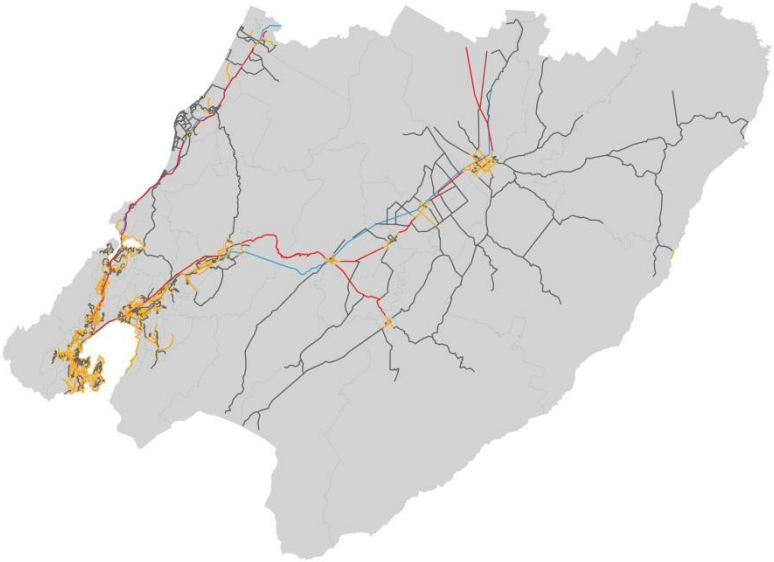
OPUS INTERNATIONAL CONSULTANTS AND ARUP

WELLINGTON TRANSPORT MODELS

Contract No C3079



TN 16: WPTM and WTSM PT Assignment Comparison

Date: December 2012

ARUP OPUS

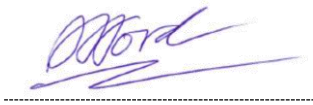
Wellington Transport Models

TN16 : WPTM and WTSM PT Assignment Comparison

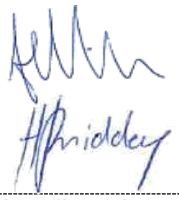
prepared for

Greater Wellington Regional Council

Prepared By



Andy Ford (GWRC)



Reviewed By

Andy Wilson (Opus)
Harriet Priddey (Arup)

Opus International Consultants Limited
Wellington Office
Level 9, Majestic Centre, 100 Willis Street
PO Box 12003, Wellington 6144
New Zealand
Ph: +64 4 471 7000

Arup
Level 17, 1 Nicholson Street
Melbourne VIC 3000
Australia
Ph: +61 3 9668 5500

Date: December 2012
Reference: g:\localauthorities\wrc\proj\5-c2050.00 - c3079 wtsm wptm\600 deliverables\630 final tech notes\tn16 wptm and wtsm pt assignment comparison final.docx
Status: Final
Revision: 1

Document History and Status

Issue	Rev	Issued To	Qty	Date	Reviewed	Approved
Draft	v1	Nick Sargent	1	19/07/2012	Andy Wilson & Harriet Priddey	
Final	1	Nick Sargent	1 Hard & 1 CD	06/12/2012	Andy Wilson & Harriet Priddey	David Dunlop

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

John Bolland:
(Peer Reviewer) _____

Nick Sargent:
(GWRC) _____

Contents

1 Introduction

The purpose of this note is to demonstrate that both the Wellington Transport Strategy Model (WTSM) and the Wellington Public Transport Model (WPTM) display similarities in their representation of travel times (perceived and actual) by selecting 11 'sample' journeys, for which origin-destination (O-D) travel times are obtained from both WPTM and WTSM[1]. The travel times are broken down into their constituent components, namely:

- Access Time;
- Total Wait Time;
- Total Board Time;
- Total In-Vehicle Time; and
- Egress Time.

Results were produced using module 6.27 in EMME. As discussed in TN18, this was made possible by the use of Module 5.32 in the transit assignment procedures (the macro has been included in **Appendix A** for completeness – a copy of the macro is held by GWRC should similar analysis be required in the future). This note is structured as follows:

- **Chapter 2** – Lists and compares the various parameters and factors used in both WTSM and WPTM;
- **Chapter 3** – Describes the process for obtaining travel times between certain O-D pairs, broken down into constituent components;
- **Chapter 4** – WPTM O-D travel times;
- **Chapter 5** – WTSM O-D travel times;
- **Chapter 6** – Compares WPTM and WTSM travel times; and
- **Chapter 7** – Conclusions.

1.1 Aims and Approach

WTSM and WPTM have been developed such that both models can be used as part of one 'Transport Model System' when it comes to future forecasting. Whilst there are subtle differences between both models, primarily due to WTSM being a strategic model and WPTM a more detailed public transport project model, both models use the same software package and operate using similar macros and assignment algorithms.

Such comparisons are important as WTSM will be used in forecasting mode to derive factors that will be applied to the Base WPTM public transport (PT) matrices in order to create future year WPTM demand. If both models represent travel costs / times in radically different ways this could lead to difficulties when applying WTSM growth to WPTM. Therefore by comparing sample journey times between WTSM and WPTM, differences and similarities regarding how certain components of a typical journey are modelled can be identified, quantified and documented, thus allowing users to take appropriate action if required in the future.

[1] While the results were produced using validated versions of both models they were not final versions. However, as the purpose of the technical note was to compare the models it was not considered worthwhile rerunning the analysis i.e. the changes were likely to be minor and as long as both models used the same networks and services then the purpose of the tech note would still be achieved.

2 Factors and Constants

2.1 Parameters

The travel times in both WTSM and WPTM are governed by a number of factors and constants. Several 'perception' factors are used to convert actual times into perceived times. Initial values used in WTSM / WPTM were taken from both existing WTSM calibrated values and international best practice. The time components are described below:

- **Walk time weight factor** – generally people perceive walking as less attractive relative to travelling on a vehicle. Calibrated factors are generally found to be in the range 1.5 to 2.0*.
- **Wait time weight factor** – generally people view waiting as less attractive relative to travelling on a vehicle due in part to perceptions over the ability of transit services to keep to timetables. The calibrated factors are generally found to be in the range 1.5 to 2.0*. On top of the wait time weight factor that gets applied to the calculated wait time (to adjust from actual to perceived values), a further weight time factor can be applied by mode, as people may perceive a 10 minute wait for a rail service differently to a 10 minute wait for a bus service.
- **In-vehicle time factors** – people perceive certain modes as being 'more attractive than other modes'. This can be modelled by applying a factor to the in-vehicle time to model 'perceived' in-vehicle time. Given that standard bus will have a factor of 1.0, all other modes are ranked according to their relative attractiveness compared to bus. Such factors are generally in the range 0.75 to 0.90 and are either taken from international best practice, calibrated or determined from study / locality specific Stated Preference (SP) surveys*.

Along with these so-called perception factors there are other constants that are used to apply costs (time penalties) to certain components of a typical journey. These additional constants are as follows:

- **Node boarding times** – boarding time penalties applied at all nodes to model the perceived inconvenience associated with boarding public transport services. The times vary by stop category, reflecting the fact the some choices are preferable to others i.e. boarding a train at a well-lit, secure station with a heated waiting room is preferable to boarding a bus at an unlit, uncovered bus stop. These are discussed in more detail in TN15.
- **Line boarding times** – similar to node boarding time penalties, except the line boarding penalty is dependent on mode (as opposed to stop category). This is designed to reflect the fact that boarding a high-quality bus such as the Airport Flyer is preferable to boarding a standard bus.
- **Headway** – defined as 60 / hourly service frequency at a particular stop. For example, if there are 10 buses an hour then the headway would be 6 minutes. By taking the headway and applying set equations, the wait time can be calculated.

2.2 Typical Journey

The components of a 'typical' journey include an access leg to the bus (or train), a wait time, a boarding penalty (converted into generalised minutes), an in-vehicle time journey

* Based on the project team's experience of public transport models in the UK, Australia and NZ.

leg and, finally, a time associated with the 'egress leg' which involves exiting the transit vehicle and accessing the final destination zone. More complex journeys are obviously possible with the inclusion of additional transit vehicle sections and transfers but for the purpose of this note, a typical journey should suffice. More detailed descriptions of the components (and journey legs) are described below:

Access Time to Bus Stop

Determined according to the highway network speed and distance and weighted by the 'walk time perception value'. Weights for the two models are listed below:

- WPTM Walk Time Perception Factor = 1.8
- WTSM Walk Time Perception Factor = 2.0

Conclusion: Minor difference resulting from calibration activity during development of WPTM (documented in TN19)

Wait Time

A function of headway (service frequency) and the mode-specific headway 'weight', which is in turn weighted by the 'wait time perception value'. The wait time is calculated as follows in **WPTM**:

1. If the headway is less than 15 minutes, wait time = 0.5 * headway; and
2. If the headway is greater than 15 minutes, wait time = 7.5 + 0.22* (headway minus 15)

Wait times are then further multiplied by the following calibrated mode specific wait time factors to obtain an interim perceived wait time:

- Bus = 1.0;
- Flyer = 0.9;
- Rail = 0.8;
- Ferry = 0.2; and
- Cable Car = 0.8.

Finally, wait time and mode specific factors are multiplied by the wait time perception factor to obtain a final perceived wait time, where the wait time perception factor is 2.0. The combination of 'mode specific wait time factors' (range 1.0 to 0.2) and the 'wait time perception factor' (2.0) results in effective wait time perception factors of:

- Bus = 2.8;
- Flyer = 1.6;
- Rail = 1.4;
- Ferry = 0.4; and
- Cable Car = 1.6.

Table 2-1 below tabulates the effective wait time factors by mode. Figure 2-1 graphically represents the different wait time curves by mode. The change in the wait time curve gradient for service headways greater than 15 minutes is clearly visible.

Table 2-1: WPTM Wait Time Factors

Mode	Wait Time Perception Factor	Mode Specific Wait Factor	Effective Wait Time Perception Factor
Bus	1.8	1.0	1.8
Airport Flyer	1.8	0.9	1.6
Rail	1.8	0.8	1.4
Cable Car	1.8	0.8	1.6
Ferry	1.8	0.2	0.4

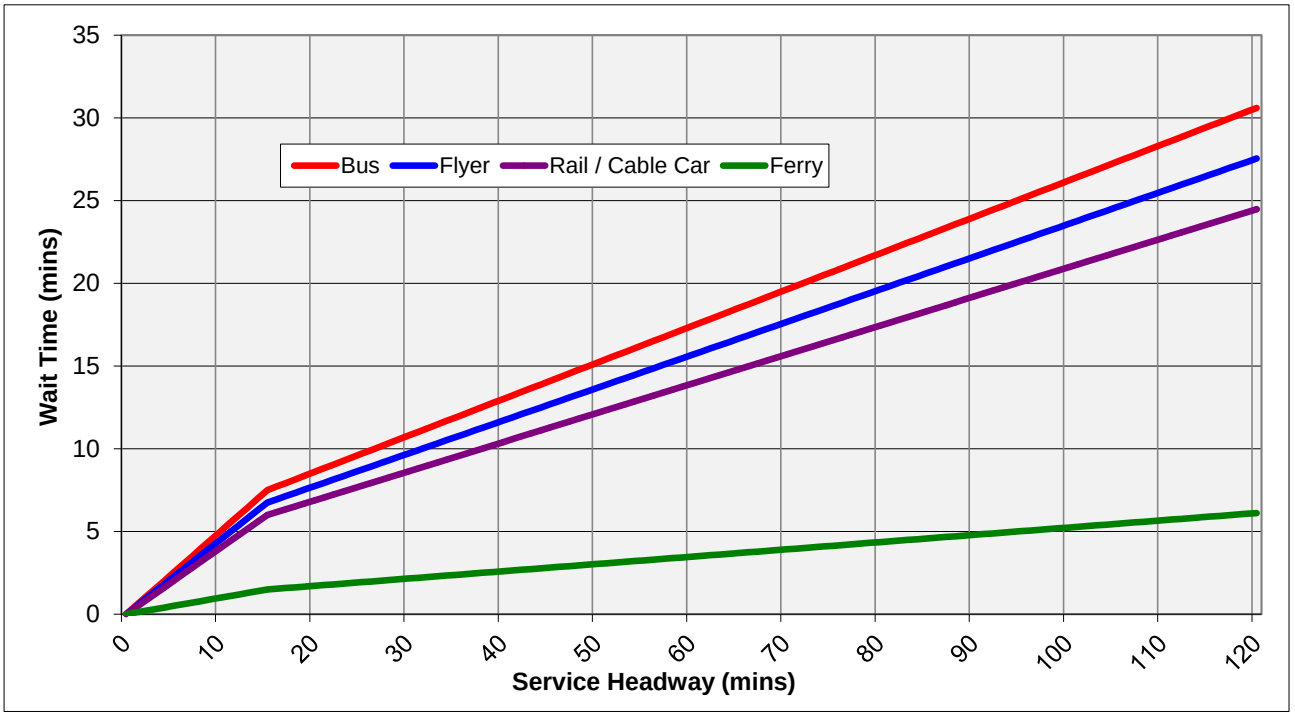


Figure 2-1: WPTM Wait Time Curves by Mode

The **WTSM** wait time is calculated by multiplying the headway by 0.25. Unlike WPTM, services with headways greater than 15 minutes do not get treated differently. Similarly, whilst the headway is multiplied by the wait time perception factor for both models (WTSM = 2.0; WPTM = 1.8), further weighting according to mode only takes place in WPTM, resulting in 'effective' wait time perception factors by mode that range from 0.2 to 1.8. In WTSM there is no variation in the wait time perception value between modes, with the value of 2.0 used across all modes.

It is therefore acknowledged that wait times will differ between models. The WPTM wait time function follows international best practice* which suggests that for journeys with a

* Based on the project team's experience of public transport models in the UK, Australia and NZ.

service frequency greater than every 15 minutes, people will often turn up without consulting timetables. Therefore the average actual wait will be 0.5 * service headway only when the headway is 15 minutes or less. For services where the headway is greater than 15 minutes, people will consult a timetable and turn up in advance of the timetabled time. Therefore applying a constant (7.5 minutes) plus a small fraction (0.22) of the headway value minus 15 minutes is considered appropriate.

In summary, WTSM and WPTM wait times are broadly similar for the main modes (bus and rail) where service frequency is greater than 15 minutes. For less frequent services the correlation between WPTM and WTSM is much weaker, with WTSM predicting longer wait times. This will have the greatest impact in the Inter peak, where service frequency is generally lower than in the AM peak.

Conclusion: Significant differences between models in terms of calculating wait time.

While the WPTM approach is valid it makes demand much less responsive to large changes in transit frequencies. This might not be such an issue for WPTM (which uses fixed demand matrices) but WTSM is a demand model and as such needs to be able to respond appropriately to large changes in frequency.

It is advised that mode shift in WTSM resulting from increased frequencies be monitored closely (particularly for services with high headways in base case scenarios). For example, the addition of one extra service on the Wairarapa line will result in substantially lower modelled travel times due to reduced waits.

Boarding Penalties

WPTM contains the following node and line boarding penalties:

- Standard bus = 3 min node penalty;
- High Quality bus stop = 1.5 min node penalty;
- Standard rail station= 1.5 min node penalty;
- Superior rail = 0 min node penalty;
- Mode = Rail; Line penalty = 1 min;
- Mode = Airport Flyer; Line penalty = 2 min; and
- Mode = All else; Line penalty = 3 min.

These are tabulated in Table 2-2 below. The separate line and node penalties are designed to accurately represent the hierarchy of perceived attractiveness across all interchange types / modes. The principles that underpin this hierarchy are as follows:

- People perceive high quality interchanges to be more attractive than purpose built and standard interchanges; and
- People perceive rail to be a more attractive mode than premium bus (airport flyer) and both these are perceived to be more attractive than standard bus

Therefore a combination of line and node boarding penalties gives a greater degree of flexibility when modelling the perceived attractiveness of these difference choices, compared with alternative methods used in WTSM of using only node boarding penalties or only line (mode) boarding penalties.

Table 2-2: Transit Penalties by Mode - WPTM

Mode	Fare element (all represented in the model in Generalised Minutes)	Standard Interchanges	Purpose Built Interchanges	High Quality / Planned Interchanges
Bus	**Fare**			
	Line Boarding Penalty (Standard Bus)	3.0	3.0	3.0
	Line Boarding Penalty (Airport Flyer)	2.0	2.0	2.0
	Node Boarding Penalty	2.5	1.5	1.5
	Total			
	Total (excluding fare, standard bus)	5.5	4.5	4.5
	Total (excluding fare, airport flyer bus)	4.5	3.5	3.5
Rail	**Fare**			
	Line Boarding Penalty	1.0	1.0	1.0
	Node Boarding Penalty	1.5	0	0
	Total			
	Total (excluding fare)	**2.5**	**1.0**	**1.0**

High quality bus stops in WPTM are found at the following locations (note: multiple nodes may represent these interchanges):

- Lambton interchange;
- Johnsonville hub;
- Porirua Station;
- Paraparaumu Station;
- Waterloo Station;
- Queensgate;
- Upper Hutt Station;
- Courtenay Place; and
- Masterton Town.

The following stations have been designated ‘superior’ stations:

- Otaki;
- Waikanae;
- Paraparaumu;
- Paremata;
- Porirua;
- Johnsonville;
- Woodside;
- Featherston; and
- Upper Hutt;

- Trentham;
- Silverstream;
- Taita;
- Naenae;
- Waterloo;
- Petone;
- Melling; and
- Wellington.

WTSM boarding penalties are described in TN15 but the key summary table has been repeated below in Table 2-3.

Table 2-3: Transit Penalties Coded into the @board Attribute

Mode	Fare element (all represented in the model in Generalised Minutes)	Standard Interchanges	Purpose Built Interchanges	High Quality / Planned Interchanges
Bus	Fare	10.0	10.0	10.0
	Boarding	3.0	3.0	3.0
	Penalty	10.0	8.0	5.0
	Total	**23.0**	**21.0**	**18.0**
	Total (excluding fare)	13.0	11.0	8.0
Rail	**Fare**	10.0	10.0	10.0
	Boarding	3.0	3.0	3.0
	Penalty	7.5	5.5	2.5
	Total	**20.5**	**18.5**	**15.5**
	Total (excluding fare)	**10.5**	**8.5**	**5.5**

As WTSM captures ticket fare as a boarding penalty (unlike WPTM) it is difficult to compare the WPTM and WTSM node / line boarding penalties as one (WTSM) includes a fare component and the other (WPTM) does not include a fare component.

In order to enable comparisons between both models, the 'fare' and 'penalty' elements have been removed from the total node boarding penalties that are output from WTSM. The result is that the WTSM boarding penalty reported in this note is 3 minutes, across all modes and stop types.

Table 2-4 below shows the boarding penalties (excluding fare) for the two main modes (bus and rail) and three interchange categories (standard, purpose built, high quality) across both models. It can be seen that both models have the same hierarchy, with bus / standard interchange having the highest boarding penalty and rail / high quality interchange having the lowest boarding penalty.

Table 2-4: Comparison of WTSM / WPTM Boarding Penalties

Mode	Interchange	WTSM Penalty	WPTM Penalty
Standard Bus	Standard	13.0	5.5
	Purpose Built	11.0	4.5
	High Quality	8.0	4.5
Rail	Standard	10.5	2.5
	Purpose Built	8.5	1.0
	High Quality	5.5	1.0

Whilst the WTSM boarding penalties are higher in general than the comparable WPTM boarding penalties, given that the hierarchies are identical this means that both models capture the perceived attractiveness of different interchange / mode combinations in the same way.

Conclusion: Both WTSM and WPTM have node boarding penalties that vary according to the mode and quality of the stop / interchange. The categorisation of stops / interchanges and penalty values differ slightly between models.

Only WPTM includes a line boarding penalty.

WTSM includes the fare in the node boarding penalty. This has been removed for subsequent analysis to enable comparisons between both models.

In-Vehicle Time

The in-vehicle time is a product of the travel time function and mode specific IVT factors:

- WPTM = varies by mode and time period
    - Bus = 1.0
    - Flyer = 0.9
    - Rail = 0.88 (IP = 0.84)
    - Ferry = 0.7
- WTSM = varies by mode
    - Bus = 1.0
    - Rail = 0.9 (IP = 0.9)
    - Ferry = 0.7

Conclusion: The IVTs are similar between both models with three exceptions:

Rail is higher (0.9) in WTSM compared to WPTM (0.88/0.84).

The Airport Flyer is a separate mode in WPTM with its own IVT factor (0.9); no differentiation between standard bus and premium bus (Airport Flyer) is made in WTSM.

The WPTM Rail IVT factors vary between the AM peak and Inter peak.

Egress Time

Egress Time is determined according to highway network speed and distance and weighted by the following 'walk time perception value':

- WPTM Walk Time Perception Factor = 1.8
- WTSM Walk Time Perception Factor = 2.0

Conclusion: Minor difference resulting from calibration activity during development of WPTM (documented in TN19)

Default Walk Speeds

In both WPTM and WTSM, the default walk speed is set at 5kph. Given that both networks are identical (apart from the zone system, centroid connectors and a number of minor walk links) this should result in similar walk times in both models for journeys between, for example, Wellington Station and zones within the CBD.

Conclusion: Walk speeds are the same (5kph) for both models.

3 Travel Time Routes

In order to compare travel times between the WPTM and WTSM modelling system, a representative sample of 11 routes across the region were chosen, covering a number of different modes and corridors. Both the actual and perceived travel time between each origin and the destination zone (the Majestic Centre, Wellington) were obtained and broken down into their constituent components.

The data covers the AM peak only, with all travel times expressed in terms of demand weighted minutes.

The travel times are 'average' travel times across all permitted (used) paths between chosen the origin / destination (O-D) pairs. Therefore when WTSM and WPTM travel times are compared, differences between the two will be a function of differences between how both models represent the main drivers of travel time and route choice:

- Headway;
- Walk time (+ perception factor);
- Wait time (+ perception factor);
- IVT time (+ perception factor); and
- Dwell times.

Variations between both models will also reflect differences in network characteristics between the two models, namely centroid connectors and access to rail stations (Park and Ride (P&R) / Kiss and Ride (K&R) is modelled differently in WPTM compared with WTSM). The chosen journeys are listed below, together with a number of other characteristics such as origin zone, destination zone, distance and number of permitted paths.

Table 3-1 below compares the number of paths, distance and number of boardings for both WTSM and WPTM (WTSM Zone locations illustrated in Appendix B).

Table 3-1: Sample Journeys

Name	Origin	Destination	WTSM			WPTM			Distance (km)	Main Mode	Secondary Mode (if applicable)	Boardings
			Origin	Destination	WTSM Paths	Origin	Destination	WPTM Paths				
Johnsonville	Johnsonville	Majestic Centre	83	57	2	832	576	2	11	Bus	Rail	1
Waikanae	Waikanae	Majestic Centre	125	57	16*	1254	576	65*	60	Rail	Bus (feed to rail)	1.9/1.16
Porirua	Porirua	Majestic Centre	93	57	18	935	576	18	22	Rail	Bus (feed to rail)	1.09/1.07
Masterton	Masterton	Majestic Centre	210	57	1	2100	576	1	103	Rail		1
Upper Hutt	Upper Hutt	Majestic Centre	141	57	3	1412	576	3	36	Rail		1
Lower Hutt	Lower Hutt	Majestic Centre	177	57	4	1773	576	7	19	Rail		1
Seatoun	Seatoun	Majestic Centre	5	57	2	52	576	6	8	Bus		1
Airport	Airport	Majestic Centre	7	57	2	71	576	2	10	Bus		1
Island Bay	Island Bay	Majestic Centre	17	57	4	173	576	4	8	Bus		1
Karori	Karori	Majestic Centre	31	57	3	315	576	7	6	Bus		1
Hospital	Hospital	Majestic Centre	13	57	14	135	576	30	3	Bus		1

* difference caused by significant enhanced zone detail in WPTM compared with WTSM in Waikanae area

The main points that can be drawn from this are as follows:

- The number of permissible paths for each journey is generally greater in WPTM than WTSM. This is because WPTM has a more detailed network of centroid connectors than WTSM i.e. there is a finer zone system so it is likely that there will be differences in the way trips access the network along centroid connectors;
- Looking at the main mode for each journey, there is a fairly even split between rail and bus journeys. More detailed analysis (not presented above) shows that the main mode for each sample journey is the same in WTSM and WPTM;
- Out of the 11 sample journeys, two contain paths that involve a transfer between modes:
    - For the Waikanae journey, the majority of WPTM paths appear to involve a bus-rail transfer, as the average number of boards is 1.9;
    - In WTSM, the majority of paths used for the Waikanae journey do not involve an interchange, as the average number of boards is 1.16;
    - The reason for this difference is that the WTSM zone system in the Waikanae area is very coarse. The centroid connector is attached to the network at a point close to the rail station, meaning that walk is the dominant mode;
    - In WPTM the zone system is more detailed. In this instance the chosen zone is connected to the network approximately 1.1km from the rail station, meaning that rail access trips are split between walk and bus modes; and
    - For the Porirua journey, both WTSM and WPTM show that approximately 10% of paths involve a transfer between bus and rail.
- There are no transfers between rail and bus at Wellington Station in either model, showing that people are choosing to walk from Wellington Station to the final destination (Majestic Centre).

It should be noted that the number of boardings in Table 3-1 are taken directly from the list of permissible paths. Given that the permissible paths have not been demand weighted, the number of boards should not be used to conclude that “90% of journeys involve 2 or more modes” (using Waikanae as an example). Whilst this example shows that 90% of permissible paths involve 2 or more boards, in reality these paths might only be used by 10% of the overall demand between the O-D pair in question.

One caveat that should be made at this point is that access to rail stations is modelled differently in WTSM compared with WPTM:

- In **WPTM** all centroid connectors are attached to the highway network at suitable locations; the access choice component of WPTM distributes rail access trips across the permissible access modes (P&R, K&R and other), with the assignment model distributing ‘other’ access trips between bus and walk access.

The paths obtained from WPTM for this analysis will not include P&R / K&R paths, to ensure comparability between the WPTM and WTSM journeys.

- **WTSM** uses ‘P-connectors’, a system of direct links between rail stations and zones within the rail catchment area, to model access to rail stations. More detail on how this works in practice is included in TN23.

4 WPTM Travel Times

Figure 4-1 and Figure 4-2 show the travel time components in the validated 2011 version of WPTM between 11 origins and the Majestic Centre (on Willis St in the Wellington CBD).

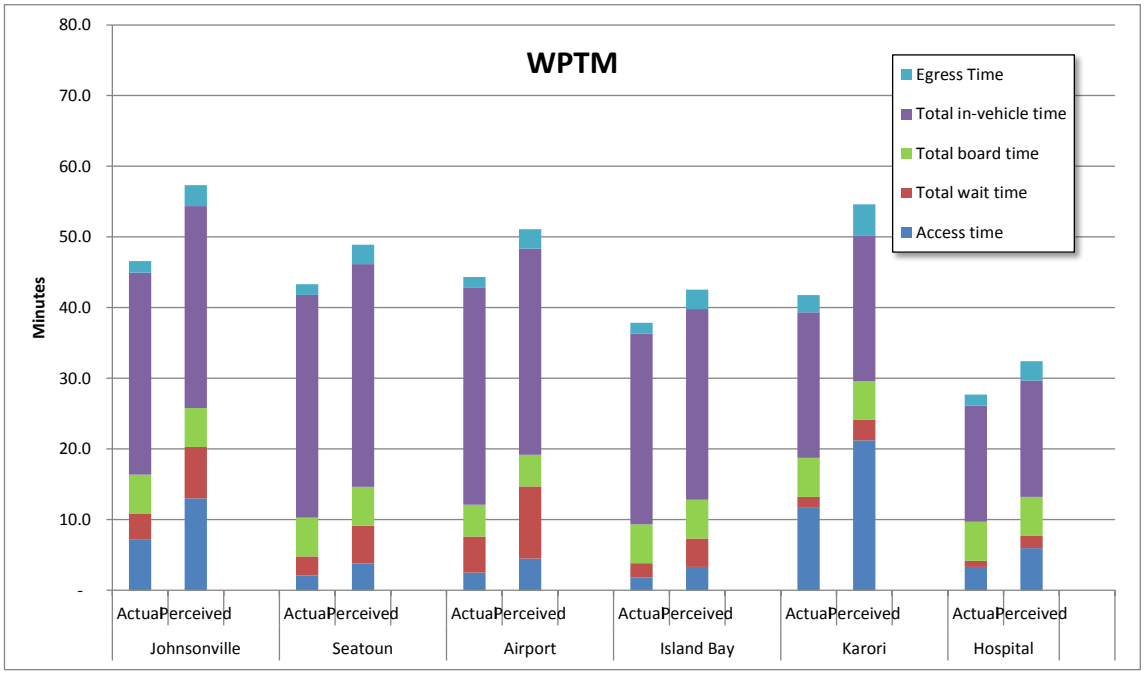


Figure 4-1: WPTM Actual and Perceived Travel Times to Wellington CBD (Bus)

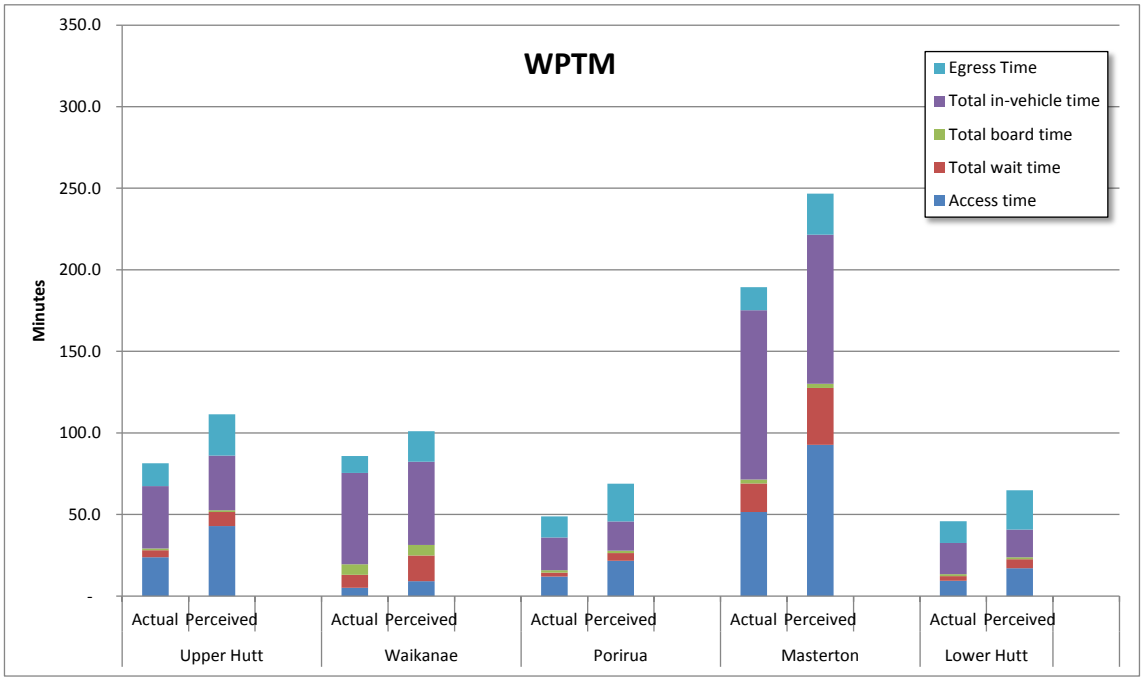


Figure 4-2: WPTM Actual and Perceived Travel Times to Wellington CBD (Rail)

Table 4-1 and Table 4-2 below tabulate the travel times for the routes shown in Figure 4-1 and Figure 4-2 above. The routes are split into two types:

- Short-distance routes along corridors within Wellington City where the primary mode is bus; and
- Longer distance routes along corridors where the primary mode is rail.

The purpose of splitting the routes into two sections is to show whether substantial differences occur in the representation of travel times across the two major modes within the region. The travel times are broken down into their constituent components, namely:

- Access Time;
- Total Wait Time;
- Total Board Time;
- Total In-Vehicle Time; and
- Egress Time.

Table 4-1: WPTM Travel Times (minutes) – Short Distance Journeys

Time Component	Johnsonville			Seatoun			Airport		
	Actual	Perceived	Diff	Actual	Perceived	Diff	Actual	Perceived	Diff
Access time	7.2	13.0	180%	2.1	3.8	180%	2.5	4.5	180%
Total wait time	3.6	7.3	200%	2.7	5.4	200%	5.1	10.2	200%
Total board time	5.5	5.5	100%	5.5	5.5	100%	4.5	4.5	100%
Total in-vehicle time	28.6	28.6	100%	31.5	31.5	100%	30.7	29.2	95%
Egress Time	1.6	3.0	180%	1.5	2.8	179%	1.5	2.8	179%
TOTAL	**46.6**	**57.3**	**123%**	**43.3**	**48.9**	**113%**	**44.3**	**51.1**	**115%**

Time Component	Island Bay			Karori			Hospital		
	Actual	Perceived	Diff	Actual	Perceived	Diff	Actual	Perceived	Diff
Access time	1.8	3.3	180%	11.8	21.2	180%	3.3	6.0	180%
Total wait time	2.0	4.0	200%	1.5	2.9	200%	0.9	1.7	200%
Total board time	5.5	5.5	100%	5.5	5.5	100%	5.5	5.5	100%
Total in-vehicle time	27.0	27.0	100%	20.6	20.6	100%	16.5	16.5	100%
Egress Time	1.5	2.8	179%	2.4	4.4	180%	1.5	2.8	179%
TOTAL	**37.9**	**42.5**	**112%**	**41.8**	**54.6**	**131%**	**27.7**	**32.4**	**117%**

Table 4-1 shows the following:

- The access time is relatively short for all journeys, except Karori. The zone in Karori is around 700m from the closest bus stop. Therefore, as the access time is a function of walk distance from the zone centroid to the chosen bus stop, a perceived access time of 21 minutes seems reasonable. The nearest bus stop is very close to the origin zone for the other 3 chosen O-D pairs, hence the short access time.
- For the Karori journey, there appears to be a trade-off between walking further to catch a high-frequency service instead of walking a slightly shorter distance to catch a less frequent service.
- Both the actual and perceived wait times appear to have been calculated correctly. The four chosen origin zones lie within close proximity to high frequency core bus routes, hence the short wait time in all instances.

- Boarding times are identical for all routes, apart from the Airport route where the boarding time is 1 minute less, as the Airport Flyer has a lower line boarding penalty (2 minutes) than standard bus (3 minutes).
- In-vehicle time appears reasonable for all routes in question. Karori is the quickest route – this seems intuitive as it is the shortest of the 4 journeys in question and also contains several stretches of bus lane.
- Egress time is short for all O-D pairs as the destination zone is adjacent to the Golden Mile, along which all major bus services run. The egress time for the Karori journey is different to that for the other three journeys as the bus services will run southbound along the Golden Mile (the other three journeys will run northbound along the Golden Mile).

Table 4-2: WPTM Travel Times (minutes) – Longer Distance Rail Journeys

Time Component	Upper Hutt			Waikanae			Porirua		
	Actual	Perceived	Diff	Actual	Perceived	Diff	Actual	Perceived	Diff
Access time	23.9	43.0	180%	5.0	9.1	180%	12.0	21.7	180%
Total wait time	4.3	8.6	200%	7.9	15.9	200%	2.4	4.7	200%
Total board time	1.0	1.0	100%	6.5	6.5	100%	1.5	1.5	100%
Total in-vehicle time	38.2	33.6	88%	56.0	50.9	91%	20.1	17.8	89%
Egress Time	14.0	25.2	180%	10.4	18.8	180%	12.9	23.2	180%
TOTAL	**81.4**	**111.4**	**137%**	**85.9**	**101.1**	**118%**	**48.8**	**68.8**	**141%**

Time Component	Masterton			Lower Hutt		
	Actual	Perceived	Diff	Actual	Perceived	Diff
Access time	51.5	92.8	180%	9.5	17.0	180%
Total wait time	17.4	34.9	200%	2.8	5.5	200%
Total board time	2.5	2.5	100%	1.2	1.2	100%
Total in-vehicle time	103.8	91.3	88%	19.1	17.0	89%
Egress Time	14.0	25.3	180%	13.3	24.0	180%
TOTAL	**189.3**	**246.7**	**130%**	**45.9**	**64.8**	**141%**

Table 4-2 shows the following:

- Access time varies across the chosen O-D pairs, depending on the distance between the origin zone and chosen public transport stop (rail or bus). Upper Hutt has the longest access time as the chosen zone is a 1.6km walk from Upper Hutt station.
- As wait time is a function of headway it is reasonable that the Lower Hutt journey (which uses Waterloo station) has the shortest wait time.
- The boarding penalty is 1 minute for both the Lower Hutt and Upper Hutt journeys, signifying that superior quality stations (with node boarding penalty = 0 min) are used for these journeys. The main mode for the Johnsonville journey is bus, hence the total boarding penalty is 6 minutes (stop = 3 min, line = 3 min).
- The Waikanae boarding penalty is 6 minutes. This can be explained by referring back to Table 3-1, which shows that 90% of paths for the Waikanae journey involve a bus to rail transfer at Waikanae station. Therefore the boarding penalty is a combination of the line / node boarding penalties for both the bus and rail legs of this journey.
- The actual in-vehicle times for Waikanae, Lower Hutt and Upper Hutt match the timetabled journey times, with the perceived journey times being 10% less, due to the effect of the rail IVT.
- Egress time for the Johnsonville journey is short, because as mentioned previously, the Golden Mile bus stops are very close to the destination zone. All other journeys involve

a short walk from the rail station to the destination zones, hence the slightly longer egress time.

Egress times from Wellington station to the Majestic Centre vary slightly across the 3 rail services. We might expect these times to be identical as all journeys end at Wellington Station and then walk (from the station) to access the zone.

5 WTSM Travel Times

Figure 5-1 and Figure 5-2 show the travel time components in a validated 2011 version of WTSM between 11 origins and the Majestic Centre (on Willis St in the Wellington CBD)[2].

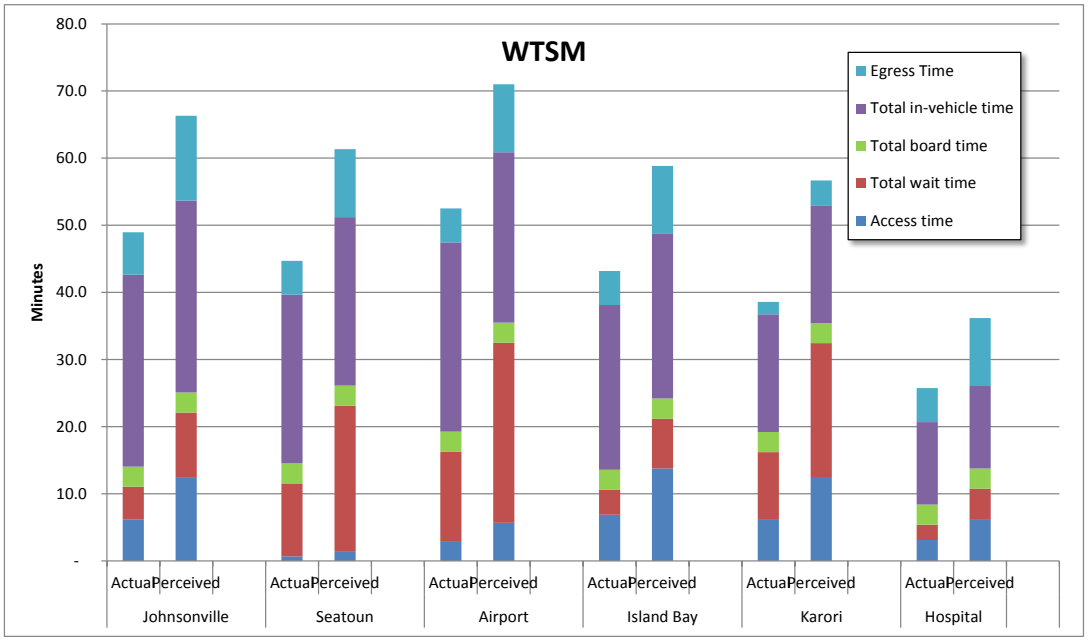


Figure 5-1: WTSM – Actual and Perceived Travel Times to Wellington CBD (Bus)

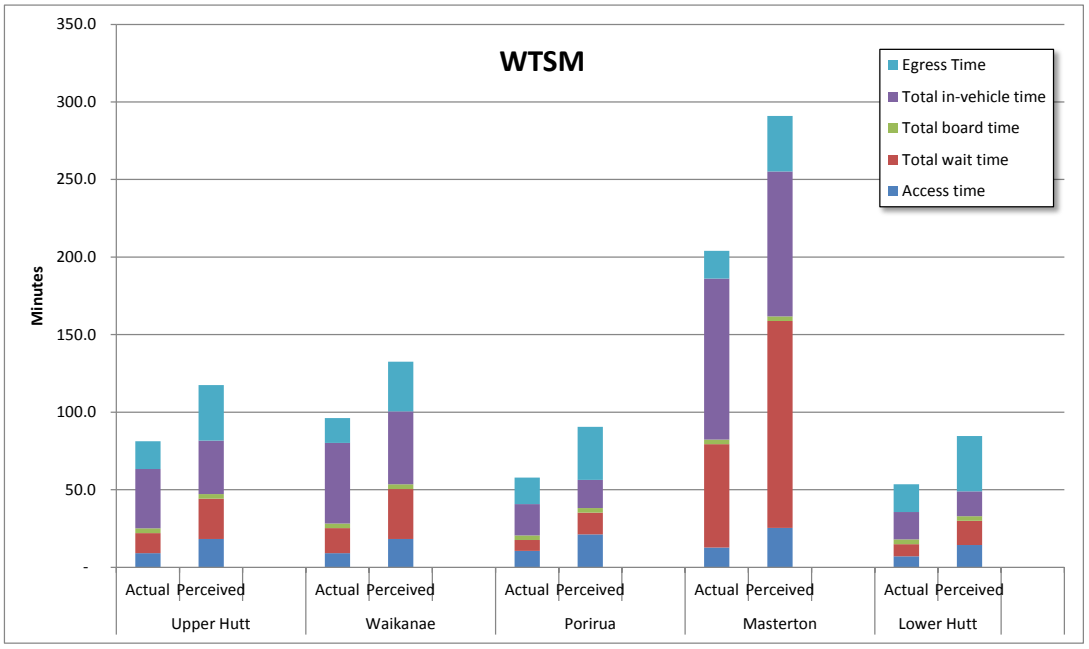


Figure 5-2: WTSM – Actual and Perceived Travel Times to Wellington CBD (Rail)

[2] While the results were produced using a validated version of the model it was not the final version of the model. At the time of writing minor changes were being considered for the base 2011 model. As the purpose of the Tech Note was to compare the models – as long as they used the same networks and services it was not considered worthwhile rerunning the analysis

Table 5-1 and Table 5-2 below tabulate the travel times for the routes shown in the figures above. The routes are split into two types:

- Short-distance routes along bus corridors within Wellington City; and
- Longer distance routes along rail corridors.

The purpose of splitting the routes into two sections is to show whether substantial differences occur in the representation of travel times across the two major modes within the region.

The travel times are broken down into their constituent components, namely:

- Access Time;
- Total Wait Time;
- Total Board Time;
- Total In-Vehicle Time; and
- Egress Time.

Table 5-1 shows the following:

- The access time varies across the 6 chosen journeys, as it is related to the distance between the origin zone and boarding bus stop. The distance between the Seatoun / Airport zones and their respective origin bus stops is fairly short; the access distance is slightly longer for Karori / Island Bay.
- The actual wait time varies from 4 minutes for the Island Bay journey (implying an 8 minute headway) to 13 minutes for the Airport journey (implying a 26 minute headway).
- The boarding time penalty is 8 minutes for all journeys.
- The modelled in-vehicle time seems reasonable for all chosen journeys.
- The egress time is fairly short, given that the destination zone is adjacent to the main PT thoroughfare in Wellington.

Table 5-1: WTSM Travel Times (minutes) – Short Distance Journeys

Time Component	Johnsonville			Seatoun			Airport		
	Actual	Perceived	Diff	Actual	Perceived	Diff	Actual	Perceived	Diff
Access time	6.2	12.4	200%	0.7	1.4	200%	2.8	5.7	200%
Total wait time	4.8	9.7	200%	10.9	21.7	200%	13.4	26.8	200%
Total board time	3.0	3.0	100%	3.0	3.0	100%	3.0	3.0	100%
Total in-vehicle time	28.6	28.6	100%	25.1	25.1	100%	28.2	25.4	90%
Egress Time	6.3	12.6	200%	5.1	10.1	200%	5.1	10.1	200%
TOTAL	**49.0**	**66.3**	**135%**	**44.7**	**61.3**	**137%**	**52.5**	**71.0**	**135%**

Time Component	Island Bay			Karori			Hospital		
	Actual	Perceived	Diff	Actual	Perceived	Diff	Actual	Perceived	Diff
Access time	6.9	13.8	200%	6.2	12.5	200%	3.1	6.2	200%
Total wait time	3.7	7.4	200%	10.0	19.9	200%	2.3	4.5	200%
Total board time	3.0	3.0	100%	3.0	3.0	100%	3.0	3.0	100%
Total in-vehicle time	24.5	24.5	100%	17.5	17.5	100%	12.3	12.3	100%
Egress Time	5.1	10.1	200%	1.8	3.7	200%	5.1	10.1	200%
TOTAL	**43.2**	**58.8**	**136%**	**38.6**	**56.7**	**147%**	**25.7**	**36.2**	**141%**

Table 5-2 shows the following:

- Access time varies widely across the 4 chosen O-D pairs, depending on the proximity of the origin zone to the boarding station.
- Wait time varies according to service frequency, with Johnsonville / Lower Hutt having shorter wait times that Upper Hutt / Waikanae, due to increased service frequencies at the former two locations.
- The boarding time penalty is 8 minutes for Johnsonville / Waikanae and 1 minutes for Lower Hutt / Upper Hutt.
- The in-vehicle times for all journeys are similar to the timetabled travel times.
- Egress time for the Waikanae, Lower Hutt and Upper Hutt rail services are broadly similar. Egress time for the Johnsonville journey is considerably less as buses run down the Golden Mile and stop adjacent to the destination zone.

Table 5-2: WTSM Travel Times (minutes) – Longer Distance Rail Journeys

Time Component	Upper Hutt			Waikanae			Porirua		
	Actual	Perceived	Diff	Actual	Perceived	Diff	Actual	Perceived	Diff
Access time	9.1	18.2	200%	9.1	18.2	200%	10.6	21.2	200%
Total wait time	13.0	26.0	200%	16.1	32.3	200%	7.0	14.0	200%
Total board time	3.0	3.0	100%	3.0	3.0	100%	3.0	3.0	100%
Total in-vehicle time	38.3	34.5	90%	51.9	47.0	90%	20.1	18.2	91%
Egress Time	17.9	35.8	200%	16.1	32.1	200%	17.1	34.2	200%
TOTAL	**81.3**	**117.5**	**145%**	**96.3**	**132.6**	**138%**	**57.8**	**90.6**	**157%**

Time Component	Masterton			Lower Hutt		
	Actual	Perceived	Diff	Actual	Perceived	Diff
Access time	12.7	25.4	200%	7.2	14.3	200%
Total wait time	66.7	133.3	200%	7.8	15.6	200%
Total board time	3.0	3.0	100%	3.0	3.0	100%
Total in-vehicle time	103.8	93.4	90%	17.8	16.0	90%
Egress Time	17.9	35.8	200%	17.9	35.8	200%
TOTAL	**204.1**	**291.0**	**143%**	**53.6**	**84.7**	**158%**

6 Comparisons between WPTM and WTSM Travel Times

6.1 Perception Factors

As noted in Section 1, there are some subtle differences between WPTM and WTSM regarding the application of perception factors. The main differences are as follows:

WTSM Walk Time Perception factor = 2.0

WPTM Walk Time Perception Factor = 1.8

WTSM Rail IVT = 0.90

WPTM Rail IVT = 0.88 (AM Peak), 0.84 (Inter Peak)

Additional mode specific wait time factors in WPTM (not a feature in WTSM)

From analysing the model results, these perception factors are applied correctly. Whilst they do account for some of the differences between the two models, their impact is minimal.

Using the example of a 20 min walk trip (actual time), such a journey would be perceived as a 36 minute journey in WTSM but a 40 minute journey in WPTM. Given the size of these differences, it is thought unlikely that such small differences would materially affect the chosen routings in either model. Additionally the walk access is only part of the generalised cost (GC) of a trip so the difference in GC would be even smaller.

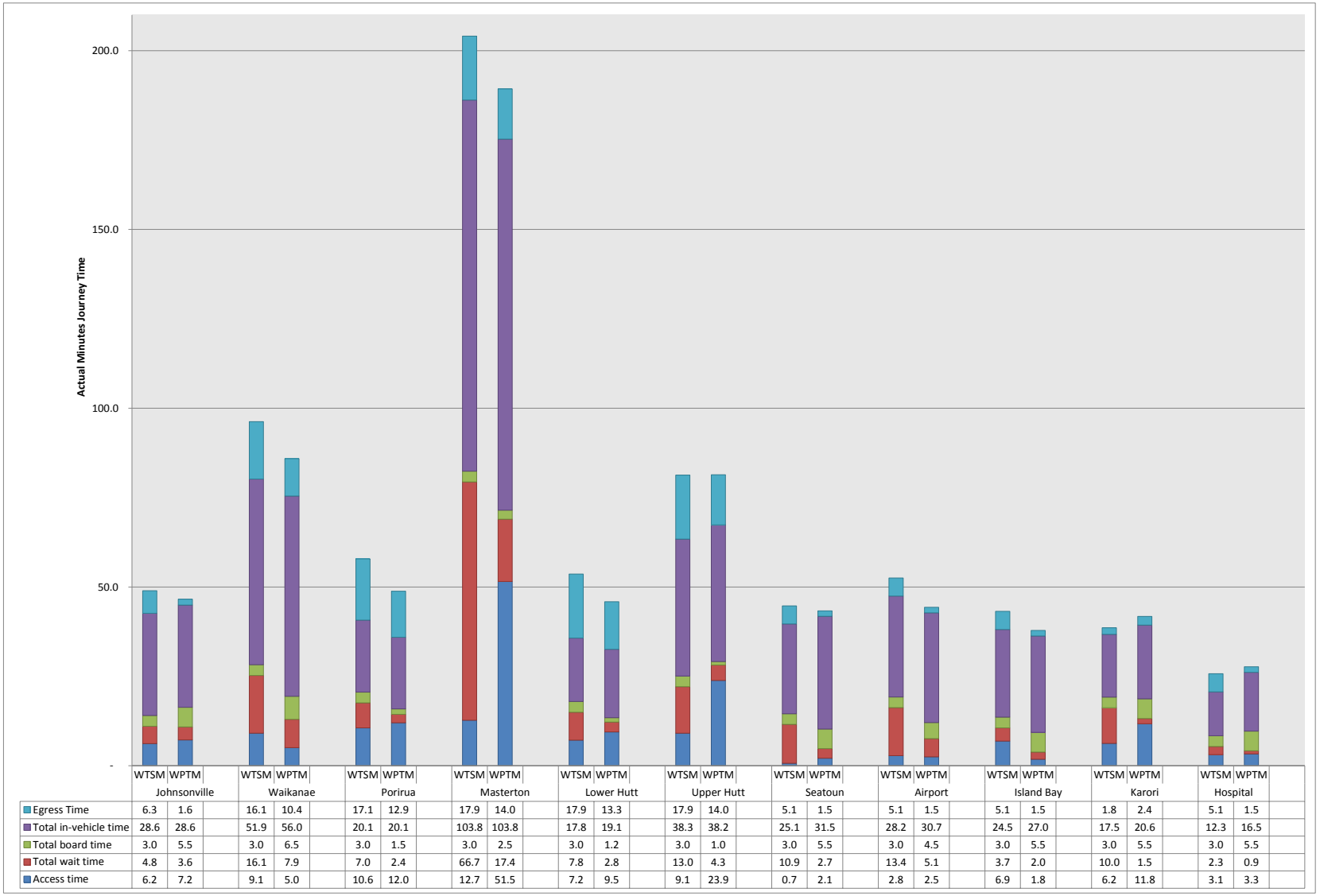
Similarly with the rail IVT factors, a trip from Waikanae to Wellington in WPTM would be perceived as taking 48.5 minutes in WPTM and 49.5 minutes in WTSM. Again, such differences are unlikely to affect modelled routings.

Therefore the analysis of differences between both models presented below is confined to looking at the actual values, as the same general conclusions could be applied to the perceived values used in both models.

6.2 Overall Comparison

Figure 6-1 below shows the total actual travel time between the eleven chosen journeys according to WTSM and WPTM. In general, overall journey times compare well between the two models however there are significant differences in wait times and access times (fortunately they offset each other).

In terms of average speed, all bus journeys have average door-to-door speeds of less than 10kph. Whilst this appears low, it should be noted that these times include access / egress legs (where walk speed = 5kph) and also include boarding time penalties that perhaps shouldn't be included when calculating actual journey time (and speed). In WPTM the in-vehicle time component of each journey is around 50% of the total journey time; this implies average bus speeds of between 12kph and 20kph, a range that seems fairly reasonable.



	WTSM	WPTM	WTSM	WPTM	WTSM	WPTM	WTSM	WPTM	WTSM	WPTM	WTSM	WPTM	WTSM	WPTM	WTSM	WPTM	WTSM	WPTM	WTSM	WPTM	WTSM	WPTM	WTSM	WPTM
	Johnsonville		Waikanae		Porirua		Masterton		Lower Hutt		Upper Hutt		Seatoun		Airport		Island Bay		Karori		Hospital			
Egress Time	6.3	1.6	16.1	10.4	17.1	12.9	17.9	14.0	17.9	13.3	17.9	14.0	5.1	1.5	5.1	1.5	5.1	1.5	1.8	2.4	5.1	1.5		
Total in-vehicle time	28.6	28.6	51.9	56.0	20.1	20.1	103.8	103.8	17.8	19.1	38.3	38.2	25.1	31.5	28.2	30.7	24.5	27.0	17.5	20.6	12.3	16.5		
Total board time	3.0	5.5	3.0	6.5	3.0	1.5	3.0	2.5	3.0	1.2	3.0	1.0	3.0	5.5	3.0	4.5	3.0	5.5	3.0	5.5	3.0	5.5		
Total wait time	4.8	3.6	16.1	7.9	7.0	2.4	66.7	17.4	7.8	2.8	13.0	4.3	10.9	2.7	13.4	5.1	3.7	2.0	10.0	1.5	2.3	0.9		
Access time	6.2	7.2	9.1	5.0	10.6	12.0	12.7	51.5	7.2	9.5	9.1	23.9	0.7	2.1	2.8	2.5	6.9	1.8	6.2	11.8	3.1	3.3		

Figure 6-1: Comparison Between WTSM and WPTM Modelled Travel Times

The main differences between the WPTM and WTSM end-to-end journey times are as follows:

- For shorter trips there are differences in access times between the two models because WPTM uses a more detailed zone system compared to WTSM. In general the WPTM access time is lower. For longer trips access time is generally similar between the two models. The exception is Upper Hutt, where the WPTM access time is longer than the WTSM access time. This can be explained in terms of the zone system; in WPTM the distance between the chosen origin zone and Upper Hutt station is 1.6km, whereas in WTSM that distance is reduced to 500m. If the distance between the chosen origin and Upper Hutt station were identical in both models, the difference in end-to-end journey times between both models would be much reduced.
- For shorter trips WPTM wait time is consistently lower than WTSM wait time due to differences in the way that wait times are calculated. For longer trips WPTM wait time is generally under half of the WTSM wait time value (in some instances considerably more), due to previously highlighted differences in how the two models represent wait times.
- For the Karori journey, the chosen path in WPTM involves a long access leg (12 min) and a short wait time (1 min). In WTSM, however, the access time is much shorter but the wait time much longer, implying that the chosen path in WPTM uses a closer bus stop (with a more infrequent service). This highlights the trade off in both models between walking and waiting.
- Line / Node boarding penalties are broadly similar between both models (once the fare component is removed from the WTSM boarding time penalties).
- In-vehicle times are very similar between both models. Given that both models use the same highway speeds, travel times functions and dwell times this is not surprising.
- Egress time is also similar between both models for shorter trips. For longer trips WTSM egress times are generally a little longer than WPTM egress times, due to the coarser zone system compared in WTSM.

7 Conclusions

This technical note documents the WPTM and WTSM O-D travel times for 11 chosen routes across the Wellington region. The routes were chosen in order to capture a representative sample of both short and long distance trips covering both of the main modes (bus and rail). The purpose of these comparisons was to draw attention to areas where both models generate similar results and areas where both models produce different results.

The end to end travel time for each O-D was broken down into its constituent components and general trends from the comparisons undertaken are as follows:

- Overall: WTSM actual travel times range from being 8% less than (faster than) WPTM travel times to being 19% greater than (slower than) WPTM travel times.
- Access Time: WTSM access time is consistently longer than WPTM access time, due to differences in the zone systems between the two models.
- Wait Time: the WPTM wait time is generally less than half of the corresponding WTSM wait time, due to differences in how both models represent the wait time. The differences are most pronounced for short journeys (where wait time is a high percentage of overall journey time) and journeys with long headways.
- The line and node boarding penalties are broadly similar for both models. Confirmation was required regarding the WTSM categorisation of stops / station by category (standard, high, superior), to enable direct comparisons with the WPTM categorisation and chosen node boarding penalties.
- The in-vehicle time is similar for both models. Given that the same rail timetables and bus travel times have been used in WPTM and WTSM this is to be expected.
- The wait time difference is the main factor driving differences in overall journey times between the two models. Differences in access / egress times due to the zone system are both secondary factors.

The team have concluded from the analysis that WTSM and WPTM produce broadly similar travel times, particularly for in-vehicle time. Where there are differences it will be important for projects teams using both models to monitor the results. Specifically, teams will need to be mindful of:

- **Differences in access times**. WPTM offers significant improvement in the modelling of the access leg of public transport journeys. Therefore, options that that are designed to generate a mode shift in WTSM from changes in access are unlikely to achieve a level of accuracy comparable to WPTM.
- **Differences in wait times**. As mentioned above, there are significant differences in wait times for both models. The team advises that mode shift in WTSM resulting from increased frequencies be monitored closely (particularly for services with high headways in base case scenarios). For example, the addition of one extra service on the Wairarapa line will result in substantially lower modelled travel times.

Given that the purpose of this technical note was to get an indication of similarities and differences between both WTSM and WPTM regarding the representation of the various components of a typical journey in both models, it was decided that a sample of 11 routes from around the region to one central destination in Wellington would be sufficient to allow valid conclusions to be drawn.

Whilst it would be beneficial to look at different destinations (such as Courtenay Place and Wellington Station), this was not possible as a result of time constraints. It is felt, however, that even if other routes were analysed, the general conclusions would be similar to the conclusions that have been outlined in this note.

APPENDIX A – Sample Macro using Module 6.27

```
~o=39

~# Results are saved to a file TRANSIT_PATHS_s*****

~# %1% = peak period to model   (AM/IP)
~# %2% = scenario to get results from
~# %3% = origin zone(s) eg 832;1254;935;2100;1412;1773;52;71;173;315;135
~# %4% = destination zone(s) eg 576
~# %5% = 1 (actual components) or 2 (perceived component)


s=%2%

~!if exist .\reports\timeComponents_%1%_%s%.rep del .\reports\timeComponents_%1%_%s%.rep
reports=.\reports\timeComponents_%1%_%s%.rep

~+;6.27
~+;5
~+;2
~+;1                    # all paths
~+;3
~+;y                    # total transit impedance
~+;3                    # time components to compute - selected
~+;y                    # first waiting time
~+;y                    # total waiting time
~+;y                    # first boarding time
~+;y                    # total boarding time
~+;y                    # in-vehicle time
~+;y                    # auxiliary transit time
~+;3                    # cost components to compute - selected
~+;y                    # first boarding cost
~+;y                    # total boarding cost
~+;y                    # in-vehicle cost
~+;y                    # auxiliary transit cost
~+;%5%                  # actual/perceived components
~+;y                    # distance
~+;y                    # number of boardings
~+;3                    # items to output for paths - selected
~+;y                    # zone numbers
~+;y                    # path number
~+;y                    # proportion
~+;y                    # volume
~+;y                    # computed attribute
~+;3                    # items to output along paths - selected
~+;n                    # node numbers
~+;y                    # mode
~+;y                    # line
~+;n                    # details of auxiliary transit subpaths
~+;y                    # computed attributes
~+;3                    # items to output for O-D pairs - selected
~+;y                    # zone numbers
~+;y                    # number of paths
~+;y                    # demand
~+;y                    # computed attributes
~+;
~+;
~+;y
~+;%3%
~+;
~+;%4%
~+;
~+;2
~+;7

reports=?
```

~/finished outputPaths

APPENDIX B – Journey Origins and Destination

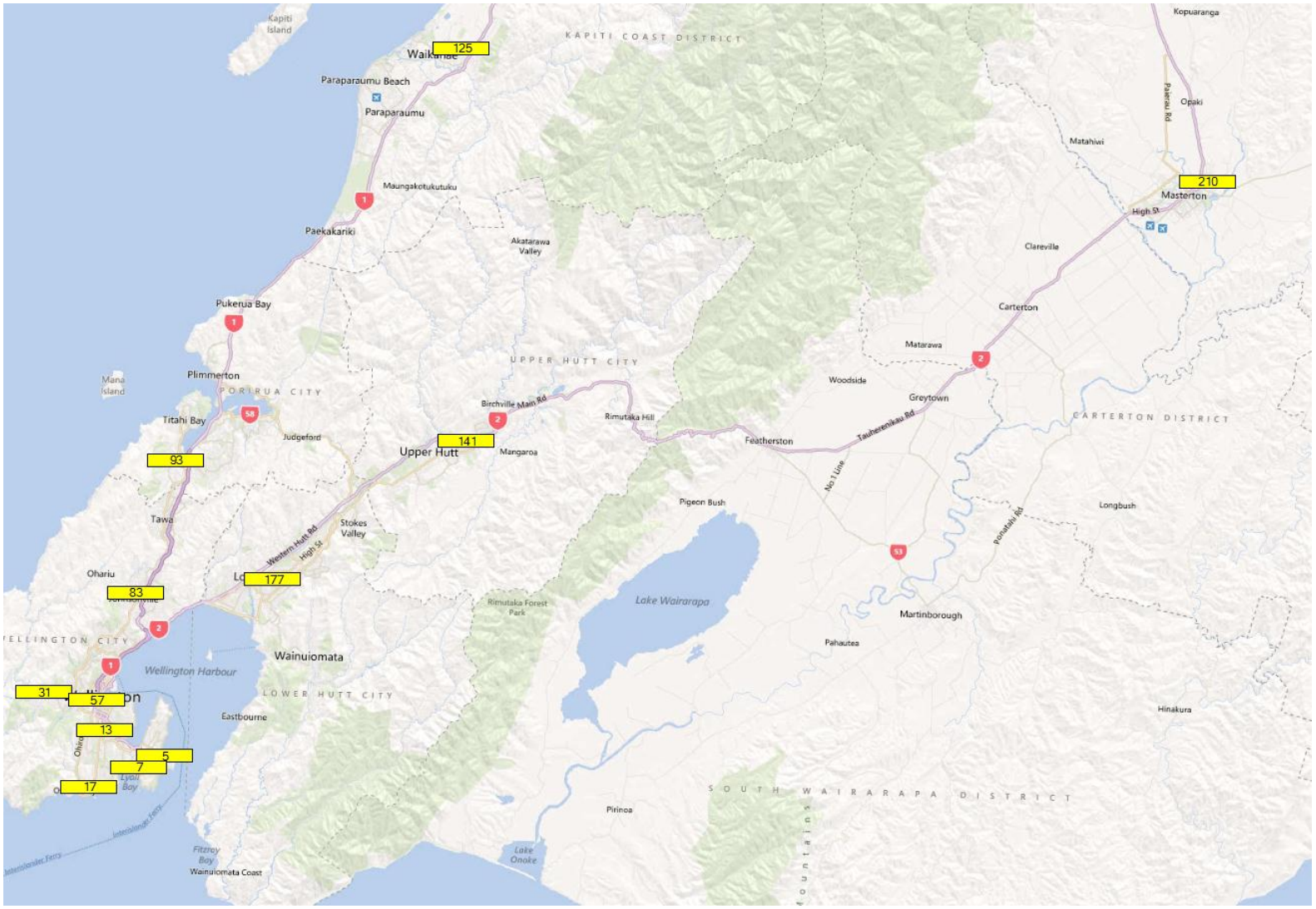


Figure 1: Region Map of Zone locations

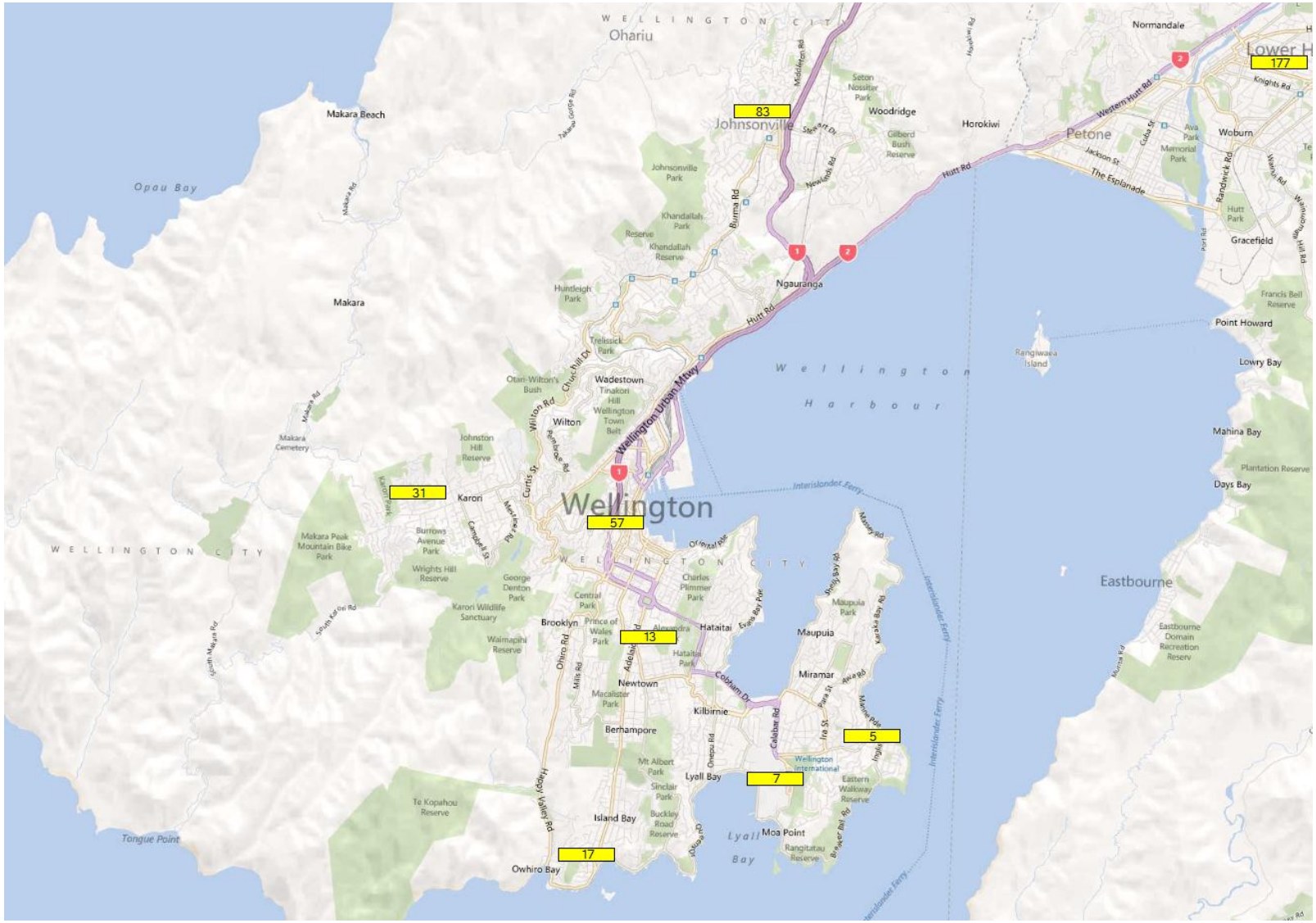


Figure 2: Wellington City Map of Zone locations