Porirua Transport Model
Stage 2

Model development report

September 2023

flow
TRANSPORTATION SPECIALISTS

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EXECUTIVE SUMMARY

Flow Transportation Specialists (Flow) has been commissioned by Porirua City Council (Council) to update Phase 1 of the interim Porirua Transport Model (PTM). Phase 2 will be used to support a wider range of current and future transportation projects within the area post Te Aranui o Te Rangihaeata – Transmission Gully motorway (TG) opening.

The purpose of the PTM model is to provide Council with a traffic modelling tool that will inform transport investment strategies for Porirua. Phase 2 provides a robust post Transmission Gully base model, reflecting 2023 travel behaviour about Porirua and Eastern suburbs. The focus of this model development report is to outline the methodology followed used to achieve this robustness and to demonstrate the applications of the model scope.

An AIMSUN traffic model has been developed to reflect the morning, inter and evening periods. The performance of each base model is summarised in Table ES1 for the peak hour. The table indicates that most of the targets in Waka Kotahi's Transport Model Development Guidelines have been achieved.

Table ES1: Transport modelling validation criteria

Criteria	Sub criteria	Description	Criteria Satisfied		
			AM	Inter	PM
Link and Turn Flows	Coefficient of determination (R^2)	A minimum of 95% in vicinity of project	Y	Y	Y
	Line of best fit	Y = 0.9x to 1.1x	Y	Y	Y
	GEH statistic	80% GEH less than 5	N	Y	N (79%)
		85% GEH less than 7.5	Y	Y	Y
		90% GEH less than 10	Y	Y	Y
	Root-Mean-Square Error (RMSE)	Acceptable: <20% Requires clarification: 20-30%	C	Y	Y
Screenline Flows	Individual Link Counts	85% GEH less than 5	Y	Y	N (84.8%)
		90% GEH less than 7.5	Y	Y	Y
		95% GEH less than 10	Y	Y	Y
		100% GEH less than 12	Y	Y	Y
	Total Screenline Counts	85% GEH less than 5	Y	Y	N
		90% GEH less than 7.5	Y	Y	Y
		95% GEH less than 10	Y	Y	Y

Criteria	Sub criteria	Description	Criteria Satisfied		
			AM	Inter	PM
Journey Times	Difference Comparison	85% or more of the modelled travel times should fall within 15% (or 1 minute, if 1 minute is greater than 15% of the travel time).	Y	Y	Y
		90% or more of the modelled travel times should fall within 25% (or 1.5 minute, if 1.5 minutes is greater than 25% of the travel time).	Y	Y	Y
	Plots	Distance / Time	Y	Y	Y

We consider that the Porirua Transportation Model reflects today's travel behaviour about Porirua and eastern suburbs. The model is considered fit for purpose of developing a forecast model to help inform future option assessments.

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APPENDICES

1 INTRODUCTION AND MODEL PURPOSE

Flow Transportation Specialists (Flow) has been commissioned by Porirua City Council (PCC) to update Phase 1 of the interim Porirua Transport Model (PTM). Phase 2 is used to support a wider range of current and future transportation projects within the area post Te Aranui o Te Rangihaeata – Transmission Gully motorway (TG) opening. These potentially include:

- Titahi Bay Road/Kenepuru corridor improvements
- Various road network changes in response to future traffic growth

Phase 1 of the PTM was developed by Wellington Transport Analytics Unit (WTAU). The purpose for Phase 1 was to inform scheme assessments around Porirua Central Business District, particularly Kenepuru Drive and Mungavin Avenue intersections with Titahi Bay Road. Additionally, high level analysis for the Eastern Porirua could be supported.

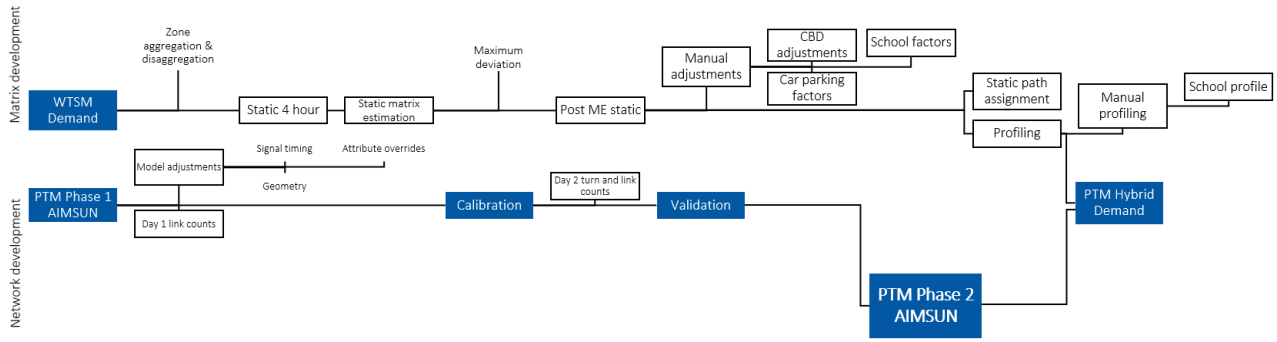
The purpose of the PTM model is to provide Council with a traffic modelling tool that will inform transport investment strategies for Porirua. Phase 2 provides a robust post Transmission Gully base model, reflecting 2023 travel behaviour about Porirua and Eastern suburbs. The focus of this model development report is to outline the methodology followed used to achieve this robustness and to demonstrate the applications of the model scope.

The model will provide Council with a reliable and evidence-based assessment tool that considers future traffic demand changes and potential transport problems. The model can be used to inform the transport needs and outcomes (in terms of timing and scale) of future transport projects. It will be able to inform option assessment and economic evaluation as part of future Business Cases, whether at Programme, Indicative or Detailed level. The modelling tool will also provide a useful tool for Council to understand the impacts of private land use development proposals.

2 MODEL DEVELOPMENT

The model has been developed using AIMSUN software, at a micro-simulation level for the Porirua area. Figure 1 summarises the methodology used to calibrate and validate the hybrid model including network and demand refinements.

Figure 1: Model demand development summary



2.1 Hybrid Model Development Overview

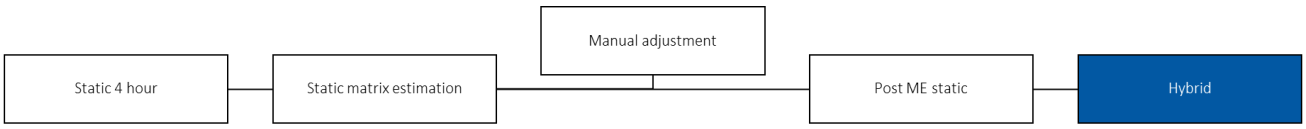
A mesoscopic level model provides an area-wide tool allowing route choice at a coarser level than micro-simulation. Whereas, micro-simulation provides a detailed assessment by simulating individual vehicle behaviours such as stop-and-go movements, merge manoeuvres and interaction with public transport. Hence, hybrid-simulation has been selected to present the core-area of the network and the rest of the network has been modelled in mesoscopic.

We have included an initial static assignment (ie an area-wide route choice) where the path assignment is utilised to inform the a detailed hybrid simulation layer. The base demands have been retrieved from the wider Wellington Transport Strategy Model (WTSM) using a cordon. We have considered a number of screenlines throughout the modelled area to ensure the origin-destination demands from the WTSM are reasonably represented. Waka Kotahi's Transport Model Development Guidelines (the Guideline) have been considered to inform the calibration and validation targets, achieved with a number of network and demand changes. The hybrid model development methodology is shown in Figure 2.

The base model has been developed to reflect today's travel behaviour about Porirua and eastern suburbs. It provides Council with a traffic modelling tool to align with other local projects such as Porirua spatial plan, and also can be used to inform Business Cases that consider short, medium and long-term transportation infrastructure needs for the area. The modelling tool will also provide a useful tool for PCC to understand the impacts of private land use development proposals.

We have reviewed traffic survey counts (including tube and intersection) provided by PCC and travel time data provided by WTAU via TomTom. The data collection and summary process used as part of the calibration/validation process of the model development is provided in a separate technical note[1] and summarised in Section 3.

Figure 2: Hybrid model development summary



2.1.1 Extent of Network

The extent of the PTM is shown in Figure 3. The model covers

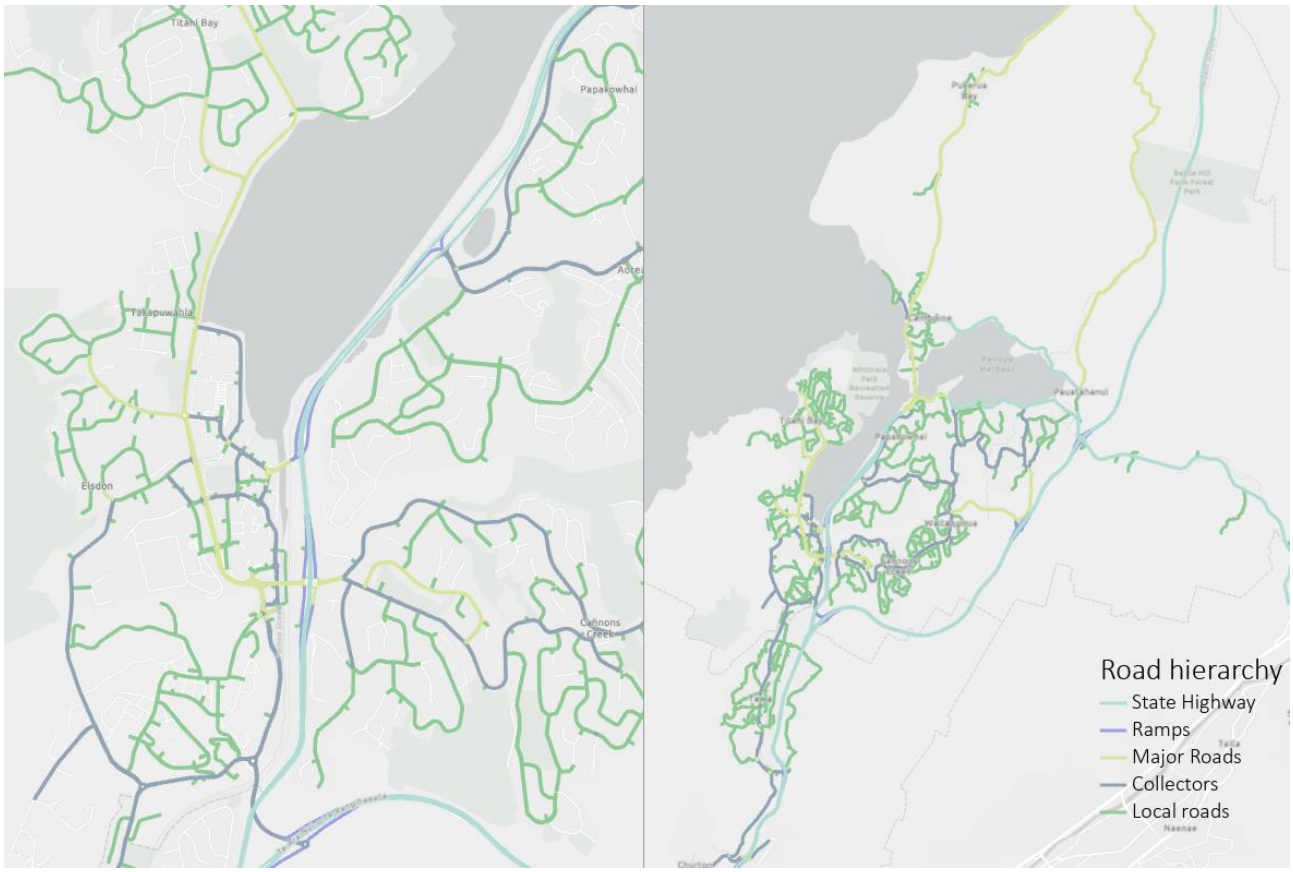
- the eastern suburbs bounded by SH58, SH59, and Transmission Gully
- Porirua CBD
- Kenepuru and Takapuwahia.

[1] Data Collection Report (TN1B230428). Flow Transportation Specialists, April 2023

The model extent includes the major roads, congestion spots, major trip generators in the area and areas where significant land use changes are expected. It covers the area where previous transport interventions where proposed, for instance Kenepuru Drive corridor[2].

The model network was originally imported from Open Street Map in Phase 1. The roading layouts, intersection layouts and priority controls, road types and speed limits have been modified based on Google aerial maps where appropriate. We note that not all local roads are included in the model, many of which are cul-de-sacs. Figure 3 presents the road network labelled at a high level to distinguish between high volume and low volume roads.

Figure 3: Extent of the PTAM



2.1.2 Model time period and demand representation

The AIMSUN model has been developed for the typical weekday morning, inter peak and evening peak periods. These are

- Morning peak period: 6:00 am to 10:00 am
- Inter peak period: 10:00 am to 2:00 pm
- Evening peak period: 3:00 pm to 7:00 pm

Traffic flows have been surveyed and processed for all periods, and the model network has been built to represent a 2022 base year. Surveys were undertaken months after the opening of the Transmission

[2] Access Kenepuru - improving Kenepuru corridor and surrounding streets, https://poriruacity.govt.nz/your-council/city-projects/kenepuru-corridor/, accessed August 2023

Gully project and where traffic patterns had generally settled. While the above modelled time periods have been checked/confirmed during Phase 1 development, we have carried out additional volume checks using the traffic counts collected near the Porirua City, after the TG opening.

Analysis of the locations confirms that the peak 1-hour periods are

- Morning peak hour 8:00 am to 9:00 am,
- Inter peak 12:00 pm to 1:00 pm, and
- Evening peak hour 4:00 pm to 5:00 pm

Figure 4: Daily traffic profile CBD east-west screenline

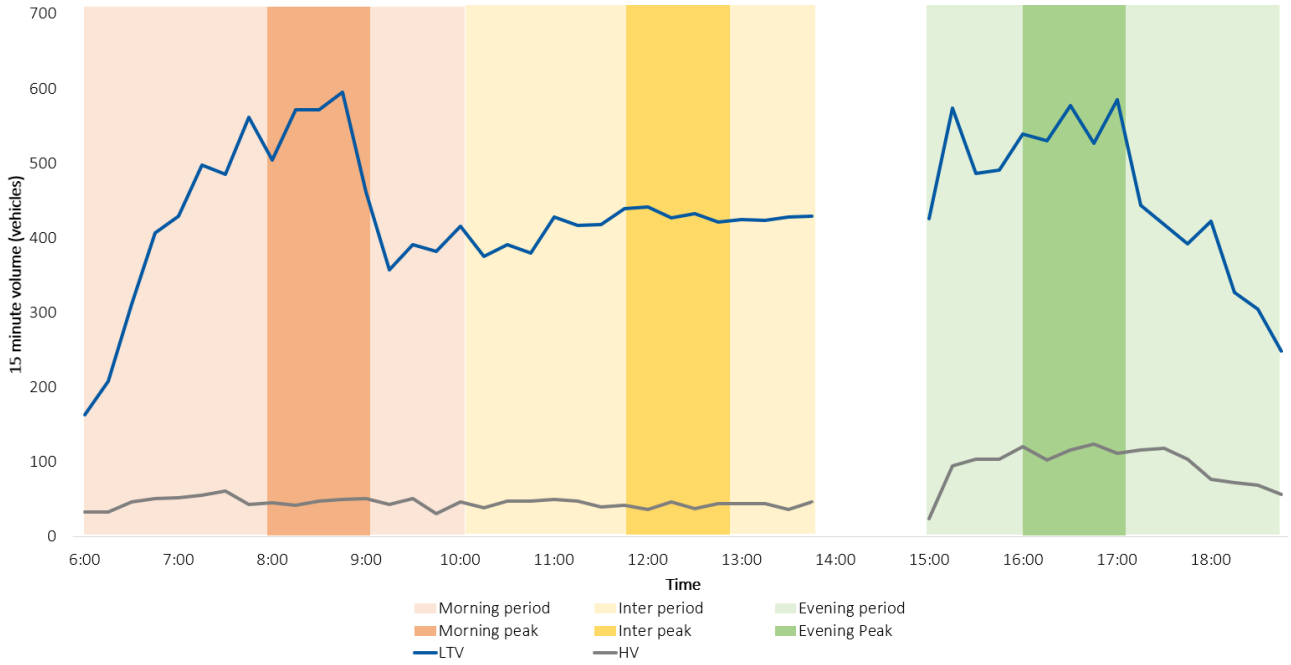
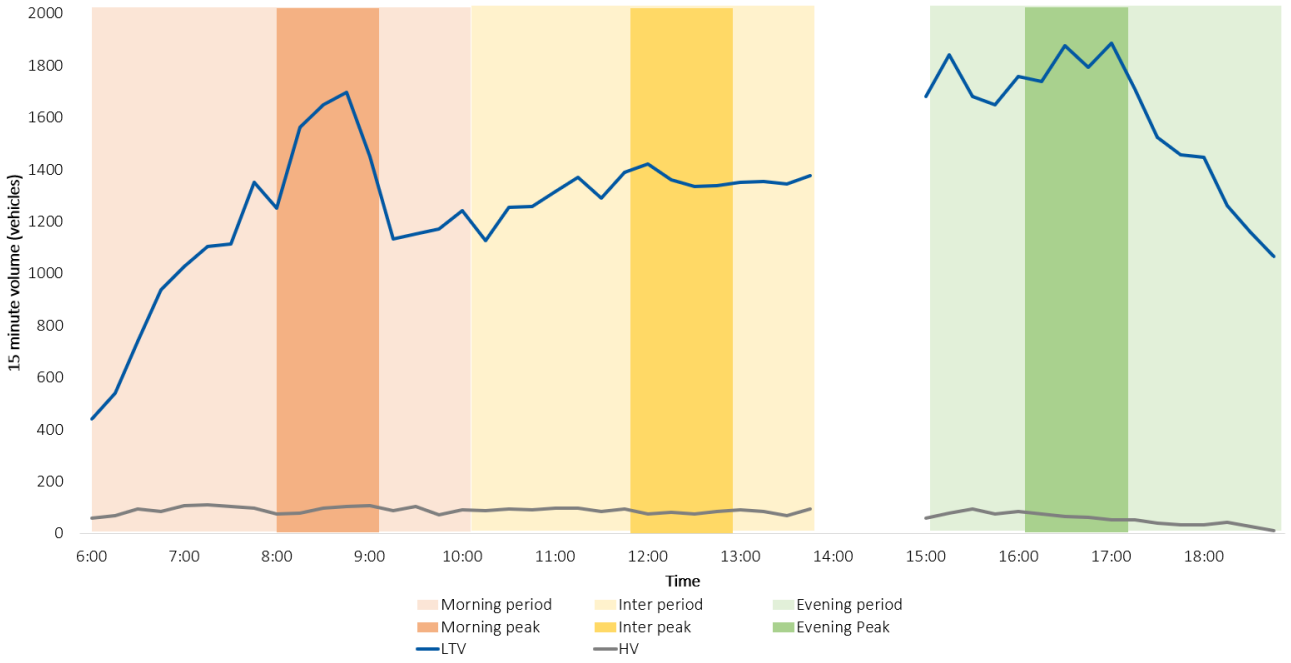


Figure 5: Daily traffic profile eastern suburbs east-west screenline



2.1.3 Model calibration / validation targets

Waka Kotahi's Transport Model Development Guidelines (The Guidelines) provides guidelines for model development in New Zealand based on the model purpose. We have considered Model Purpose Type C: Urban Area model to inform the calibration/validation target.

2.1.4 Road hierarchy and road types

AIMSUN classifies road types according to categories, where sections of road network have similar attributes and therefore can be grouped together. These include

- **Speed limit:** Operating speed of road, considering the posted speed limit and how vehicles use the road (based on TomTom data)
- **Lane capacity**: This is the maximum number of vehicles per hour the road is capable of carrying per lane per hour
- **Speed**: This is the free flow speed of the road
- **JD function**: This is the side friction input to the static travel time function[3]. Side friction refers to local effects not directly accounted for by the function, such as a narrow road width, car parking etc. A higher value denotes a higher side friction penalty
- **User cost**: A higher value represents a higher link cost.

We have checked the speed limits of the roads within the modelled area and assigned different road types according to the existing situation based on comparison between modelled and actual travel times.

The wider project team agreed to change the global speed limit factor from 1.1 in Phase 1 to 1.0 for cars and from 1.05 to 0.90 for trucks. This change was considered to ensure consistency with other AIMSUN models around the Wellington region.

The speed limit, lane capacity and user-defined cost of each road type used in the model are shown in Table 1 below, while Figure 6 illustrates where these road types have been applied in the model.

Table 1: PTAM road types and parameters

Road Type	Speed Limit (km/hr)	Capacity (PCUs/hr/lane)	User-defined cost	Post speed limit (km/hr)	Distance applied (km)
Collector - high friction / poor alignment	40	1200	1.3	50	5
Collector - low friction / good alignment	45	1600	1.2	50	65
Hill / Curve Sections	25	800	2	50	5

[3] Travel Time Functions for Transport Planning Purposes: Davidson's Function, its Time-Dependent form and an Alternative Travel Time Function - AKÇELIK, R. (1991)

Local Access Road	25	250	2.5	10-50	100
Local Access Road, medium friction	30	600	2	50	<5
Local High-Speed Street	45	800	1.6	50	120
Motorway - Merge Section	100	1900	0.85	100	<5
Motorway	100	2100	0.8	100	75
On / Off Ramps	70	1800	1.1	100	10
Rural - restricted speed	70	1400	1.2	50-70	40
Rural - unrestricted speed	100	1400	1.2	100	20
Rural state highway	80	1800	1	80	25
Urban arterial - high speed	70	1700	1	70	<5
Urban arterial - medium speed	50	1600	1	50	20
Urban Arterial - low speed	45	1500	1	50	5

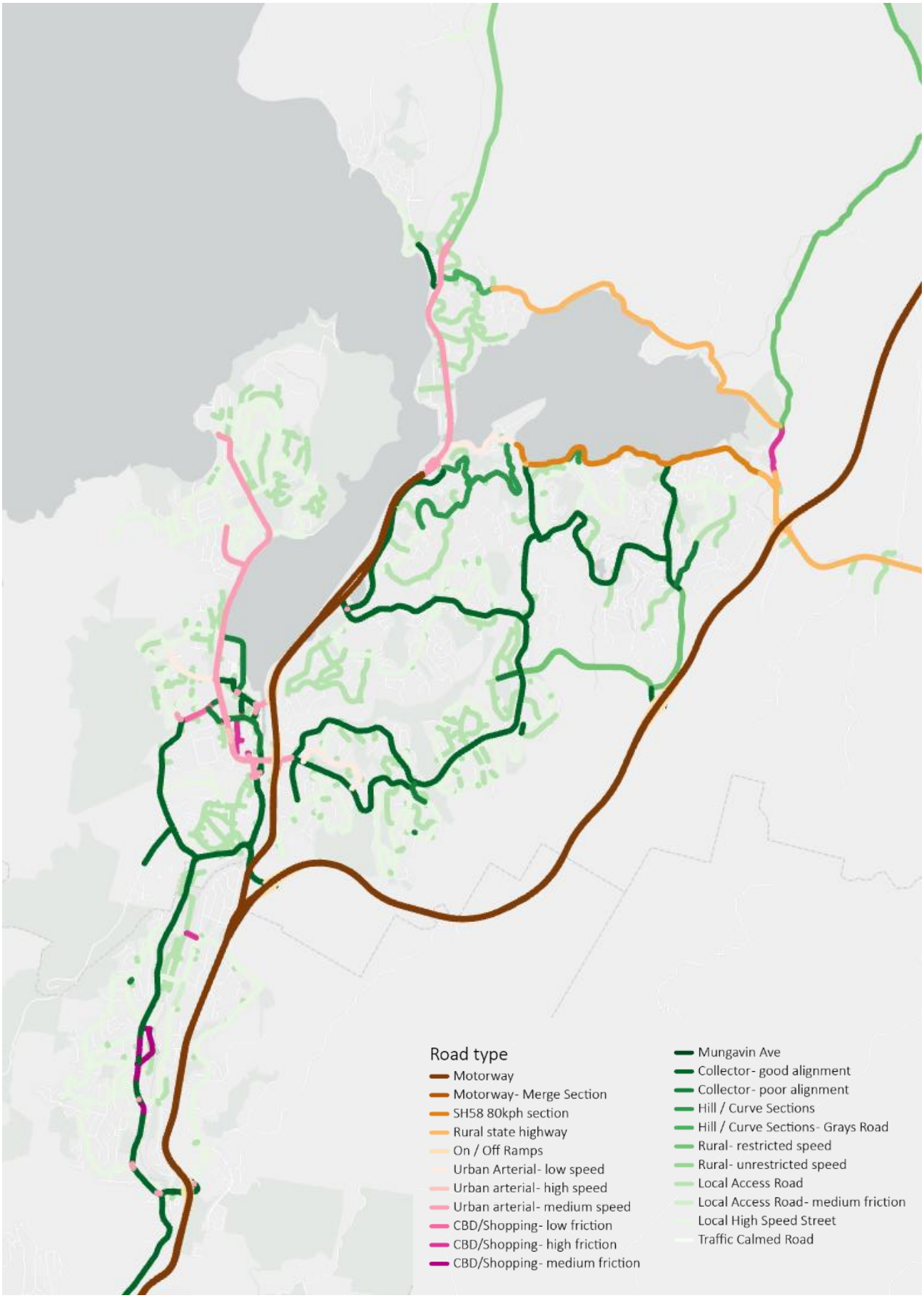
Through the calibration and journey time validation process a few of roads were given parameters to align the modelled to the observed journey times

- we noted the posted speed limit on SH58 varies between 80 kph and 50 kph between SH59 and Transmission Gully, however through calibration and comparing actual travel speeds, we have observed a 65 kph operating speed in some sections and applied this where appropriate
- the terrain towards the western end of Grays Road has a reduced speed limit and capacity applied from Phase 1. This has been retained for Phase 2
- we developed a lower speed and capacity road type for traffic calmed roads, particularly applied to influence cost (and therefore) route choice in the CBD where speed tables are present
- Table 2 summarises detailed road types.

Table 2: PTAM calibration road types and parameters

Road Type	Speed Limit (km/hr)	Capacity (PCUs/hr/lane)	User-defined cost	Distance applied (km)
SH58 80kph section	65	1800	1.3	5
Hill / Curve Sections - Grays Road	20	600	3	<5
Traffic Calmed Road	20	550	2	<5
CBD/Shopping - high friction	30	450	2.5	5
CBD/Shopping - medium friction	30	800	1.8	<5
CBD/Shopping - low friction	35	1100	1.6	<5

Figure 6: PTAM road network shown by road types



2.2 Stage 1 network coding refinements

Stage 1 developed a model framework that has been built on in Stage 2. This includes considerations to

- Model extent
- Updated traffic data
- Delay functions
- Signal timing
- Public transport

We consider the Phase 1 framework appropriate to use for Phase 2 and is summarised in subsequent section with detail provided in PTM Stage 1 Technical Note 1[4]. The following changes have been made to Stage 1 network during the development of Stage 2.

2.2.1 Model extent

The model extent has been extended from Stage 1 to include Porirua Eastern Suburbs and Kenepuru. The existing road network was imported from the WTSM with additional links imported from OpenStreetMap. We have provided more detail on the updated model extent in a separate technical note[5].

2.2.2 Delay functions

The modelled travel times and travel cost applied to turns and sections were determined by delay functions developed in Stage 1 and include parameters such as volume, capacity, length, opposing flow, etc. The functions applied at a Macroscopic level in the PTM include the

- Volume Delay Function
- Turn Penalty Function
- Junction Delay Function
    - we included a minor update to reflect the static run was increased from 2-hour duration to 4-hours.

Detailed explanation of the functions is provided in PTM Stage 1 Technical Note 1 [5].

2.2.3 Public transport

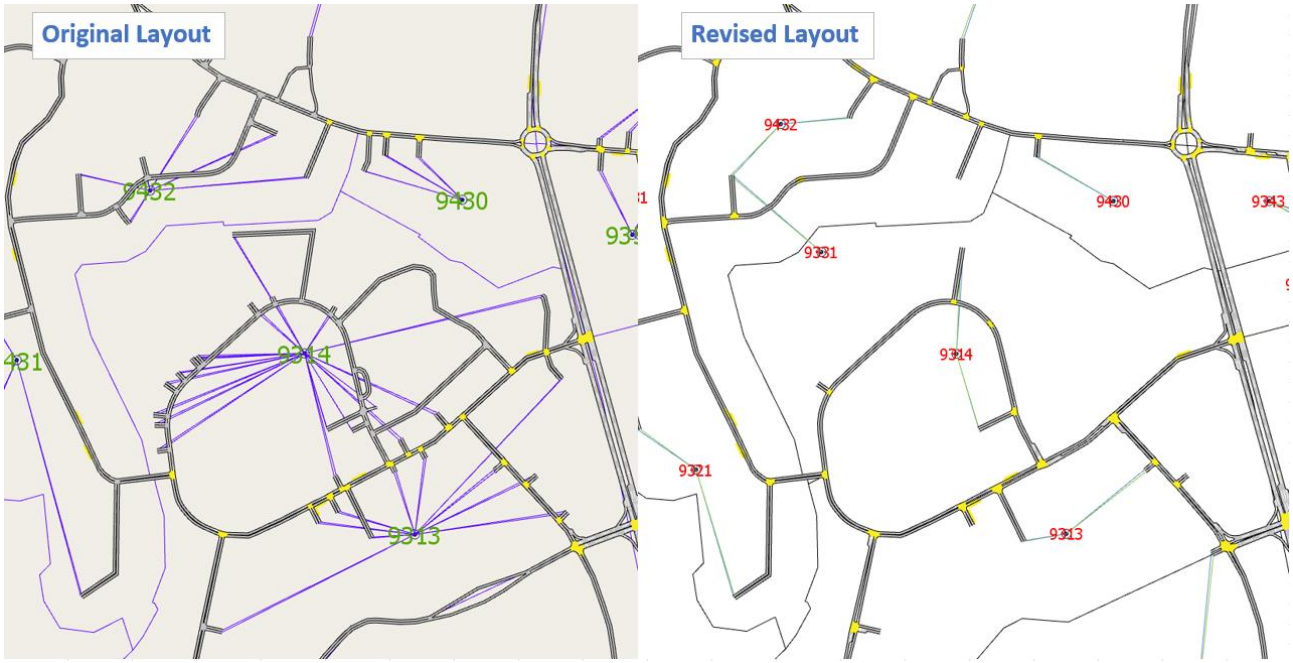
We have retained the Public Transport network coding from Phase 1

2.2.4 Zone connectors

The zone structure and the number of zone connectors defined for each zone has been refined. This has been based on the visual check of land uses in each zone and their accesses to the surrounding road network. An example of the zone connector changes is provided in figure below:

[4] Porirua Traffic Model (Stage 1): Tech Note 1 – PTM Network. Wellington Transport Analytics Unit, October 2022
[5] Data Collection Report (TN1B230428). Flow Transportation Specialists, April 2023

Figure 7: Example of zone connector changes



2.2.5 Intersection coding

Stage 2 included several updates to the intersection coding including:

- Updated signal phase timing for signalised intersections (2022 timing data)
- Priority Intersection initial and final safety margins: these values have been reduced based on the observations of vehicle behaviours in the model. In general, the micro initial and final safety margins have been reduced from 5 seconds and 3 seconds to 2.5 seconds and 1.5 seconds respectively. The initial safety margin applied in the meso layer has also been reduced from 6 seconds to 4 seconds. We note that the revised micro-simulation safety margins above are in-line with the parameters used in the N2A model (for Wellington CBD)
- Additional left turn/right turn short lanes have been provided at priority intersections to reduce queuing on collector road/arterial road intersections, if the road space is wide enough to allow a through vehicle to by-pass a stopped vehicle waiting for gaps. We understand this may increase the risk of model producing excessive missed turn volumes and we have carried out additional checks/fixes to minimise the missed turns in the model
- Roundabout coding changes
    - Geometry changes (lane widths and lane allocations) based on the aerial images
    - Calibration to align with observed behaviour using attribute overrides on initial and final safety margins, and visibility along the mainline
    - Approach speeds were reduced using a Python script for the road sections within 50 metres to the roundabout

2.2.6 Dynamic route choice assignments

A number of dynamic assignment parameters are used in the PTM and are generally consistent with similar Aimsun models around the Wellington region. We have reproduced the parameter summary from Stage 1 and included the amendment for Stage 2 in Table 3 below.

Table 3: PTAM calibration road types and parameters

Parameter	Description	Stage 1 value	Stage 2 value
Model Interval	Represents the length of path calculation intervals. A lower value represents traffic more sensitive to path changes over the simulation period	15 minutes	5 minutes
Number of Intervals	Represents the number of previous intervals to consider in assignment path calculations – typically should equate to 30 minutes	2	6
Attractiveness Weight	Attractiveness is a parameter within turns which by default is the capacity of the turn. The Attractiveness weight is how much of an impact this should have on vehicle routing. The Aimsun default is 2	2	2
User-Defined Cost Weight	Similar to the attractiveness weight but applied to sections. The User-Defined Costs have been specified by road type in PTM and are listed in Table 2.	Various	Various, Table 2
Fixed Routes	This is the percentage of vehicles which follow the provided static paths – this is the users who are familiar with the typical network conditions and generally travel via the same routes. The vehicles not on fixed paths are routed purely on network conditions	Cars: 70% Trucks: 100%	Cars: 60% Trucks: 100%
Max paths from input assignment	This is the maximum number of paths which can be considered from the static assignment input paths. A value too low will hinder the ability of vehicles on fixed paths to adjust routes due to congestion while a high value may lead to an overly sensitive and unstable assignment	3	3

3 DATA COLLECTION AND PROCESSING

3.1 What data has been collected for model development

It was identified at Phase 1 inception that any new data collection should be delayed as traffic was still settling into a typical pattern after the opening of Transmission Gully (opened in March 2022).

As such, the Stage 1 model development heavily relied on the data collected before TG opening. The scope of the Stage 2 modelling identified that additional data collection would be required to refine the model and this has been undertaken in mid/late 2022 at key intersections and along key road sections about the Porirua urban area.

3.1.1 Traffic data

Table 4 below provides a quick overview of the additional traffic data collected to assist the development of the stage 2 model.

Table 4: Traffic Data Collected

Count Type	Description	Number of Sites
Tube Counts	The vast majority of the tube counts were collected during Nov & Dec 2022. We note that some April/May 2022 data was also collected but this appeared to show different traffic patterns compared to the data collected later in the year.	57
Intersection Turning Counts	Manual intersection counts (from video surveys) have been obtained at a number of key intersections within the study area in late Nov 2022. The data was collected on a Tuesday and a Wednesday in the same week. The Aug/Sep traffic counts (also Tuesdays and Wednesdays) used to support the city centre modelling assessment will also be used to assist PTM Stage 2 development.	28
Waka Kotahi TMS Counts	We understand that TMS data was originally obtained in the Phase 1 model development. We however note that the previous data only provided all vehicle counts in each hour and we have extracted 15 mins data for each vehicle classes (when available) obtained in November 2022	18
Transmission Gully Counts	It was noted in the Stage 1 model development that traffic data along TG was not available as the traffic was still settling at the time. To rectify this, TG traffic volume data has been requested and hourly count data has been provided by Waka Kotahi near the Waitangirua Interchange and SH58 Interchange.	3

Table 4: Traffic Data Collected

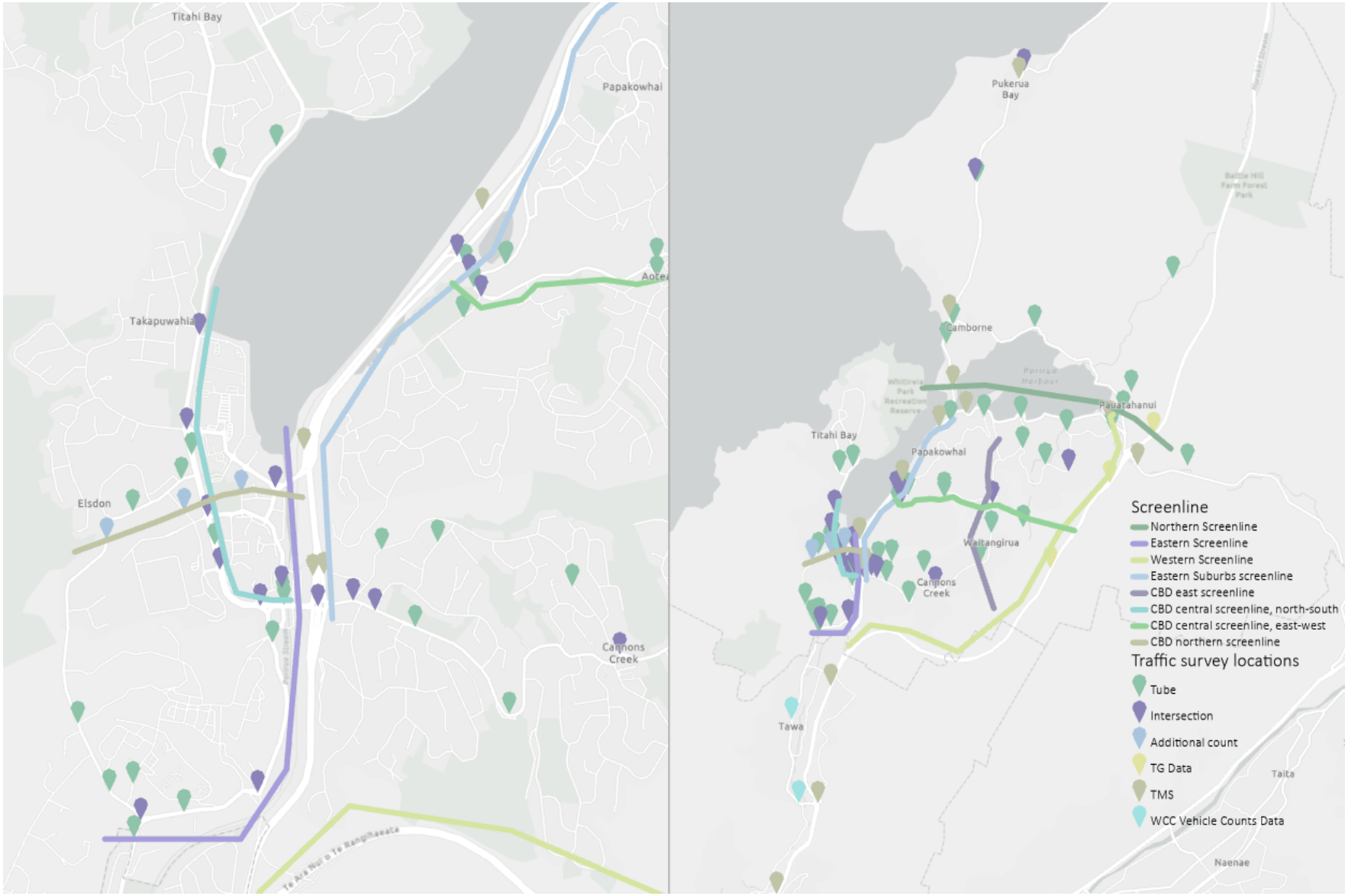
Count Type	Description	Number of Sites
Signal Timing (SCATS)	SCATS signal timing data from May 2022 has been used to determine the phase timing of the 11 intersections within the modelled area.	11
Wellington City Council Vehicle Counts data	This data has been obtained from WCC's vehicle counts website. We have only extracted data on Main Road due to the limitations with the data. It is also noted that the Main Road counts west of Willowbank Road were affected by a slip on Main Road north in August 2022, therefore they have not been used.	1
Additional CBD Counts	Additional screenline data was retrieved to verify the traffic volumes in the CBD area and address Peer Review's comments about additional screenlines.	3

For each of the above count sites, traffic volume data between 6 am and 2 pm and 3 pm to 7 pm has been obtained and the vast majority of the counts are in 15 minutes format.

Figure 8 below shows the locations of the traffic data collected. Based on the location of these counts, the following screenlines were used to help verify the modelled traffic volumes:

- Northern Screenline: this screenline covers SH59, TG and Paekākāriki Hill Road
- Eastern Screenline: this screenline covers the traffic volumes west of TG
- Western Screenline: this screenline checks the traffic volumes east of SH59
- Eastern Suburbs screenline: this one captures the volumes travelling through the eastern suburbs
- CBD east screenline: this screenline checks the total traffic travelling in/out of Porirua central area
- CBD central screenline, north-south: this north-south screenline checks the volumes east of Titahi Bay Road (commercial area)
- CBD central screenline, east-west: this screenline has been proposed to capture the north-south traffic volumes through the middle of the CBD area

Figure 8: Traffic Data Locations – Porirua CBD (left) and wider network (right)



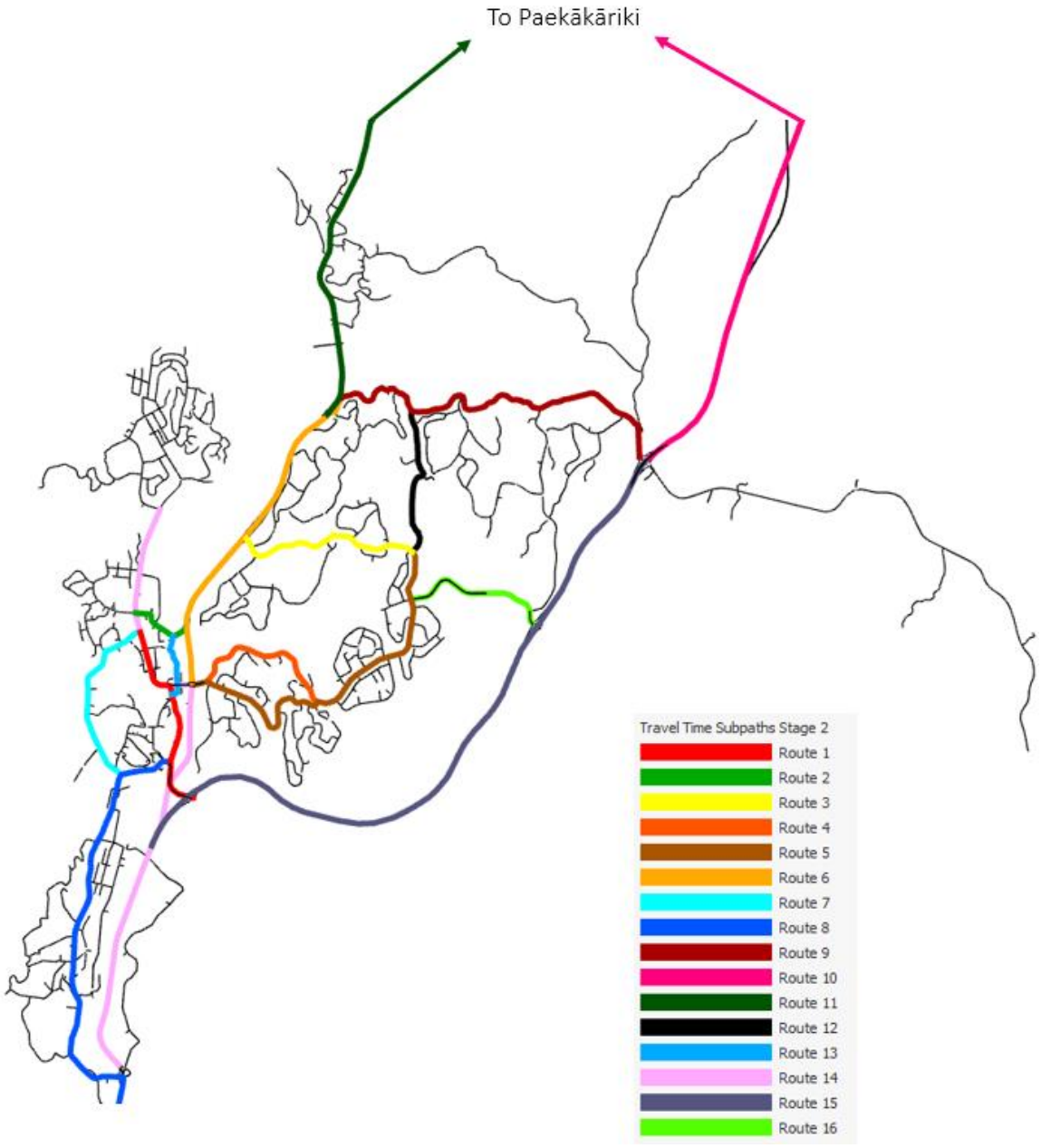
3.1.2 Journey Time collected

To assist the development of the Stage 2 model, travel time data has been obtained from the TomTom database. To ensure a large enough sample can be collected along each route, the average Tuesday, Wednesday and Thursday data between 6 am and 7 pm has been obtained from the entire month of November 2022. A description of the travel time routes considered is provided as follows and they are also shown in Figure 9 overleaf.

- Route 1: between Prosser Street and SH1 via Kenepuru Drive
- Route 2: between Titahi Bay Road and SH59 via Semple St
- Route 3: Whitford Brown Avenue and Warspite Avenue between Omapere Street and SH59
- Route 4: Mungavin Avenue between Champion Street and Warspite Avenue
- Route 5: Mungavin Ave and Warspite Avenue between Waitangairua Link Rd and Champion Street
- Route 6: SH59 between Mungavin Interchange and Paremata Crescent
- Route 7: Raiha Street between Prosser Street and Main Road
- Route 8: Main Road between Kenepuru Drive/Kenepuru Link roundabout and SH1
- Route 9: SH58 between SH1 and SH59
- Route 10: SH1 Transmission Gully between Paekākāriki and SH58
- Route 11: SH59 between Paekākāriki and SH58
- Route 12: Omapere Street between SH58 and Warspite Avenue
- Route 13: Lyttleton Avenue between Parumoana Street and Kenepuru Drive
- Route 14: Titahi Bay Road and SH1 between Te Pene Avenue and Grenada Interchange
- Route 15: SH1 between SH58 and SH59
- Route 16: Waitangirua Link Road between Warspite Avenue and TG

The available journey time data is sufficient for the PTM Stage 2 development.

Figure 9: Travel Time Routes



3.2 Land-use data collection

In addition to the above survey data, land use information has also been reviewed. This includes using spatial information from Open Street Map and the District Plan, household information from the 2018 Census[6] at meshblock detail and trip generation estimates from industry sources.

We have considered the following information to assist in the model development

- household numbers (NZ census) and predicted trip generation
- trip generation for key destinations, including schools in the area
- car parking information for the CBD area
- travel to work analysis using information contained in the commuter[7] waka database
- information provided from Council detailing recent residential development around the Kenepuru area.

The above information has been considered to adjust the prior OD matrix and discussed in more detail in the following sections.

4 AIMSUN ZONE OD MATRIX DEVELOPMENT

4.1 Wellington Transport Strategic Model (WTSM)

The prior demands of the PTM Stage 2 model have been informed by a cordon of the WTSM model. The model has been updated recently to reflect a 2018 base scenario and a more refined demand system. To assist the PTM development, cordon demands have been obtained from a WTSM 2023 forecast model which reflects a post-Transmission Gully opening environment.

The PTM Stage 2 prior demands have been developed based on the 3-hour WTSM demands for each peak period. The cordon demands provided for PTM Stage 2 include a 1-hour peak and 2-hour shoulder periods for the AM and PM periods and an average hour of Inter Peak period. For AM and PM peak periods, the 3-hour demands have been calculated using 1 x Peak Hour + 2 x Shoulder Period demands. For Interpeak, the 3-hour demand has been calculated by 3 x Average Interpeak demands.

4.2 Prior Demand Development

The above 3-hour WTSM demands have then been disaggregated into PTM zones based on the linear regression of the anticipated trip generation in each PTM zone:

- The Census Meshblock data have been used to understand the land use within each PTM/WTSM zone and the regression factors developed for the Wellington's Ngauranga to Airport (N2A) model have been applied to these land uses
- The light vehicles and heavy vehicle demands have been disaggregated separately based on the regression factors defined for each vehicle type

[6] https://www.stats.govt.nz/2018-census/
[7] https://commuter.waka.app/

- We note that the regression factors above do not consider school trip generations. As such, the percentage of school trips in each WTSM zone have been calculated from the raw WTSM trip purpose matrices and they have been applied to the trip generation calculated above to obtain the predicted school trips
- For Porirua CBD area, it is considered more appropriate to disaggregate WTSM zones based on the number of car parks, as they represent the actual origin/destination of the vehicle trips. As such, the Porirua City Car Parking GIS layer has been obtained from Porirua City Council and the parking numbers in each WTSM and PTM zone have been estimated using GIS software
- For the Kenepuru East area, the vast majority of PTM zones represent smaller areas than a single meshblock. The land use assumptions for these zones have been based on a combination of Census data collected in 2018 and the Kenepuru Landing building consent information provided by Porirua City Council
- The Public Transport Station zones included in the WTSM have also been introduced in PTM. This includes all bus stations and Park and Ride sites within the model extent. The predicted traffic generation for the Porirua and Paramata Park and Ride sites have been reviewed and they are generally in line with the carpark capacities for each site. No further disaggregation/adjustment of the PT station demands have been undertaken.

Table below provides a summary of the number of WTSM zones and PTM Zones before and after disaggregation.

Table 5: WTSM to PTM zone disaggregation

Model	WTSM	PTM
Number of Zones	152	215

The 3-hour demands from WTSM have been factored up to 4-hour demands based on the profile assigned for each origin and destination pair, and for light vehicles and heavy vehicles separately. These 4-hour demand matrices have been regularly checked and updated during the demand calibration process, due to the on-going adjustments to the flow profiles applied in the hybrid layer.

Before the above disaggregated prior demands have been used for matrix estimation, they have been broadly checked against the traffic volume data collected in the area, with the following changes being applied:

- A traffic volume comparison between WTSM and the traffic data collected in November 2022 has been undertaken at the early stage of the model development. It has been identified that the WTSM predicted trips (noting it is a forecast model) are lower than the observed data during the peak hour, particularly in the CBD area north of Titahi Bay Road corridor
- After the initial 4-hour WTSM demands have been obtained, they have been run in the PTM static layer and a comparison of the CBD screenline traffic demands between the observed data have been undertaken. The comparison confirms the results of the observation earlier and the initial demands appear to be lower than the observed volumes, by some 30% in different peaks. As such, we have applied a 30% increase to the Porirua CBD demands in all three peaks

- We note that there are a high number of schools in the Porirua area and home to school trips usually have some notable impacts in the urban/rural area like Porirua. A check has been undertaken which compares the school trips predicted by WTSM and the school rolls and Census home to school mode share data, obtained from Stats NZ's Commuter Wata website. The results indicate that an average of 0.1 outbound and 0.3 inbound car trips per student has been predicted by WTSM. These appears to be low compared to the 40% (usually higher) average passenger mode share reported by the 2018 Census Home to School data. To make sure the school traffic in the area will be properly presented in the PTM, we have therefore increased the school zone trips to reflect an inbound and outbound trip generation of 0.35 car trips per student.

Table below provides a comparison of the total observed traffic volumes against the raw WTSM 4 hour and adjusted prior matrix demands (a comparison of the CBD screenline flows is also provided):

Figure 10: Prior matrix adjustment – all network volumes

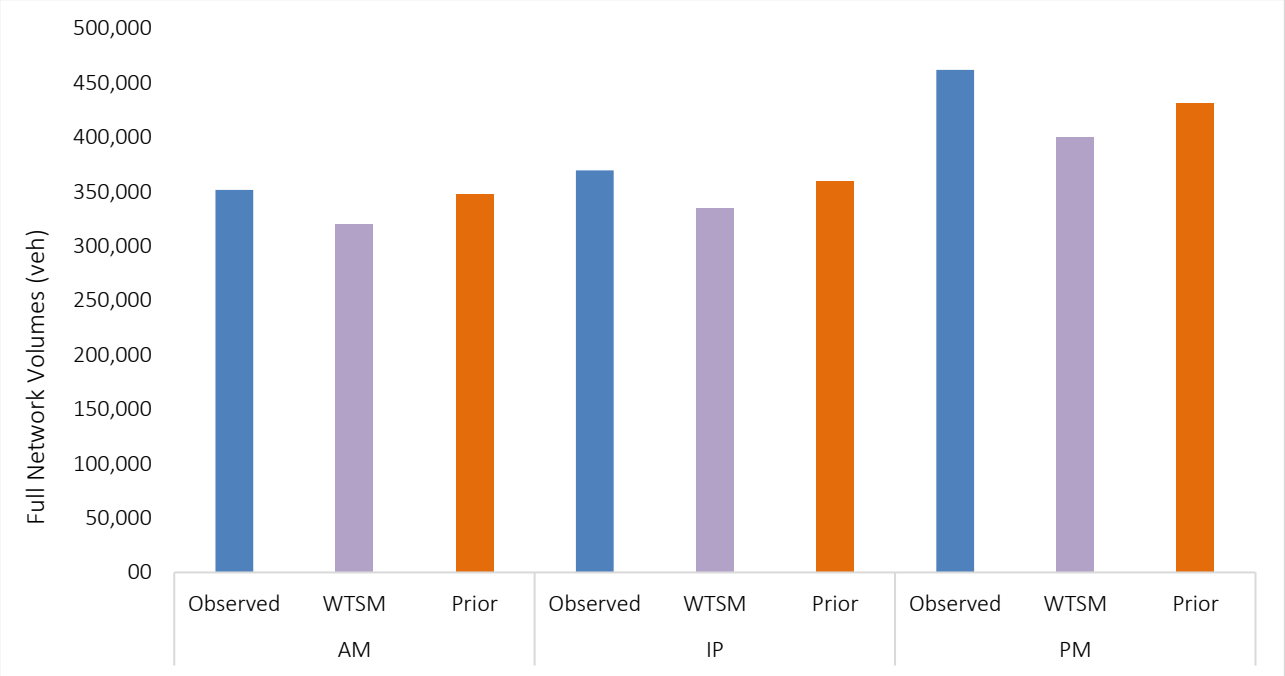


Figure 11: Prior matrix adjustment –CBD screenline volumes

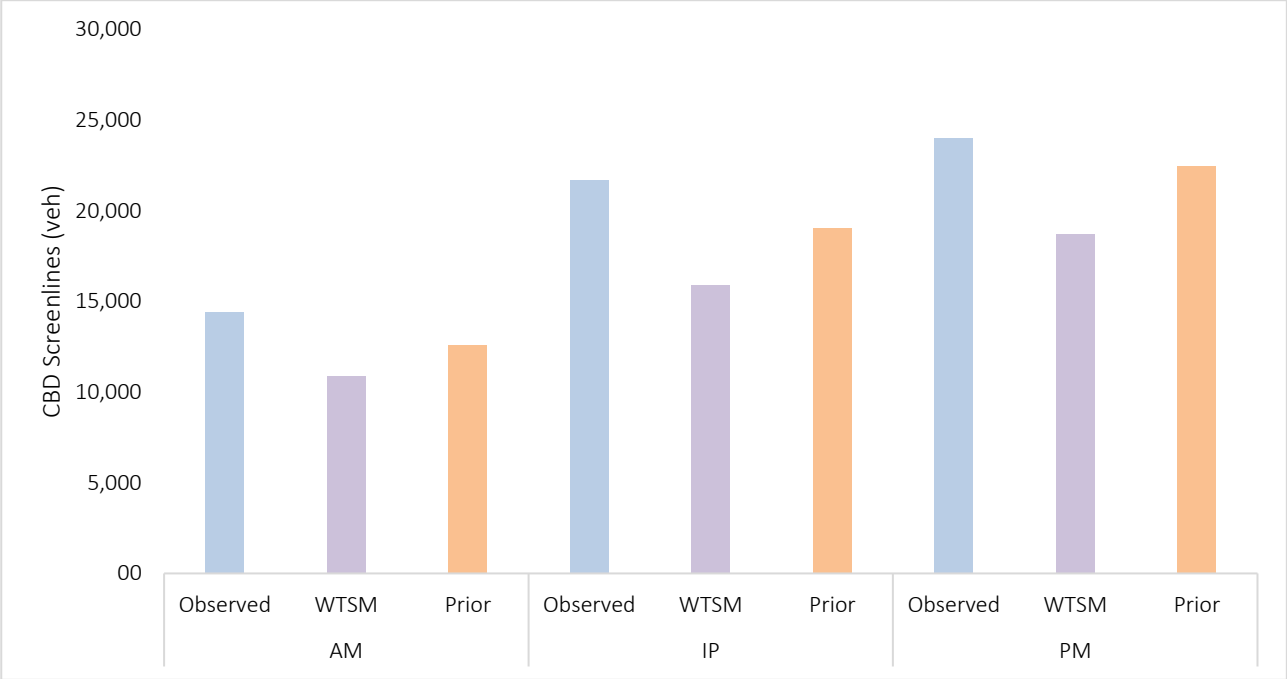


Table 6: Prior Matrix Adjustment – Individual count comparisons, full network

	Raw WTSM (4 hours)			Prior (Adjusted, 4 hours)		
	AM	IP	PM	AM	IP	PM
R-square	0.943	0.935	0.958	0.944	0.941	0.961
Line of best fit	Y = 0.97X	Y = 0.94X	Y = 0.89X	Y = 1.05X	Y = 1.01X	Y = 0.96X

The above results indicate that the adjustments applied to the raw WTSM matrices have generally increased the demands in the prior matrix, and they have improved the comparisons between the observed and modelled traffic volumes. We note that the Line of best fit comparison indicates that the Raw WTSM demands appear low for all three peak periods and these have been improved with the Prior matrix demands.

4.3 Prior OD matrix adjustment (estimation)

The matrix estimation tool within AIMSUN has been used to further refine the AIMSUN OD matrix disaggregated from the prior matrix.

The OD matrix estimation process uses the assignment of the 'prior' traffic demand matrix (4 hours), which is then adjusted within the static adjustment (estimation) process using link counts obtained from traffic data. This process creates an adjusted (estimated) matrix which better reflects the traffic volumes within the surveyed traffic link count data set.

The adjusted 4 hr traffic demands are then reassigned to the model and then corrected again using the real data set (RDS) and the 'prior' matrix. This process has been repeated several times until the convergence parameters are met, with the final estimated matrix being that used for static path assignment and dynamic micro-simulation validation purposes.

The adjustment constraint parameters applied during estimation are shown in Table 7.

Table 7: OD Matrix - Estimation adjustment constraints parameters

Vehicle Type	Demand Matrix Elasticity	Trip Length Distribution Elasticity	Demand bounds – Max deviation
Car	1.0 (all periods)	0.20 (AM and IP) and 0.5 (PM)	Applied
Truck	0.50 (AM and IP) and 1.0 (PM)	0.20 (AM and IP) and 0.5 (PM)	Applied

We have tested a lower demand elasticity with no max deviation constraints. This results in a poorer validation outcome. We have instead used the default demand elasticity of 1.0 and applied upper and lower bounds on more specific zones using the matrix deviation method.

The deviation restrictions are applied at a Sector level for each peak. The main purpose is to limit the number of short trips generated through estimation. The changes for the include restrictions to

- Residential and CBD ie to and from zones 2, 3, 5, and 6 to and from zone 1.
- Internal CBD trips, particularly during the inter peak period
- External to residential zones in the evening peak and visa versa in the morning peak.

The above changes help limit the extent to which the prior matrix is manipulated in the estimation process and results in a good level of validation.

After the Aimsun OD adjustment process, a further check of the full 4-hour demands have been undertaken and additional refinements have been applied to the demands at the following locations:

- Supermarkets within the CBD
- Schools
- Between residential and commercial demand sectors.

4.3.1 Calibration and validation data sets

We note the Model Development guidelines recommend independent traffic count data for calibration (estimation) and validation where possible, but that withholding good quality data from demand development process is likely to result in poorer demand development.

As such, we note that we have used all the link counts[8] obtained on one of the surveyed days (Tuesday, in general) for the calibration (demand estimation) process and used turn counts derived from the same locations, but a different day (Wednesdays) for model validation. Table overleaf provides a quick summary of the count sets used in the calibration and validation process. Appendix A presents the location of the calibration and validation data sets.

[8] These includes intersection video survey data, tube count data and Stage Highway count data from TMS website and Waka Kotahi

Table 8: Count Set Used

Count Set	Calibration	Validation
Intersection Counts	Link counts obtained on Tuesdays (by summarising the turning movements)	Turn Counts obtained on Wednesdays
Tube Counts	Link counts obtained on Tuesdays	Link Counts obtained on Wednesdays
Waka Kotahi's TMS and TG data	Link counts obtained on Tuesdays	Link Counts obtained on Wednesdays
Additional Counts obtained for screenline	Link counts obtained on Tuesdays	Link Counts obtained on Wednesdays

4.3.2 Matrix Totals

Table 9 provides the matrix totals through the base year (2022) demand development process for both morning and evening modelled periods. Three matrices are compared

- 4 hr WTSM matrix
- prior matrix which includes additional refinements
- final matrix after matrix demand estimation

Table 9: Demand matrix totals (4 hours)

	AM peak period		Inter Peak Period		PM peak period	
	Light	Heavy	Light	Heavy	Light	Heavy
WTSM	52,700	2,200	53,600	2,100	66,500	1,900
Prior Matrix	57,100	2,500	57,100	2,100	71,100	1,900
Final Matrix	58,700	3,150	56,000	2,800	75,000	3,000
Difference between prior and final	1,600	650	1,100	700	3,900	1,100
% Difference	+3%	+26%	-2%	+25%	+5%	+57%

The above process demonstrates that (with regard to the development of the final demand set)

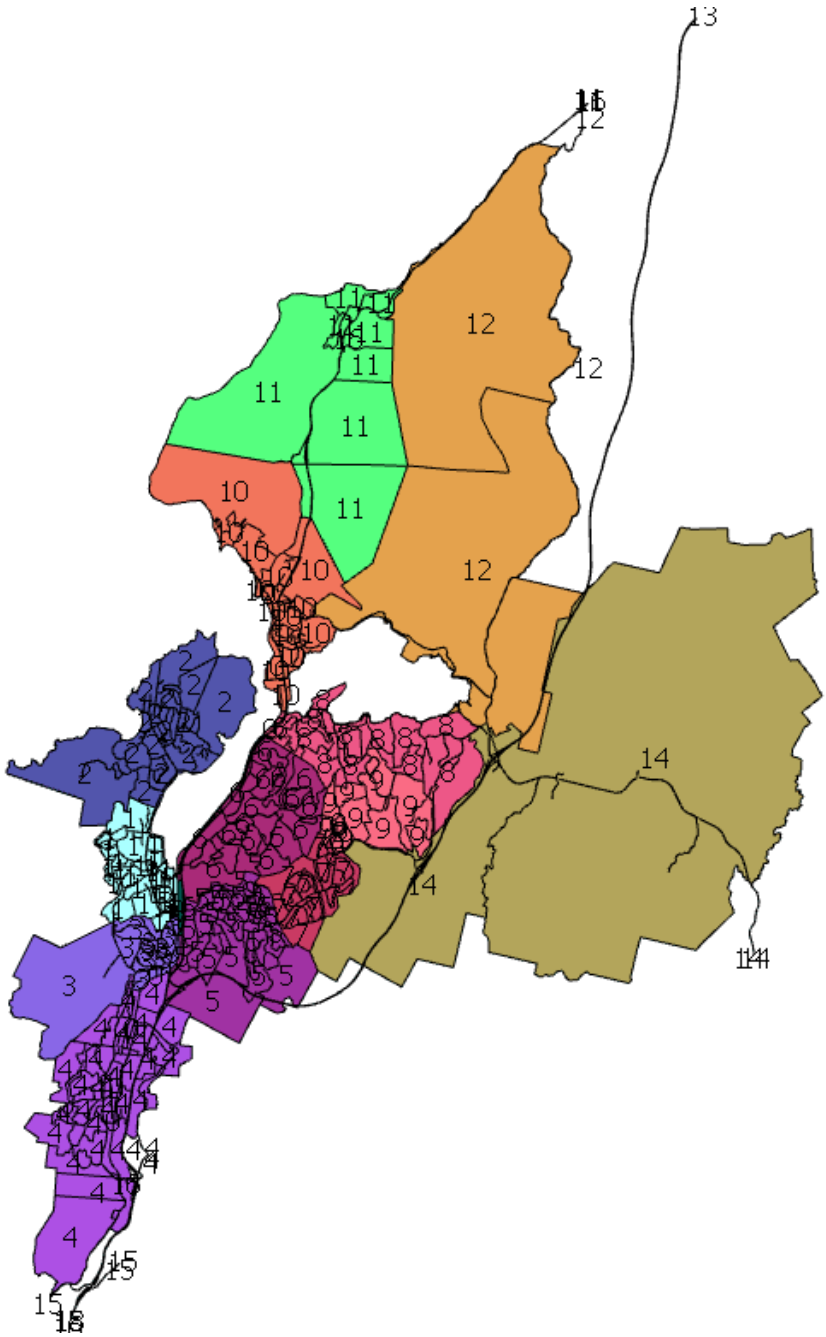
- the largest change is from the raw WTSM demands to the prior matrix
- the changes between the prior and final matrix through the matrix estimation process are more limited and reflect a relatively good prior matrix
- the total number of trips in the morning peak period and evening peak period have been increased by 3% and 4% respectively, indicating the decision to increase demands in WTSM is appropriate
- significant increases have been predicted for heavy vehicle volumes, it is however noted that the WTSM may have underestimated the heavy vehicle demands for short distance (< 10 km) trips. This has been discussed further in the trip length discussion section below.

4.3.3 Trip length distribution check and sector analysis

We have analysed the trip length distribution, which compares the WTSM raw demands, 'prior' matrix and the estimated matrix. Trip length figures are provided at Appendix B for all vehicles. The figures generally show similar trip length distributions between the 'prior' and estimated traffic demands and the total number of trips remains similar. However, the PM peak period exhibits an increase in trips of between 1 and 5 kms. This has been examined further through sector analysis.

The sector analysis aims to show the extent to which the matrix estimation process has altered the original demand matrix distribution. Difference matrices have been created to compare the original traffic demands (referred to as the 'prior' matrix) against the estimated matrix. To complete this assessment, the traffic demand matrix was aggregated into 15 sectors as shown Figure 12.

Figure 12: Network sectors



The following are noted for the morning peak period

- The largest change is between the CBD (and surrounds) to the Linden/Tawa Area, indicating an increase of some 500 - 600 trips in both directions
- From SH1 south of Grenada Interchange to Tawa/Linden and Transmission Gully north
- An increase of some 380 vehicles, or 30% is also observed between the residential areas surrounds the CBD to the commercial/retail areas
- The remaining changes to the 'prior' matrix are generally less than 300 trips over 4 hours
- The observation indicates that the increased demands are generally associated with the demands to/from the city centre areas. This is in-line with the observation that the raw demands predicted by WTSM compared low to the observed traffic volumes
- For heavy vehicles, significant increases have been predicted to trips less than 10 km. We note that it is not uncommon for a strategic model such as WTSM to underestimate short distance heavy vehicle trips and it is expected that the matrix estimation process will help refine heavy vehicle trips based on the traffic count data.

The following are noted in the evening peak period

- the largest changes are an increase of Sector 15 trips, by some 950 vehicles, or 170%. A closer look indicates that the increased demands are mostly associated with trips from SH1 to Grenada Village and Glenside areas. We note that the model run with prior demand predicted a low traffic volume on the SH1 northbound off ramp to Westchester Drive, and these have been increased during the calibration process to match the observed volumes on the off ramp
- High demands between CBD and Tawa/Linden area, and between SH1 and TG north have also been observed during the PM peak, which is similar to the AM peak adjustments
- Similar to the AM peak, heavy vehicle percentages for trip distances less than 10 km have been increased significantly

The interpeak matrix estimate show similar trend to the ones observed in the AM and PM, with the largest increases being between CBD and Tawa/Linden/Cannons Creek areas. The overall adjustment to the interpeak demands are considered to be minor.

4.4 Static and Hybrid Simulation

A static assignment is developed to provide initial route choice paths, which are then fed into the dynamic micro-simulation. This is similar to the other models developed in the Greater Wellington Region.

The PTM model development structure includes

1. 4 hour demands which are assigned to the static assignment
2. Paths from the static assignment are then passed through as an input
3. The dynamic micro-simulation is a stochastic route choice assignment model (SRC), which uses the same demands in Step 1 above, but with traffic volume profiles applied to each demand sectors, for light vehicles and heavy vehicles separately

The profiles applied in the micro-simulation layer has been based on 15 mins count data collected at various locations of the network (provided in Appendix B). These locations have been selected so they can generally represent the directional traffic patterns of the surrounding land uses. The following adjustments have been also applied to the profiles as appropriate to account for the impacts of traffic congestion/travel time between origin and destination:

- A time shift change has been applied to all profiles to account for the travel time required for vehicles to reach their destinations in the first hour. This have been achieved by shifting the demands (5% to 8% of the total demands) from the last 30 mins of each peak to the fist 30 mins of the peak period
- Adjustments to the profiles which might be affected by congestions (for example, CBD outbound during AM peak) have also been applied
- While the vast majority of profiles used in the model represent the release of traffic onto the network, it was found during the model validation stage that it was difficult to obtain a correct profile for SH1 and Porirua CBD arrival flows due to the location of profiles being various distances away from them. As such, additional arrival profile on SH1 and to Porirua CBD have been used to make sure the model can capture the arrival flows to these locations correctly
- In addition to the above, it has been noted that significant queuing is observed along SH1 in the southbound direction between TG and south of Grenada Interchange, during the AM peak period. As such, additional time shift factors have been applied to the AM peak SH1 southbound arrival profiles (Profile 18) to account for the additional time required to travel to the interchange

Typical examples of the demand profile adjustments have been provided in Appendix B of this report.

5 MODEL VALIDATION CRITERIA

Waka Kotahi's Transport Model Development Guidelines (The Guidelines)[9] have been endorsed by Waka Kotahi. This report has therefore referred to The Guidelines for the model validation criteria. Table 10 to Table 11 below outline the criteria adopted in this project for link counts, turn counts and journey times respectively.

Criteria for a Type C model are referred to in the following tables. The Guidelines state that a Type C model relates to a model considering urban area assessment traffic assignment model.

Table 10: Link and Turn count validation criteria

Link Count Criteria	Waka Kotahi Model Validation Guideline
Coefficient of determination (R^2)	A minimum of 95% in vicinity of project
Line of best fit	Y = 0.9x to 1.1x
GEH statistic (Link and Turn Counts)	◆ At least 85% of individual link flows should have a GEH less than 5 ◆ At least 90% of individual link flows should have a GEH less than 7.5 ◆ 95% of individual link flows shall have a GEH less than 10
Percentage-Root-Mean-Square Error (RMSE)	◆ Acceptable: <20% ◆ Requires clarification: 20-30% ◆ Unlikely to be appropriate: >30%
Screenline volumes, individual counts	◆ At least 85% of individual screenline link flows should have a GEH less than 5 ◆ At least 90% of individual screenline link flows should have a GEH less than 7.5 ◆ At least 95% of individual screenline link flows shall have a GEH less than 10 ◆ 100% of individual screenline link flows shall have a GEH less than 12
Total Screenline Volumes	◆ At least 85% of total screenline link flows should have a GEH less than 5 ◆ At least 90% of total screenline link flows should have a GEH less than 7.5 ◆ At least 95% of total screenline link flows shall have a GEH less than 10

Table 11: Comparison of journey time validation criteria

Journey Time Criteria	**Transport Agency Model Validation Guideline**
Within 15%	85% or more of the modelled travel times should fall within 15% (or 1 minute, if 1 minute is greater than 15% of the travel time).
Within 25%	90% or more of the modelled travel times should fall within 25% (or 1.5 minutes, if 1.5 minutes is greater than 25% of the travel time).

6 MODEL CALIBRATION

The following results relate to the calibration stage, i.e. traffic data used as part of matrix estimation. Details of the subsequent validation are provided in Section 7.

[9] Waka Kotahi (2019), Transport Model Development Guidelines

Appendix A shows the locations of all link counts used in calibration.

It should be mentioned that a good comparison between the modelled and observed counts is generally expected after the matrix estimation process, as the demands have been adjusted to match the count data.

6.1.1 Coefficient of Determination

The coefficient of determination (R-square) values for each model are provided in Table 12. Ideally these coefficients should satisfy an R-square of 95% in the vicinity of the project. As shown, each model achieves an R-square value of over 95% for total vehicles.

Table 12: Coefficient of determination (R^2) results for estimation link counts

Time Period	Number of Counts	R^2
Morning Peak	232	0.979
Inter Peak	232	0.990
Evening Peak	232	0.990

6.1.2 GEH statistic for link flows

The GEH statistic is considered a more robust assessment when comparing modelled traffic volumes against actual observed volumes, as a large percentage difference measure may relate to a small absolute difference on a lightly trafficked link. Similarly, a link with a greater volume may dampen both the absolute and percentage differences. The GEH statistics for link flows after matrix estimation are shown in Table 13.

It should be noted that the GEH values are generally used to compare hourly volumes, so a high percentage of GEH values achieving the criteria across a 4 – hour period is generally expected.

Table 13: Link count GEH summary statistics

Targets in Guidelines	Time Period	Number of Counts	% of Counts
80% GEH < 5	Morning Peak	216	93%
	Inter Peak	223	96%
	Evening Peak	228	98%
90% GEH < 10	Morning Peak	229	99%
	Inter Peak	231	99.5%
	Evening Peak	231	99.6%

7 MODEL VALIDATION

As mentioned previously, the calibration and validation targets reflect the Waka Kotahi project model category type C from the Guidelines.

Validation has been carried out for the 4-hour peak period for all vehicle types combined, for

- **Turn and link counts**: peak hour check of intersection turning movements and link counts throughout the modelled area
- **Journey times:** journey time check between observed data and model outputs for selected key corridors as shown in Figure 9
- **Screenline counts:** similar to turn and link counts, this checks the individual link and total volumes across the screenlines as shown in Figure 7.

We have provided second and third hour outputs for each peak period as follows:

- 7:00 am to 8:00 am (hour 2), 8:00 am to 9:00 am (hour 3) for the morning peak
- 11:00 am to 12:00 pm (hour 2), 12:00 pm to 1:00 pm (hour 3) for the inter peak
- 4:00 pm to 5:00 pm (hour 2), 5:00 pm to 6:00 pm (hour 3) for the evening peak

7.1 Flow validation results

We have reviewed the values for the entire modelled periods and are confident they are reasonably reflective of the existing travel behaviour. The full model outputs are provided in Appendix C while subsequent sections provide summaries of the peak hour for the morning, inter, and evening periods.

7.1.1 Coefficients of determination

The coefficient of determination (R-square) values for each model are provided for link and turn counts for day 2 for the peak hour. We have reviewed the values for the entire modelled periods and are confident they are reasonably reflective of the existing travel behaviour. We have provided the full model outputs are provided in Appendix C.

Ideally these coefficients should satisfy an R-square of 95% and the line of best fit should be between 0.90x and 1.10x.

Table 14: Coefficient of determination (R^2) and line of best fit results for validation counts

Time Period	Number of counts	R^2		Line of Best Fit	
		Hour 2	Hour 3	Hour 2	Hour 3
Morning Peak	289	0.97	0.98	0.928	1.01
Inter Peak	289	0.95	0.96	0.985	0.965
Evening Peak	289	0.96	0.96	0.960	0.985

The results indicates that R-square values of over 95% are achieved for all model time periods.

Appendix C presents plots of the observed versus modelled link counts for the modelled time periods. Each observed count has only been used once, ie the counts include all turns at the surveyed intersections (no link counts) and link counts at all the tube survey locations.

The plots show a good correlation between observed and modelled counts. The lines of best fit are well within the targets in the Guideline.

Appendix A shows the locations of all counts used in validation, while Appendix C provides the link and turn count spreadsheet.

7.1.2 Percentage Root-Mean-Square-Error (RMSE)

The RMSE percentage is calculated for the turn and independent link counts and is provided as one value for each modelled time period. The Guideline states that the RMSE should be less than 20%, with a value less than 30% being acceptable subject to clarification.

Table 15 outlines the RMSE results for all turn counts, and the results for the independent link counts.

Table 15: Percentage root mean square error results for validation counts

Time Period	Number of counts	% RMSE	
		Hour 2	Hour 3
Morning Peak	289	27%	21%
Inter Peak	289	19%	20%
Evening Peak	289	22%	19%

Table 15 indicates that when considering all the link and turn counts the RSME percentage value is within 30% for the turn counts. We note that with a large number of low volume turn counts the RSME criteria is usually difficult to meet.

7.1.3 GEH statistic for link and turn flows

The GEH statistics for the turn and link count validation is shown in Table 16. Noting that the link count comparison is with an independent set of count data.

The targets set in the Guidelines require a high level of accuracy when considering the methodology used for this study, with regard to matrix estimation. Flow avoids the use of turning count information in matrix estimation where possible as there is a high likelihood for short trips being created, and as such, meeting the targets set for turning count validation is more challenging to achieve. It is also noted in the AM and PM peak that there is a number of GEH values between 5 and 6, which reflects a high number of counts satisfying the GEH < 7.5 criteria (these are some 8% – 13% above the criteria).

In light of this however, the level achieved is consider appropriate and robust.

Table 16: GEH summary statistics hour 2

Hour	GEH Range	AM peak hour		IP peak hour		PM peak hour		Target
		Number of Counts	Percentage within criteria	Number of Counts	Percentage within criteria	Number of Counts	Percentage within criteria	
Hour 2	**GEH < 5**	243	85%	255	89%	223	78%	80%
	GEH < 7.5	274	96%	282	98%	268	94%	85%
	GEH < 10	3	99%	1	99%	7	98%	90%
Hour 3	**GEH < 5**	216	76%	249	86%	227	79%	80%
	GEH < 7.5	270	95%	277	97%	266	93%	85%
	GEH < 10	1	99%	4	99%	5	98%	90%
Total counts		287		288		286		

7.1.4 Screenline percentage differences

As a means to determine the model's accuracy, the Guideline requires an assessment of total and individual screenline counts, whereby the volume of traffic across screenlines sets the required accuracy needing to be achieved.

Table 17 summarises the percentages within the GEH criteria achieved for total directional counts.

Table 17: Total directional counts across screenlines

		Hour 2			Hour 3		
Targets in Guidelines	Time Period	Number of Counts	%	Target met	Number of Counts	%	Target met
85% of screenline GEH < 5	Morning Peak	14 of 16	88%	Y	14 of 16	88%	Y
	Inter Peak	15 of 16	94%	Y	12 of 16	75%	N
	Evening Peak	11 of 16	69%	N	14 of 16	88%	Y
90% of screenline GEH < 7.5	Morning Peak	15 of 16	94%	Y	16 of 16	100%	Y
	Inter Peak	16 of 16	100%	Y	15 of 16	94%	Y
	Evening Peak	15 of 16	94%	Y	16 of 16	100%	Y
95% of screenlines GEH < 10	Morning Peak	16 of 16	100%	Y	16 of 16	100%	Y
	Evening Peak	16 of 16	100%	Y	16 of 16	100%	Y

All criteria are met with the exception of 2 target in the inter and evening peaks. This is very close to being met as well. Again, we note that the model has achieved a high percentage of counts satisfying the GEH < 7.5 criteria. For PM peak, only 69% of the total screenline volumes satisfied the GEH < 5

criteria. We however note that three screenlines have been reported with a GEH between 6.1 and 6.6, which is very close to GEH = 5 criteria. In addition, inconsistent traffic volumes between Tuesday and Wednesday traffic count data have been reported at the following locations, which may have affected the screenline validation of the PM peak model (based on Wednesday data):

- Hagley Street east approach at the Titahi Bay Road/Hagley Road intersection (Tuesday volumes 20% lower in the eastbound direction)
- Lyttleton Avenue east approach at the Titahi Bay Road/Lyttleton Avenue intersection (Tuesday volumes 13% lower in the eastbound direction)
- Parumoana Street south of The Ramp (Tuesday volumes 9% and 10% lower in the northbound and southbound direction respectively)
- Titahi Bay Road east of Kenepuru Drive (Tuesday volumes some 5% and 7% lower in the westbound and eastbound direction respectively).

Table 18 summarises the percentages within the GEH criteria achieved for individual directional counts.

Table 18: Individual counts across screenlines

		Hour 2			Hour 3		
Targets in Guidelines	Time Period	Number of Counts	%	Target met	Number of Counts	%	Target met
85% of screenline GEH < 5	Morning Peak	55 of 64	86%	Y	54 of 64	84.8%	N
	Inter Peak	63 of 66	96%	Y	58 of 66	88%	Y
	Evening Peak	54 of 64	84%	Y	55 of 64	86%	Y
90% of screenline GEH < 7.5	Morning Peak	63 of 64	98%	Y	62 of 64	97%	Y
	Inter Peak	66 of 66	100%	Y	63 of 66	95%	Y
	Evening Peak	62 of 64	97%	Y	62 of 64	97%	Y
95% of screenline GEH < 10	Morning Peak	64 of 64	100%	Y	64 of 64	100%	Y
	Inter Peak	66 of 66	100%	Y	66 of 66	100%	Y
	Evening Peak	64 of 64	100%	Y	64 of 64	100%	Y
100% of screenline GEH < 12	Morning Peak	64 of 64	100%	Y	64 of 64	100%	Y
	Inter Peak	66 of 66	100%	Y	66 of 66	100%	Y
	Evening Peak	64 of 64	100%	Y	64 of 64	100%	Y

All criteria are met with the exception of 1 target (84.8%) in the morning peaks. This is very close to being met as well.

7.2 Journey Time Comparisons

Figure 11 to Figure 11 show the differences between observed and modelled journey times. The journey time distance-time plots are provided in Appendix D of this report.

Journey times were provided by WTAU (via TomTom) and compared to the modelled journey times. The journey times for 16 key corridors have been assessed in both directions, being

- R1 and R2 between Prosser Street and SH1 via Keneperu Drive
- R3 and R4 between Titahi Bay Rd and SH59 via Semple St
- R5 and R6 between Omapere Street and Whitford Brown Avenue
- R7 and R8 between Champion Street at Warspite Avenue and Champion St
- R9 and R10 between Waitangairua Link Rd and Mungavin Ave via Mungavin
- R11 and R12 between SH58 and Titahi Bay Rd via SH59
- R13 and R14 between Prosser Street and Main Rd via Raiha St
- R15 and R16 between Kenepuru Dr/Kenepuru Link roundabout and SH1 via M
- R17 and R18 between SH1 and SH59 via SH58
- R19 and R20 between Paekakariki and SH58
- R21 and R22 between Paekakariki and SH58 via SH59
- R23 and R24 between SH58 and Warspite Ave via Omapere St
- R25 and R26 between Parumoana St and Kenepuru Dr via Lyttelton Ave
- R27 and R28 between Te Pene Ave and Takapu Rd via Titahi Bay Rd-SH1
- R29 and R30 between SH58 and SH59 via SH1
- R31 and R32 between Warspite Ave and TG via Waitangirua Link Rd

Figure 9 shows the modelled journey time routes and the sub routes split locations of each corridor.

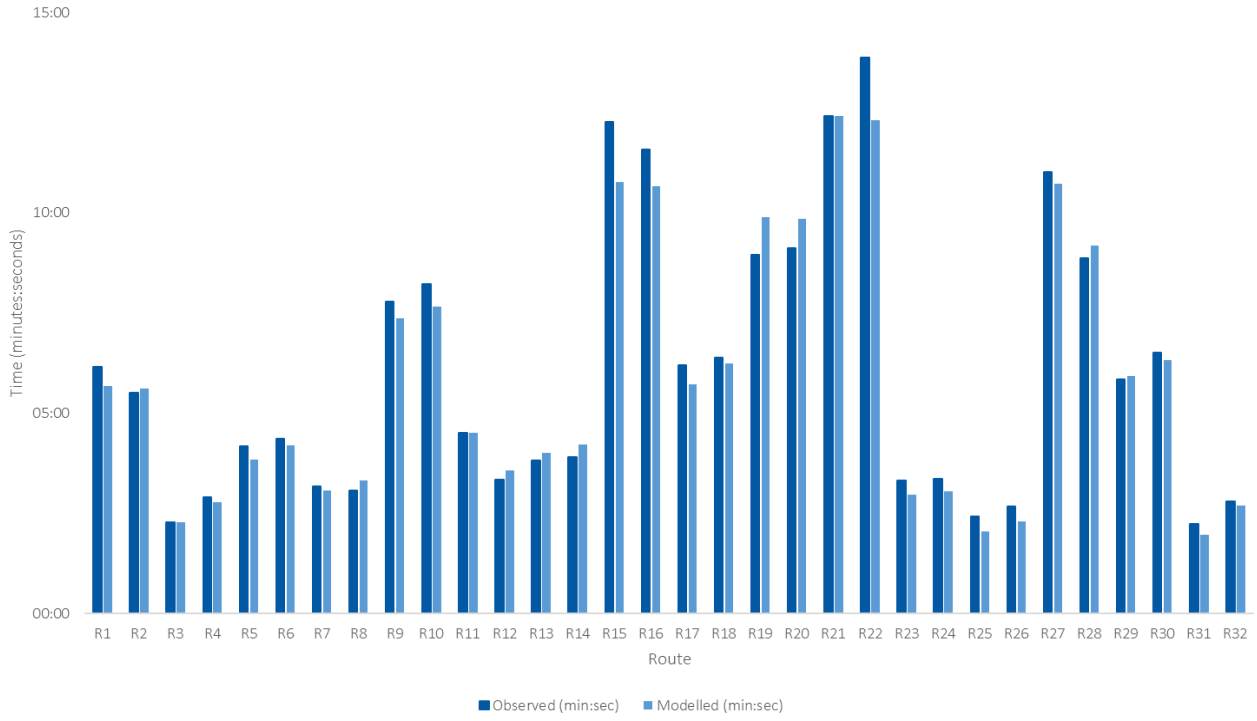
The modelled times are summarised and compared to observed times in Figure 13, Figure 14, and Figure 15 for morning, inter and evening peak hour, respectively.

The criteria for comparing observed and modelled travel times in the Transport Model Development Guideline is shown in Table 19.

7.2.1 Morning Peak Period

The observed and modelled travel time for each route for the morning peak hour are shown in Figure 13. There is little variability comparing the 2 travel times with most modelled routes being within 1-minute of the observed.

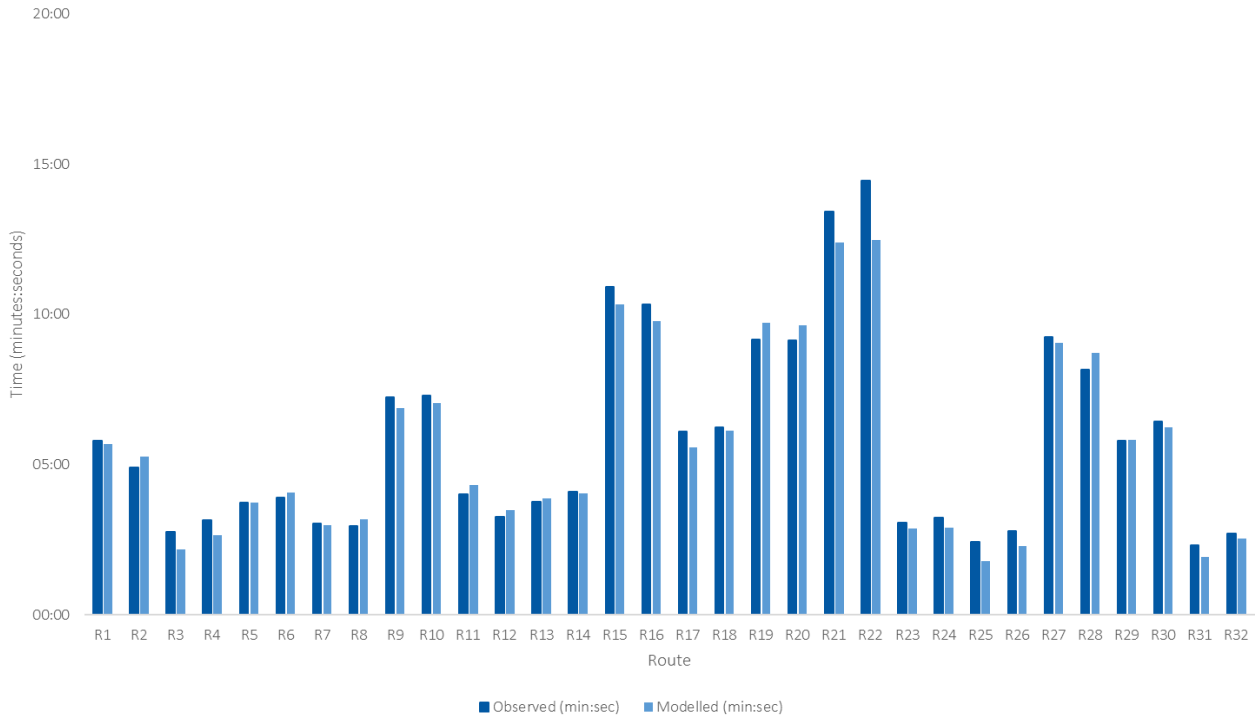
Figure 13: Journey Time Comparison – Morning peak



7.2.2 Inter Peak Period

The observed and modelled travel time for each route for the inter peak hour are shown in Figure 14. There is little variability comparing the 2 travel times with most modelled routes being within 1-minute of the observed.

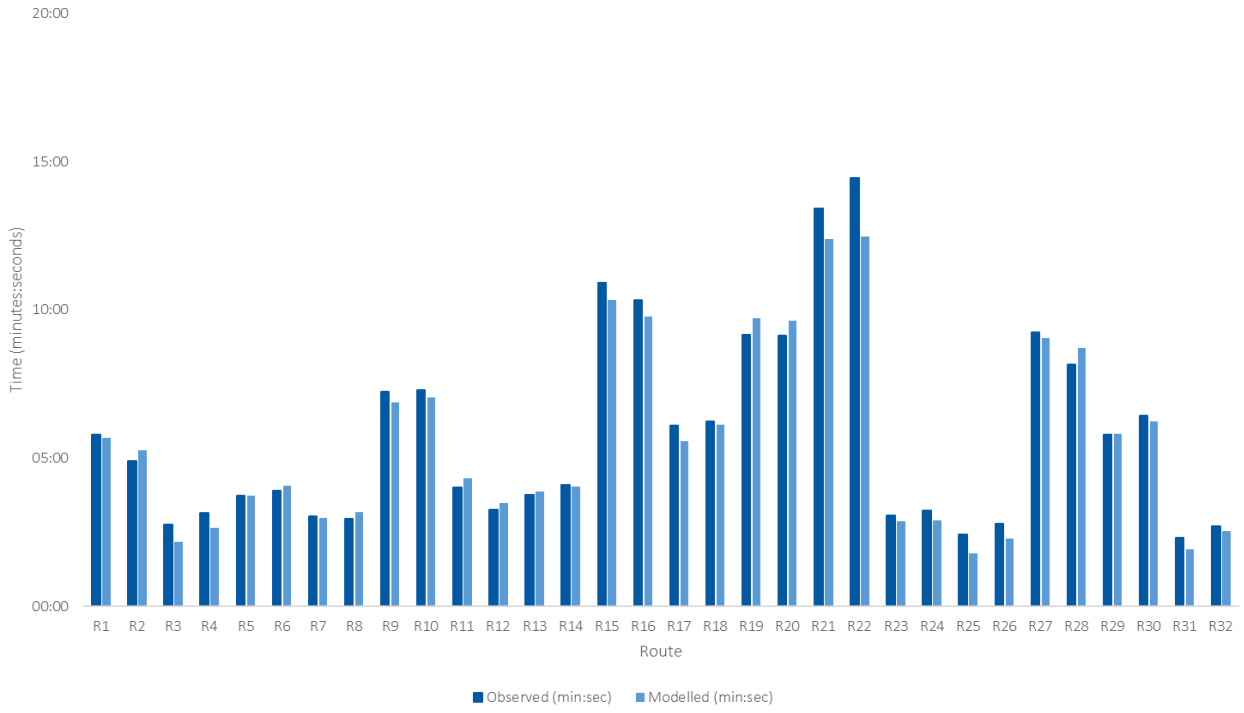
Figure 14: Journey Time Comparison – Inter Peak



7.2.3 Evening Peak Period

The observed and modelled travel time for each route for the evening peak hour are shown in Figure 15. There is little variability comparing the 2 travel times with most modelled routes being within 1-minute of the observed except for route 20 from Paekakariki to SH58. The exception is 1% over the suggested guideline and is mostly outside of the core study area.

Figure 15: Journey Time Comparison – Evening Peak



7.2.4 Journey time validation summary

We have compared the differences between the observed and modelled travel times to The Guidelines. Table 19 summarises the validation criteria with all routes being reasonably representative for a Type C model in all modelled peaks.

Table 19: Journey time route comparison

Journey time criteria	AM peak hour	IP hour	PM peak hour
85% or more of the modelled travel times should fall within 15% (or 1 minute, if 1 minute is greater than 15% of the travel time).	32 of 32 (100%)	32 of 32 (100%)	31 of 32 (97%)
90% or more of the modelled travel times should fall within 25% (or 1.5 minute, if 1.5 minutes is greater than 25% of the travel time).	32 of 32 (100%)	32 of 32 (100%)	32 of 32 (100%)

We believe there is generally a good match between modelled and observed journey times within the network.

8 MODEL VALIDATION SUMMARY

This report has outlined the development of the PTM. The performance of each of the peak period base models is summarised in Table 20 for the peak hour. The table indicates that most of the targets in Waka Kotahi's Transport Model Development Guidelines have been achieved.

As a result, we are of the view that the PTM reflects today's travel behaviour about Porirua CBD and Porirua Eastern Suburbs and is considered fit for purpose for developing a forecast model and option assessments to an urban area assessment level (Type C).

Table 20: Transport modelling validation criteria status for each modelled peak hour

Criteria	Sub criteria	Description	Criteria Satisfied		
			AM	Inter	PM
Link and Turn Flows	Coefficient of determination (R^2)	A minimum of 95% in vicinity of project	Y	Y	Y
	Line of best fit	Y = 0.9x to 1.1x	Y	Y	Y
	GEH statistic	80% GEH less than 5	N	Y	N (79%)
		85% GEH less than 7.5	Y	Y	Y
		90% GEH less than 10	Y	Y	Y
	Root-Mean-Square Error (RMSE)	Acceptable: <20% Requires clarification: 20-30%	C	Y	Y
Screenline Flows	Individual Link Counts	85% GEH less than 5	Y	Y	N (84.8%)
		90% GEH less than 7.5	Y	Y	Y
		95% GEH less than 10	Y	Y	Y
		100% GEH less than 12	Y	Y	Y
	Total Screenline Counts	85% GEH less than 5	Y	Y	N
		90% GEH less than 7.5	Y	Y	Y
		95% GEH less than 10	Y	Y	Y
Journey Times	Difference Comparison	85% or more of the modelled travel times should fall within 15% (or 1 minute, if 1 minute is greater than 15% of the travel time).	Y	Y	Y
		90% or more of the modelled travel times should fall within 25% (or 1.5 minute, if 1.5 minutes is greater than 25% of the travel time).	Y	Y	Y
	Plots	Distance / Time	Y	Y	Y

APPENDIX A Calibration and validation locations

Calibration and validation count locations

Figure A16: Locations of calibration (estimation) and validation counts – Morning Peak

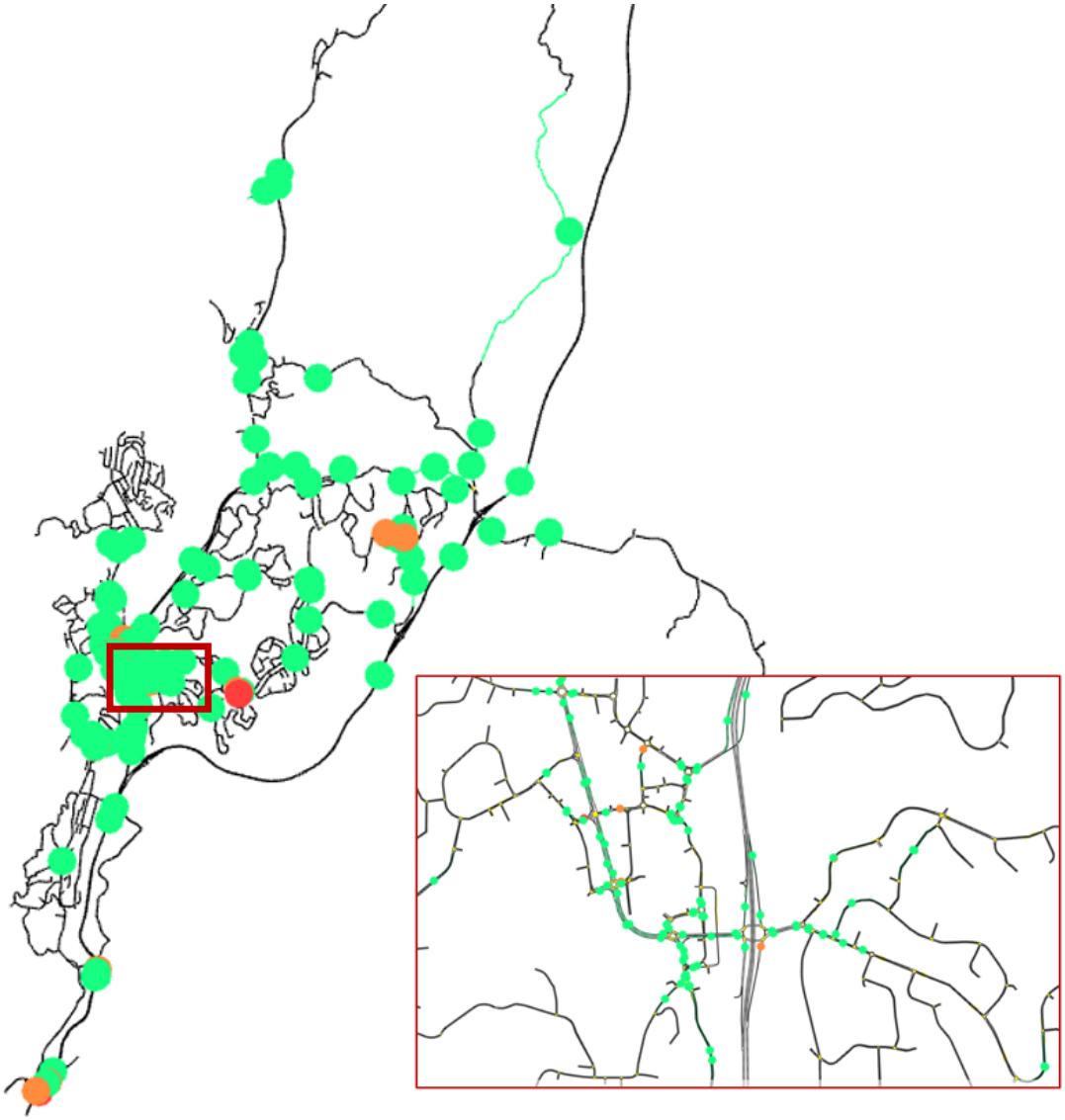


Figure A17: Locations of calibration (estimation) and validation counts – Inter Peak

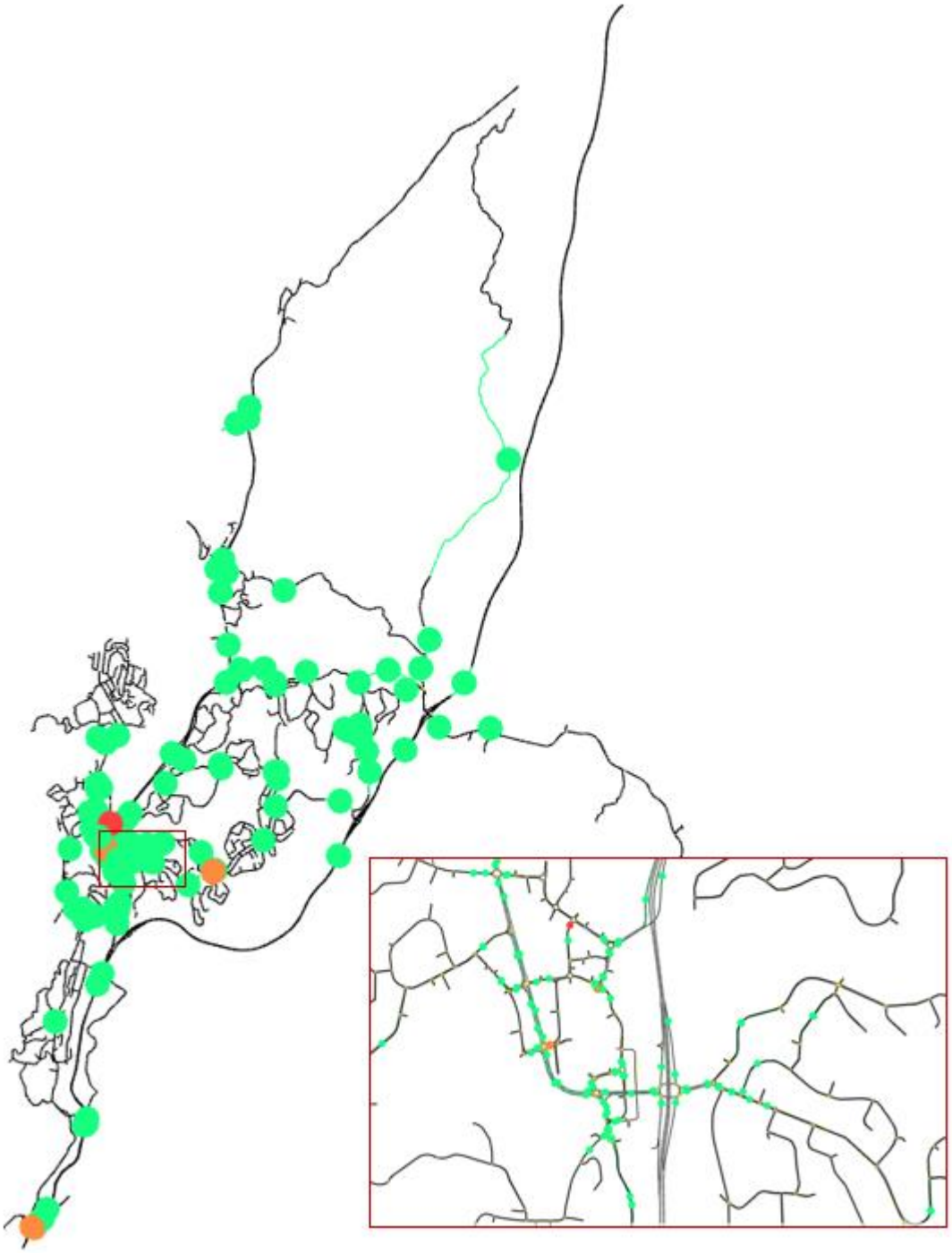
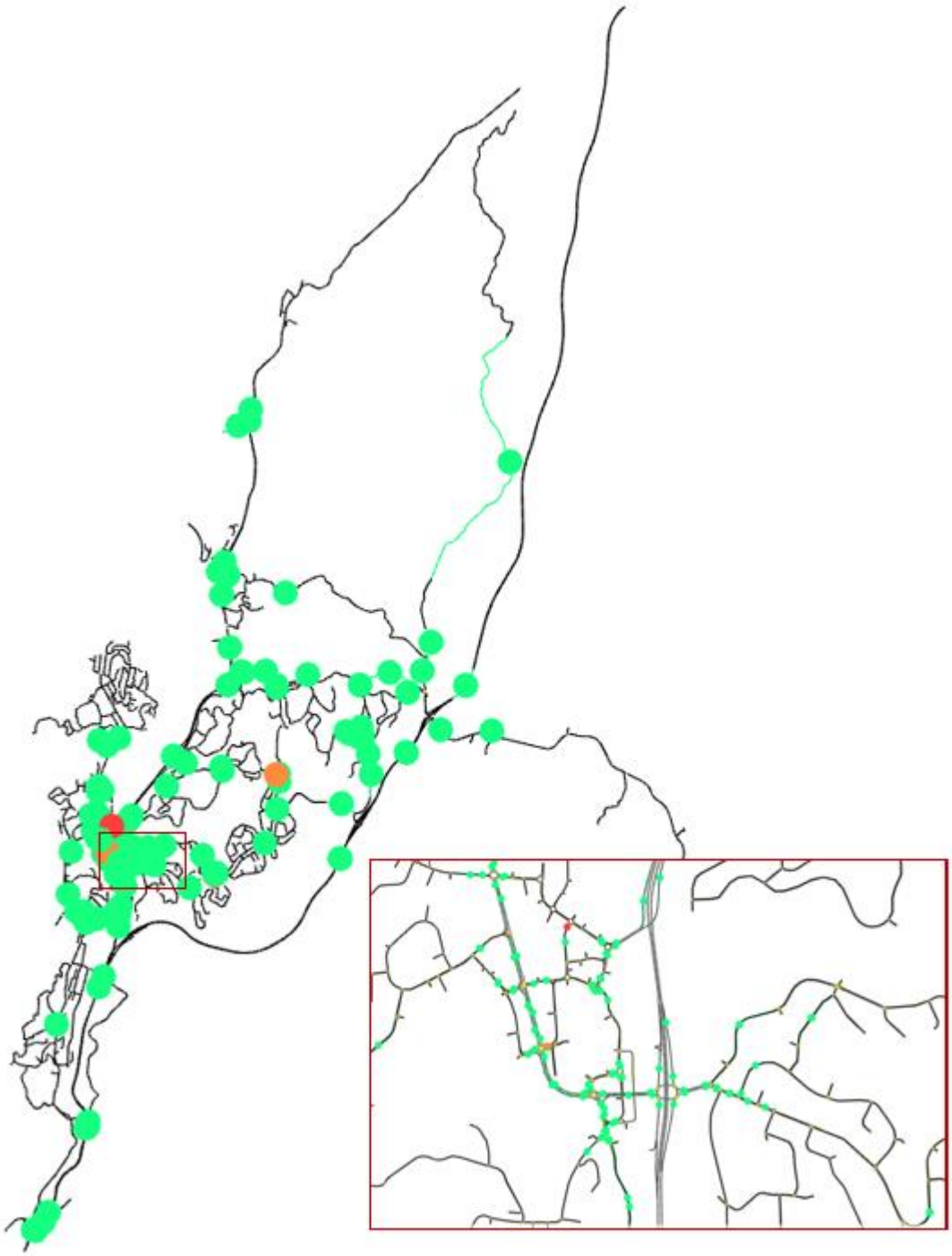


Figure A18: Locations of calibration (estimation) and validation counts – Evening Peak



APPENDIX B Trip length distribution and sector analysis

Figure B1: Trip length distributions through Matrix Estimation Assignment – morning peak - Cars

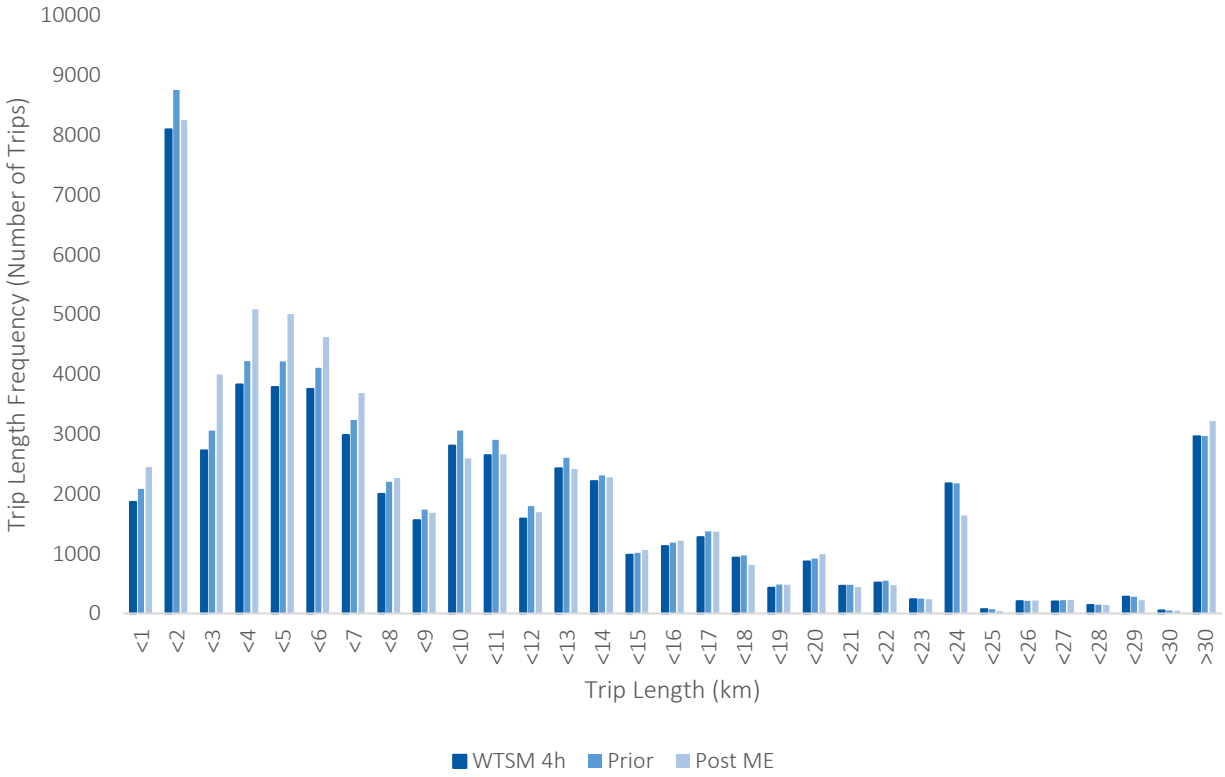


Figure B2: Trip length distributions through Matrix Estimation Assignment – morning peak - Trucks

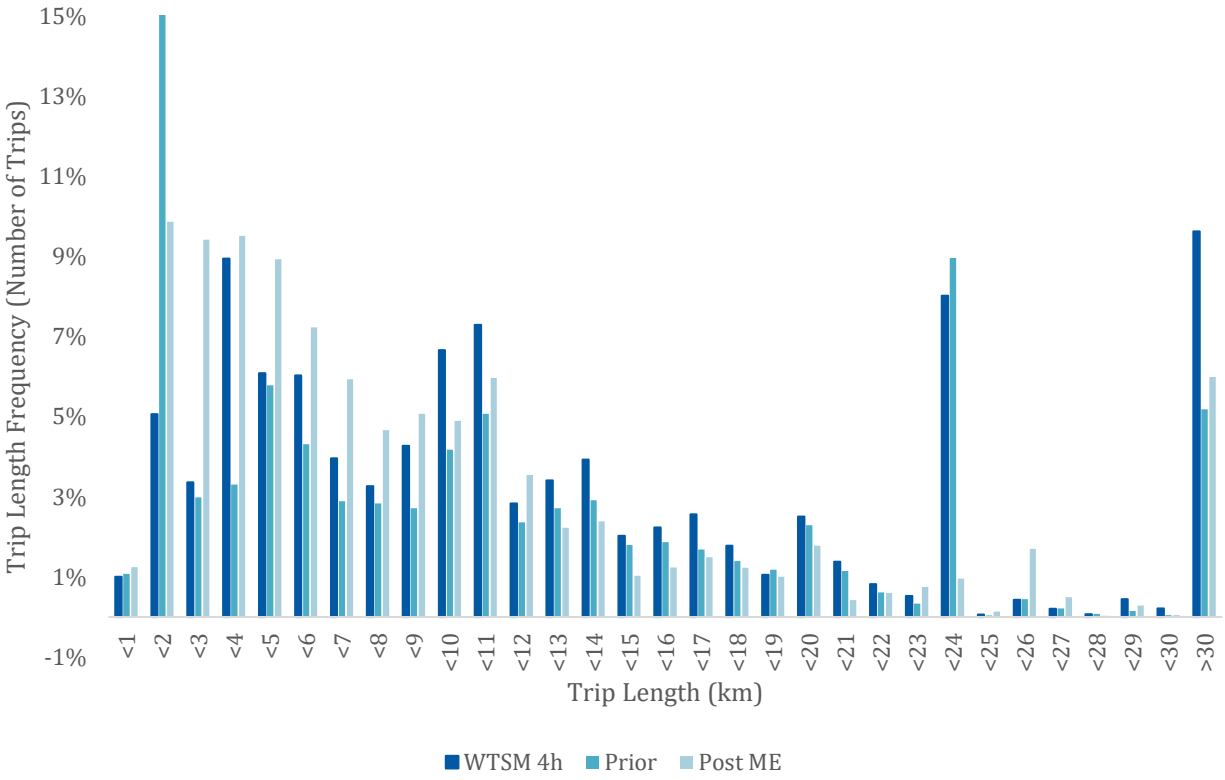


Figure B3: Trip length distributions through Matrix Estimation Assignment – Inter peak - Cars

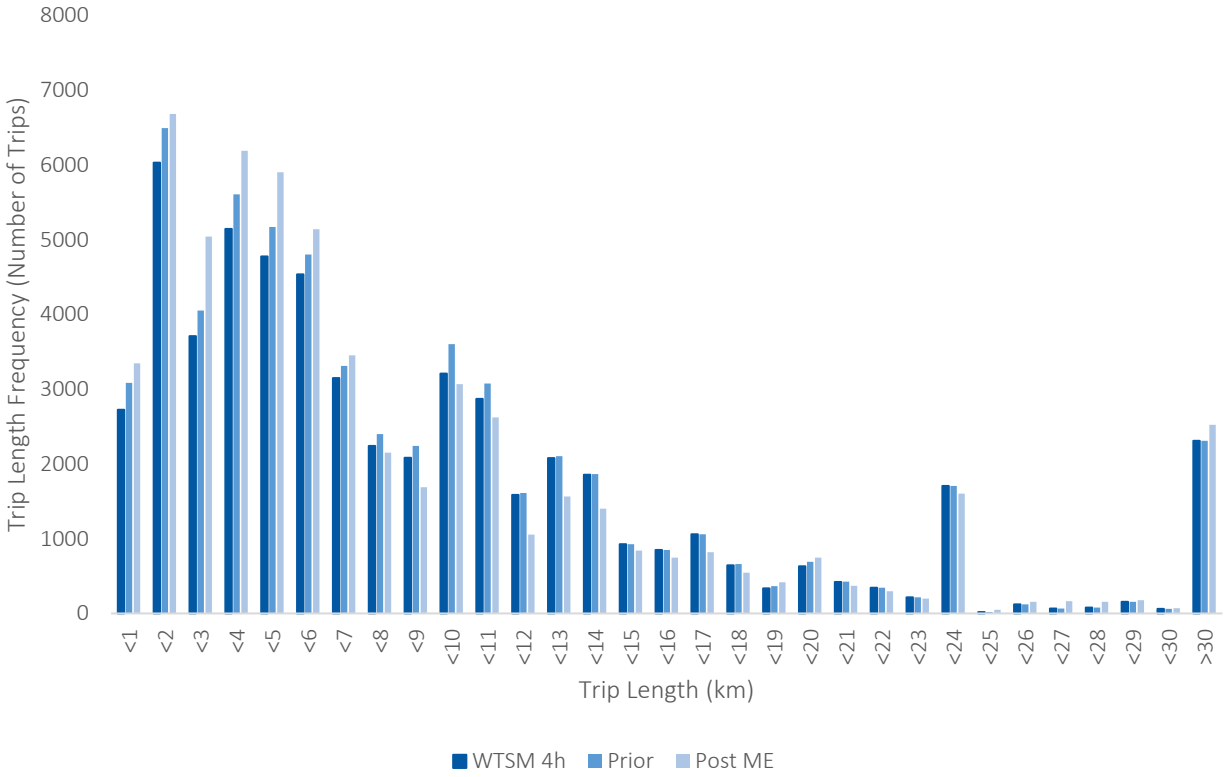


Figure B4: Trip length distributions through Matrix Estimation Assignment – Inter peak - Trucks

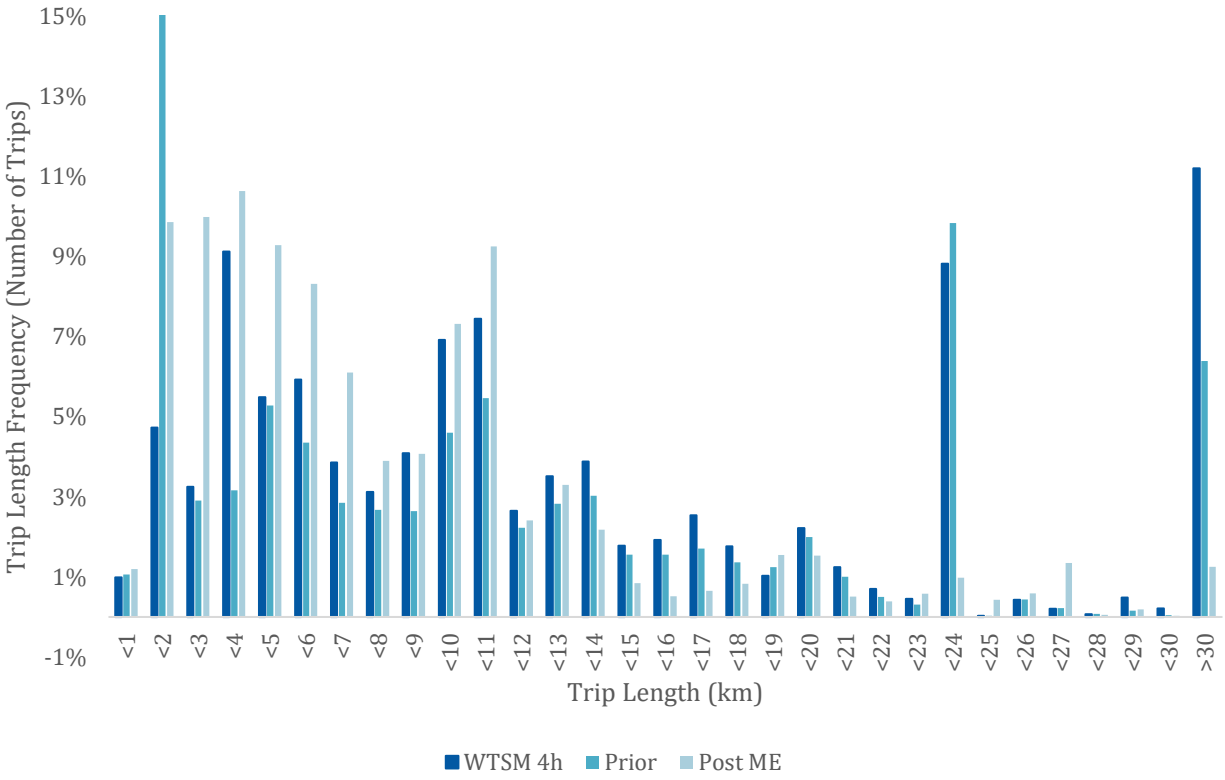


Figure B5: Trip length distributions through Matrix Estimation Assignment – Evening peak - Cars

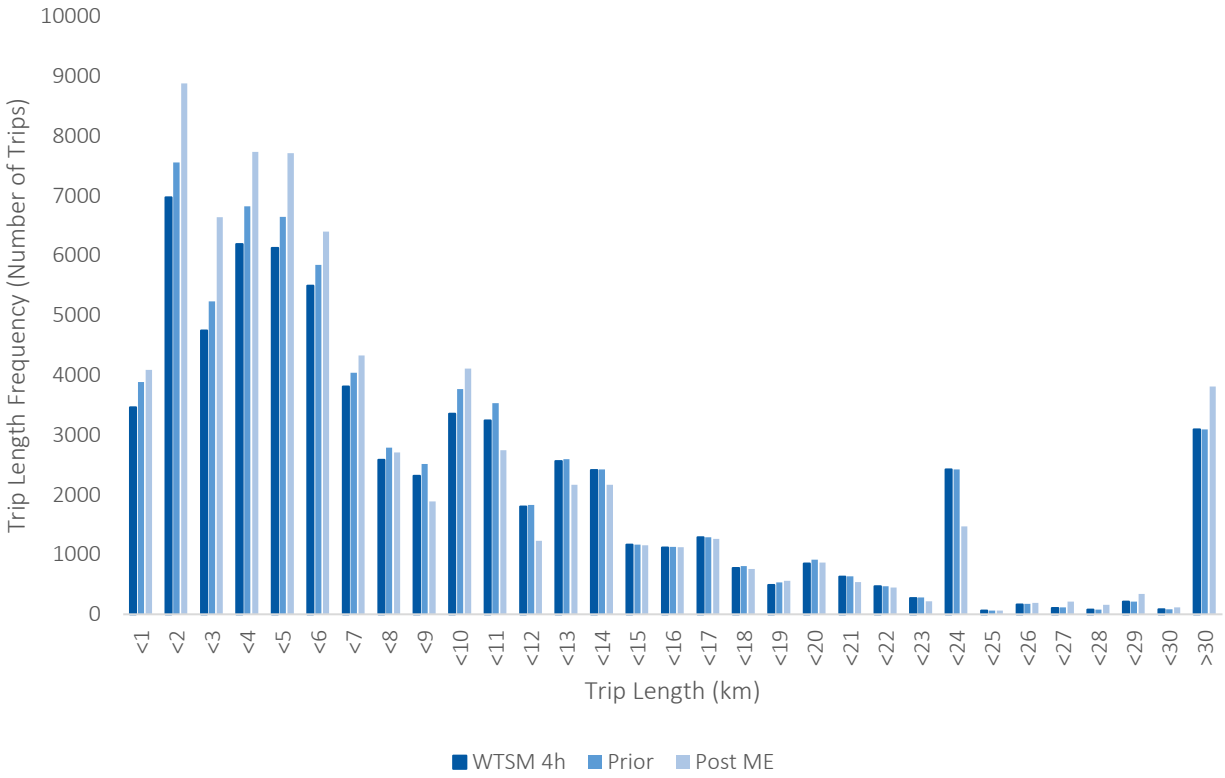


Figure B6: Trip length distributions through Matrix Estimation Assignment – Evening peak - Trucks

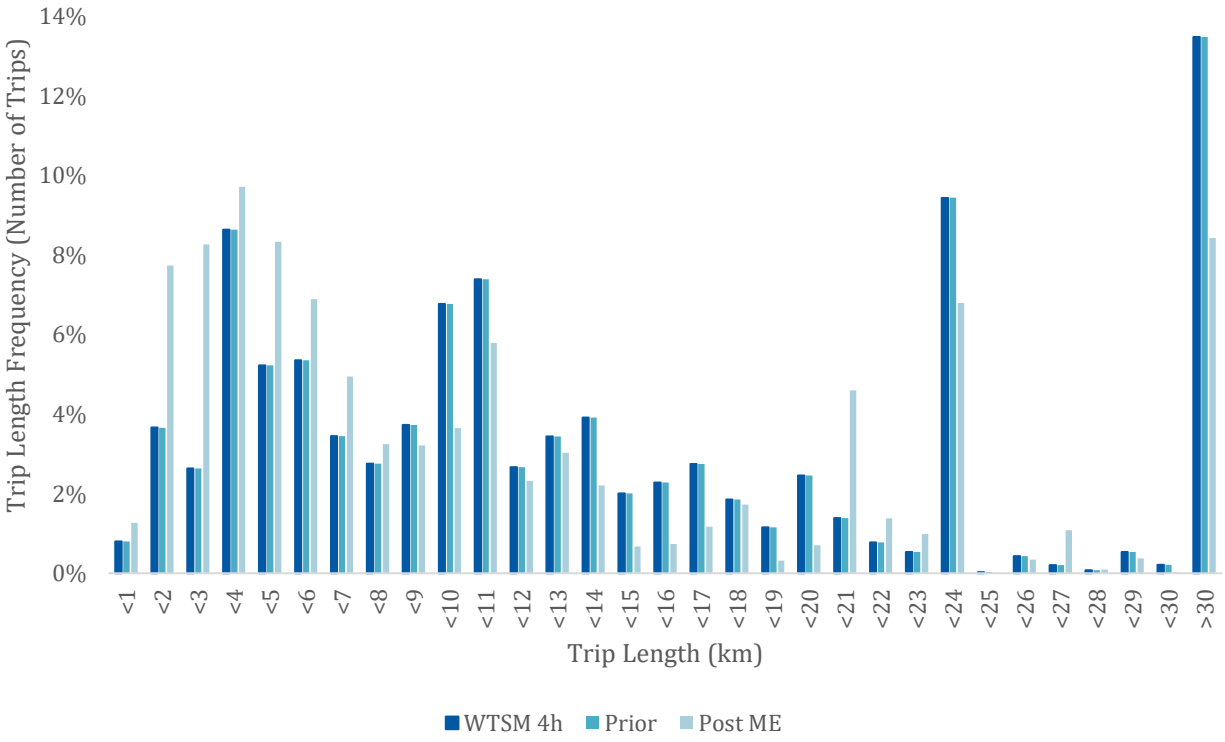


Figure B2: Demand sectors

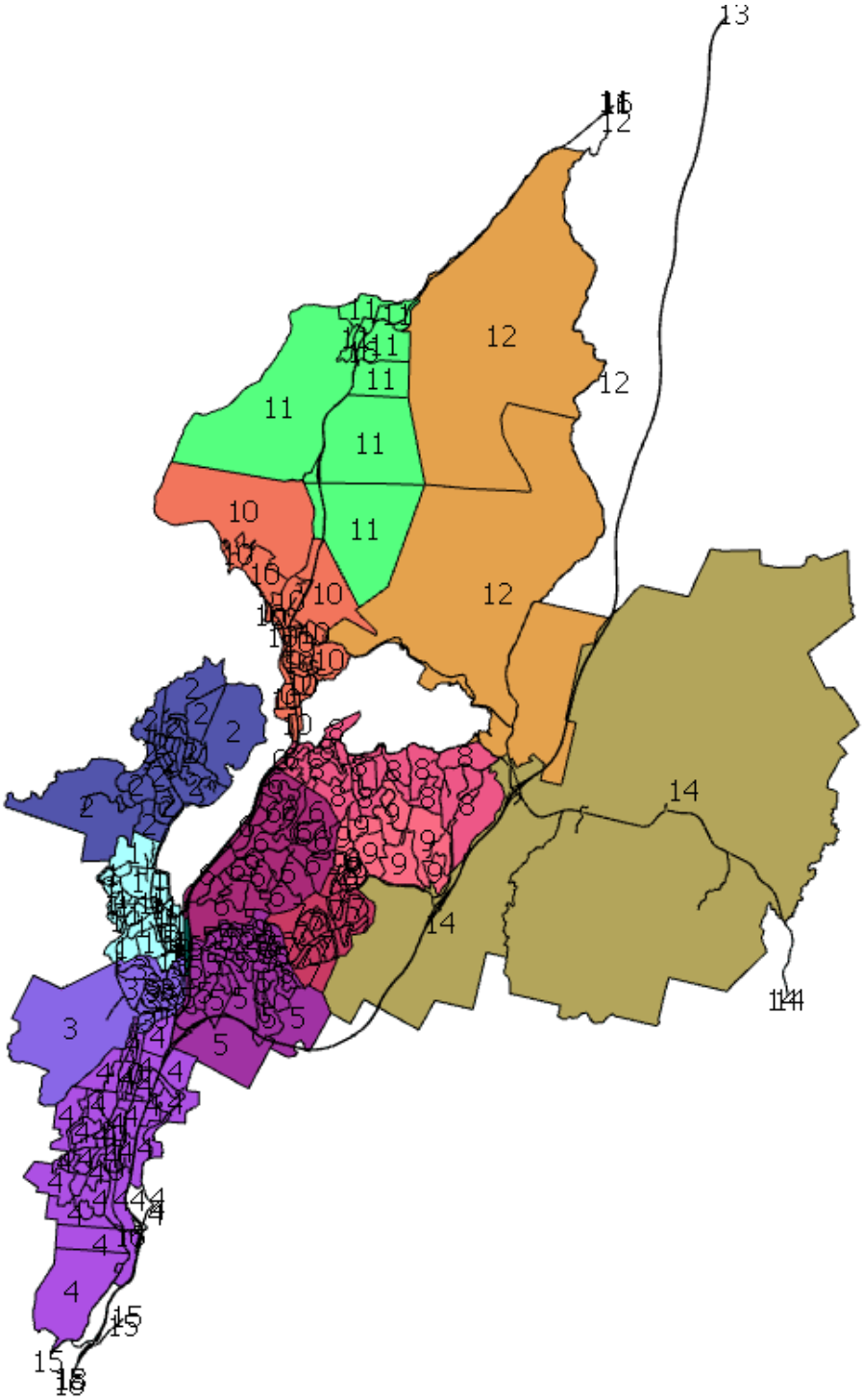


Table B1: Morning peak prior sector matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	1,254	284	314	464	202	270	110	150	91	186	107	11	0	82	958	4,483
2	1,334	541	219	276	111	166	54	72	45	89	39	6	0	51	841	3,846
3	291	60	80	258	62	64	31	42	25	53	16	4	25	36	290	1,339
4	959	167	490	2,766	181	192	86	109	66	128	27	11	69	86	3,308	8,645
5	1,088	104	220	300	297	163	162	88	68	84	16	8	35	77	961	3,672
6	908	138	226	284	144	517	119	522	172	201	59	15	22	163	1,077	4,567
7	797	62	142	173	179	157	231	122	115	74	13	13	51	138	638	2,905
8	661	94	182	363	133	298	143	522	361	240	42	46	79	519	891	4,573
9	468	51	99	185	77	173	88	214	185	115	18	19	50	229	507	2,478
10	432	74	113	149	71	187	46	158	88	574	186	18	0	141	570	2,808
11	313	61	51	62	26	113	15	50	26	356	400	13	0	41	307	1,834
12	36	7	13	50	8	17	9	28	19	26	10	24	12	62	74	395
13	260	25	175	206	72	71	56	140	86	0	0	26	0	1,167	2,088	4,372
14	614	96	278	310	148	268	160	461	243	248	45	73	789	179	104	4,018
15	1,420	268	507	2,141	331	332	159	200	121	218	55	21	582	34	824	7,213
	10,837	2,032	3,110	7,990	2,041	2,988	1,470	2,878	1,711	2,593	1,033	308	1,713	3,005	13,439	57,146

Table B1: Morning peak estimated sector matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	1,633	329	598	1,054	352	562	161	155	105	204	88	7	0	242	850	6,340
2	1,074	549	172	347	71	204	44	70	50	95	32	4	0	68	792	3,572
3	395	62	100	388	51	27	27	25	21	21	4	3	44	65	223	1,454
4	1,480	127	631	2,778	204	154	81	84	59	96	16	8	93	111	3,221	9,143
5	1,151	109	465	259	362	137	215	84	91	47	7	6	72	161	892	4,058
6	842	116	181	295	206	533	388	492	215	208	47	10	46	296	1,010	4,884
7	430	45	81	110	214	202	238	121	127	79	11	9	54	144	607	2,472
8	475	67	123	196	143	304	146	490	395	251	33	33	85	617	834	4,192
9	392	43	86	110	96	216	96	222	196	121	14	14	54	255	481	2,395
10	452	66	96	169	96	236	145	197	96	528	159	11	0	312	533	3,094
11	252	49	39	61	32	126	19	56	26	369	402	4	0	100	291	1,824
12	21	5	9	30	6	12	7	20	14	15	3	24	9	40	71	286
13	255	30	147	112	67	53	38	94	43	0	0	21	0	915	2,013	3,788
14	550	57	235	152	134	200	106	324	122	251	40	48	605	178	59	3,060
15	1,451	266	289	2,485	346	425	160	221	138	256	47	13	968	9	1,018	8,092
	10,852	1,919	3,252	8,545	2,379	3,392	1,871	2,655	1,697	2,540	904	213	2,029	3,513	12,894	58,655

Table B1: Morning Peak Difference Sector Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	380	45	284	589	150	292	51	5	14	18	-18	-5	0	161	-108	1,857
2	-261	7	-47	70	-40	38	-10	-2	5	6	-7	-2	0	18	-50	-274
3	103	2	20	130	-11	-37	-4	-17	-4	-32	-12	-2	19	28	-67	115
4	521	-39	141	12	24	-38	-5	-25	-7	-32	-11	-4	24	25	-87	498
5	63	5	245	-41	65	-26	53	-4	22	-37	-8	-2	37	83	-69	386
6	-66	-22	-45	11	62	16	269	-30	43	7	-12	-5	24	133	-68	317
7	-368	-17	-61	-64	35	45	7	-1	12	6	-2	-3	3	6	-31	-433
8	-186	-27	-59	-167	10	6	4	-32	34	11	-9	-13	6	99	-57	-381
9	-76	-8	-13	-75	19	44	7	9	11	6	-4	-5	4	26	-26	-82
10	20	-8	-16	20	25	49	98	38	8	-46	-28	-7	0	171	-37	286
11	-61	-12	-12	-1	6	13	4	6	0	12	2	-10	0	59	-16	-9
12	-14	-2	-5	-19	-3	-6	-2	-8	-5	-11	-7	0	-2	-22	-2	-109
13	-5	5	-28	-95	-5	-18	-18	-46	-42	0	0	-5	0	-252	-75	-584
14	-64	-39	-43	-158	-14	-68	-55	-138	-122	2	-5	-25	-185	0	-46	-958
15	31	-2	-218	344	15	94	2	21	17	38	-8	-8	386	-25	193	880
	16	-112	142	555	338	404	401	-223	-14	-53	-128	-95	316	508	-545	1,509

Table B1: Morning peak percentage difference sector matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	30%	16%	91%	127%	74%	108%	46%	4%	15%	10%	-17%	-41%	0%	197%	-11%	41%
2	-20%	1%	-22%	25%	-36%	23%	-18%	-2%	10%	7%	-17%	-33%	0%	35%	-6%	-7%
3	35%	4%	25%	50%	-18%	-58%	-13%	-41%	-16%	-61%	-75%	-39%	76%	77%	-23%	9%
4	54%	-23%	29%	0%	13%	-20%	-6%	-23%	-11%	-25%	-41%	-33%	36%	29%	-3%	6%
5	6%	5%	112%	-14%	22%	-16%	33%	-4%	33%	-44%	-53%	-30%	106%	107%	-7%	11%
6	-7%	-16%	-20%	4%	43%	3%	226%	-6%	25%	3%	-20%	-33%	110%	82%	-6%	7%
7	-46%	-28%	-43%	-37%	19%	28%	3%	-1%	11%	7%	-12%	-25%	5%	4%	-5%	-15%
8	-28%	-29%	-33%	-46%	7%	2%	3%	-6%	9%	5%	-21%	-28%	7%	19%	-6%	-8%
9	-16%	-15%	-13%	-41%	24%	25%	8%	4%	6%	5%	-21%	-27%	8%	11%	-5%	-3%
10	5%	-11%	-15%	13%	35%	26%	212%	24%	9%	-8%	-15%	-40%	0%	121%	-6%	10%
11	-20%	-19%	-24%	-1%	24%	12%	30%	11%	0%	3%	1%	-71%	0%	145%	-5%	-1%
12	-40%	-33%	-35%	-39%	-30%	-33%	-24%	-29%	-25%	-43%	-73%	1%	-20%	-35%	-3%	-27%
13	-2%	21%	-16%	-46%	-7%	-25%	-32%	-33%	-49%	0%	0%	-20%	0%	-22%	-4%	-13%
14	-10%	-41%	-15%	-51%	-9%	-25%	-34%	-30%	-50%	1%	-11%	-34%	-23%	0%	-44%	-24%
15	2%	-1%	-43%	16%	4%	28%	1%	10%	14%	18%	-14%	-40%	66%	-74%	23%	12%
	0%	-6%	5%	7%	17%	14%	27%	-8%	-1%	-2%	-12%	-31%	18%	17%	-4%	3%

Table B1: Inter peak prior sector matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	2,600	863	772	834	634	841	374	511	308	606	326	32	0	190	1,534	10,424
2	1,007	518	170	184	114	150	57	86	49	112	66	6	0	42	438	3,000
3	860	168	196	449	178	187	101	122	76	152	40	10	66	82	522	3,209
4	1,140	205	519	2,241	233	236	125	160	96	188	42	14	126	96	2,493	7,914
5	708	107	173	194	239	144	144	106	70	101	34	7	41	64	507	2,639
6	935	145	185	199	148	452	132	254	166	275	101	16	37	134	555	3,734
7	459	57	111	111	155	133	162	125	95	84	15	10	69	110	322	2,019
8	564	87	119	148	114	240	125	344	266	278	57	37	137	352	406	3,273
9	357	51	78	89	77	165	93	266	146	155	25	20	90	197	250	2,060
10	597	103	129	137	97	246	77	268	144	714	373	29	0	161	400	3,477
11	196	60	29	31	21	66	13	44	20	249	392	15	0	25	114	1,274
12	32	6	9	12	8	14	9	36	17	27	20	39	18	43	36	325
13	45	0	48	108	50	45	55	123	60	0	0	12	0	740	1,032	2,316
14	172	36	63	86	55	100	79	271	140	132	21	34	742	123	53	2,107
15	1,816	388	591	2,690	494	509	290	353	212	396	106	32	964	45	473	9,359
	11,487	2,796	3,192	7,513	2,614	3,527	1,837	3,069	1,864	3,471	1,616	314	2,290	2,403	9,136	57,129

Table B1: Inter peak estimated sector matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	2,950	988	922	1,558	1,099	788	498	425	287	567	263	16	0	241	1,426	12,027
2	964	529	183	162	145	90	58	46	26	67	35	2	0	24	288	2,617
3	990	145	102	470	90	81	43	62	52	67	17	6	77	83	323	2,607
4	1,694	150	515	2,423	179	217	80	134	107	174	33	8	162	97	2,756	8,731
5	1,259	121	112	197	252	203	157	147	131	116	32	4	59	77	287	3,156
6	814	103	69	207	218	432	190	234	166	255	82	7	29	102	472	3,380
7	433	40	44	71	168	149	170	112	90	75	11	3	45	59	117	1,586
8	400	50	58	168	156	170	100	324	256	244	41	16	121	280	358	2,743
9	229	26	51	100	155	125	81	306	145	147	20	5	51	95	217	1,753
10	539	75	51	149	94	235	54	253	110	700	339	38	0	266	350	3,252
11	160	39	11	29	18	56	8	34	12	306	417	22	0	21	87	1,221
12	17	3	7	11	6	6	3	20	6	28	20	39	9	21	23	219
13	137	0	76	181	92	33	37	126	42	0	0	5	0	707	1,266	2,703
14	232	26	93	129	81	74	49	243	91	203	37	16	791	123	7	2,195
15	1,733	236	201	2,010	287	416	139	269	217	324	75	17	1,179	6	734	7,844
	12,552	2,530	2,496	7,863	3,039	3,075	1,669	2,736	1,739	3,273	1,423	203	2,523	2,203	8,711	56,035

Table B1: Inter Peak Difference Sector Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	350	125	150	724	465	-54	124	-86	-21	-38	-63	-17	0	51	-108	1,604
2	-43	11	12	-23	31	-60	2	-40	-23	-45	-32	-4	0	-18	-151	-382
3	130	-23	-95	21	-87	-106	-58	-60	-24	-85	-23	-5	10	2	-199	-601
4	554	-55	-4	182	-54	-19	-45	-25	11	-14	-8	-6	37	1	263	817
5	552	14	-61	3	13	60	13	42	62	14	-1	-3	18	13	-220	516
6	-121	-43	-116	9	70	-20	58	-19	0	-20	-19	-9	-8	-32	-83	-354
7	-26	-17	-67	-41	13	16	8	-13	-5	-9	-4	-7	-25	-51	-205	-433
8	-165	-37	-61	20	42	-70	-25	-20	-10	-34	-15	-21	-15	-72	-47	-530
9	-128	-25	-27	11	78	-40	-12	40	0	-9	-5	-15	-39	-102	-33	-307
10	-58	-29	-78	12	-4	-11	-23	-15	-35	-15	-33	8	0	105	-51	-225
11	-36	-21	-18	-2	-3	-10	-5	-10	-7	57	26	7	0	-4	-27	-53
12	-14	-3	-2	-1	-2	-8	-6	-16	-11	1	0	0	-9	-22	-13	-106
13	92	0	29	73	42	-11	-18	3	-17	0	0	-6	0	-33	233	387
14	61	-10	30	42	26	-26	-30	-28	-49	71	15	-18	49	0	-46	88
15	-84	-152	-389	-680	-206	-93	-151	-84	5	-72	-31	-15	215	-38	261	-1,515
	1,065	-265	-696	350	425	-452	-168	-333	-125	-198	-193	-111	233	-200	-425	-1,094

Table B1: Inter peak percentage difference sector matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	13%	15%	19%	87%	73%	-6%	33%	-17%	-7%	-6%	-19%	-52%	0%	27%	-7%	**15%**
2	-4%	2%	7%	-12%	27%	-40%	3%	-47%	-47%	-40%	-48%	-70%	0%	-43%	-34%	**-13%**
3	15%	-14%	-48%	5%	-49%	-57%	-58%	-49%	-31%	-56%	-57%	-45%	16%	2%	-38%	**-19%**
4	49%	-27%	-1%	8%	-23%	-8%	-36%	-16%	11%	-7%	-20%	-43%	29%	1%	11%	**10%**
5	78%	13%	-35%	1%	5%	41%	9%	39%	88%	14%	-4%	-46%	44%	20%	-43%	**20%**
6	-13%	-29%	-63%	4%	47%	-5%	44%	-8%	0%	-7%	-19%	-54%	-22%	-24%	-15%	**-9%**
7	-6%	-30%	-61%	-37%	9%	12%	5%	-11%	-5%	-11%	-25%	-73%	-36%	-46%	-64%	**-21%**
8	-29%	-43%	-51%	14%	37%	-29%	-20%	-6%	-4%	-12%	-27%	-57%	-11%	-20%	-12%	**-16%**
9	-36%	-49%	-35%	13%	101%	-24%	-13%	15%	0%	-6%	-20%	-77%	-43%	-52%	-13%	**-15%**
10	-10%	-28%	-61%	9%	-4%	-4%	-29%	-6%	-24%	-2%	-9%	29%	0%	65%	-13%	**-6%**
11	-18%	-35%	-61%	-6%	-15%	-16%	-38%	-23%	-36%	23%	7%	50%	0%	-17%	-23%	**-4%**
12	-45%	-55%	-21%	-10%	-22%	-56%	-64%	-45%	-63%	2%	1%	0%	-50%	-51%	-36%	**-33%**
13	205%	0%	61%	68%	84%	-26%	-33%	2%	-29%	0%	0%	-53%	0%	-4%	23%	**17%**
14	35%	-28%	47%	49%	48%	-26%	-38%	-10%	-35%	54%	73%	-53%	7%	0%	-86%	**4%**
15	-5%	-39%	-66%	-25%	-42%	-18%	-52%	-24%	2%	-18%	-29%	-48%	22%	-86%	55%	**-16%**
	9%	**-9%**	**-22%**	**5%**	**16%**	**-13%**	**-9%**	**-11%**	**-7%**	**-6%**	**-12%**	**-35%**	**10%**	**-8%**	**-5%**	**-2%**

Table B1: Evening peak prior sector matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	3,131	1,682	840	1,166	1,345	1,404	889	939	551	826	565	55	0	373	1,597	15,364
2	940	648	152	177	142	170	70	108	58	122	95	8	0	69	357	3,116
3	927	243	215	534	274	259	154	189	109	181	88	16	91	150	543	3,971
4	904	241	382	2,852	289	253	146	268	145	174	50	29	176	182	2,658	8,747
5	689	141	170	208	361	184	209	157	96	122	54	11	60	108	453	3,023
6	913	188	171	205	201	591	178	339	210	320	153	22	51	202	451	4,196
7	421	68	101	108	204	153	221	165	112	89	18	13	86	142	252	2,153
8	507	93	100	123	129	417	145	551	322	287	74	50	166	391	310	3,666
9	332	58	69	78	93	199	122	381	193	165	33	26	115	223	196	2,281
10	604	125	125	143	128	303	103	371	184	929	513	42	0	221	315	4,106
11	90	21	19	24	21	39	13	40	19	243	517	16	0	32	81	1,177
12	30	7	8	11	10	17	12	53	23	30	25	46	26	53	29	379
13	103	38	39	89	58	71	70	166	71	0	0	16	0	1,099	1,051	2,871
14	222	67	77	98	112	209	201	665	288	218	51	77	1,114	170	50	3,619
15	1,750	661	516	3,282	841	786	462	629	335	507	203	53	1,730	84	562	12,400
	11,563	4,281	2,982	9,098	4,206	5,054	2,994	5,023	2,718	4,213	2,438	481	3,613	3,499	8,904	71,068

Table B1: Evening peak estimated sector matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	3,242	1,763	819	1,684	1,419	1,069	917	795	522	739	397	36	0	340	1,964	15,705
2	934	652	121	239	156	117	75	85	46	99	66	4	0	57	365	3,014
3	984	147	235	570	309	88	86	126	133	73	30	10	145	148	344	3,430
4	1,577	279	597	3,011	472	249	117	307	225	202	48	19	329	209	3,145	10,787
5	719	155	158	250	369	483	226	313	264	193	68	5	66	82	319	3,669
6	892	199	42	134	459	668	398	398	261	447	174	11	23	107	322	4,535
7	433	75	107	148	222	315	226	128	89	119	21	1	25	25	202	2,137
8	564	113	69	130	229	468	98	559	442	370	76	25	191	314	298	3,945
9	350	65	78	128	307	223	105	526	201	224	36	12	129	150	251	2,787
10	615	136	32	97	185	373	94	398	188	934	502	37	0	299	236	4,127
11	67	18	4	12	24	37	10	32	15	270	541	15	0	40	45	1,130
12	23	5	6	7	3	9	0	22	13	19	17	49	9	14	14	211
13	140	45	69	141	19	47	4	166	78	0	0	4	0	703	1,211	2,628
14	224	65	112	124	29	122	9	546	274	303	63	22	957	169	16	3,036
15	2,022	509	91	3,665	498	827	132	697	473	636	209	29	2,480	45	1,513	13,824
	12,788	4,225	2,541	10,342	4,700	5,095	2,498	5,099	3,223	4,628	2,245	280	4,356	2,702	10,244	74,965

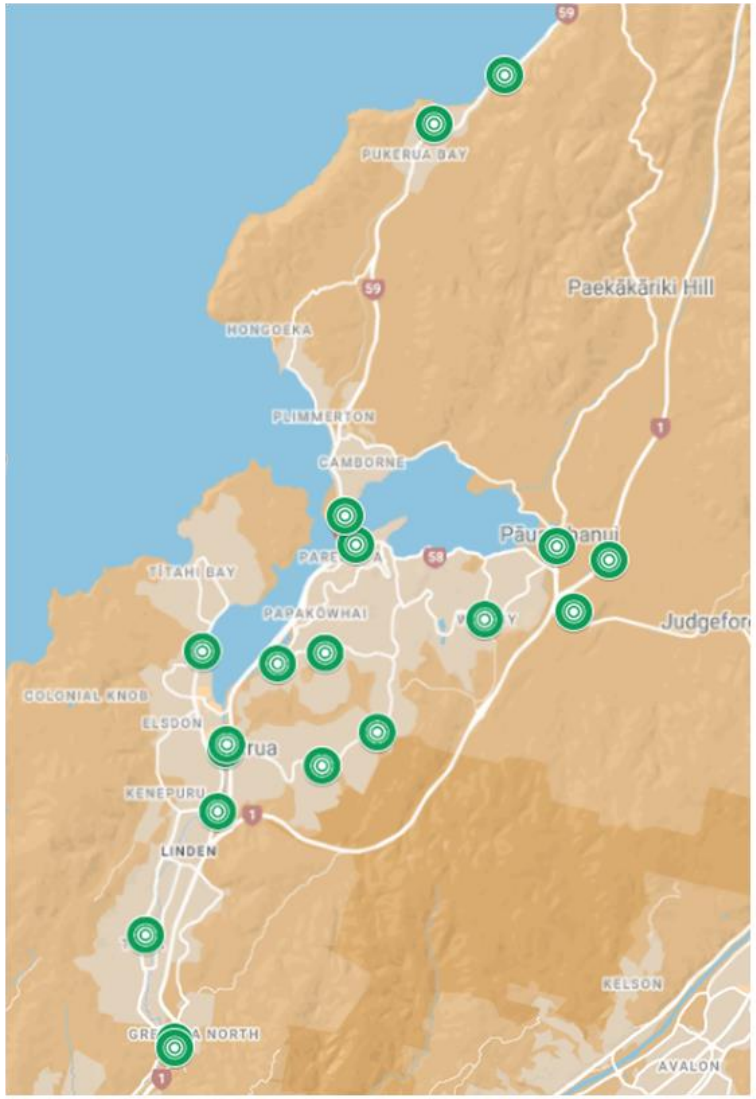
Table B1: Evening peak difference sector matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	111	81	-22	518	74	-335	28	-145	-29	-87	-168	-19	0	-33	367	341
2	-6	4	-31	61	14	-53	5	-24	-12	-23	-30	-4	0	-12	7	-102
3	58	-96	21	37	35	-171	-68	-63	24	-108	-58	-6	54	-2	-199	-541
4	673	38	216	159	183	-4	-29	39	80	29	-2	-10	153	27	487	2,040
5	30	14	-12	41	8	300	17	155	167	71	14	-6	6	-27	-134	645
6	-21	11	-129	-71	258	77	220	60	50	128	21	-11	-28	-96	-129	339
7	12	7	7	40	19	162	5	-37	-23	30	3	-12	-60	-117	-50	-16
8	56	19	-32	7	100	50	-47	8	119	83	2	-25	25	-77	-12	279
9	19	8	9	50	214	23	-16	145	8	58	4	-15	15	-73	55	506
10	12	11	-93	-46	58	71	-9	27	3	5	-10	-5	0	77	-80	21
11	-22	-4	-15	-12	3	-2	-4	-8	-4	26	24	-1	0	8	-35	-47
12	-7	-2	-2	-3	-6	-8	-12	-31	-10	-11	-8	3	-16	-40	-15	-167
13	37	7	30	52	-39	-23	-66	0	7	0	0	-13	0	-396	160	-243
14	2	-2	36	27	-83	-88	-191	-119	-14	86	11	-55	-157	0	-34	-583
15	271	-152	-425	383	-343	42	-330	68	138	129	6	-24	750	-39	951	1,424
	1,225	-56	-441	1,243	494	41	-496	76	505	415	-193	-201	742	-797	1,340	3,897

Table B1: Evening peak percentage difference sector matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	4%	5%	-3%	44%	5%	-24%	3%	-15%	-5%	-11%	-30%	-34%	0%	-9%	23%	2%
2	-1%	1%	-20%	35%	10%	-31%	8%	-22%	-21%	-19%	-31%	-47%	0%	-17%	2%	-3%
3	6%	-39%	10%	7%	13%	-66%	-44%	-33%	22%	-60%	-66%	-40%	60%	-1%	-37%	-14%
4	74%	16%	57%	6%	63%	-1%	-20%	15%	55%	16%	-4%	-34%	87%	15%	18%	23%
5	4%	10%	-7%	20%	2%	163%	8%	99%	174%	58%	25%	-54%	9%	-25%	-29%	21%
6	-2%	6%	-76%	-35%	128%	13%	123%	18%	24%	40%	14%	-51%	-54%	-47%	-29%	8%
7	3%	10%	7%	37%	9%	106%	2%	-23%	-21%	34%	15%	-92%	-70%	-82%	-20%	-1%
8	11%	21%	-31%	6%	78%	12%	-32%	1%	37%	29%	2%	-50%	15%	-20%	-4%	8%
9	6%	13%	13%	65%	229%	12%	-13%	38%	4%	35%	11%	-55%	13%	-33%	28%	22%
10	2%	9%	-74%	-32%	45%	23%	-9%	7%	2%	1%	-2%	-11%	0%	35%	-25%	1%
11	-25%	-16%	-81%	-49%	12%	-5%	-29%	-20%	-23%	11%	5%	-5%	0%	24%	-44%	-4%
12	-24%	-26%	-22%	-30%	-66%	-48%	-99%	-58%	-44%	-36%	-32%	6%	-64%	-74%	-50%	-44%
13	36%	18%	78%	58%	-67%	-33%	-94%	0%	10%	68%	0%	-77%	0%	-36%	15%	-8%
14	1%	-4%	47%	27%	-74%	-42%	-95%	-18%	-5%	39%	22%	-71%	-14%	0%	-68%	-16%
15	16%	-23%	-82%	12%	-41%	5%	-71%	11%	41%	25%	3%	-45%	43%	-47%	169%	11%
	11%	-1%	-15%	14%	12%	1%	-17%	2%	19%	10%	-8%	-42%	21%	-23%	15%	5%

Figure B2: Hybrid Simulation Demand Profiles



Profile	Description	Area/Direction informed
Profile 1	Titahi Bay Road - between SH1 and Kenepuru Drive	Porirua CBD to All
Profile 2	Titahi Bay Road - North of Te Hiko St	Porirua North to All
Profile 3	Kenepuru Link south of Kenepuru Dr	Kenepuru to All
Profile 4	Main Road - Lincoln Ave to Surrey St	Linden/Tawa to All
Profile 5	MUNGAVIN AVENUE - BETWEEN CHAMPION STREET TO GEAR TERRACE	Mungavin to All
Profile 6	Whitford Brown Avenue - Between Width Change To Okowai Road - June 2021	Aotea/Papakowhai to All
Profile 7	WARSPITE AVENUE - BETWEEN FANTAME STREET TO WAIHORA CRESCENT	Waitangirua to All
Profile 8	SH58 West of Joeseph Banks + East of Paremata RAB	Paremata/south of SH59 to All
Profile 9	Discovery Dr west of James Cook Dr	Whitby to All
Profile 10	TMS 0590018 Mana Esplanade	Mana to All
Profile 11	SH59_Pukerua Beach Road_Intersection	Pukerua Bay to All
Profile 12	PAEKAKARIKI HILL ROAD - BETWEEN CENTRE OF SPEED HUMP TO GRAYS ROAD -	Paekakariki Hill/Pauatahanui to All
Profile 13	TG north of SH58	TG North to All
Profile 14	PAUATAHANUI EAST - Telemetry Si	Judgeford/SH58 to All
Profile 15	TMS - Grenada Interchange NB	SH1 south to All
Profile 16	Park n Ride Trips	Park n Ride Trips from (AM) and to (PM) All
Profile 17	SH1 east of Pukerua Beach Rd	Pukerua Beach to All
Profile 18	TMS - Grenada Interchange SB	All to SH1 south
Profile 19	Titahi Bay Road - between SH1 and Kenepuru Drive	All to Porirua CBD
Profile 20	Okowai Road - Between Whitford Brown Av To Frances Brown Av - Nov 2022	School Trips to/from All (AM peak only)

Figure B2: Example of Adjusted Demand Profiles – Profile 1 (CBD Departure)

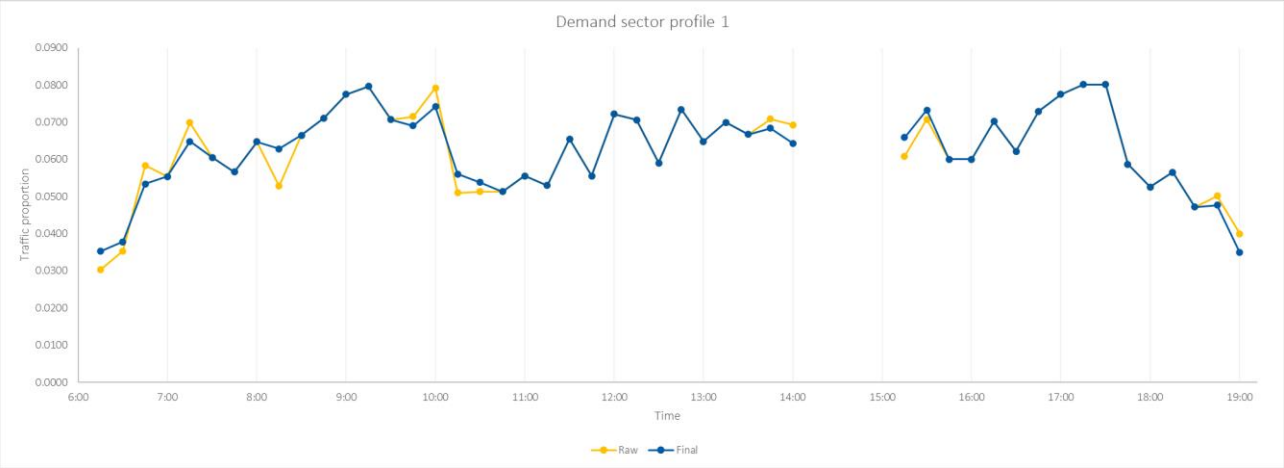
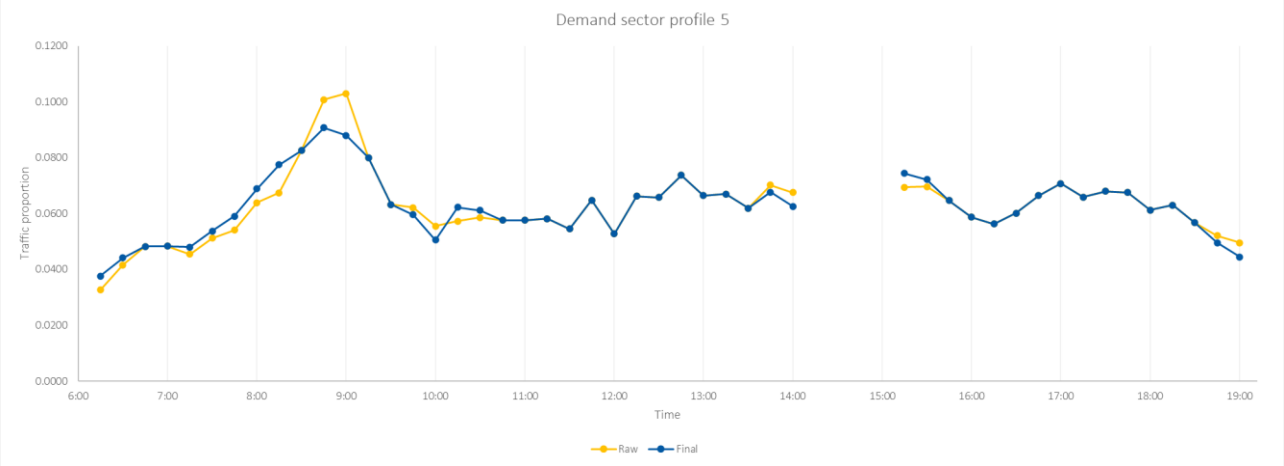


Figure B2: Example of Adjusted Demand Profiles – Profile 5 (Sector 5 Departure)



APPENDIX C Link and turn count validation, and scatter plots

Figure C1: Observed versus modelled link counts - Morning peak

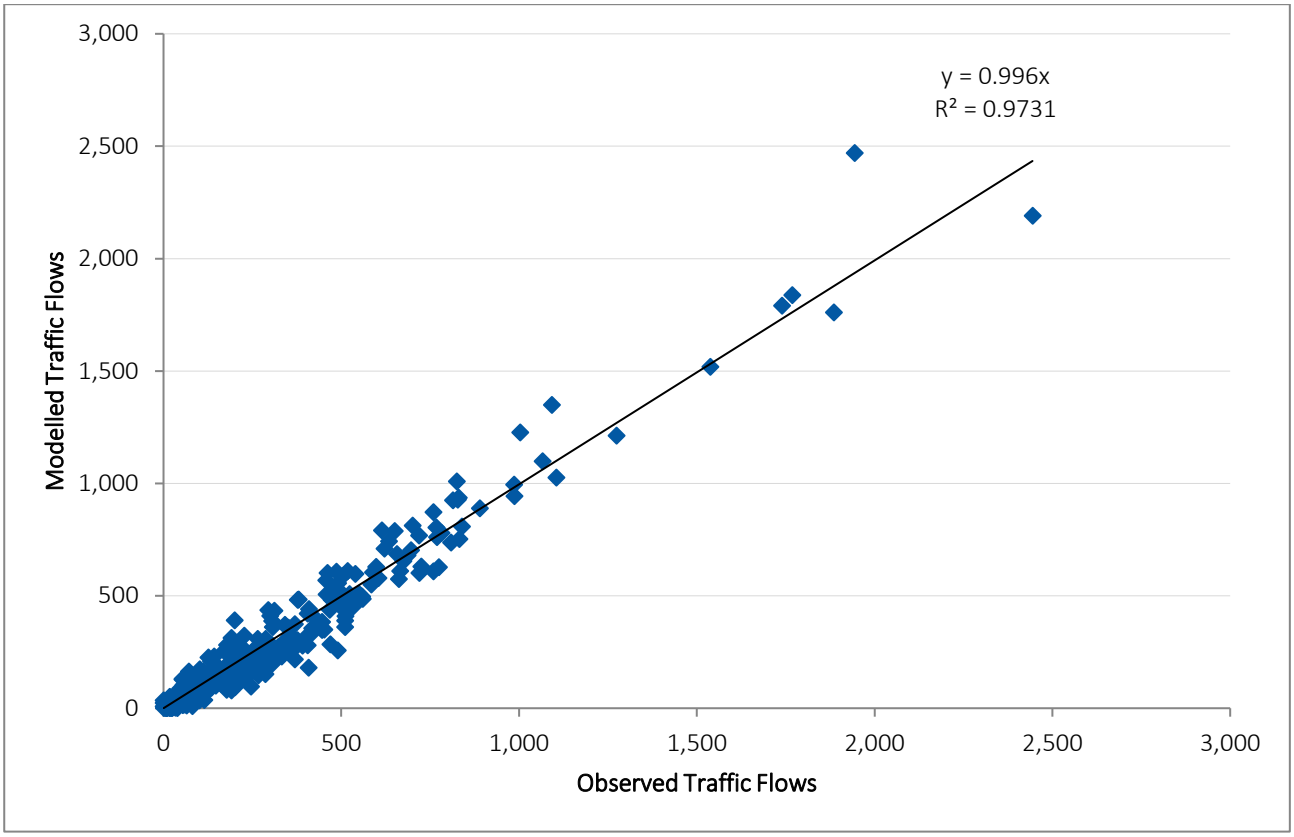


Figure C2: Observed versus modelled counts - Inter peak

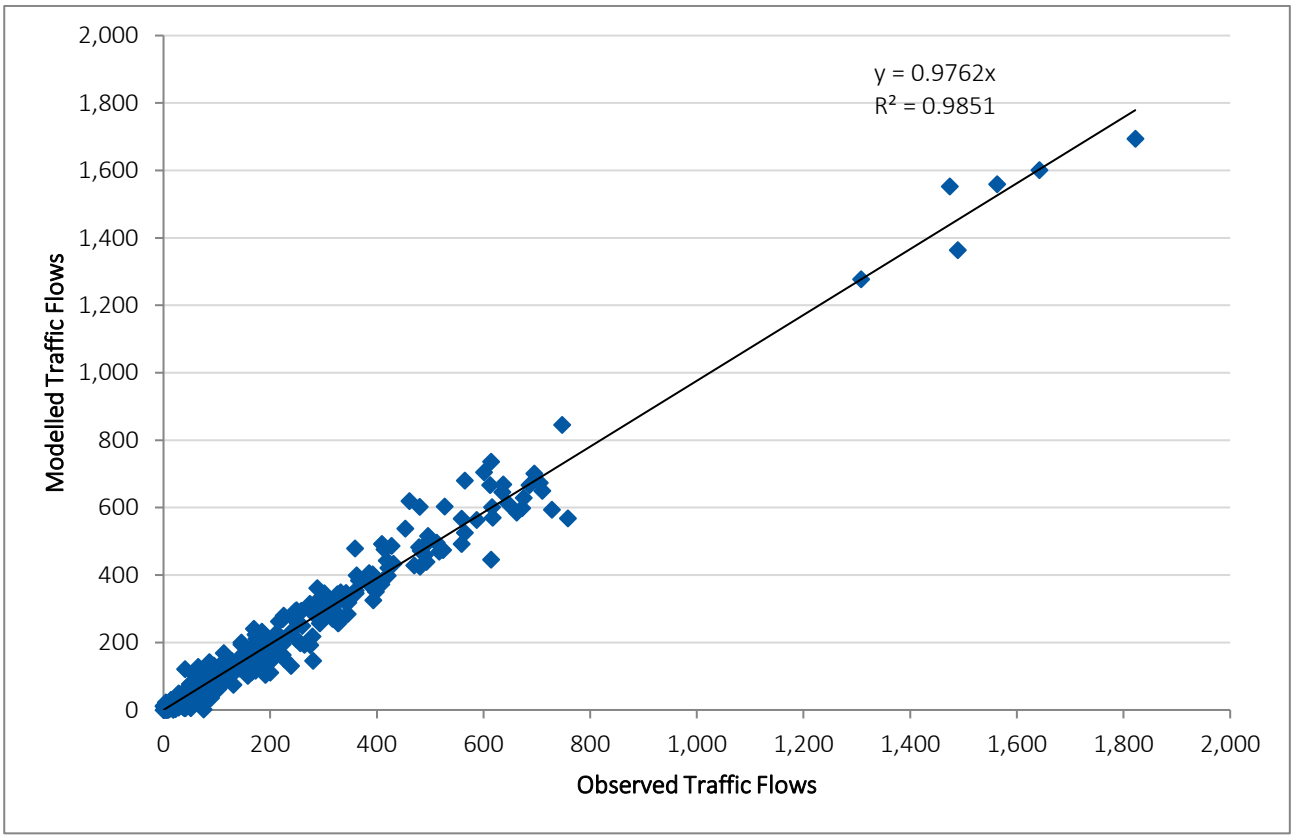
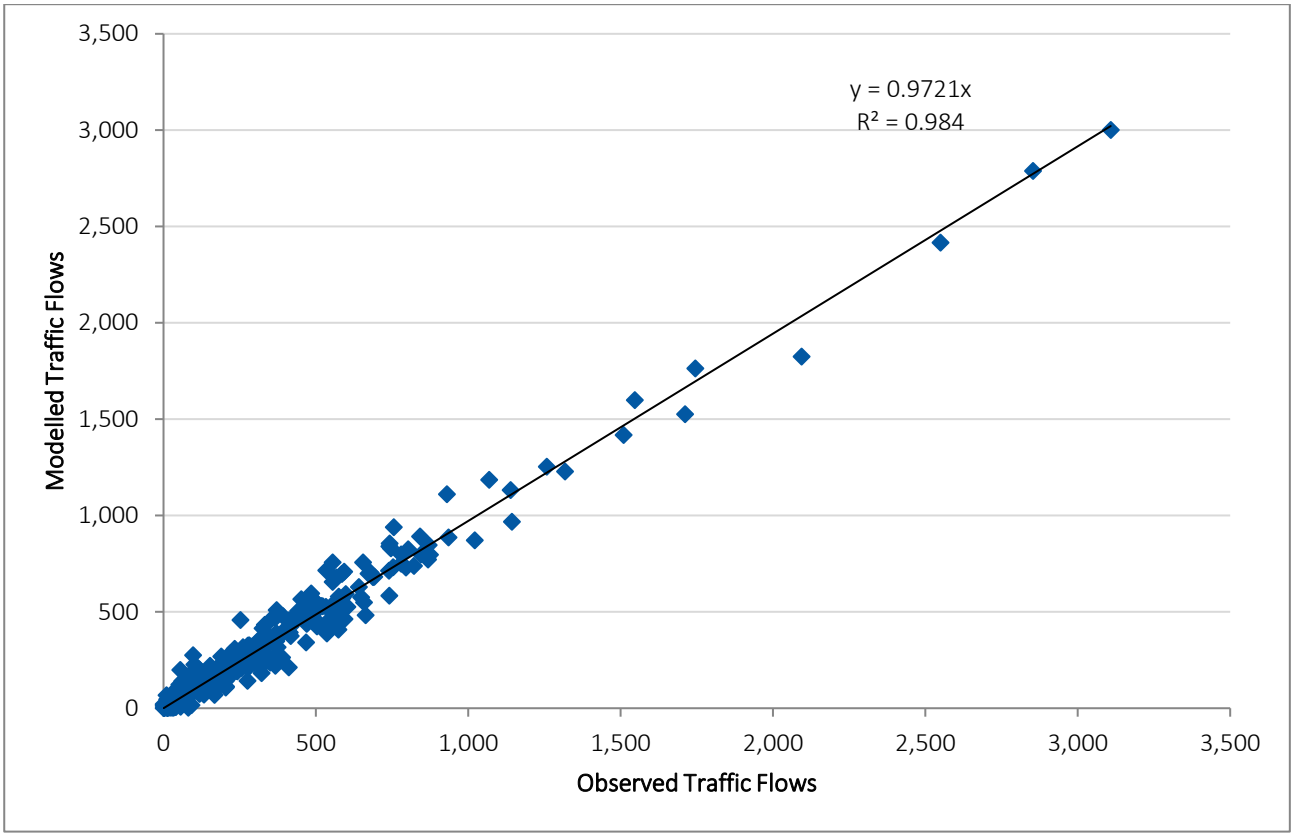


Figure C3: Observed versus modelled counts - Evening peak



APPENDIX D Peak Hour Journey Time Plots

Morning Peak Period Observed vs Modelled Summary

Table D1: SH10 Journey Time Comparison – Morning peak

	0700 to 0800				0800 to 0900			
Route	**Observed (min:sec)**	**Modelled (min:sec)**	**Difference (%)**	**Criteria**	**Observed (min:sec)**	**Modelled (min:sec)**	**Difference (%)**	**Criteria**
R1	05:23	05:30	2%	Pass	06:10	05:41	-8%	Pass
R2	04:37	05:10	12%	Pass	05:31	05:36	2%	Pass
R3	02:02	02:11	7%	Pass	02:16	02:16	0%	Pass
R4	02:32	02:40	5%	Pass	02:54	02:47	-4%	Pass
R5	03:36	03:46	5%	Pass	04:10	03:50	-8%	Pass
R6	03:45	04:07	9%	Pass	04:22	04:11	-4%	Pass
R7	02:57	03:03	3%	Pass	03:11	03:04	-3%	Pass
R8	02:47	03:10	14%	Pass	03:04	03:19	8%	Pass
R9	06:46	07:05	5%	Pass	07:46	07:22	-5%	Pass
R10	07:01	07:27	6%	Pass	08:13	07:39	-7%	Pass
R11	03:54	04:17	9%	Pass	04:31	04:31	0%	Pass
R12	03:16	03:31	8%	Pass	03:20	03:34	7%	Pass
R13	03:31	03:51	9%	Pass	03:49	04:01	5%	Pass
R14	03:44	04:01	8%	Pass	03:54	04:13	8%	Pass
R15	10:47	10:45	0%	Pass	12:17	10:47	-12%	Pass
R16	10:00	09:58	0%	Pass	11:35	10:40	-8%	Pass
R17	06:01	05:41	-5%	Pass	06:12	05:43	-8%	Pass
R18	06:15	06:12	-1%	Pass	06:23	06:15	-2%	Pass
R19	08:58	09:59	11%	Pass	08:57	09:53	11%	Pass
R20	09:06	09:44	7%	Pass	09:07	09:51	8%	Pass
R21	12:14	12:17	0%	Pass	12:25	12:25	0%	Pass
R22	13:25	12:10	-9%	Pass	13:53	12:18	-11%	Pass
R23	03:16	02:56	-10%	Pass	03:19	02:58	-10%	Pass
R24	03:16	02:58	-9%	Pass	03:22	03:03	-9%	Pass
R25	02:16	01:53	-17%	Pass	02:25	02:03	-15%	Pass
R26	02:27	02:11	-11%	Pass	02:40	02:17	-14%	Pass
R27	12:24	10:34	-15%	Pass	11:01	10:43	-3%	Pass
R28	08:00	08:19	4%	Pass	08:53	09:11	3%	Pass
R29	05:58	05:57	0%	Pass	05:51	05:56	1%	Pass
R30	06:29	06:21	-2%	Pass	06:31	06:19	-3%	Pass
R31	02:14	01:58	-12%	Pass	02:14	01:58	-12%	Pass
R32	02:39	02:39	0%	Pass	02:48	02:41	-4%	Pass

Inter Peak Period Observed vs Modelled Summary

Table D2: SH10 Journey Time Comparison – inter Peak

	1100 to 1200				1200 to 1300			
Route	**Observed (min:sec)**	**Modelled (min:sec)**	**Difference (%)**	**Criteria**	**Observed (min:sec)**	**Modelled (min:sec)**	**Difference (%)**	**Criteria**
R1	05:32	05:34	1%	Pass	05:47	05:40	-8%	Pass
R2	04:50	05:12	8%	Pass	04:54	05:15	2%	Pass
R3	02:31	02:10	-14%	Pass	02:46	02:11	0%	Pass
R4	03:01	02:38	-13%	Pass	03:09	02:38	-4%	Pass
R5	03:46	03:44	-1%	Pass	03:45	03:44	-8%	Pass
R6	03:56	04:04	4%	Pass	03:54	04:05	-4%	Pass
R7	02:59	02:59	0%	Pass	03:02	02:59	-3%	Pass
R8	02:55	03:07	7%	Pass	02:57	03:11	8%	Pass
R9	07:18	06:53	-6%	Pass	07:15	06:52	-5%	Pass
R10	07:27	07:21	-1%	Pass	07:17	07:03	-7%	Pass
R11	03:58	04:14	7%	Pass	04:01	04:20	0%	Pass
R12	03:16	03:28	6%	Pass	03:15	03:29	7%	Pass
R13	03:46	03:53	3%	Pass	03:45	03:53	5%	Pass
R14	04:03	04:00	-1%	Pass	04:06	04:03	8%	Pass
R15	10:51	10:22	-4%	Pass	10:55	10:20	-12%	Pass
R16	09:57	09:45	-2%	Pass	10:20	09:47	-8%	Pass
R17	06:04	05:34	-8%	Pass	06:06	05:34	-8%	Pass
R18	06:09	06:08	0%	Pass	06:14	06:07	-2%	Pass
R19	09:12	09:49	7%	Pass	09:09	09:43	11%	Pass
R20	09:11	09:39	5%	Pass	09:07	09:38	8%	Pass
R21	13:20	12:29	-6%	Pass	13:25	12:23	0%	Pass
R22	14:21	12:25	-13%	Pass	14:26	12:28	-11%	Pass
R23	03:02	02:53	-5%	Pass	03:04	02:53	-10%	Pass
R24	03:04	02:55	-5%	Pass	03:14	02:55	-9%	Pass
R25	02:20	01:47	-23%	Pass	02:26	01:48	-15%	Pass
R26	02:42	02:15	-17%	Pass	02:47	02:18	-14%	Pass
R27	08:58	08:54	-1%	Pass	09:15	09:03	-3%	Pass
R28	08:02	08:35	7%	Pass	08:09	08:43	3%	Pass
R29	05:49	05:51	1%	Pass	05:48	05:50	1%	Pass
R30	06:29	06:15	-4%	Pass	06:26	06:14	-3%	Pass
R31	02:15	01:56	-14%	Pass	02:20	01:55	-12%	Pass
R32	02:39	02:31	-5%	Pass	02:42	02:33	-4%	Pass

Evening Peak Period Observed vs Modelled Summary

Table D3: SH10 Journey Time Comparison – Evening Peak

	1600 to 1700				1700 to 1800			
Route	**Observed (min:sec)**	**Modelled (min:sec)**	**Difference (%)**	**Criteria**	**Observed (min:sec)**	**Modelled (min:sec)**	**Difference (%)**	**Criteria**
R1	07:19	06:20	-13%	Pass	06:38	06:56	5%	Pass
R2	05:25	05:39	4%	Pass	05:19	05:41	7%	Pass
R3	03:10	02:27	-23%	Pass	03:08	02:48	-10%	Pass
R4	03:03	02:55	-4%	Pass	03:05	02:55	-5%	Pass
R5	03:43	03:50	3%	Pass	03:50	03:50	0%	Pass
R6	03:53	04:20	12%	Pass	03:59	04:20	8%	Pass
R7	03:34	03:07	-13%	Pass	03:31	03:12	-9%	Pass
R8	02:57	03:32	20%	Pass	03:05	03:34	16%	Pass
R9	07:01	07:02	0%	Pass	07:08	07:01	-2%	Pass
R10	07:18	07:22	1%	Pass	07:40	07:24	-3%	Pass
R11	04:30	04:51	8%	Pass	04:22	05:10	18%	Pass
R12	03:17	03:37	10%	Pass	03:19	03:38	10%	Pass
R13	03:41	04:00	9%	Pass	03:23	03:54	16%	Pass
R14	03:55	04:12	7%	Pass	03:41	04:12	14%	Pass
R15	10:21	10:25	1%	Pass	10:11	10:23	2%	Pass
R16	10:10	10:04	-1%	Pass	09:57	09:57	0%	Pass
R17	06:08	05:45	-6%	Pass	06:01	05:42	-5%	Pass
R18	06:14	06:18	1%	Pass	06:12	06:17	1%	Pass
R19	09:04	09:42	7%	Pass	09:06	09:35	5%	Pass
R20	08:56	10:04	13%	Pass	08:42	10:06	16%	High
R21	12:35	13:00	3%	Pass	12:19	12:50	4%	Pass
R22	13:32	13:22	-1%	Pass	13:19	13:35	2%	Pass
R23	02:52	02:58	3%	Pass	02:58	03:00	1%	Pass
R24	03:05	03:02	-1%	Pass	03:02	03:02	0%	Pass
R25	02:29	01:53	-25%	Pass	02:34	01:55	-26%	Pass
R26	02:56	02:39	-9%	Pass	02:47	02:43	-3%	Pass
R27	10:29	10:36	1%	Pass	10:18	11:13	9%	Pass
R28	08:50	09:23	6%	Pass	09:02	09:29	5%	Pass
R29	05:48	05:53	1%	Pass	05:45	05:52	2%	Pass
R30	06:26	06:20	-2%	Pass	06:21	06:18	-1%	Pass
R31	02:13	02:05	-6%	Pass	02:15	02:03	-9%	Pass
R32	02:43	02:38	-3%	Pass	02:43	02:35	-5%	Pass

Figure D1: Journey time plot, R1: Prosser Street to SH1 via Keneperu Drive morning peak hour

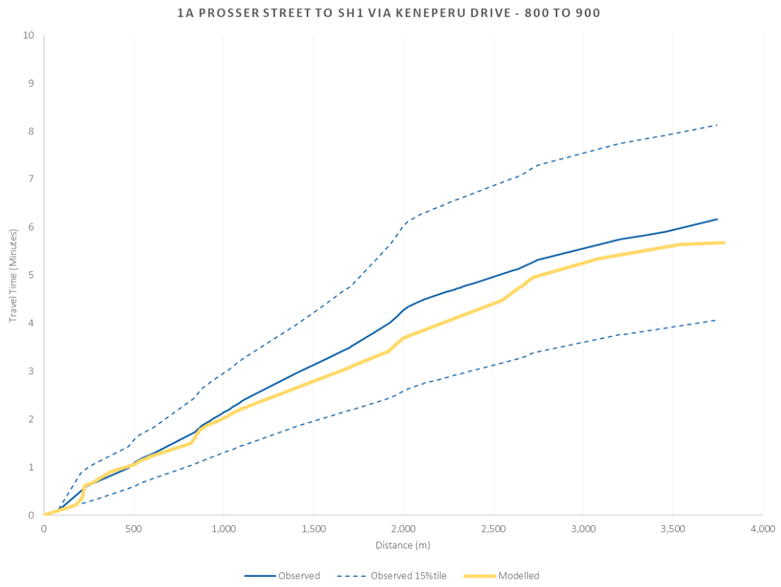


Figure D2: Journey time plot, R1: Prosser Street to SH1 via Keneperu Drive inter peak hour

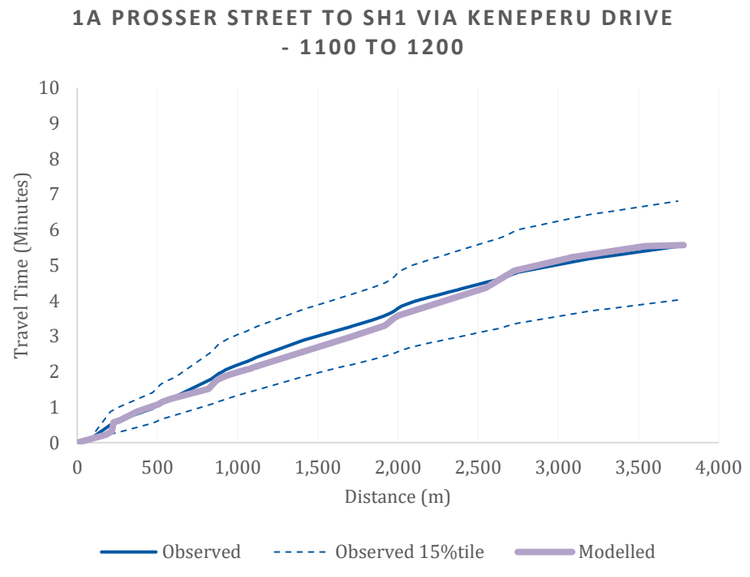


Figure D3: Journey time plot, R1: Prosser Street to SH1 via Keneperu Drive evening peak hour

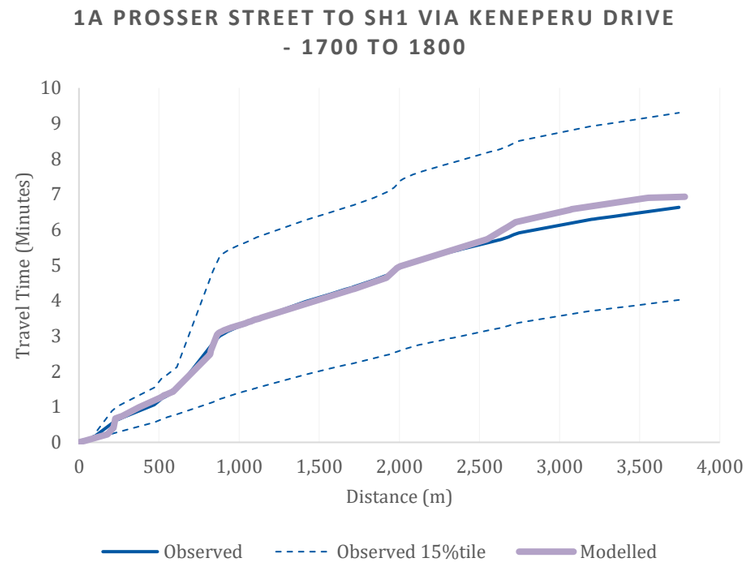


Figure D4: Journey time plot, R2: SH1 SB offramp to Prosser Street via Keneperu Drive morning peak hour

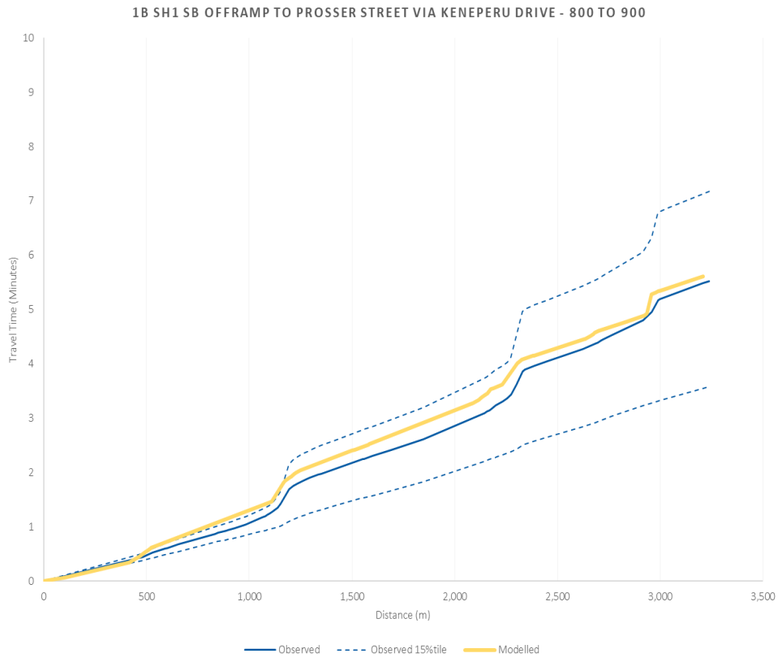


Figure D5: Journey time plot, R2: SH1 SB offramp to Prosser Street via Keneperu Drive inter peak hour

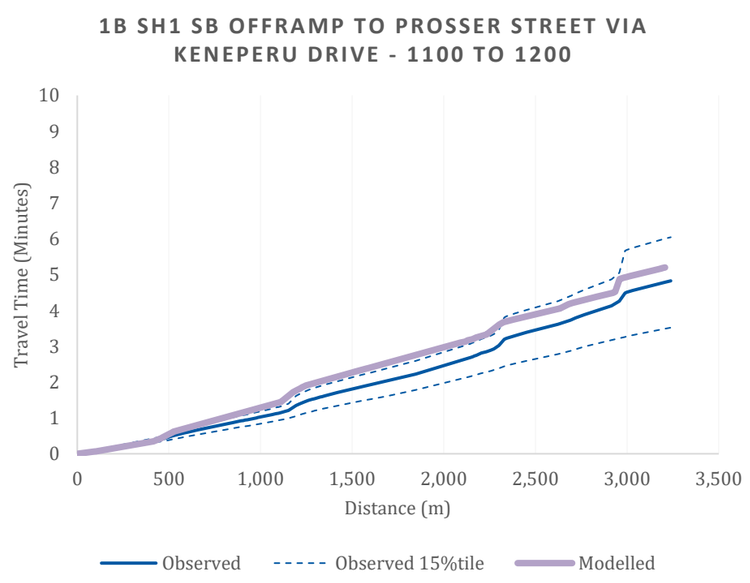


Figure D6: Journey time plot, R2: SH1 SB offramp to Prosser Street via Keneperu Drive evening peak hour

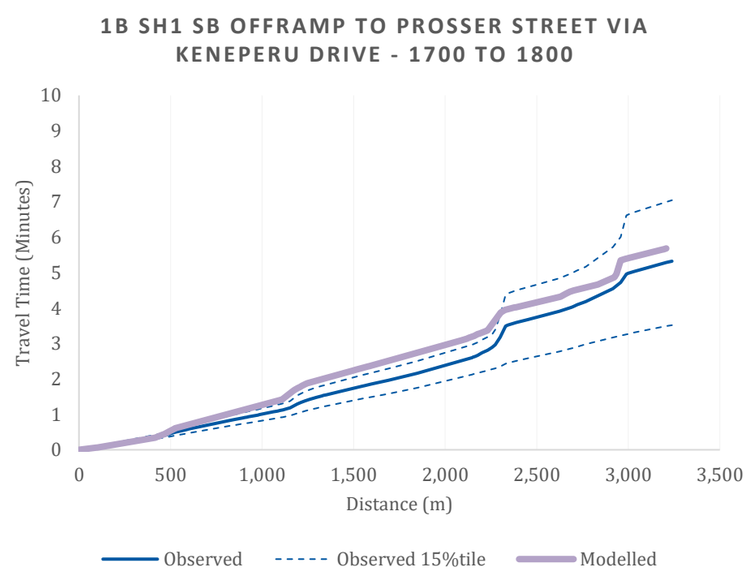


Figure D7: Journey time plot, R3: Titahi Bay Rd to SH59 via Semple St morning peak hour

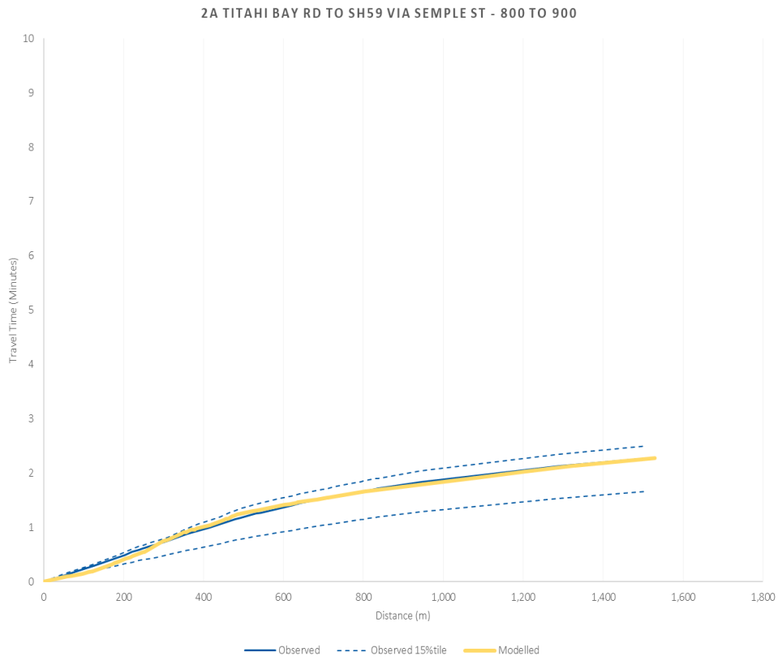


Figure D8: Journey time plot, R3: Titahi Bay Rd to SH59 via Semple St inter peak hour

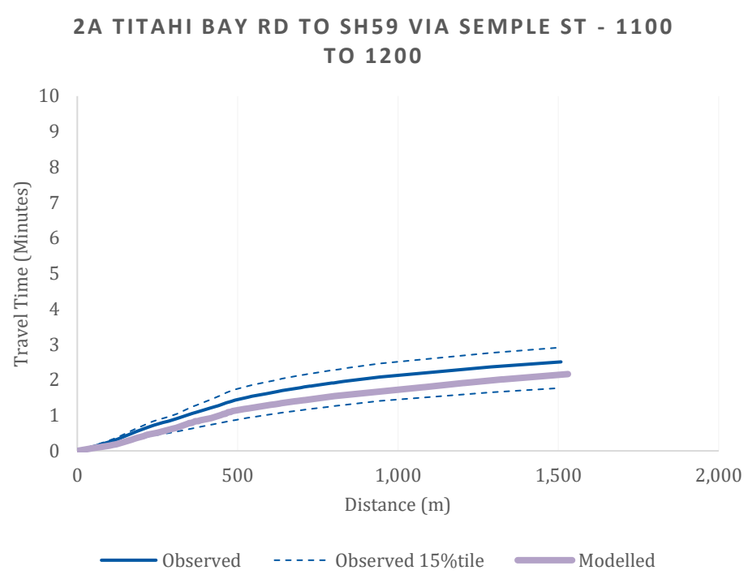


Figure D9: Journey time plot, R3: Titahi Bay Rd to SH59 via Semple Stevening peak hour

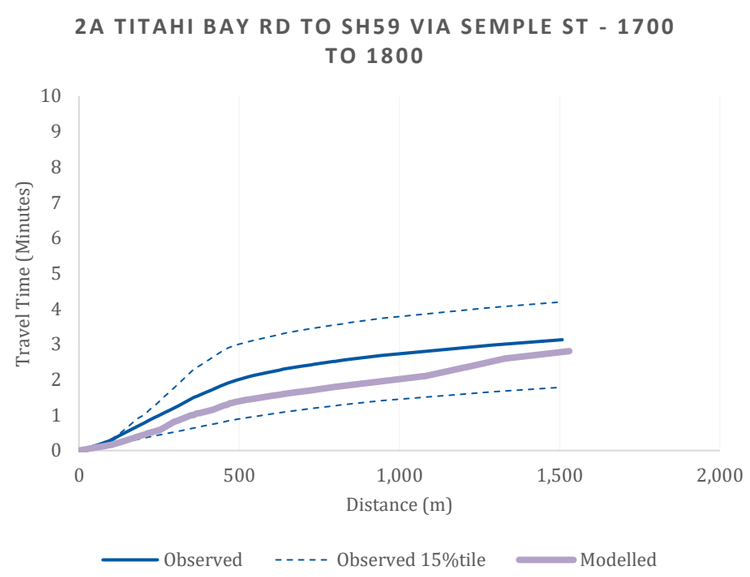


Figure D10: Journey time plot, R4: SH59 to Titahi Bay Rd via Semple Stmorning peak hour

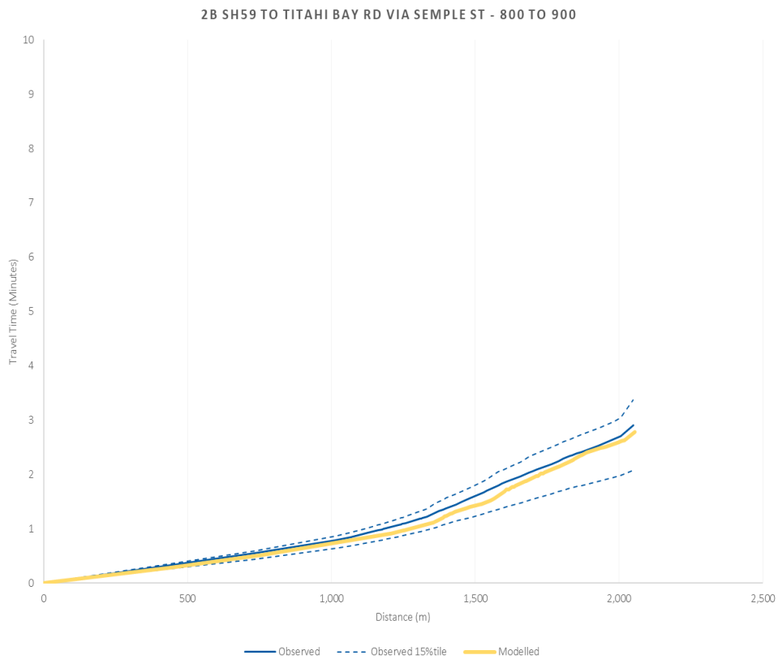


Figure D11: Journey time plot, R4: SH59 to Titahi Bay Rd via Semple St inter peak hour

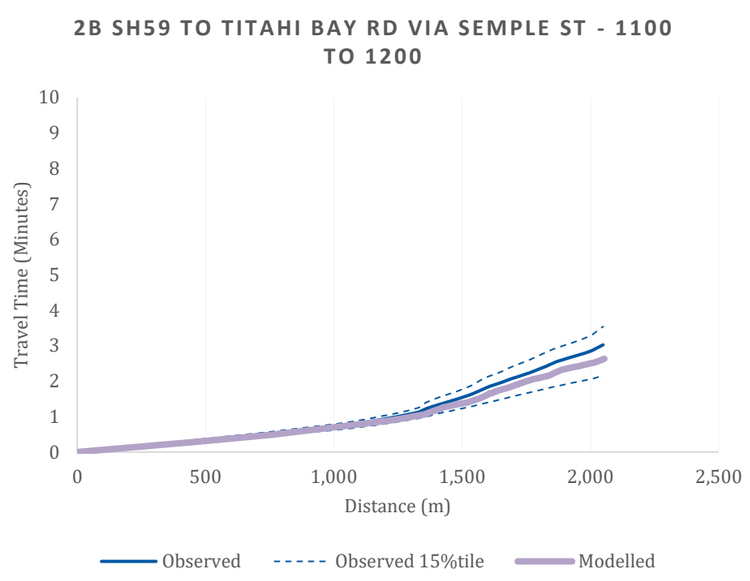


Figure D12: Journey time plot, R4: SH59 to Titahi Bay Rd via Semple St evening peak hour

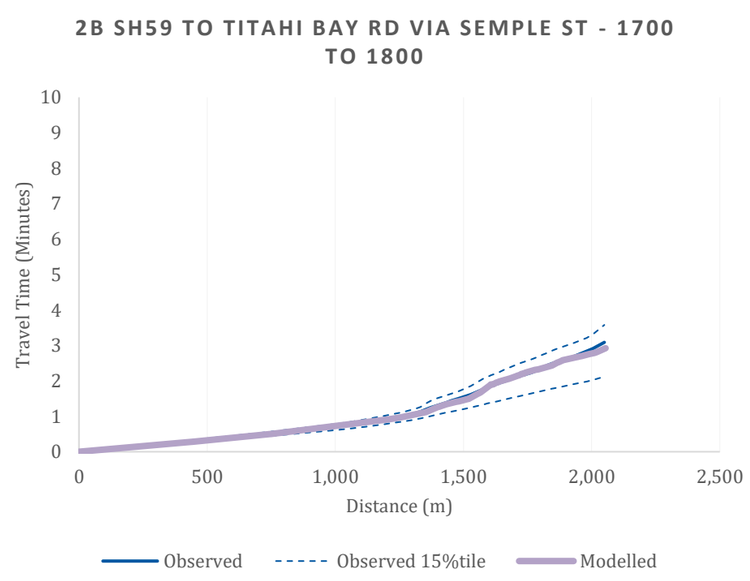


Figure D13: Journey time plot, R5: Omapere Street to Whitford Brown Avenue morning peak hour

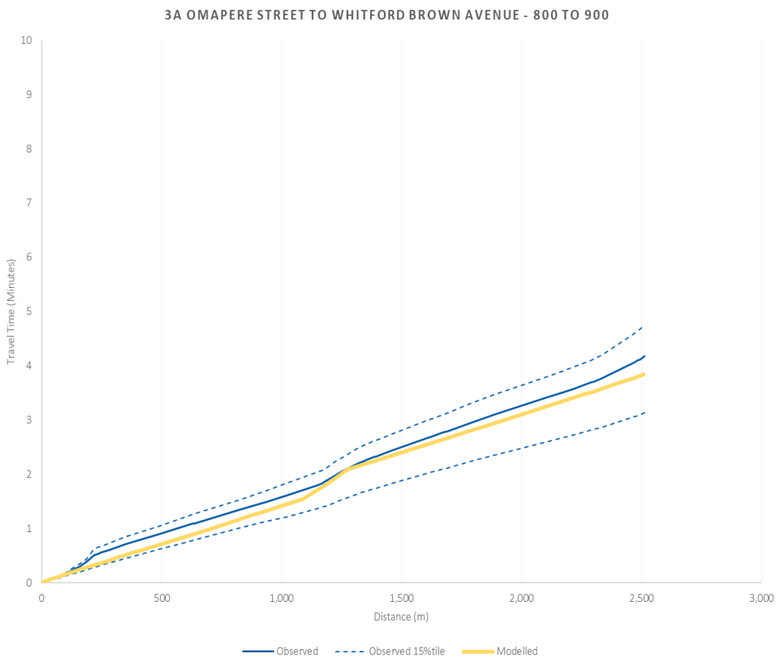


Figure D14: Journey time plot, R5: Omapere Street to Whitford Brown Avenue inter peak hour

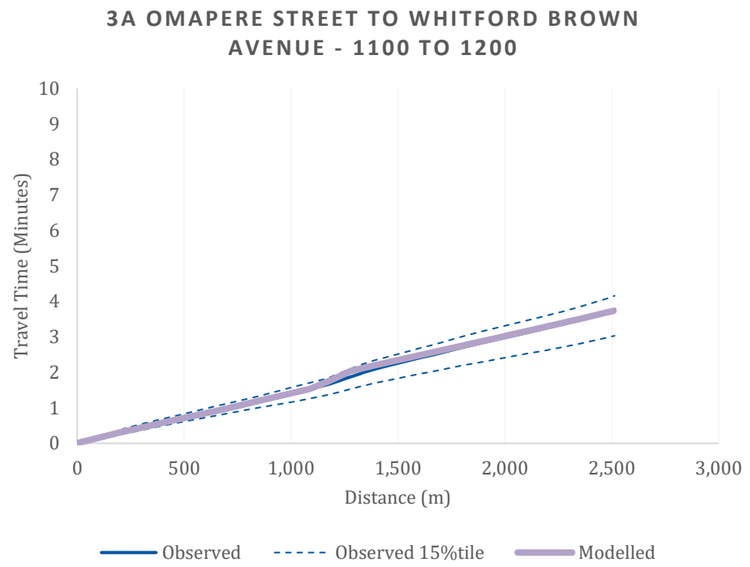


Figure D15: Journey time plot, R5: Omapere Street to Whitford Brown Avenue evening peak hour

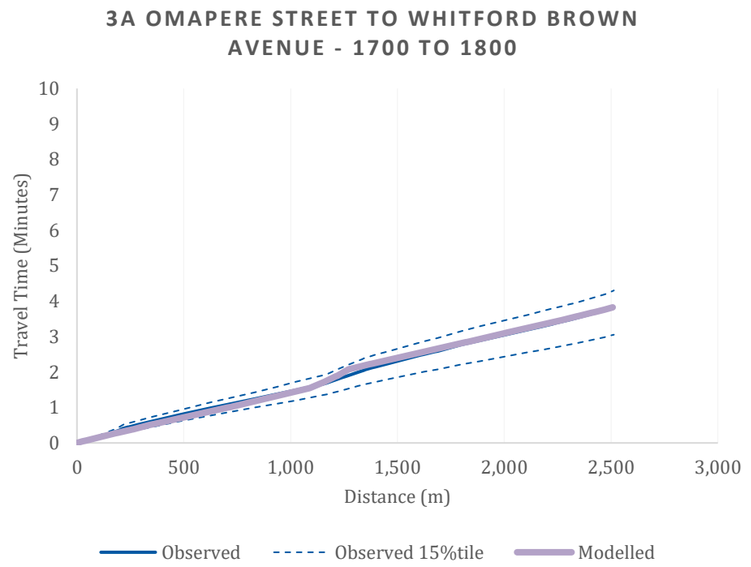


Figure D16: Journey time plot, R6: Whitford Brown Avenue to Omapere Street morning peak hour

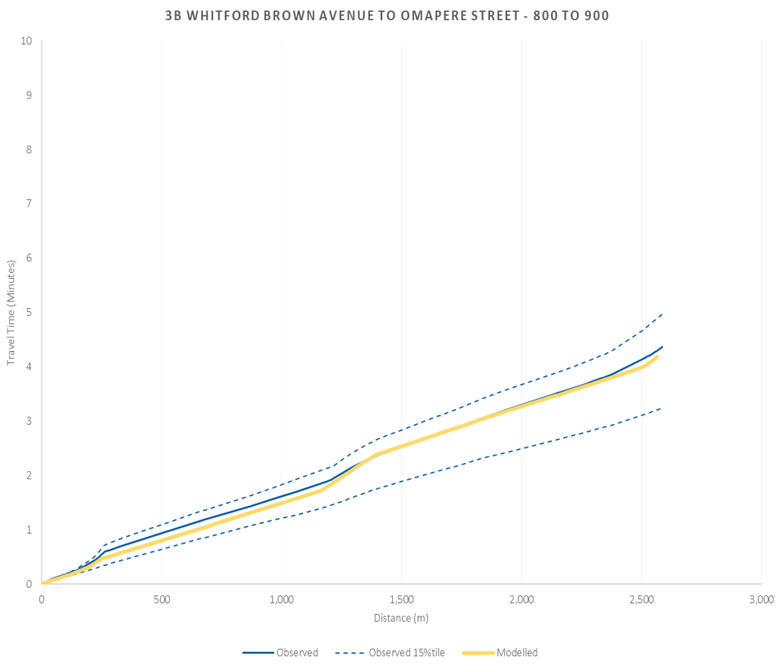


Figure D17: Journey time plot, R6: Whitford Brown Avenue to Omapere Street inter peak hour

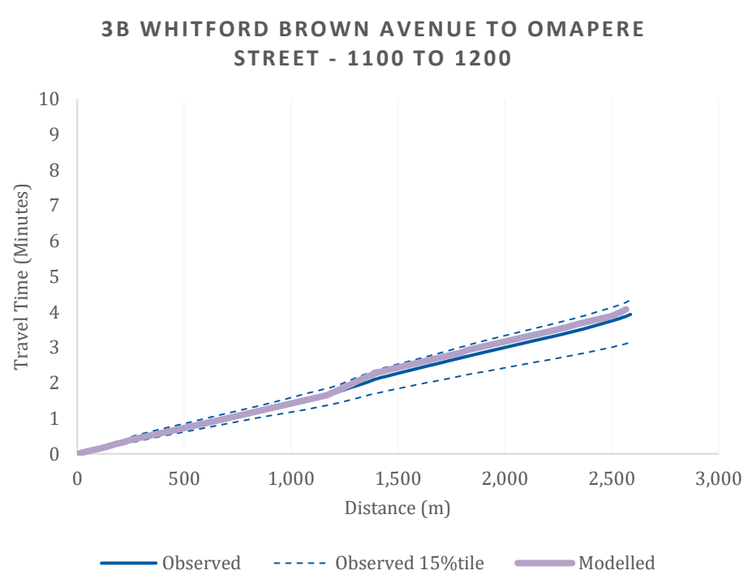


Figure D18: Journey time plot, R6: Whitford Brown Avenue to Omapere Street evening peak hour

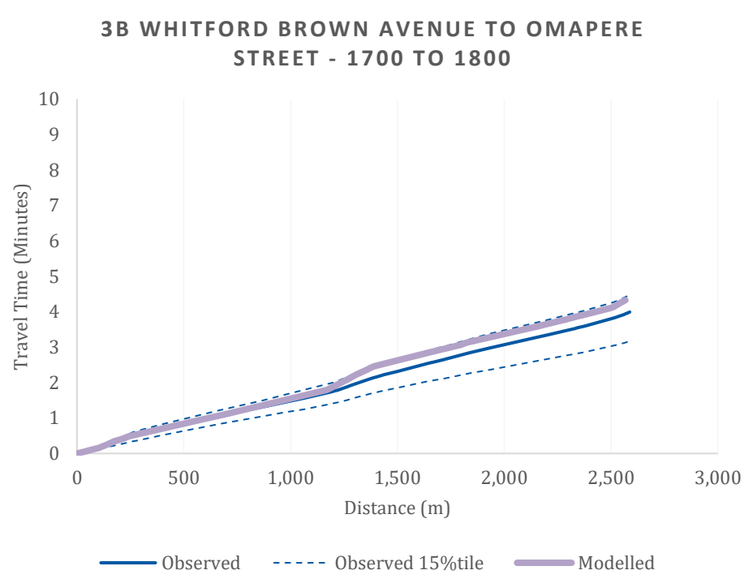


Figure D19: Journey time plot, R7: Champion Street at Warspite Avenue to Champion St morning peak hour

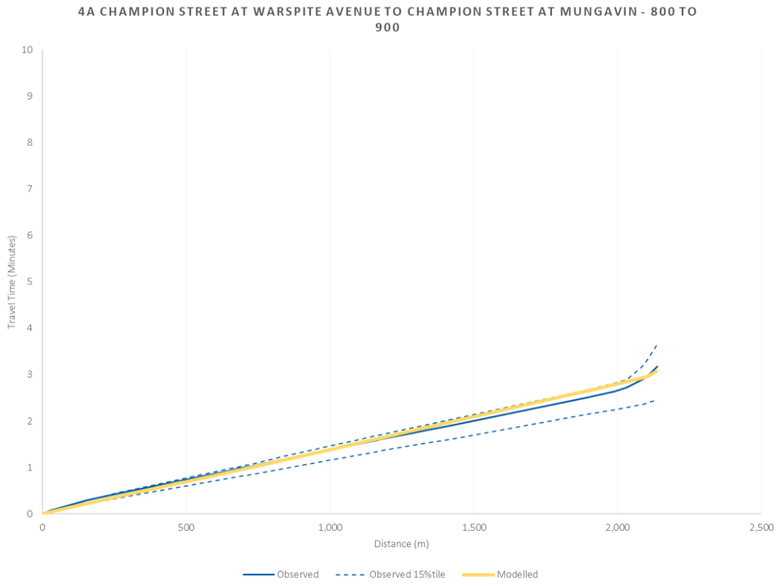


Figure D20: Journey time plot, R7: Champion Street at Warspite Avenue to Champion St inter peak hour

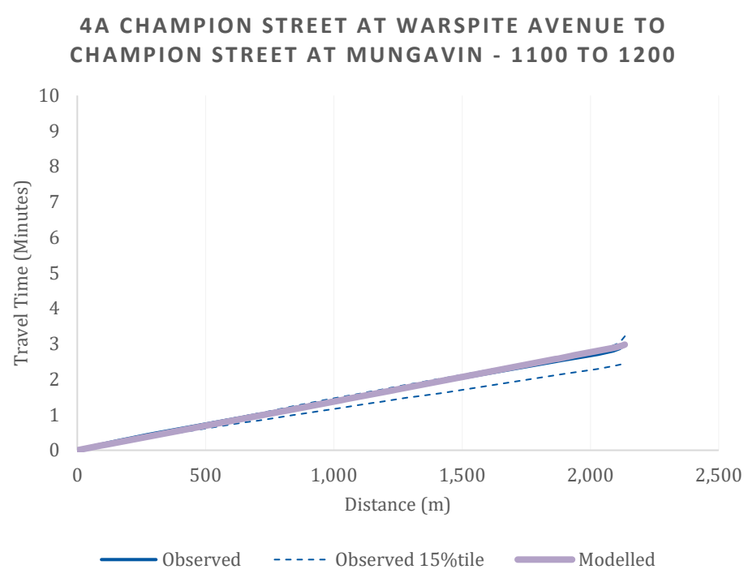


Figure D21: Journey time plot, R7: Champion Street at Warspite Avenue to Champion St evening peak hour

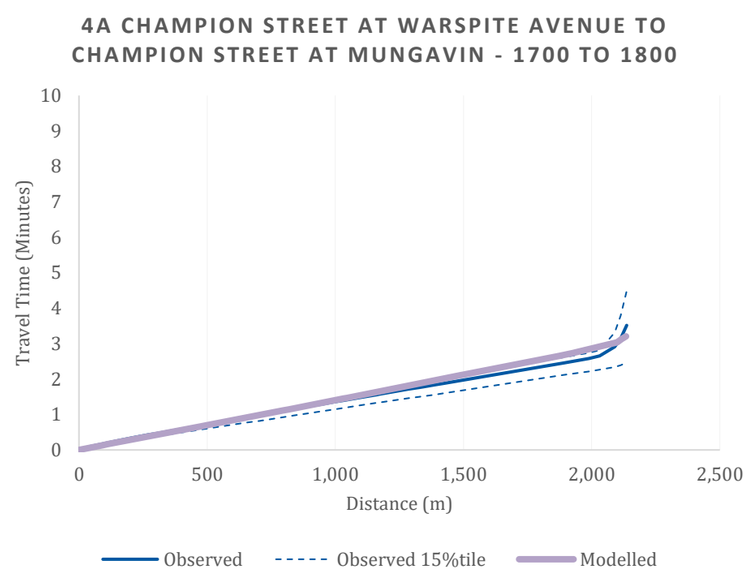


Figure D22: Journey time plot, R8: Champion Street at Mungavin to Champion Street at morning peak hour

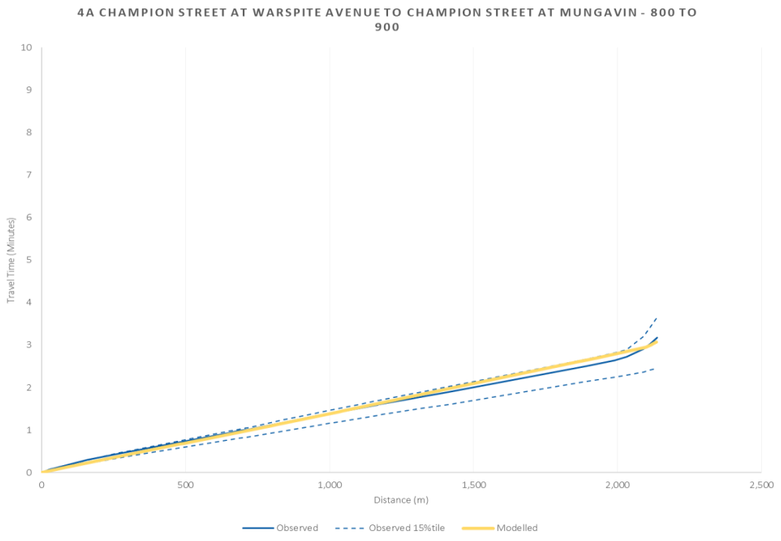


Figure D23: Journey time plot, R8: Champion Street at Mungavin to Champion Street at inter peak hour

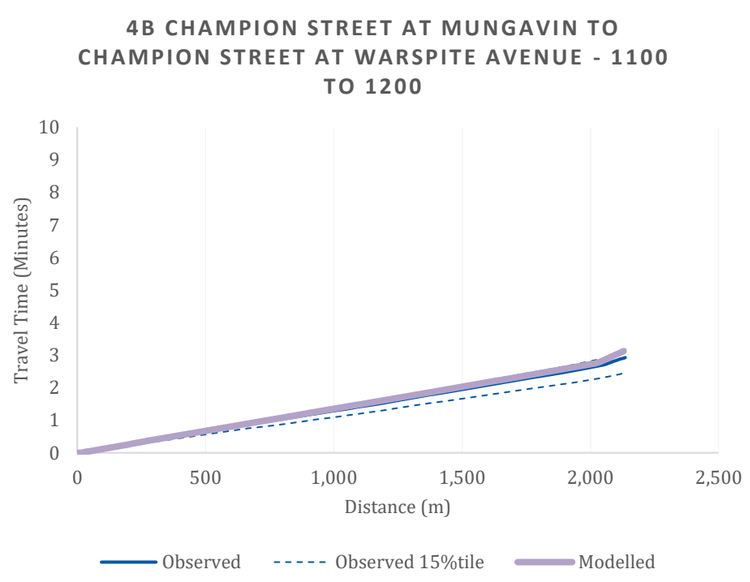


Figure D24: Journey time plot, R8: Champion Street at Mungavin to Champion Street at evening peak hour

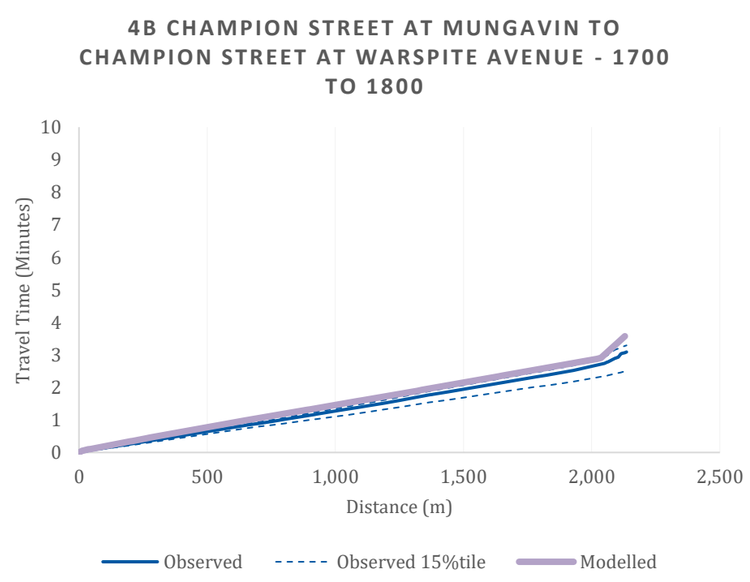


Figure D25: Journey time plot, R9: Waitangairua Link Rd to Mungavin Ave via Mungavin morning peak hour

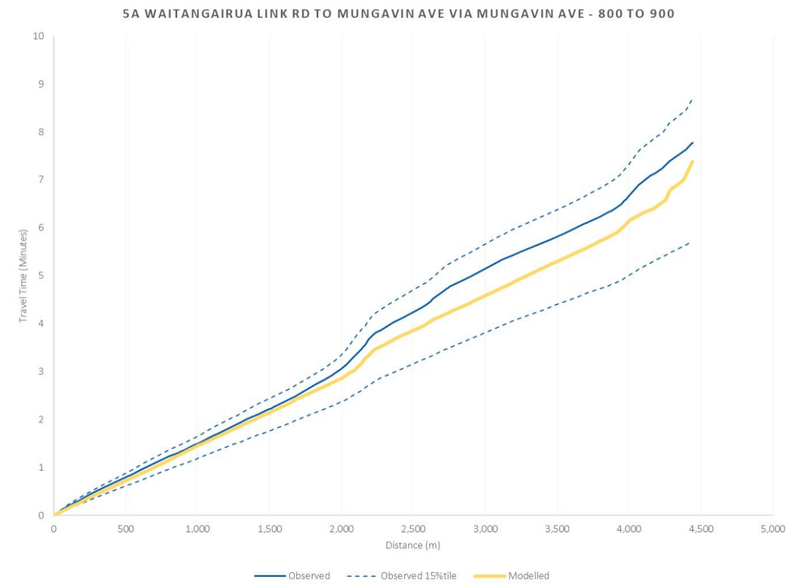


Figure D26: Journey time plot, R9: Waitangairua Link Rd to Mungavin Ave via Mungavin inter peak hour

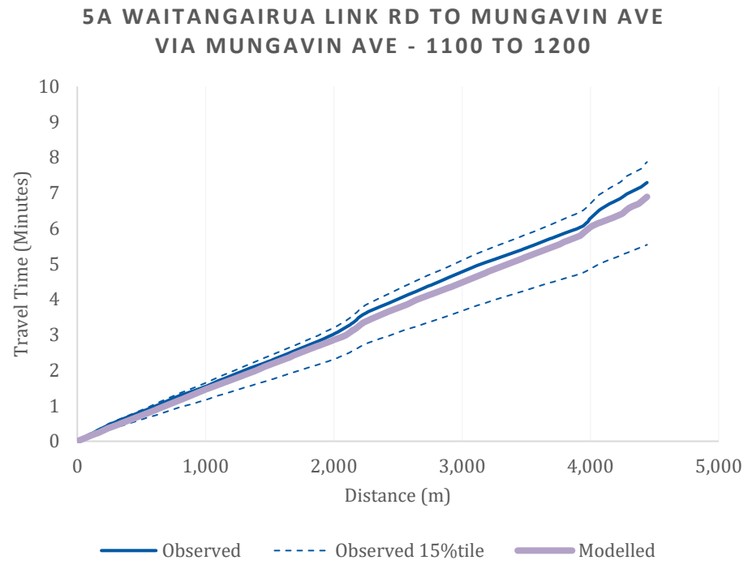


Figure D27: Journey time plot, R9: Waitangairua Link Rd to Mungavin Ave via Mungavin evening peak hour

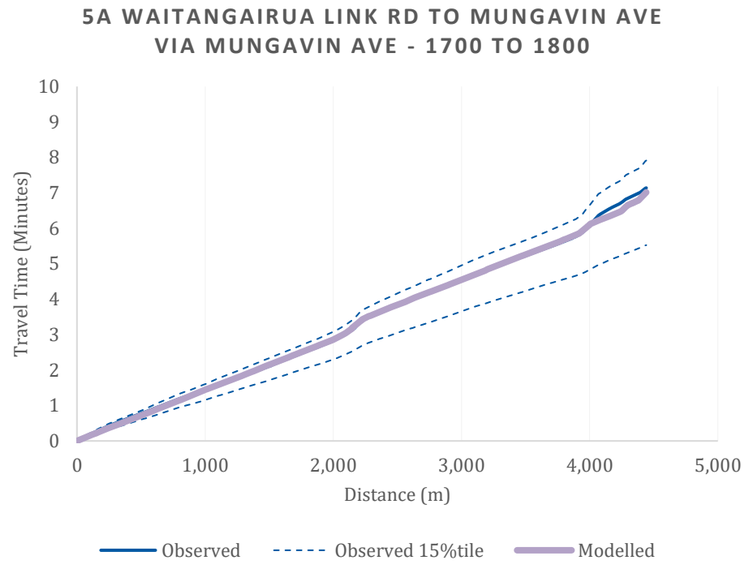


Figure D28: Journey time plot, R10: Mungavin Ave to Waitangairua Link Rd via Mungavin morning peak hour

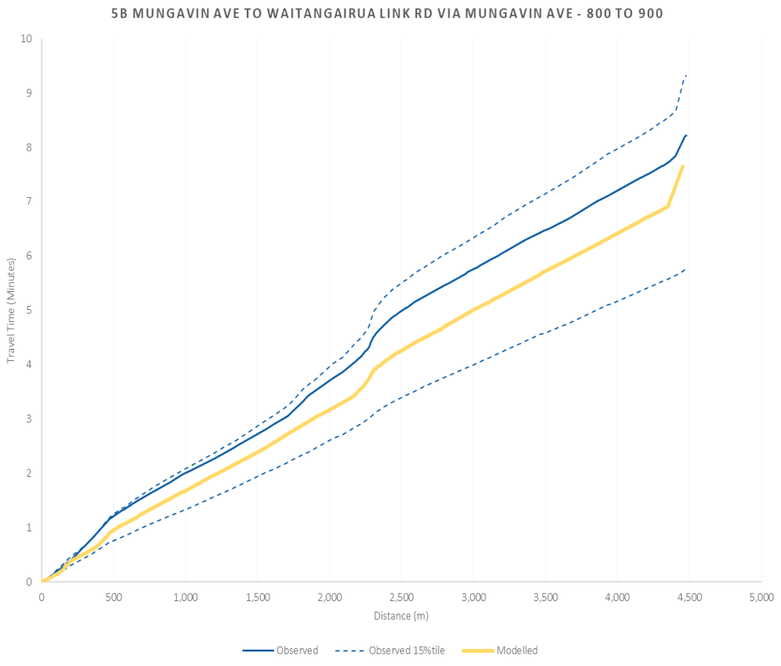


Figure D29: Journey time plot, R10: Mungavin Ave to Waitangairua Link Rd via Mungavin inter peak hour

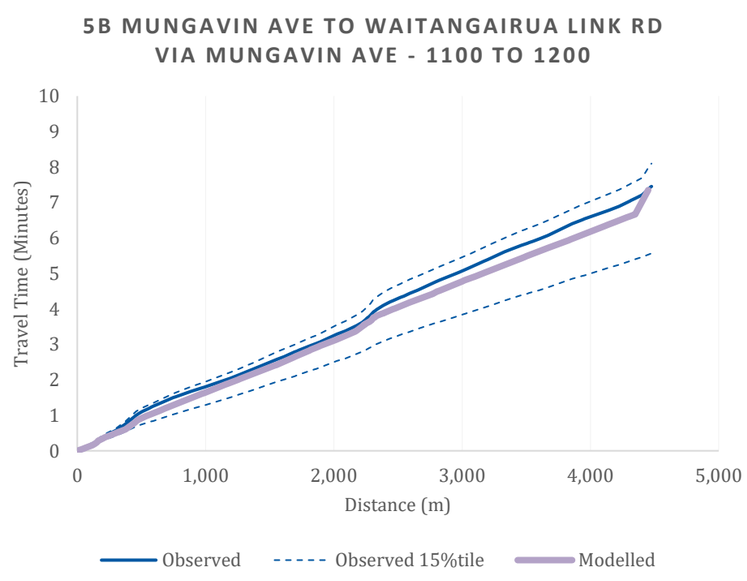


Figure D30: Journey time plot, R10: Mungavin Ave to Waitangairua Link Rd via Mungavin evening peak hour

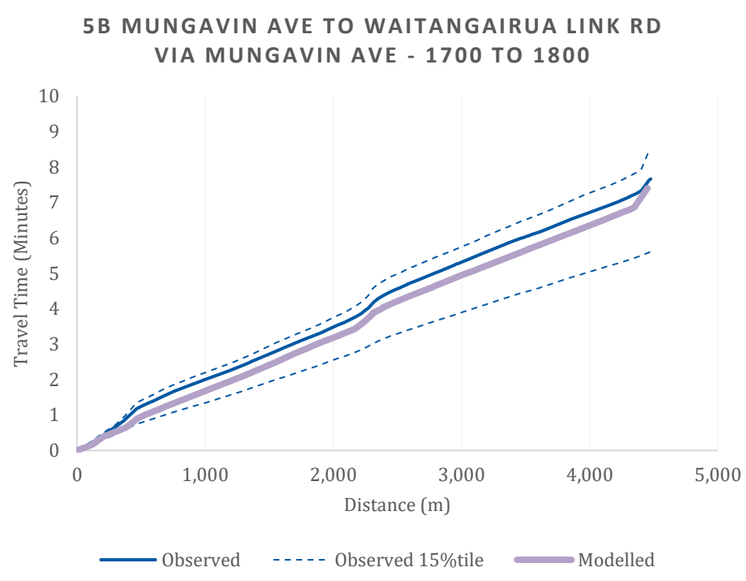


Figure D31: Journey time plot, R11: SH58 to Titahi Bay Rd via SH59 morning peak hour

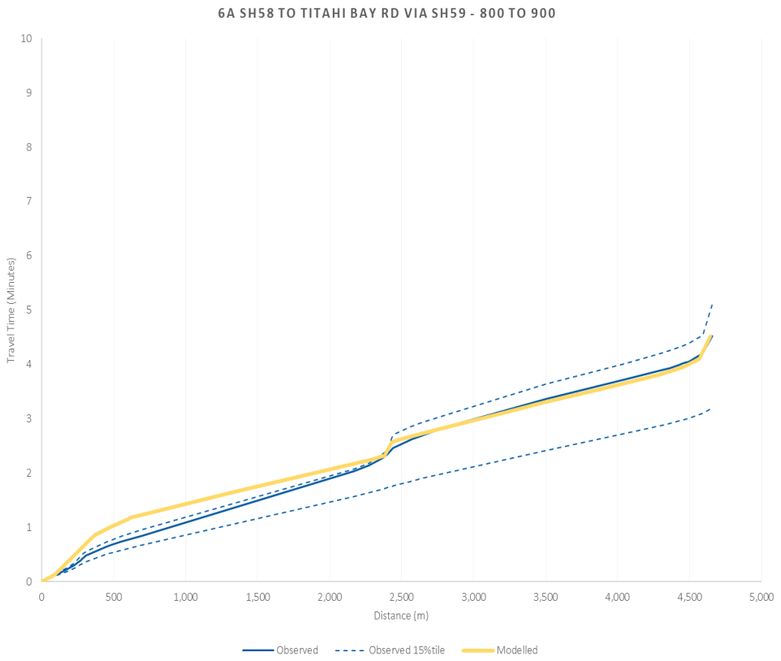


Figure D32: Journey time plot, R11: SH58 to Titahi Bay Rd via SH59 inter peak hour

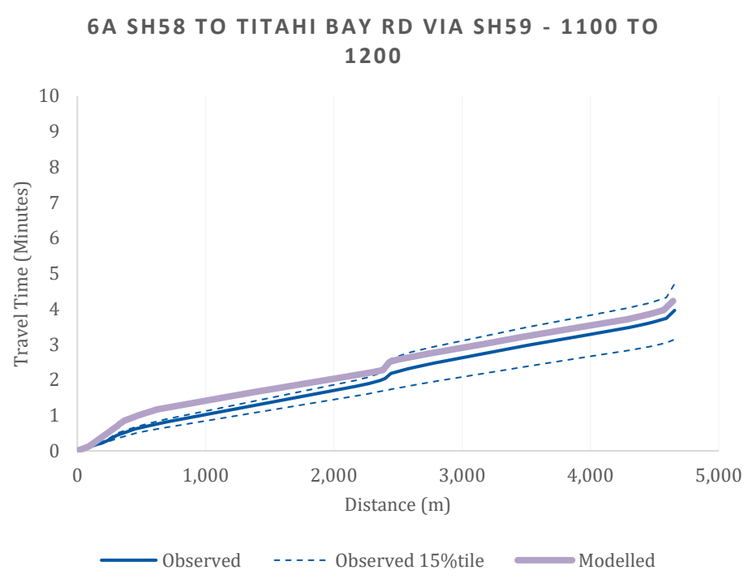


Figure D33: Journey time plot, R11: SH58 to Titahi Bay Rd via SH59 evening peak hour

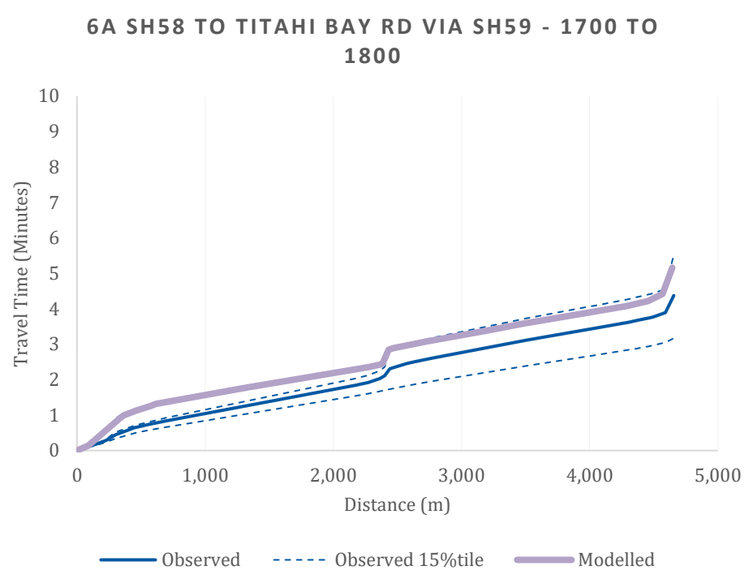


Figure D34: Journey time plot, R12: Titahi Bay Rd to SH58 via SH59 morning peak hour

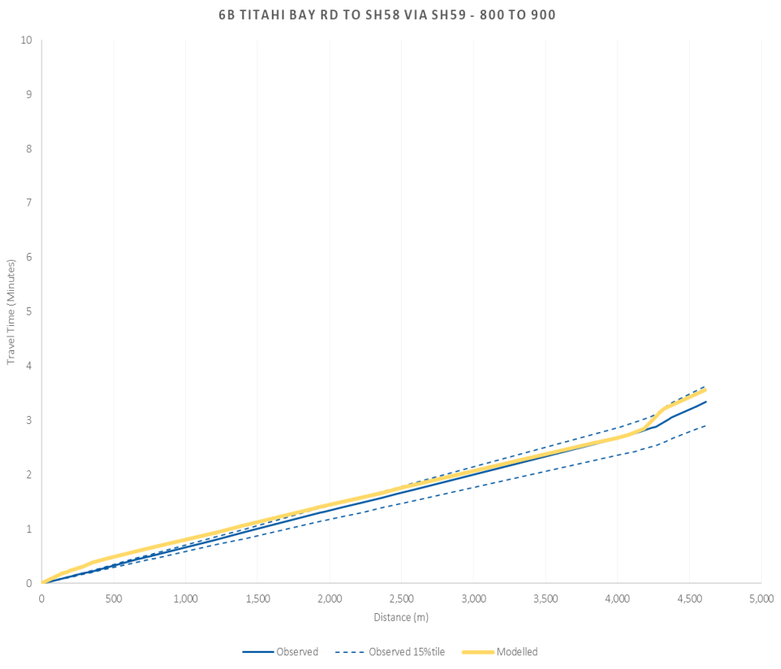


Figure D35: Journey time plot, R12: Titahi Bay Rd to SH58 via SH59 inter peak hour

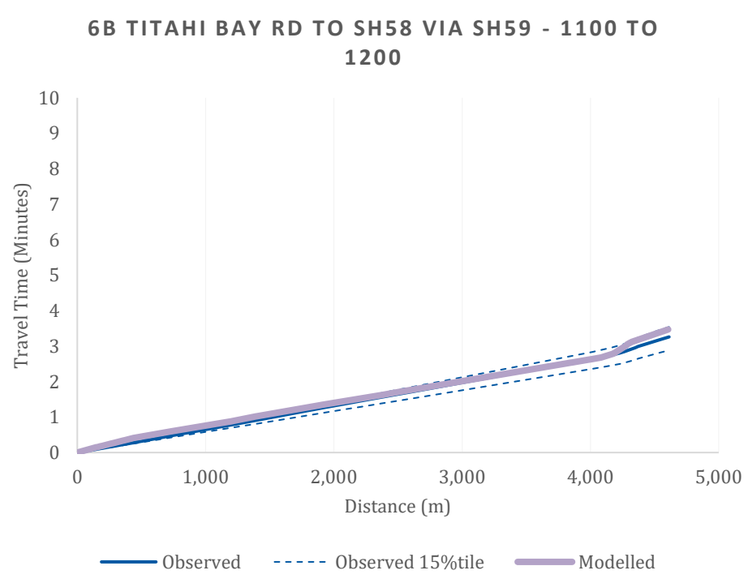


Figure D36: Journey time plot, R12: Titahi Bay Rd to SH58 via SH59 evening peak hour

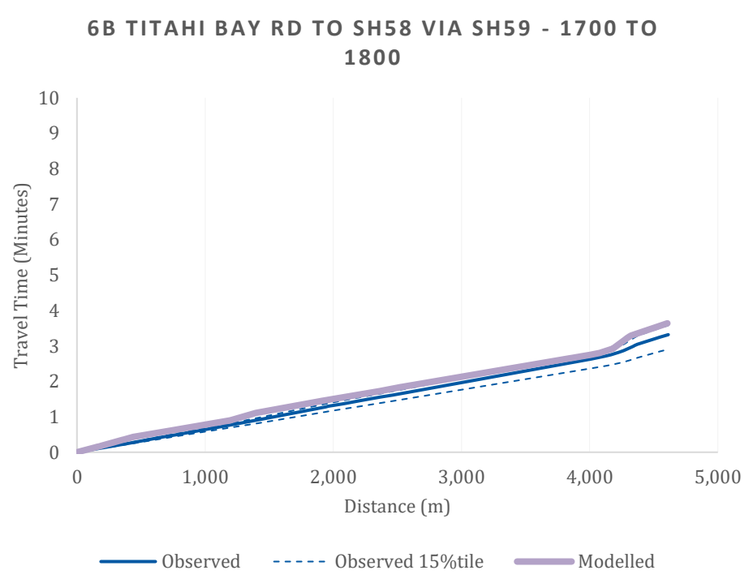


Figure D37: Journey time plot, R13: Prosser Street to Main Rd via Raiha St morning peak hour

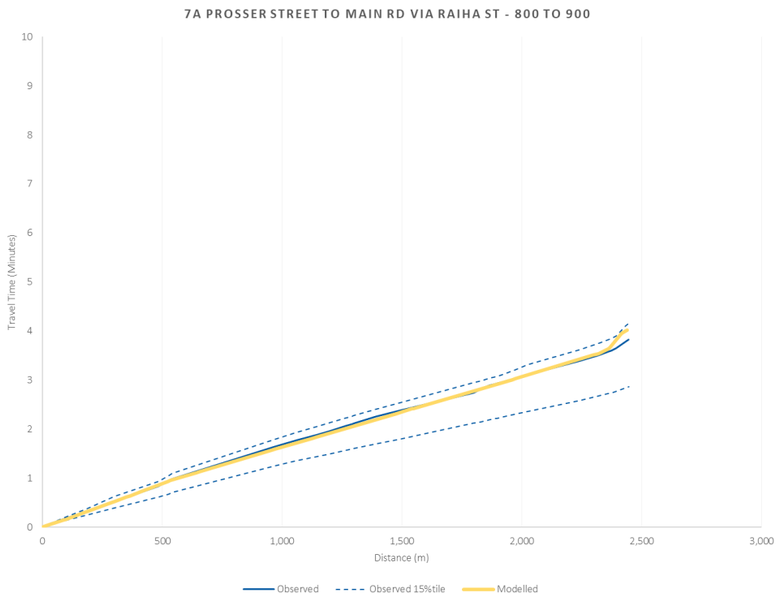


Figure D38: Journey time plot, R13: Prosser Street to Main Rd via Raiha St inter peak hour

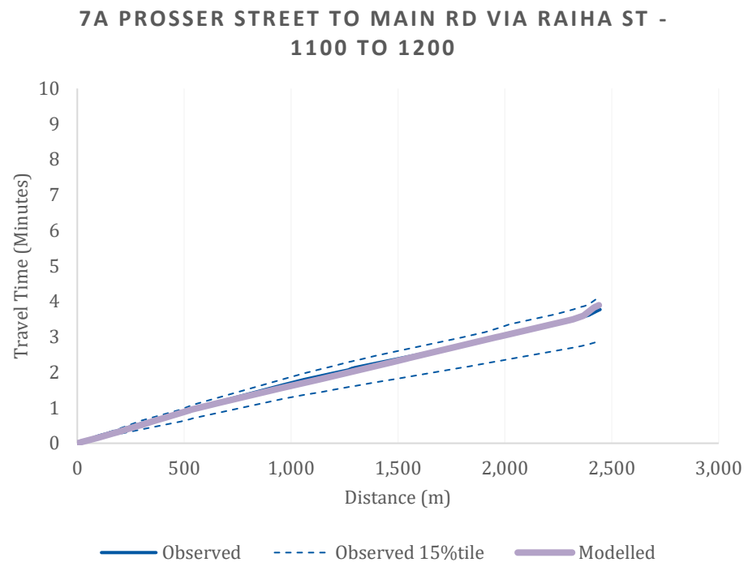


Figure D39: Journey time plot, R13: Prosser Street to Main Rd via Raiha St evening peak hour

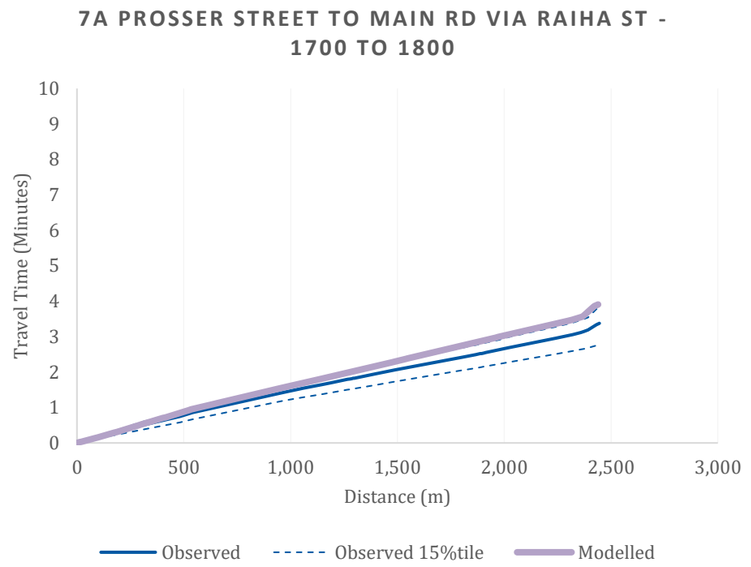


Figure D40: Journey time plot, R14: Main Rd to Prosser Street via Raiha St morning peak hour

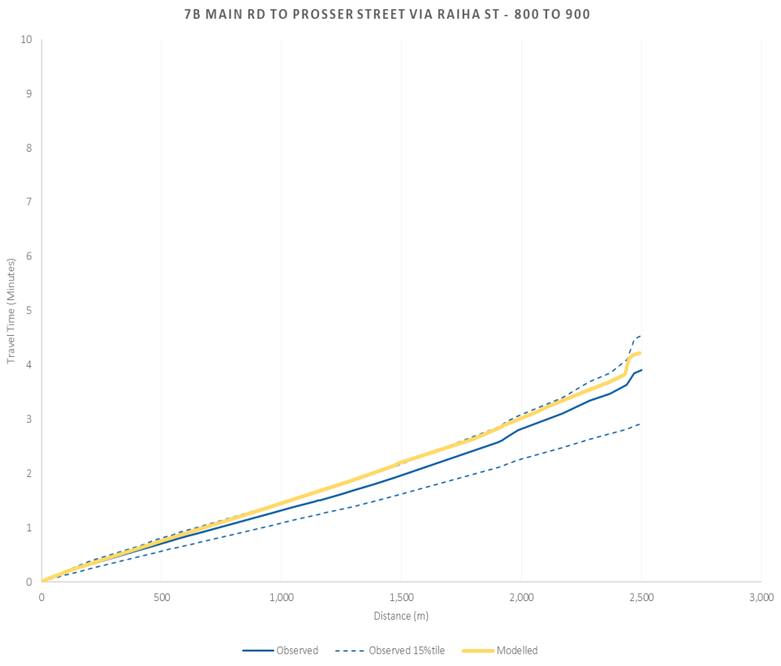


Figure D41: Journey time plot, R14: Main Rd to Prosser Street via Raiha St inter peak hour

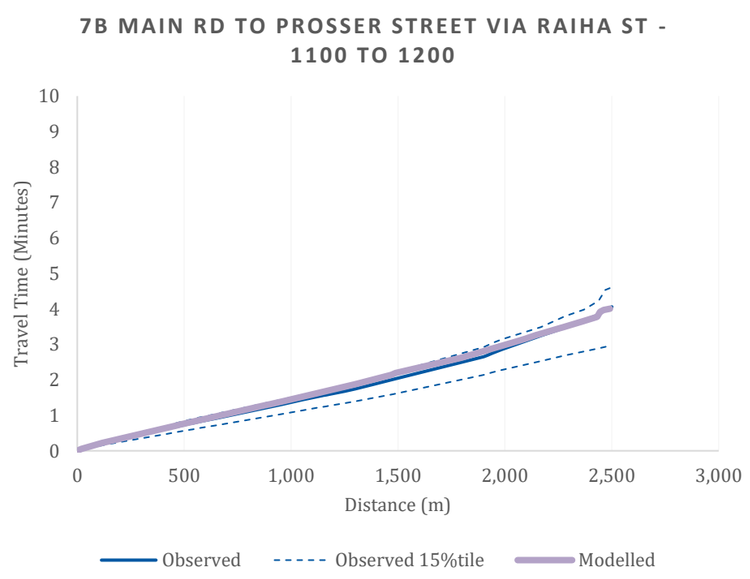


Figure D42: Journey time plot, R14: Main Rd to Prosser Street via Raiha St evening peak hour

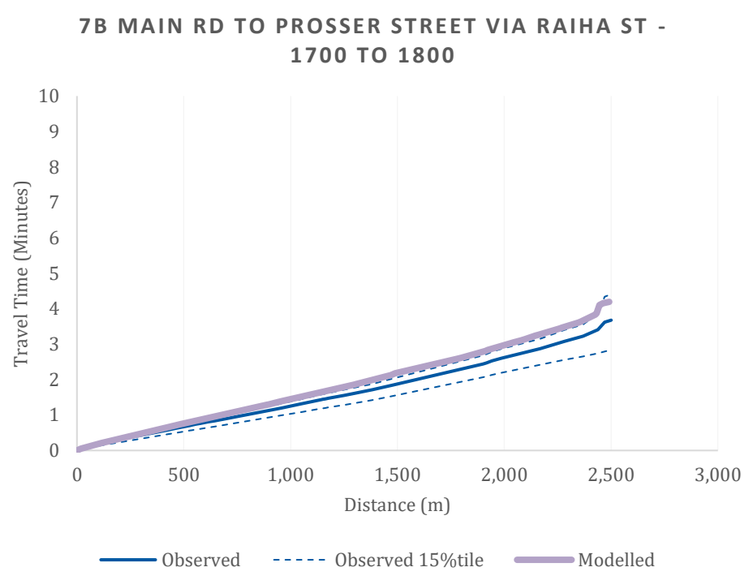


Figure D43: Journey time plot, R15: Kenepuru Dr/Kenepuru Link roundabout to SH1 via M morning peak hour

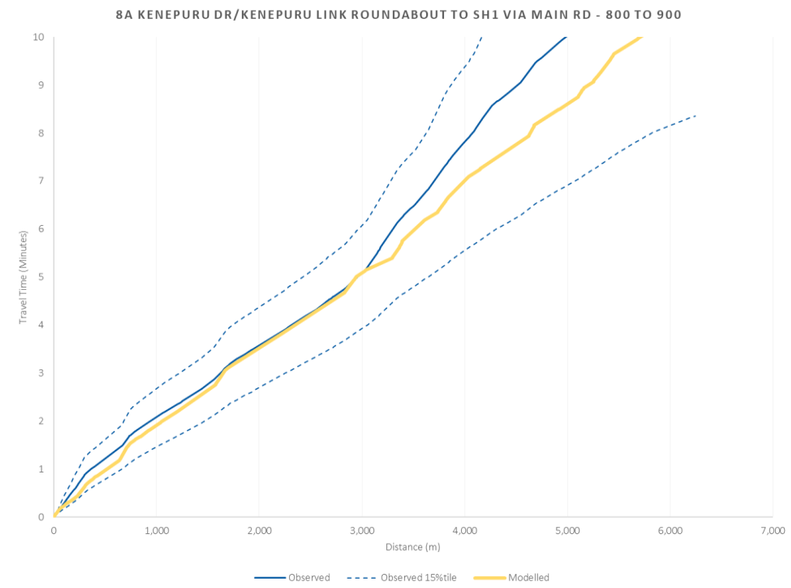


Figure D44: Journey time plot, R15: Kenepuru Dr/Kenepuru Link roundabout to SH1 via M inter peak hour

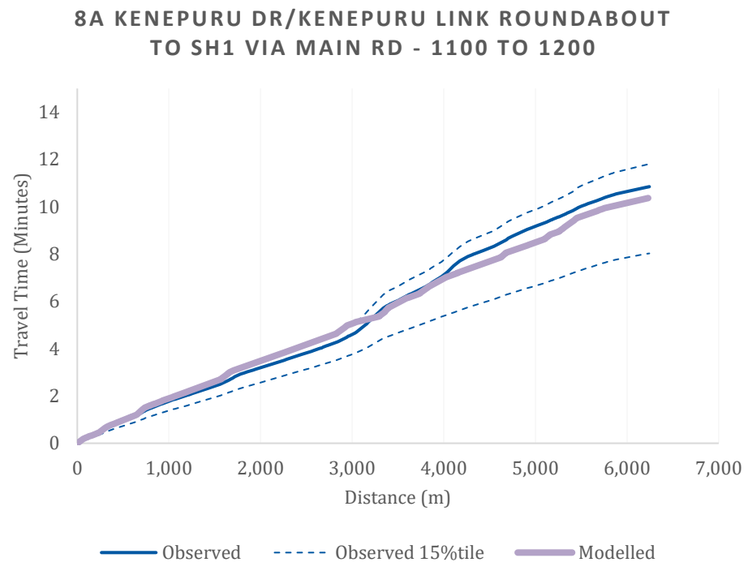


Figure D45: Journey time plot, R15: Kenepuru Dr/Kenepuru Link roundabout to SH1 via M evening peak hour

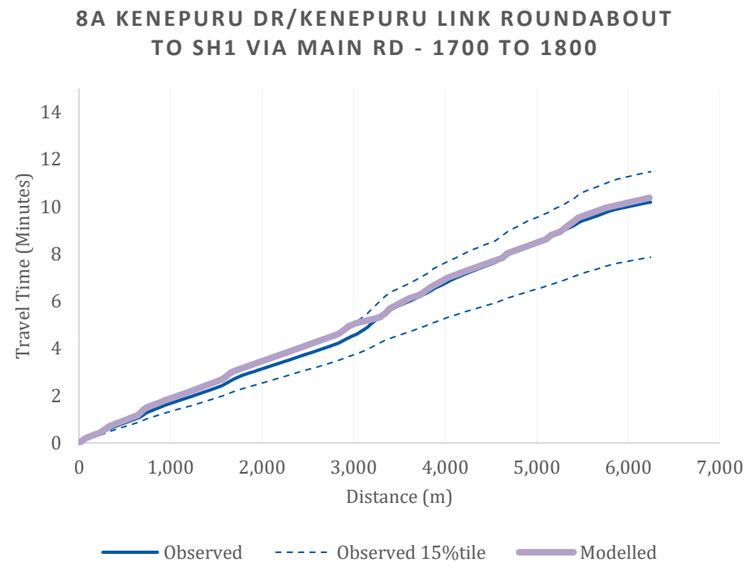


Figure D46: Journey time plot, R16: SH1 to Kenepuru Dr/Kenepuru Link roundabout via M morning peak hour

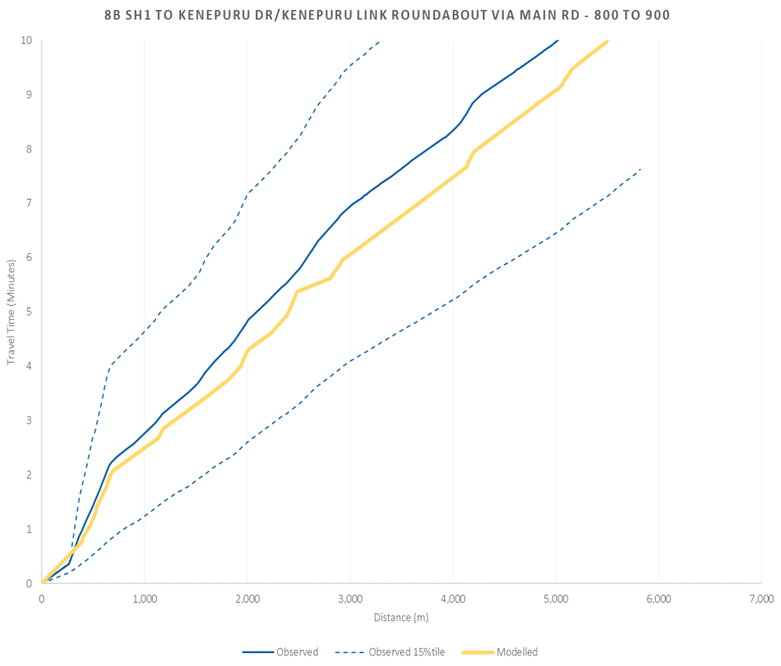


Figure D47: Journey time plot, R16: SH1 to Kenepuru Dr/Kenepuru Link roundabout via M inter peak hour

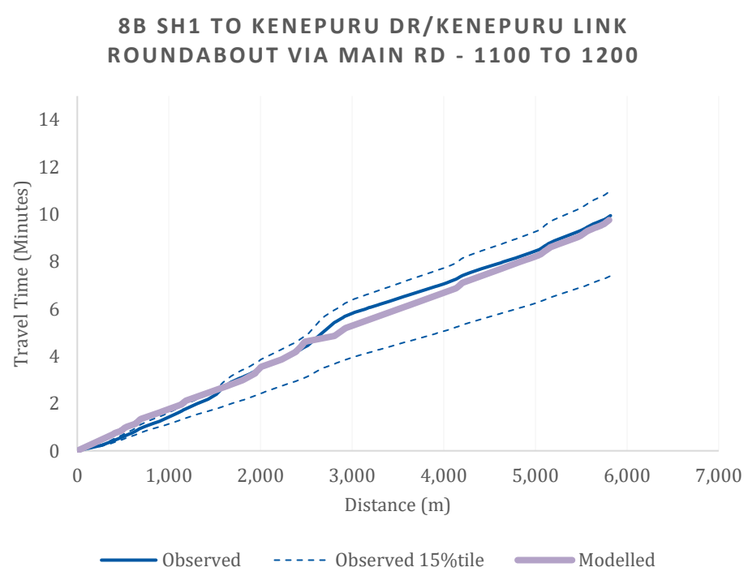


Figure D48: Journey time plot, R16: SH1 to Kenepuru Dr/Kenepuru Link roundabout via M evening peak hour

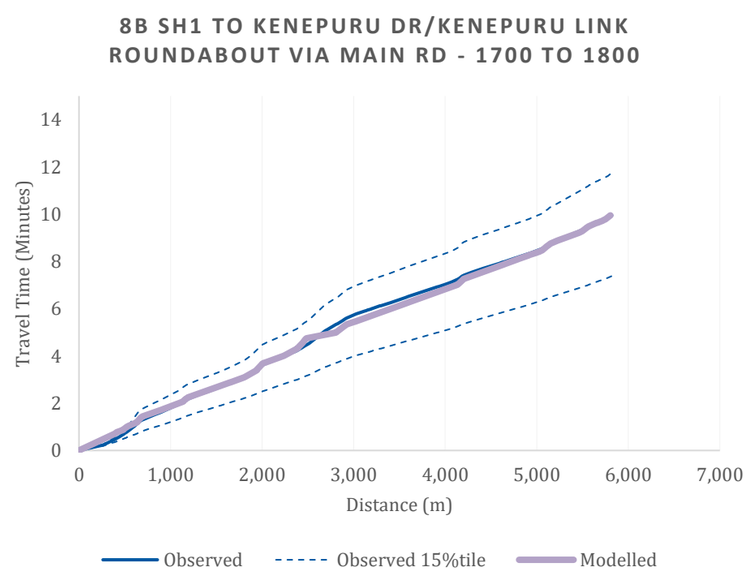


Figure D49: Journey time plot, R17: SH1 to SH59 via SH58 morning peak hour

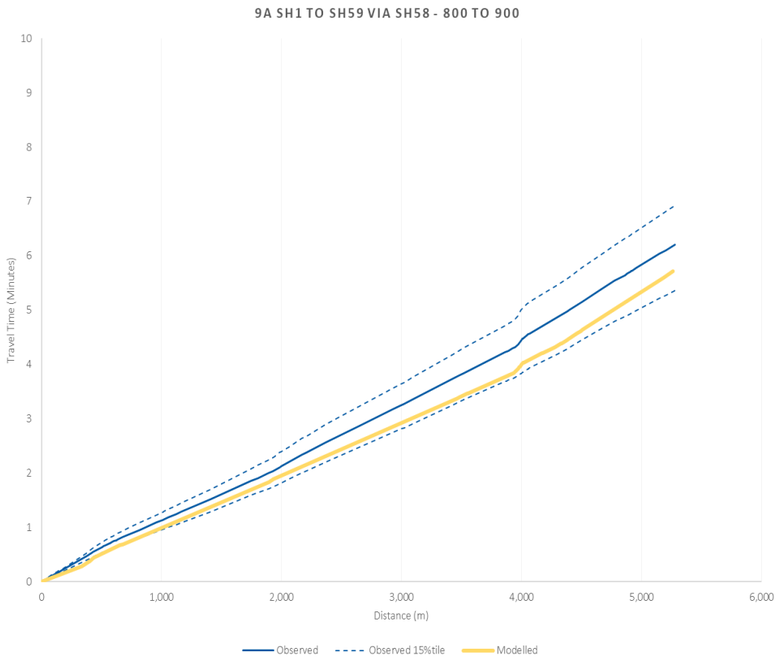


Figure D50: Journey time plot, R17: SH1 to SH59 via SH58 inter peak hour

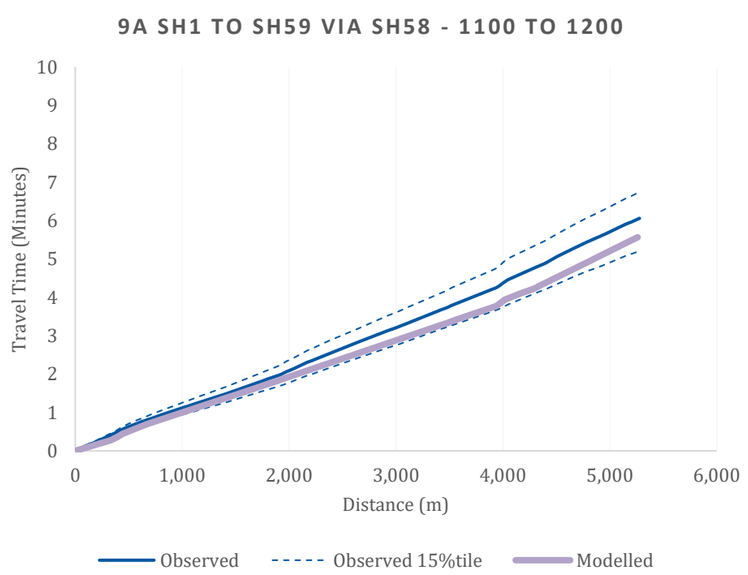


Figure D51: Journey time plot, R17: SH1 to SH59 via SH58 evening peak hour

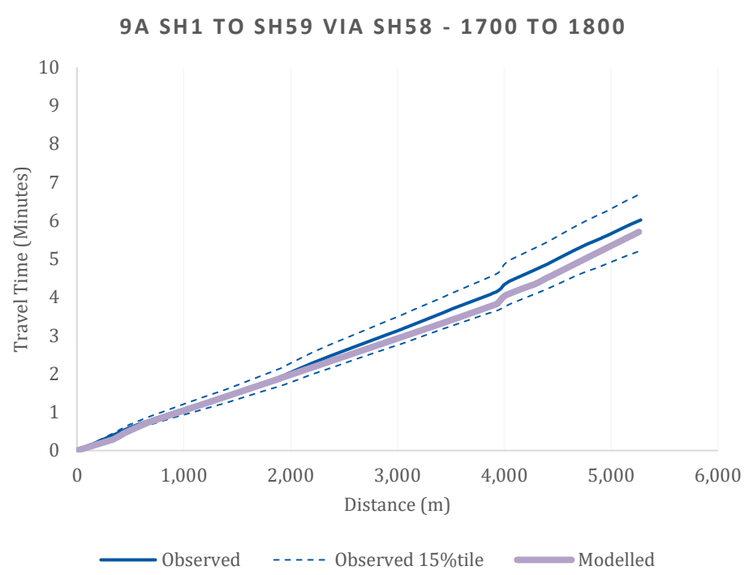


Figure D52: Journey time plot, R18: SH59 to SH1 via SH58 morning peak hour

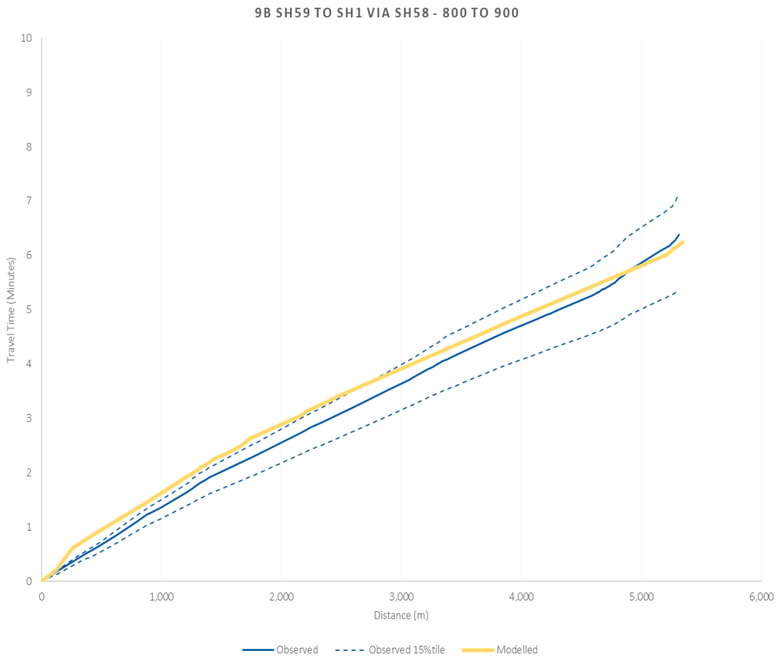


Figure D53: Journey time plot, R18: SH59 to SH1 via SH58 inter peak hour

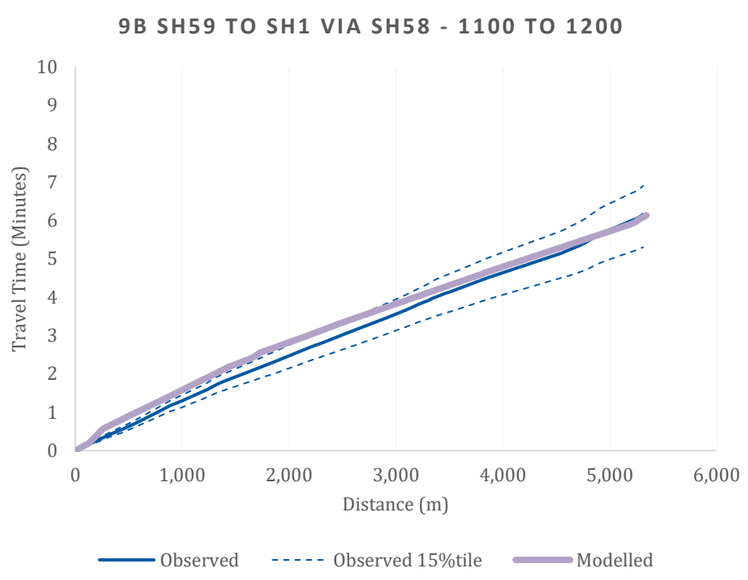


Figure D54: Journey time plot, R18: SH59 to SH1 via SH58 evening peak hour

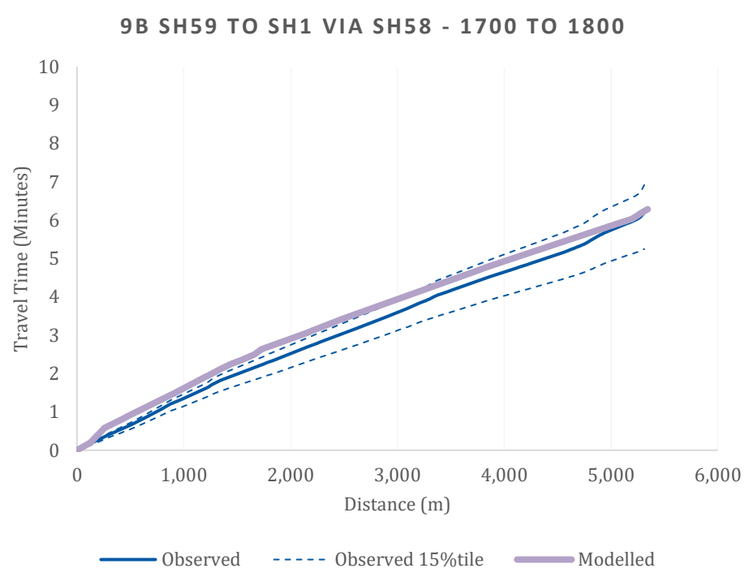


Figure D55: Journey time plot, R19: Paekakariki to SH58 morning peak hour

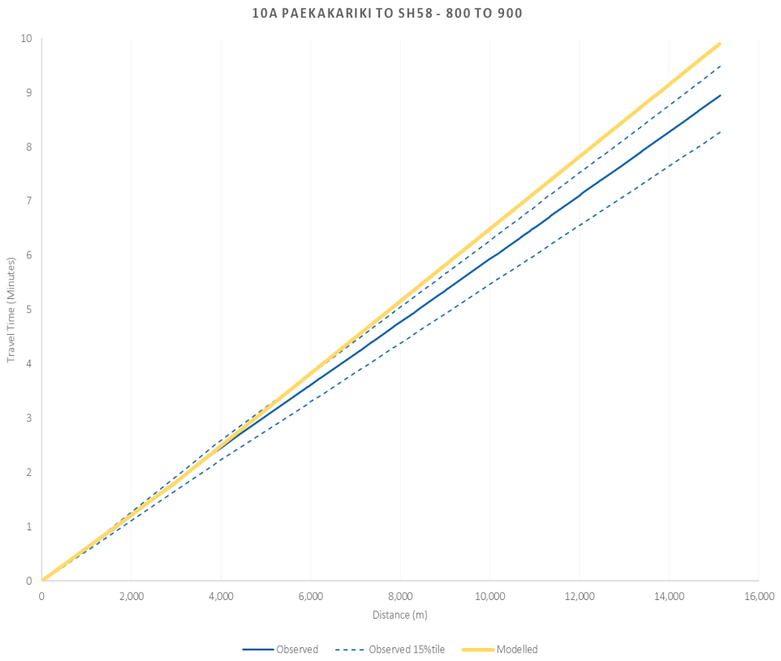


Figure D56: Journey time plot, R19: Paekakariki to SH58 inter peak hour

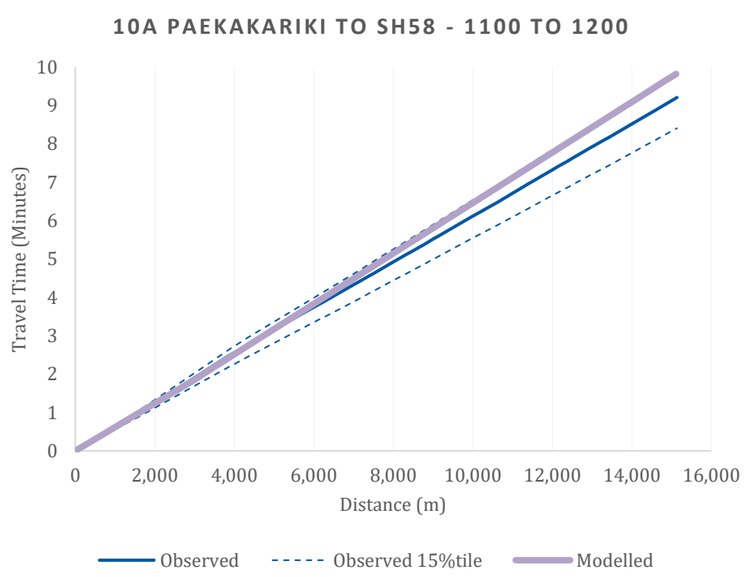


Figure D57: Journey time plot, R19: Paekakariki to SH58 evening peak hour

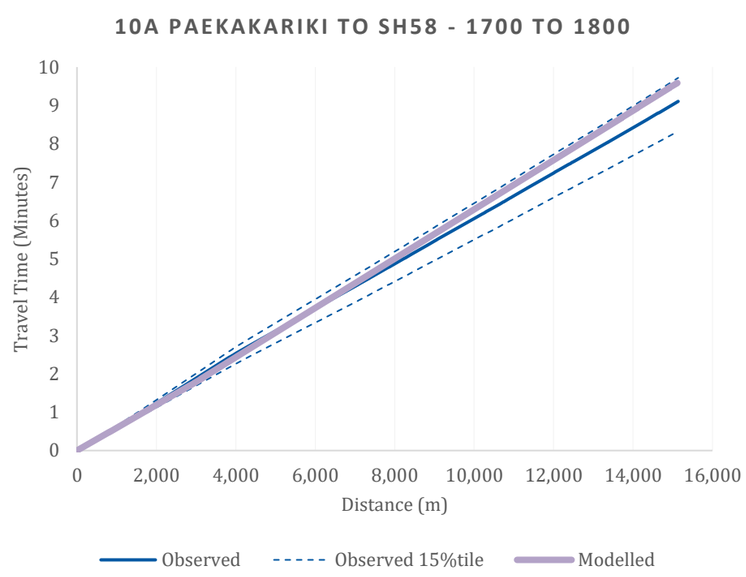


Figure D58: Journey time plot, R20: SH58 to Paekakariki morning peak hour

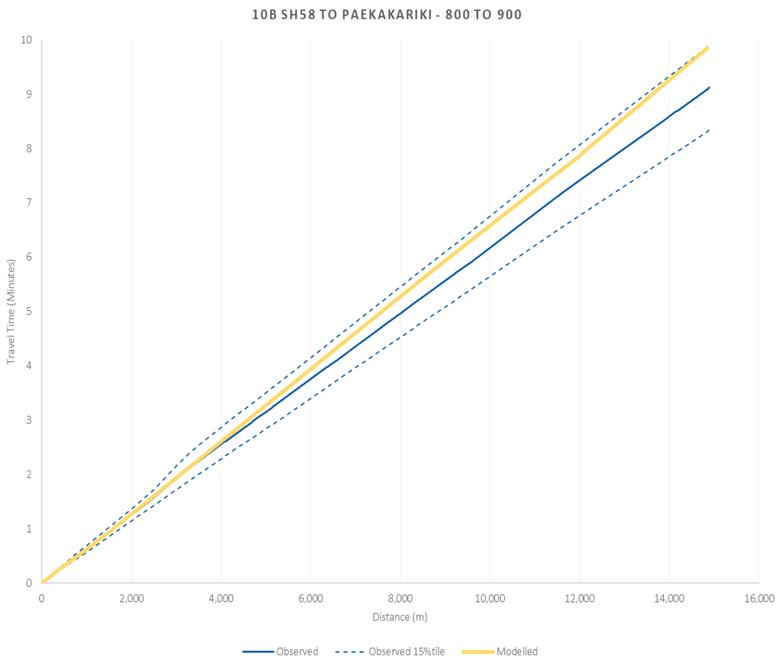


Figure D59: Journey time plot, R20: SH58 to Paekakariki inter peak hour

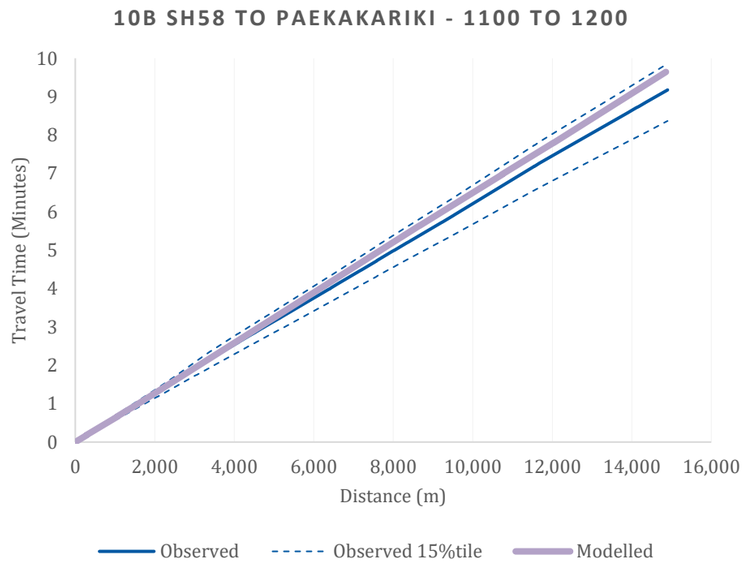


Figure D60: Journey time plot, R20: SH58 to Paekakariki evening peak hour

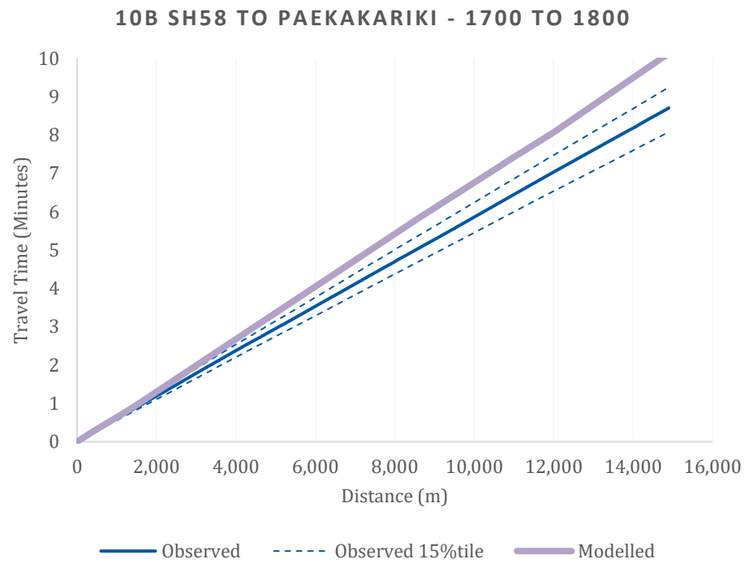


Figure D61: Journey time plot, R21: Paekakariki to SH58 via SH59 morning peak hour

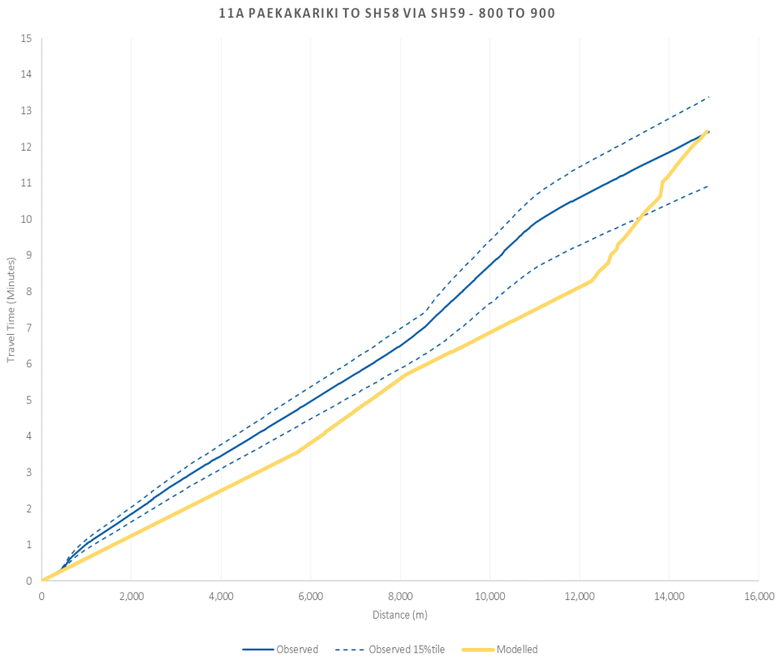


Figure D62: Journey time plot, R21: Paekakariki to SH58 via SH59 inter peak hour

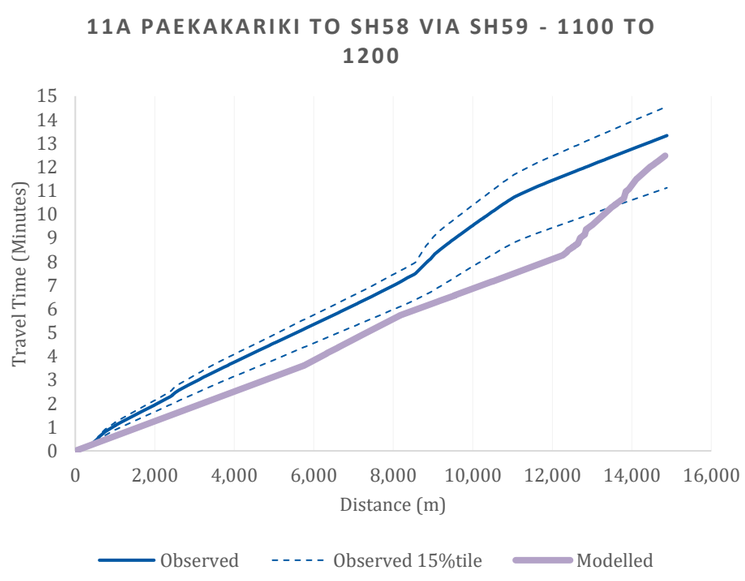


Figure D63: Journey time plot, R21: Paekakariki to SH58 via SH59 evening peak hour

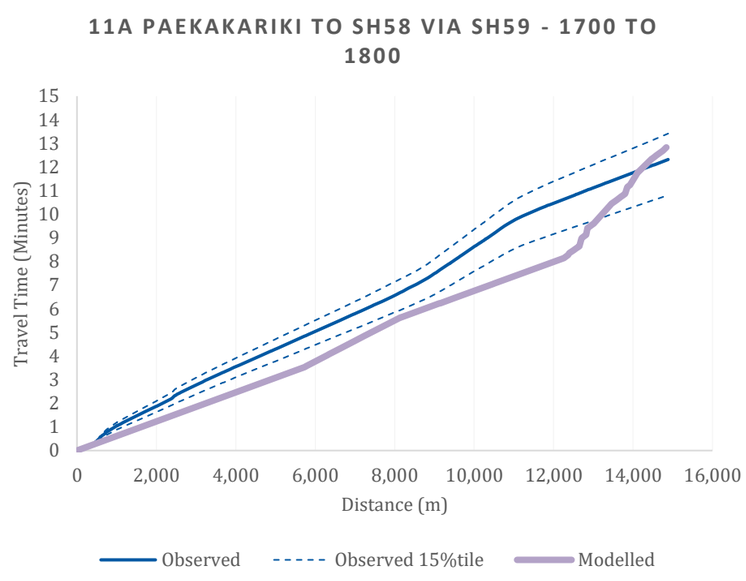


Figure D64: Journey time plot, R22: SH58 to Paekakariki via SH59 morning peak hour

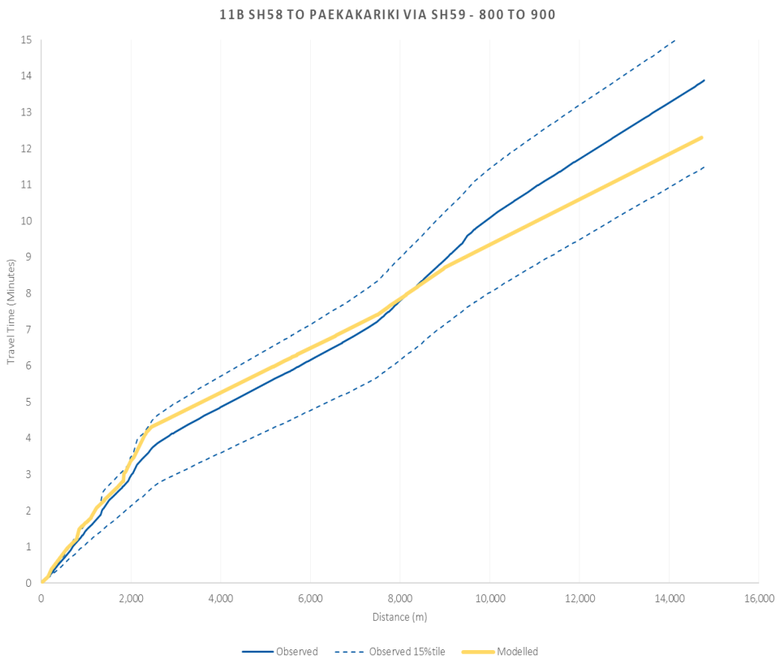


Figure D65: Journey time plot, R22: SH58 to Paekakariki via SH59 inter peak hour

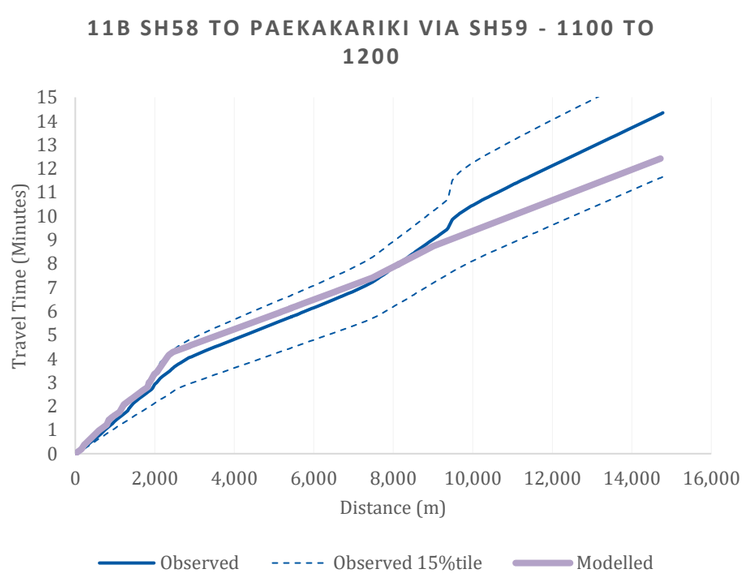


Figure D66: Journey time plot, R22: SH58 to Paekakariki via SH59 evening peak hour

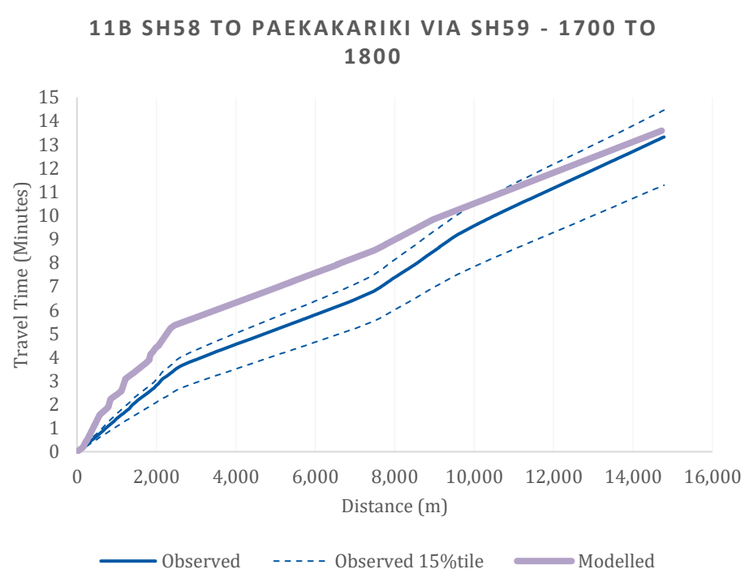


Figure D67: Journey time plot, R23: SH58 to Warspite Ave via Omapere St morning peak hour

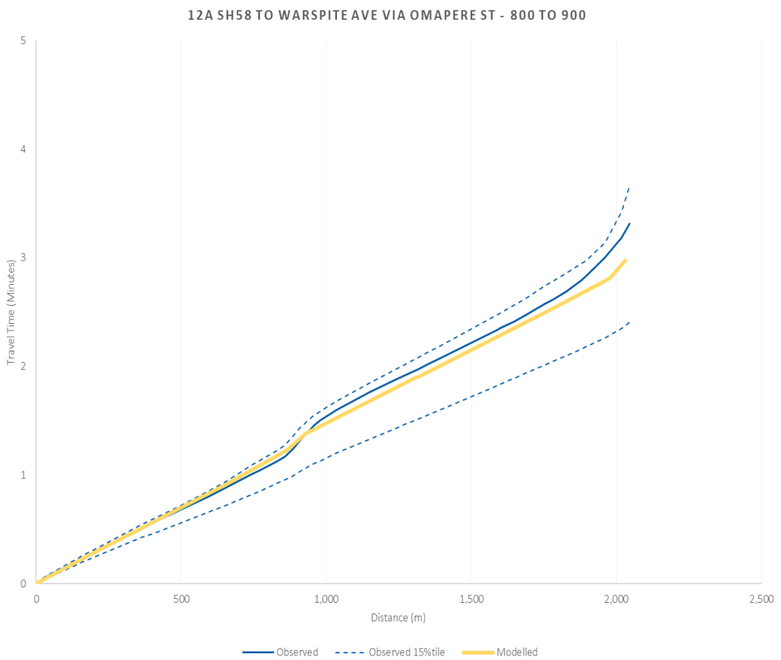


Figure D68: Journey time plot, R23: SH58 to Warspite Ave via Omapere St inter peak hour

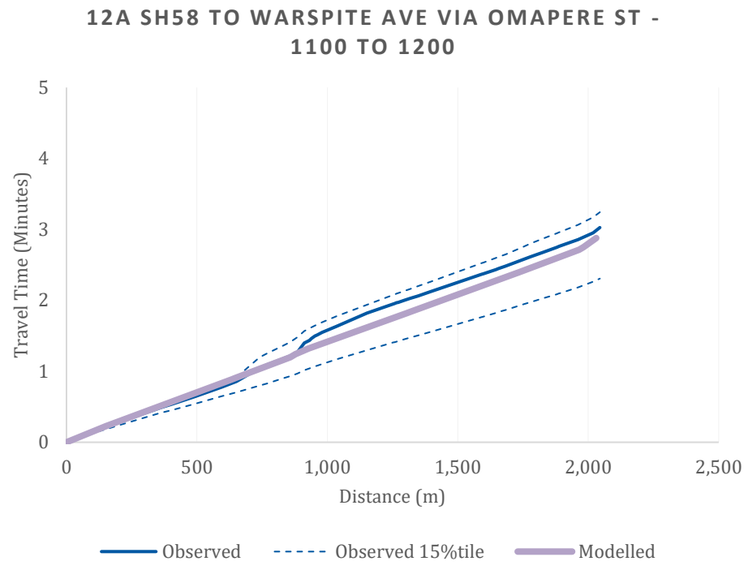


Figure D69: Journey time plot, R23: SH58 to Warspite Ave via Omapere St evening peak hour

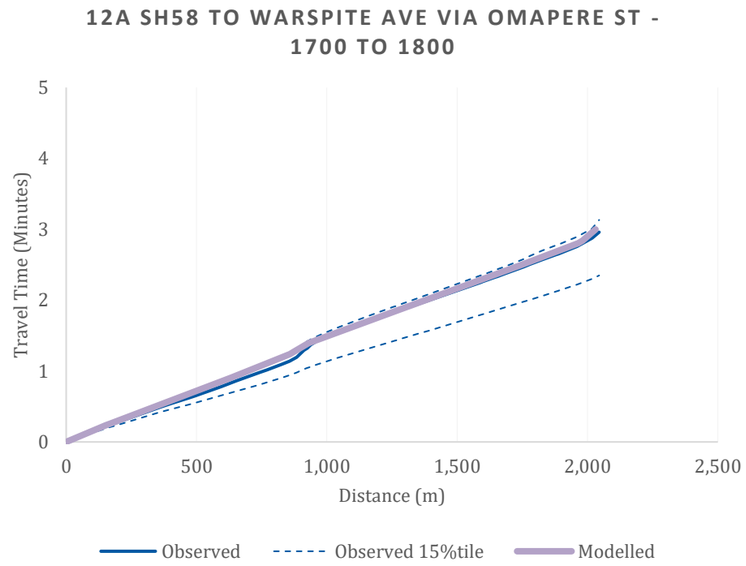


Figure D70: Journey time plot, R24: Warspite Ave to SH58 via Omapere St morning peak hour

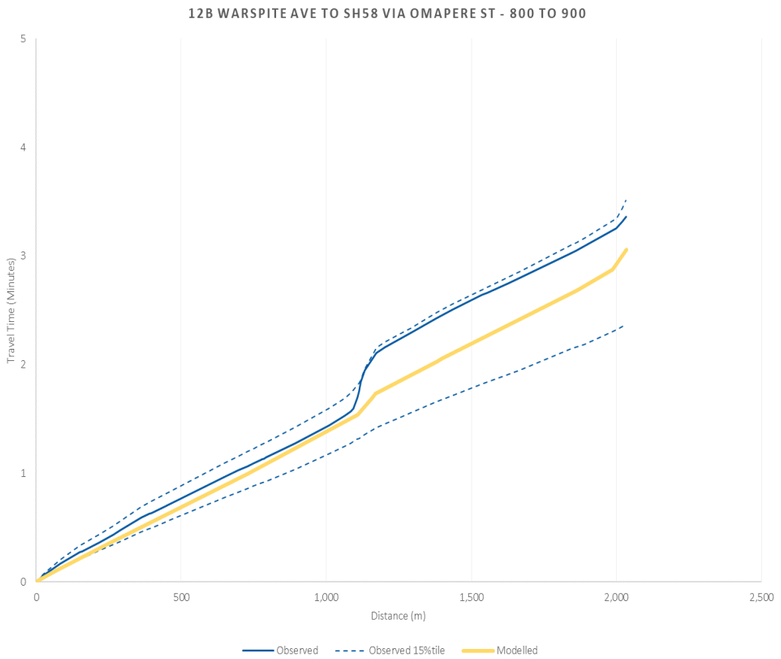


Figure D71: Journey time plot, R24: Warspite Ave to SH58 via Omapere St inter peak hour

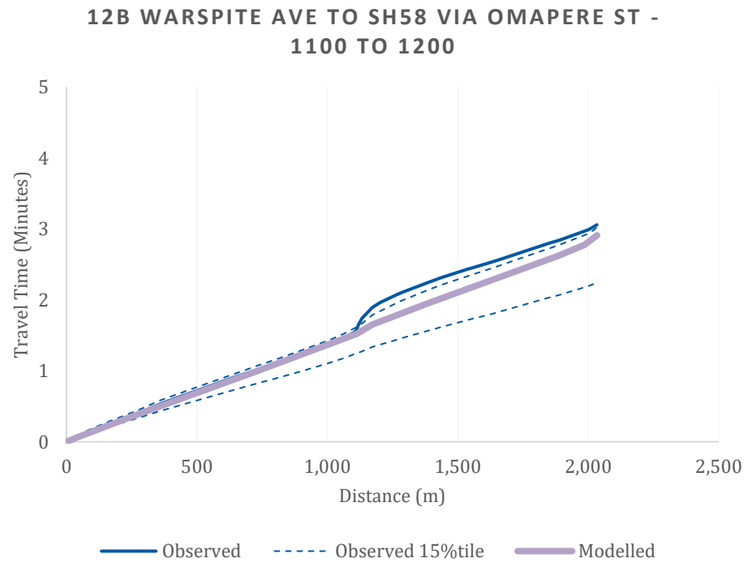


Figure D72: Journey time plot, R24: Warspite Ave to SH58 via Omapere St evening peak hour

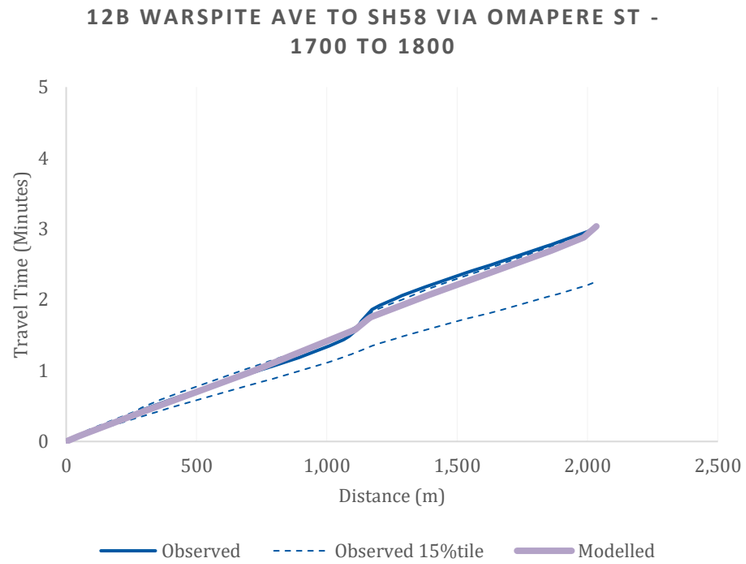


Figure D73: Journey time plot, R25: Parumoana St to Kenepuru Dr via Lyttelton Ave morning peak hour

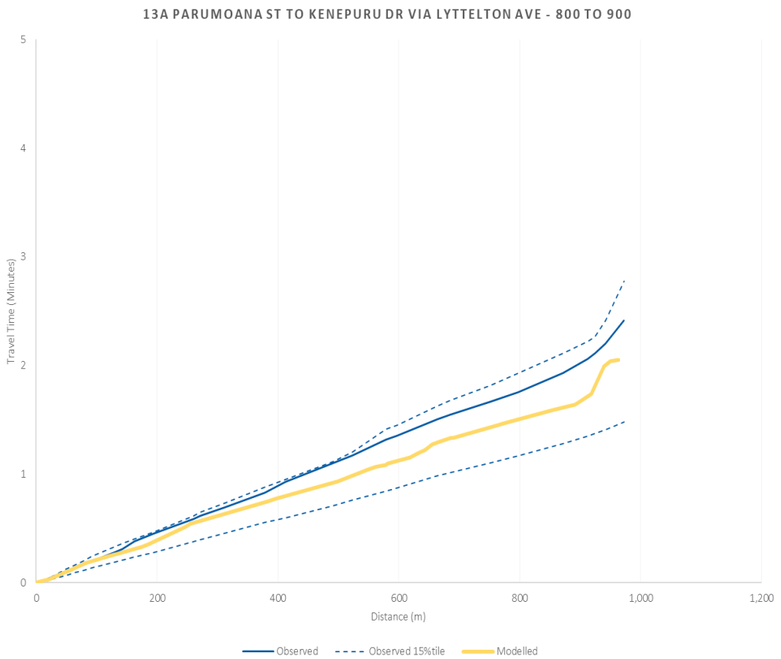


Figure D74: Journey time plot, R25: Parumoana St to Kenepuru Dr via Lyttelton Ave inter peak hour

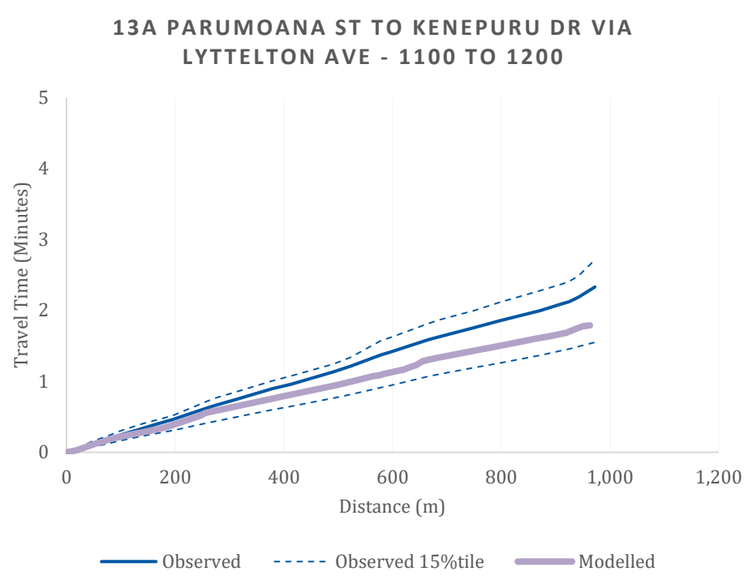


Figure D75: Journey time plot, R25: Parumoana St to Kenepuru Dr via Lyttelton Ave evening peak hour

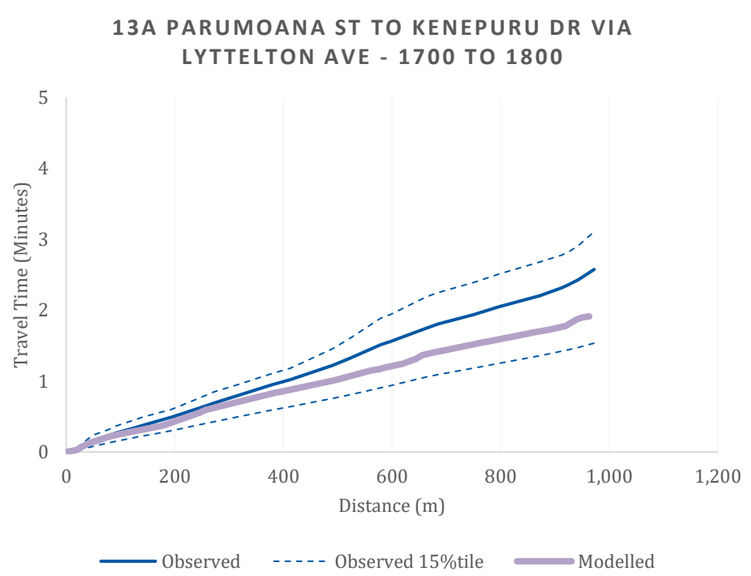


Figure D76: Journey time plot, R26: Kenepuru Dr to Parumoana St via Lyttelton Ave morning peak hour

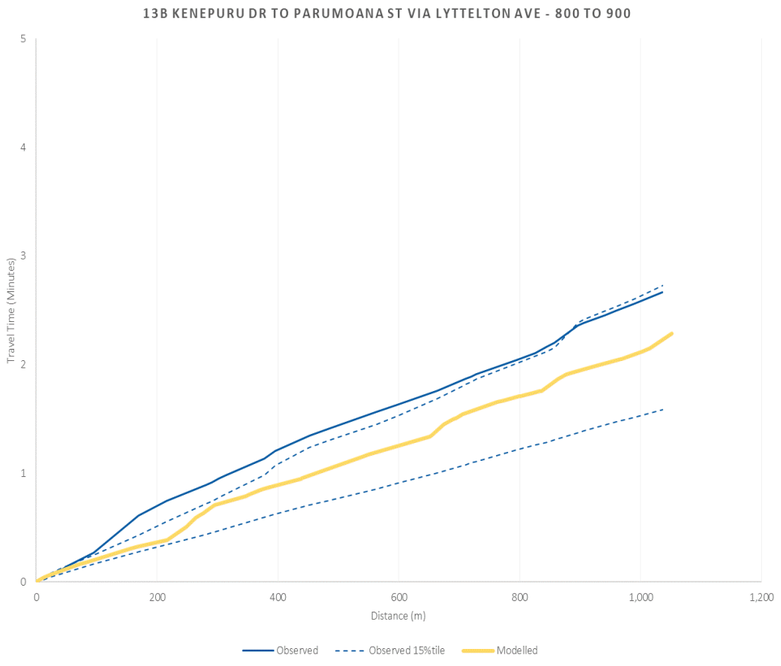


Figure D77: Journey time plot, R26: Kenepuru Dr to Parumoana St via Lyttelton Ave inter peak hour

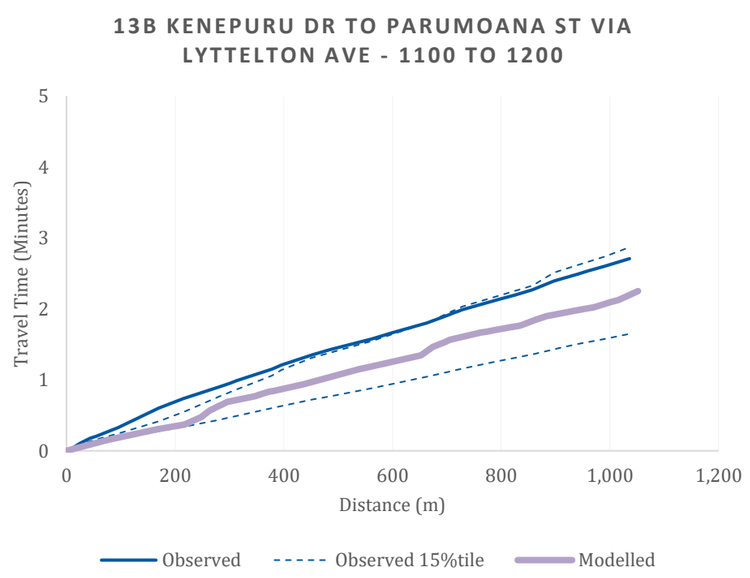


Figure D78: Journey time plot, R26: Kenepuru Dr to Parumoana St via Lyttelton Ave evening peak hour

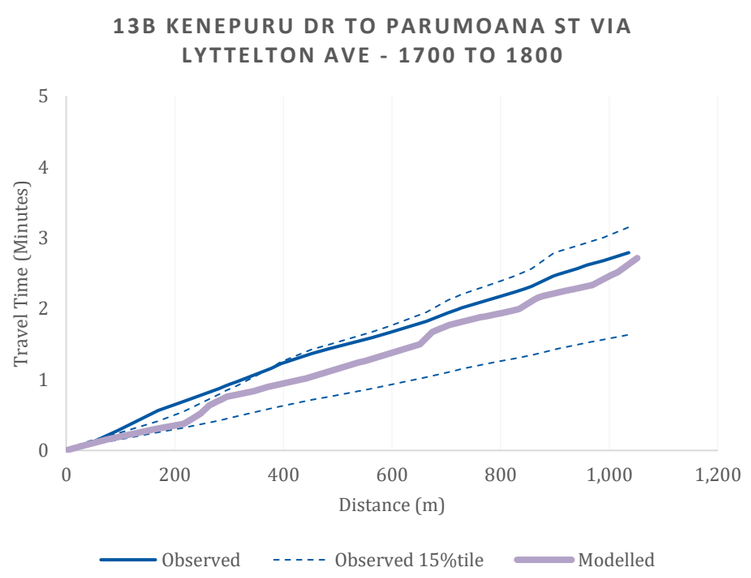


Figure D79: Journey time plot, R27: Te Pene Ave to Takapu Rd via Titahi Bay Rd-SH1 morning peak hour

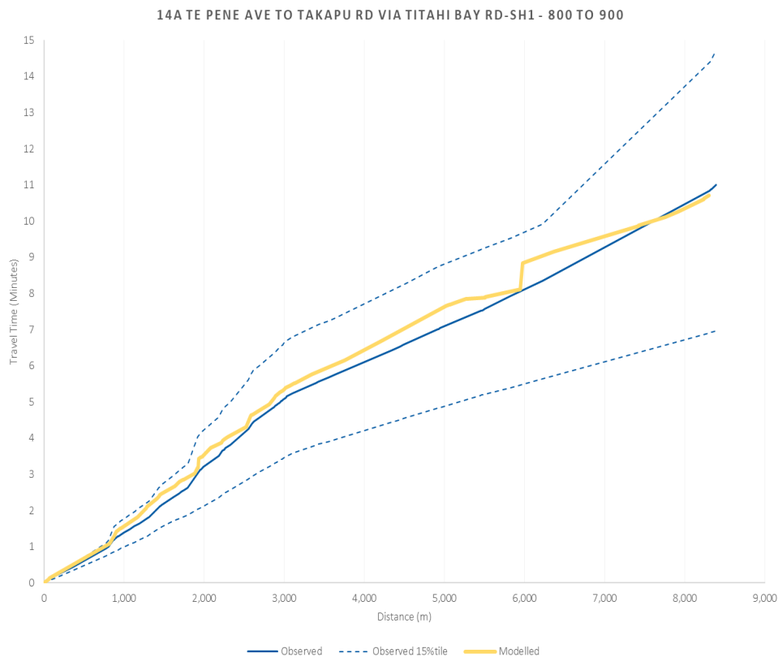


Figure D80: Journey time plot, R27: Te Pene Ave to Takapu Rd via Titahi Bay Rd-SH1 inter peak hour

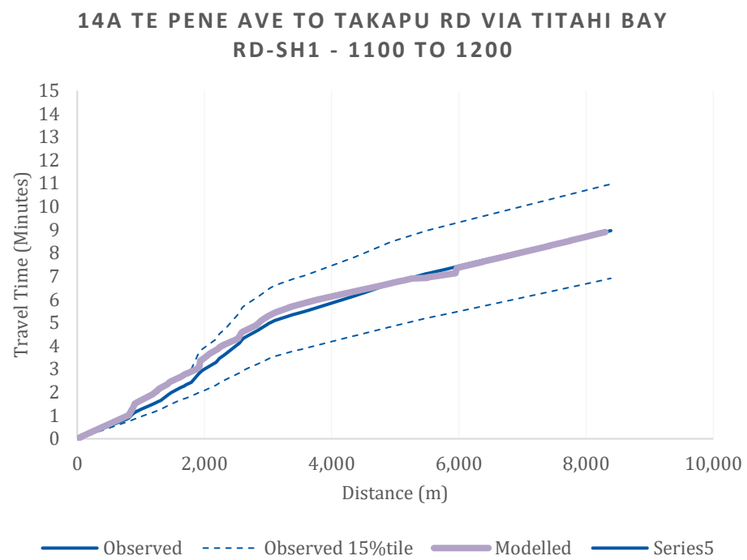


Figure D81: Journey time plot, R27: Te Pene Ave to Takapu Rd via Titahi Bay Rd-SH1 evening peak hour

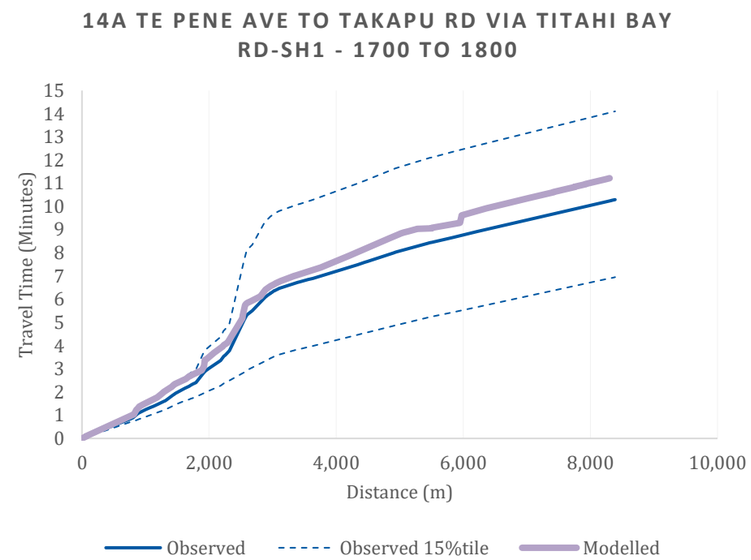


Figure D82: Journey time plot, R28: Takapu Rd to Te Pene Ave via Titahi Bay Rd-SH1 morning peak hour

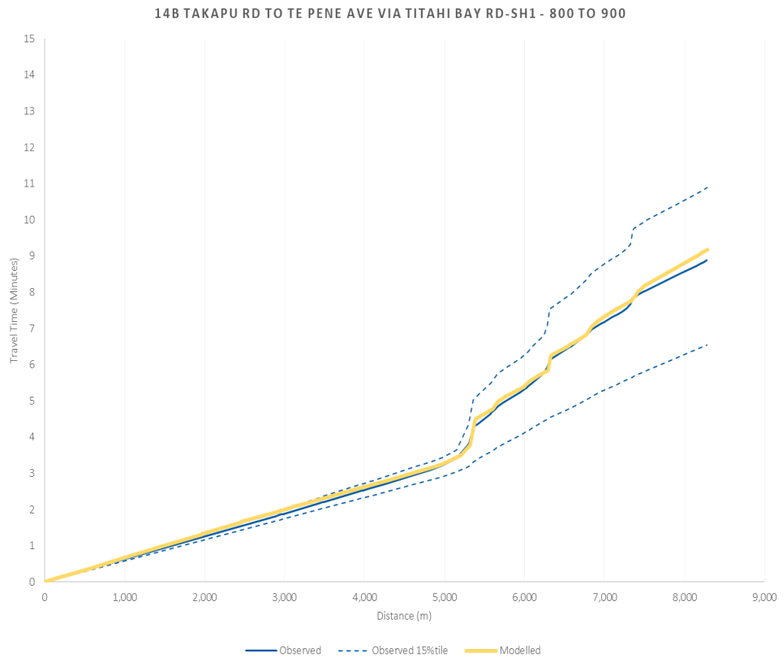


Figure D83: Journey time plot, R28: Takapu Rd to Te Pene Ave via Titahi Bay Rd-SH1 inter peak hour

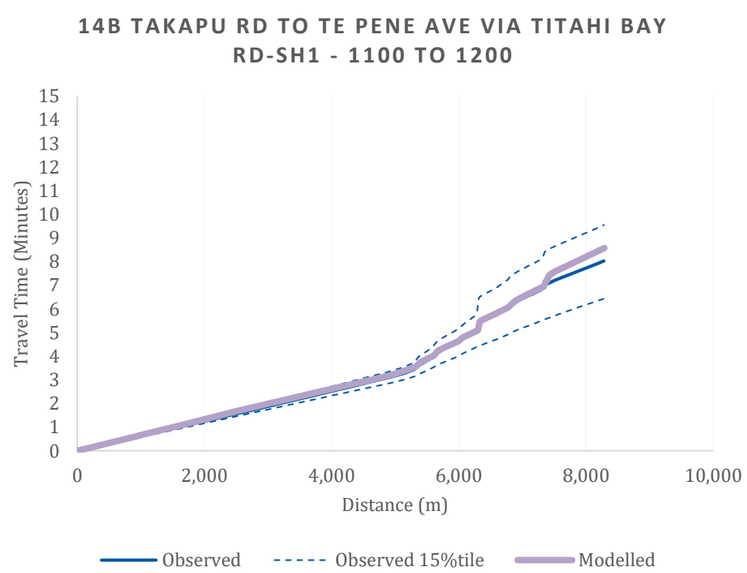


Figure D84: Journey time plot, R28: Takapu Rd to Te Pene Ave via Titahi Bay Rd-SH1 evening peak hour

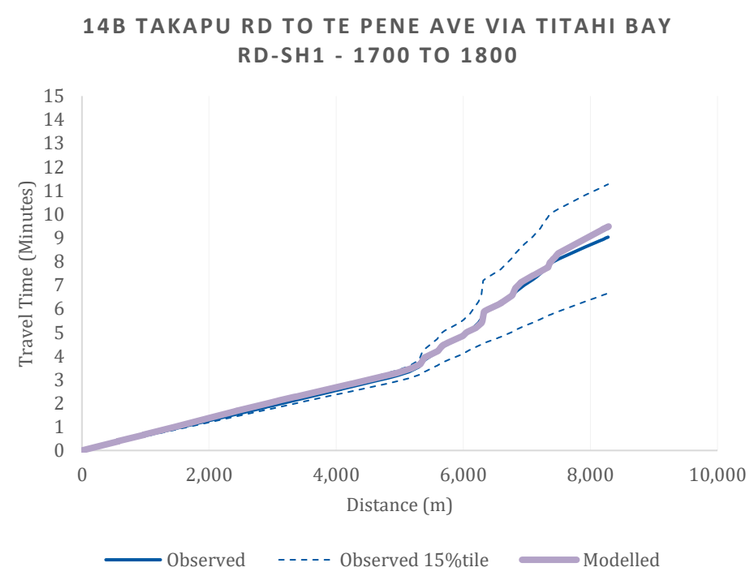


Figure D85: Journey time plot, R29: SH58 to SH59 via SH1 morning peak hour

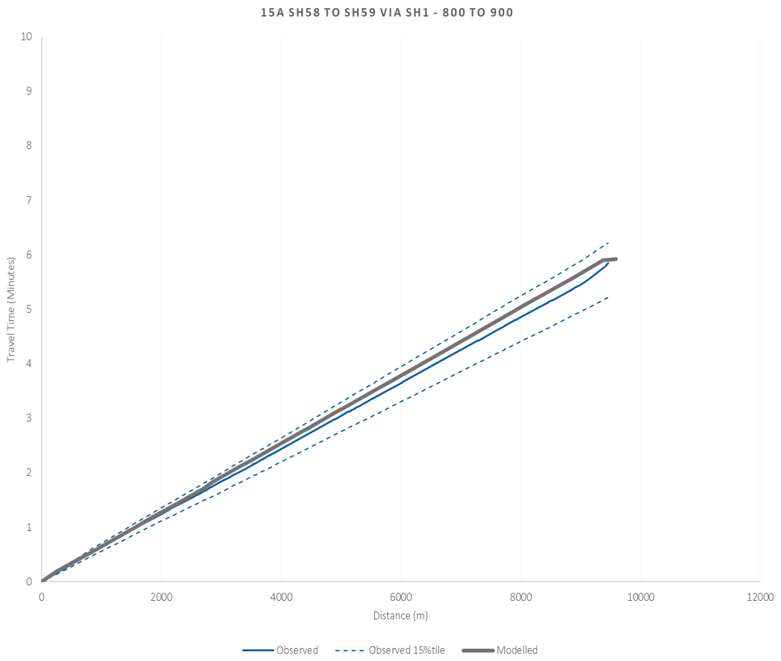


Figure D86: Journey time plot, R29: SH58 to SH59 via SH1 inter peak hour

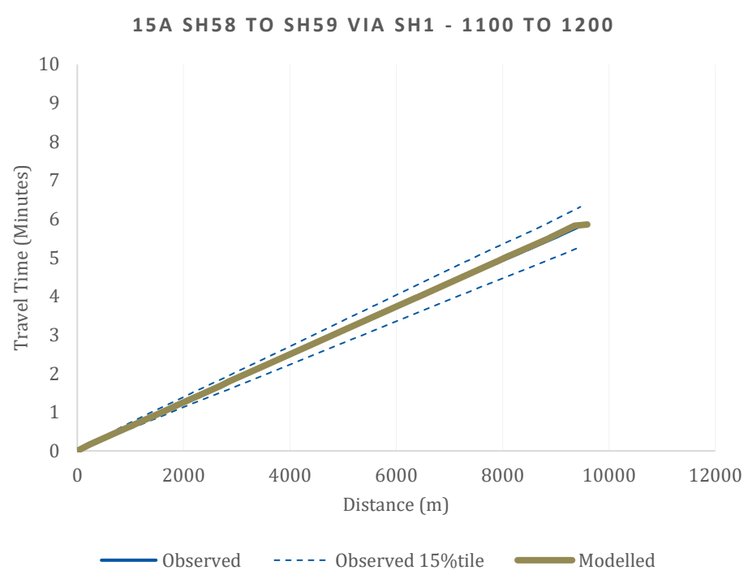


Figure D87: Journey time plot, R29: SH58 to SH59 via SH1 evening peak hour

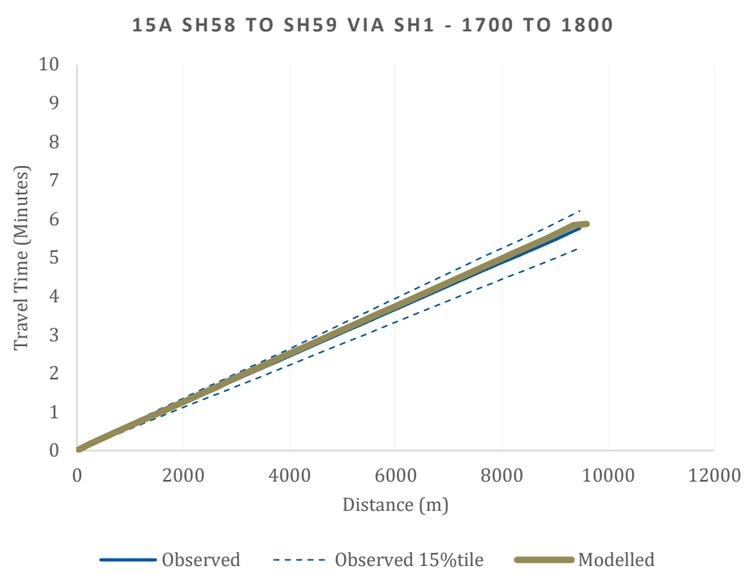


Figure D88: Journey time plot, R30: SH59 to SH58 via SH1 morning peak hour

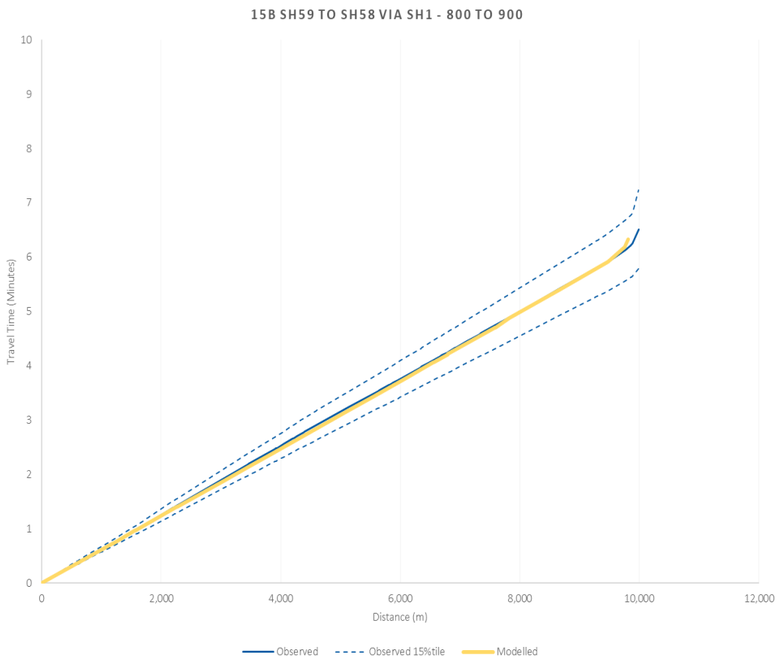


Figure D89: Journey time plot, R30: SH59 to SH58 via SH1 inter peak hour

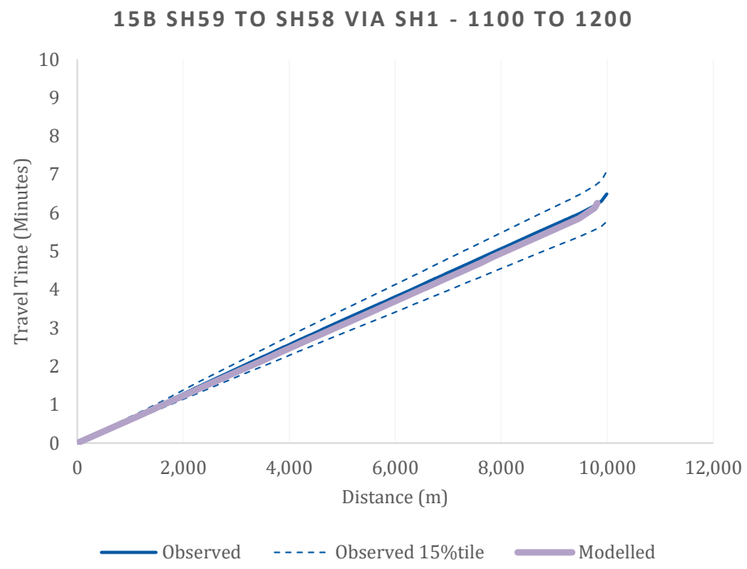


Figure D90: Journey time plot, R30: SH59 to SH58 via SH1 evening peak hour

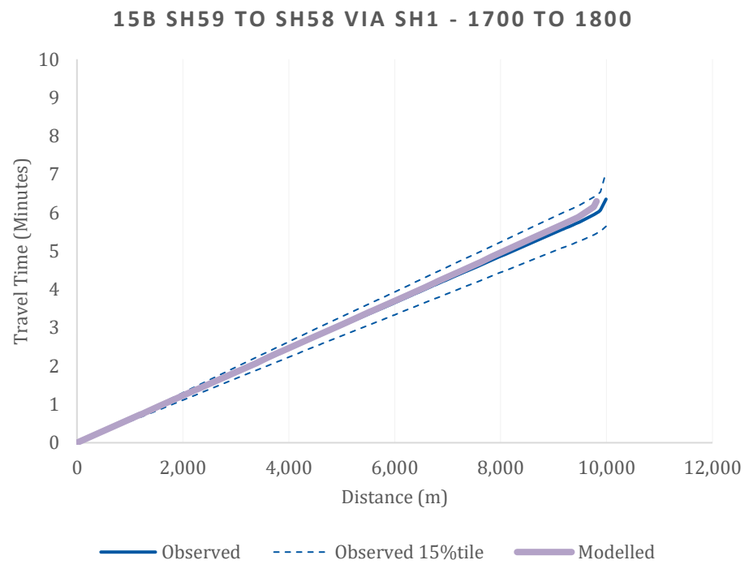


Figure D91: Journey time plot, R31: Warspite Ave to TG via Waitangirua Link Rd morning peak hour

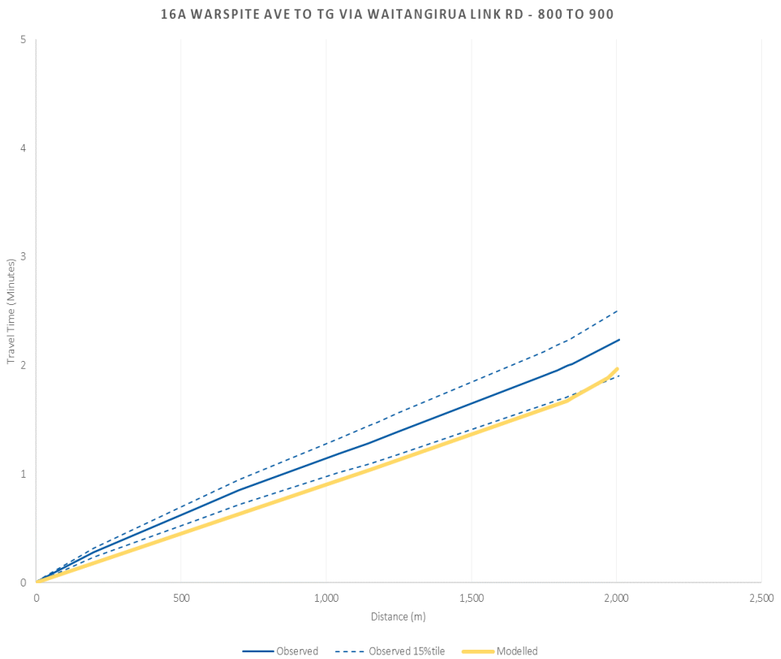


Figure D92: Journey time plot, R31: Warspite Ave to TG via Waitangirua Link Rd inter peak hour

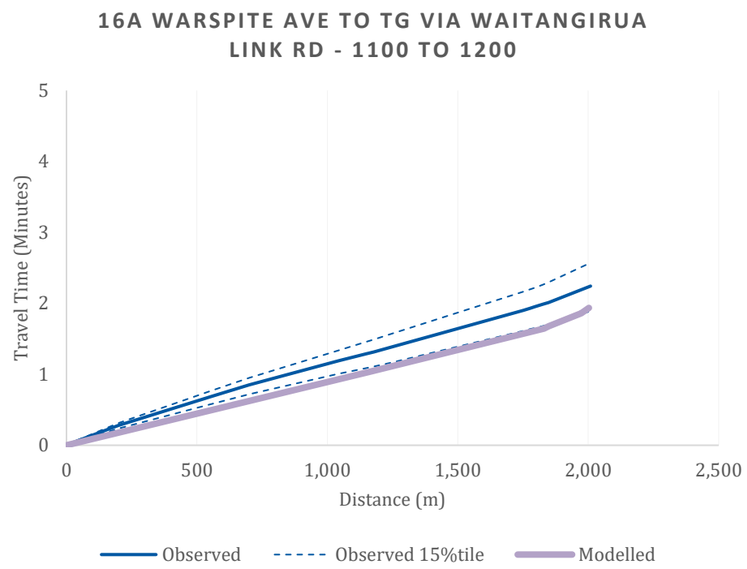


Figure D93: Journey time plot, R31: Warspite Ave to TG via Waitangirua Link Rd evening peak hour

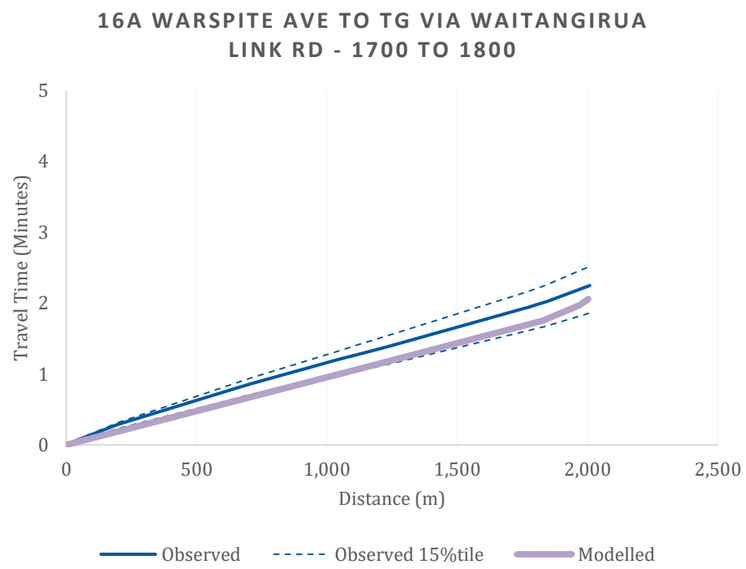


Figure D94: Journey time plot, R32: TG to Warspite Avevia Waitangirua Link Rd morning peak hour

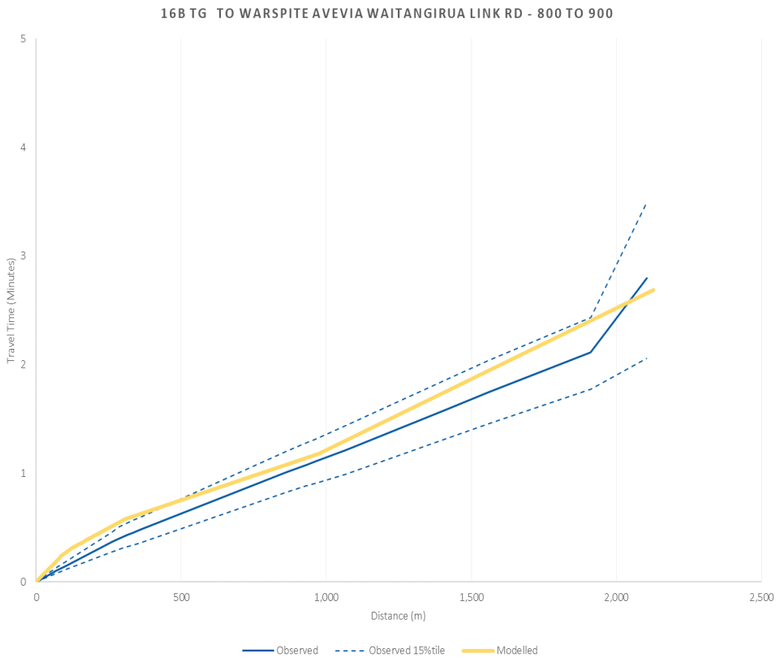


Figure D95: Journey time plot, R32: TG to Warspite Avevia Waitangirua Link Rd inter peak hour

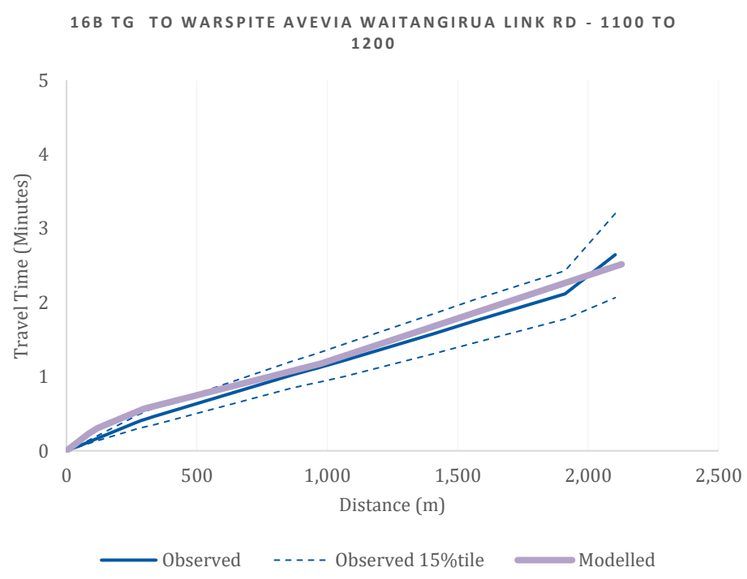


Figure D96: Journey time plot, R32: TG to Warspite Avevia Waitangirua Link Rd evening peak hour