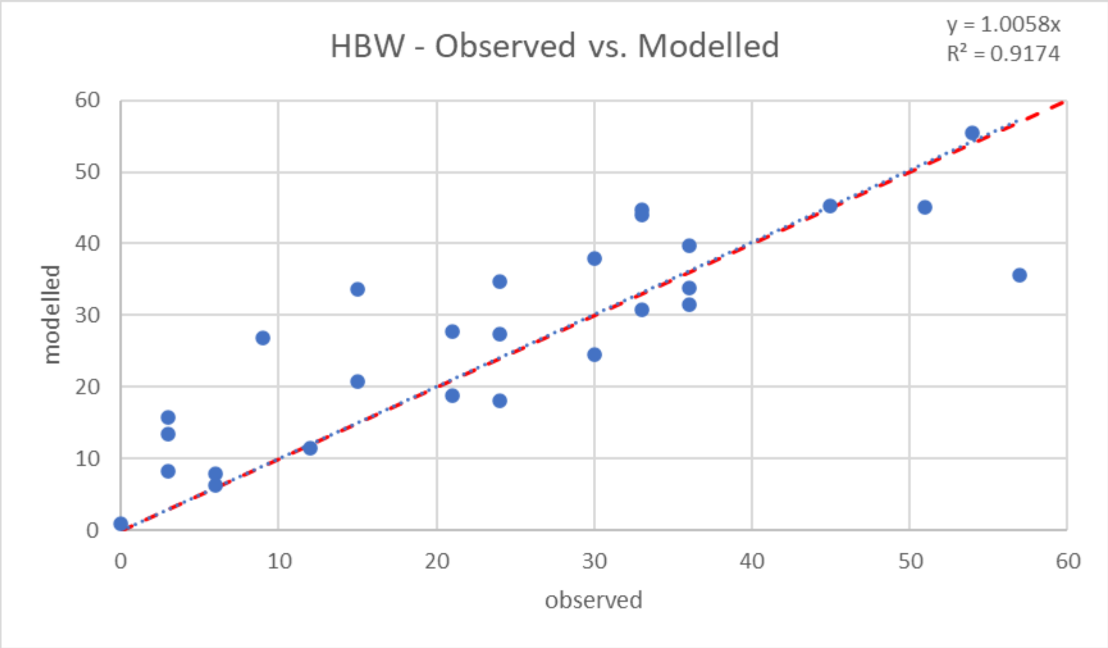


Figure 11-3 HBW trip production

Overall, this is considered a good fit of the 2018 HBW trip productions that retain high explanatory power with no geographic factoring applied.

11.2.5.2 Attraction

The regression analysis for HBW produced the following trip attraction rates:

Table 11-2 HBW trip attraction rates

	Retail	Agriculture	Industry	Education	Services
Attraction rate	0.001	0.022	0.012	0.031	0.015

11.2.6 Home Based Education

The home based education model relies on the primary, secondary and tertiary attractions to generate demand.

This initial approach produced the following trip production and attraction rates:

Table 11-3 HBE trip attraction rates

	Primary roll	Secondary roll	Tertiary Roll
Trip attraction rates	0.067	0.026	0.118

11.2.7 Other

As described in the data analysis section of the report, a target of approximately 25% of total cycle trips was set for 'Other' trips.

Setting this target, resulted in the following trip production / attraction rates:

Table 11-4 Other trip production rates

	Households	Total employment
Trip rate	0.0056	0.0053

11.2.8 Trip Totals

The generation step produced the following two-way trip totals by purpose:

Table 11-5 Total trips by purpose

Purpose	Trips
HBW	1,480
HBE	1,550
Other	750
Total	3,780

11.3 Trip Distribution Model

11.3.1 Model Structure

Through the development of the Wellington Cycle Model, a singly constrained distribution model was developed in order to avoid the instability and issues created by a doubly-constrained distribution model for cycle trips.

This method uses the zonal productions and proportionally assigns their destination based on the impedance cost, and attraction totals at the destinations. Whilst it is recognised that this means that at a zonal basis the model is no longer doubly-constrained, this is considered acceptable for the following reasons:

- Production and attraction trip rates and the influencing factors for cycling are less understood than traditional transport modes
- Due to the relatively low number of cyclists (compared to other modes) there is much more limited data to draw on to make accurate predictions of production and attraction
- Due to the short trip length distribution of cyclists, a doubly-constrained gravity model will struggle with imbalances in productions and reachable attractions

The distribution model therefore takes the following form:

$$T_{ij} = P_i \cdot \frac{Imp \cdot \mathrm{k} \cdot A_j}{\Sigma^n Imp \cdot \mathrm{k} \cdot A_n}$$

Where;

T_{ij}	=	Trip from zone i to zone j
P_i	=	Trip productions from zone i
Imp	=	Impedance function (as per trip generation)
K	=	k-matrix
A_j	=	Trip attractions to zone j
A_n	=	Trip attractions to zone n

11.3.2 Travel costs

The travel costs were those used in the trip generation model, being skimmed from the cycle network. These perceived costs include perception factors based on the cycle facilities.

11.3.3 Distribution Model Fit

Comparison between modelled and observed trip length distribution for HBW and HBE are shown in **Figure 11-4** and **Figure 11-5** respectively. For the 'Other' trip purpose, very limited data is available to calibrate a trip length distribution. A target mean trip length of 3.7km was determined from the data available. The distribution model estimated a trip length of 3.4km.

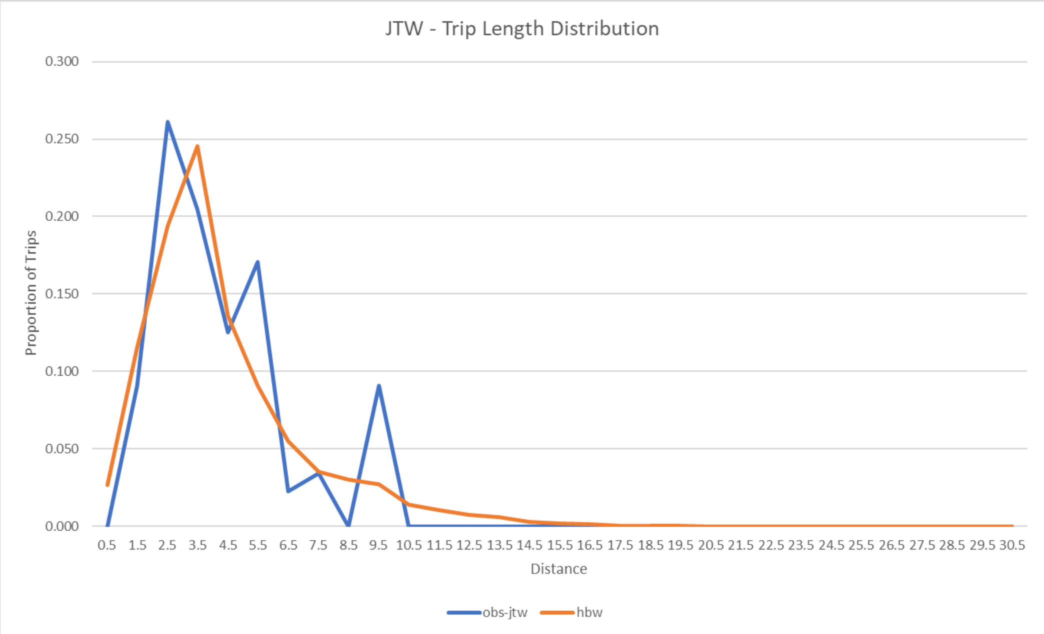


Figure 11-4 HBW vs JTW trip length distribution

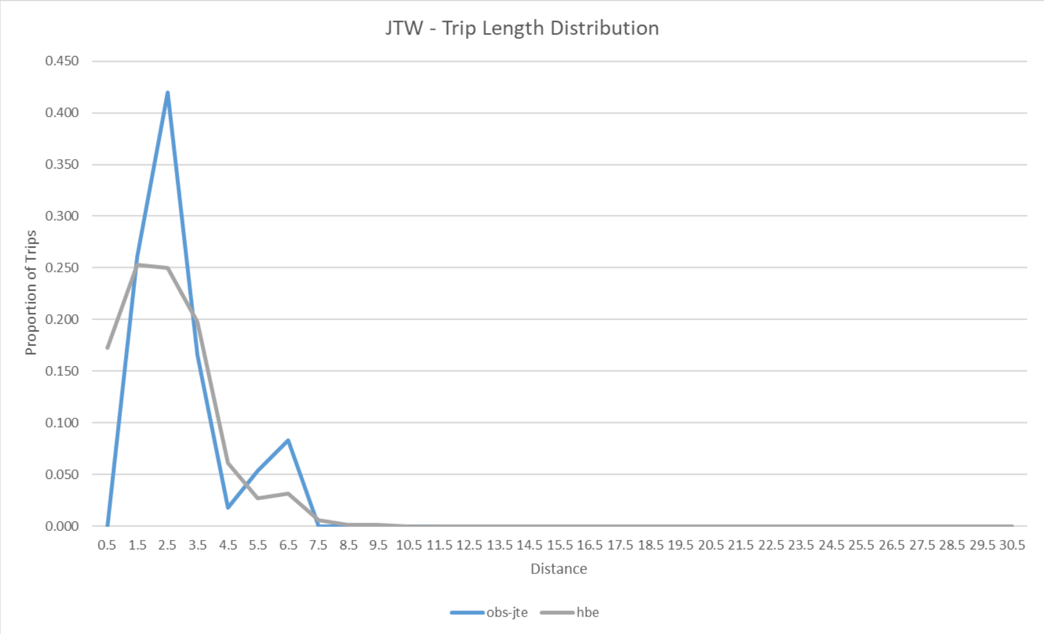


Figure 11-5 HBE vs JTE trip length distribution

11.4 Assignment Model

The assignment model was developed with the following design principles:

- To reflect the differing actual and perceived speeds on differing road and facility types
- To reflect the widely dispersed speeds and perceptions of the users
- To separately identify the 'true' and 'perceived' travel costs, suitable for use in subsequent economic analysis
- To skim perceived travel costs and real distances for use in demand models, that reflect the facility type
- To be of a form suitable for a strategic model, utilising network data generally available in the models

The model used the following assignment method:

- Each trip purpose is split into three equal segments to reflect different speeds and perceptions. These are nominally referred to as Low, Medium and High confidence
- Assign cruise speeds to each segment and facility type
- Assume fixed delay at intersection. This was assumed to be 15 seconds for all approaches to traffic signals and 15 seconds to minor approaches at priority-controlled intersections
- Assign perception factors reflecting attractiveness of each type, based on the confidence segments
- Add additional perception factors to reflect gradient and route amenity
- Include a distance component to help stabilise route choice to avoid overly long routes being taken as a result of low perception factors

The cost function used in the assignment is therefore as follows:

$$GC = \left(\frac{distance}{speed} + delay\right) \cdot Pf \cdot Pa \cdot Ph + 0.25 \cdot distance$$

Where;

GC	=	Generalised Cost
Distance	=	Real distance
Speed	=	Cycle cruise speed (by confidence, facility)

Delay = Intersection delay

Pf = Facility perception factor

Pa = Amenity perception factor

Ph = Hilliness perception factor

The average cruise speeds were adopted from SAMM. The cruise speeds were derived in part from Strava data, although it is recognised that such data is expected to be inherently biased towards the more passionate and confident cyclists. The adopted values are indicated in **Table 11-6**.

Table 11-6 Mode cruise speeds, km/h

No.	Facility type	Low confidence	Medium confidence	High confidence
0	None	14.1	14.1	14.1
1	Separated shared path	17.6	17.6	17.6
2	Separated cycleway	23.5	23.5	23.5
3	Separated trail	13.5	13.5	13.5
4	On-road painted	16.9	16.9	16.9
5	On-road barrier	22.5	22.5	22.5
6	Shared zone	16.8	16.8	16.8
7	Local area traffic management	21	21	21
8	Bus Lanes	28	28	28

Perception factors were then applied to the cruise and intersection delay based on facility type, confidence level and road type. The road type was used as a proxy for traffic volume and speed. The initial factors were derived from the SAMM but were modified as part of calibrating the base models.

It should be noted that the perception factors are all automatically allocated based on the facility type and road type. Meaning that the user of the model only needs to select the appropriate facility type.

The following tables show the perception factors for each confidence level, facility type and road type.

Table 11-7 Low confidence perception factors

Facility type	Shopping	Local road	Collector road	Arterial road	Rural road
None	1.5	1.25	1.38	1.5	1.88
Separated shared path	1	1	1	1	1.5
Separated cycleway	0.91	0.91	0.91	0.91	1.36
Separated trail	1	1		1	1.5
On-road painted	1.05	1.05	1.16	1.26	1.58
On-road barrier	1	1	1	1	1.5
Shared zone	1	1	1	1	1.5
Local area traffic management	1.11	1.11	1.11	1.11	1.67
Bus Lanes	1.05	1.05	1.05	1.05	1.58

Table 11-8 Medium confidence perception factors

Facility type	Shopping	Local road	Collector road	Arterial road	Rural road
None	1.3	1	1.1	1.2	1.5
Separated shared path	0.83	0.83	0.83	0.83	1.25
Separated cycleway	0.74	0.74	0.74	0.74	1.11
Separated trail	0.83	0.83	0.83	0.83	1.25
On-road painted	0.87	0.87	0.96	1.04	1.3
On-road barrier	0.8	0.8	0.8	0.8	1.2
Shared zone	0.8	0.8	0.8	0.8	1.2
Local area traffic management	0.91	0.91	0.91	0.91	1.36
Bus Lanes	0.87	0.87	0.87	0.87	1.3

Table 11-9 High confidence perception factors

Facility type	Shopping	Local road	Collector road	Arterial road	Rural road
None	1.1	0.92	1	1.16	1.32
Separated shared path	0.8	0.8	0.8	0.8	1.2
Separated cycleway	0.74	0.74	0.74	0.74	1.11
Separated trail	0.8	0.8	0.8	0.8	1.2
On-road painted	0.8	0.8	0.88	0.96	1.2
On-road barrier	0.8	0.8	0.88	0.96	1.2
Shared zone	0.8	0.8	0.8	0.8	1.2
Local area traffic management	0.8	0.8	0.8	0.8	1.2
Bus Lanes	0.8	0.8	0.8	0.8	1.2

Routes with high amenity had an additional amenity factor applied, such as a coastal road or other 'destination' cycleways. These factors were to reflect such routes that would generally be more attractive than equivalent routes with lower amenity. The need for such factors was identified through the validation, which found an underestimation (or overestimation) of cycle flows on routes with such attributes. The amenity factors adopted in the base model were as indicated in the following table:

Table 11-10 Amenity factors

Route	Amenity factor
Costal Pathway / Walkway	1.5

Street gradient effects were also considered to affect the perceived attractiveness of routes (gradients would also be likely to change the actual speed, however both the real and perceived effects were reflected in these factors. A simple system was used as follows:

- A 6-level rating of 'hilliness'
- Applied to up-hill gradients, or steep downhill gradients

The adopted factors were as per the following table:

Table 11-11 Street gradient factors

Slope minimum	Slope maximum	Hilliness factor
-inf	-0.06	1.2
-0.06	0.015	1
0.015	0.03	1.1
0.03	0.06	1.2
0.06	0.09	1.6
0.09	inf	2

11.5 Cycle Model Validation

Once all the model components were implemented, the validation against cycle flows was used to revise the parameters to improve the fit of the flows against the observed data. This involved extensive analysis of both individual outliers and overall trends. The type of changes tested or adopted through analysis included:

- Reduction in average trip lengths. The earlier model runs indicated long trip lengths and a general trend of over-estimation of counts, modelled trip lengths were reduced. It is also recognised that data sources such as the Census data use the term "main mode" to define the trip mode. Therefore, multi-modal trips that would extend the trip length can not be easily distinguished and could therefore increase the observed average trip length.
- Adjustment of hilliness factors. Hilliness factors were adjusted throughout the model calibration process, including the addition of a factor for very steep downward slopes.
- Reduction of overall demand targets. Even with the reduction in average trip lengths, the model appeared to be significantly over-estimating counts across screenlines. The total demand targets were reduced to balance between what the Census / HTS data was saying and the observed count data. A contributing factor to the initial estimation may be a result of the 2018 census data using the term "usually travel" for questions about travel mode, rather than the travel mode on Census day. "Usually" is likely to be interpreted differently between different respondents and makes judgement of an "average" number of cyclists difficult.
- Introduction of "Shopping Street" road class factors. It was identified that some key routes that were coded as a "Shopping Street" were being over-estimated. These links were initially incorporated into the "Local Street" class. The "Shopping Streets" were given higher perception factors (increase in generalised cost) to recognise the presence of vehicles pulling in and out of parking spots, delivery / pick-up of goods etc. that make riding a bike along these corridors typically less attractive.
- Adjustment of facility perception factors, particularly for high confidence cyclists. Throughout the calibration and validation process the facility perception factors were fine tuned to improve the route choice response in the model. As the cost skims are fed into the generation and distribution, this also involved re-running and re-checking the generation and distribution.
- Adjustment of network coding / facility type classification. Network coding and facility type classifications were refined / corrected throughout the model development process.

It is not practical to document the numerous parameter values tested from the significant number of model runs undertaken during the model development.

11.5.1 Flow Validation

As discussed, a relatively limited set of daily cycle counts across the network were available. The data was factored / adjusted to represent a March 2018 average count. The key statistical check on the overall level of validation was the correlation coefficient (R^2). The other measures recommended in the transport modelling guidelines are not considered appropriate for a daily cycle model, due to both low volume of counts for cycling and the daily nature of the model being built (i.e., the GEH measure in the guidelines is appropriate for hourly volumes). The scatterplot of the validation is shown in **Figure 11-6**.

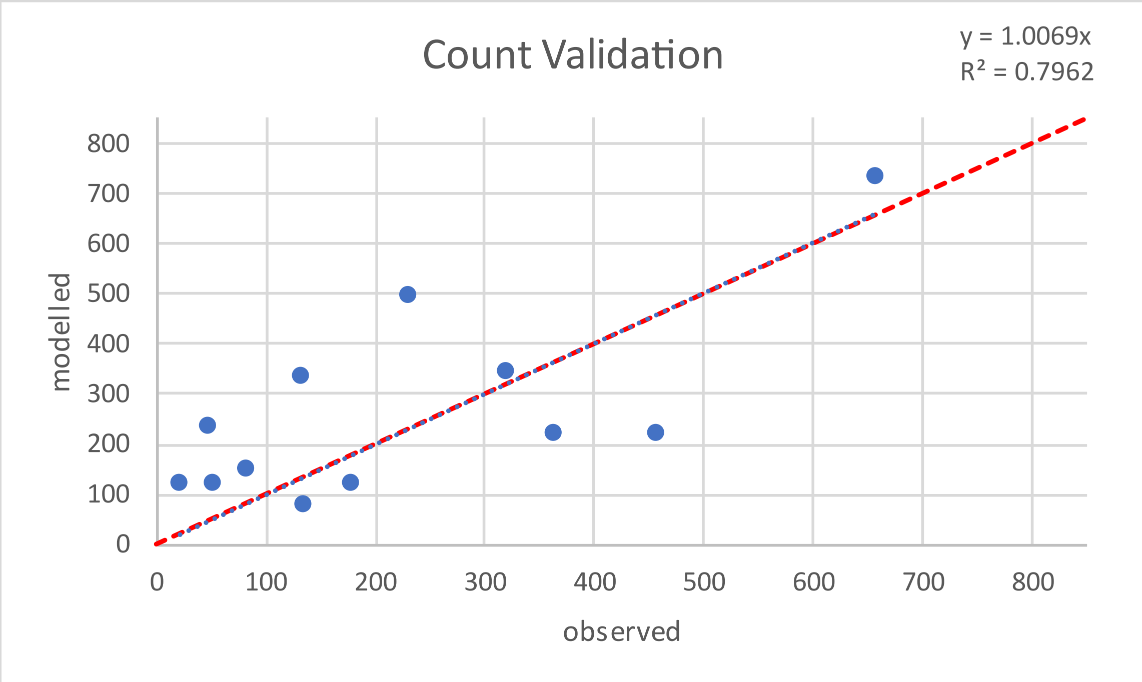


Figure 11-6 Daily cycle flow validation

11.6 Cycle Demand Response

11.6.1 Approach

The predicted cycle demands between zones will respond to three key elements:

- Land use
- Cycle network and facilities
- Relative costs of other travel modes

The first two responses are captured in the base model structure as follows:

The response to land use includes:

- A direct response to population through the generation model
- Changes to trip attraction due to changes in employment and education rolls
- Changes in trip generation related to changes in accessibility (e.g., new schools or employment will alter the accessibility of cycling, and hence the trip generation).

The response to the cycle network and facilities includes:

- Changes in actual or perceived travel times will alter the route taken in the assignment model
- Changes in perceived travel costs will alter the accessibility, and therefore the trip generation

- Changes in perceived travel costs will alter the relative attractiveness of destinations, and therefore the trip distribution

The change in demand due to the relative costs of other modes is included only in forecasting model (i.e., when predicting future year demands). This is described in the following section.

11.6.2 Incremental Mode Shift Model

This model predicts a change in cycle demands in response to the combined relative changes in travel costs by cycle and mechanised modes. Mechanised travel is via car and PT. The split between car and PT travel is done via the NSTM, and not relitigated in the cycle model. An incremental model structure is used to retain the precision of the cycle model trips, which would likely be lost by the dominant modes with an absolute model structure. That is, in an absolute logit model structure, even small errors in predicting the very dominant mechanised modes would have significant impact on the cycle trips. The incremental structure means that the initially estimated future year cycle trips are adjusted in relation to the change in travel costs.

The process for the incremental mode shift adjustment is as follows:

- Get the car and PT generalised cost for the 2018 base and forecast years from NSTM and create the base and forecast composite mechanised costs (M_{2018}, $M_{Forecast}$)
- Calculate the change in mechanised costs ($dM = M_{Forecast} - M_{2018}$)
- Calculate the change in cycle costs ($dC = C_{Forecast} – C_{2018}$)
- Calculate the initial cycle mode share for the forecast year $MS = Trips_{cycle}/(Trips_{cycle}+Trips_{mechanised})$
- Apply an incremental logit choice model to predict the change in cycle mode share
- Calculate the adjusted cycle trips based on the adjusted mode share

The incremental logit is as follows:

$$MS' = MS \cdot \frac{e^{(-s.dC)}}{MS \cdot e^{(-s.dC)} + (1 - MS) \cdot e^{(-s.dM)}}$$

Where;

MS	=	Initial forecast cycle mode share
MS’	=	Adjusted cycle mode share
dC	=	Change in cycle cost between 2018 and forecast year
dM	=	Change in mechanised cost between 2018 and forecast year
S	=	Sensitivity parameter

The composite mechanised costs use a log-sum formulation:

$$M = -\frac{1}{\lambda} log \sum_{k} e^{-\lambda.C_k}$$

Where;

M	=	Mechanised composite cost
K	=	Mode k (car or PT)
C	=	Cost for mode k
λ	=	Main mode split parameter

All calculations are done on an origin-destination basis and the output of this stage is car and PT ‘diverted trips’ matrix that can be fed-back to the car/PT model.

11.7 Consideration of E-bikes

There is uncertainty as to what impacts future increases in e-bikes may have on cycling within New Plymouth, as well as uncertainty in forecasting these increases in e-bike usage. The following assumptions are made in order to simplify the consideration of e-bikes within the NSTM:

- Focus on privately owned bikes, rather than ride-sharing systems
- E-bikes offer faster speeds, allowing greater distances with less physical exertion, but comes with high capital costs
- Market uptake to be assumed to be global across the network

To represent this in the model, the following elements require adjusting in the model:

- Relative speed / distance travelled, when compared to conventional bikes
- Relative reduction in penalty applied to slopes
- Saturation of e-bikes into the market over time

Research previously conducted has suggested the following set of parameters:

Table 11-12: E-bike Parameter Adjustments

Parameter	2035	2053
Change in perceived trip length	-50%	-50%
Change in travel speed (flat terrain)	30%	30%
Change in hilliness perception	-50%	-50%
E-bike proportion	45%	75%

Regarding the hilliness perception factor, the 50% reduction is not applied to the absolute number, but rather the value over 1. For example, a standard perception factor of 1.2 would not become 0.6 for e-bikes, but rather 1.1.

A

Appendix A – Link Flow Validation Results

Ngāmotu Strategic Transport Model

Link Validation Results

Screenlines

MRun14

Ref	Screenline	Direction	Anode	Bnode	Description	Link Ref	AM_Mod_Total (AM Peak Average Peak Hour (07:00-09:00) – Modelled – Total)	AM_Mod_Light (Light)	AM_Mod_Heavy (Heavy)	AM_Obs_Total (Observed – Total)	AM_Obs_Light (Light)	AM_Obs_Heavy (Heavy)	IP_Mod_Total (Interpeak (09:00-16:00) – Modelled – Total)	IP_Mod_Light (Light)	IP_Mod_Heavy (Heavy)	IP_Obs_Total (Observed – Total)	IP_Obs_Light (Light)	IP_Obs_Heavy (Heavy)
320237_EB		EB	963	905	Smart Rd (Dec)	963_905	1,243	1,161	82	1,531	1,485	47	1,355	1,274	81	1,470	1,411	59
320238_EB		EB	938	875	Paynters Ave Dec	938_875	1,301	1,220	81	1,242	1,203	40	1,365	1,285	80	1,062	1,014	48
370239_WB	2	WB	870	872	Te Henui Bridge Inc.	870_872	1,288	1,219	69	1,235	1,182	53	1,273	1,204	69	1,050	1,009	41
380239_EB	102	EB	949	871	Te Henui Bridge Dec.	949_871	1,091	1,018	72	970	936	35	1,228	1,159	69	997	954	42
03A00001_NB		NB	1881	907	Te Arei Rd	1881_907	188	172	15	272	265	7	155	140	15	193	181	12
03A00001_SB		SB	907	1881	Te Arei Rd	907_1881	119	103	15	185	171	14	153	138	15	180	170	10
4400000_EB		EB	887	886	Molesworth St	887_886	428	404	24	550	522	28	483	460	23	550	519	31
4400000_WB		WB	886	887	Molesworth St	886_887	256	244	12	566	528	38	356	344	12	597	562	34
4400004_EB	113	EB	894	893	Breakwater Rd	894_893	192	171	21	339	321	18	166	145	20	323	304	19
4400004_WB	13	WB	893	894	Breakwater Rd	893_894	148	127	21	244	219	26	184	163	21	336	314	22
4500003_EB	109	EB	1025	1024	Sea View Rd	1025_1024	648	618	30	743	743	-	498	469	29	522	522	-
4500003_WB	9	WB	1024	1025	Sea View Rd	1024_1025	325	298	27	343	343	-	487	460	27	499	499	-
4500009_EB	112	EB	1758	945	Hurford Rd	1758_945	417	377	40	510	496	14	352	312	40	271	257	14
4500009_WB	12	WB	945	1758	Hurford Rd	945_1758	226	189	37	190	178	12	323	287	36	271	259	12
4520001_EB	107	EB	1518	1129	SH45 Powderham St	1518_1129	1,283	1,229	54	1,306	1,278	28	1,184	1,131	53	1,108	1,076	32
7038_NB		NB	1216	1217	Cutfield Rd St Aubyn St to Devon St West	1216_1217	82	77	5	25	24	2	141	137	4	49	47	2
7038_SB		SB	1217	1216	Cutfield Rd St Aubyn St to Devon St West	1217_1216	222	207	15	42	41	2	201	186	15	52	51	1
7039_NB		NB	1428	1429	Mangorei Rd Smith Rd to Karina Rd	1428_1429	103	96	7	116	109	6	139	133	7	174	168	7
7039_SB		SB	1429	1428	Mangorei Rd Smith Rd to Karina Rd	1429_1428	147	143	4	252	241	11	118	114	4	181	173	8
7045_SB	103	SB	1063	1064	Awanui St Mangorei Rd to Nevada Dr	1063_1064	121	116	5	114	110	4	162	157	5	159	155	4
7045_NB	3	NB	1064	1063	Awanui St Mangorei Rd to Nevada Dr	1064_1063	402	390	12	290	284	6	319	305	14	206	199	7
7046_WB		WB	1731	1175	Clemow Rd Record St to Fitzroy Rd	1731_1175	46	45	1	51	42	9	38	37	1	74	68	6
7046_EB		EB	1175	1731	Clemow Rd Record St to Fitzroy Rd	1175_1731	59	57	3	48	42	6	98	96	3	84	76	7
7047_WB		WB	1675	1674	Maratahu St Tukapa St to Frankley Rd	1675_1674	63	61	2	23	23	0	57	54	2	47	46	1
7047_EB		EB	1674	1675	Maratahu St Tukapa St to Frankley Rd	1674_1675	14	13	1	37	35	1	25	24	1	47	46	0
7052_EB		EB	1410	1139	Pendarves St Carrington St to Liardet St	1410_1139	41	39	2	64	60	4	91	89	2	105	102	3
7052_WB		WB	1139	1410	Pendarves St Carrington St to Liardet St	1139_1410	5	5	0	123	120	3	5	5	0	93	91	2
11178_WB		WB	1315	1314	Gill St Liardet St to Gover St	1315_1314	176	170	6	73	70	2	265	258	7	173	170	3
11178_EB		EB	1314	1315	Gill St Liardet St to Gover St	1314_1315	77	72	6	91	87	4	187	181	6	200	191	9
11180_NB	8	NB	1680	1233	Dawson St Vivian St to Centre R/About	1680_1233	173	164	10	147	143	4	335	326	9	335	328	7
11180_SB	108	SB	1233	1680	Dawson St Vivian St to Centre R/About	1233_1680	305	298	7	349	336	13	253	247	6	324	313	11
11185_WB		WB	1203	1812	Coronation Ave Coronation Ave to Upjohn St	1203_1812	433	411	22	333	320	14	485	463	22	384	370	14
11185_EB		EB	1812	1203	Coronation Ave Coronation Ave to Upjohn St	1812_1203	568	546	22	397	378	19	487	464	23	320	306	14
17180_SB		SB	1782	1268	Standish St NP Dawson St to Wallace Pl	1782_1268	78	77	1	62	61	1	78	77	1	97	95	2
17180_NB		NB	1268	1782	Standish St NP Dawson St to Wallace Pl	1268_1782	92	91	1	50	49	1	66	65	1	54	53	1
17190_SB	111	SB	1048	1663	Tukapa St Wallath Rd to Horne St	1048_1663	74	70	4	75	72	3	127	123	4	109	105	4
17190_NB	11	NB	1663	1048	Tukapa St Wallath Rd to Horne St	1663_1048	148	144	4	139	133	6	125	121	4	116	111	4
17196_EB		EB	1691	1690	Hori St Carrington St to Brooklands Rd	1691_1690	337	319	17	187	176	12	333	316	17	285	276	10
17196_WB		WB	1690	1691	Hori St Carrington St to Brooklands Rd	1690_1691	374	357	17	249	241	8	361	343	18	264	256	9
18371_NB		NB	1315	1323	Gover St Gill St to Devon St Easf	1315_1323	128	120	9	76	70	6	243	234	9	163	157	6
18371_SB		SB	1323	1315	Gover St Gill St to Devon St Easf	1323_1315	151	146	4	150	140	10	192	187	5	230	221	8
18372_NB		NB	897	1161	Ngamotu Rd Breakwater Rd to Centenial Dr	897_1161	65	62	4	143	123	19	125	121	4	258	240	18
18372_SB		SB	1161	897	Ngamotu Rd Breakwater Rd to Centenial Dr	1161_897	155	151	3	187	171	15	112	108	3	232	218	14
18379_SB		SB	1252	870	Mangorei Rd Devon St East to Northgate	1252_870	34	33	1	106	103	4	102	99	3	147	142	5
18379_NB		NB	870	1252	Mangorei Rd Devon St East to Northgate	870_1252	112	109	4	169	159	10	114	110	4	164	152	12
19329_SB		SB	1559	1045	Wills Rd NP Keene Dr to Waitaha Pl	1559_1045	63	61	1	45	42	3	56	54	1	44	41	3
19329_NB		NB	1045	1559	Wills Rd NP Keene Dr to Waitaha Pl	1045_1559	37	36	1	27	23	3	56	54	1	49	46	3
19331_WB		WB	1229	1316	Gill St Gover St to Eliot St	1229_1316	26	26	1	94	88	6	41	40	1	190	182	7
19331_EB		EB	1316	1229	Gill St Gover St to Eliot St	1316_1229	42	39	2	87	82	5	97	95	3	180	175	6
19333_NB	8	NB	1451	1450	Morley St Wallace Pl to Vivain St RHS	1451_1450	286	271	15	229	213	16	437	422	14	409	394	15
19333_SB	108	SB	1450	1451	Morley St Wallace Pl to Vivain St RHS	1450_1451	546	530	16	458	440	18	496	480	16	474	462	12
19335_WB		WB	1876	1882	Manutahi Rd Corbett Rd to Mountain Rd SH3A	1876_1882	76	57	19	169	156	13	123	104	19	111	95	16
19335_EB		EB	1882	1876	Manutahi Rd Corbett Rd to Mountain Rd SH3A	1882_1876	178	158	20	92	74	17	133	114	20	112	96	15
19337_EB	101	EB	1343	1344	Henwood Rd Manutahi Rd to Egmont Rd	1343_1344	29	27	1	41	36	5	23	22	1	41	37	5
19337_WB	1	WB	1344	1343	Henwood Rd Manutahi Rd to Egmont Rd	1344_1343	37	31	6	53	44	9	47	41	6	50	41	9
20336_WB		WB	1375	1374	Junction St Tarahua Rd to Durham Ave	1375_1374	110	106	4	68	64	4	108	104	4	79	75	4
20336_EB		EB	1374	1375	Junction St Tarahua Rd to Durham Ave	1374_1375	98	93	4	121	111	10	122	118	4	146	138	8
20341_EB		EB	1466	1070	Omata Rd Harriet Pl to Barrett Rd	1466_1070	85	75	10	48	45	3	106	96	10	57	55	2
20341_WB		WB	1070	1466	Omata Rd Harriet Pl to Barrett Rd	1070_1466	127	117	11	71	69	2	118	107	10	65	63	2
23113_NB		NB	1279	1281	Egmont Rd Katere Rd to Urban/Rural Bdy	1279_1281	34	28	7	57	38	19	66	59	7	92	80	11
23113_SB		SB	1281	1279	Egmont Rd Katere Rd to Urban/Rural Bdy	1281_1279	66	63	2	103	94	9	45	43	2	89	77	11
23117_SB		SB	1213	1214	Currie St Gill St/Ariki St to Courtenay St/Powderham St	1213_1214	131	124	7	42	40	3	328	321	7	114	111	3
23117_NB		NB	1214	1213	Currie St Gill St/Ariki St to Courtenay St/Powderham St	1214_1213	48	47	1	55	52	2	12	12	0	108	106	2
23121_EB		EB	1735	1173	Devon St East Liardet St to Gover St	1735_1173	205	195	9	118	112	5	172	163	9	255	247	8
23121_WB		WB	1173	1735	Devon St East Liardet St to Gover St	1173_1735	69	64	4	94	89	5	93	88	4	200	194	6
23122_NB	11	NB	1539	1042	Frankley Rd waimea St to Fernleigh St	1539_1042	132	127	5	82	79	2	167	162	5	122	118	4
23122_SB	111	SB	1042	1539	Frankley Rd waimea St to Fernleigh St	1042_1539	203	198	5	192	190	2	173	168	5	123	120	3
23123_SB		SB	1079	1085	Beach St Devon St East to End	1079_1085	183	178	5	58	54	5	189	184	5	84	78	6
23123_NB		NB	1085	1079	Beach St Devon St East to End	1085_1079	42	40	2	64	60	4	68	66	2	108	104	4
23128_NB		NB	1887	1054	Egmont St Devon St West to St Aubyn St	1887_1054	77	73	4	121	106	15	198	194	4	263	249	14
23128_SB		SB	1054	1887	Egmont St Devon St West to St Aubyn St	1054_1887	58	56	2	115	109	7	65	63	2	218	211	7
23129_EB		EB	1550	1551	Tukapa St Waimea St to Omata Rd RP1554 O/S175	1550_1551	367	351	16	313	301	12	459	443	16	534	430	105
23129_WB		WB	1551	1550	Tukapa St Waimea St to Omata Rd RP1554 O/S175	1551_1550	542	526	16	625	607	18	482	465	17	545	526	19
24113_SB		SB	1285	1286	Egmont Rd Urban/Rural Bdy to Waiwakaiho Rd	1285_1286	39	36	3	73	54	20	45	42	3	97	86	12
24113_NB		NB	1286	1285	Egmont Rd Urban/Rural Bdy to Waiwakaiho Rd	1286_1285	63	61	3	115	86	29	46	44	2	98	75	23
24114_WB		WB	1464	1463	Ngamotu Rd Rosendale Ave to CrownHill St	1464_1463	53	51	2	84	77	7	80	78	2	140	135	5
24114_EB		EB	1463	1464	Ngamotu Rd Rosendale Ave to CrownHill St	1463_1464	107	105	2	101	98	3	90	88	2	146	144	3
24114-2_WB		WB	1464	1463	Ngamotu Rd Rosendale Ave to CrownHill St	1464_1463	53	51	2	84	77	7	80	78	2	140	135	5
24114-2_EB		EB	1463	1464	Ngamotu Rd Rosendale Ave to CrownHill St	1463_1464	107	105	2	101	98	3	90	88	2	146	144	3
24115_EB		EB	1274	1275	Doralto Rd Huatoki St to Woodleigh St	1274_1275	38	37	1	29	26	3	52	51	1	47	44	3
24115_WB		WB	1275	1274	Doralto Rd Huatoki St to Woodleigh St	1275_1274	70	68	2	63	61	2	68	65	2	46	45	1
24118_NB	5	NB	1402	1403	Mangorei Rd Tupare Pl to Tupuhi Pl	1402_1403	67	62	5	117	110	7	59	54	5	95	90	5
24118_SB	105	SB	1403	1402	Mangorei Rd Tupare Pl to Tupuhi Pl	1403_1402	42	39	3	135	129	6	41	38	3	97	92	5
24119_EB		EB	1449	1543	Wallace Pl Morley St to Tukapa St	1449_1543	299	285	15	268	255	12	442	427	15	457	444	13
24119_WB		WB	1543	1449	Wallace Pl Morley St to Tukapa St	1543_1449	531	515	16	447	427	20	491	475	16	471	458	14
24123_SB	111	SB	1626	1625	Barrett Rd Pararewa Dr to Honeyfield Dr	1626_1625	23	22	1	24	22	2	35	34	1	45	44	1

Ref	PM_Mod_Total (PM Peak (16:00-18:00) – Modelled – Total)	PM_Mod_Light	PM_Mod_Heavy	PM_Obs_Total (Observed)	PM_Obs_Light	PM_Obs_Heavy	Daily_Mod_Total (Daily 24hrs – Modelled)	Daily_Mod_Light	Daily_Mod_Heavy	Daily_Obs_Total (Observed)	Daily_Obs_Light	Daily_Obs_Heavy	Total Flow Stats – Difference AM	IP	PM	ADT	ADT_H	% Difference AM	IP	PM	ADT	ADT_H	Total GEH AM	IP	PM	HCV GEH AM	IP	PM
1 WB	1,446	1,380	66	1,452	1,412	40	18,332	17,201	1,131	17,565	16,738	827	8	72	-6	767	304	1%	6%	0%	4%	37%	0	2	0	2	3	4
101 EB	32	31	1	60	58	2	351	334	17	576	526	50	-13	-18	-27	-225	-33	-31%	-44%	-46%	-39%	-66%	2	3	4	2	2	1
2 WB	2,224	2,153	71	1,955	1,909	45	23,469	22,396	1,073	23,236	22,403	833	-159	-72	269	233	239	-9%	-4%	14%	1%	29%	4	2	6	1	2	3
102 EB	1,774	1,719	55	1,850	1,796	54	22,800	21,716	1,084	23,425	22,448	977	-109	-12	-76	-626	106	-7%	-1%	-4%	-3%	11%	3	0	2	1	0	0
3 NB	1,035	1,008	27	1,080	1,052	28	13,769	13,282	486	13,633	13,116	517	3	28	-44	136	-31	0%	3%	-4%	1%	-6%	0	1	1	2	1	0
103 SB	1,161	1,140	21	1,274	1,250	24	12,241	11,842	399	14,283	13,821	462	-243	-131	-113	-2,041	-63	-24%	-13%	-9%	-14%	-14%	8	4	3	1	1	1
4 WB	476	440	36	684	654	30	7,044	6,432	612	8,570	8,013	557	-4	-81	-207	-1,526	55	-1%	-15%	-30%	-18%	10%	0	4	9	1	1	1
104 EB	818	778	40	834	798	36	6,955	6,301	654	8,830	8,210	620	-130	-108	-16	-1,875	34	-27%	-19%	-2%	-21%	5%	6	5	1	1	0	1
5 NB	594	564	29	740	713	27	8,410	7,896	514	9,341	8,863	478	-222	-22	-146	-932	36	-24%	-3%	-20%	-10%	7%	8	1	6	0	0	0
105 SB	793	767	26	931	912	19	7,596	7,141	455	9,178	8,812	366	-219	-68	-139	-1,581	89	-37%	-11%	-15%	-17%	24%	10	3	5	1	1	1
6 WB	1,463	1,413	50	1,323	1,283	40	17,593	16,750	842	16,734	16,022	713	114	61	140	858	130	10%	5%	11%	5%	18%	3	2	4	2	1	1
106 EB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						#####	#####	#####	#####	#####	#####
7 WB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						#####	#####	#####	#####	#####	#####
107 EB	1,245	1,202	43	1,144	1,118	26	16,543	15,841	702	15,732	15,358	374	-23	77	102	811	328	-2%	7%	9%	5%	88%	1	2	3	4	3	3
8 NB	1,213	1,195	18	1,014	990	25	10,840	10,528	311	10,108	9,822	287	84	29	198	731	25	22%	4%	20%	7%	9%	4	1	6	1	1	1
108 SB	711	693	18	741	719	21	10,363	10,072	291	10,499	10,187	312	43	-49	-30	-136	-21	5%	-6%	-4%	-1%	-7%	1	2	1	2	0	1
9 WB	904	881	23	805	805	-	7,276	6,919	357	7,494	7,494	-	-18	-12	98	-219	357	-5%	-2%	12%	-3%		1	1	3	7	7	7
109 EB	470	445	25	498	498	-	7,093	6,706	388	7,720	7,720	-	-95	-24	-28	-627	388	-13%	-5%	-6%	-8%		4	1	1	8	8	7
10 NB	344	338	6	350	339	11	3,757	3,650	107	4,048	3,907	142	36	-13	-6	-292	-35	17%	-5%	-2%	-7%	-25%	2	1	0	1	1	2
110 SB	328	322	6	313	304	9	3,828	3,728	100	3,778	3,669	108	55	16	15	51	-8	25%	6%	5%	1%	-8%	3	1	1	1	0	1
11 NB	419	412	7	379	367	12	4,689	4,557	132	3,979	3,845	134	52	47	40	710	-3	19%	17%	11%	18%	-2%	3	3	2	0	0	1
111 SB	411	404	7	354	347	7	4,670	4,540	131	3,949	3,852	97	9	58	57	721	34	3%	21%	16%	18%	35%	1	3	3	1	1	0
12 WB	514	486	28	497	489	7	4,640	4,163	477	4,113	3,965	148	36	52	18	527	329	19%	19%	4%	13%	222%	2	3	1	5	5	5
112 EB	301	268	32	252	242	10	4,830	4,306	524	4,133	3,964	169	-93	81	49	696	355	-18%	30%	19%	17%	210%	4	5	3	5	5	5
13 WB	260	244	16	376	365	12	2,608	2,333	275	4,418	4,132	287	-96	-152	-116	-1,810	-12	-39%	-45%	-31%	-41%	-4%	7	9	7	1	0	1
113 EB	195	180	15	303	290	13	2,399	2,132	267	4,216	3,968	248	-147	-157	-107	-1,817	19	-43%	-49%	-35%	-43%	8%	9	10	7	1	0	1
Sites																												
300227_EB	818	778	40	834	798	36	6,955	6,301	654	8,830	8,210	620	-130	-108	-16	-1,875	34	-27%	-19%	-2%	-21%	5%	6	5	1	1	0	1
300227_WB	476	440	36	684	654	30	7,044	6,432	612	8,570	8,013	557	-4	-81	-207	-1,526	55	-1%	-15%	-30%	-18%	10%	0	4	9	1	1	1
300230_EB	878	839	39	774	745	29	7,370	6,727	643	8,098	7,550	548	-59	-52	104	-728	96	-15%	-9%	13%	-9%	17%	3	2	4	1	1	2
300230_WB	486	450	36	647	618	29	7,523	6,922	601	8,364	7,827	536	71	-46	-161	-841	65	10%	-8%	-25%	-10%	12%	3	2	7	1	1	1
300233_EB	1,255	1,203	52	863	826	38	12,763	11,889	874	10,475	9,883	592	62	203	392	2,289	283	9%	29%	45%	22%	48%	2	7	12	3	3	2
300233_WB	848	802	47	803	784	19	10,419	9,627	792	9,364	8,931	433	112	78	45	1,055	360	15%	12%	6%	11%	83%	4	3	2	4	4	5
300240_SB	734	721	13	718	708	10	7,261	6,999	262	7,861	7,595	266	-104	-26	16	-600	-5	-21%	-5%	2%	-8%	-2%	5	1	1	0	0	1
300240_NB	400	388	12	467	451	16	6,379	6,171	208	6,779	6,466	313	-58	-6	-67	-400	-105	-10%	-1%	-14%	-6%	-34%	2	0	3	3	2	1
300244_SB	484	464	20	557	548	9	4,588	4,235	353	5,465	5,248	216	-136	-19	-73	-877	137	-37%	-6%	-13%	-16%	63%	8	1	3	2	2	3
300244_NB	321	300	22	461	446	15	5,024	4,644	380	5,651	5,372	278	-146	5	-140	-627	102	-26%	1%	-30%	-11%	37%	7	0	7	2	2	2
310235_WB	1,372	1,310	61	1,388	1,355	33	17,647	16,592	1,055	16,879	16,153	727	24	74	-16	768	329	2%	6%	-1%	5%	45%	1	2	0	2	3	4
310237_WB	1,766	1,704	63	1,938	1,900	38	20,298	19,219	1,078	20,686	19,922	764	-18	-68	-172	-388	314	-1%	-5%	-9%	-2%	41%	0	2	4	0	3	3
310239_WB	1,463	1,413	50	1,323	1,283	40	17,593	16,750	842	16,734	16,022	713	114	61	140	858	130	10%	5%	11%	5%	18%	3	2	4	2	1	1
320237_EB	1,713	1,650	63	1,654	1,604	50	19,087	18,026	1,061	21,119	20,418	701	-288	-115	59	-2,032	360	-19%	-8%	4%	-10%	51%	8	3	1	4	3	2
320238_EB	1,401	1,349	51	1,177	1,145	33	18,534	17,512	1,021	15,978	15,409	569	59	303	223	2,556	452	5%	29%	19%	16%	79%	2	9	6	5	4	3
370239_WB	1,485	1,434	51	1,256	1,231	25	17,915	17,021	894	15,090	14,549	541	53	223	229	2,825	352	4%	21%	18%	19%	65%	1	7	6	2	4	4
380239_EB	1,280	1,237	43	1,154	1,126	28	16,524	15,638	886	14,630	14,127	502	121	231	126	1,895	384	12%	23%	11%	13%	76%	4	7	4	5	4	3
03A00001_NB	161	149	11	199	193	6	2,211	2,014	197	2,656	2,541	115	-84	-38	-38	-445	82	-31%	-20%	-19%	-17%	71%	6	3	3	2	1	2
03A00001_SB	212	200	11	288	284	4	2,147	1,950	197	2,696	2,576	120	-66	-27	-76	-549	77	-36%	-15%	-26%	-20%	64%	5	2	5	0	1	3
4400000_EB	595	577	18	628	610	18	6,729	6,423	306	7,451	7,010	442	-122	-67	-33	-722	-135	-22%	-12%	-5%	-10%	-31%	6	3	1	1	2	0
4400000_WB	414	405	9	652	637	15	4,747	4,593	154	7,676	7,191	485	-310	-241	-238	-2,929	-330	-55%	-40%	-36%	-38%	-68%	15	11	10	5	5	2
4400004_EB	195	180	15	303	290	13	2,399	2,132	267	4,216	3,968	248	-147	-157	-107	-1,817	19	-43%	-49%	-35%	-43%	8%	9	10	7	1	0	1
4400004_WB	260	244	16	376	365	12	2,608	2,333	275	4,418	4,132	287	-96	-152	-116	-1,810	-12	-39%	-45%	-31%	-41%	-4%	7	9	7	1	0	1
4500003_EB	470	445	25	498	498	-	7,093	6,706	388	7,720	7,720	-	-95	-24	-28	-627	388	-13%	-5%	-6%	-8%		4	1	1	8	8	7
4500003_WB	904	881	23	805	805	-	7,276	6,919	357	7,494	7,494	-	-18	-12	98	-219	357	-5%	-2%	12%	-3%		1	1	3	7	7	7
4500009_EB	301	268	32	252	242	10	4,830	4,306	524	4,133	3,964	169	-93	81	49	696	355	-18%	30%	19%	17%	210%	4	5	3	5	5	5
4500009_WB	514	486	28	497	489	7	4,640	4,163	477	4,113	3,965	148	36	52	18	527	329	19%	19%	4%	13%	222%	2	3	1	5	5	5
4520001_EB	1,245	1,202	43	1,144	1,118	26	16,543	15,841	702	15,732	15,358	374	-23	77	102	811	328	-2%	7%	9%	5%	88%	1	2	3	4	3	3

Ngāmotu Strategic Transport Model

Link Validation Results

Screenlines

MRun14

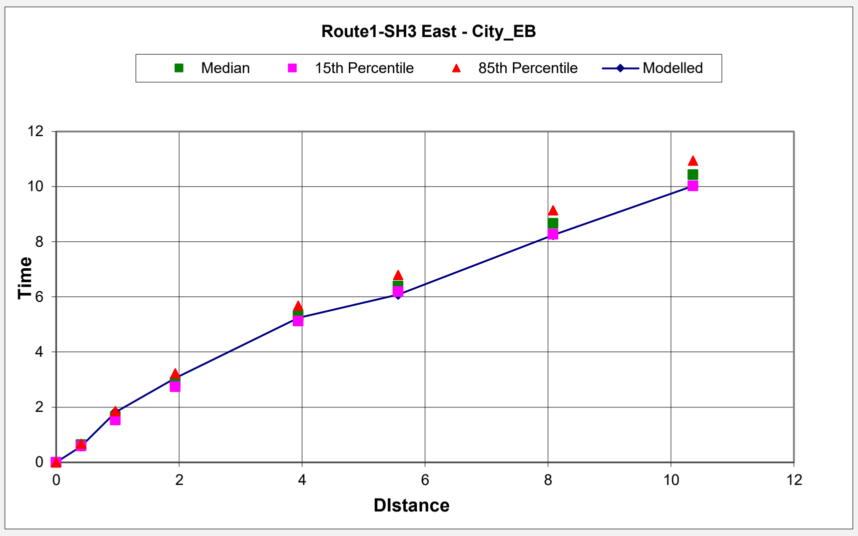
							AM_Mod_Total	AM_Mod_Light	AM_Mod_Heavy	AM_Obs_Total	AM_Obs_Light	AM_Obs_Heavy	IP_Mod_Total	IP_Mod_Light	IP_Mod_Heavy	IP_Obs_Total	IP_Obs_Light	IP_Obs_Heavy	PM_Mod_Total	PM_Mod_Light	PM_Mod_Heavy	PM_Obs_Total	PM_Obs_Light	PM_Obs_Heavy	Daily_Mod_Total	Daily_Mod_Light	Daily_Mod_Heavy	Daily_Obs_Total	Daily_Obs_Light	Daily_Obs_Heavy																
							AM Peak Average Peak Hour (07:00-09:00)						Interpeak (09:00-16:00)						PM Peak (16:00-18:00)						Daily 24hrs						Total Flow Stats										Total			HCV		
							Modelled			Observed			Modelled			Observed			Modelled			Observed			Modelled			Observed			Difference					% Difference					GEH			GEH		
Ref	Screenline	Direction	Anode	Bnode	Description	Link Ref	Total	Light	Heavy	Total	Light	Heavy	Total	Light	Heavy	Total	Light	Heavy	Total	Light	Heavy	Total	Light	Heavy	Total	Light	Heavy	Total	Light	Heavy	AM	IP	PM	ADT	ADT_H	AM	IP	PM	ADT	ADT_H	AM	IP	PM	AM	IP	PM
24123_NB	11	NB	1625	1626	Barrett Rd Pararewa Dr to Honeyfield Dr	1625_1626	40	39	1	48	46	2	37	36	1	45	42	3	40	39	1	43	42	1	521	506	15	598	571	27	-8	-7	-3	-77	-11	-16%	-17%	-8%	-13%	-43%	1	1	1	1	1	0
24126_SB		SB	1484	1460	Paritutu Rd Ngamotu Rd to Simons St	1484_1460	32	31	1	45	42	3	32	31	1	53	51	3	42	41	1	66	64	2	464	452	12	764	735	30	-13	-21	-24	-301	-17	-29%	-39%	-36%	-39%	-59%	2	3	3	2	1	1
24126_NB		NB	1460	1484	Paritutu Rd Ngamotu Rd to Simons St	1460_1484	20	19	1	47	44	3	26	25	1	52	50	2	32	32	0	55	55	1	352	343	9	756	732	25	-27	-27	-23	-404	-16	-57%	-51%	-41%	-53%	-65%	5	4	3	2	1	0
24131_SB		SB	1128	1129	Brougham St Devon St west to Powderham St	1128_1129	17	16	1	46	44	2	32	32	1	138	133	4	72	71	1	121	117	3	500	492	8	1,634	1,572	62	-29	-106	-49	-1,134	-54	-63%	-77%	-40%	-69%	-87%	5	11	5	1	2	2
24131_NB		NB	1129	1128	Brougham St Devon St west to Powderham St	1129_1128	0	0	-	59	57	2	0	0	-	89	87	2	0	0	-	84	83	1	1	1	0	1,248	1,221	26	-59	-89	-84	-1,247	-26	-100%	-100%	-100%	-100%	-100%	11	13	13	2	2	2
24132_SB		SB	1358	1320	Hobson St Molesworth St to Devon St East RO	1358_1320	357	335	22	338	309	29	400	379	21	442	409	34	527	511	17	508	476	32	5,664	5,381	283	5,849	5,427	422	19	-42	19	-184	-139	6%	-9%	4%	-3%	-33%	1	2	1	1	2	3
24132_NB		NB	1320	1358	Hobson St Molesworth St to Devon St East RO	1320_1358	207	197	10	376	357	19	265	255	10	391	373	18	297	289	7	391	377	14	3,547	3,418	130	5,037	4,819	218	-169	-126	-94	-1,490	-89	-45%	-32%	-24%	-30%	-41%	10	7	5	2	2	2
25063_WB		WB	1545	1546	Tukapa St Sanders Ave to David St	1545_1546	345	329	16	334	322	13	498	482	16	528	513	15	679	667	12	601	588	13	6,861	6,653	208	7,020	6,832	188	10	-30	78	-159	20	3%	-6%	13%	-2%	11%	1	1	3	1	0	0
25063_EB		EB	1546	1545	Tukapa St Sanders Ave to David St	1546_1545	504	488	16	479	459	20	492	477	15	567	549	19	512	500	12	525	513	12	6,785	6,583	202	7,276	7,060	216	25	-75	-13	-491	-15	5%	-13%	-3%	-7%	-7%	1	3	1	1	1	0
25064_WB		WB	1545	1546	Tukapa St Sanders Ave to David St o/s69	1545_1546	345	329	16	333	321	12	498	482	16	518	504	14	679	667	12	612	597	14	6,861	6,653	208	7,005	6,816	188	12	-20	67	-144	19	4%	-4%	11%	-2%	10%	1	1	3	1	0	1
25064_EB		EB	1546	1545	Tukapa St Sanders Ave to David St o/s69	1546_1545	504	488	16	466	448	18	492	477	15	541	524	17	512	500	12	540	527	12	6,785	6,583	202	7,165	6,959	206	38	-49	-28	-380	-4	8%	-9%	-5%	-5%	-2%	2	2	1	1	0	0
25065_SB		SB	1588	1188	Omata Rd Tukapa St to Seaview Rd	1588_1188	229	217	12	216	208	8	216	204	12	197	193	4	230	221	9	251	249	2	3,011	2,851	160	2,952	2,898	55	13	19	-21	59	106	6%	10%	-8%	2%	193%	1	1	1	1	3	3
25065_NB		NB	1188	1588	Omata Rd Tukapa St to Seaview Rd	1188_1588	190	178	12	165	155	11	196	184	12	168	162	6	274	265	9	239	232	7	2,851	2,698	153	2,589	2,497	91	24	29	35	262	62	15%	17%	15%	10%	68%	2	2	2	0	2	1
25066_NB	3	NB	1736	1392	Mangorei Rd Te Mete Tce to Cumberland St	1736_1392	131	123	8	183	172	11	199	191	8	278	267	11	317	311	6	398	390	8	2,838	2,732	106	3,826	3,695	130	-52	-79	-81	-988	-25	-28%	-28%	-20%	-26%	-19%	4	5	4	1	1	1
25066_SB	103	SB	1392	1736	Mangorei Rd Te Mete Tce to Cumberland St	1392_1736	246	240	6	392	380	13	185	180	5	293	282	12	184	180	4	279	271	8	2,669	2,599	70	4,119	3,980	139	-146	-108	-95	-1,450	-69	-37%	-37%	-34%	-35%	-50%	8	7	6	2	2	2
25072_EB		EB	1262	1735	Devon St East Eliot St to Hobson St	1262_1735	205	195	9	170	163	7	172	163	9	249	242	7	255	246	9	229	224	5	2,633	2,510	123	2,959	2,876	82	34	-77	25	-325	41	20%	-31%	11%	-11%	49%	2	5	2	1	1	1
25072_WB		WB	1735	1262	Devon St East Eliot St to Hobson St	1735_1262	69	64	4	95	89	6	93	88	4	189	183	6	381	367	14	176	172	4	1,925	1,841	84	2,229	2,160	69	-27	-96	205	-303	15	-28%	-51%	116%	-14%	22%	3	8	12	1	1	3
25074_WB		WB	1328	1312	Gilbert St Liardet St to Gover St	1328_1312	48	47	2	49	48	1	60	59	2	55	55	1	73	72	1	93	92	1	823	804	19	777	768	10	-1	5	-19	46	10	-1%	8%	-21%	6%	101%	0	1	2	1	1	0
25074_EB		EB	1312	1328	Gilbert St Liardet St to Gover St	1312_1328	20	19	0	101	97	4	32	31	1	58	56	2	136	134	3	84	82	1	666	651	14	913	889	24	-81	-26	53	-248	-10	-81%	-45%	63%	-27%	-41%	10	4	5	2	1	1
25078_WB		WB	1358	1445	Molesworth St Eliot St to Hobson St	1358_1445	198	189	9	328	308	20	256	246	9	351	333	18	287	280	7	369	356	12	3,418	3,296	122	4,574	4,354	220	-130	-95	-82	-1,156	-98	-40%	-27%	-22%	-25%	-45%	8	5	5	3	2	2
25078_EB		EB	1445	1358	Molesworth St Eliot St to Hobson St	1445_1358	345	324	22	304	288	16	392	371	21	401	376	26	519	502	16	470	444	26	5,545	5,269	276	5,386	5,055	330	42	-9	49	159	-54	14%	-2%	10%	3%	-16%	2	0	2	1	1	2
26073_NB		NB	1687	1476	Carrington Rd Urban/Rural BDY to Baker Rd	1687_1476	11	10	1	23	20	2	22	21	1	42	39	2	33	32	1	66	64	2	296	284	13	595	567	28	-11	-20	-33	-298	-15	-51%	-49%	-50%	-50%	-55%	3	4	5	1	1	1
26073_SB		SB	1476	1687	Carrington Rd Urban/Rural BDY to Baker Rd	1476_1687	26	25	1	54	51	3	21	20	1	44	41	3	21	20	1	42	40	2	303	290	13	595	563	32	-28	-22	-21	-292	-20	-51%	-51%	-49%	-49%	-61%	4	4	4	2	1	1
26075_SB	105	SB	1157	1158	Carrington St Tarahua Rd to Huatoki St 3565 O/S 404	1157_1158	105	99	5	95	88	7	176	171	5	168	160	8	263	259	4	268	262	6	2,436	2,368	68	2,348	2,260	89	10	8	-5	88	-20	10%	4%	-2%	4%	-23%	1	1	0	1	1	1
26075_NB	5	NB	1158	1157	Carrington St Tarahua Rd to Huatoki St 3565 O/S 404	1158_1157	211	205	5	238	225	13	174	169	5	164	154	11	180	176	4	164	156	8	2,480	2,411	68	2,344	2,211	133	-27	10	16	136	-64	-11%	6%	10%	6%	-48%	2	1	1	2	2	2
26077_NB		NB	1041	1888	Liardet St Gill St to Devon St East	1041_1888	0	0	-	66	57	9	0	0	-	176	168	8	0	0	-	176	166	10	1	1	0	2,111	2,004	107	-66	-176	-176	-2,111	-107	-100%	-100%	-100%	-100%	-100%	11	19	19	4	4	5
26077_SB		SB	1888	1041	Liardet St Gill St to Devon St East	1888_1041	58	56	2	111	100	12	61	59	2	226	217	9	89	87	3	174	163	11	892	867	25	2,488	2,367	121	-54	-165	-84	-1,596	-96	-48%	-73%	-49%	-64%	-80%	6	14	7	4	3	3
26078_EB	102	EB	1252	1251	Devon St East Watson St to Nobs Line	1252_1251	431	416	15	661	615	46	459	444	15	703	663	40	494	482	12	696	670	26	6,276	6,078	198	8,796	8,321	475	-229	-243	-202	-2,520	-277	-35%	-35%	-29%	-29%	-58%	10	10	8	5	5	3
26078_WB	2	WB	1251	1252	Devon St East Watson St to Nobs Line	1251_1252	250	239	11	462	441	22	357	345	12	652	627	25	739	719	20	698	678	20	5,554	5,375	179	8,146	7,854	292	-212	-295	40	-2,592	-113	-46%	-45%	6%	-32%	-39%	11	13	2	3	3	0
27065_NB	10	NB	1655	1596	Seaview Rd Devon St west to cook St	1655_1596	110	104	6	95	88	7	153	148	6	155	147	7	220	216	4	198	189	9	2,146	2,074	72	2,219	2,123	97	15	-2	22	-73	-25	16%	-1%	11%	-3%	-26%	2	0	2	0	1	2
27065_SB	110	SB	1596	1655	Seaview Rd Devon St west to cook St	1596_1655	181	176	5	128	122	6	156	151	5	127	123	4	171	167	4	142	140	2	2,226	2,158	68	1,898	1,846	52	53	29	29	327	16	42%	23%	21%	17%	31%	4	2	2	0	1	1
27067_SB		SB	1889	1196	Cook St Clerke Pl to Grenville St	1889_1196	17	16	1	19	17	3	41	40	1	48	45	3	77	77	1	62	59	3	593	581	12	709	677	33	-2	-7	16	-117	-21	-12%	-14%	25%	-16%	-64%	1	1	2	1	1	2
27067_NB		NB	1196	1889	Cook St Clerke Pl to Grenville St	1196_1889	63	62	1	35	33	2	41	40	1	46	45	1	35	35	1	45	45	1	601	590	11	671	659	13	28	-4	-10	-70	-2	81%	-10%	-22%	-10%	-12%	4	1	2	1	0	0
27074_NB		NB	1576	1608	Frankley Rd Govett Ave to Waimea St	1576_1608	42	40	2	50	49	1	70	68	2	78	76	2	120	119	1	157	153	4	1,009	985	23	1,215	1,185	30	-8	-8	-36	-207	-7	-16%	-11%	-23%	-17%	-22%	1	1	3	0	0	2
27074_SB		SB	1608	1576	Frankley Rd Govett Ave to Waimea St	1608_1576	80	78	2	139	135	4	66	64	2	79	75	3	63	62	1	74	71	3	925	904	21	1,202	1,158	44	-59	-13	-11	-277	-23	-43%	-16%	-15%	-23%	-52%	6	2	1	1	1	1
27076_WB		WB	1558	1557	waimea St Pembroke St to Frankley Rd	1558_1557	404	389	16	271	262	9	396	380	16	256	250	6	447	435	11	327	319	8	5,544	5,342	202	3,682	3,599	83	133	139	120	1,861	118	49%	54%	37%	51%	142%	7	8	6	2	3	1
27076_EB		EB	1557	1558	waimea St Pembroke St to Frankley Rd	1557_1558	372	356	16	230	222	8	394	377	17	241	233	8	491	480	11	303	298	5	5,557	5,345	212	3,429	3,339	90	142	153	188	2,127	122	62%	63%	62%	62%	135%	8	9	9	2	3	2
27077_EB		EB	1504	1072	Poplar Gr Barrett Rd to Viginia Pl	1504_1072	101	98	4	86	78	7	96	92	4	105	100	5	104	101	2	119	114	5	1,342	1,296	46	1,402	1,332	70	16	-9	-15	-60	-24	19%	-9%	-13%	-4%	-35%	2	1	1	2	1	1
27077_WB		WB	1072	1504	Poplar Gr Barrett Rd to Viginia Pl	1072_1504	70	67	4	73	69	4	100	96	4	104	101	3	144	141	3	127	125	3	1,396	1,350	46	1,402	1,364	38	-3	-4	17	-6	8	-4%	-4%	13%	0%	21%	0	0	1	0	0	0
27078_WB		WB	1177	1176	Clemow Rd Fitzroy Rd to End	1177_1176	24	23	1	25	22	3	21	20	1	70	67	3	22	22	0	79	76	3	293	286	7	913	872	41	-1	-50	-57	-619	-34	-3%	-71%	-72%	-68%	-83%	0	7	8	2	2	2
27078_EB		EB	1176	1177	Clemow Rd Fitzroy Rd to End	1176_1177	13	12	1	27	25	3	21	20	1	73	70	3	30	30	0	75	73	2	289	282	7	917	887	30	-14	-52	-45	-628	-23	-53%	-71%	-60%	-68%	-76%	3	8	6	2	2	1
27080_WB		WB	1261	1717	Devon St West Egmont St to Dawson St 408	1261_1717	140	132	8	108	105	3	262	253	8	232	228	4	356	350	6	259	256	2	3,499	3,393	106	3,149	3,105	44	33	30	98	350	61	30%	13%	38%	11%	138%	3	2	6	2	2	2
27080_EB		EB	1717	1261	Devon St West Egmont St to Dawson St 408	1717_1261	182	170	12	210	205	5	217	209	8	310	304	6	301	294	7	263	258	5	3,076	2,959	116	3,864	3,789	76	-28	-93	38	-789	41	-14%	-30%	14%	-20%	54%	2	6	2	2	1	1
27081_SB	110	SB	1090	1091	Belair Ave South Rd to Omata Rd	1090_1091	93	91	2	91	88	3	113	111	3	127	123	4	157	155	2	171	164	7	1,603	1,570	33	1,879	1,823	57	1	-13	-14	-277	-24	1%	-11%	-8%	-15%	-42%	0	1	1	1	1	2
27081_NB	10	NB	1091	1090	Belair Ave South Rd to Omata Rd	1091_1090	142	139	3	121	117	5	110	107	3	122	118	3	124	122	2	152	150	2	1,611	1,576	35	1,829	1,784	45	21	-12	-28	-218	-10	17%	-10%	-19%	-12%	-22%	2	1	2	1	0	0
26081_NB		NB	2225	2113	Egmont Rd Speed Limit to S/H3 Junction Rd	2225_2113	57	54	3	85	64	21	50	47	3	86	71	15	72	70	2	131	122	10	750	713	36	1,204	1,015	189	-28	-36	-59	-454	-153	-33%	-42%	-45%	-38%	-81%	3	4	6	5	4	3
26081_SB		SB	2113	2225	Egmont Rd Speed Limit to S/H3 Junction Rd	2113_2225	52	49	3	108	99	10	53	50	2	87	74	13	58	56	2	76	69	6	727	694	32	1,194	1,055	139	-57	-35	-18	-467	-107	-52%	-40%	-23%	-39%	-77%	6	4	2	3	4	2
7051_EB		EB	2145	2144	Kelly St Inglewood Pukatea St to Inglewood High School	2145_2144	52	51	1	51	46	5	51	50	1	55	52	3	51	50	1	80	77	3	699	683	16	844	802	42	1	-4	-29	-145	-25	1%	-7%	-37%	-17%	-61%	0	1	4	2	1	1
7051_WB		WB	2144	2145	Kelly St Inglewood Pukatea St to Inglewood High School	2144_2145	34	33	1	64	61	3	40	39	1	54	52	2	57	56	1	57	56	1	572	558	14	781	757	24	-30	-14	0	-209	-10	-46%	-26%	0%	-27%	-43%	4	2	0	1	0	0
11186_EB		EB	2240	2104	Brookes St SH3 to Mahoe St	2240_2104	18	17	1	18	16	2	21	21	1	32	29	3	22	21	1	49	44	6	285	273	12	438	394	44	0	-10	-27	-154	-32	2%	-33%	-56%	-35%	-73%	0	2	5	1	2	3
11186_WB		WB	2104	2240	Brookes St SH3 to Mahoe St	2104_2240	10	9	1	36	32	4	18	18	1	39	36	3	30	29	1	52	50	2	259	250	9	535	495	39	-26	-20	-22	-276	-31	-72%	-52%	-42%	-52%	-78%	5	4	3	2	2	1
18389_NB		NB	2290	2289	Nelson St Waitara End of Traffic Island to Parris St	2290_2289	144	131	13	214	202	11	176	164	12	231	222	9	266	257	9	199	195	4	2,540	2,381	159	3,077	2,958	119	-70	-56	67	-536	40	-33%	-24%	34%	-17%	34%	5	4	4	0	1	2
18389_SB		SB	2289	2290	Nelson St Waitara End of Traffic Island to Parris St	2289_2290	227	215	12	175	155	20	179	167	12	224	208	16	186	177	9	270	254	15	2,579	2,420	159	3,003	2,790	212	52	-45	-84	-424	-54	30%	-20%	-31%	-14%	-25%	4	3	6	2	1	2
17188_NB		NB	2291	2292	North St Waitara Bridge East AButment to Richmond/Mi	2291_2292	164	157	7	188	180	9	179	172	7	234	228	6	280	275	5	238	232	5	2,653	2,564	88	3,023	2,946	77	-25	-55	42	-370	12	-13%	-23%	18%	-12%	16%	2	4	3	1	1	0
17188_SB		SB	2292	2291	North St Waitara Bridge East AButment to Richmond/Mi	2292_2291	217	210	7	140	132	8	193	187	7	240	235	5	192	187	5	303	299	4	2,691	2,602	88	3,197	3,126	71	76	-46	-111	-506	18	55%	-19%	-37%	-16%	25%	6	3	7	0	1	1
20342_SB		SB	2199	2206	Wairau Rd lower Telford Tce to Messenger Tce	2199_2206	11	11	1	45	42	3	21	21	1	51	47	3	25	24	1	54	52	1	274	265	10	623	590	33	-34	-30	-29	-349	-23	-75%	-58%	-54%	-56%	-70%	6	5	5	2	2	1
20342_NB		NB	2206	2199	Wairau Rd lower Telford Tce to Messenger Tce	2206_2199	20	19	1	29	26	4	22	21	1	50	47	3	21	21	1	62	60	2	289	279	10	601	568	33	-9	-28	-40	-312	-23	-33%	-56%	-66%	-52%	-70%	2	5	6	2	2	1
7041_EB		EB	2194	2199	Tasman Parade Wairau Rd to Jans Tce	2194_2199	73	71	1	29	27	2	55	53	1	62	59	4	56	55	1	86	84	2	792	774	18	802	764	38	43	-8	-30	-10	-20	147%	-13%	-35%	-1%	-53%	6	1	4	1	1	1
7041_WB		WB	2199	2194	Tasman Parade Wairau Rd to Jans Tce	2199_2194	33	32	1	59	57	3	56	55	1	63	59	4	84	83	1	63	60	3	778	760	18	801	760	42	-26	-7	21	-23	-24	-43%	-10%	34%	-3%	-57%	4	1	2	1	2	1

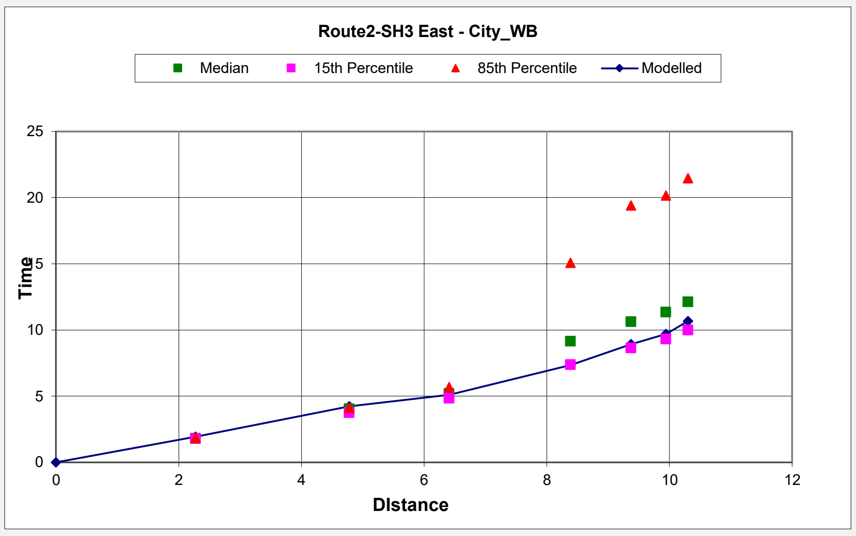
B

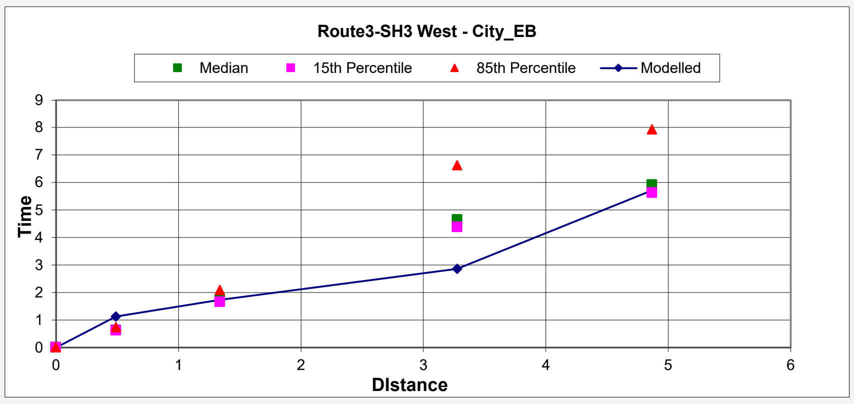
Appendix B – Travel Time Validation Results

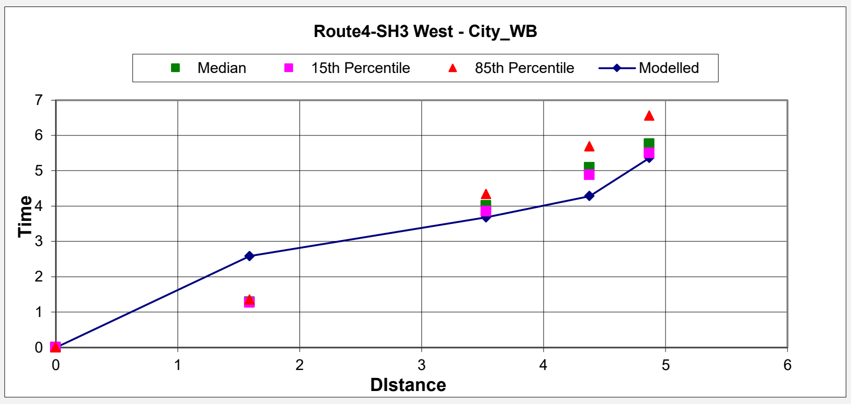
Ngāmotu Strategic Transport Model (Ngāmotu STM)

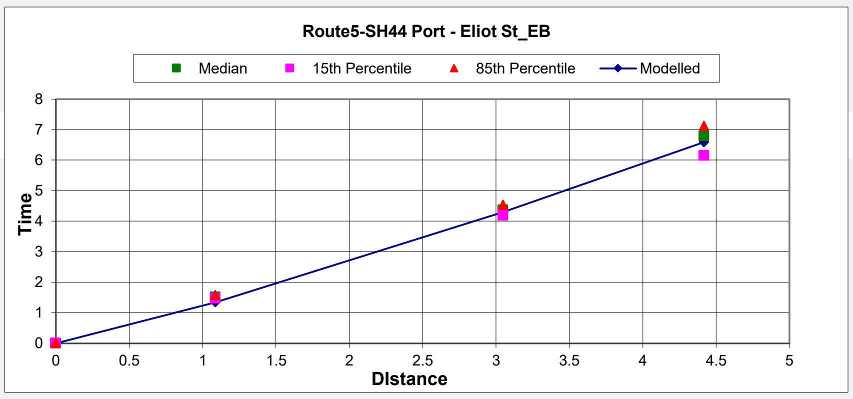
2018 Route Travel Time (min) vs Distance (km) Plots - AM Peak Hour

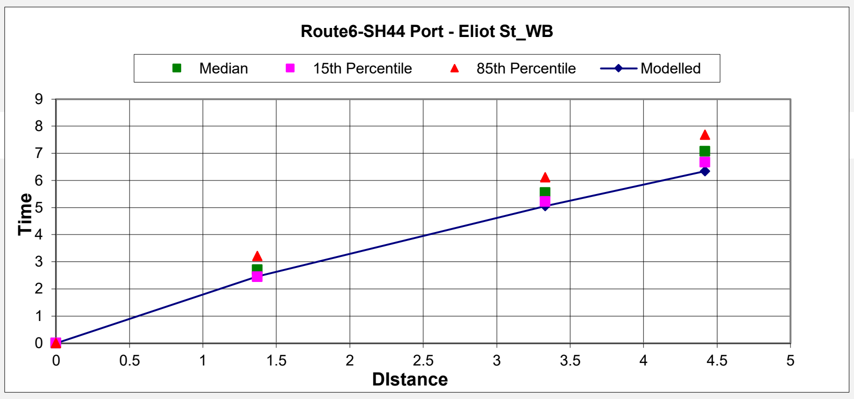


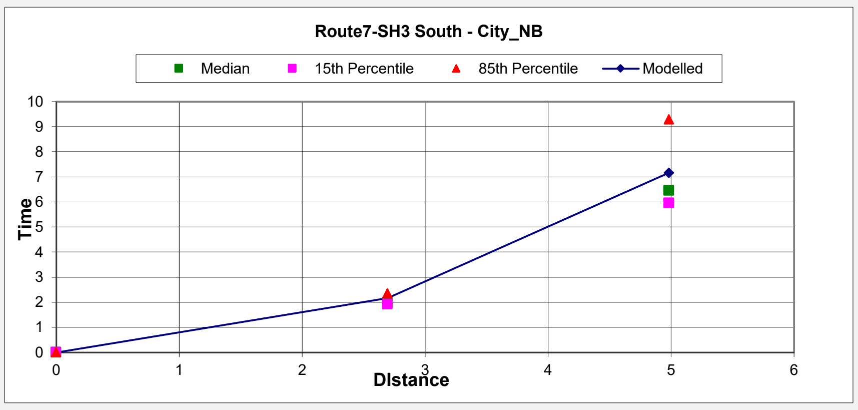


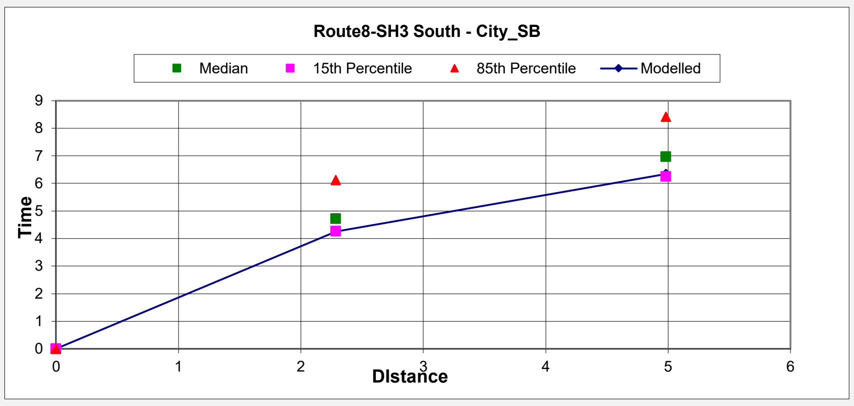


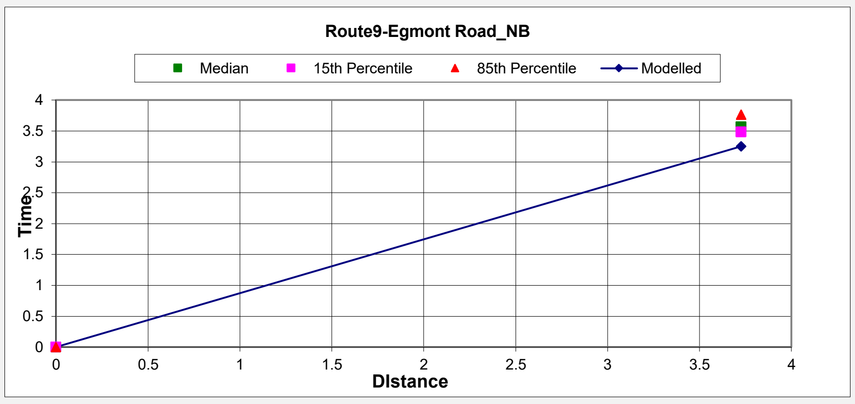


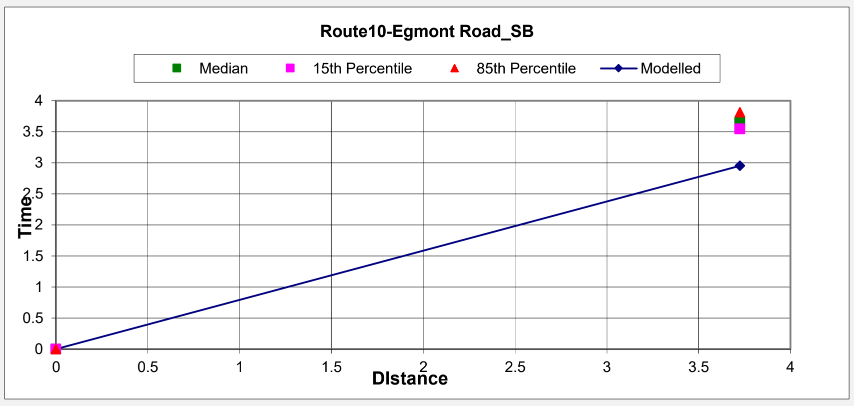


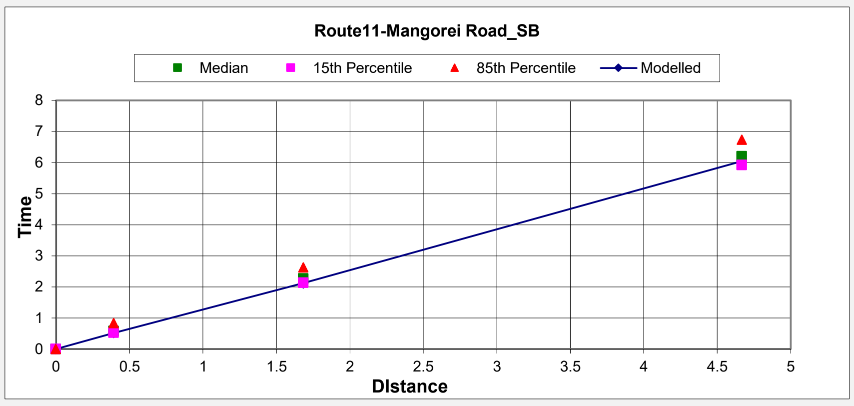


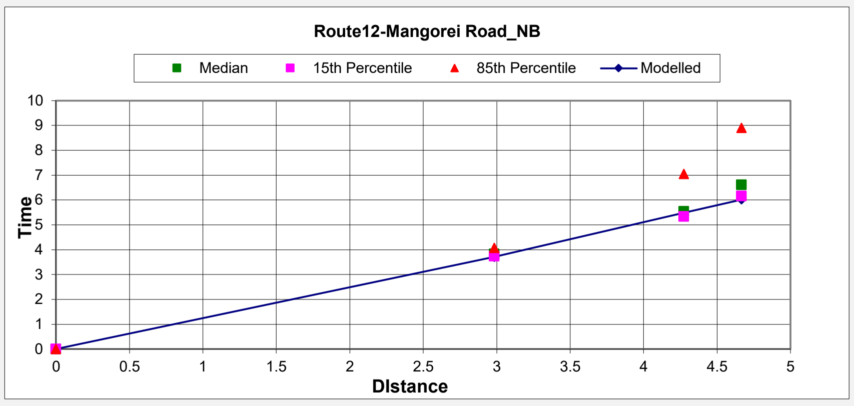




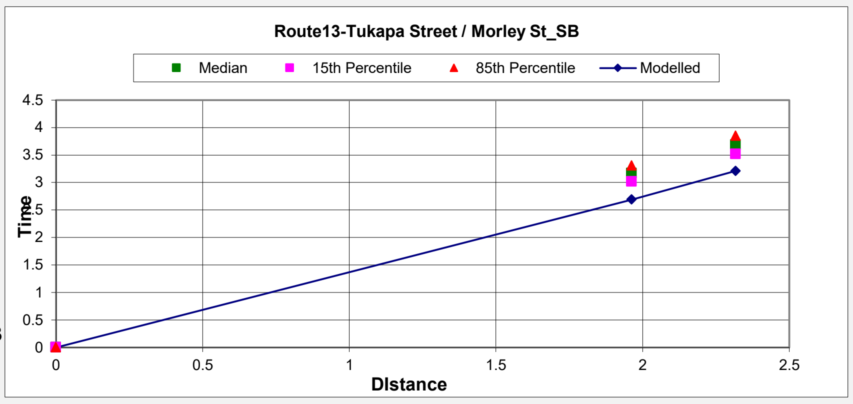


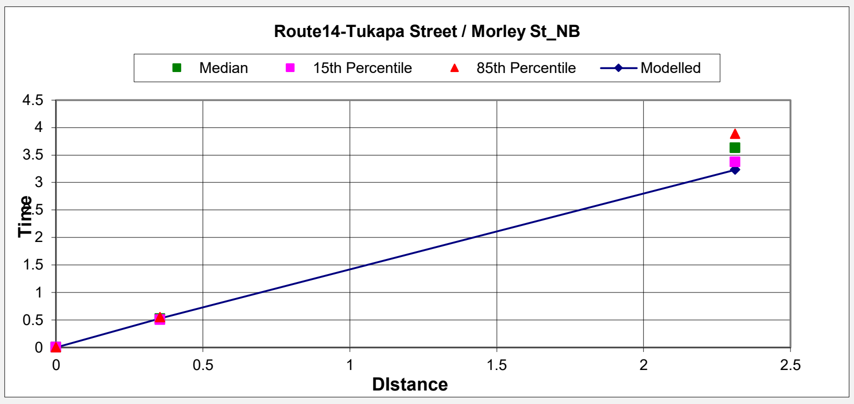


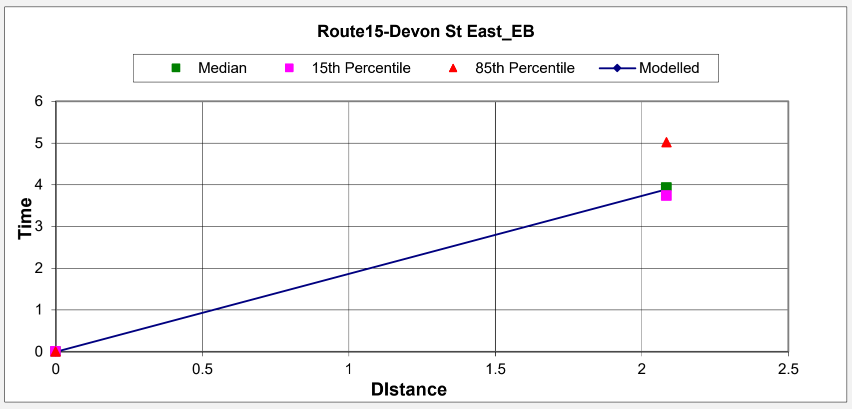

Route11-Mangorei Road_SB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

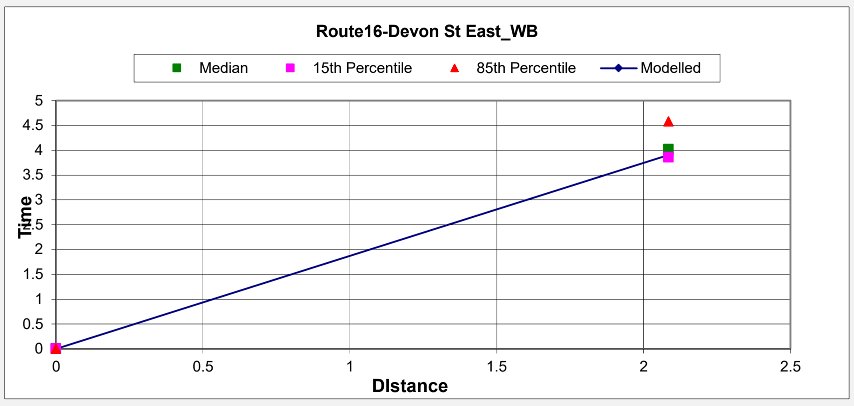

Route12-Mangorei Road_NB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

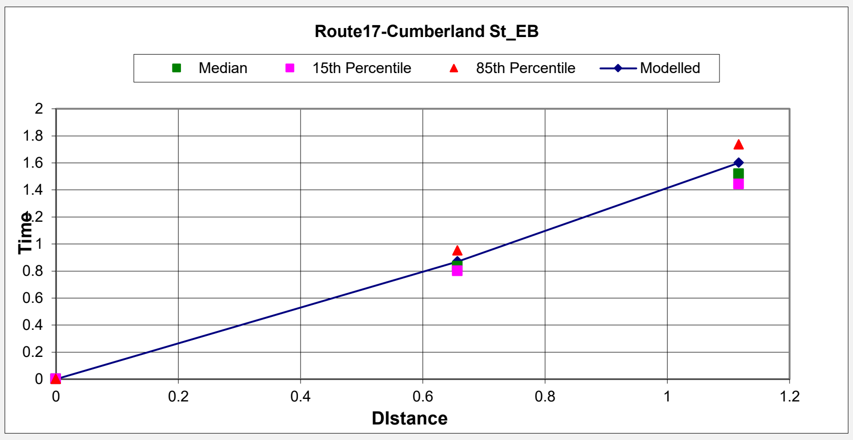
-3.23

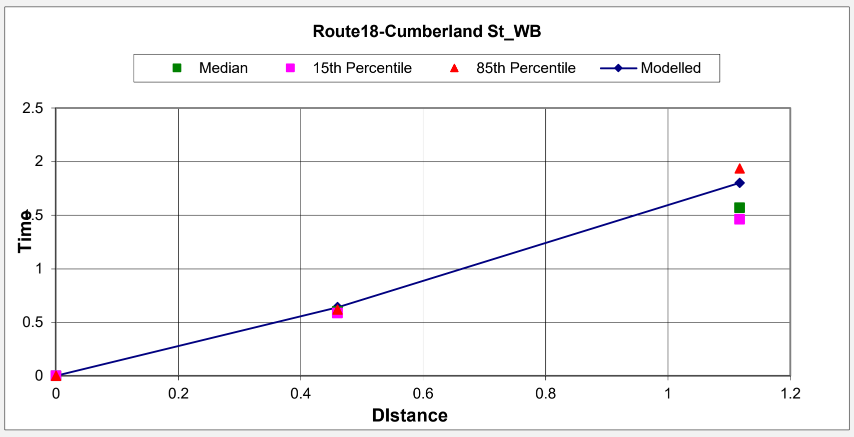

Route13-Tukapa Street / Morley St_SB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

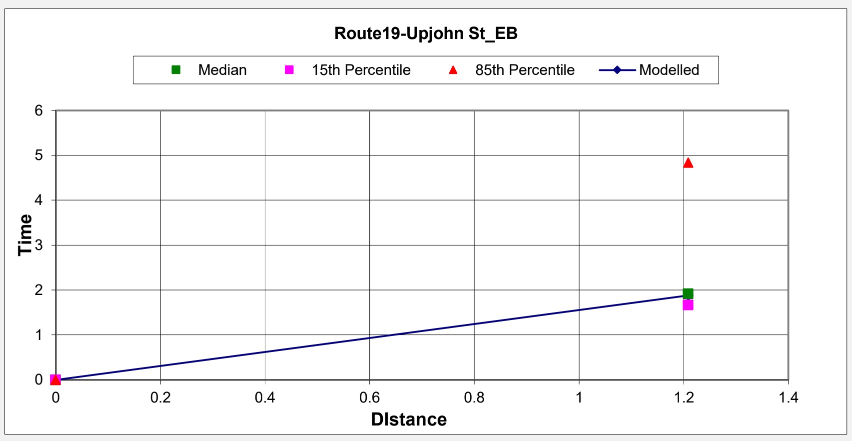

Route14-Tukapa Street / Morley St_NB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

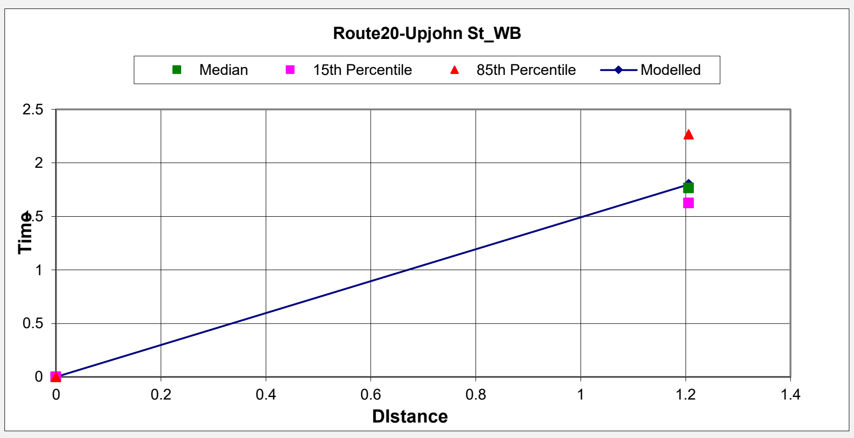

Route15-Devon St East_EB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

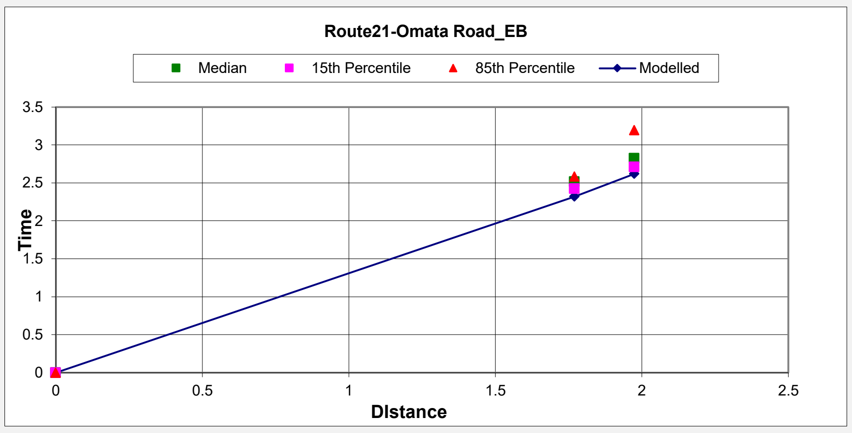

Route16-Devon St East_WB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

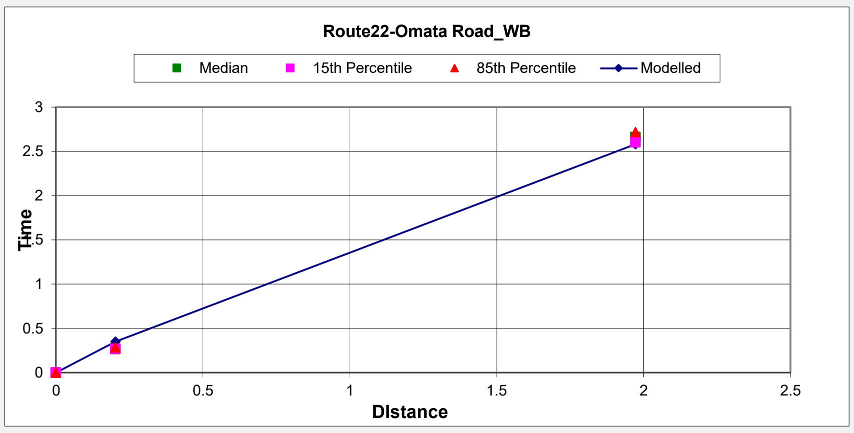

Route17-Cumberland St_EB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

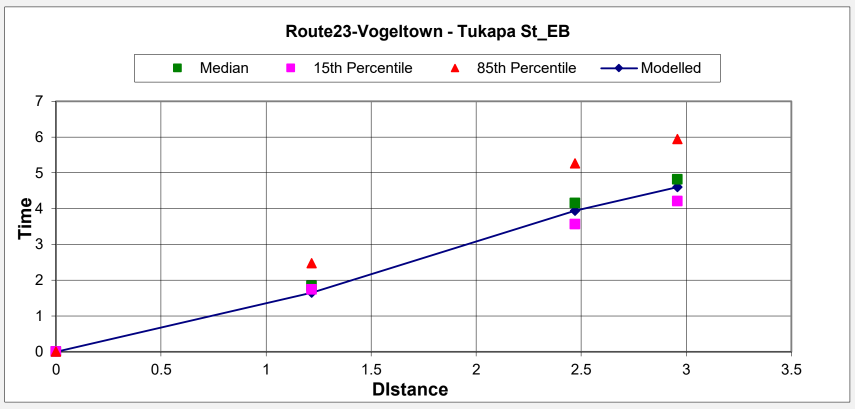

Route18-Cumberland St_WB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

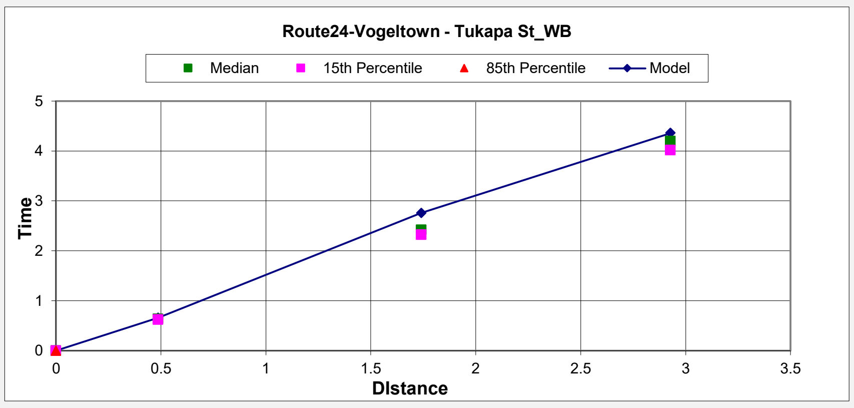

Route19-Upjohn St_EB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

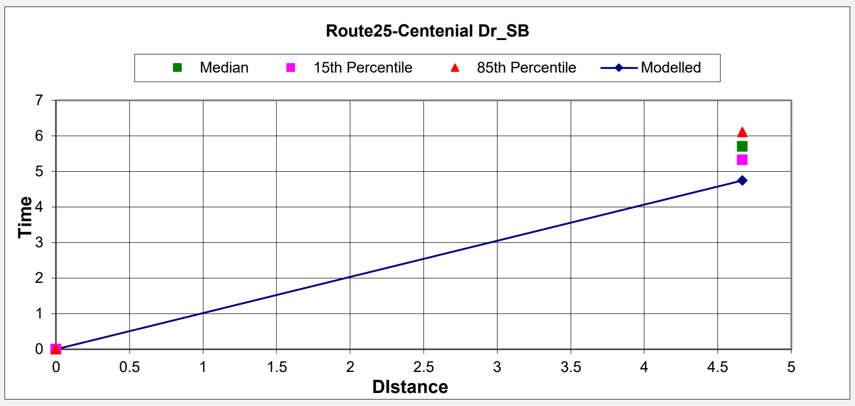

Route20-Upjohn St_WB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

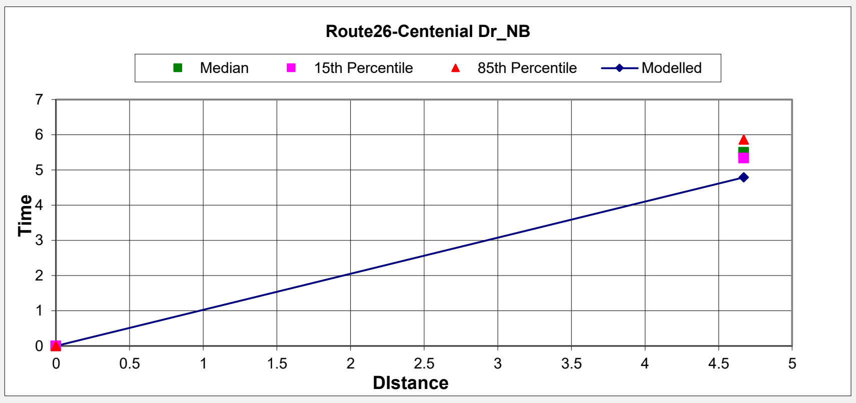

Route21-Omata Road_EB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

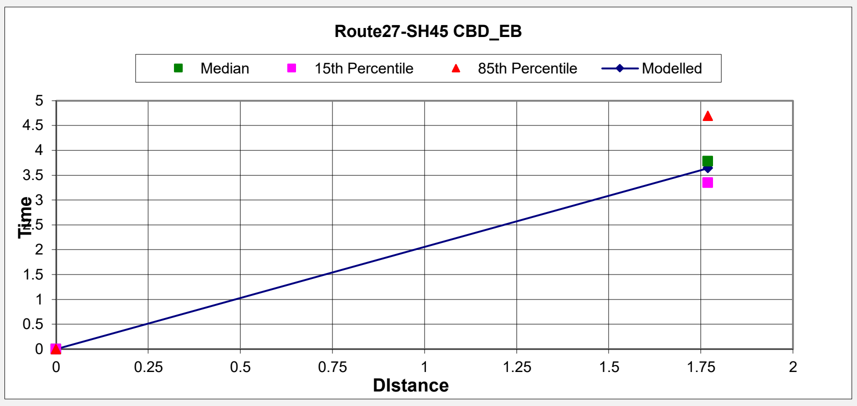

Route22-Omata Road_WB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

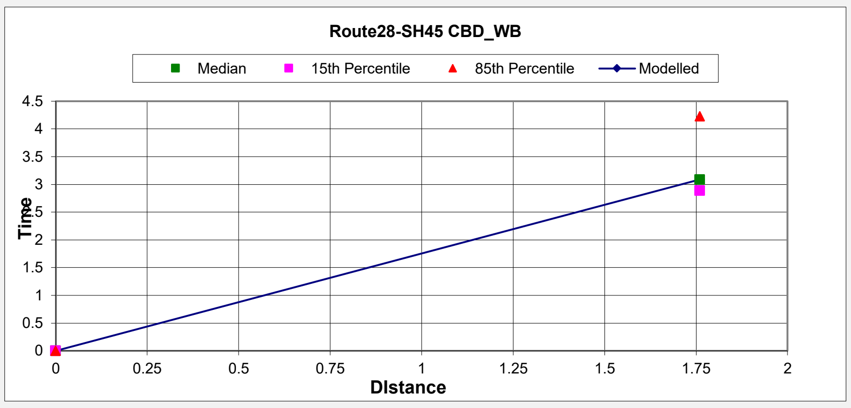

Route23-Vogeltown - Tukapa St_EB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance


Route24-Vogeltown - Tukapa St_WB
Median
15th Percentile
85th Percentile
Model
Time
Distance


Route25-Centenial Dr_SB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

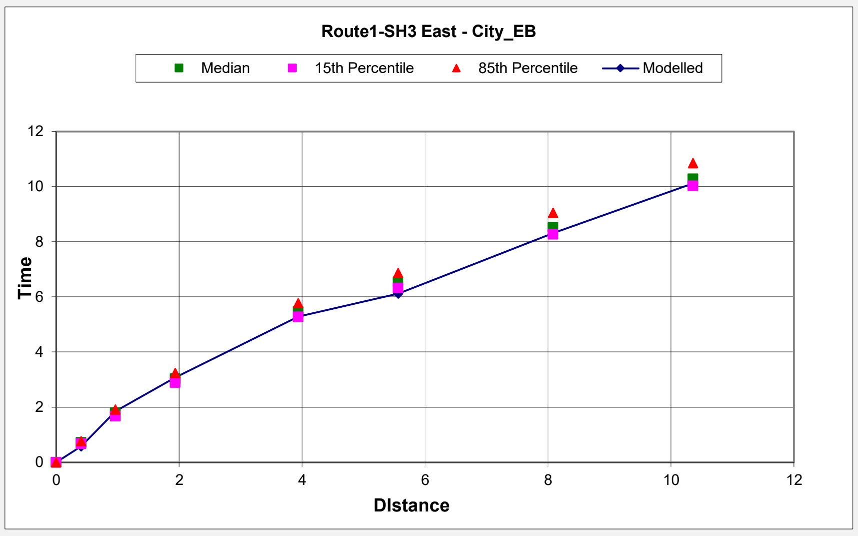

Route26-Centenial Dr_NB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

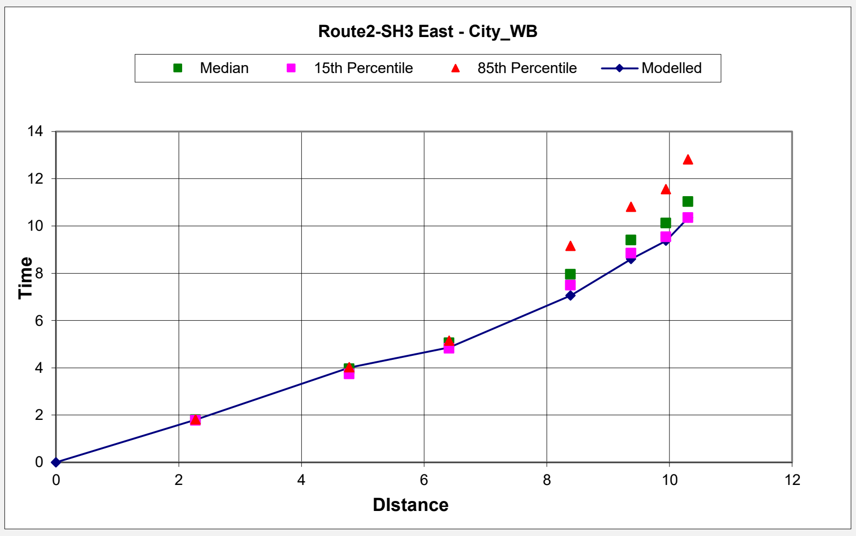

Route27-SH45 CBD_EB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

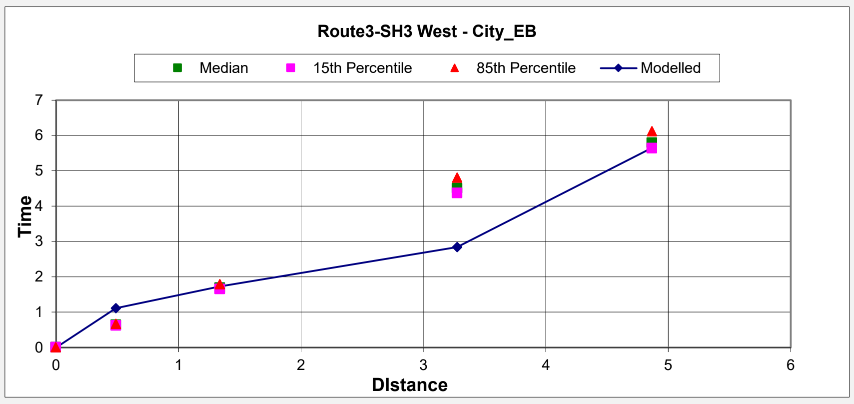

Route28-SH45 CBD_WB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

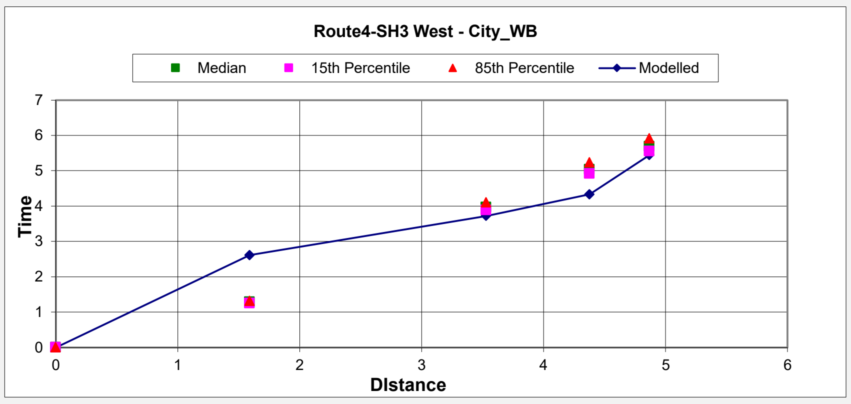
Ngāmotu Strategic Transport Model (Ngāmotu STM)

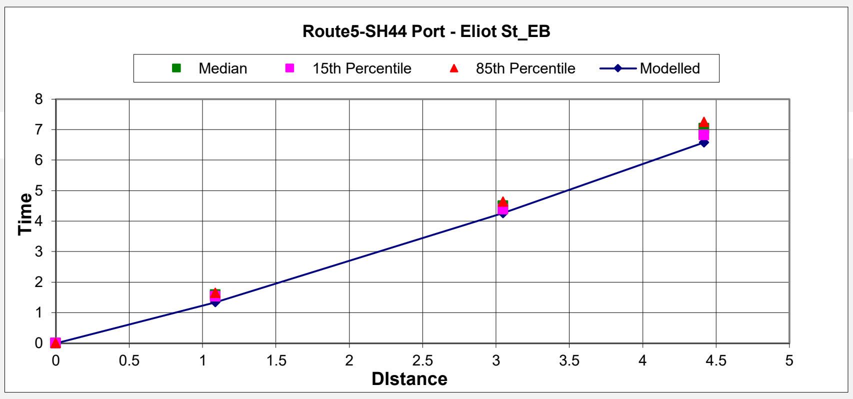
2018 Route Travel Time (min) vs Distance (km) Plots - Inter Peak Hour

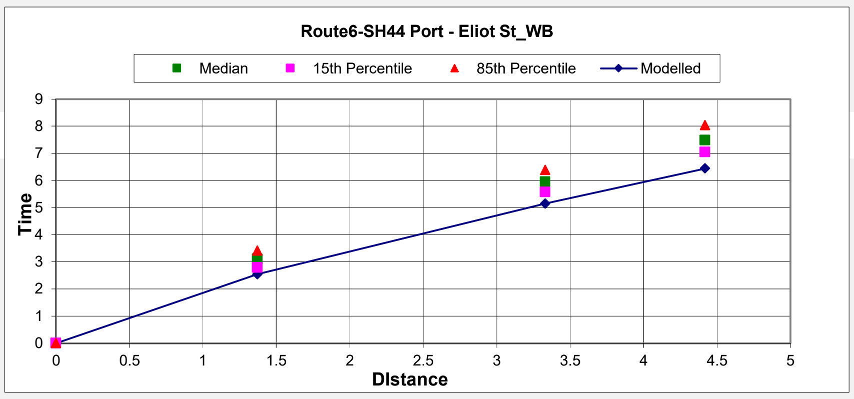


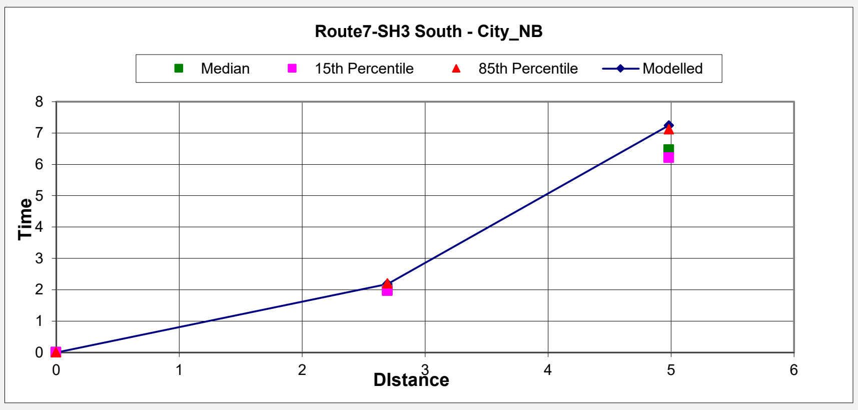


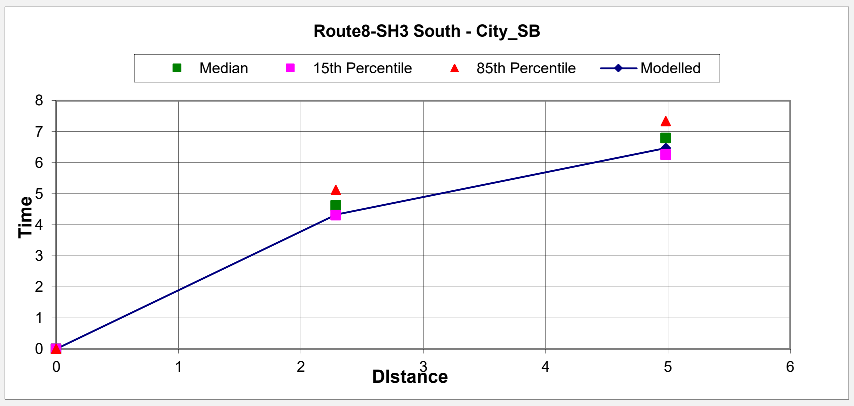


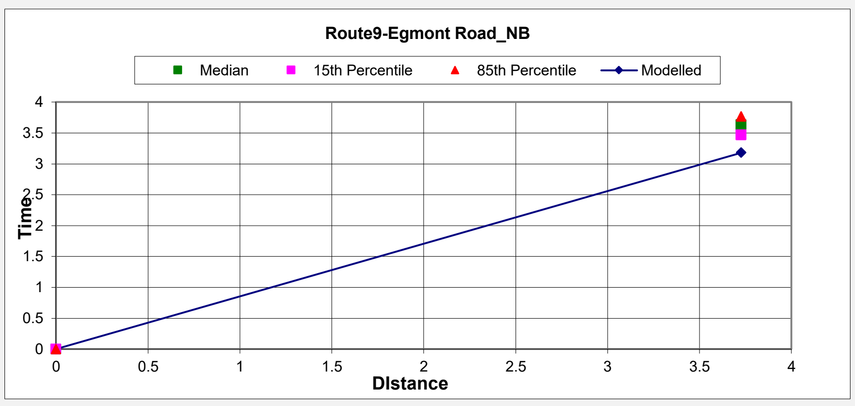


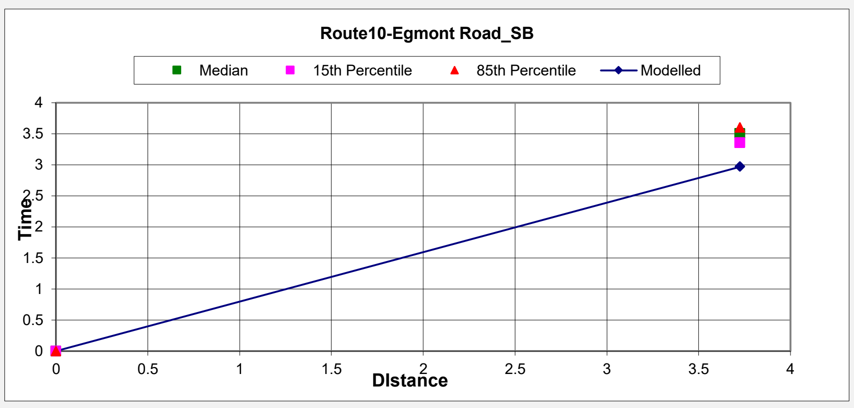


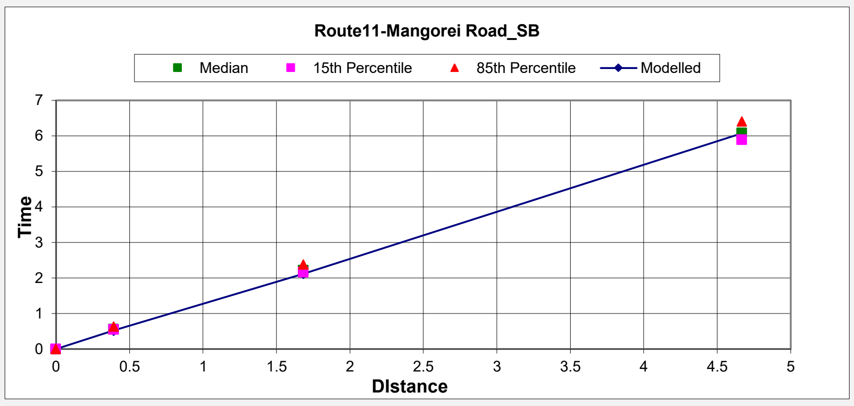


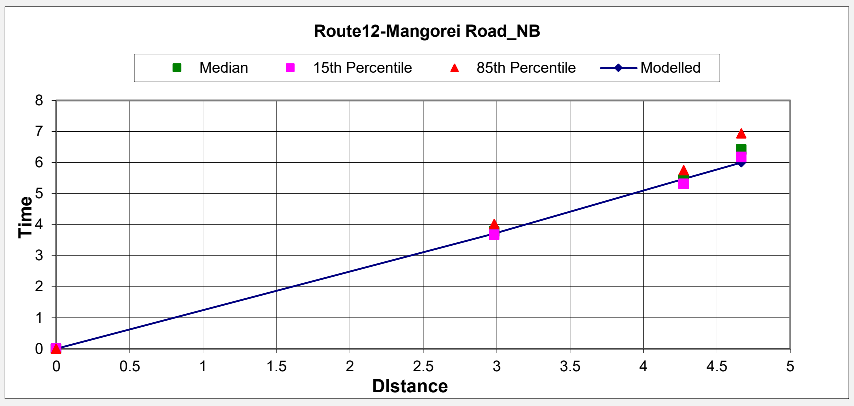




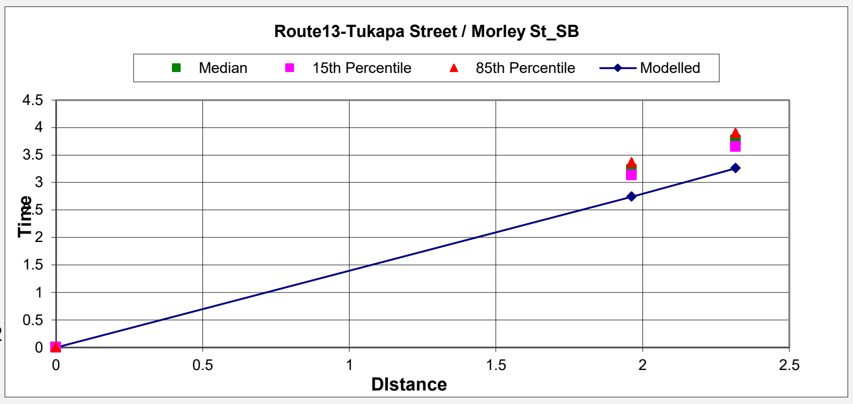


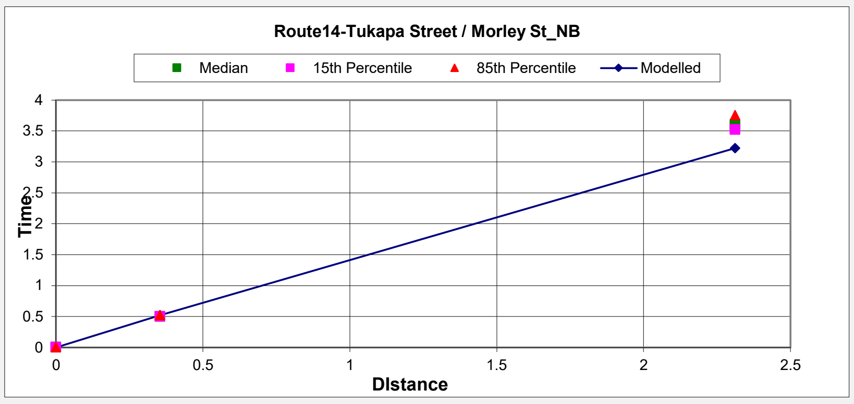


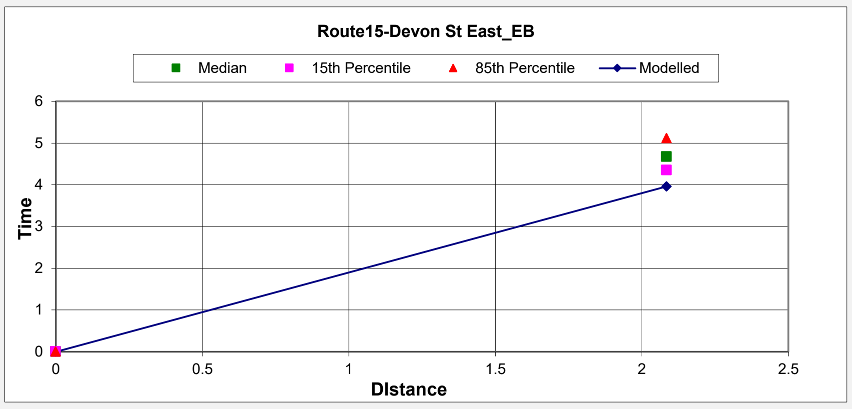

Route11-Mangorei Road_SB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

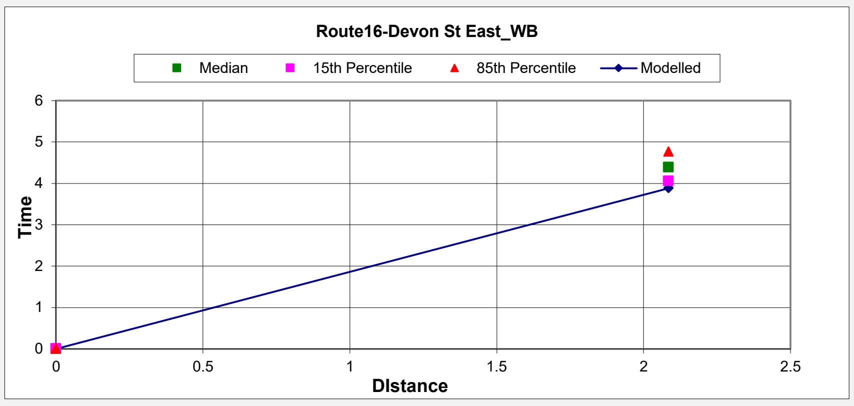

Route12-Mangorei Road_NB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

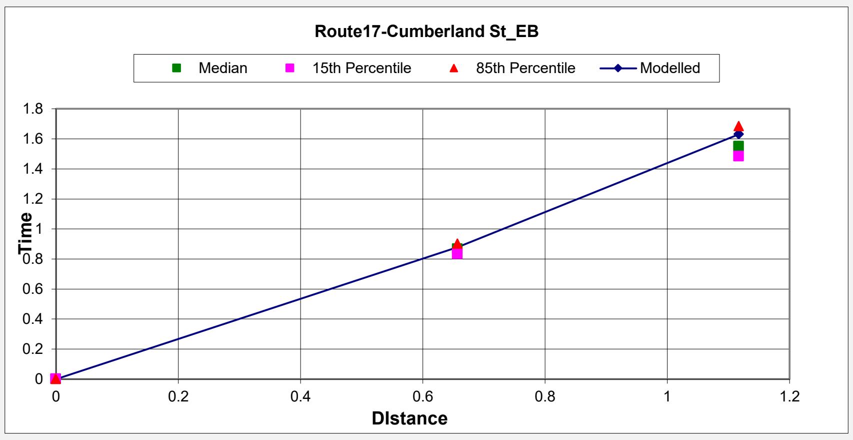
-3.22

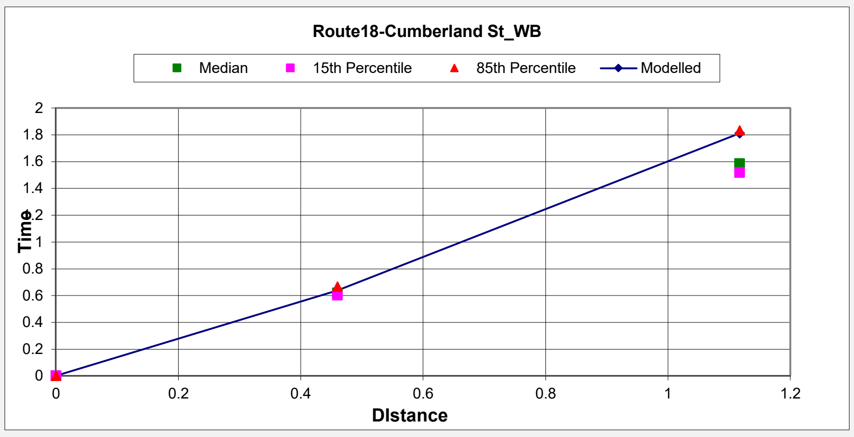

Route13-Tukapa Street / Morley St_SB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

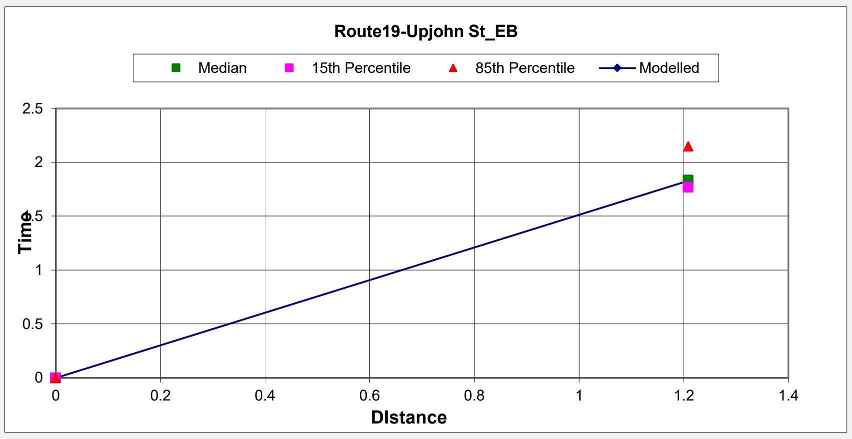

Route14-Tukapa Street / Morley St_NB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

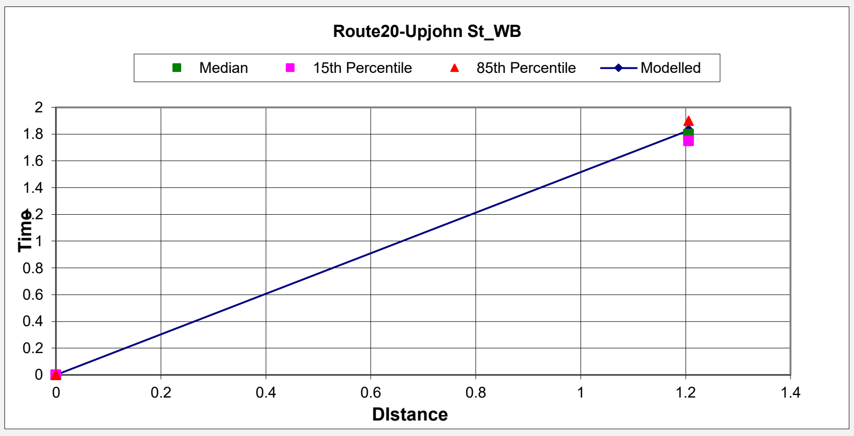

Route15-Devon St East_EB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

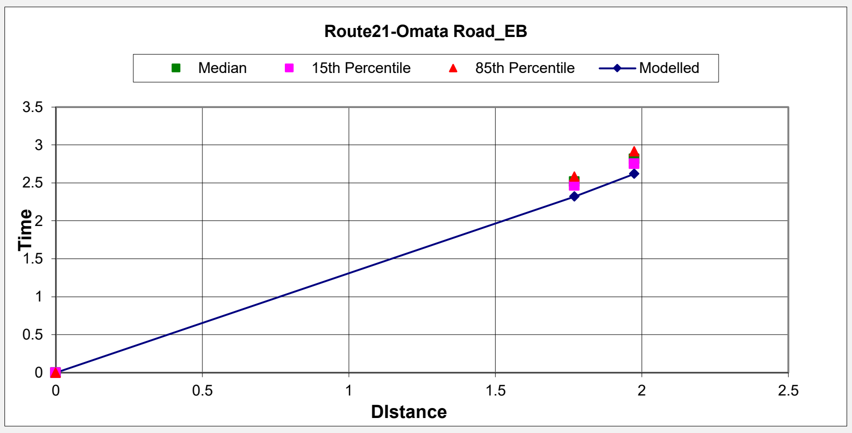

Route16-Devon St East_WB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

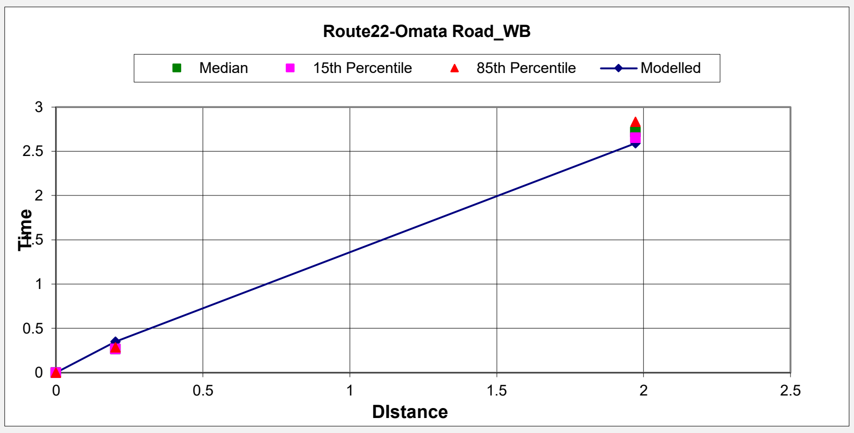

Route17-Cumberland St_EB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

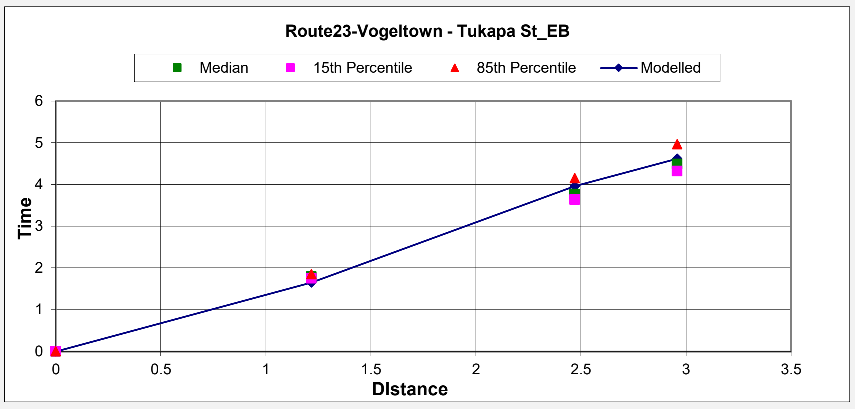

Route18-Cumberland St_WB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

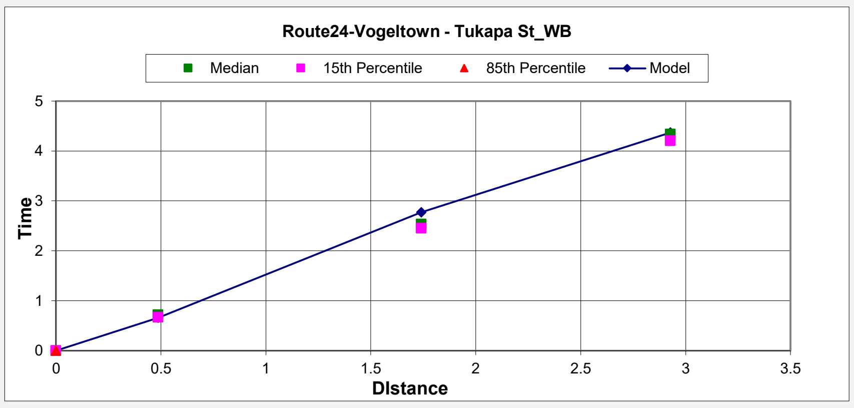

Route19-Upjohn St_EB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

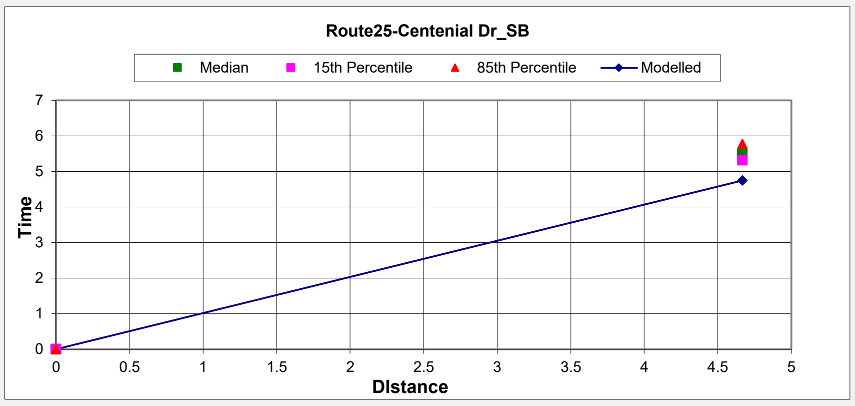

Route20-Upjohn St_WB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

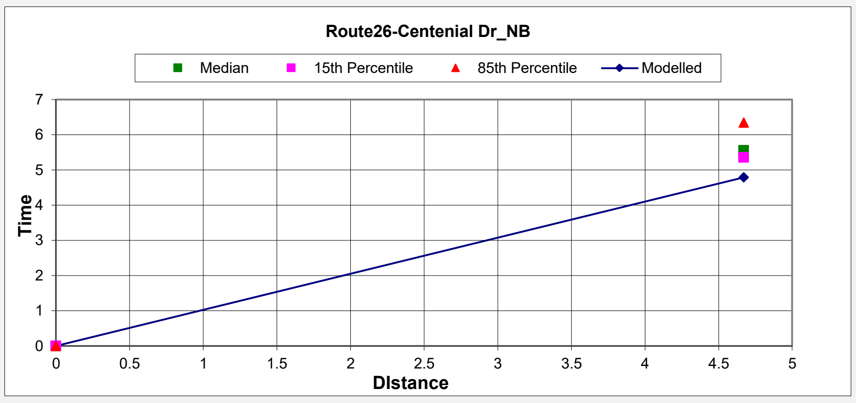

Route21-Omata Road_EB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

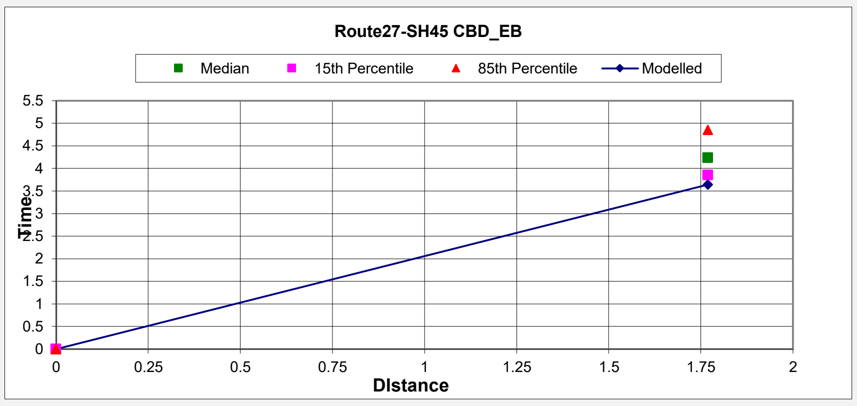

Route22-Omata Road_WB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

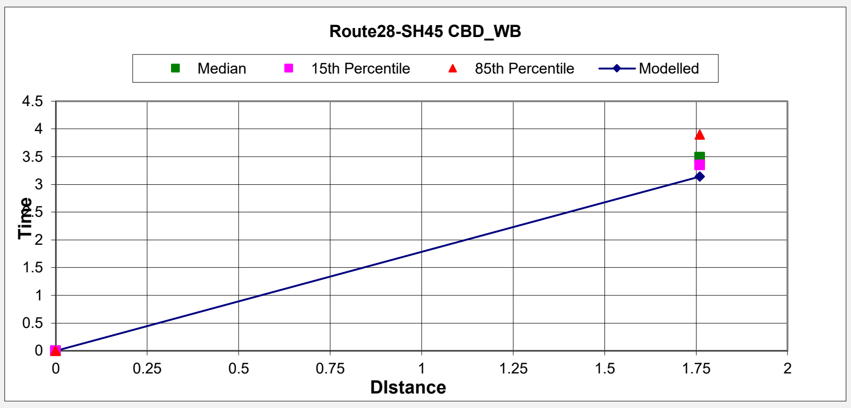

Route23-Vogeltown - Tukapa St_EB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance


Route24-Vogeltown - Tukapa St_WB
Median
15th Percentile
85th Percentile
Model
Time
Distance


Route25-Centenial Dr_SB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

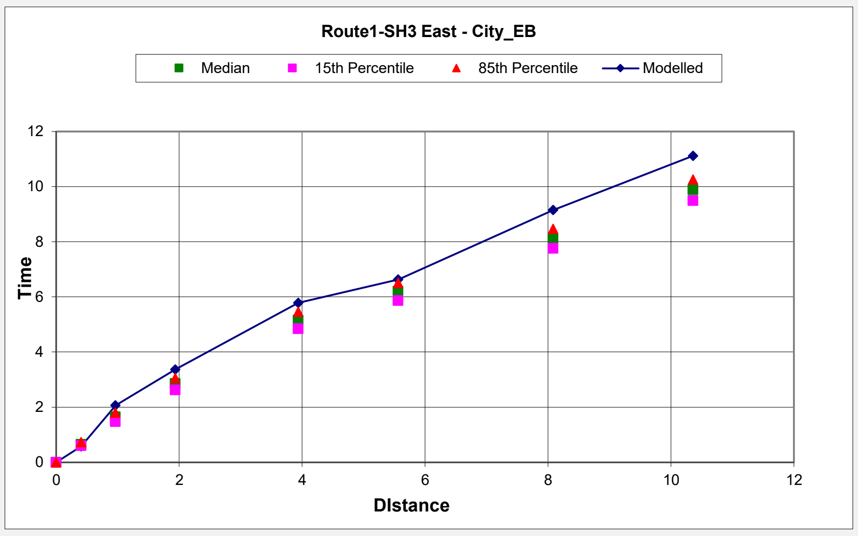

Route26-Centenial Dr_NB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

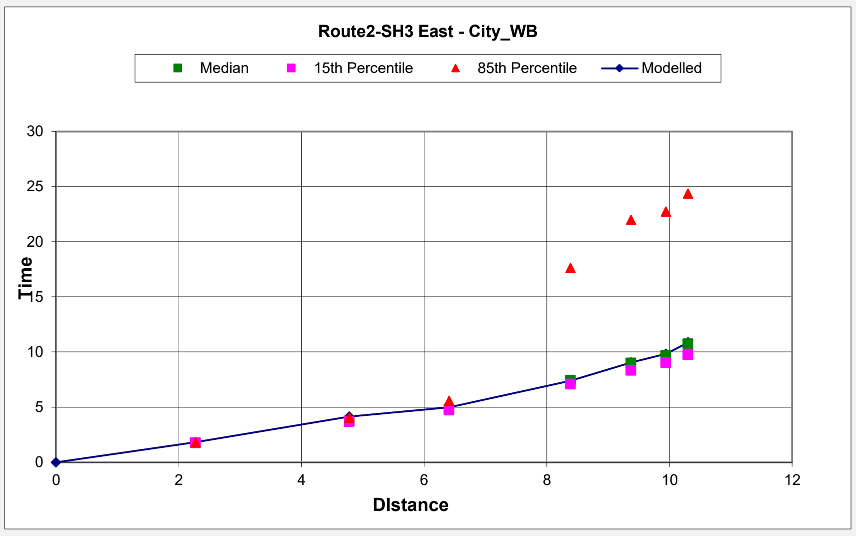

Route27-SH45 CBD_EB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

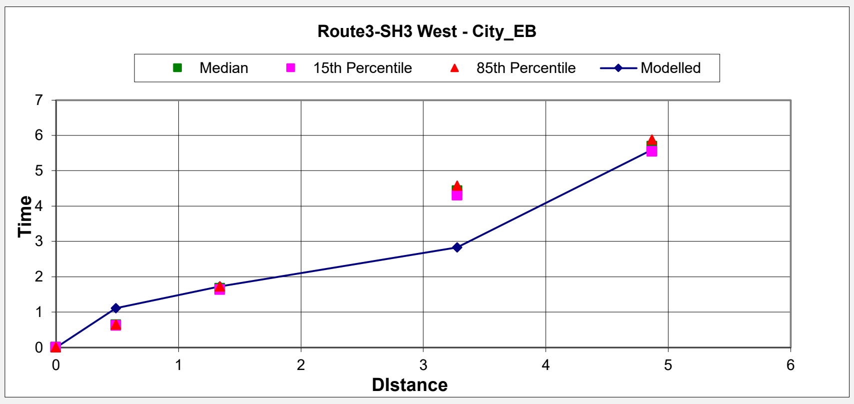

Route28-SH45 CBD_WB
Median
15th Percentile
85th Percentile
Modelled
Time
Distance

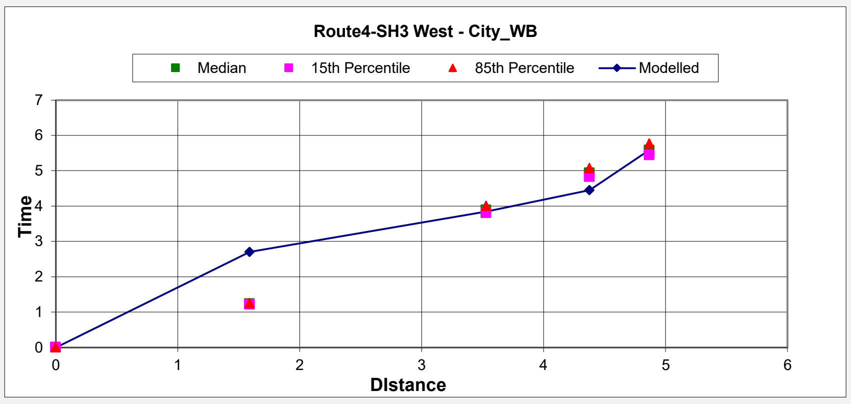
Ngāmotu Strategic Transport Model (Ngāmotu STM)

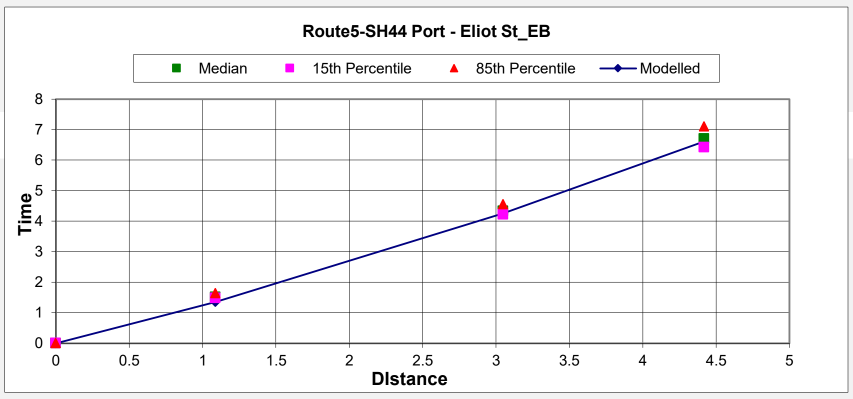
2018 Route Travel Time (min) vs Distance (km) Plots - PM Peak Hour

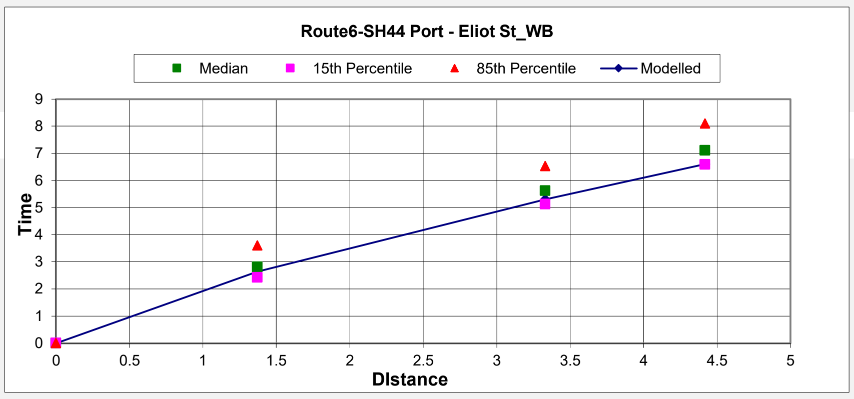


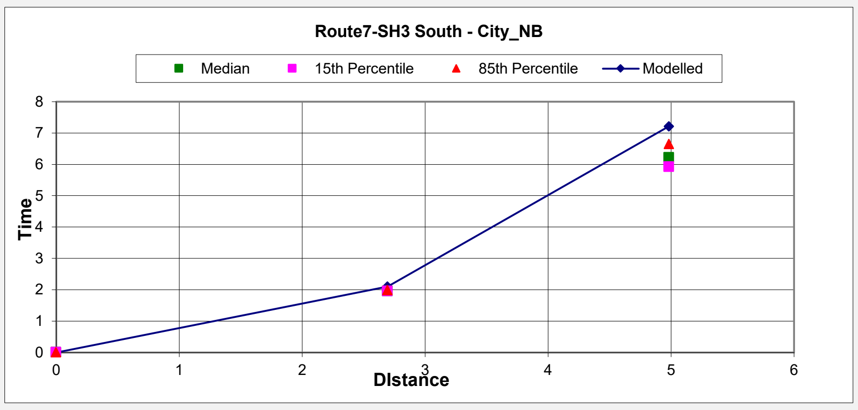


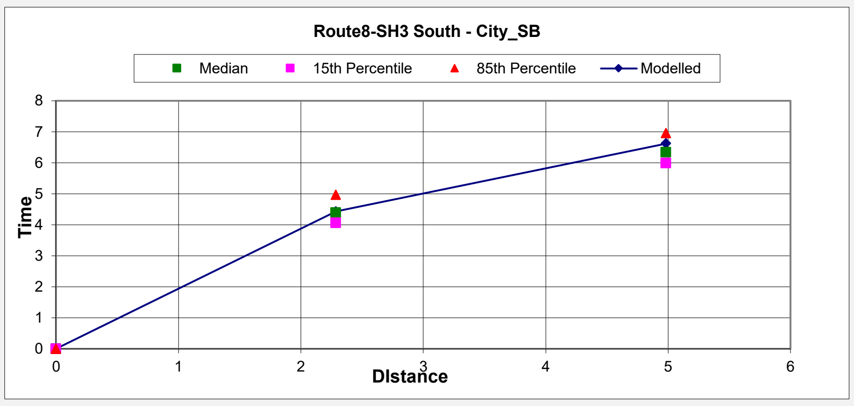


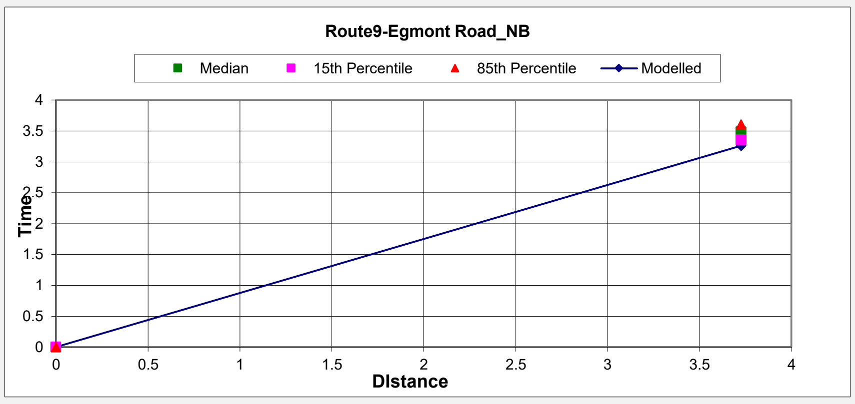


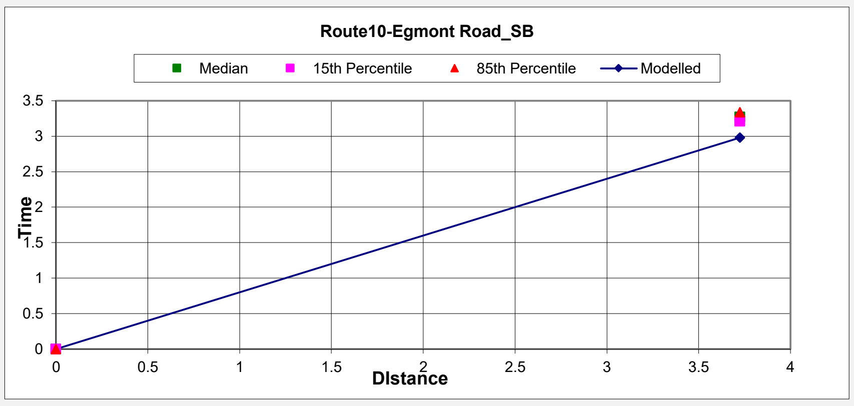


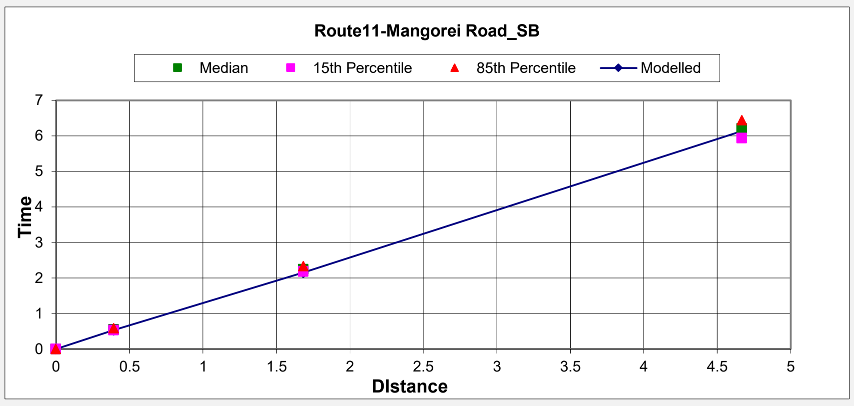


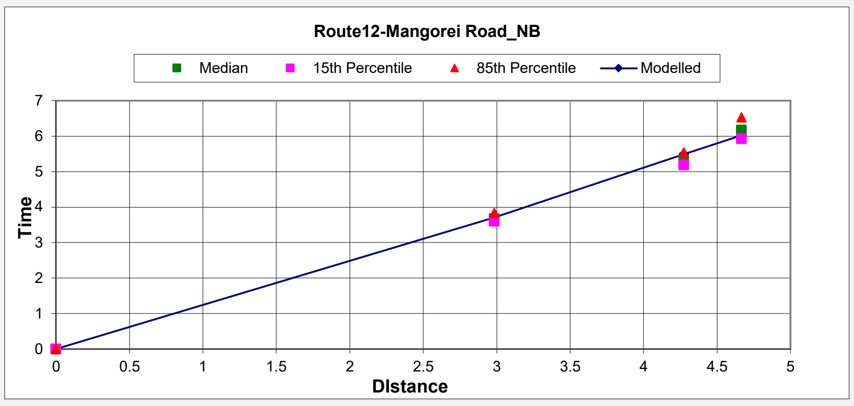




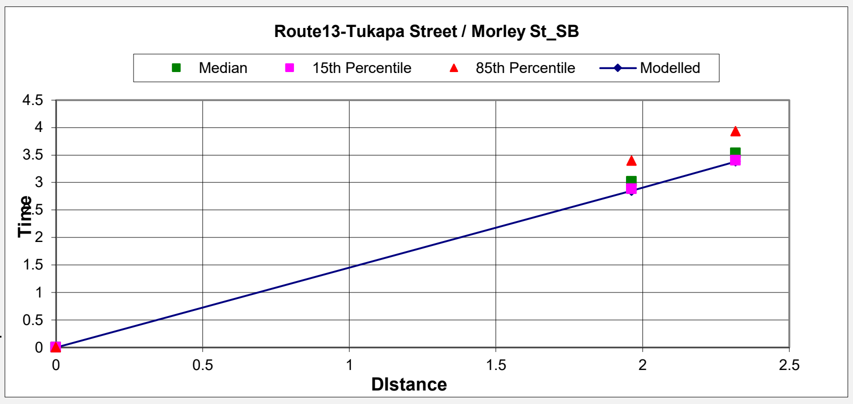


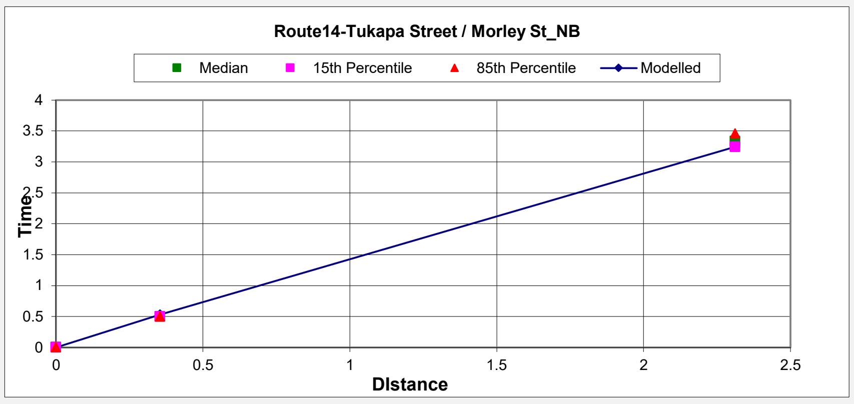


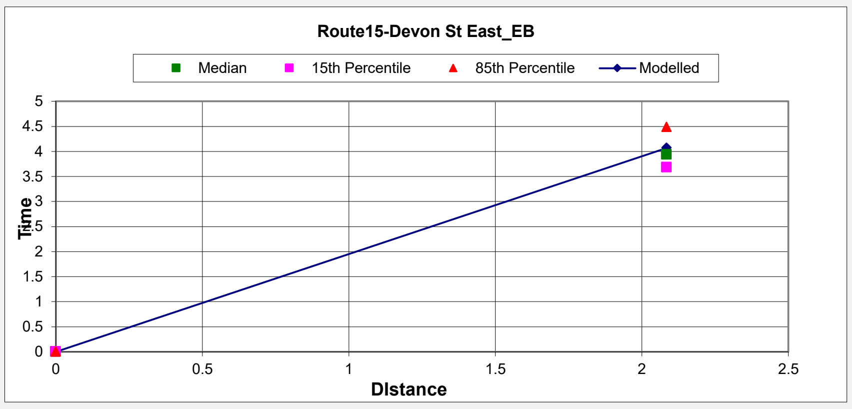

Route11-Mangorei Road_SB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

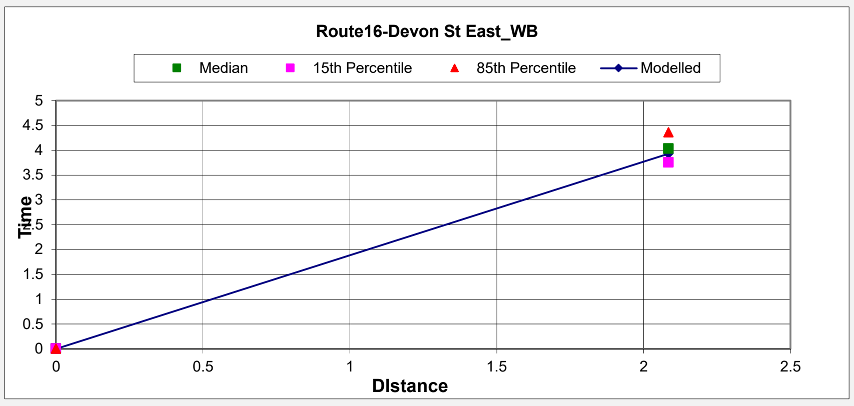

Route12-Mangorei Road_NB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

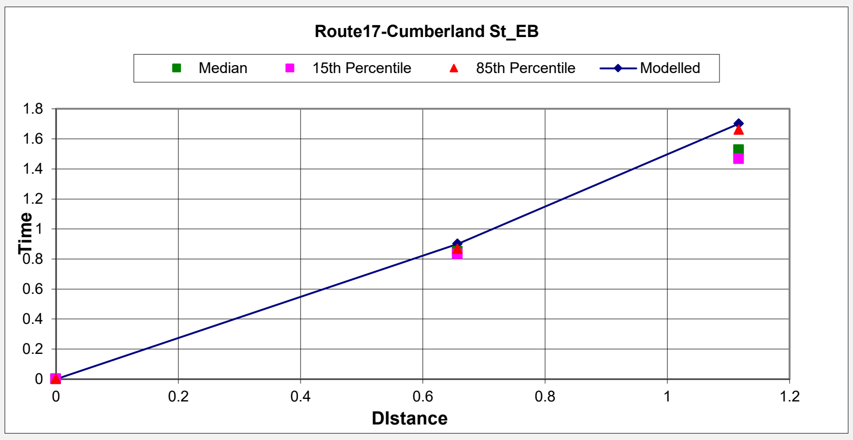
-3.24

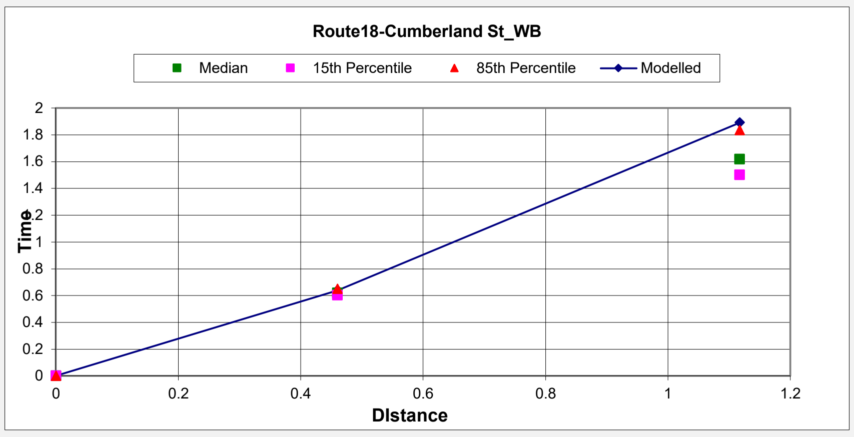

Route13-Tukapa Street / Morley St_SB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

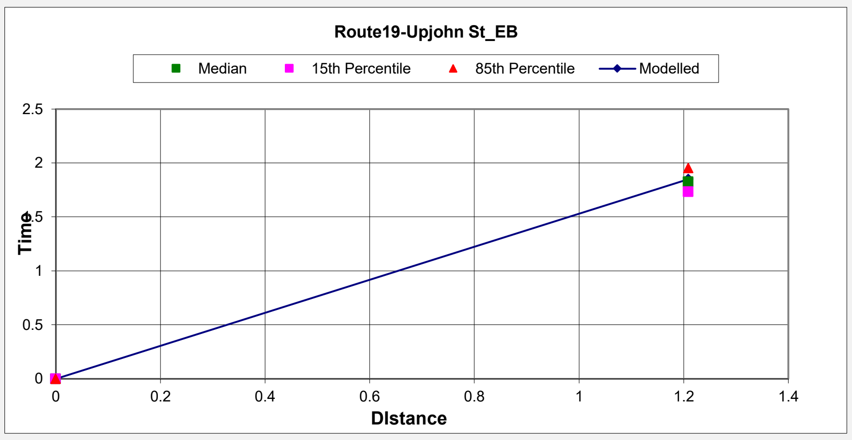

Route14-Tukapa Street / Morley St_NB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

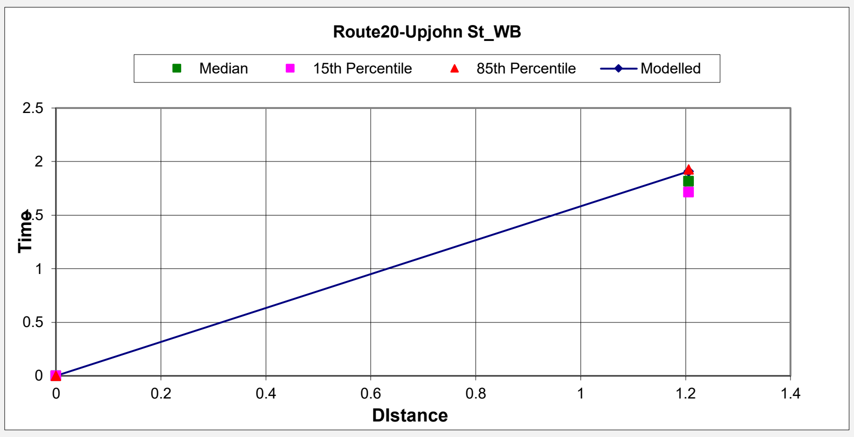

Route15-Devon St East_EB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

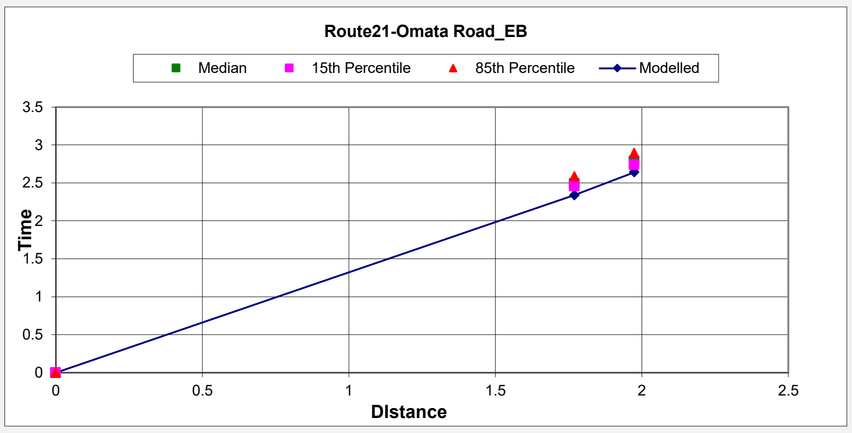

Route16-Devon St East_WB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

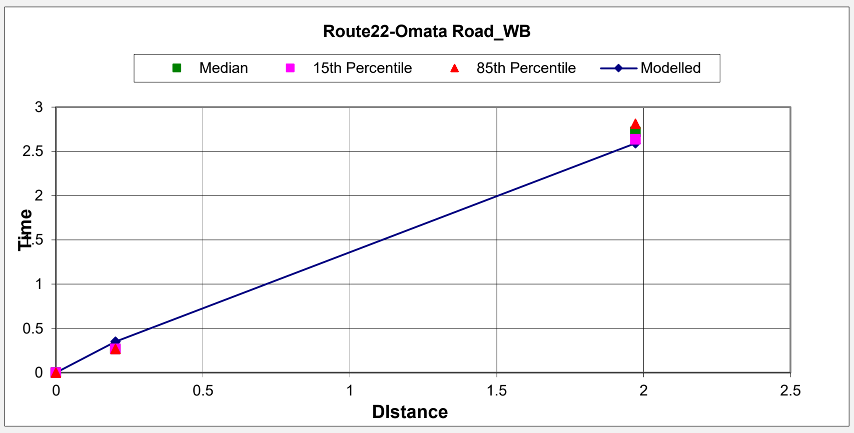

Route17-Cumberland St_EB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

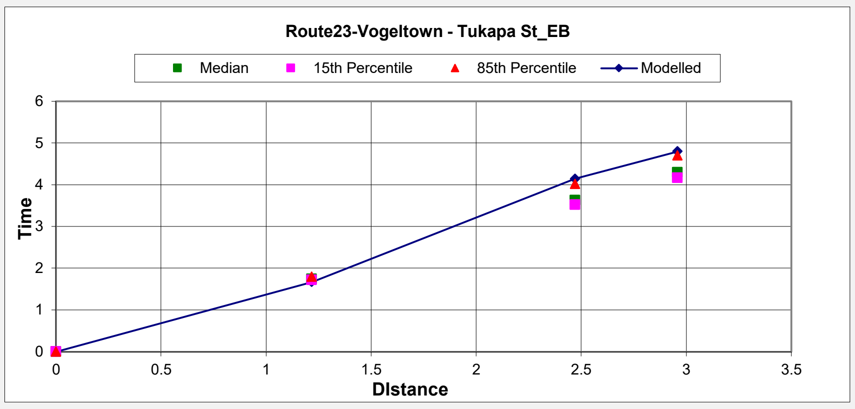

Route18-Cumberland St_WB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

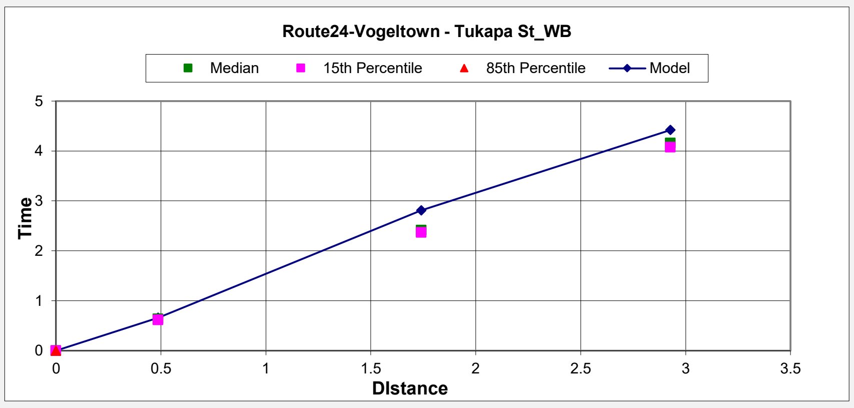

Route19-Upjohn St_EB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

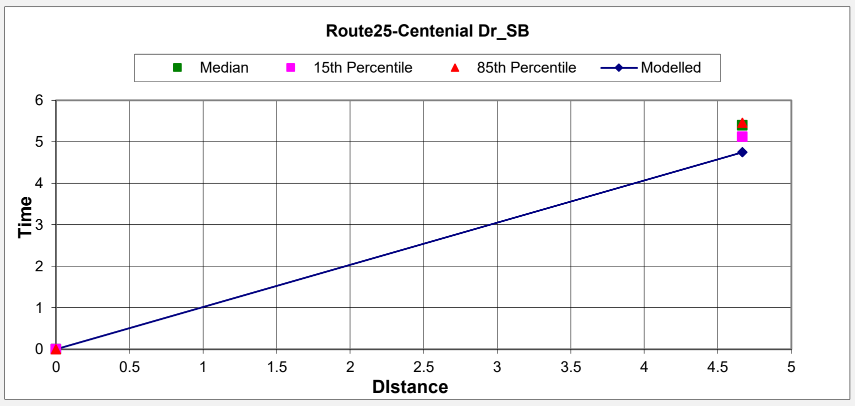

Route20-Upjohn St_WB
Median
15th Percentile
85th Percentile
Modelled
Time
DIstance

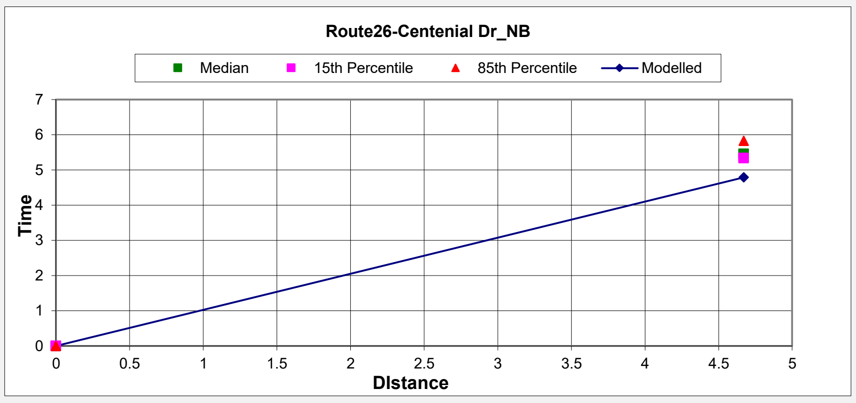

Route21-Omata Road_EB
Median
15th Percentile
85th Percentile
Modelled
Time
0
0.5
1
1.5
2
2.5
3
3.5
Distance
0
0.5
1
1.5
2
2.5

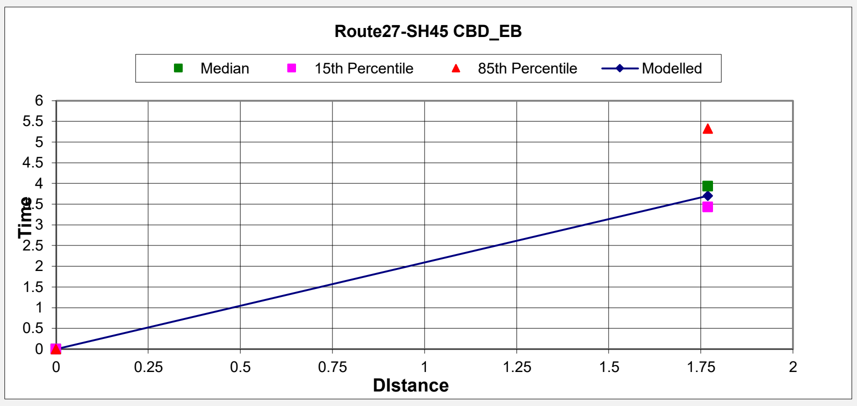

Route22-Omata Road_WB
Median
15th Percentile
85th Percentile
Modelled
Time
0
0.5
1
1.5
2
2.5
3
Distance
0
0.5
1
1.5
2
2.5

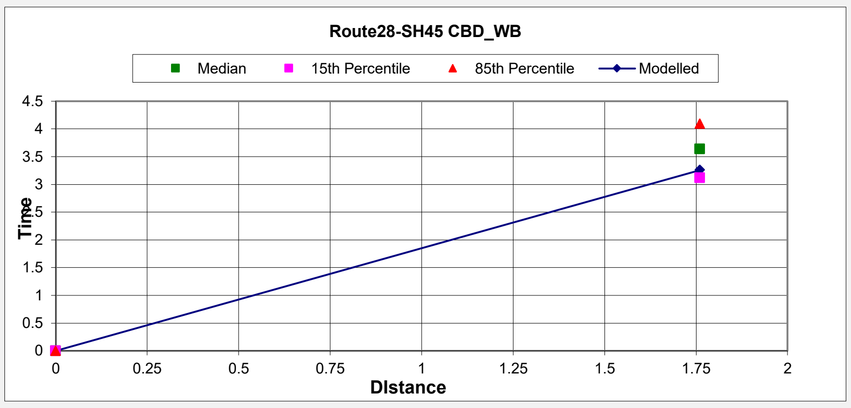

Route23-Vogeltown - Tukapa St_EB
Median
15th Percentile
85th Percentile
Modelled
Time
0
1
2
3
4
5
6
Distance
0
0.5
1
1.5
2
2.5
3
3.5


Route24-Vogeltown - Tukapa St_WB
Median
15th Percentile
85th Percentile
Model
Time
0
1
2
3
4
5
Distance
0
0.5
1
1.5
2
2.5
3
3.5


Route25-Centenial Dr_SB
Median
15th Percentile
85th Percentile
Modelled
Time
0
1
2
3
4
5
6
Distance
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5


Route26-Centenial Dr_NB
Median
15th Percentile
85th Percentile
Modelled
Time
0
1
2
3
4
5
6
7
Distance
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5


Route27-SH45 CBD_EB
Median
15th Percentile
85th Percentile
Modelled
Time
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
Distance
0
0.25
0.5
0.75
1
1.25
1.5
1.75
2


Route28-SH45 CBD_WB
Median
15th Percentile
85th Percentile
Modelled
Time
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
Distance
0
0.25
0.5
0.75
1
1.25
1.5
1.75
2

C

Appendix C – PT Lines Validation Results

Ngāmotu Strategic Transport Model

Public Transport Routes - Line Validation Results

	Bus Route No.	AM		IP		PM		Diffs			GEH		
		Observed	Modelled	Observed	Modelled	Observed	Modelled	AM	IP	PM	AM	IP	PM
Public Bus Routes	3101	7	19	5	11	32	9	12	6	-23	3.4	2.0	5.1
	5001	20	32	12	22	16	26	12	10	10	2.4	2.5	2.1
	5002	25	37	14	29	16	36	12	15	21	2.2	3.2	4.1
	5003	16	9	11	6	15	7	-6	-5	-7	1.8	1.7	2.2
	5004	26	12	16	8	25	8	-14	-8	-17	3.2	2.3	4.1
	5005	11	13	6	9	16	10	2	3	-6	0.6	0.9	1.8
	5006	22	15	12	10	10	10	-6	-2	0	1.4	0.7	0.1
	5007	20	14	6	9	13	10	-6	3	-3	1.5	1.0	0.9
	5008	27	23	13	17	14	20	-4	5	6	0.8	1.2	1.6
	5009	19	16	9	9	15	9	-3	0	-5	0.6	0.1	1.6
	5020	24	52	12	29	24	23	29	18	0	4.7	3.9	0.1
School Bus Routes	5012	21	21	6	5	0	0	0	-1	0	0.0	0.4	
	5021	13	35	5	9	0	0	22	4	0	4.6	1.3	
	5022	20	10	5	2	0	0	-10	-3	0	2.7	1.6	
	5024	14	5	5	2	0	0	-9	-3	0	2.9	1.9	
	5030	9	35	1	3	0	0	26	2	0	5.6	1.2	
	5031	32	2	9	3	0	0	-30	-6	0	7.4	2.2	
	5032	2	19	1	7	0	0	18	6	0	5.5	2.9	
	5033	2	12	1	11	0	0	11	9	0	4.0	3.8	
	5034	18	24	3	2	0	0	6	-1	0	1.4	0.7	
	5035	8	5	3	4	0	0	-2	1	0	0.9	0.6	
	5041	7	3	1	0	0	0	-4	-1	0	1.6	1.0	
	5042	15	1	1	1	0	0	-13	-1	0	4.8	0.9	
	5043	2	8	0	3	0	0	7	2	0	3.0	1.9	
	5044	4	11	7	5	0	0	7	-2	0	2.6	0.9	
	5045	0	12	1	0	0	0	12	-1	0	4.8	1.7	
	5051	33	5	7	3	0	0	-28	-4	0	6.3	1.9	
	5052	36	31	6	0	0	0	-5	-6	0	0.8	3.3	
	5053	30	12	8	10	0	0	-18	2	0	4.0	0.5	
	5054	29	7	4	6	0	0	-22	2	0	5.2	0.7	
	5055	0	45	2	15	0	0	45	13	0	9.5	4.5	
	5091			9	0	0	0	0	-9	0		4.3	
	5092			4	0	0	0	0	-4	0		2.8	
	5093			8	0	0	0	0	-8	0		4.1	
	5095			4	0	0	0	0	-4	0		2.7	
	5098	23	4	7	1	0	0	-19	-6	0	5.1	3.0	