TN16 - WELLINGTON TRANSPORT ANALYTICAL TOOLS 2019-21 UPDATE - 2018 INTERIM WTSM VALIDATION

PREPARED FOR GREATER WELLINGTON REGIONAL COUNCIL

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Greater Wellington Regional Council

TN16 - Wellington Transport Analytical Tools 2019-21 update - 2018 iNTERIM wtsm vALIDATION

CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. Introduction

1.1 Project Overview

This technical note is part of a series documenting the 2019-2021 update of components of the Wellington Regional Transportation Planning Analytical Tools ("Analytical Tools", "Tools"). The higher-level Analytical Tools are maintained and operated by Greater Wellington Regional Council (GWRC), who are the client for this project. This project is being primarily delivered by Stantec and Jacobs, supported by GWRC transport planners.

1.2 Purpose of this Report

This report summarises the changes implemented in the Wellington Transport Strategy Model (WTSM) to produce an interim 2018 version during the first stage of the project, and details the validation of the model to March 2018 conditions.

It is organised into the following sections:

- Summary of the changes implemented in the interim version and their impact on demand
- Light vehicles validation
- Heavy vehicles validation
- Public transport validation
- Conclusion

As detailed throughout this note, validation for the 2018 interim WTSM was found to be generally poor and did not achieve the validation targets for this category of model.

It must be noted that the WTSM will be entirely rebuilt as part of Stage 2 of this project. Given the timing and status of projects that apply WTSM, it is no longer anticipated that this interim 2018 version of WTSM will be used on project work, with GWRC indicating that the current 2013 version likely to still be used until the new, fully rebuilt strategic model is developed. Therefore no further attempts were made to improve on these results and they are presented here for reference.

2. Description of 2018 Interim WTSM

2.1 Background

The current version of the WTSM was built during the 2001-2003 period, based on 2001 Household Travel Survey and census data. It was subsequently updated after the 2006 and 2013 censuses (another update was carried out in 2011 based on land use estimates, due to the 2011 census being postponed to 2013 following the Canterbury Earthquakes).

As part of Stage 2 of this project, the model will be completely redeveloped based on 2018 land use data and a new Household Travel Survey. Stage 1 however delivered a number of incremental improvements to the current model, some of which were needed for and used on specific project work and others that will be carried over to the new version of the model. These improvements and updated components were included in an interim 2018 version of WTSM, which was initially planned to be used while the new version was being developed.

The changes made to the 2013 WTSM leading to this interim 2018 version have been documented in a series of Technical Notes and are as follows:

- Land use input into the model was updated to 2018 based on census data (see TN12 – Data Analysis – Land Use)
- New modules were added to represent car and public transport trips associated with Wellington Airport (TN10 – Airport Model) and car trips associated with the Interislander and Bluebridge ferry terminals (TN14 – Ferry Terminals Model)

- The freight heavy vehicle model was updated using 2018 fleet GPS data (TN11 – Heavy Vehicle Model Update)
- New processes were implemented in the modelling of access to rail including park-and-ride to allow representing the impact of traffic congestion or parking costs on rail demand (TN13 – Park-and-Ride)
- The representation of parking in Wellington CBD was improved to better reflect parking charges and time between parked vehicles and origin/destination (TN7 – Parking updates)
- Adjustments were made to trips within the Wellington CBD to address a known issue with the model, with too many short car trips occurring in this area (TN 8 – CBD Short trips adjustments)
- Economic input parameters such as vehicle operating costs, values of times, PT fares, and CBD parking charges were updated to 2018 (TN9 – Model Input Parameters)
- Representation of delays on the network was improved at strategic locations, especially at and near merges on the State Highway network (TN7 – Improved delay representation)

In addition to these delay representation improvements, the WTSM networks were updated to 2018 as follows:

- The road network was updated to reflect changes that have occurred since 2013, with the most notable changes being the Kapiti Expressway and the Arras Tunnel
- PT networks were updated based on the 2019 General Transit Feed Specification (GTFS) data. 2019 data was used to represent the post Public Transport Operational Model (PTOM) network and services, as using 2018 data would have led to the model being out-of-date compared to current networks (see Section 4 in 'TN15 – WTPM Update' for more detail)
- Coding of the network was fine-tuned at some locations including motorway interchanges, and a number of coding errors were rectified, including a few cases of erroneous link distances

Finally, data for a wide array of metrics were collated and processed, to feed into the model update and provide observed patterns for the model validation. This data collection and analysis exercise is described in 'TN4 – Data Analysis'.

2.2 Incremental Impact on Results

In order to understand the respective effect of all these changes, their incremental impact on a few selected high-level metrics were assessed. Each change has been implemented one at a time, with some additional intermediate steps to provide more detail:

- New park-and-ride calculations
- New networks (both road and PT)
- Demographic increase, i.e. population per zone factored up to 2018 (7.5% increase regionally) but with no change in distribution per category of person type, household type, and employment category
- New land use distribution per category of person, household and employment (this was separated from the previous step in order to understand the respective impact of population increase vs changes in population categories)
- Updated car ownership
- New airport and ferry terminal models
- CBD trip adjustments to reduce amount of short car trips
- Updated freight model
- Updated PT fares to 2018
- Updated vehicle operating costs (VOC) to 2018
- Updated values of times (VoT) to 2018

- Updated Wellington CBD parking costs to 2018. This step is essentially superseded by the following steps which leads to new calculations of CBD parking costs, but it is presented here for completeness
- New CBD parking calculations, with improved representation of parking costs and terminal times

The last of these incremental steps essentially leads to the final 2018 Interim WTSM. Resulting impacts on the number of car trips, light vehicle-kilometres, bus boardings and rail boardings for the AM peak period are shown in the following figure, all indexed to the 2013 WTSM results.

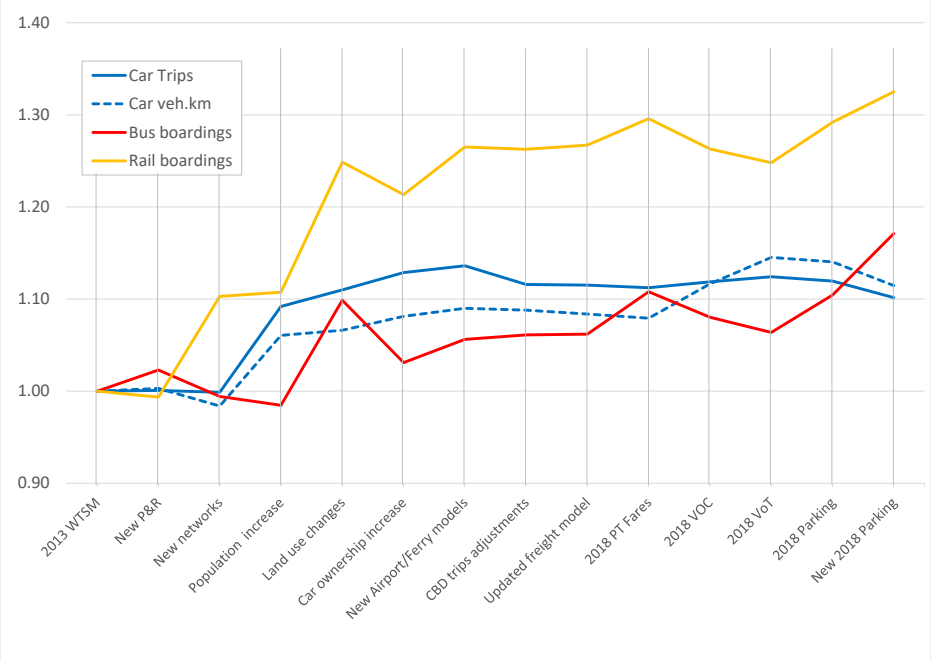

Figure 2-1: AM Peak Incremental Changes, Indexed to WTSM 2013

Results are mostly as expected, in terms of their impact on overall demand and on modal share. The cumulative impact of these changes however leads to a faster increase in public transport than car use, especially for rail. The following observations can however be made:

- The changes to road and PT networks leads to a large increase (about 10%) in rail boardings. This is caused by the improvements on the rail network since 2013 (faster travel times and higher frequencies) but also by the new vehicle delay functions and erroneous distances on the road network having been corrected which affect the balance of rail vs bus or car generalised costs. Particularly, demand on the Johnsonville line increases strongly, as it always tends to be the corridor most susceptible to shift between rail and bus and is the most impacted with the majority of these network changes being located along this corridor.
- In terms of changes to the land use input into WTSM, population increase leads to a rise in car trips but has little impact on PT demand, likely due to most of the increase occurring in areas less serviced by PT. However, the opposite occurs once accounting for changes in population type (people and household categories, employment types), which leads to a strong increase in PT trips, especially rail.
- The impact of updating each economic parameter appears sensible and generally moderate, however the new parking generalised cost calculations further push up the share of public transport.

The cumulated impact of these changes is that, although private vehicle trips increase largely in line with population increase, public transport and especially rail experience a much higher growth.

3. Light Vehicle Validation

Assigned volumes for light vehicles (cars and light commercial vehicles) were compared against traffic counts, looking both at individual counts and at total demand across a number of screenlines. The

location of traffic counts and screenlines are shown in Figure 3-1 and Figure 3-2. The additional screenlines developed for the model rebuild are not reported for consistency with the 2013 and previous updates.

Traffic volume validation uses the difference between observed and modelled volumes, as well as the GEH statistical values, a standard empirical measure used to compare modelled flows against observed traffic counts.

The Waka Kotahi Economic Evaluation Manual (EEM) stated that:

- At least 60% of individual link flows should have GEH less than 5.0
- At least 95% of individual link flows should have GEH less than 10.0
- 100% of individual link flows should have GEH of less than 12.0
- Screenline flows should have GEH of less than 4.0 in most cases

These targets are designed for mesoscopic traffic models rather than multi-modal strategic transport models such as WTSM for which more lee-way is generally afforded, but they can nevertheless be used as guidelines.

Since the development of WTSM, a more comprehensive Transport Model Development Guidelines (TMDG) manual has been introduced by Waka Kotahi that provides validation guidelines for different types of model and by project application. In these guidelines, the WTSM is a "Type A" regional transport model. The criteria and validation targets specified in the TMDG are:

- At least 65% of individual link counts should have a GEH less than 5.0
- At least 75% of individual link counts should have a GEH less than 7.5
- At least 85% of individual link counts should have a GEH less than 10.0
- At least 95% of individual link counts should have a GEH less than 12.0
- Screenlines should have a GEH of less than 5.0 for 60% or more of screenlines.

These criteria and targets for regional models are very similar to the EEM equivalents, which have historically been applied to the WTSM although the pass/fail criteria have sensibly been generally relaxed slightly to reflect the expectations for a strategic model's performance.

Ultimately, the criteria used for validation of vehicle volumes across the network was the same as for previous updates, using GEH threshold of 5.0, 10.0 and 12.0, enabling direct comparison of the performance of the interim 2018 WTSM against previous versions, especially the latest 2013 update.

The method employed in previous updates of WTSM for the reporting of GEHs was to divide the 2-hour observed and modelled flows by two to generate an "average hour" flow. Guidelines for the use of the GEH statistics do not explicitly stipulate that they require one-hour flows, but the GEH value is sensitive to flow magnitude and it is understood that the targets do relate to one-hour flows. The same approach was therefore used for this validation, with hourly volumes used.

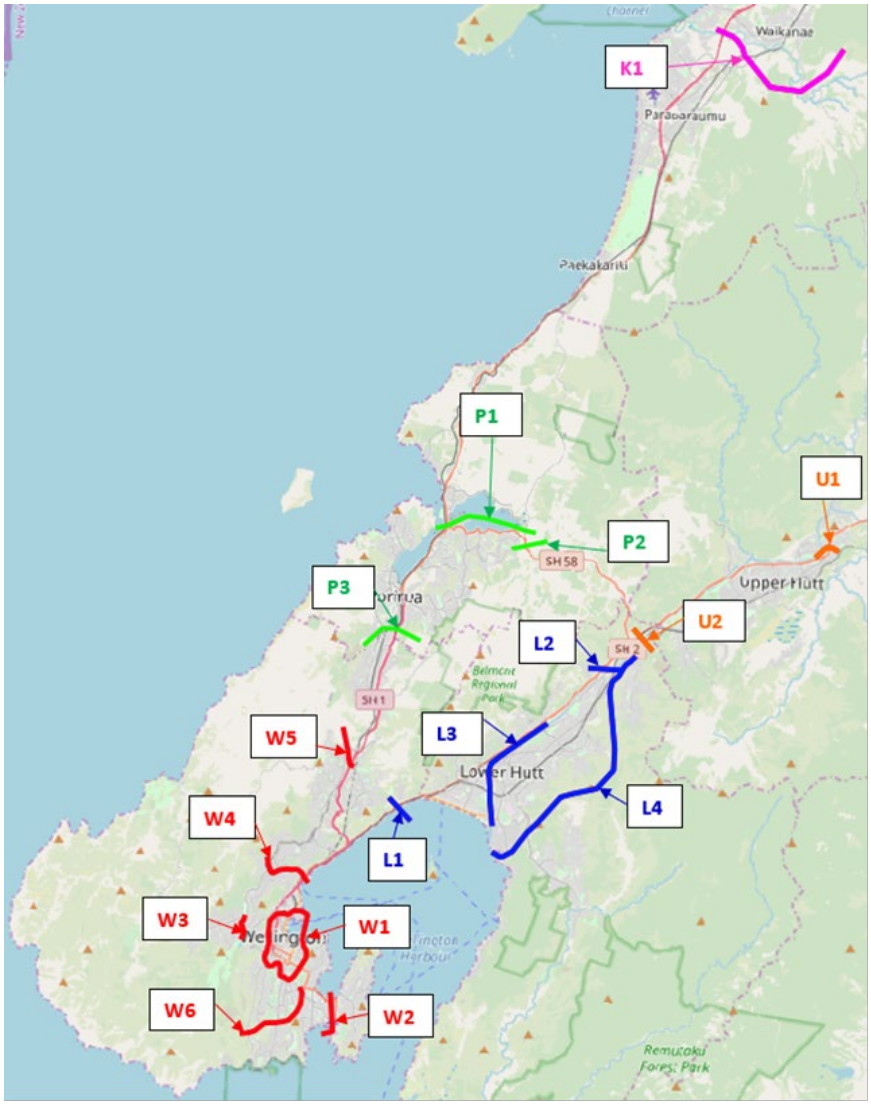

Figure 3-1: Screenlines

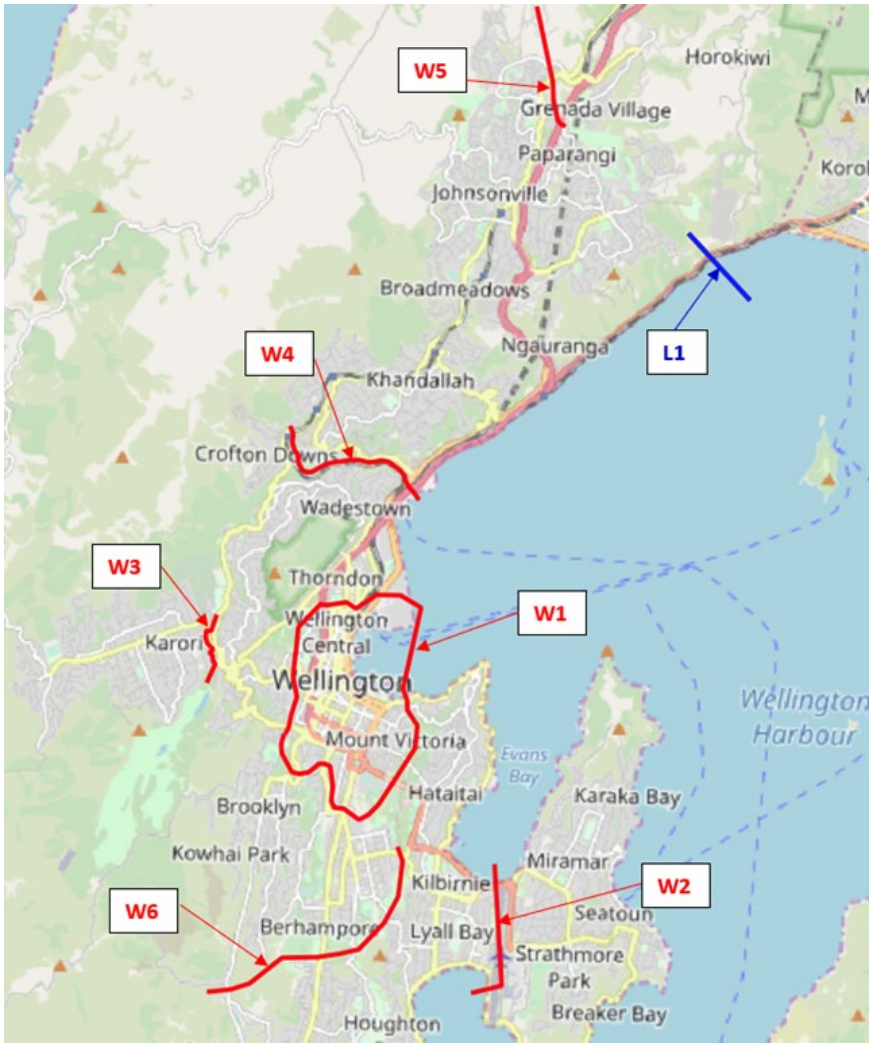

Figure 3-2: Screenlines – Wellington City

3.1 Screenline Validation

The following tables detail the validation of the 2018 WTSM light vehicle volume assignment against total observed demand across the screenlines shown in the previous section.

Table 3-1 shows the validation achieved for each screenline and time period, while Table 3-2 presents the screenline validation summary and compares it with results from the 2013 update.

Table 3-1: Light Vehicle Screenline Validation (one hour flows)

Description	AM				IP				PM			
	Obs	Mod	Diff	GEH	Obs	Mod	Diff	GEH	Obs	Mod	Diff	GEH
W1-CBD in	11,718	14,645	25%	25.5	7,649	8,458	11%	9.0	8,738	9,841	13%	11.5
W1-CBD out	7,827	8,235	5%	4.6	7,344	8,345	14%	11.3	11,862	14,194	20%	20.4
W2-Miramar In	2,137	2,274	6%	2.9	1,570	1,564	0%	0.1	1,918	2,053	7%	3.0
W2-Miramar Out	1,911	1,966	3%	1.2	1,591	1,588	0%	0.1	2,403	2,363	-2%	0.8
W3-Karori out	397	530	34%	6.2	482	643	33%	6.8	1,017	1,192	17%	5.3
W3-Karori in	1,153	1,288	12%	3.9	535	686	28%	6.1	573	704	23%	5.2
W4-Thorndon out	3,510	3,873	10%	6.0	3,537	3,954	12%	6.8	7,403	7,867	6%	5.3
W4-Thorndon in	7,123	8,182	15%	12.1	3,482	4,020	15%	8.8	4,177	4,858	16%	10.1
W5-Churton Park out	1,886	1,797	-5%	2.1	2,041	1,663	-19%	8.8	3,302	3,158	-4%	2.5
W5-Churton Park in	3,122	3,258	4%	2.4	1,862	1,670	-10%	4.6	2,179	2,104	-3%	1.6
L1-Ngauranga to Petone out	2,490	2,891	16%	7.7	2,131	2,500	17%	7.7	3,228	4,144	28%	15.1
L1-Ngauranga to Petone in	3,150	3,969	26%	13.7	2,121	2,550	20%	8.9	2,833	3,423	21%	10.6
L2-Lower to Upper Hutt out	1,689	1,811	7%	2.9	1,442	1,645	14%	5.2	3,715	3,027	-19%	11.8
L2-Lower to Upper Hutt in	3,538	3,057	-14%	8.4	1,490	1,637	10%	3.7	2,034	2,116	4%	1.8
L3-Lower Hutt in	4,250	4,498	6%	3.8	3,428	3,354	-2%	1.3	4,659	4,440	-5%	3.2
L3-Lower Hutt out	3,716	3,676	-1%	0.7	2,952	3,364	14%	7.3	3,995	4,904	23%	13.6
L4-Wainui-Stoke in	2,977	3,548	19%	10.0	1,117	1,598	43%	13.1	1,220	1,677	37%	12.0
L4-Wainui-Stoke out	867	1,230	42%	11.2	1,181	1,567	33%	10.4	3,149	3,431	9%	4.9
U1-Upper Hutt North in	1,095	1,207	10%	3.3	494	771	56%	11.0	582	882	52%	11.1
U1-Upper Hutt North out	378	748	98%	15.6	497	780	57%	11.2	1,223	1,226	0%	0.1
U2-Upper Hutt South out	1,819	1,878	3%	1.4	1,438	1,572	9%	3.5	3,198	2,496	-22%	13.2
U2-Upper Hutt South in	3,055	2,541	-17%	9.7	1,372	1,581	15%	5.4	2,015	2,055	2%	0.9
P1-Porirua North out	1,137	1,197	5%	1.7	1,158	1,029	-11%	3.9	1,999	1,854	-7%	3.3
P1-Porirua North in	1,777	1,917	8%	3.3	1,135	1,006	-11%	3.9	1,328	1,308	-2%	0.6
P2-SH58 west	986	1,050	7%	2.0	365	550	51%	8.7	899	905	1%	0.2
P2-SH58 east	916	919	0%	0.1	373	525	41%	7.2	929	933	0%	0.1
P3-Porirua South out	2,007	1,751	-13%	5.9	1,872	1,467	-22%	9.9	3,295	2,759	-16%	9.8
P3-Porirua South in	2,691	2,733	2%	0.8	1,834	1,481	-19%	8.7	2,334	2,065	-12%	5.7
Total	**79,316**	**86,670**	**9%**		**56,489**	**61,566**	**9%**		**86,202**	**91,978**	**7%**	

Table 3-2: Light Vehicle Screenline Validation Summary

	WTSM 2013			WTSM 2018		
	AM	IP	PM	AM	IP	PM
GEH<5	64%	46%	50%	57%	29%	46%
GEH<10	89%	89%	86%	79%	82%	64%
GEH<12	93%	89%	89%	86%	96%	82%

Results from the screenline validation shows that modelled traffic volumes are overall too high for all time periods, between 7 and 9%.

This is principally caused by modelled car trips having increased between 11% and 13% overall since 2013, driven by a number of changes in model inputs but mostly the 7.5% regional growth in population between 2013 and 2018 (as shown in Figure 2-1). In contrast, observed traffic across all screenlines has increased by 3-7% over the same period, and has actually decreased for some strategic screenlines such as W1 around the CBD.

As a result, overall screenline validation does not achieve the EEM or Waka Kotahi targets and shows a worsening compared with the 2013 model, especially in the Inter Peak.

3.2 Individual Link Validation

In addition to overall demand across screenlines, validation for individual traffic counts was examined and is reported in this section.

Figure 3-3 to Figure 3-5 show scattergram plots of observed counts vs modelled flows, as well as the resulting coefficient of determination R^2. Both the EEM and the TMDG recommend R^2 values above 0.85, with the TMDG additionally targeting a line of best fit with a slope between 0.9 and 1.1.

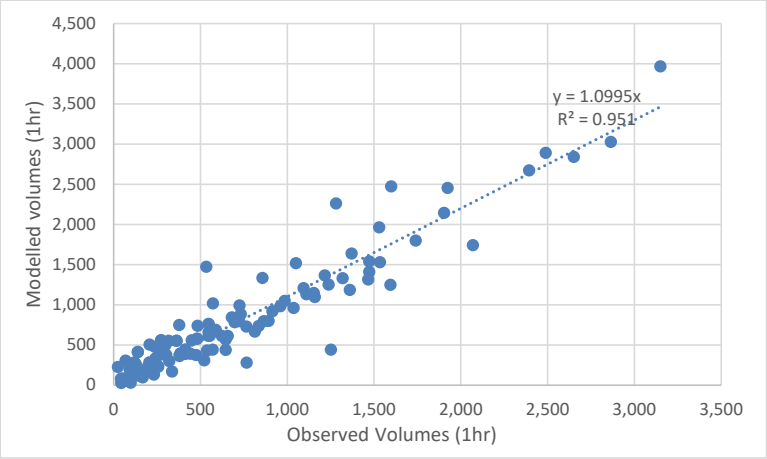

Figure 3-3: Light Vehicles Individual Counts Validation – AM Peak

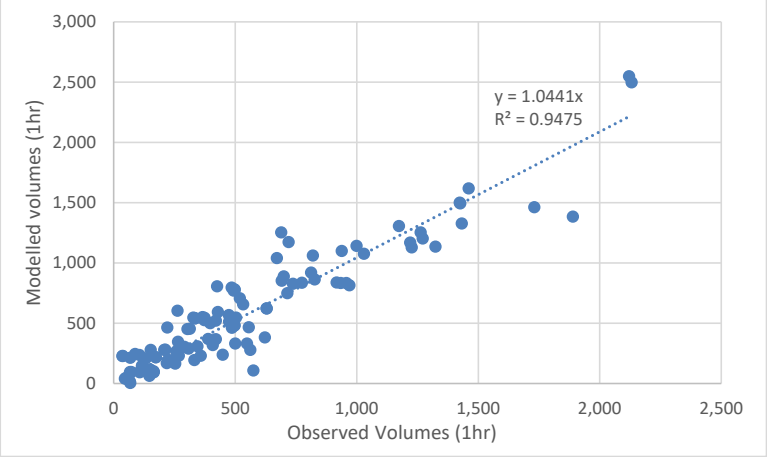

Figure 3-4: Light Vehicles Individual Counts Validation – Inter Peak

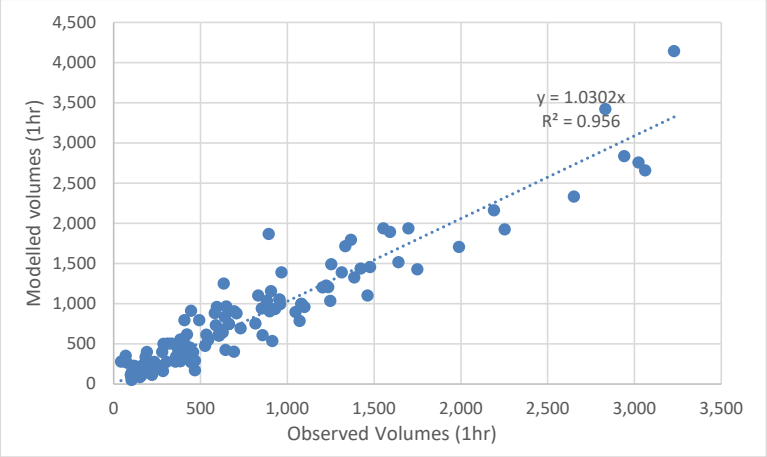

Figure 3-5: Light Vehicles Individual Counts Validation – PM Peak

Table 3-1 summarises individual count validation, showing overall GEH and R^2 as well as the targets from the two guidelines. Results from the 2013 update are shown for comparison.

Table 3-3: Light Vehicle Link Validation Summary

	Target		WTSM 2013			WTSM 2018		
	EEM	TDMG	AM	IP	PM	AM	IP	PM
Counts with GEH < 5	60%	65%	50%	58%	50%	50%	51%	47%
Counts with GEH < 10	95%	85%	77%	83%	78%	74%	80%	81%
Counts with GEH < 12	100%	95%	87%	88%	88%	84%	89%	88%
R^2	>0.85		0.94	0.91	0.94	0.95	0.94	0.96

Results show that while the 2013 model did not achieve the targets for link validation, the interim 2018 model performs slightly worse in most cases.

3.3 Travel Times

Vehicle travel time validation was based on different routes than the previous update and using TomTom GPS data, as detailed in 'TN4 – Data Analysis'.

The routes used for comparison are shown in Figure 3-6 and Figure 3-7. Results are presented in Table 3-4 which shows a comparison of observed and modelled travel times for all three time periods.

The TMDG states that for a Category A Model:

- 80% of routes should be within 15% or 1 minute (if higher)
- 85% of routes should be within 25% or 1.5 minutes (if higher)

Figure 3-6: Travel Time Routes

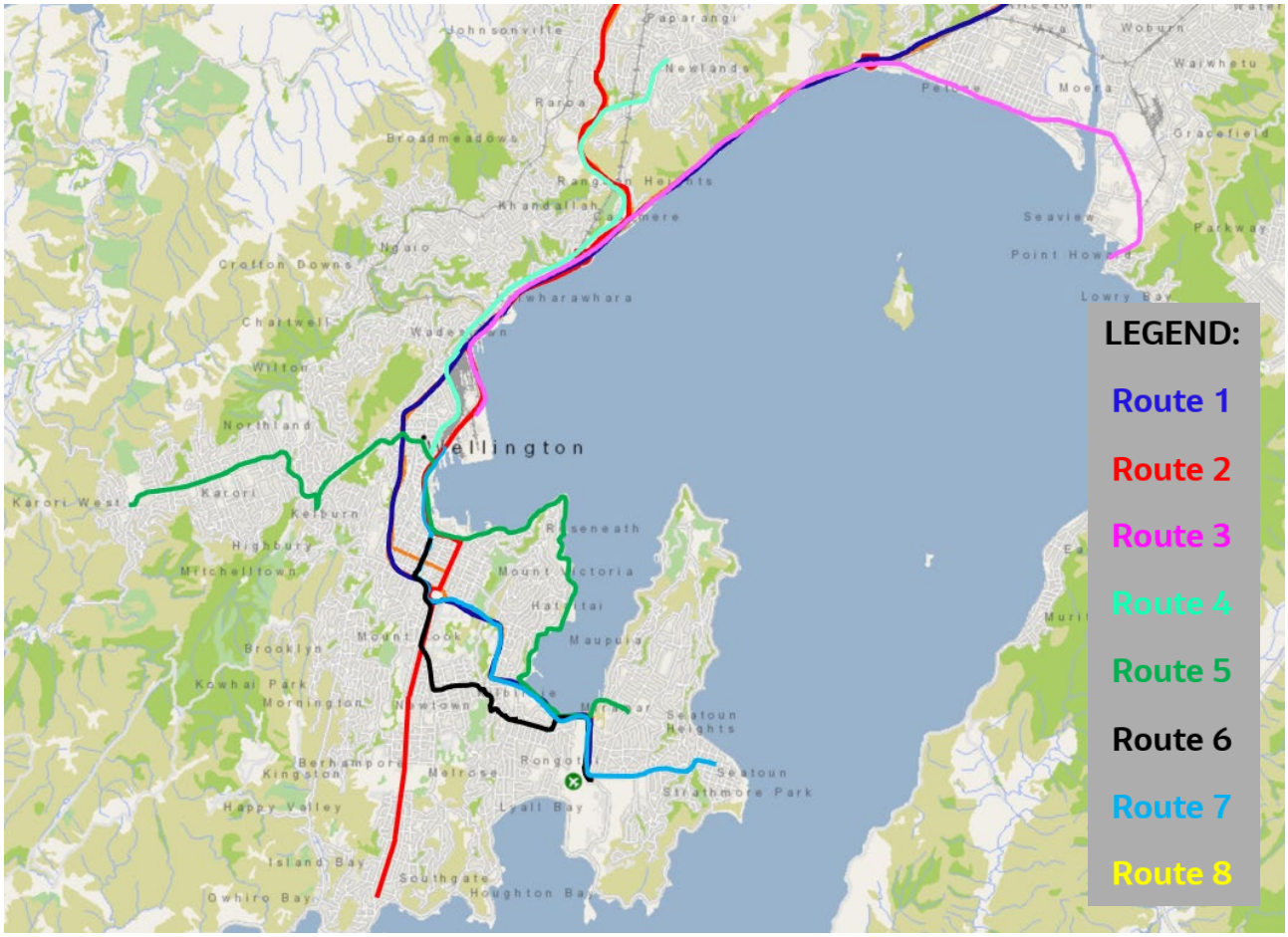

Figure 3-7: Travel Time Routes - Wellington

Table 3-4: Light Vehicle Screenline Validation Summary

Route	AM				IP				PM			
	Obs. (min)	Mod. (min)	15% - 1min	25% - 1.5min	Obs. (min)	Mod. (min)	15% - 1min	25% - 1.5min	Obs. (min)	Mod. (min)	15% - 1min	25% - 1.5min
1-N/b Airport to Masterton	117	115	Y	Y	108	103	Y	Y	128	134	Y	Y
1-S/b Masterton to Airport	137	138	Y	Y	111	106	Y	Y	115	123	Y	Y
2-N/b Island Bay to Paekakariki	55	54	Y	Y	53	51	Y	Y	79	64	N	Y
2-S/b Paekakariki to Island Bay	76	66	Y	Y	53	50	Y	Y	62	56	Y	Y
3-N/b Centreport to Seaview	19	18	Y	Y	19	17	Y	Y	27	40	N	N
3-S/b Seaview to Centreport	41	38	Y	Y	18	16	Y	Y	19	21	Y	Y
4-N/b Rail Station to Newlands	15	13	Y	Y	14	12	N	Y	16	16	Y	Y
4-S/b Newlands to Rail Station	24	18	N	N	14	11	N	Y	15	11	N	N
5-E/b Karori to Miramar	35	30	N	Y	30	27	Y	Y	33	34	Y	Y
5-W/b Miramar to Karori	36	31	N	Y	31	27	Y	Y	41	30	N	N
6-E/b Waterfront to Airport	19	18	Y	Y	20	17	N	Y	23	22	Y	Y
6-W/b Airport to Waterfront	21	19	Y	Y	19	15	N	N	26	19	N	N
7-E/b Rail Station to Seatoun	21	23	Y	Y	20	19	Y	Y	25	27	Y	Y
7-W/b Seatoun to Rail Station	32	24	N	N	22	20	Y	Y	35	24	N	N
8-E/b Paremata to Haywards	14	15	Y	Y	14	14	Y	Y	13	17	N	Y
8-W/b Haywards to Paremata	17	16	Y	Y	14	14	Y	Y	13	15	Y	Y
Achieves Validation?			**75%**	**88%**			**75%**	**94%**			**56%**	**69%**

Results show that none of the time periods achieve the TMDG target of 80% of routes within 15% or 1 minute, and the PM peak does not achieve the second target of 85% of routes being within 25% or 1.5 minutes either. However, the AM and Inter Peak are close, and only one route from achieving the 80% target.

In comparison, while the 2013 validation used different routes, applying the TMDG threshold to the 2013 model would lead to a similar outcome in the AM peak but better results for the Inter peak and PM peak, which both would meet the criteria.

It must be noted that although screenline validation indicates that the model generates too much traffic, modelled travelled speeds tend to be too high in most cases. This will be considered in the new model when developing the new road assignment and associated vehicle delay functions.

4. Heavy Vehicle Validation

4.1 Screenline Validation

Validation of heavy commercial vehicle (HCV) volumes across the network was carried out similarly as for light vehicles, using the same screenlines. Note that "heavy" includes both medium and heavy commercial vehicles.

Table 4-1 below details the validation of the 2018 WTSM heavy vehicle volume assignment against total observed demand across all screenlines, while Table 4-2 presents a summary of screenline validation compared with the 2013 model.

Table 4-1: Heavy Vehicle Screenline Validation

Description	AM				IP				PM			
	Obs	Mod	Diff	GEH	Obs	Mod	Diff	GEH	Obs	Mod	Diff	GEH
W1-CBD in	689	542	-21%	5.9	521	399	-23%	5.7	385	374	-3%	0.5
W1-CBD out	364	436	20%	3.6	473	411	-13%	2.9	529	443	-16%	3.9
W2-Miramar In	59	77	32%	2.3	74	57	-23%	2.1	45	51	13%	0.9
W2-Miramar Out	77	66	-14%	1.3	73	55	-25%	2.3	42	58	39%	2.3
W3-Karori out	15	24	62%	2.1	32	21	-32%	2.0	39	23	-41%	2.9
W3-Karori in	52	30	-44%	3.6	26	22	-14%	0.7	11	19	81%	2.2
W4-Thorndon out	188	297	58%	7.0	268	311	16%	2.5	221	329	49%	6.5
W4-Thorndon in	378	374	-1%	0.2	270	283	5%	0.8	170	263	55%	6.3
W5-Churton Park out	119	155	31%	3.1	139	143	3%	0.3	127	125	-2%	0.2
W5-Churton Park in	133	168	27%	2.9	129	142	11%	1.2	73	109	49%	3.8
L1-Ngauranga to Petone out	134	247	85%	8.2	144	249	73%	7.5	90	229	154%	11.0
L1-Ngauranga to Petone in	109	291	167%	12.9	123	228	85%	7.9	74	197	165%	10.5
L2-Lower to Upper Hutt out	111	180	62%	5.7	104	155	50%	4.5	126	149	18%	1.9
L2-Lower to Upper Hutt in	212	171	-19%	2.9	105	148	42%	3.9	81	132	62%	4.9
L3-Lower Hutt in	339	277	-18%	3.5	277	204	-26%	4.6	190	185	-3%	0.3
L3-Lower Hutt out	194	189	-3%	0.4	224	217	-3%	0.5	177	192	8%	1.1
L4-Wainui-Stoke in	165	86	-48%	7.0	83	78	-5%	0.5	64	62	-2%	0.2
L4-Wainui-Stoke out	65	72	11%	0.8	61	82	35%	2.5	128	65	-49%	6.4
U1-Upper Hutt North in	48	100	108%	6.0	26	96	268%	8.9	17	77	366%	8.9
U1-Upper Hutt North out	13	107	728%	12.1	26	105	311%	9.8	24	90	274%	8.7
U2-Upper Hutt South out	79	189	140%	9.5	72	166	133%	8.7	54	159	197%	10.2
U2-Upper Hutt South in	71	182	157%	9.9	81	162	101%	7.4	47	135	187%	9.2
P1-Porirua North out	87	118	36%	3.1	92	98	7%	0.7	73	88	20%	1.7
P1-Porirua North in	91	114	25%	2.3	100	98	-2%	0.2	78	86	10%	0.9
P2-SH58 west	43	80	87%	4.8	29	56	98%	4.3	37	54	46%	2.5
P2-SH58 east	51	75	48%	3.0	28	55	95%	4.2	26	62	142%	5.5
P3-Porirua South out	107	149	40%	3.8	124	131	6%	0.7	124	112	-10%	1.1
P3-Porirua South in	143	158	11%	1.2	131	132	0%	0.0	77	100	30%	2.5
Total	**4,133**	**4,956**	**20%**		**3,827**	**4,304**	**12%**		**3,126**	**3,967**	**27%**	

Table 4-2: Heavy Vehicle Screenline Validation Summary

	WTSM 2013			WTSM 2018		
	AM	IP	PM	AM	IP	PM
GEH<5	75%	89%	79%	64%	75%	64%
GEH<10	96%	100%	100%	93%	100%	89%
GEH<12	100%	100%	100%	93%	100%	100%

There are no validation criteria specifically for vehicle types, however, comparisons to the overall metrics have been undertaken. Results at a screenline level are generally good, with most screenlines having a GEH of less than five and almost all of them being less than 12. However, it is noted that GEH values are sensitive to the magnitude of the flow, so are not a good comparator for heavy vehicles which are generally significantly less than light vehicles. Alternative checks were applied in 'TN11 – Heavy Vehicle Model Update', which will also be undertaken for the rebuild model in Stage 2 of this project.

It is also noted that the updated heavy vehicle model was calibrated and applied at 780 zone level and based on Census Usually Resident Population rather than the Estimated Resident Population definition applied here. Applying the model documented in TN11 at 225 zone level with Estimated Resident Population produced much higher modelled flows than shown in this section. While a small element of the difference was the change in population definition, which was expected, a large difference was associated with the change in the model zoning. To bring the new heavy vehicle model flows into line in the interim, the internal attraction model coefficients were factored down globally to reduce the modelled flows.

4.2 Individual Link Validation

Heavy vehicle validation for individual traffic counts was also examined and is reported in this section.

Figure 4-1 to Figure 4-3 below show scattergram plots of observed vs modelled counts, as well as the resulting coefficient of determination R^2 and the slope of the line of best fit with the intercept forced through zero.

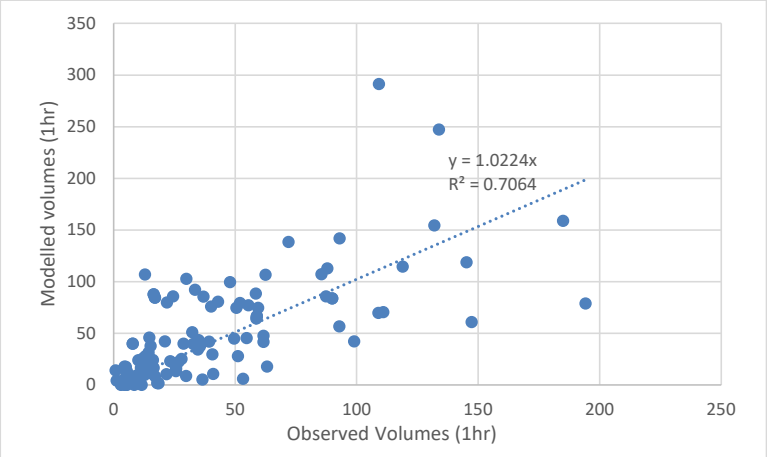

Figure 4-1: Heavy Vehicles Individual Counts Validation – AM Peak

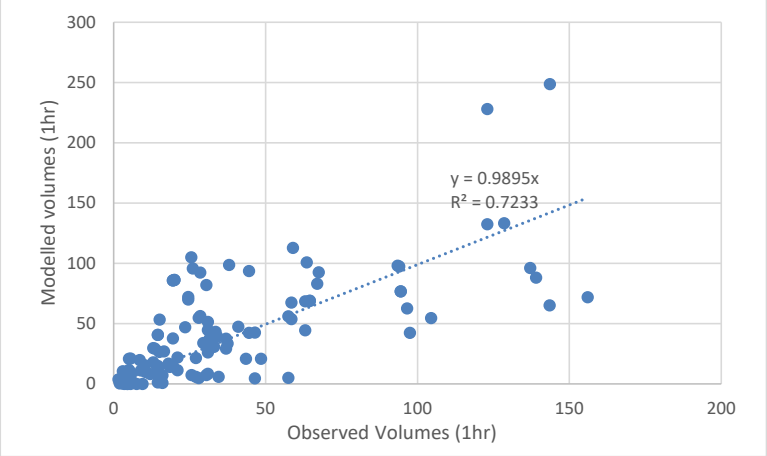

Figure 4-2: Heavy Vehicles Individual Counts Validation – Inter Peak

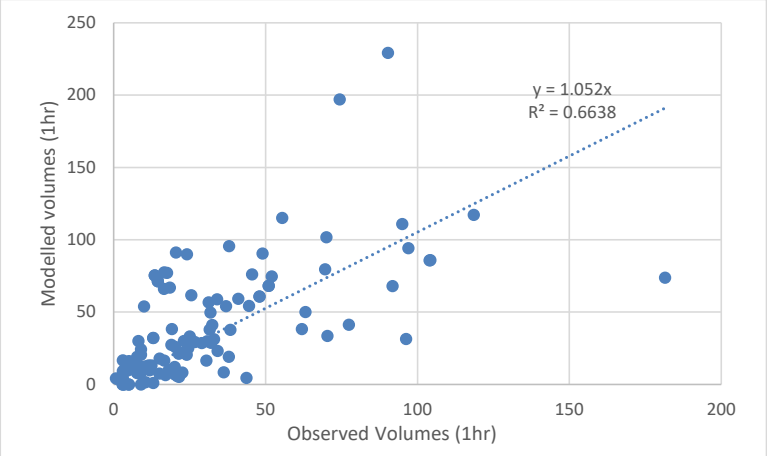

Figure 4-3: Heavy Vehicles Individual Counts Validation – PM Peak

Compared with light vehicles, there is more scatter in terms of modelled flows replicating observed. This reflects the relatively low volumes and the challenge of re-producing these flows in a large, regional strategic model. While the discrepancies are large in percentage terms, the absolute magnitude of the differences is small.

The following table shows results for heavy vehicle link validation from WTSM 2018, compared with the 2013 version of the model.

Table 4-3: Heavy Vehicle Link Validation Summary

	WTSM 2013			WTSM 2018		
	AM	IP	PM	AM	IP	PM
Proportion of counts with GEH < 5	79%	87%	83%	76%	76%	80%
Proportion of counts with GEH < 10	98%	99%	98%	98%	98%	98%
Proportion of counts with GEH < 12	98%	100%	100%	98%	98%	100%
R^2	0.54	0.67	0.50	0.71	0.72	0.66

The 2018 synthetic model results are similar to the 2013 factored matrix outputs in terms of GEH statistics for modelled link flows compared with observed. The 2018 modelled flows also meet or exceed the criteria in the EEM and TMDG in terms of GEH, however, this is primarily because the commercial vehicle volumes are relatively small in magnitude. Again, alternative checks will be applied with the model rebuild in Stage 2.

5. Public Transport Validation

5.1 Bus Patronage

Bus patronage was also validated against observed flows across screenlines. Again the same screenlines as 2013 were used to allow direct comparison. However, the method used to derive observed patronage was different (see 'TN15 – WTPM Update' for more detail). Observed volumes were obtained in two ways:

- A tool was developed to extract volumes passing through each bus stop from Electronic Ticketing Machine (ETM) data and the General Transit Feed Specification (GTFS) bus sequences. Resulting values were checked against the CBD cordon survey locations to verify the tool accuracy. Results were found to be a good match and it was therefore used to inform observed bus patronage at most count locations on the screenlines.
- For some locations, results could not easily be extracted from this tool. These were mostly locations on the State Highway network or on main arterials where a high number of bus routes converge but with no nearby bus stop. For those, a similar approach to the 2011 Wellington Public Transport Model development was used where a "reference assignment" was carried out, with the raw observed bus matrices from ETM data assigned onto the bus network only. Due to the absence of alternative routes for most of these locations, they represent a reliable proxy for observed bus volumes.

This approach represents an improvement from the 2011 WPTM model development which relied entirely on this "reference assignment".

Validation results are shown in the following table which shows the observed and modelled volumes, as well as the percentage difference and the GEH. It is noted that there are no industry standard validation criteria or targets for public transport assignments. Validation results are only shown for the AM and Inter peak, and not the PM peak consistent with earlier model updates.

Due to the highly sensitive nature of ETM data in terms of confidentiality, numbers have been removed and only high-level statistic results are shown.

Table 5-1: Bus Patronage Screenline Validation

2018	AM				IP			
	Reference	Modelled	Diff	GEH	Reference	Modelled	Diff	GEH
W1-CBD in	5,618	5,041	-10%	7.9	1,065	1,017	-4%	1.5
W1-CBD out	572	1,063	86%	17.2	772	1,098	42%	10.6
W2-Miramar In	87	128	47%	3.9	102	181	78%	6.7
W2-Miramar Out	678	734	8%	2.1	115	171	49%	4.7
W3-Karori out	39	100	158%	7.4	94	130	39%	3.4
W3-Karori in	678	734	8%	2.1	133	126	-5%	0.6
W4-Thorndon out	70	233	230%	13.2	158	283	80%	8.5
W4-Thorndon in	1,505	729	-52%	23.2	210	188	-11%	1.6
W5-Churton Park out	32	49	56%	2.8	13	14	10%	0.4
W5-Churton Park in	42	27	-35%	2.5	14	17	25%	0.9
L1-Ngauranga to Petone out	87	71	-19%	1.8	59	146	149%	8.6
L1-Ngauranga to Petone in	234	51	-78%	15.3	73	66	-9%	0.8
L2-Lower to Upper Hutt out	28	28	0%	0.0	53	79	48%	3.1
L2-Lower to Upper Hutt in	155	299	93%	9.5	47	38	-18%	1.3
L3-Lower Hutt in	366	279	-24%	4.9	182	139	-24%	3.4
L3-Lower Hutt out	224	163	-27%	4.4	203	276	36%	4.7
L4-Wainui-Stoke in	323	364	13%	2.2	77	72	-6%	0.5
L4-Wainui-Stoke out	25	86	239%	8.1	68	173	154%	9.5
U2-Upper Hutt South out	61	19	-69%	6.6	35	23	-35%	2.3
U2-Upper Hutt South in	67	80	20%	1.5	32	7	-77%	5.5
P3-Porirua South out	33	24	-27%	1.7	15	14	-7%	0.3
P3-Porirua South in	85	2	-97%	12.5	15	2	-85%	4.3
Total	**11,008**	**10,304**	**-6%**		**3,534**	**4,261**	**21%**	

Results show that modelled bus demand is overall too low in the AM peak and too high in the Inter Peak.

For the AM peak, this is mostly caused by bus volumes from Johnsonville to the Wellington CBD being too low through screenlines W1 and W4. This is a result of the new vehicle delay function and correction of distance errors on links along this bus route, leading to some demand shifting from bus to rail. Elsewhere volumes actually tend to be too high.

For the Inter Peak, the increase in demand is largely caused by the revised CBD parking costs calculations that lead to higher generalised costs for car users and a shift to public transport.

Table 5-2 below summarises screenline validation, showing overall GEH performances. Results for 2013 are shown for comparison, which show that screenline validation has worsened for the 2018 interim version of the model.

Table 5-2: Bus Patronage Screenline Validation Summary

	WTSM 2013		WTSM 2018	
	AM	IP	AM	IP
GEH<5	62%	85%	55%	73%
GEH<10	92%	88%	77%	95%
GEH<12	92%	100%	77%	100%

5.2 Rail Patronage

This section details the validation of rail patronage in WTSM, by looking at total boardings and loading profiles on each main corridor (Kapiti line, Hutt Valley line and Johnsonville line).

As per the 2013 update, no detailed observed patterns were available so boardings and alightings from extensive surveys carried out in 2011 for the development of the WPTM were used, factored per line to match with total patronage obtained through rail guard counts and Metlink data.

The resulting observed and modelled boardings per line are summarised in Table 5-3 below.

Table 5-3: Rail Line Validation

Line	AM Peak Inbound			Inter Peak Inbound		
	Observed	Modelled	%	Observed	Modelled	%
Johnsonville Line	1,758	3,014	71%	208	341	64%
Kapiti Line	5,505	5,333	-3%	483	681	41%
Hutt Valley Line	6,338	7,789	23%	370	531	43%
Total	13,600	16,136	19%	1,061	1,553	46%

Results show that for the AM peak rail volumes are significantly too high on the Johnsonville line. This is again caused by the new vehicle delay function and correction of distance errors for a number of links on the road network between Johnsonville and Wellington CBD which, while it leads to a more accurate representation of car travel times, also leads to slower bus journeys and a resulting shift to rail.

Volumes are also generally too high on the Hutt Valley Line but they are a good match to observed on the Kapiti line. Overall AM peak volumes are 19% higher than observed.

For the Inter Peak, modelled volumes are over 40% too high on all lines. Again, this is partly a result of the road network changes (as can be seen with the Johnsonville performing worst), and the effect of the new CBD parking cost shifting demand to public transport.

The observed and modelled loading profiles for each line in the inbound direction are shown in Figure 5-1 to Figure 5-3.

The WTSM uses 'p-connectors' to represent access to rail and the process to represent the impact of congestion for car access (park and ride and kiss and ride has been improved as part of this project (see TN7 – Park and Ride).

While the following plots reflect that modelled rail demand is overall too high, especially for the Johnsonville line, the relative shapes of volume profiles are however similar to observed with the main stations being well represented. The Kapiti line in particular is a very close match in the AM peak, even in terms of number of boardings. This indicates that the adjustments in travel times on p-connectors have had no adverse effect on rail patronage.

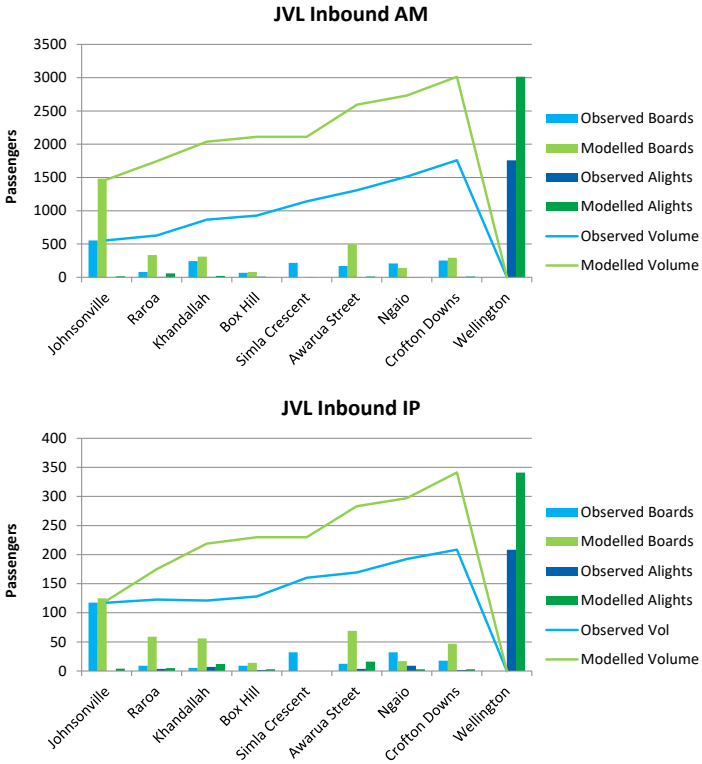

Figure 5-1: Rail Loading Profiles – Johnsonville Line

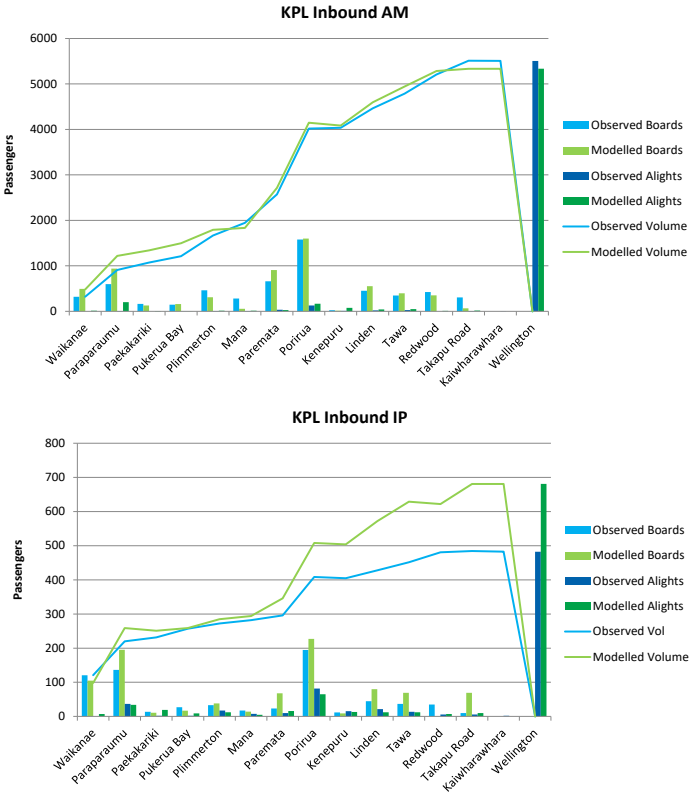

Figure 5-2: Rail Loading Profiles – Kapiti Line

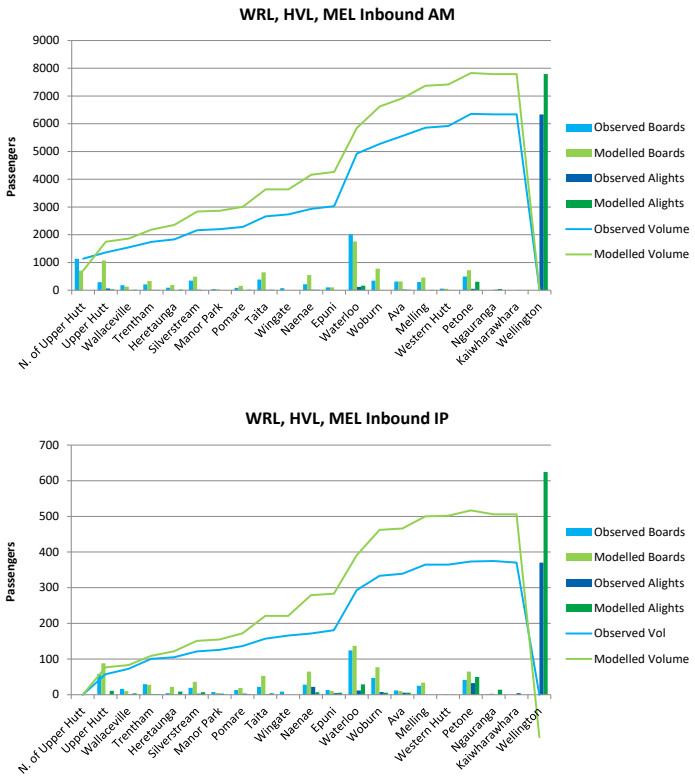

Figure 5-3: Rail Loading Profiles – Hutt Valley Line

6. Conclusion

This technical note reports the performance of the interim WTSM updated to 2018, validated against a number of observed patterns.

For each criterion, the outcome is summarised below:

- **Traffic counts and screenlines volumes for light vehicles:** traffic volumes are between 7 and 9% too high overall, and are particularly high on strategic screenlines such as to/from the CBD in the peak direction. This leads to the validation not meeting EEM or TMDG criteria.
- **Traffic counts and screenlines volumes for medium / heavy vehicles:** The updated HCV model reported in TN11 needed further adjustment for application at 225 zone level. As it is no longer expected that the 2018 interim model will be applied, a limited number of checks have been undertaken and reported, and it is acknowledged that the GEH check is not ideal for small volumes.
- **Light vehicle journey time validation:** the interim WTSM generally does not match TMDG targets, with speed being commonly too high.
- **Screenline volumes for bus passengers:** bus volumes are too low in the AM peak which is mostly caused by the new vehicle delay function and the issue noted with network coding correction, leading to a mode share imbalance between Johnsonville and the Wellington CBD. Otherwise, the new CBD parking costs lead to too much bus demand, especially in the Inter Peak.
- **Rail count and loading profiles:** the AM peak is the reverse of bus demand, with far too much demand on the Johnsonville line, but rail demand is too high overall, especially in the Inter Peak.

In summary, the interim 2018 WTSM leads to a relatively poorer representation of observed travel patterns in the Wellington region than the previous 2013 version. The main issues are twofold:

- Demographic changes since the 2013 census, coupled with trip rates being fixed in strategic transport models such as the WTSM, lead to a notable increase in trips overall. However this increase has not occurred to the same extent in reality, especially considering car trips which represent by far the main

mode share in the region. Volumes for light vehicles on some strategic screenlines, especially peak direction trips from and to the CBD, seem to have actually declined during the modelled peak periods.

- Some of the adjustments made to the WTSM have adversely impacted on the model calibration . These include changes to the network (fixed distance errors, new vehicle delay functions), the new CBD parking costs calculation, or additional traffic generated by the new airport and ferry terminal models.

Some of these issues could be resolved through recalibration of components of the model (noting that this was out-of-scope), and a number of adjustment tests were carried out such as reducing trip rates or removing the new CBD parking costs. However this demonstrates that the WTSM, which is calibrated based on 2001 Household Travel Survey data, is showing its age and struggling to replicate current observed conditions and travel patterns, especially with new additional components impacting on its calibration.

As noted in the introduction, the interim 2018 WTSM is no longer expected be used on project work. The current 2013 version will be used until a fully rebuild strategic model is developed as part of Stage 2 of this project, therefore no further work was undertaken to improve these results. However, some findings that will be relevant for the development of the rebuilt version of WTSM are as follows:

- WTSM, consistent with similar standard 4-step models, is based on fixed trip rates by trip purpose and vehicle/family category calculated from household travel survey data. Based on this validation and initial analysis from more recent surveys, it is possible that trip rates may have decreased since its development in 2001, or mode share, trip length, and the amount of trip chaining has changed considerably. As a result, WTSM is no longer able to replicate travel patterns to an acceptable level. It is important that the next version of the model can replicate the root cause for changing trip patterns. Having functionality to easily adjust trip rates in the next model will also be useful if similar trends continue.

- Traffic counts indicate that peak period volumes, while still increasing, are not rising as fast as previously, and not in line with the 7.5% population increases. However some screenline totals show a decrease compared with 2013, especially in the peak direction to/from the Wellington CBD, i.e. in the most congested part of the network. This appears counter-intuitive based on anecdotal evidence and will need to be further investigated to ensure the dataset used for validation of the next model is representative of actual conditions. One potential explanation would be that peak spreading leads to flow breakdowns earlier than before, resulting in less throughput during the modelled periods. The new, extended peak periods to be modelled in the next version of WTSM would alleviate this issue.

- Modal share between the Johnsonville corridor and the Wellington CBD has consistently been the most sensitive to changes in generalised costs, both between car and PT and between bus and rail. This has led to issues in this validation due to the changes carried out on the network (these also impacted on validation of the WPTM as detailed in 'TN16 – WPTM validation'). Particular care will be needed in the next model to ensure modal share is correctly represented on this corridor, but also sensitivity to changes in generalised costs.

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