greater WELLINGTON
REGIONAL COUNCIL
Te Pane Matua Taiao

PTSS Short List Evaluation - Modelling Report

Data and Analysis Team, Strategic Planning

For more information, contact Greater Wellington:

Andy Ford
Wellington
PO Box 11646

T 04 830 4266
F 04 385 6960
www.gw.govt.nz

June 2013

www.gw.govt.nz
info@gw.govt.nz

Contents

1. Introduction

The Public Transport Spine Study (PTSS) is a study looking at options for improving public transport along a core spine between Wellington Station, Courtenay Place and Newtown/ Kilbirnie.

The first phase of the project, completed in April 2012, was a long list evaluation of potential option / route alignments for improving public transport between Wellington Station, Courtenay Place and Newtown.

Following the conclusion of this phase, eight potential options, for different modes and alignments, were taken forward to be studied in more detail at the medium list stage.

The medium list phase of the project was completed in July 2012, with three chosen options chosen for assessment at the short list phase:

- BP (BP) – Central Alignment;
- Bus Rapid Transit (BRT) – Central Alignment; and
- Light Rail Transit (LRT) – Central Alignment.

Following discussions between project partners and stakeholders at the start of the short list phase, it was decided that the study area needed to be widened to look at the whole of south-east Wellington, an area encompassing:

- Newtown;
- Kilbirnie;
- Island Bay;
- Lyall Bay;
- Miramar; and
- Wellington Airport.

The study was led by Greater Wellington Regional Council (GWRC), supported by project partners NZTA and WCC, with AECOM the lead consultant. In addition to reports produced at the medium and long list phases of the project, a full set of documentation can be found by using the link at:

http://www.gw.govt.nz/ptspinestudy/

The short list evaluation is underpinned by transport modelling that has been undertaken by GWRC using the Wellington Transport Strategy Model (WTSM), the Wellington Public Transport Model (WPTM) and the Wellington Highway Traffic Model (WTM).

The project consultant, AECOM, have produced three relatively high level reports for this final stage of the project:

- Executive Summary Report;
- Summary Report; and
- Option Evaluation Report.

This modelling report accompanies the Option Evaluation Report and documents the modelling system, assumptions and results in a greater level of detail.

The content of the report is as follows:

- a brief overview of the modelling system used for the **long and medium list evaluation**;
- a **baseline assessment** of current and future travel demand and travel times;
- a **corridor and route evaluation** documenting how the chosen options were selected;
- a description of the **modelling system** used for the short list evaluation;
- descriptions of each of **the three chosen options**;
- **results** from each of the chosen options are presented;
- the **time and monetised benefits** from each option are summarised; and
- results from a number of **model sensitivity tests** are presented.

The following appendices also accompany the report. Note that the appendix number relates to the chapter that it accompanies:

- **Appendix 6** – ETM Boardings (CONFIDENTIAL)
- **Appendix 7 –** WTM Highway Capacities;
- **Appendix 8** – Modelling of Transfers in WTSM and WPTM;
- **Appendix 9.1** – Additional Modelling Results;
- **Appendix 9.2** – PT Indicators;
- **Appendix 9.3** – Highway Indicators; and
- **Appendix 10** – PT Time Benefits.

2. Long and Medium List Evaluation

This section of the report outlines modelling work that was undertaken as part of the long list and medium list evaluation phases of this project.

2.1 Long List Evaluation

No modelling was undertaken for the long list evaluation

An original list of 88 options was assessed and simplified into six public transport modal options and five alignment options.

The six options that were evaluated were:

- personalised rapid transit (‘pods’);
- mini-buses;
- on-street buses;
- bus rapid transit;
- light rail; and
- heavy rail.

The various options were assessed according to:

- attractiveness to users;
- engineering feasibility;
- accessibility;
- ability to support forecast demand;
- financial viability;
- environmental impacts; and
- safety.

Several modes and alignments were ruled out and a final list of eight options was taken forward to the medium list assessment:

- two high quality on-street bus options along a central alignment (essentially the Golden Mile) or along a waterfront alignment (essentially following the Quays), with both options then continuing south along Kent / Cambridge Terrace, through to Adelaide Road;

- two bus rapid transit options along the same two alignments as above;
- two light rail transit options along the same two alignments as above;
- a heavy rail extension underground along an alignment to be determined; and
- a heavy rail extension at street level along a waterfront alignment.

2.2 Medium List Evaluation

The medium list assessment of options was a 'technical, broad brush' assessment in contrast to the 'high level, strategic' assessment undertaken at the long list stage.

The options were assessed using a multi-criteria evaluation framework, supported by technical assessments covering:

- engineering assessment
- social/ cultural assessment;
- urban planning/ design;
- statutory planning evaluation;
- transport modelling; and
- cost estimation.

The eight options were assessed against these criteria and ranked, relative to the base situation.

2.2.1 Modelling Assumptions

The medium list modelling used the 2006 WTSM as the new 2011 version of the model was not ready at this time.

The AECOM technical note "Wellington PT Spine Study – Medium List Modelling Assumptions", 1st May 2012, covers the assumptions in more detail.

All eight reported options were modelled using the same generic alignment through Wellington CBD as additional detail was not required for this stage of the project.

Decisions relating to stop location, exact alignments and under vs overground heavy rail were not deemed essential until the short list stage of the study.

The model was run for a single year, 2041, using a medium land use forecast. The base scenario included all do minimum projects, namely projects within Wellington CDB and all of the Wellington RoNS schemes.

2.2.2 Outcome

The result of the medium list multi-criteria analysis was that the following options were taken forward to the more detailed short list phase:

- BP – Central Alignment;
- BRT – Central Alignment; and
- LRT – Central Alignment.

2.3 Summary

- the **long list evaluation considered 88 potential modal / alignment options**, selecting eight preferred options for the medium list;
- the **medium list considered these eight options** in more detail;
- the **medium list modelling assumptions** were fairly generic across all options, thus making it hard to differentiate between them;
- three central alignment options – **BP, BRT and LRT** – were selected from the medium list for **further consideration at the short list phase;** and
- **the short list modelling framework** was designed to provide sufficient detail to allow for differentiation between the options.

3. Modelling System

This section outlines the transportation models that are used for the short-list evaluation and is structured as follows:

- overview of modelling system;
- Wellington Transport Model 2009 (WTM);
- Wellington Transport Strategy Model 2011 (WTSM); and
- Wellington Public Transport Model 2011 (WPTM).

3.1 Overview

The three models that are used for the PTSS assessment are detailed in **Figure 3.1** overleaf.

The strategic WTSM model covers the whole of the region and uses land use forecasts, population estimates and household trip rates to generate demand for a range of forecast years.

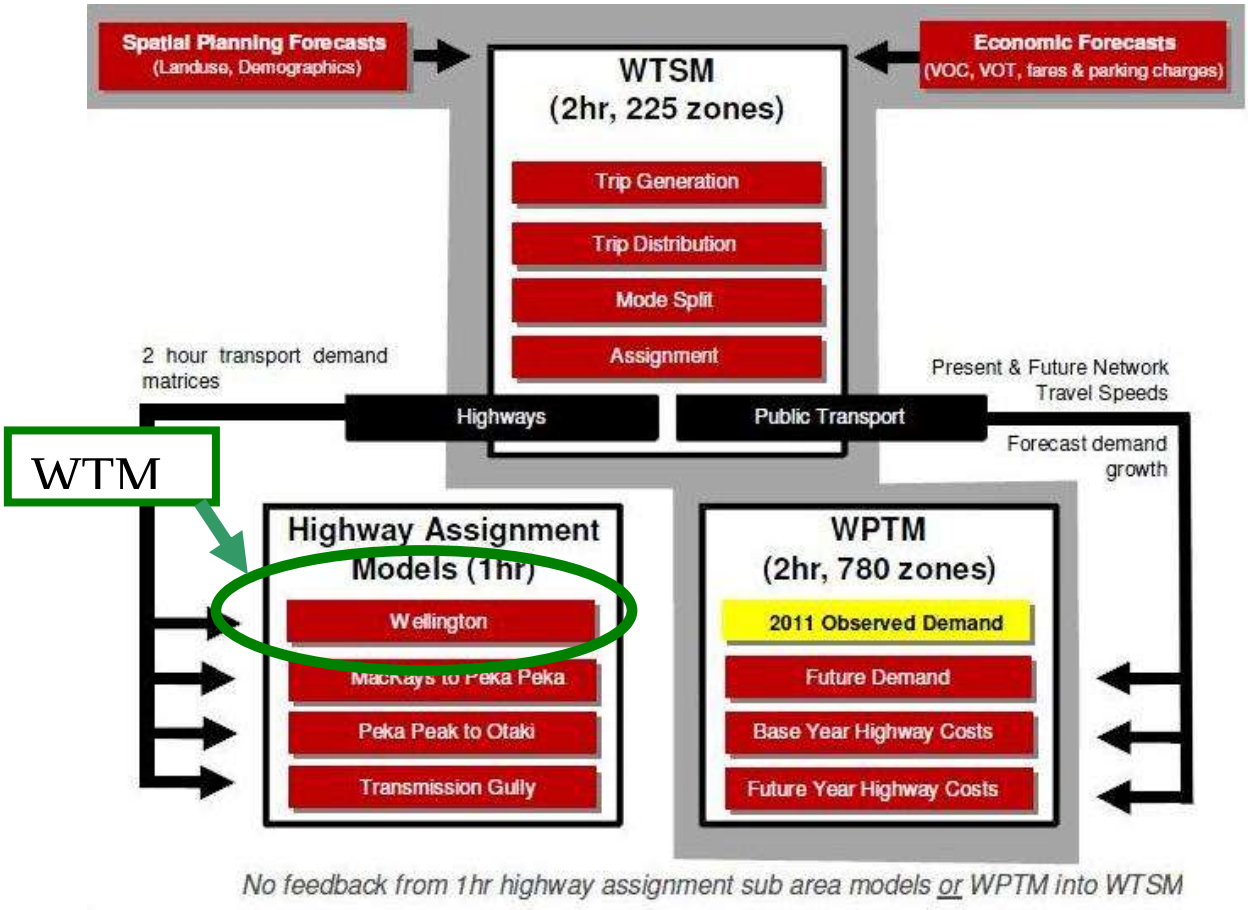
As the PTSS is a detailed study focussing on public transport improvements within Wellington, WPTM was chosen for the detailed public transport assessment.

WPTM is a bespoke public transport model built from observed data, in order to improve the representation of public transport trips within the region.

The PTSS study is primarily a public transport study and with this in mind, it was determined that WTSM was adequate for the assessment of highway benefits and impacts.

It was, however, decided that the more detailed WTM could be used to provide inputs to the strategic model to improve the representation of capacities at key intersections within the study area.

Figure 3.1 Wellington Transport Modelling System



3.2 Wellington Transport Strategy Model (WTSM)

The WTSM has a base year of 2011 and is the 'parent' model for both WPTM and WTM.

WTSM takes land use forecasts, demographic forecasts and economic parameters, such as a person's value of time, vehicle operating costs and PT fares, and uses this information as follows:

- **generates trips** based upon the planning and economic data;
- **distributes these trips** based upon the location of housing, employment and education within the region.;
- **splits trips between modes**, namely car and PT; and
- **assigns trips to the highway and PT networks** to provide information relating to traffic flows and PT patronage.

The region is fairly coarsely represented by 225 model zones. This level of detail is satisfactory as the model is a strategic model designed to provide high-level policy analysis and outputs that can be used to feed into other models.

The base model is validated against highway counts, public transport counts, travel times and other region wide data and is then used in forecast with updated land use forecasts, economic parameters and infrastructure assumptions (road schemes, PT schemes) to provide future estimates of highway and PT patronage across the region.

As mentioned above, WTSM is informed by data from WTM where appropriate.

3.3 Wellington Public Transport Model (WPTM)

The WPTM is a new model that has a base year of 2011. It has 780 model zones allowing for a more accurate representation of travel time and demand.

The demand data within WPTM comes from two observed data sources:

- electronic ticket machine (ETM) data from bus operators, capturing every bus journey during a designated 35 day period; and

- rail survey data, capturing all boarding's at stations within the region on a certain day and using this information, together with a sample of travel surveys undertaken at each station, to derive rail demand.

The underlying WPTM demand data is more accurate than the synthetic demand that is generated by WTSM.

Whilst the PT and highway networks are identical between WPTM and WTSM, WPTM offers an extra level of sophistication. It is able to offer more detailed representation of the various components of a typical PT journey i.e. walk to PT stop, wait, board PT vehicle, travel to alighting stop, alight, walk to destination.

In order to create future year versions of WPTM, growth between 2011 and forecast versions of WTSM is applied to the 2011 base year observed demand in WPTM.

3.4 Wellington Transport Model (WTM)

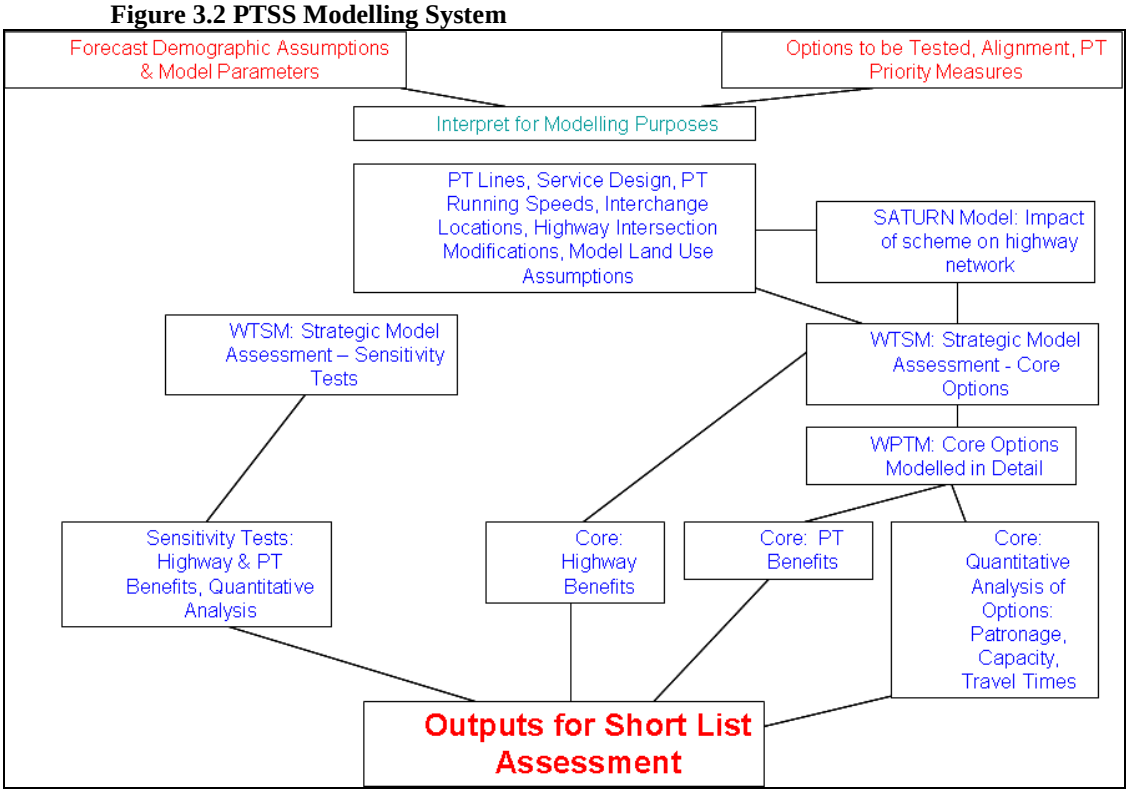
WTM is a highway model covering the whole of the Wellington City from Ngauranga Gorge southwards. Whilst the underlying highway demand in WTM comes from WTSM, WTM has a much more detailed zone system and represents intersections in a more sophisticated manner.

It is this ability to represent signal timings and capacities at major junctions and calculate flows, delays and travel times that meant that outputs from WTM were chosen to inform the representation of intersection capacities at key locations in Wellington CBD.

3.5 Model System Summary

Figure 3.2 below is a schematic showing the modelling system as used for the PTSS testing.

Figure 3.2 PTSS Modelling System



The modelling phases of the PTSS short list assessment were as follows:

- define the core BP, BRT and LRT options to be tested;
- agree land use assumptions and future year model parameters;
- implement options into the modelling system;
- run the three components of the modelling system in turn for the core tests – WTM, WTSM and WPTM;
- analyse core model runs and report highway and PT impacts;
- run sensitivity tests in WTSM and WPTM;
- undertake high-level analysis of the sensitivity tests; and
- report core model runs in detail and the sensitivity tests in a lower level of detail.

3.6 Summary

- the **modelling system consists of 3 models;**
- **WTSM;**
  - Wellington Transport Strategy Model - covers the whole region, uses land use and economic forecasts to generate estimates of trips. **The main model used to generate forecasts for the PTSS;**
  - provides inputs to WPTM;
  - used for the **assessment of PTSS highway impacts and benefits;**
- **WPTM;**
  - Wellington Public Transport Model – built from observed bus and rail data;
  - **Used for the assessment of PT impacts and benefits for the PTSS;**
- **WTM;**
  - Wellington Transport Model – a highway model of Wellington City, built to **assess the impact of highway schemes on the highway network; and**
  - passes intersection data into WTSM.

4. Reporting Templates

To help understand and interpret the results from the models, analysis has been undertaken using sector systems which aggregate model zones into groups to report indicators such as:

- PT demand;
- highway demand;
- PT mode share;
- PT boardings;
- PT transfers;
- available PT capacity;
- PT vehicle / passengers kilometres travelled; and
- vehicle / passenger hours travelled.

4.1 Six Sector System

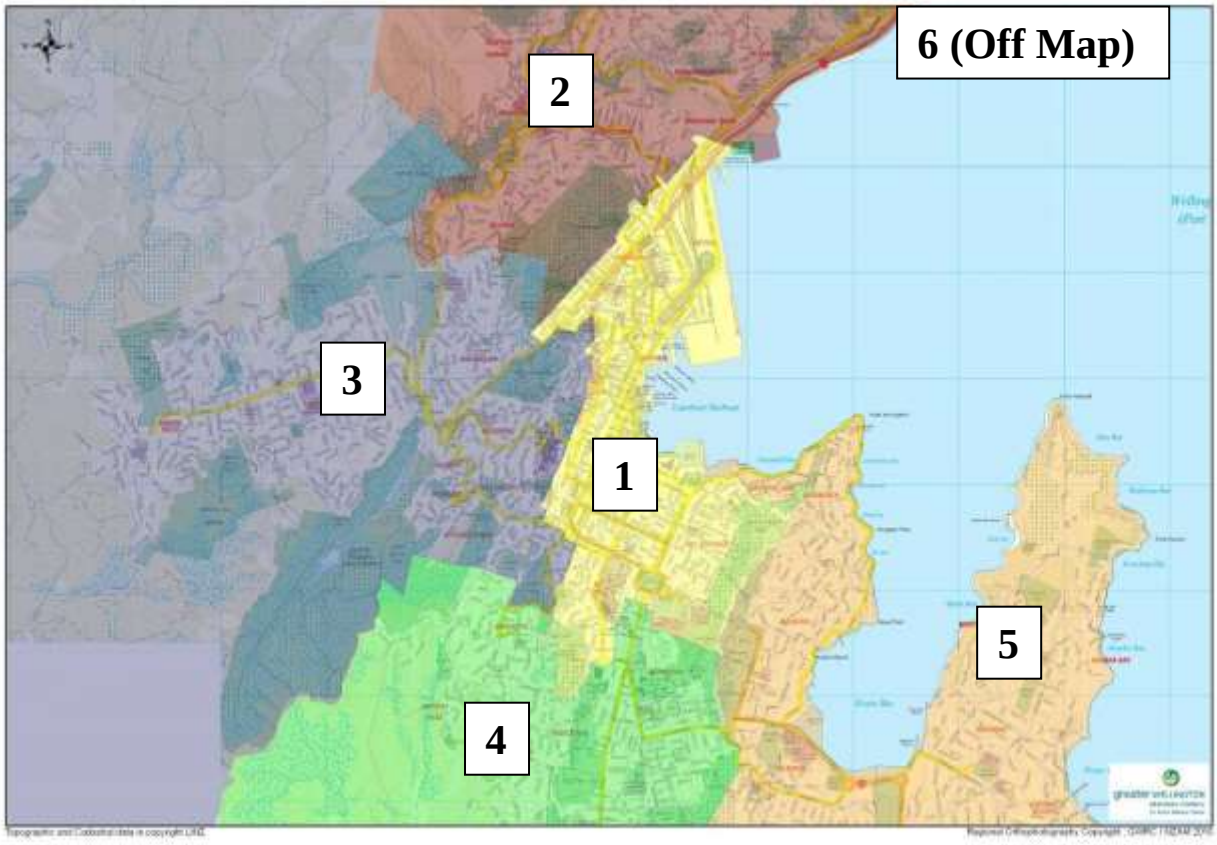
Figure 4.1 shows a six sector system that has been used to analyse wider travel patterns between Wellington City's various suburbs and the rest of the region.

The sectors are defined as follows:

- 1 – CBD
- 2 – Northern Suburbs - Johnsonville, Newland, Grenada, Khandallah, Wadestown;
- 3 – Western Suburbs – Karori, Kelburn;
- 4 – Southern Suburbs – Island Bay, Berhampore, Newtown;
- 5 – Eastern Suburbs – Miramar, Kilbirnie, Lyall Bay, Hataitai; and
- 6 – Rest of Region;

This sector system is used to generally present high level analysis for the 2011 assessment (Chapter 5), long route assessment (Chapter 6) and model results (Chapter 9).

Figure 4.1 – Wellington Six Sector System



4.2 Eight Sector System

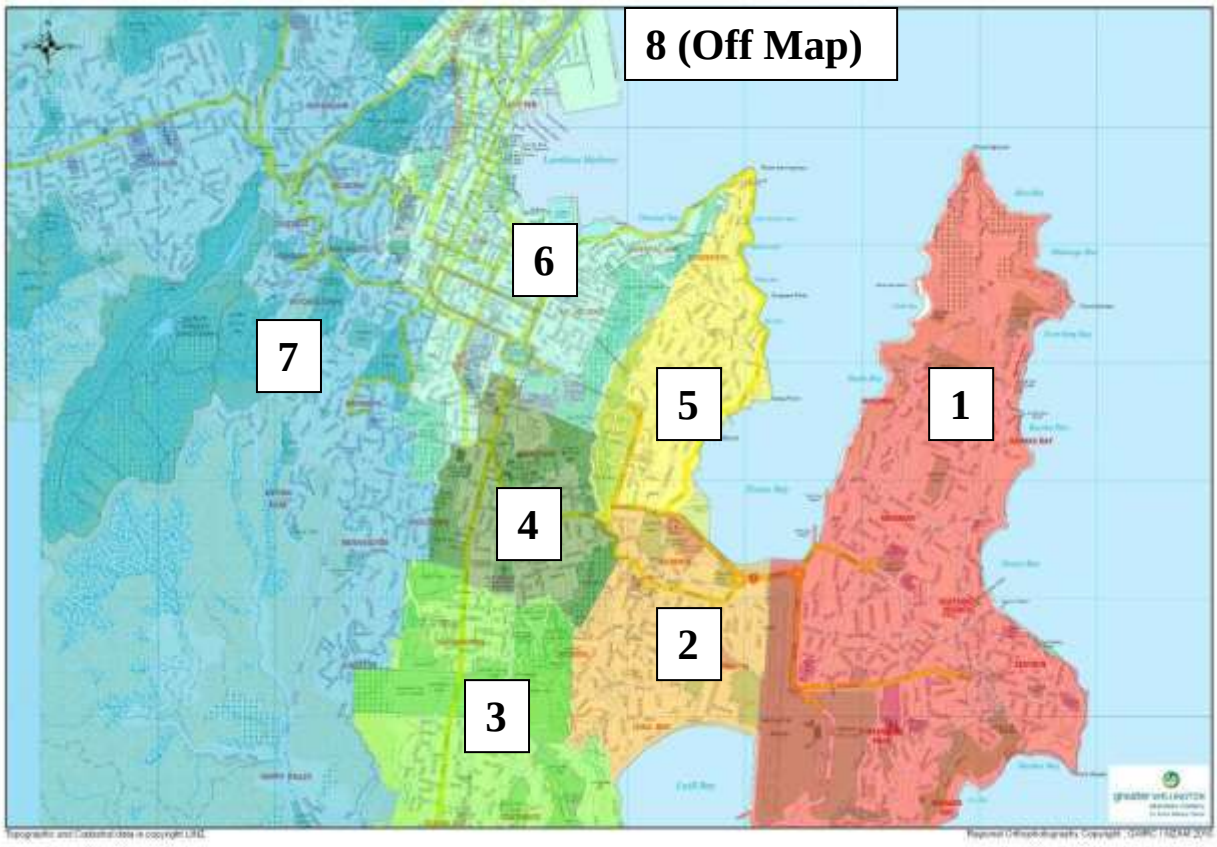
Figure 4.2 overleaf shows an eight sector system that is used to understand travel patterns between specific southern and eastern suburbs in the study area and Wellington CBD.

The sectors are defined as follows:

- 1 – Miramar;
- 2 – Kilbirnie / Lyall Bay;
- 3 – Mt Victoria / Hataitai;
- 4 – Island Bay / Berhampore;
- 5 – Newtown;
- 6 – Wellington CBD;
- 7 – Rest of Wellington TA (Brooklyn, Karori, Kelburn, Wadestown, Khandallah, Johnsonville, Newlands); and
- 8 – Rest of Region (including Porirua, Kapiti, Lower Hutt, Upper Hutt and Wairarapa).

This sector system is used to present more detailed analysis associated with the 2011 assessment (Chapter 5), long route assessment (Chapter 6), model results (Chapter 9) and evaluation of PT benefits (Chapter 10).

Figure 4.2 – Wellington Eight Sector System



4.3 Summary

- Two sector systems are used to present analysis in this report;
- A **six sector system** covering Wellington's suburbs and the rest of the region is used to present **high-level analysis**; and
- A **more detailed eight sector system** is used to look at how the impacts and effects of the options vary throughout the **study area** (defined as the southern and eastern suburbs of Wellington City TA).

5. 2011 Assessment

This short list phase was broken down into two distinct parts, they were to:

- assess the feasibility and practicality of extending the PT spine to the north and south to create a network;
- assess the performance of BP, BRT and LRT along these chosen alignments, including detail cost estimates and the assessment of economic benefits.

To support this process, the baseline 2011 situation was analysed and potential growth between 2011 and 2031 documented to give an indication of what pressures might be placed on the transport network in the future.

5.1 Structure of the 2011 Assessment

This chapter is structured as follows:

- overview of PT and highway trips within Wellington City and Wellington Region;
- analysis of mode share, focussing on the study area;
- analysis of PT trips to and through Wellington CBD;
- analysis of through PT and car trips;
- PT passengers entering Wellington CBD;
- potential patronage by corridor;
- analysis of rail trips arriving at Wellington Station in the AM peak;
- analysis of bus boardings within Wellington City in the AM peak;
- comparison of PT and car travel times and speeds; and
- predicted growth in car and PT trips between 2011 and 2031.

5.2 PT Demand, Car Demand and Mode Share

Table 5.1 below shows the AM peak mode share for trips to Wellington CBD and all trips regardless of destination. The sectors are based on the six sector template as detailed in **Chapter 4**.

Table 5.1 AM peak Public Transport Mode Share, By Origin Sector, 2011

Origin Sector	Destination: CBD	Destination: All
CBD	10%	10%
Northern	32%	15%
Western	26%	16%
Southern	28%	17%
Eastern	34%	17%
Rest	48%	11%
Total	30%	13%

The data shows the following:

- the AM peak PT mode share across the region is 13%, rising to 30% when just focussing on trips to the CBD;
- PT mode share to the CBD from the northern suburbs (32%) is slightly higher than from the western (26%) and southern (28%) suburbs; and
- the PT mode share to Wellington CBD from the rest of the region (48%) is higher than for the individual Wellington suburbs, as rail provides a viable alternative to private car for such trips.

Table 5.2 below shows the Inter-peak mode share for trips to Wellington CBD and all trips regardless of destination.

Table 5.2 Inter-peak Public Transport Mode Share, By Origin Sector, 2011

Origin Sector	Destination: CBD	Destination: All
CBD	4%	10%
Northern	11%	5%
Western	11%	6%
Southern	9%	6%
Eastern	12%	6%
Rest	20%	4%
Total	8%	5%

The inter-peak PT mode share across the whole region is 5%. Whilst the PT mode share to Wellington CBD is greater, at 8%, it is considerably lower than the AM peak PT mode share.

The PT mode share from suburbs within Wellington City TA to Wellington CBD is between 9% and 12% in the inter-peak. The PT mode share from the rest of the region to Wellington CBD in the inter-peak is 20%, due to the attractiveness of rail.

5.2.1 PT Trips

Figure 5.1 is a schematic showing which trips are categorised as through trips for the purpose of this analysis. For example, from the northern sector a through trip is defined as a trip heading across the CBD to the southern and eastern suburbs.

Figure 5.1 Wellington – Schematic showing Trips defined as Through Trips

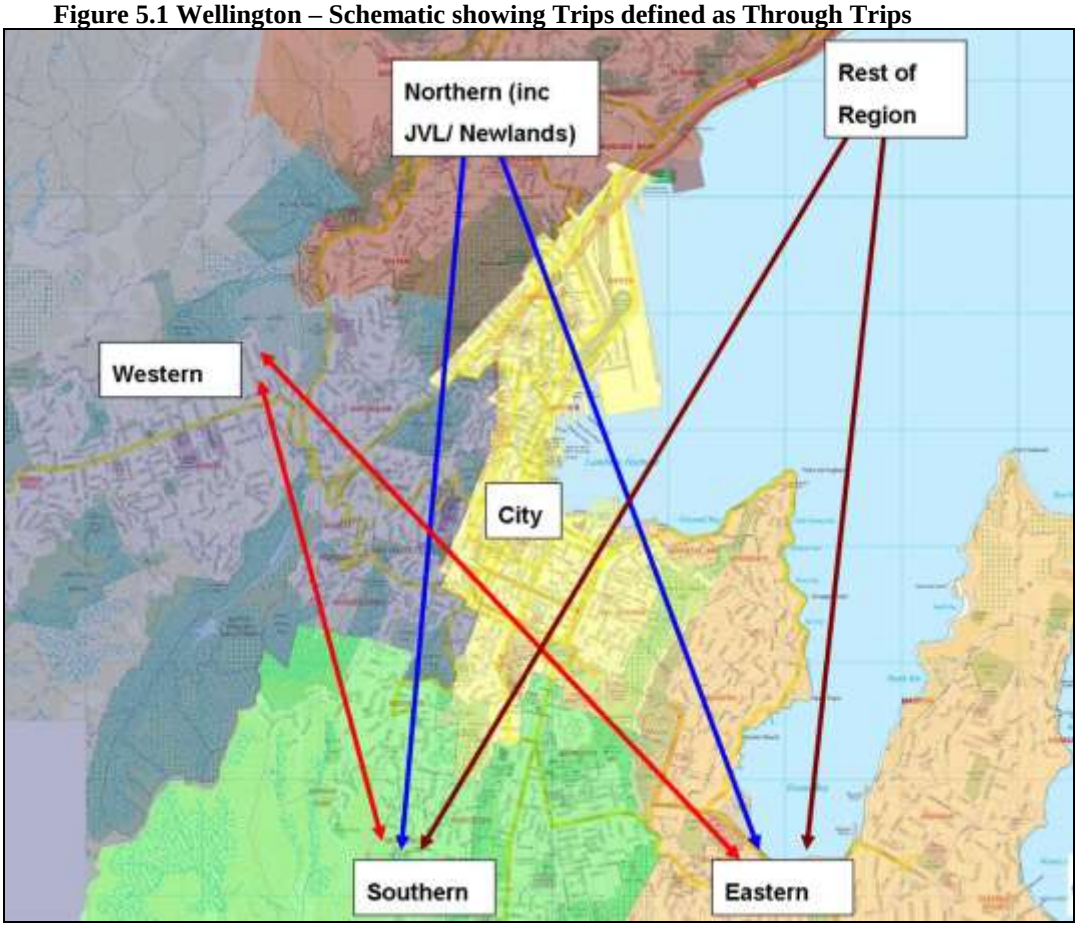


Table 5.3 and Table 5.4 below show AM and inter-peak PT trips in 2011 from WPTM, categorised as follows:

- trips to Wellington CBD from the origin sector in question, and the percentage of the overall origin trips from this sector that they comprise;
- trips defined as through trips and the percentage of the overall origin trips from this sector that they comprise; and

- trips solely within the same sector (e.g CBD to CBD), and the percentage of the overall origin trips from this sector that they comprise;
- all trips originating from that sector.

Table 5.3 AM peak PT Trips, By Origin Sector

Origin Sector	Dest CBD	% of Total	Through Trips	% of Total	All Other trips	% of Total	Total
CBD	1,344	57%	-	0%	1,008	43%	2,351
Northern	3,513	82%	34	1%	717	17%	4,264
Western	1,547	85%	62	3%	201	11%	1,809
Southern	2,028	84%	158	7%	218	9%	2,404
Eastern	2,389	80%	120	4%	484	16%	2,992
Rest	10,087	73%	526	4%	3,560	26%	13,791
Total	**20,907**	**76%**	**900**	**3%**	**6,187**	**22%**	**27,612**

Table 5.4 Inter-peak PT Trips, By Origin Sector

Origin Sector	Dest CBD	% of Total	Through Trips	% of Total	All Other trips	% of Total	Total
CBD	1,192	48%	-	0%		0%	2,499
Northern	345	50%	22	3%	249	36%	690
Western	340	60%	64	11%	120	21%	572
Southern	452	65%	74	11%	118	17%	692
Eastern	431	65%	74	11%	113	17%	668
Rest	669	23%	120	4%	2,053	71%	2,878
Total	**3,430**	**43%**	**354**	**4%**	**2,653**	**33%**	**7,999**

Three main conclusions can be drawn from the data presented in **Tables 5.3 and 5.4** above:

- in the AM peak around three-quarters of PT trips in the region have their final destination in Wellington CBD;
- in the Inter-peak, around 40% of PT trips either terminate or originate in Wellington CBD. This shows that the inter-peak demand is less Wellington CBD centric, as there are fewer commuter trips and more leisure / shopping trips involving travel to local centres rather than Wellington CBD;
- through trips comprise a very small percentage of total PT demand - 3% in the AM peak and 4% in the inter-peak;
- around 500 ‘through trips’ in the AM come from the rest of the region; and

- most through trips from the rest of the region will be rail arrivals into Wellington station who continue their onward trip by bus. These trips represent around 4% of total arrivals into Wellington Station in the AM peak.

5.2.2 Combined PT and Car Trips

Table 5.5 below shows all AM peak trips (car and PT combined) in 2011 from WTSM, categorised as follows:

- trips to Wellington CBD from the origin sector in question, and the percentage of the overall origin trips from this sector that they comprise;
- trips defined as through trips and the percentage of the overall origin trips from this sector that they comprise;
- all other trips; and
- all trips.

Table 5.5 AM peak Trips (Car and PT), By Origin Sector, 2011

Origin Sector	Dest CBD	% of Total	Through Trips	% of Total	All Other trips	% of Total	Total
CBD	15,857	61%	-	0%	10,269	39%	26,126
Northern	9,511	38%	955	4%	14,888	59%	25,353
Western	5,986	48%	1,028	8%	5,543	44%	12,558
Southern	6,941	47%	2,065	14%	5,609	38%	14,615
Eastern	7,183	37%	2,053	11%	10,218	53%	19,453
Rest	18,943	14%	1,946	1%	112,231	84%	133,120
Total	**64,420**	**28%**	**8,047**	**3%**	**158,758**	**69%**	**231,225**

Table 5.6 Inter- Peak Trips (Car and PT), By Origin Sector, 2011

Origin Sector	Dest CBD	% of Total	Through Trips	% of Total	All Other trips	% of Total	Total
CBD	17,169	62%	-	0%	10,715	38%	27,885
Northern	2,765	20%	686	5%	10,134	75%	13,585
Western	2,241	36%	597	10%	3,413	55%	6,250
Southern	2,812	34%	955	11%	4,583	55%	8,350
Eastern	2,612	22%	1,329	11%	7,956	67%	11,897
Rest	3,108	3%	3,226	3%	88,706	93%	95,041
Total	**30,708**	**19%**	**6,792**	**4%**	**125,508**	**77%**	**163,008**

Table 5.5 and Table 5.6 show:

- a lower percentage (28%) of all trips terminate in the CBD in the AM peak compared with previously reported analysis of PT trips (76% terminate in CBD). This is because, as previously mentioned, the PT network is focussed around serving Wellington CBD and has a high mode share in this regard. For trips elsewhere in the region, PT is not a competitive option and therefore people chose to drive;

- looking at all trips across the region there are 8,000 through trips in the AM peak compared with over 200,000 trips in total across the region and 64,000 trips terminating in Wellington CBD;

- through demand, expressed as a percentage of the number of trips terminating in Wellington CBD, is 13% in the AM peak; and

- in the Inter-peak, only 19% of trips head to Wellington CBD (AM peak – 28%) but through trips as a percentage of total trips (4%) is similar to the AM peak figure (3%).

Of the through trips in both the AM peak and inter-peak, most trips will be 'captive' trips and only a fairly low percentage would be likely to consider switching from car to PT, even if a step-change in PT service was provide. This is because:

- for some trip types and purposes – light goods vehicles and taxis – private motor vehicle will always be the mode of choice; and

- for other trips, people will still value the convenience that private vehicles brings.

In summary, analysis of through trip patterns shows that:

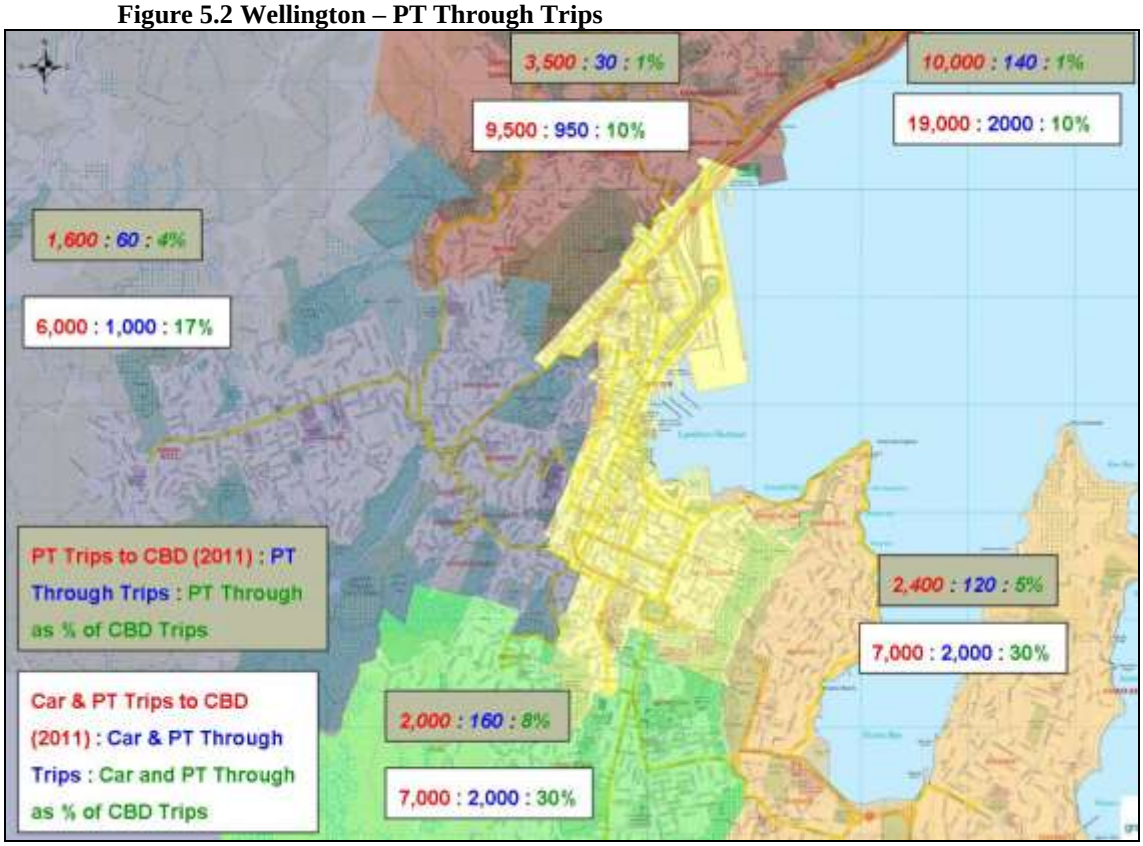
- very few through trips are currently made in both the AM peak and Inter-peak;

- limited demand exists to support an increase in through trips even if PT improvements were to be made; and

- the pattern of travel demand is very Wellington centric – the majority of trips in the AM peak and, to a lesser extent, inter-peak, are made by persons wanting to access the CBD.

Figure 5.2 summarises **Tables 5.5 and 5.6** and shows PT and total (car and PT) trips to the CBD and through trips, in the AM peak. The percentage of through trips, expressed as a percentage of trips to the CBD, is also presented for each of the sectors. This analysis excludes any trips where both the origin and destination sector is the CBD – such trips account for around 5% of AM peak PT trips to the CBD and around 20% of AM peak car trips to the CBD.

Figure 5.2 Wellington – PT Through Trips



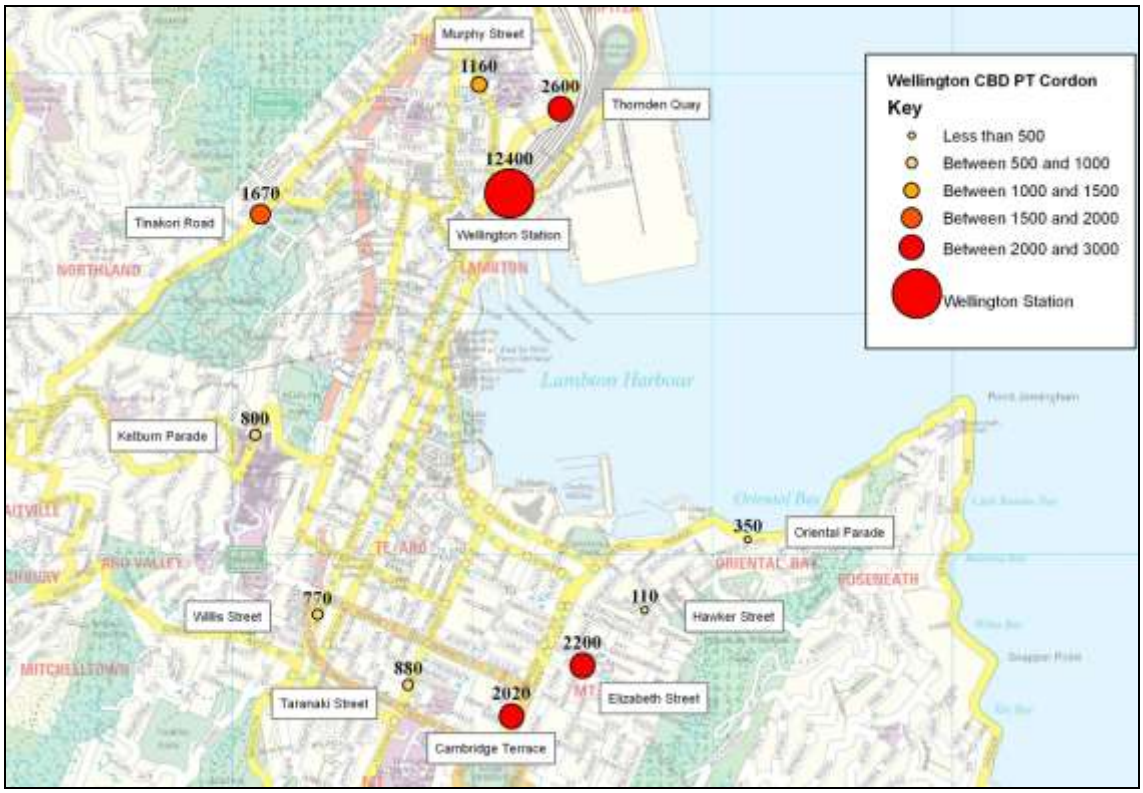
5.3 Public Transport Cordon Demand

An understanding of PT travel patterns into Wellington CBD is important when assessing which corridors generate major PT flows into Wellington CBD.

The Wellington CBD PT Cordon survey, undertaken annually by GWRC, counts all PT users arriving into the CBD by bus and rail (also cable car and ferry but these numbers are not covered by this analysis) in the AM peak, 7am to 9am.

Figure 5.3 shows data from the 2011 version of the survey.

Figure 5.3 Wellington CBD PT Cordon, 2011



It shows that:

- just under 12,500 people arrive into Wellington Station in the AM peak;
- of the bus PT corridors serving Wellington, the following have substantial passengers flows (defined as over 1,000 pax per hour):
    - Thorndon Quay – serving buses from Northern Suburbs, Hutt Valley and Wainuiomata;
    - Cambridge Terrace – serving busses from Lyall Bay, Island Bay, Newtown area;
    - Elizabeth Street – serving buses from Miramar Peninsula and Kilbirnie;

5.4 Future Corridor Flows

Figure 5.4 below is a stylised depiction of the network giving an indication of the current number of people (car and PT users) within 800m of a current PT service who currently travel to the CBD by either PT or car.

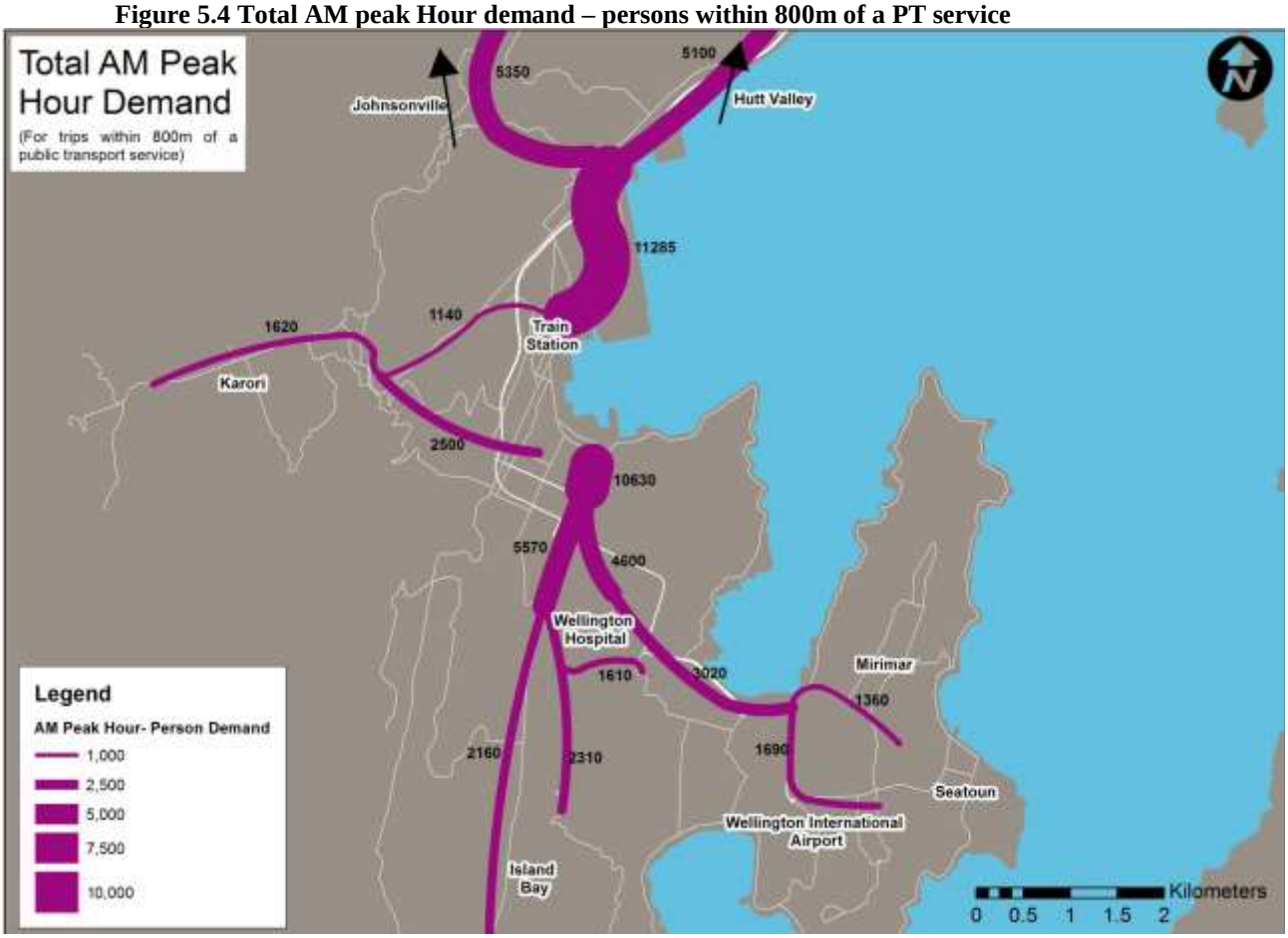
It provides an indication of potential PT patronage, by corridor (assuming an 800m walk catchment) and can be used to assess which corridors might have levels of demand that could support a rapid transit system.

It shows that person trips to the CBD along the major PT corridors are as follows:

- outside Wellington City SH2 Corridor* – 5,100;
- northern suburbs and SH1 Corridor* – 5,350;
- western suburbs – 3,640;
- southern suburbs – 5,570; and
- eastern suburbs – 4,600.

*(note: excludes car access trips as majority will come from outside 800m PT catchment)

Figure 5.4 Total AM peak Hour demand – persons within 800m of a PT service



5.5 Public Transport and Highway Travel Times

Figure 5.5 below shows PT travel times, distance and average speeds from major local centres into Wellington CBD (Willis Street).

The times come from the current Metlink timetables and represent a range of travel times in the AM peak (7am to 9am).

PT travel time is governed by a number of factors:

- service loadings (i.e. bus stop dwell times);
- bus lanes;
- general traffic experienced by buses; and
- length of route – longer routes, with a greater percentage of the route in the less congested suburbs and less in the more congested CBD area, should have faster average travel times than shorter routes from suburbs closer to the CBD.

Figure 5.5 Current PT travel times from Wellington suburbs to Wellington CBD

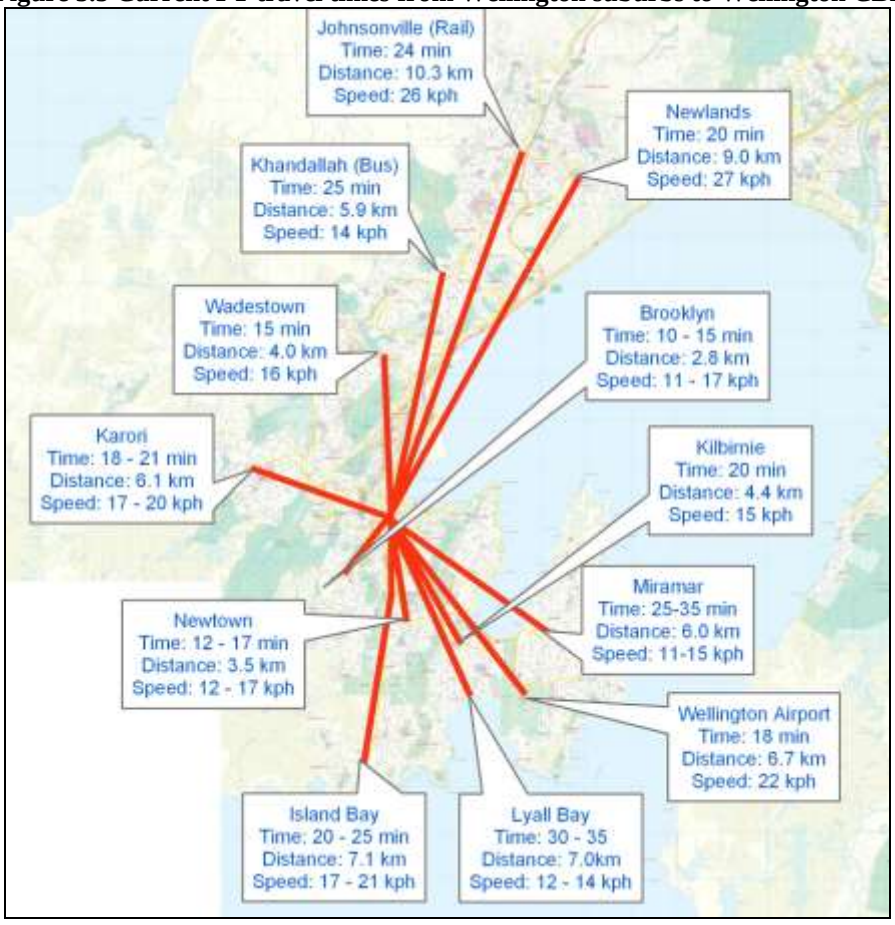


Figure 5.6 shows highway travel times for the same routes, extracted from WTM.

The purpose of presenting both the PT and highway travel times and speeds is to give an indication of the differences between the two.

This will help identify areas where perhaps PT travel speeds are poor, relative to car speeds, and need to be improved to make PT a more attractive proposition. Conversely it will also identify areas where travel times are similar, showing that PT is already quite an attractive proposition and that any further improvements might have a marginal return in terms of increasing the PT mode share.

Figure 5.6 Current highway travel times from Wellington suburbs to Wellington CBD

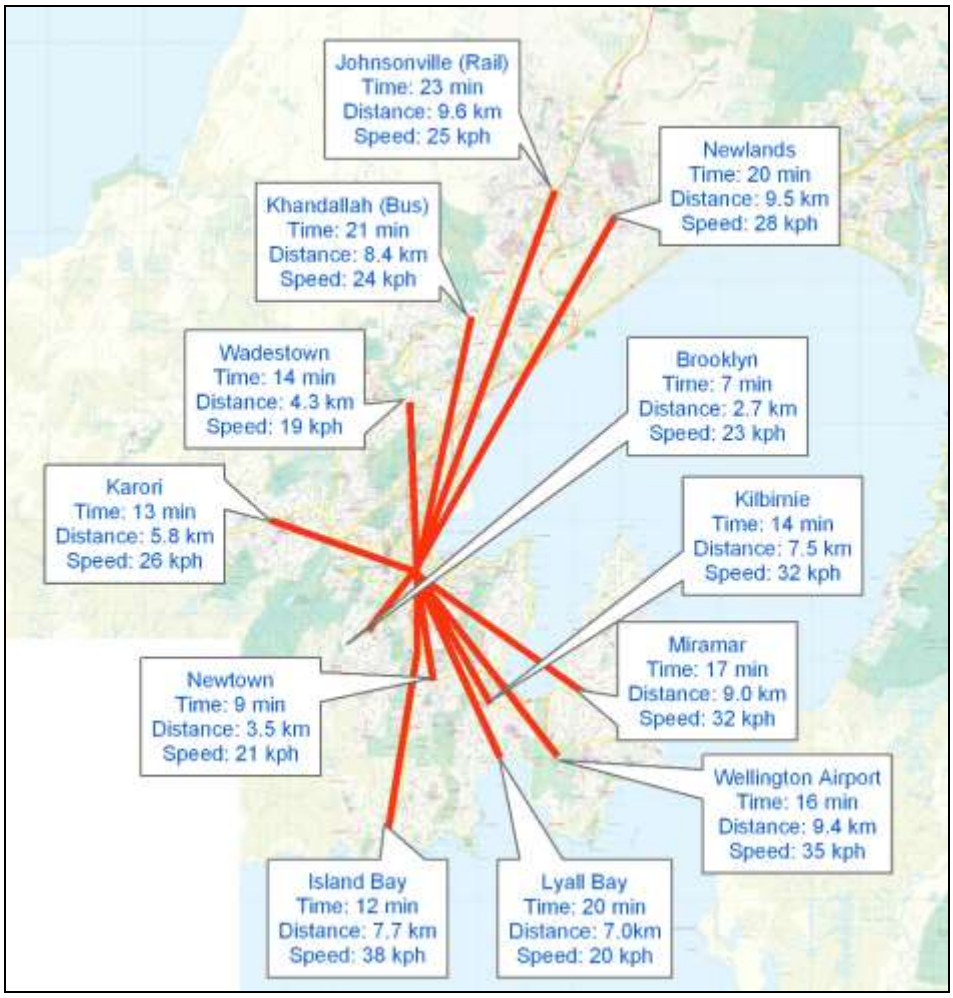


Table 5.7 overleaf takes the information presented in **Figures 5.5 and 5.6** and ranks each suburb according to:

- PT speed – 1 (fastest) to 12 (slowest) ;
- absolute difference between PT and Highway Speeds - 1 (least difference) to 12 (greatest difference); and
- combined rank.

Table 5.7 Comparison and Ranking of PT and Highway Travel Times to Wellington CBD, AM peak, 2011

Journey	Distance	PT Speed	Speed – Rank	Car Speed	Diff car PT	Rank	Comb Rank
JVL - CBD	10	26	2	25	-1	1	3
Newlands - CBD	9	27	1	28	+1	2	3
Khandallah - CBD	6	14	8	24	+10	7	15
Wadestown - CBD	4	16	6	19	+3	3	9
Karori - CBD	6	17	4	26	+9	5	9
Newtown - CBD	3.5	12	9	21	+9	5	14
Island Bay - CBD	7	17	4	38	+21	11	15
Lyall Bay - CBD	7	12	9	20	+8	4	13
Airport - CBD	7	22	3	35	+13	9	12
Miramar - CBD	6	11	10	32	+21	11	21
Kilbirnie - CBD	4.5	15	7	32	+17	10	17
Brooklyn - CBD	3	11	10	23	+12	8	18

The entries highlighted in yellow have the highest combined rank i.e. a slow PT travel time and large differences between the current PT and highway travel times.

These trips can be grouped into four corridors, as detailed below together with an indication of PT person trips in the AM peak 2hr period:

- Khandallah / Ngaio – ~500;
- Brooklyn – ~500;
- Airport / Miramar / Kilbirnie – ~2000; and
- Island Bay / Newtown - ~2000.

This data shows that whilst Brooklyn and Khandallah are ranked as having poor PT travel times and large differences between PT and highway travel times, actual PT demand from both areas is low compared with demand from elsewhere.

The demand along the other two corridors is much greater, however, showing that more people could potentially benefit from improvements made to PT travel time and that scope exists for increasing the PT mode share along these corridors.

5.6 Rail trips to Wellington CBD

Figures 5.7 and 5.8 below contain data from the 2011 Wellington rail surveys. They show the actual geo-coded final destination for passengers alighting from rail services at Wellington Station in the AM peak.

Figure 5.7 AM peak Rail Trips – Final Destination and Egress Mode for passengers alighting at Wellington Station – CBD

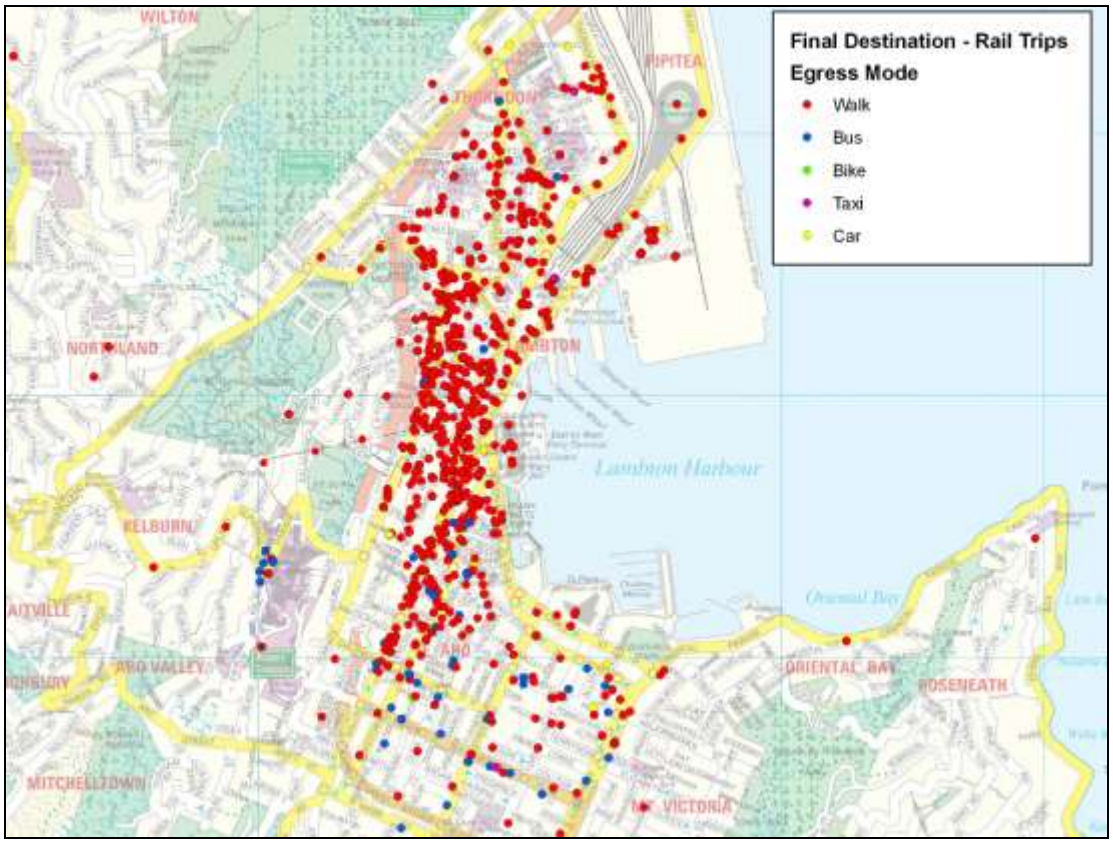


Figure 5.8 AM peak Rail Trips – Final Destination and Egress Mode for passengers alighting at Wellington Station – Wider Network

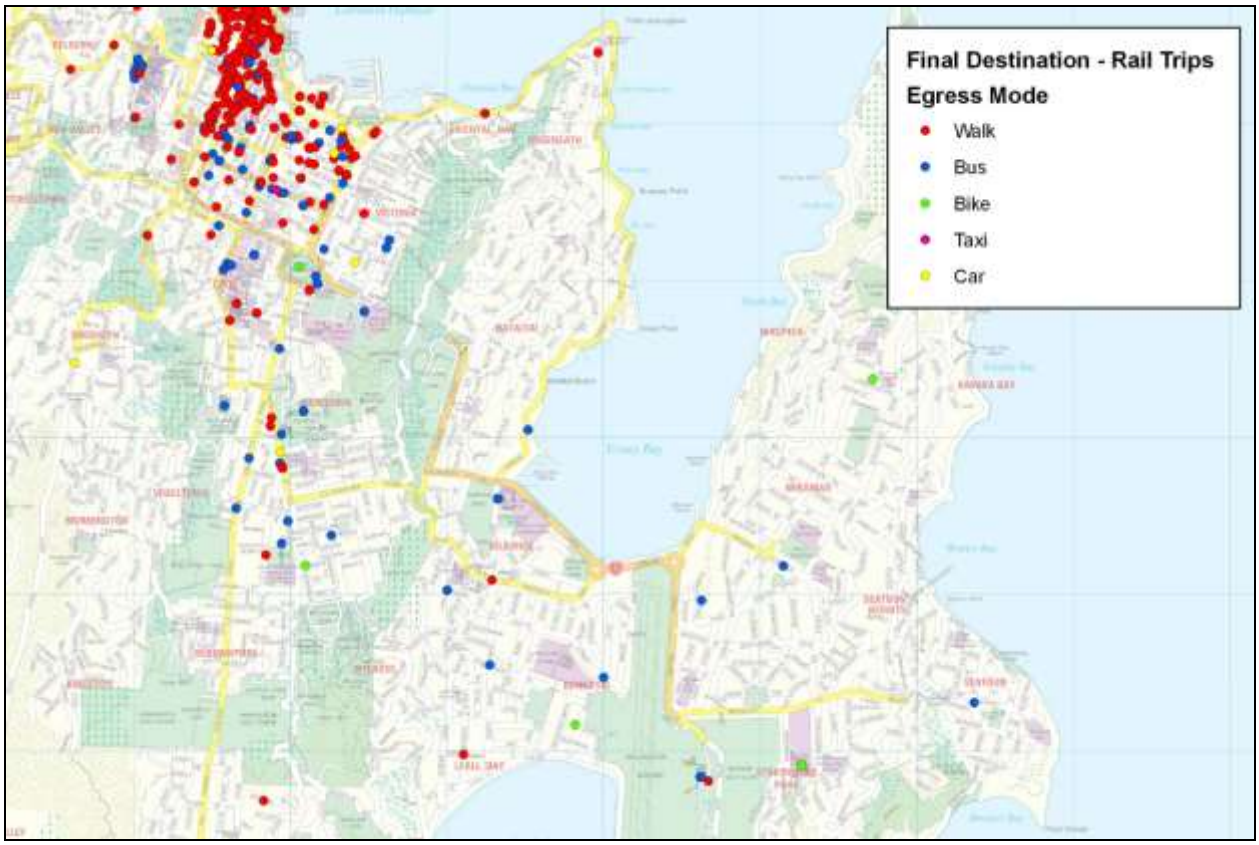


Table 5.8 shows the average egress distance for passengers alighting at Wellington Station in the AM peak and Inter-peak.

Table 5.8 Average Rail Egress Distance from Wellington Station

	Average Rail Egress Distance (kilometres)	
Origin / Destination	**AM**	**IP**
Walk	0.78	1.24
Bus	2.01	1.78
Bike	2.35	2.23
Taxi	1.01	0.64
Car	1.41	1.28
Average	**0.88**	**1.30**

Figures 5.7 and 5.8 show that the vast majority of persons (over 90%) alighting at Wellington Station in the AM peak work close to the station and walk to their final destination. **Table 5.7** shows that the average walk egress distance is less than 800m in the AM peak (straight line distance).

It is interesting to note that relatively few people alighting at Wellington Station have a final destination towards the Courtenay Place end of the Golden Mile. For those who do travel towards Courtenay Place, the majority still walk.

Figure 5.8 shows that those people taking the bus to a final destination such as Kilbirnie, Newtown or further afield comprise a very small percentage of the 12,500 persons alighting at Wellington Station in the AM peak.

5.7 Bus Boardings

Figures 5.9 and 5.10 show average boarding numbers at bus stops within Wellington in the AM peak (7am to 9am) from the southern and northern suburbs respectively. The data is taken from Electronic Ticket Machine (ETM) data covering March 2013.

Figure 5.9 AM peak Bus Boardings – Southern

CONFIDENTIAL

Figure 5.10 AM peak Bus Boardings – Northern

CONFIDENTIAL

The majority of stops within Wellington City TA are relatively lightly used in the AM peak. This is because relatively closely spaced stops (200 – 300m in most instances) combined with low population densities leads to low stop utilization.

Certain stops / areas have high numbers of boardings in the AM peak – these stops are either purpose built interchanges (Johnsonville) or urban centres where a number of routes converge providing a high frequency service into Wellington CBD. Often people are willing to walk a little further to board services at high frequency stops rather than walk a shorter distance and wait for a less frequent service.

Stops with the highest number of boardings in the AM peak (outside of the CBD) are found in the following areas:

- Johnsonville Station / Newlands Shops;
- Karori Mall / Karori Park / Karori Rd;
- Island Bay (The Parade);
- Newtown Shopping Centre (Riddiford Road);
- Kilbirnie Shops;
- Hataitai Shops; and
- Miramar Peninsula (Strathmore and Seatoun).

5.8 Future Growth

When designing PT infrastructure it is necessary to look into the future and forecast changes in PT and car trips in order that infrastructure improvements can be designed to cope with these forecast increases in PT and car demand.

Tables 5.9 and Table 5.10 below show the absolute and percentage increase in trips between 2011 and a 2031 horizon year.

Table 5.9 AM peak – PT, Car and Car and PT Growth Rates – 2011 to 2031

Origin	2011 PT	2031 PT	% Inc	2011 Car	2031 Car	% Inc	2031 Comb	2031 Comb	% Inc
CBD	2,548	3,315	30%	20,973	26,859	28%	23,521	30,174	28%
Northern Suburbs	3,808	5,013	32%	16,757	20,530	23%	20,565	25,543	24%
Western Suburbs	2,058	2,201	7%	7,601	8,524	12%	9,659	10,725	11%
Southern Suburbs	2,474	3,154	27%	9,581	11,744	23%	12,056	14,898	24%
Eastern Suburbs	3,277	3,682	12%	13,508	16,424	22%	16,785	20,105	20%
Rest of Region	15,517	16,629	7%	99,713	113,981	14%	115,230	130,609	13%
Total	**29,683**	**33,994**	**15%**	**168,133**	**198,061**	**18%**	**197,816**	**232,055**	**17%**

In the AM peak, the growth in both PT and car trips between 2011 and 2031 is similar (18% and 21% respectively). Looking at a more detailed sector level, there are some large differences in growth rates. Wellington CBD, northern and southern suburbs have PT and car growth rates of between 30% and 40%, with lower growth predicted for the western and eastern suburbs.

It is also interesting to note that eastern suburbs have much higher car growth rates (28%) than PT growth rates (16%). This is partly due to the Wellington Inner City RoNS schemes improving highway travel times between the eastern suburbs and Wellington CBD.

Table 5.10 Inter-peak – PT, Car and Car and PT Growth Rates – 2011 to 2031

Origin	2011 PT	2031 PT	% Inc	2011 Car	2031 Car	% Inc	2031 Comb	2031 Comb	% Inc
CBD	2,837	3,020	6%	26,693	32,426	21%	29,529	35,446	20%
Northern Suburbs	705	829	18%	12,969	15,520	20%	13,674	16,349	20%
Western Suburbs	356	357	1%	5,726	6,438	12%	6,082	6,796	12%
Southern Suburbs	468	510	9%	7,706	9,291	21%	8,174	9,800	20%
Eastern Suburbs	682	705	3%	11,279	13,388	19%	11,961	14,093	18%
Rest of Region	3,836	3,686	-4%	92,198	106,079	15%	96,034	109,765	14%
Total	**8,883**	**9,107**	**3%**	**156,571**	**183,142**	**17%**	**165,454**	**192,249**	**16%**

The pattern of growth in the Inter-peak is broadly similar to that seen in the AM peak. Wellington CBD, northern and southern suburbs have the highest PT growth rates, whilst car growth rates are relatively even across the region.

Overall, average PT growth rates in the inter-peak are 5% across the region compared to 20% for cars. The main driver for this differential is the delivery of the Wellington region RoNS schemes that result in improved highway travel times across the region, encouraging more trips to be made by car.

Table 5.11 shows that the AM peak PT mode share across the region remains relatively constant between 2011 and 2031. There are minor changes when the data is analysed by sector - northern and southern suburbs exhibit a slight increase in the PT mode share, whilst western and eastern suburbs experience a slight decrease.

Table 5.11 AM peak and Inter-peak PT Mode Share– 2011 and 2031, Six Sector System

Origin	AM 2011	AM 2031	IP 2011	IP 2031
CBD	10.8%	11.0%	9.6%	8.5%
Northern Suburbs	18.5%	19.6%	5.2%	5.1%
Western Suburbs	21.3%	20.5%	5.9%	5.3%
Southern Suburbs	20.5%	21.2%	5.7%	5.2%
Eastern Suburbs	19.5%	18.3%	5.7%	5.0%
Rest of Region	13.5%	12.7%	4.0%	3.4%
Total	**15.0%**	**14.6%**	**5.4%**	**4.7%**

Table 5.12 below shows the change in PT mode share using the eight sector system. Kilbirnie and Miramar see large predicted decreases in PT mode share, and reinforces the analysis above..

Table 5.12 AM peak and Inter-peak PT Mode Share – 2011 and 2031, 8 Sector System

Origin	AM 2011	AM 2031	IP 2011	IP 2031
Miramar	20.6%	17.7%	5.5%	4.5%
Kilbirnie / Lyall Bay	16.2%	15.2%	6.4%	5.2%
Mt Victoria / Hataitai	20.7%	21.8%	5.2%	5.1%
Island Bay / Berhampore	23.5%	23.8%	5.9%	5.5%
Newtown	17.9%	17.4%	6.0%	4.8%
CBD	10.8%	10.8%	9.6%	8.3%
Rest of Wellington	19.1%	19.6%	5.2%	4.9%
Rest of Region	13.5%	12.7%	4.0%	3.4%
Total	**15.0%**	**14.6%**	**5.4%**	**4.7%**

5.9 Summary

The baseline assessment can be summarised as follows:

- the AM peak region wide **PT mode share is 13%** in 2011
- the **PT mode share to Wellington CBD in 2011 is ~30%,** with the rest of the region having a higher PT mode share (40-50%) to the CBD than Wellington City TA (25-35%);
- the **PT mode share is lower in the inter-peak** compared with the AM peak;
- **PT demand is Wellington centric** – approximately 75% of PT trips in the AM peak terminate in Wellington CBD;
- **64,000 combined car and PT trips are made to Wellington CBD in the AM peak**, of which 21,000 are made by PT (these figures include trips where both the origin and destination is within Wellington CBD);
- **few through trips** are currently made by PT or by car in both the AM peak and Inter-peak;
- the **greatest differences between highway and PT travel times / speeds to Wellington CBD** are found for trips originating from the southern and eastern suburbs in the AM peak;
- **several corridors** have levels of demand that could potentially **support high quality public transport services;**
- **over 90% of rail passengers walk a short distance** from Wellington station to their final destination;
- relatively **few people currently connect from inbound rail services to onwards bus services at Wellington Rail Station;**
- the **heaviest bus boardings** in the AM peak occur in Karori, between Island Bay and Newtown, Kilbirnie, Miramar and in Hataitai;
- between 2011 and 2031, **PT and car trips to Wellington CBD are forecast to grow by 15% and 18% respectively in the AM peak;**
- between 2011 and 2031, the forecast growth in PT trips is only 3% in the inter-peak; and
- in both the AM peak and inter-peak the PT mode share does not really change between 2011 and 2031.

6. Long Route Assessment

This chapter draws upon the baseline assessment and forecast growth to outline how the chosen rapid transit corridors were selected.

6.1 High Quality Corridor Specification

A transit corridor should provide a high quality, high frequency, high capacity public transport offering.

Whilst no criteria exist against which the potential for rapid transit can be assessed, patronage is key. Sufficient users are required in order to make the service a success, allow it to operate at a high frequency and justify rapid transit priority measures designed to enhance PT travel times.

The benefits from any scheme will largely be a function of travel times savings and the number of people who will benefit from these travel time savings.

Table 6.1 outlines the BP, BRT and LRT vehicle specifications that are assumed for the PTSS. The capacities stated below are full vehicle capacities – they include a limited number of standees but not enough standees that the vehicle is approaching what could be termed 'crush capacities'.

Table 6.1 BP, BRT and LRT Vehicle Specification

Mode	Vehicle Capacity
Bus	64
BRT	100
LRT	180

Table 6.2 shows that in order to deliver a minimum level of service that would make BRT and LRT attractive, service frequencies of around 20 and 12 vph respectively are required.

To support such service frequencies, potential patronage in excess of 1,600 passengers per hour would ideally be required, assuming 80% load factors (above which international research suggests that passengers start to feel vehicles become congested).

Table 6.2 High Quality Corridor Minimum Specification

Mode	Passengers per hour	Frequency	VPH	Speed
BRT	~1600	2.5 min +	20	25 + kph
LRT	~1600	4 min +	12	25 + kph

Figure 6.1 is a schematic showing AM peak 2031 PT demand within 800m of an existing PT service.

Figure 6.1 AM peak Hour PT person trips within 800m of a PT service , 2031

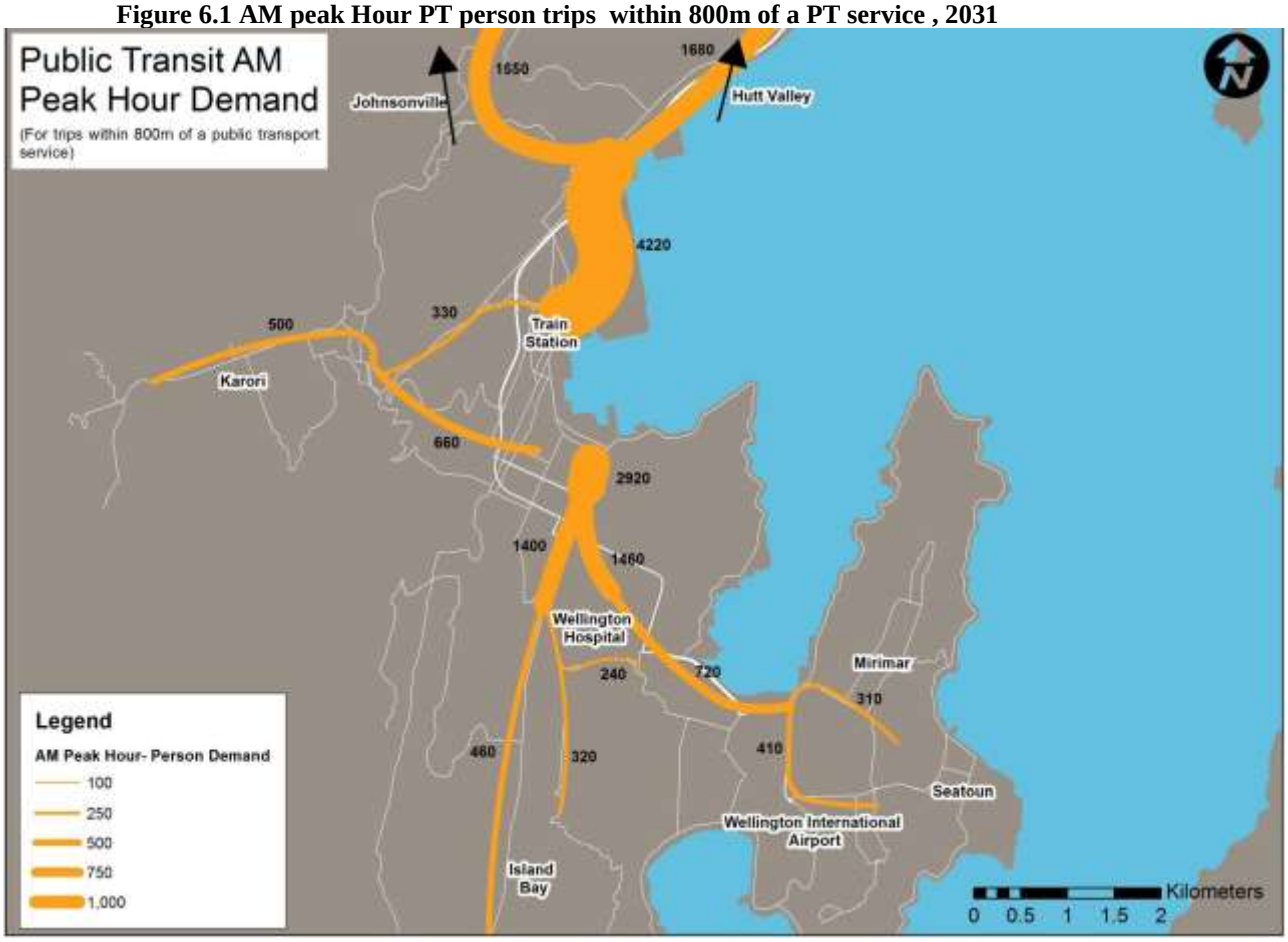


Figure 6.1 above shows that taking 1,600 passengers per hour as the benchmark demand needed to justify investigating the case for introducing rapid transit along a certain corridor, no corridor achieves that required level of demand:

- Kilbirnie = ~1,450 passengers per hour;
- Newtown = ~1,400 passengers per hour;
- Johnsonville = ~1,500 passengers per hour; and
- Karori = ~1,000 passengers per hour.

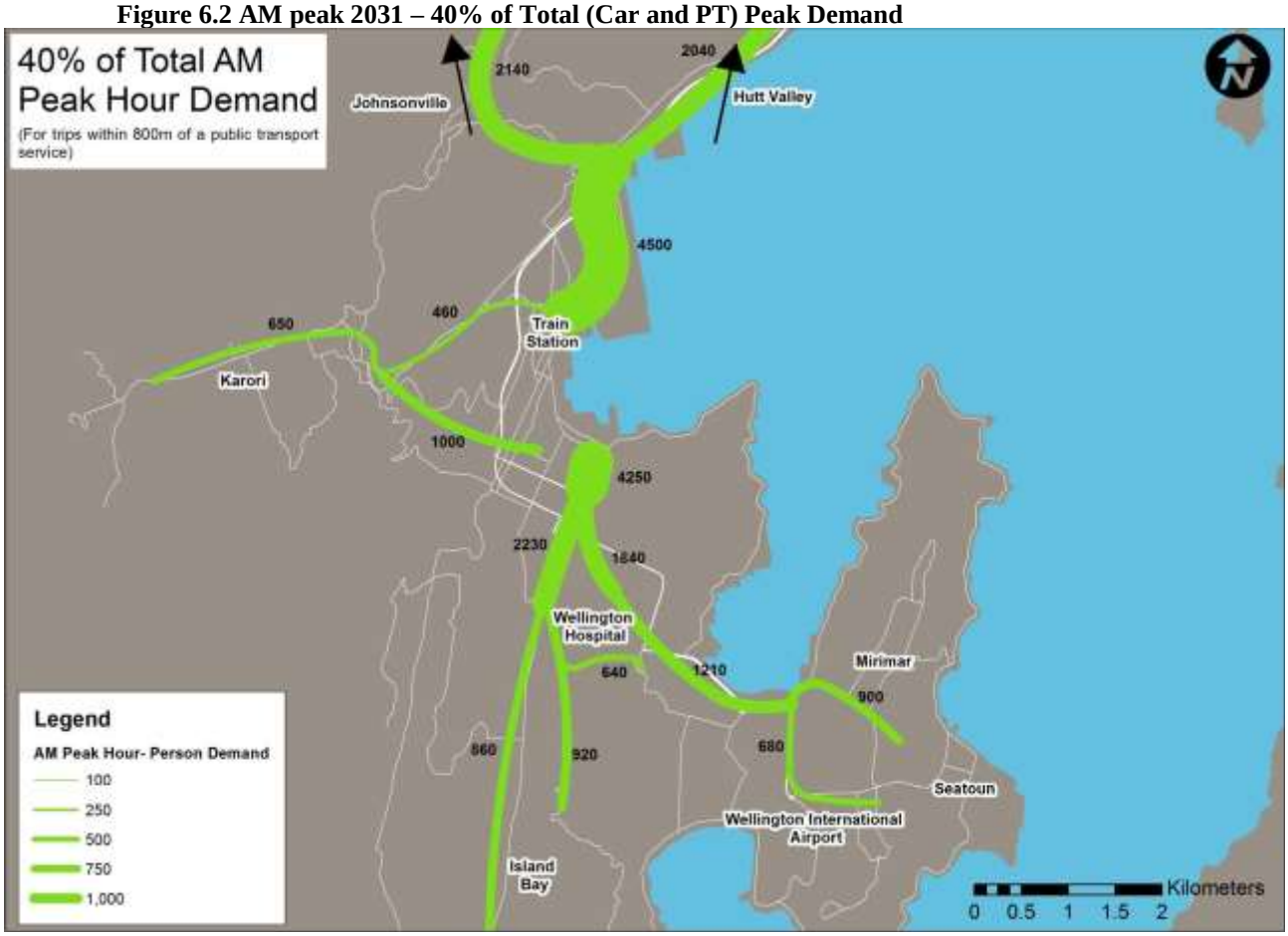
It should be noted that this analysis does ignore the potential mode shift effects that might increase PT demand from affected areas by between 5% and 10%.

Figure 6.2 considers total (car and PT) demand within 800m of a PT service in 2031 and assumes a 40% PT mode share. Using this method, four potential rapid transit corridors listed above have demand exceeding the 1,600 pax / hr benchmark;

- Karori;

- Johnsonville;
- Miramar; and
- Newtown.

Figure 6.2 AM peak 2031 – 40% of Total (Car and PT) Peak Demand



6.1.1 Karori

Karori is discounted as a potential rapid transit corridor because:

- the demand (1,460) is not sufficient;
- current demand is split between Kelburn and Glenmore Road; and
- existing bus lanes along Glenmore Road provide adequate levels of bus priority measures.

6.1.2 Johnsonville

Whilst patronage on the Johnsonville line is sufficient for it to be considered as a rapid transit corridor, this option was discounted in the medium list and is again discounted in the short-list evaluation for the following reasons:

- Johnsonville and Newlands are already well served by frequent and fast PT services (Chapter 5) and have a relatively high PT mode share. Increasing this any further would be difficult;

- the rail service has recently been upgraded and provides fast access into Wellington. Given the levels of investment undertaken during this upgrade and the additional investment / modifications required to convert the line to LRT, it would be difficult to justify such additional investment in the medium term;

- it is unlikely that converting the line to BRT / LRT would result in substantial travel time benefits as the current rail service is akin to a timetabled BRT / LRT service;

- most rail passengers arriving at Wellington station walk short distances to their final destination (Chapter 5). Whilst providing a through BRT / LRT service between Johnsonville and Newtown might encourage more through trips to be made, the number of such trips would still be low relative to terminating trips; and

- conversion from heavy rail to LRT would likely take a number of years and cause considerable inconvenience to current users, resulting in loss of patronage with persons shifting from PT to car. It might then take a number of years to get patronage levels back up to pre-LRT levels.

6.1.3 Southern Corridors

When considered in isolation, both southern corridors have enough potential demand to justify investigating BRT / LRT.

Figure 6.3 below shows that if both catchments were considered as effectively one corridor then the potential level of demand would comfortably exceed that required to justify investigating BRT / LRT options.

A corridor to the south and west of Wellington was therefore chosen as the focus for a potential future rapid transit corridor for the following reasons:

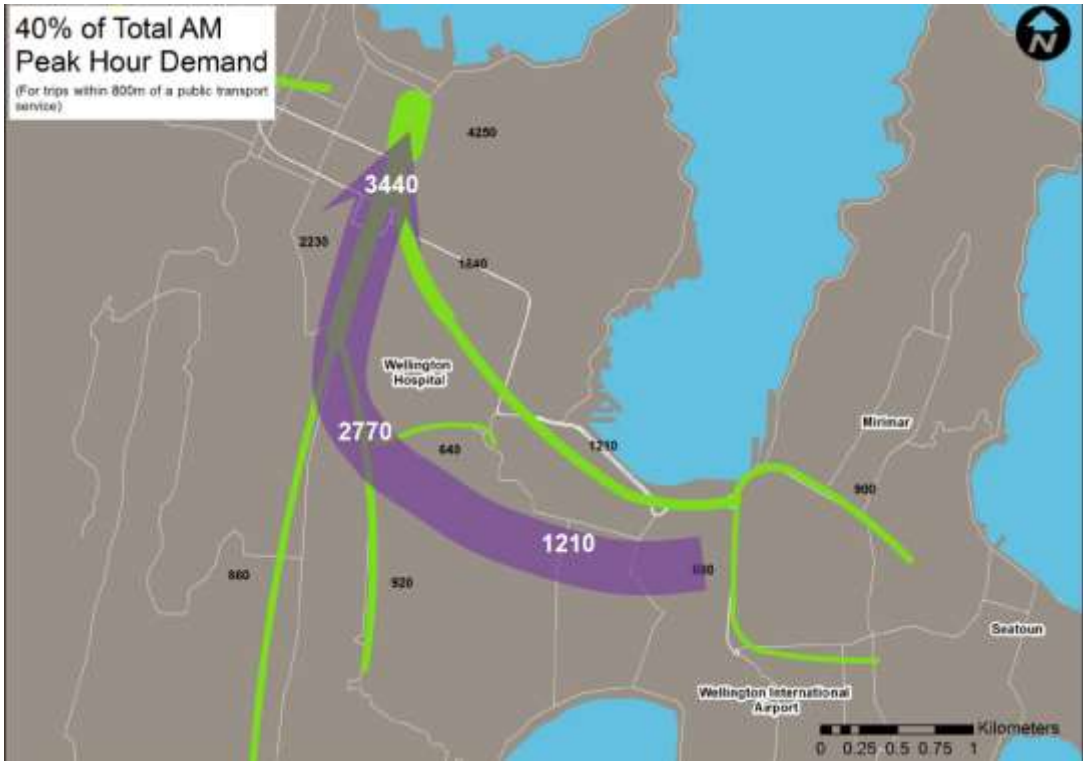
- potential **demand is high enough** to justify BRT / LRT;

- more people wanting to access the CBD live within 800m of this potential alignment than do so for any other potential corridor catchment;

- **PT travel times from these areas to the CBD are poor**, relative to car travel times;

- the current **mode share of between 25% - 30% is relatively low** and potential exists to improve this in the future;

Figure 6.3 AM peak 2031 – 40% of Total (Car and PT) Peak Hour Person Demand, South-Eastern Corridor



6.2 Travel Times

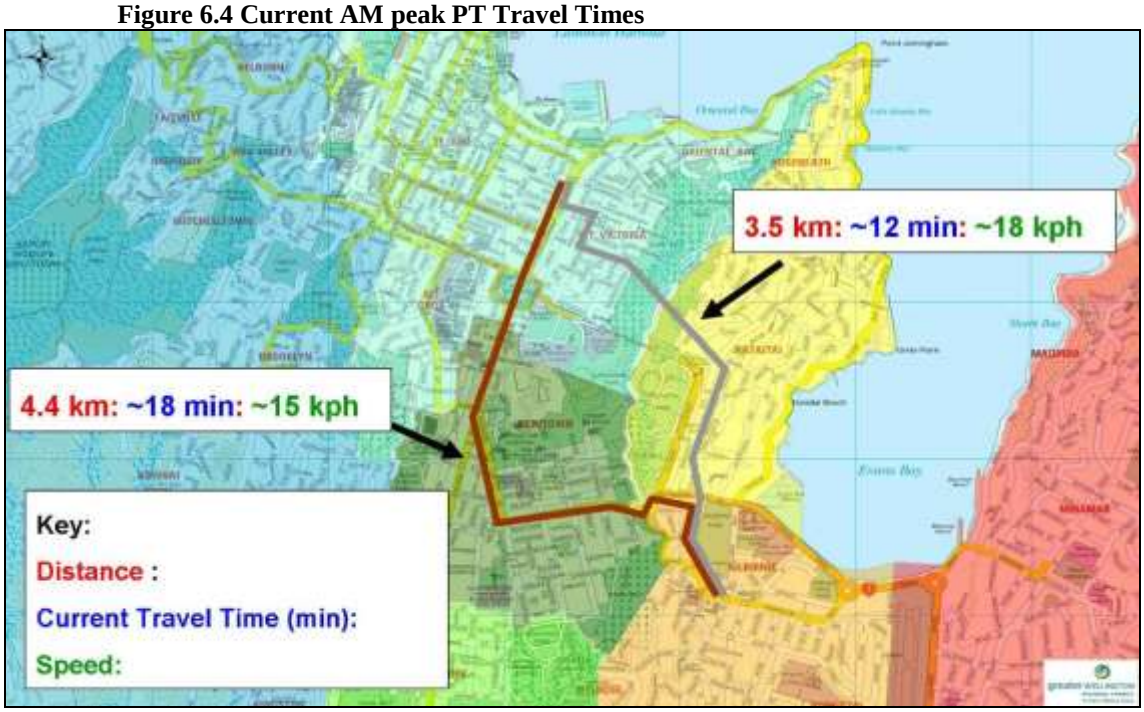
6.2.1 Current Travel Times

The current travel times between Kilbirnie / Newtown and Courtenay Place in the AM peak are shown in **Table 6.3** below. Travel times are taken from Real Time Passengers Information (RTI) data obtained directly from buses via the latest GPS technology. The times and routes are also depicted in **Figure 6.4** below.

Table 6.3 Current PT Travel Times

Route	Distance	AM peak Travel Time	Average Speed
Kilbirnie – Newtown	2.0 km	8.0 min	15 kph
Kilbirnie – Newtown – Courtenay Place	4.4 km	18.0 min	15 kph
Newtown – Courtenay Place	2.4 km	10.0 min	15 kph
Kilbirnie – Courtenay Place (via Hataitai)	3.5 km	12.0 min	18 kph

Figure 6.4 Current AM peak PT Travel Times



Current travel speeds between Kilbirnie / Newtown and Wellington CBD range from 15kph to 18kph. Travelling from Kilbirnie to Courtenay Place via Newtown is nearly 1km longer than travelling via the bus tunnel and equates to a six minute differences in travel times between these competing routes.

6.2.2 Future Potential Travel Times

Following discussions between the study partners it was determined that using an upgraded and duplicated Mt Victoria tunnel as a dedicated PT corridor could be an option for any BRT and LRT scheme between Wellington CBD and Kilbirnie.

Table 6.4 shows estimated PT travel times for the various options, plus the current 'fastest travel time' between Kilbirnie and Courtenay Place. It assumes that the maximum speed for any BRT / LRT system would be 25kph (allowing for junction delays and stop dwell times) – such an average speed is similar to that attained by LRT / BRT networks around the world with similar characteristics to the network proposed for Wellington.

Table 6.4 Potential PT Travel Times

Route	Distance	AM peak Travel Time (minutes)	Average Speed	Improvement on Current Travel Time (minutes)
Kilbirnie – Courtenay Place (via Mt vic)	3.5	6	~25-30 kph	6+
Kilbirnie – Newtown – Courtenay Place	4.4	10	25-30 kph	8
Newtown – Courtenay Place	2.4	5	25 kph	5
Kilbirnie – Newtown	2.0	5	25 kph	3

Table 6.4 shows that a direct BRT / LRT route between Kilbirnie and Courtenay Place via Mt Victoria Tunnel could provide up to six minutes of time savings over current 2011 travel times.

Looking at the options between Kilbirnie and Courtenay Place via Newtown, a potential BRT / LRT scheme provides eight minutes of time savings compared against current travel times.

Compared against the more direct route between Kilbirnie and Courtenay Place via Mt Victoria tunnel, the Newtown route is three minutes slower and would only provide two minutes of travel time savings over and above the quickest reference case travel time between Kilbirnie and Courtenay Place (via Hataitai).

To have a competitive travel time, an average speed of 35kph would have to be obtained between Kilbirnie and Newtown. Given topographical constraints and restrictions caused by running through central Newtown, achieving such travel speeds is considered unrealistic

An alternative route for getting between Kilbirnie and Newtown, involving an 800m tunnel between Kilbirnie and Coutts Street (Wellington Zoo), was investigated was deemed impractical due to a number of issues.

Figure 6.5 below is a graphical representation of the data presented in **Table 6.4.**

Figure 6.5 Estimated Future AM peak PT Travel Times

If looking solely at potential travel times and excluding other factors such as cost, a rapid transit route from Kilbirnie to Courtenay Place via Mt Victoria tunnel would provide considerably more benefits for passengers from the eastern suburbs than a route from Kilbirnie to Courtenay Place via Newtown.

6.3 Potential LRT Routes

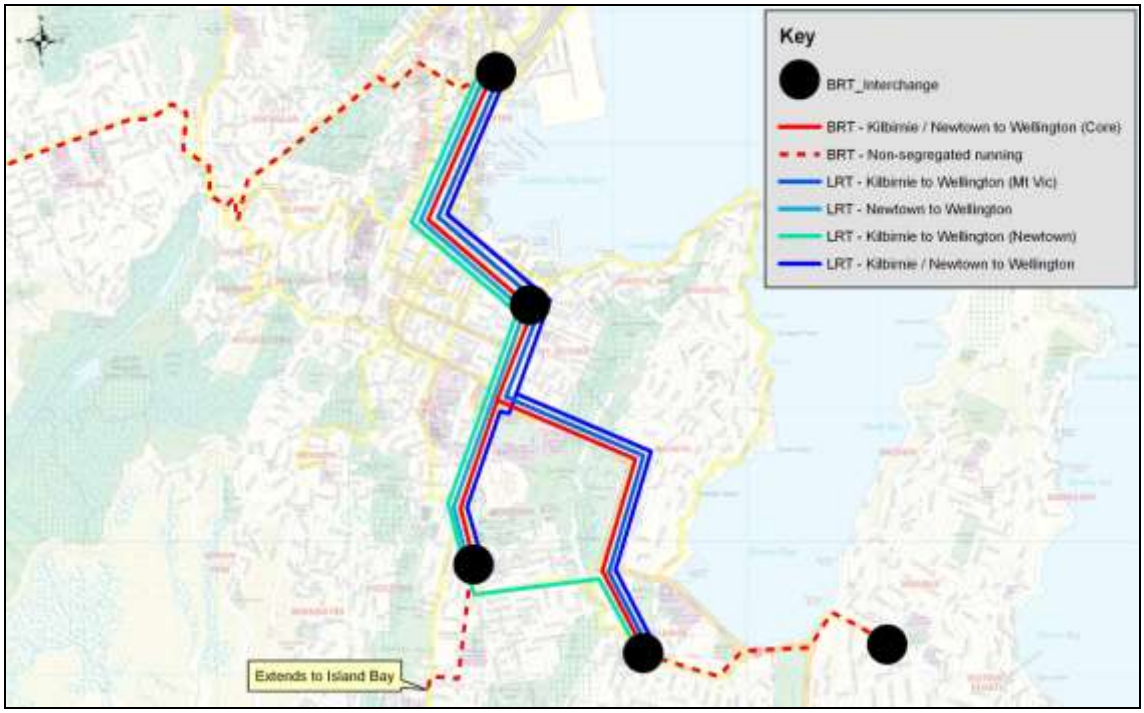
A number of possible LRT alignments were considered for serving the study area:

- a single LRT line from Wellington Station to Kilbirnie via Mt Victoria Tunnel;
- a single LRT line from Wellington Station to Kilbirnie via Newtown;
- a single LRT line from Wellington Station to Newtown; and
- a Y-shaped LRT line from Wellington Station, splitting at Basin Reserve with one branch going to Newtown and another going to Kilbirnie.

Feeder bus services would link into the LRT network at Kilbirnie and Newtown depending on the precise LRT option being considered.

Figure 6.6 below shows the potential LRT routes that were considered and evaluated, together with a BRT route that will be described in more detail in **Chapter 7**.

Figure 6.6 Potential LRT Routes and BRT Route



6.3.1 Kilbirnie Option

A single LRT option between Kilbirnie and Wellington Station was considered.

Passengers from Miramar / Lyall Bay wanting to access Wellington CBD would have to transfer at Kilbirnie Interchange onto LRT services.

Whilst passengers on the Kilbirnie branch would benefit from enhanced LRT travel times (these benefits would be eroded somewhat by the need to transfer), people travelling from Island Bay / Newtown to the CBD would experience little travel time savings as they'd still be travelling on normal bus services.

Many of the costs associated with LRT – depots, moving services, laying down track along the Golden Mile – would still be incurred but the level of benefits would be somewhat lower than an option that includes improvements to the south (Newtown, Island Bay) and the east (Kilbirnie, Miramar).

6.3.2 Newtown Option

A single LRT option between Newtown and Wellington Station was also considered.

Passengers from Miramar / Kilbirnie to Wellington CBD would travel over Constable Street and transfer onto LRT at Newtown, benefiting somewhat from the LRT travel time savings (again, eroded somewhat by the need to transfer)

Similar to the Kilbirnie option, the Newtown option would only really benefit users travelling between Newtown and Wellington CBD yet would also incur a lot of the fixed costs associated with LRT.

An increase in the number of buses between Kilbirnie and Newtown would cause congestion along Constable Street and Crawford Road, detrimentally affecting PT travel times.

6.3.3 Y Shaped Route

Modelling of the two single routes detailed above and a Y-shaped route suggests that creating this split route would provide higher benefits than two single routes, maximise the number of persons benefiting from LRT services.

The study team and project partners concluded that there would be merit in consistency between the BRT and LRT options considered for analysis at this short-list stage.

The route would provide a high quality PT corridor between Wellington CBD and the Hospital and take advantage of capacity improvements along Ruahine Street / Mt Victoria Tunnel to improve PT travel times between the eastern suburbs and Wellington CBD.

6.3.4 Potential BRT Routes

Unlike an LRT system where vehicles have to stick to designated corridors, BRT vehicles would be able to mix with general traffic as well as running on segregated rapid transit corridors.

This provides a large degree of flexibility in terms of designing routes. The principle around which a potential BRT network was designed is one whereby the core route – Kilbirnie to Wellington Station and Newtown to Wellington

Station – is served by a high frequency BRT service running along a segregated alignment.

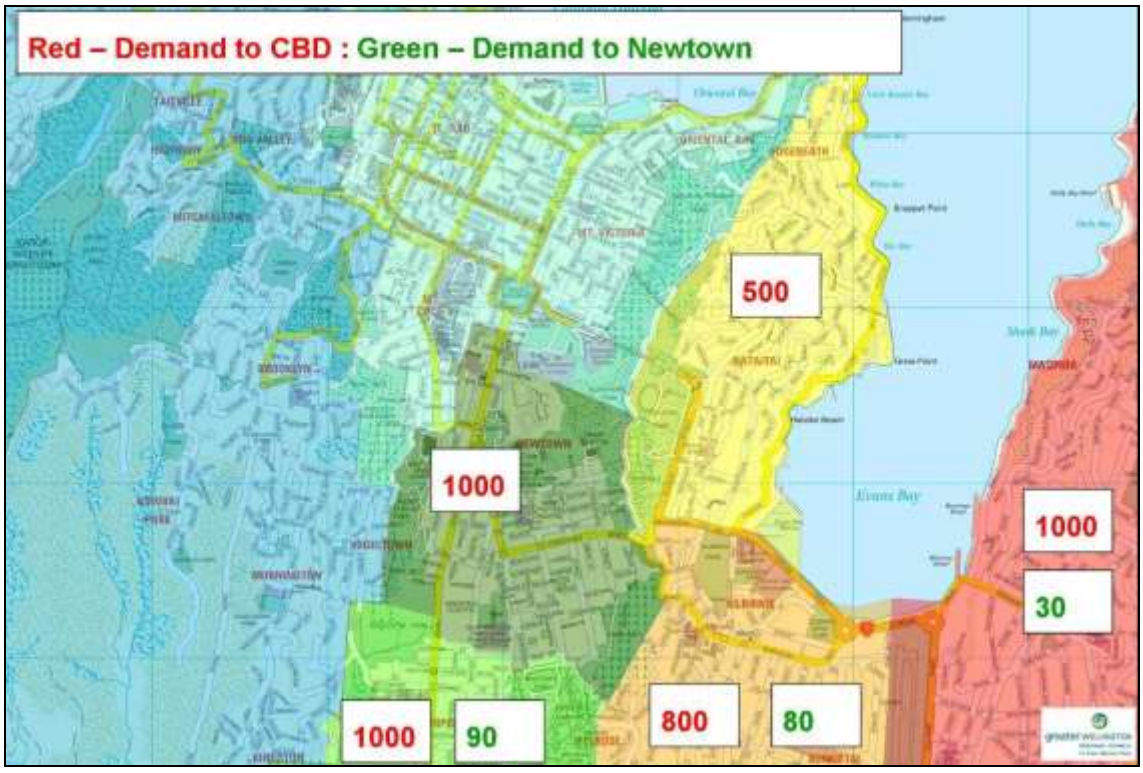
Some services will be extended at either end of the core route, potentially creating through routes between Karori / Newlands and Miramar / Island Bay. Passengers from these areas would then benefit from BRT standard vehicles, increased service frequencies and improved travel times along the core route.

6.4 Current Demand

Figure 6.7 overleaf shows 2011 demand from each sector to Wellington CBD and demand from selected sectors to Newtown over the AM peak 2hr period. It shows that:

- around 2,000 trips access Wellington CBD from Island Bay / Newtown;
- approximately 2,300 passengers travel between the eastern suburbs and Wellington CBD in the AM peak;
- very few trips are made between Miramar / Kilbirnie and Newtown and between Island Bay and Newtown; and
- current demand is roughly split 50:50 between the southern (Island Bay / Newtown) and eastern (Miramar / Kilbirnie catchments).

Figure 6.7 Demand to Wellington CBD and Demand to Newtown – AM peak, 2011



6.5 Summary

Corridor Analysis

- a high quality transit corridor should provide a **high quality, high frequency, high capacity public transport** offering;
- service frequencies greater than **12-20 vph (dependent on vehicle capacity)** and patronage greater than **1,600 pax/ hr are guideline minimum requirements** for any such corridor;
- four possible corridors were identified within Wellington City TA - **Karori, Johnsonville, Island Bay / Newtown and Kilbirnie / Miramar**;
- **Karori** was ruled out due to **insufficient levels of demand**;
- **Johnsonville** was ruled out due to **the costs** involved with converting the current rail service to LRT and the **high current PT mode share** limiting opportunities for increasing PT mode share from the area;
- a **corridor to the south** (Island Bay/ Newtown) **and east** (Kilbirnie/ Miramar) of Wellington was chosen because:
  - potential **demand is high enough** to justify investigating BRT / LRT;
  - more people wanting to access the CBD live within 800m of this potential alignment than do so for any other potential corridor catchment;
  - **PT travel times from these areas to the CBD are poor**, relative to car travel times;
  - **the current mode share of between 25% - 30% is relatively low** and potential exists to improve this in the future;

LRT Route Definition

- analysis of current and potential travel times show that a high quality route between **Kilbirnie and Courtenay Place (via Mt Victoria tunnel) would provide a 6 minute improvement** over current travel times.
- a route between **Kilbirnie and Courtenay Place (via Constable Street and Newtown) would only provide a 3 minute improvement** on the current fastest travel time between these two points;
- **four potential LRT routes** were considered:
  - Kilbirnie to CBD via Mt Victoria tunnel;
  - Kilbirnie to CBD via Constable Street and Newtown;
  - Newtown to CBD;

- Split route – Kilbirnie to CBD (via Mt Victoria tunnel) and Newtown to CBD;

- The **preferred option, a Y-shaped split route** was chosen because:

  - A route between Kilbirnie and Wellington CBD via Constable Street and Newtown does not provide adequate travel time savings for passengers from Miramar compared with the alternative route via Mt Victoria tunnel;

  - A tunnel between Kilbirnie and Wellington Zoo was discounted, mainly on the ground of costs;

  - both the Island Bay / Newtown and Kilbirnie / Miramar catchments are large enough to justify a high quality transit route in their own right.

- single routes from **Newtown and Kilbirnie to Wellington CBD respectively would only benefit part of the combined catchment;**

- **combining the two single routes should optimise the benefits of any scheme;**

- a Y-shaped route will result in **very high frequencies along the core Golden Mile;**

- a Y-shaped route will provide **options for potential extensions** to the south and east at a later date; and

- a Y-shaped route is similar to and can **be directly compared against the BRT** option.

7. Short List Options - Infrastructure and Services

The chapter outlines the reference case and three core options and is split into three sections.

7.1.1 Scheme characteristics that are largely common to all options

- planned infrastructure changes along the Golden Mile;
- services that are moved onto a secondary spine and the rationale for doing this;
- integrated ticketing.

7.1.2 Scheme characteristics that are specific to individual options

- infrastructure changes, stop locations, priority measures and assumed travel speeds;
- new service characteristics and frequencies;
- changes made to existing bus services;
- feeder bus services; and
- vehicles per hour travelling along the Golden Mile.

7.1.3 Alterations made to the highway network to provide capacity for PT

- Implications of these alterations for general traffic.

7.2 Golden Mile

It was agreed that the Golden Mile would be both designed and modelled in a similar manner for the BRT and LRT options, along the Golden Mile regardless of which option might be pursued so that vehicle frequencies along the Golden Mile can be reduced and service reliability improved.

Practical and modelling assumptions relating to PT along the Golden Mile are as follows:

- the number of bus stops along the Golden Mile is reduced in all options from eight to five. Normal bus services that run along the Golden Mile will use the same stops as BRT and LRT services (All options);
- the Golden Mile will be closed to general traffic in both directions between Cambridge Terrace and Taranaki Street all day (7am to 7pm) (BRT and LRT only). Limited access will be allowed to Courtenay Place in the Inter-peak;
- the major infrastructure change that will affect general traffic is that Willis Street (a section of the Golden Mile) will be closed to general traffic throughout the working day between Manners Mall / Boulcott Street and Old Bank Arcade (BRT and LRT only);

- PT will run on the western side of what is currently Lambton Quay, with highway traffic moved to the eastern side (All options); and

- a secondary bus spine will run along Featherston Street, Wakefield Street, Customhouse Quay and Jervois Quay to relieve bus capacity issues along the Golden Mile (BRT and LRT only).

The degree of priority given to public transport services at signals along the Golden Mile differs between options:

- Reference case ==> status quo;

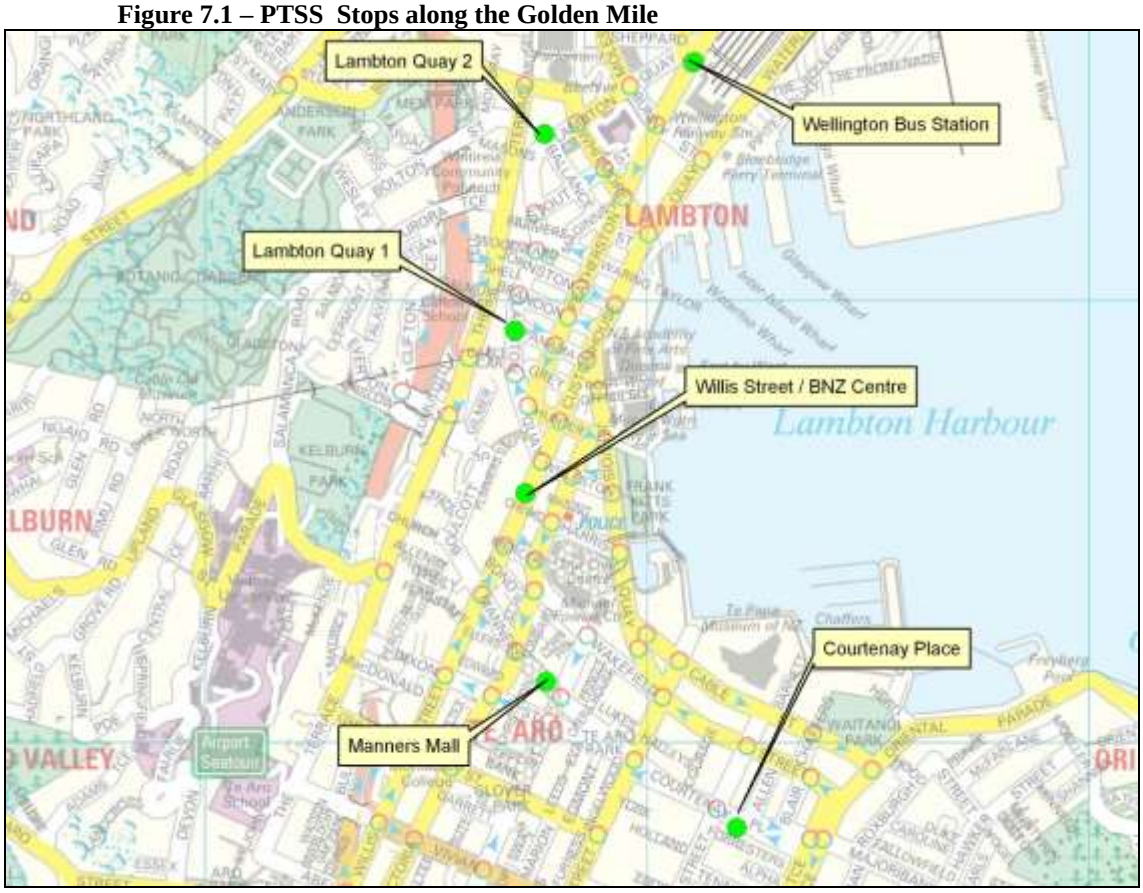
- BP ==> some additional priority; and

- BRT / LRT ==> maximum priority.

Stop dwell times will also vary along the Golden Mile between options as it is assumed that buses, having fewer entry / exit points than BRT / LRT vehicles, will have longer stop dwell times than BRT / LRT vehicles.

Figure 7.1 below shows a map of the proposed stops along the Golden Mile, defined as between These are not set in stone – rather they form a current best estimate of where the five stops should be located. The principle that the number of stops needs to be reduced is important and was a key finding of the 2009 Central City – Bus Operational Review (Opus 2009).

Figure 7.1 – PTSS Stops along the Golden Mile



The issue of whether the Golden Mile could be open to general traffic along its whole length during the off-peak period (i.e. weekends and evenings) has not been pursued as it is not of critical importance to the PTSS at this stage.

7.3 Secondary Spine

At present upwards of 80 vehicles per hour travel along certain sections of the Golden Mile between Courtenay Place and Wellington Station.

One of the recommendations of the Opus 2009 study was that the number of buses travelling along the Golden Mile should be reduced, as a lot of delays are currently caused by buses holding up other buses.

The Wellington City Bus Review, which forms the starting point for the PTSS public transport networks, envisages some rationalisation of services along the Golden Mile to improve PT travel times.

The PTSS builds further upon this rationalisation in the BRT and LRT options and assumes:

- some through bus services are split and terminate at Courtenay Place / Wellington Station, requiring passengers to transfer onto BRT / LRT services;

- a number of bus services from Johnsonville and Hutt Valley that currently run through to Courtenay Place are diverted onto a second spine that will form an anti-clockwise circuit along Featherston Street - Victoria St – Wakefield Street – Customhouse Quay - Jervois Quay; and

- BRT and LRT vehicles running along the Golden Mile will provide a similar capacity to what is currently offered but will result in fewer vehicles per hour by virtue of their higher vehicle capacities.

Figure 7.2 below shows the second spine, with **Table 7.1** containing a list of current services that get diverted onto the second spine in all options.

The majority of the affected services come from Johnsonville and the Hutt Valley. Current evidence suggests that loads on these services between Manners Mall and Courtenay Place are low, as the majority of passengers alight along Lambton Quay and Willis Street with very few continuing as far as Courtenay Place.

Given that integrated ticketing, superior interchange facilities (Courtenay Place, Wellington Station) and superior travel times along the Golden Mile are key components of the BRT and LRT options, transferring from secondary spine services at Wellington Station onto BRT / LRT services will be practical, efficient and free.

Moving services onto the secondary spine should result in few adverse impacts for passengers who currently use affected services and any such adverse impacts should be outweighed by system wide gains from improved travel times along the Golden Mile.

The secondary spine will only need to be used during peak periods.

Figure 7.2 – Secondary Spine

Table 7.1 Secondary Spine Bus Services

Service Number	Service Description	AM peak hour frequency[1]
3	Johnsonville to Lyall Bay	6
46	Broadmeadows	3
52	Johnsonville / Newlands to Wellington (peak only to Wellington)	2
53	Johnsonville West to Wellington (peak only to Wellington)	3
56	Johnsonville / Paparangi to Wellington (peak only to Wellington)	3
80	Wainouiomata Commuter	1
81	Eastbourne	3
83	Eastbourne via Lower Hutt	2
84	Gracefield	1
85	Eastbourne Express	1
92	Te Marua to Wellington	2
210	Titahi bay – Wellington (Peak only to Wellington)	2

[1] The peak hourly frequency represents, roughly, arrivals between 7.30am and 8.30am. Some routes (80,84,85) only have one service during the AM peak 2 hour period and these services are included in the peak hour. The peak frequencies above account for 60/65% of all services that would run along the Secondary Spine in the AM peak 2hr (7am to 9am) period

7.4 Common Infrastructure Assumptions

Bus travel times are a function of three main factors:

- highway travel speeds - buses share road space with cars for the majority of their journey and are subject to the same levels of congestion (bus lanes / BP mitigate the impact that general traffic has upon bus travel times in certain locations);

- bus stop spacing - every time a bus stops to pick up passengers it must decelerate on the approach to the stop, wait for a gap in the traffic when leaving the stop and then accelerate back up to speed;

- bus stop dwell time - independent of the deceleration and acceleration time, the dwell time is related to the number of people alighting / boarding at a certain stop, their method of payment (smartcard, cash) and the number of exit / entry points on the vehicle;

All of the PTSS options include improvements to each of these three components of travel time.

7.4.1 Highway Travel Times

Highway travel times for buses, BRT and LRT will be improved by a combination of priority measures at signals, standard bus lanes and segregated public transport corridors.

7.4.2 Stop Spacing

An increase in stop spacing along the Golden Mile (all options) and along the BRT and LRT corridors will improve public transport travel times.

7.4.3 Ticketing and Access

Currently around 75% of trips within Wellington are paid for using stored value smartcards. The advantage of this method of payment over cash is that it is quicker and reduces boarding times.

The usage of such technology has increased dramatically over the last few years.

For the PTSS it has been assumed that a form of integrated ticketing will be operational in 2021 and that it will include the following key components:

- currently, persons transferring from rail to bus (or vice versa) have to pay two separate fares in most instances, reducing the attractiveness of multi-modal trips. Integrated ticketing will work out your fare depending on your initial boarding stop and final alighting stop, regardless of how many times you change services.

- all fares will either be paid using smartcards or cash tickets purchased from self-service ticket machines. No cash payment will be accepted on-board;

- there will be a greater number of card readers on all forms of public transport, so that passengers can walk onto the bus and swipe their card once on-board rather than when entering / exiting the vehicle; and

- all vehicles will have a minimum of two entries / exits (BRT and LRT vehicles will have more). Some vehicles will have access from both sides. This will reduce boarding / alighting times.

7.5 Reference Case

The reference case networks are essentially the Wellington City Bus Review networks as of November 2012, apart from a number of services that have been linked to create through routes for operational reasons:

- **New Service 3**: Current service 3 (Lyall Bay to Wellington Station) is combined with current service 57/58 (Newlands to Wellington);

- **New Service 7**: Current service 7 (Kingston to Wellington Station) is combined with current service 56 (Grenada to Wellington); and

- **New Service 8**: Current service 8 (Brooklyn to Wellington Station) is combined with current service 54 (Churton Park to Wellington).

Figure 7.3 below is a map showing these changes.

Figure 7.3 – Routes altered in the Reference Case and BP Options

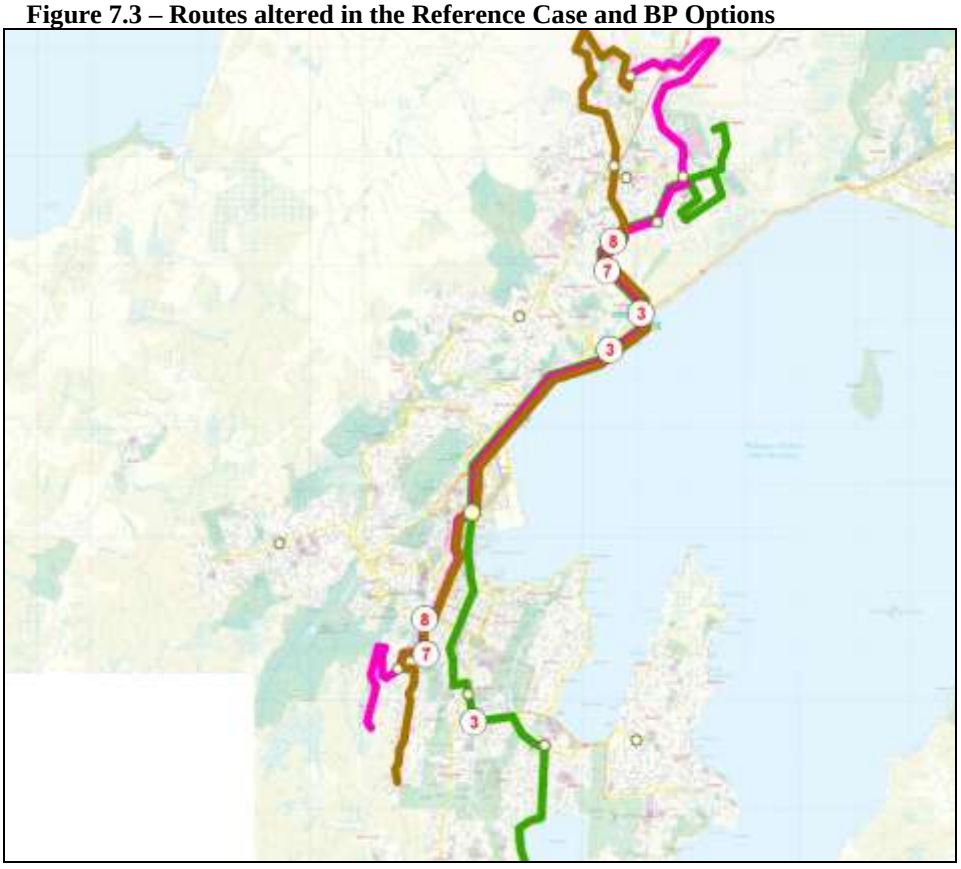


Table 7.2 and **Table 7.3** show bus frequencies along the Golden Mile in the AM peak and Inter-peak.

Table 7.2 Reference Case AM peak bus frequencies along Golden Mile

Section	Northbound service frequency (vph)	Southbound service frequency (vph)
Courtenay Place – Taranaki Street	59	68
Taranaki Street – Willis Street	65	92
Willis Street – Lambton Quay	79	89
Lambton Quay – Bowen Street	79	89

Table 7.3 Reference Case Inter-peak Bus Frequencies along Golden Mile

Section	Northbound service frequency (vph)	Southbound service frequency (vph)
Courtenay Place – Taranaki Street	26	25
Taranaki Street – Willis Street	26	38
Willis Street – Lambton Quay	39	35
Lambton Quay – Bowen Street	39	35

The data shows that on most sections of the Golden Mile in the AM peak the number of vehicles per hour is high, leading to congestion similar to that currently experienced along the Golden Mile at peak times.

7.6 Bus Priority Option

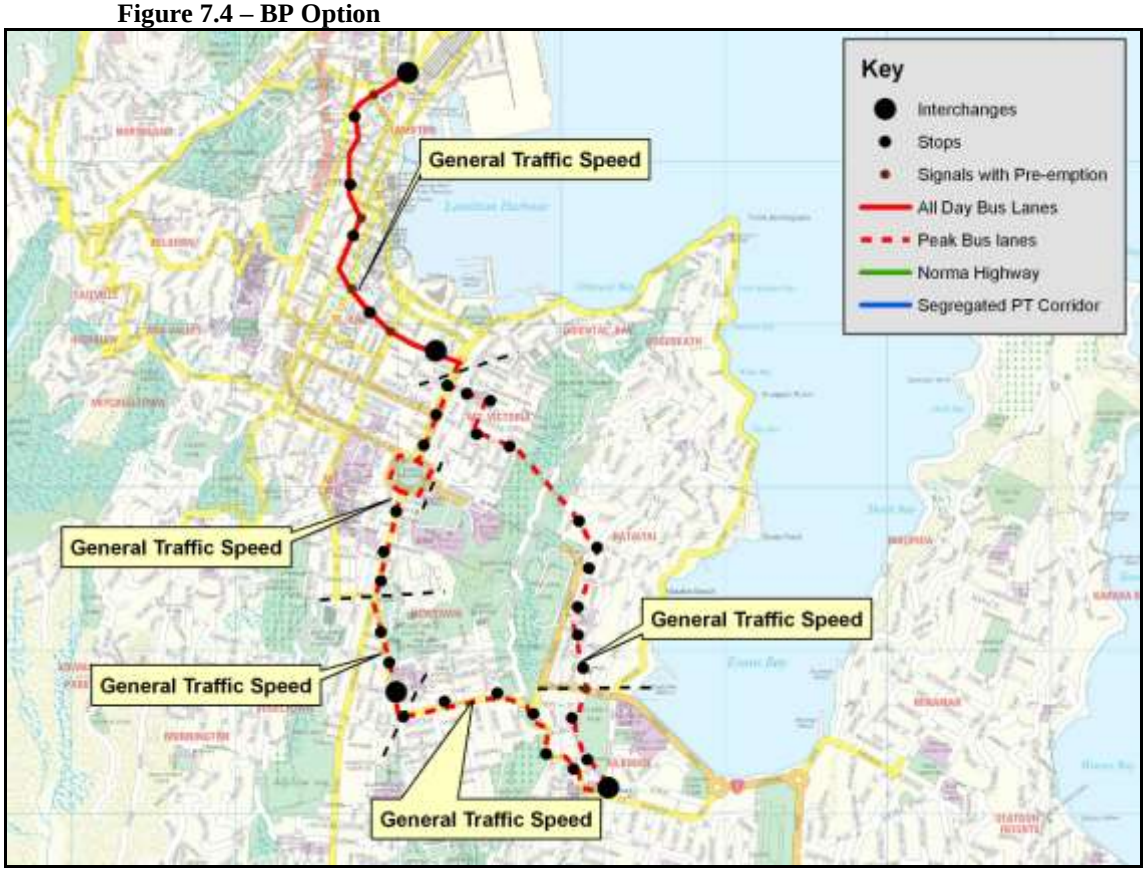
The bus priority networks are exactly the same as the reference case networks. The only difference between the reference case and bus priority options relates to additional bus priority measures at selected intersections in the AM peak and a reduced number of stops along the Golden Mile.

The Inter-peak bus priority networks are identical to the Inter-peak reference case networks (apart from the reduced number of stops along the Golden Mile).

7.6.1 Bus Priority Option

Figure 7.4 below is a map of the bus priority option showing infrastructure changes, stop locations, priority measures and assumed travel speeds.

Figure 7.4 – BP Option



Peak bus lanes are planned along all sections of the core bus priority network. These bus lanes do not result in any significant reduction in capacity for general traffic as they utilise existing road space or existing parking.

Buses will run at the same speed as general traffic, unless they are in bus lanes in which case they will run at around 25kph (this varies slightly in the model depending on the type of road).

Buses will be given limited priority at the following intersections:

- SH1 / Kilbirnie Crescent;
- Elizabeth Street / Cambridge Terrace;
- Constable Street / Riddiford Road;
- Victoria Street / Manners Mall;
- Taranaki Street / Manners Mall; and
- Courtenay Place / Tory Street.

Stop spacing and stop dwell times are identical to those in the reference case, except along the Golden Mile.

The Golden Mile has peak period bus lanes along most of its length, with general traffic permitted along all sections except:

- Taranaki Street to Willis Street; and
- BNZ Centre past old Bank Arcade to Panama Street on Lambton Quay.

On Lambton Quay to the north of Panama Street, PT runs on the western side, segregated from general traffic on eastern side

7.6.2 Interchanges

The bus priority network does not require any forced transferring between buses. Limited interchanging will however occur at the following locations:

- Kilbirnie; and
- Newtown.

7.6.3 Golden Mile bus frequencies

Bus frequencies in the bus priority option are identical to those in the reference case.

7.7 Bus Rapid Transit Option

7.7.1 BRT Vehicles

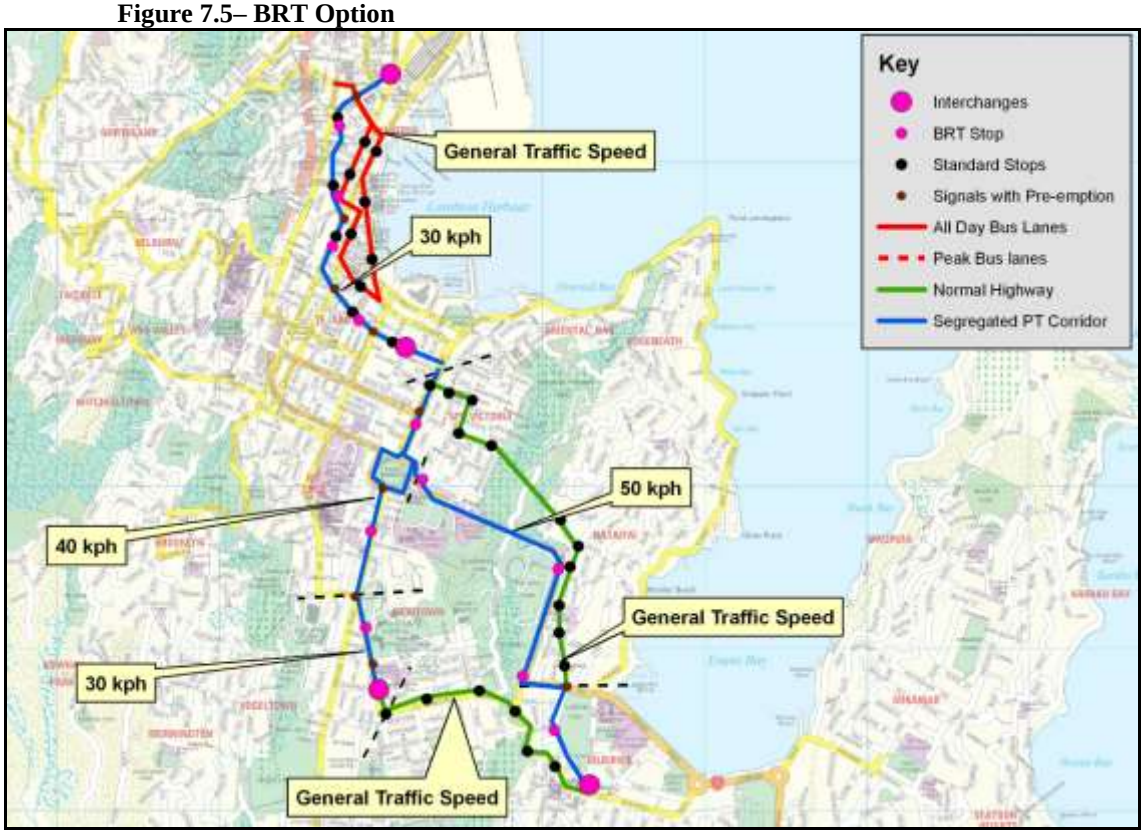
It is envisaged that BRT vehicles will be low-floor, articulated vehicles of a similar standard to LRT vehicles. The vehicles will have multiple entry / exit points, possibly on both sides, and will contain ample space for both seating and standing passengers.

Given the superior ride quality and design of BRT vehicles relative to normal buses, standing is generally considered more acceptable than it would be on a bus (but less acceptable than on a LRT vehicle)

7.7.2 BRT Option

Figure 7.5 is a map of the BRT option showing infrastructure changes, stop locations, priority measures and assumed travel speeds.

Figure 7.5– BRT Option



Normal buses run with general traffic between Kilbirnie and Newtown, via Constable Street, and between Kilbirnie and Courtenay Place via Hataitai (to service limited local demand within Hataitai).

All-day bus lanes are introduced along the secondary spine, as services will be re-routed from the Golden Mile to optimise BRT travel times. The removal of parking and limited reductions in highway intersection capacities is required to accommodate these bus lanes.

BRT vehicles will join the BRT network at Kilbirnie / Newtown and run fully segregated from general traffic along their entire route length from Kilbirnie / Newtown to Wellington Station. There are 4 intermediate BRT stops between Kilbirnie Interchange and Courtenay Place and 3 between Newtown Interchange and Courtenay Place.

Along the Golden Mile there are 5 stops, including Courtenay Place interchange but excluding Wellington Station.

Free flow BRT running speeds are assumed to be between 25kph and 50kph, depending on the section of route. In reality the actual outturn speeds are lower due to stop dwell times and a limited amount of delay incurred at intersections.

BRT vehicles will receive full priority at all signals along their route, minimising the intersection delays that they might experience.

Full signal priority will be given to BRT vehicles along the Golden Mile.

7.7.3 BRT Network

The flexibility of the BRT network allows BRT vehicles to run with general traffic from Island Bay and Miramar, feeding into the dedicated, segregated BRT corridor at Kilbirnie and Newtown.

From these interchange points onwards, the BRT will run along a fully segregated BRT corridor, picking up passengers at selected BRT stations and having full priority over general traffic at intersections.

BRT services will not be segregated from general traffic through Mt Victoria Tunnel. BRT services will feed into the inside lane of general traffic before peeling off again at the exit point from each tunnel bore to re-join the segregated corridor.

BRT will run either side of the central reserve along Cambridge/ Kent Terrace.

BRT then joins the Golden Mile and runs along its entire length, segregated from general traffic and receiving full priority at signalised intersections, before reaching Wellington Station.

Along the segregated core sections of the network, namely Kilbirnie/ Newtown to Wellington Station, BRT will be separated from normal buses to optimise travel times. In the model, buses running along the same stretch of road as LRT/ BRT services actually have the same travel speeds as BRT/ LRT, as the model does not allow for PT services using the same stretch of road to have different speeds. In reality this is not an issue as few normal buses run along the BRT/ LRT corridors outside of the Golden Mile where they will both share the same road space and have the same speeds.

From Wellington Station, some BRT services from Island Bay will head to Karori, providing a superior level of service and connectivity for these passengers.

7.7.4 BRT Routes and Frequencies

Figure 7.6 shows the routes that will be served by BRT vehicles under the BRT option. The services and frequencies are as follows:

- BRT 1 – Miramar to Wellington Station, 8 vph (AM), 3 vph (IP);
- BRT 2 – Seatoun to Wellington Station, 8 vph (AM), 3 vph (IP);
- BRT 3a – Island Bay to Wellington Station, 6 vph (AM), No service in inter-peak; and
- BRT 3b – Island Bay to Karori, 10 vph (AM), 6 vph (IP).

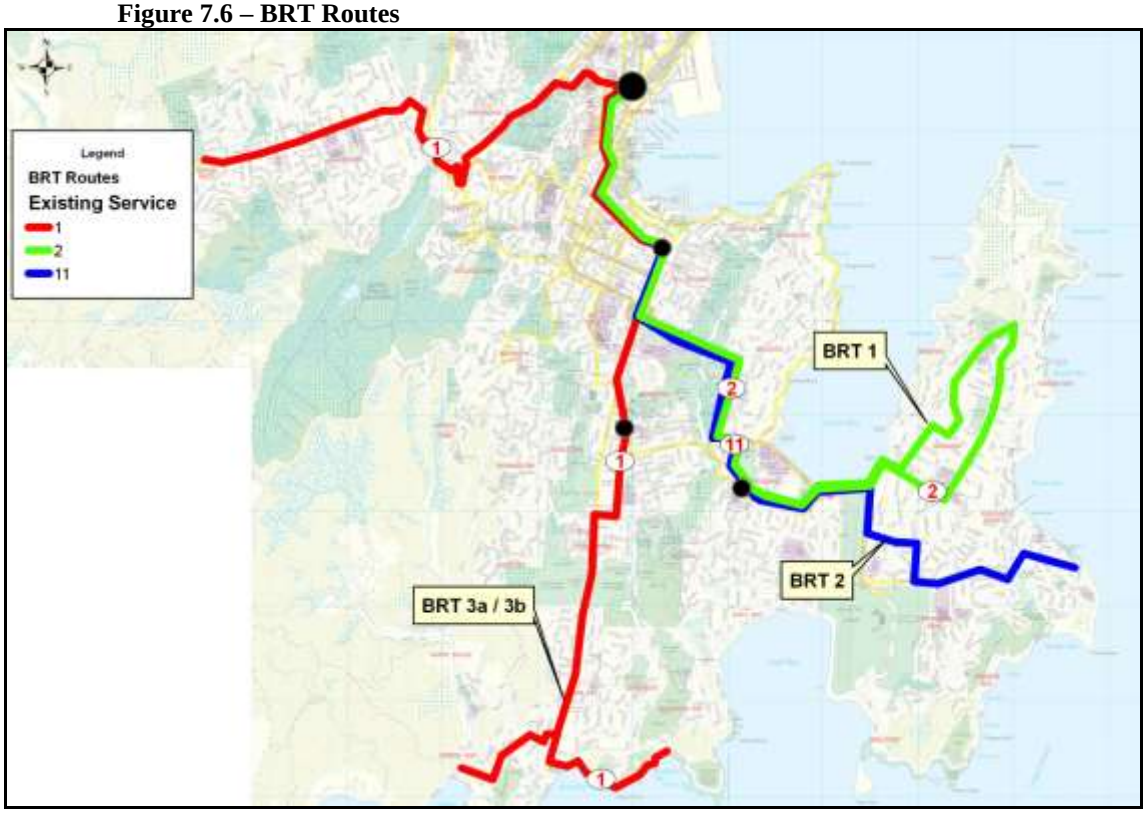
The combined frequencies along core sections of the network are as follows:

- Kilbirnie to Courtenay Place – 16 vph (AM), 16 vph (IP);
- Newtown to Courtenay Place – 16 vph (AM), 16 vph (IP); and

- Karori to Courtenay Place – 10 vph (AM), 16 vph (IP).

These frequencies are indicative at present and have been designed to match capacity to forecast demand. Given the flexibility of the BRT system, short-running BRT services could operate between Wellington Station and Kilbirnie / Newtown at peak times to best match capacity and demand.

Figure 7.6 – BRT Routes



7.7.5 BRT feeder bus services

The BRT option involves limited transferring between services at the following locations:

- **Miramar – Services 25 (Strathmore) and 24 (Miramar Circular)** are truncated and now connect with BRT services at Miramar shops. Enhanced service frequencies are provided to compensate for the need to interchange;

- **Kilbirnie – Service 14**, from Rongotai to Kilbirnie and onwards to Hataitai and Courtenay Place, travels through Kilbirnie, allowing passengers to transfer onto BRT for a faster journey into the CBD and onwards to Courtenay Place;

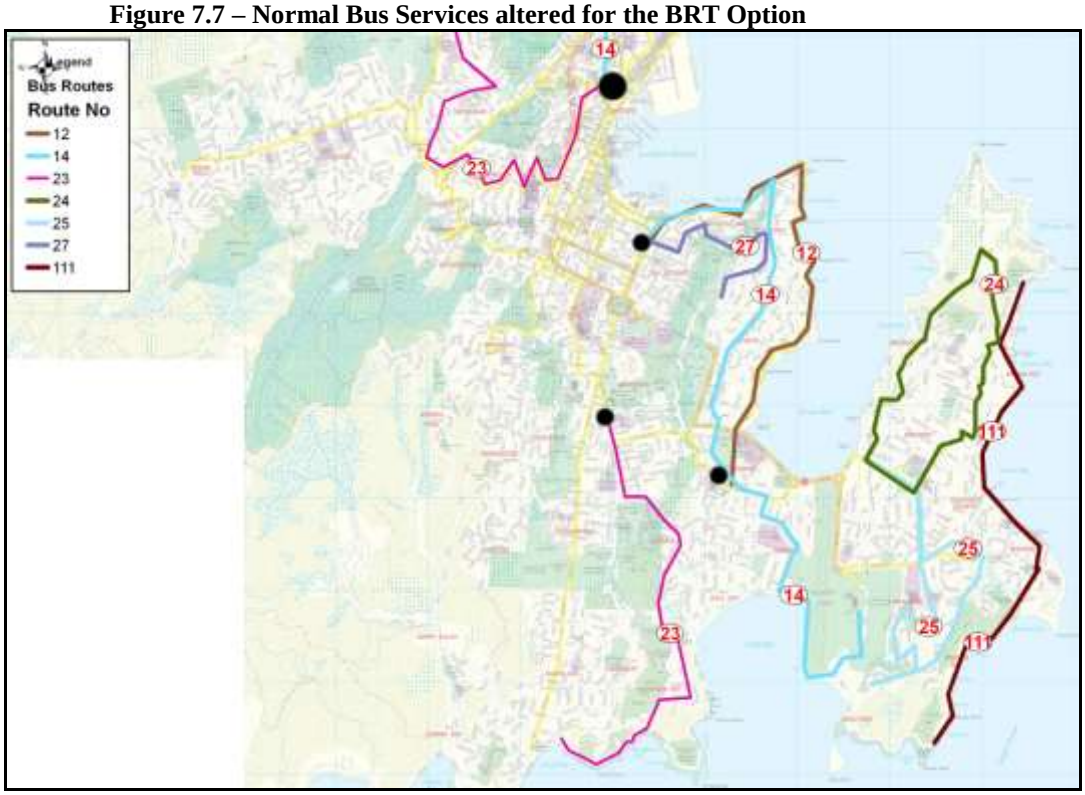
- **Newtown – Service 23**, from Houghton Bay to CBD, is truncated at Newtown with passengers transferring onto the BRT;

- **Courtenay Place – services 12, 14 and 27** are truncated at Courtenay Place, allowing transfer onto BRT for onwards connections along the Golden Mile. This removes standard buses from the Golden Mile, optimising BRT travel times and reducing congestion; and

- **Wellington Station** – services 14 and 23 are truncated at Wellington Station, with passengers transferring onto BRT. Again, the purpose of this is to reduce operational costs and to optimise BRT travel times along the Golden Mile.

Figure 7.7 below shows the normal bus services that have been altered for the BRT option.

Figure 7.7 – Normal Bus Services altered for the BRT Option



The changes to normal bus services presented above are an indication of what needs to be done to competing and feeder bus services in order to optimise BRT travel times and patronage.

Whilst the exact routes that are altered could be discussed and debated, the general principle is more important - that other services need to be altered to optimise BRT travel times and benefits.

7.7.6 BRT Golden Mile service frequencies

Table 7.4 and **Table 7.5** below shows service frequencies (BRT and buses) along the Golden Mile in the AM peak and Inter-peak together with the number and percentage of BRT vehicles.

Table 7.4 BRT Option Vehicle Frequencies along Golden Mile, AM peak

	Total Vehicles per Hour		BRT Vehicles per Hour		% BRT	
Section	**NB**	**SB**	**NB**	**SB**	**NB**	**SB**
Courtenay Place – Taranaki Street	33	33	32	32	96%	96%
Taranaki Street – Willis Street	39	39	32	32	81%	81%
Willis Street – Lambton Quay	53	53	32	32	60%	60%
Lambton Quay – Bowen Street	53	53	32	32	60%	60%

Table 7.5 BRT Option Vehicle Frequencies along Golden Mile, Inter-peak

	Total Vehicles per Hour		BRT Vehicles per Hour		% BRT	
Section	**NB**	**SB**	**NB**	**SB**	**NB**	**SB**
Courtenay Place – Taranaki Street	14	16	12	12	86%	75%
Taranaki Street – Willis Street	16	18	12	12	75%	67%
Willis Street – Lambton Quay	23	25	12	12	52%	48%
Lambton Quay – Bowen Street	23	25	12	12	52%	48%

Compared to the reference case and BP options, the BRT option results in a drop in the number of PT vehicles travelling along the Golden Mile. This is likely to improve PT service reliability.

The majority of vehicles along the Golden Mile are BRT vehicles. The Airport Flyer still runs along the entire length of the Golden Mile, whilst select services from the inner southern suburbs run along the Golden Mile from Willis Street to Wellington Station as they cannot be easily moved onto the secondary spine:

- Service 7 – Brooklyn to Newlands;
- Service 8 – Kowhai Park to Grenada;
- Service 19 – Aro Valley to Khandallah; and
- Service 26 – Highbury to Ngaio.

7.8 Light Rail Transit Option

7.8.1 LRT Vehicles

It is envisaged that the LRT units will have 2 carriages. The vehicles will be low-floor vehicles, allowing easy access for persons with disabilities.

The broad layout of the vehicles will be similar to that of the BRT vehicles, except that there will be more entry / exit doors for the LRT ,fewer seats and more standing room.

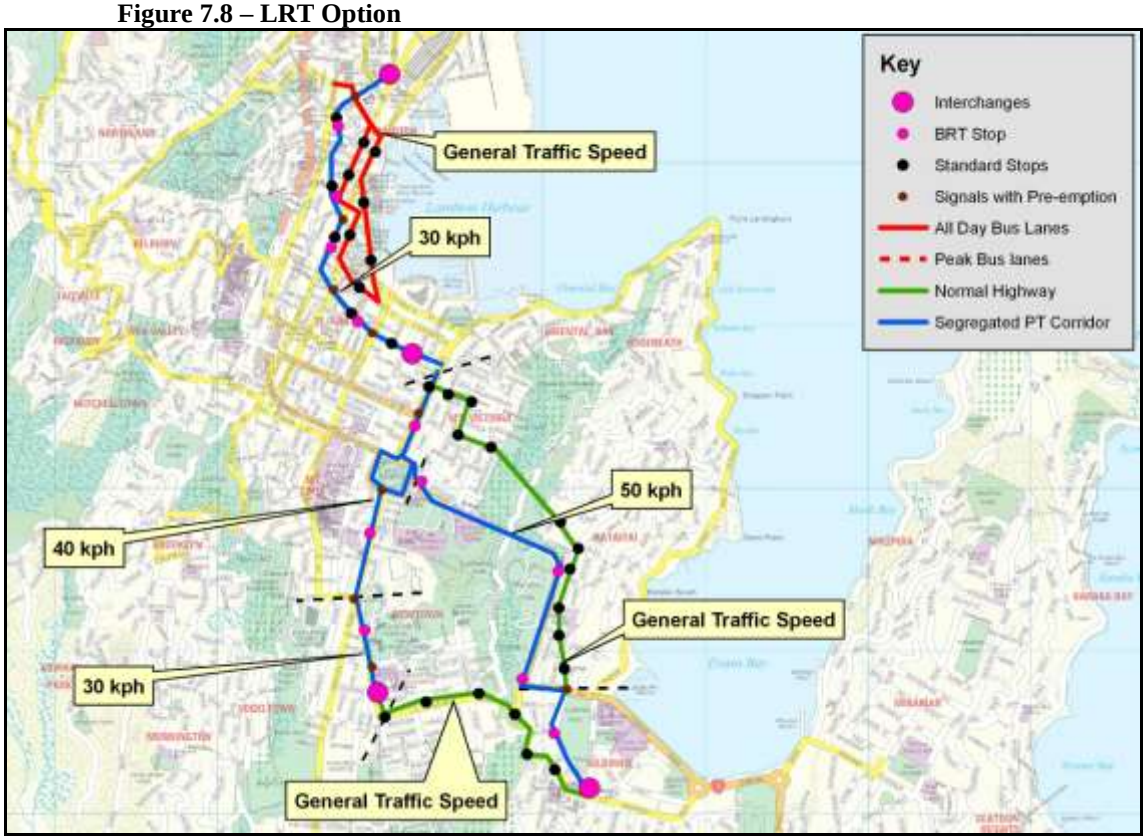
This is typical of LRT vehicles around the world, where the ratio of seated to standing capacity is roughly 50:50, as opposed to normal buses where the ratio is 75:25.

Given the superior ride quality of LRT over BRT and normal bus, standing is more acceptable and less of an inconvenience compared with buses and, to a lesser extent, BRT vehicles.

7.8.2 LRT Option

Figure 7.8 below is a map of the LRT option showing infrastructure changes, stop locations, priority measures and assumed travel speeds.

Figure 7.8 – LRT Option



Buses run with general traffic between Kilbirnie and Newtown, via Constable Street, and between Kilbirnie and Courtenay Place via Hataitai.

All-day bus lanes are introduced along the secondary spine, as services will be re-routed from the Golden Mile to optimise LRT travel times. The removal of parking and limited reductions in highway intersection capacity is required to accommodate these bus lanes.

LRT vehicles will run fully segregated from general traffic along their entire route length from Kilbirnie / Newtown to Wellington Station. There are 4

intermediate LRT stops between Kilbirnie Interchange and Courtenay Place and 3 between Newtown Interchange and Courtenay Place.

There are 5 stops along the Golden Mile, including Courtenay Place interchange but excluding Wellington Station.

Free flow LRT running speeds are assumed to be between 25kph and 50kph, depending on the section of route. In reality the actual outturn speeds are lower due to stop dwell times and a limited amount of delays incurred at intersections.

LRT vehicles will receive full priority at all signals along their route, reducing intersection delays that they might experience.

Full signal priority will be given to LRT vehicles along the Golden Mile.

7.8.3 LRT Routes and Frequencies

The LRT network consists of two branches serving Kilbirnie and Newtown, with services running from these points to Courtenay Place and then onwards to Wellington Station, providing a combined frequency between Courtenay Place and Wellington Station of 24 services per hour. The LRT services are as follows:

- LRT 1 – Kilbirnie to Courtenay Place, 12 vph (AM), 6 vph (IP); and
- LRT 2 – Newtown to Courtenay Place, 12 vph (AM), 6 vph (IP).

Newtown and Kilbirnie LRT stops will be premium interchanges where passengers can easily transfer from feeder bus services onto LRT services.

Whilst interchanging between modes will incur small time penalties and a certain ‘inconvenience’ factor, premium interchanges and timed services will keep these dis-benefits to a minimum.

The benefits of this approach:

- are to optimise LRT travel times and benefits by removing conflicts between LRT vehicles and buses;
- are to optimise LRT patronage and reduce bus operating costs by removing competing bus services;
- could increase frequencies on feeder bus services to compensate for the need to transfer between bus and LRT.

Time savings as a result of improved LRT travel times will be set against any dis-benefits incurred when interchanging between modes.

7.8.4 LRT Feeder bus services

The LRT option focuses interchanging at the LRT termini and, to a minor, extent, Courtenay Place:

- **Service 1 - Karori to Island Bay** - service is split in two at Newtown and Wellington Station respectively, with passengers transferring onto LRT at these locations;

- **Service 3 - Lyall Bay to Johnsonville** – routed via Wallace Street and Secondary Spine;

- **Service 11 - Seatoun to Wellington Station** – truncated at Newtown to feed passengers onto LRT services. Enhanced service frequencies to compensate for this need to transfer;

- **Service 2 - Miramar to Wellington Station** – truncated at Newtown to feed passengers onto LRT services. Enhanced service frequencies to compensate for the need to transfer onto LRT;

- **Services 25 (Strathmore) and 24 (Miramar Circular) -** truncated and now connect with LRT services at Kilbirnie interchange. Enhanced service frequencies are provided to compensate for the need to interchange;

- **Service 14 - Rongotai to Kilbirnie and onwards to Hataitai and Courtenay Place** - travels through Kilbirnie, allowing people to transfer onto BRT for a faster journey into the CBD and onwards to Courtenay Place;

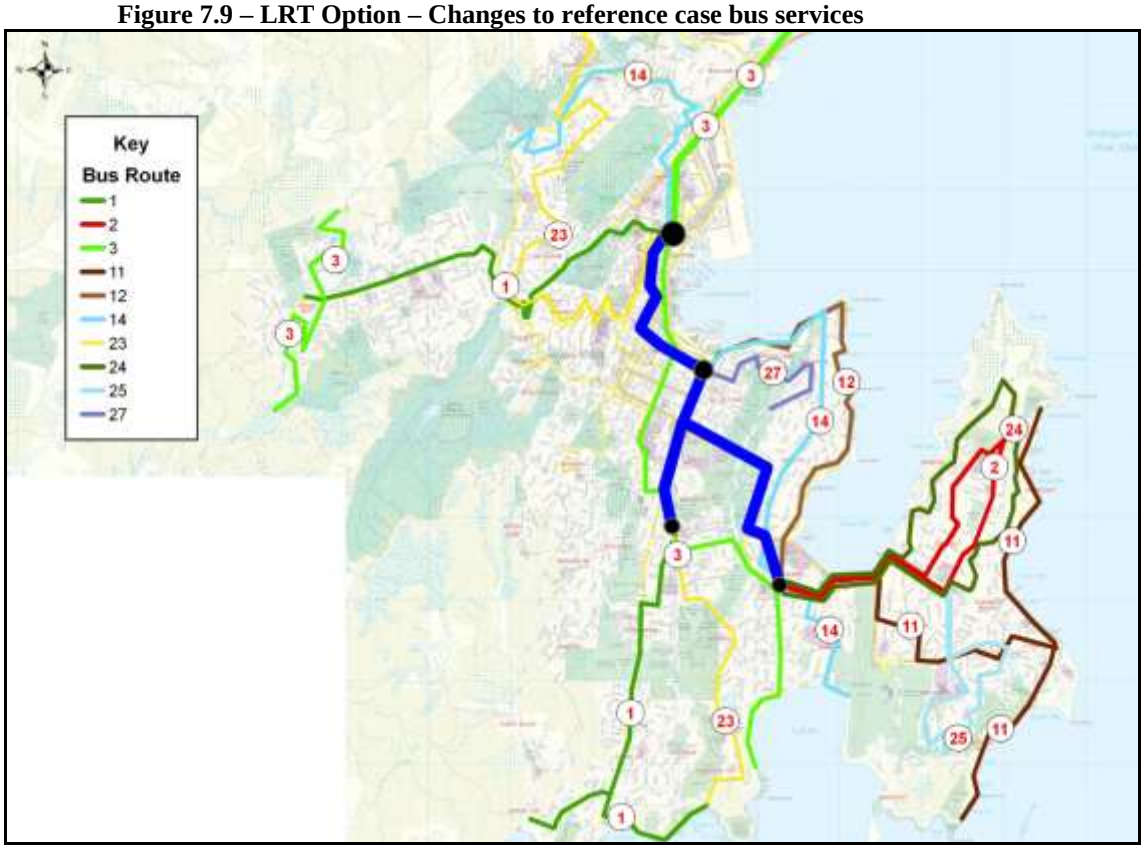
- **Service 23 - Houghton Bay to CBD** - truncated at Newtown with passengers transferring onto the LRT;

- **Services 12, 14 and 27** - truncated / split at Courtenay Place, allowing transfer onto LRT for onwards connections along the Golden Mile; and

- **Services 14 and 23** - truncated / split at Wellington Station, with passengers transferring onto LRT.

Figure 7.9 shows the alterations made to normal bus services in the LRT option.

Figure 7.9 – LRT Option – Changes to reference case bus services



The changes to reference case bus services documented above are an indication of what needs to be done to competing and feeder bus services in order to optimise LRT travel times and patronage. Similar to the BRT, the principle of altering routes to optimise the LRT system is more important at this stage that the exact changes that are proposed.

7.8.5 LRT Golden Mile service frequencies

Table 7.6 and **Table 7.7** shows service frequencies along the Golden Mile in the LRT option:

Table 7.6 LRT Option Vehicle Frequencies along Golden Mile, AM peak

	Total Vehicles per Hour		LRT Vehicles per Hour		% LRT	
Section	**NB**	**SB**	**NB**	**SB**	**NB**	**SB**
Courtenay Place – Taranaki Street	26	34	24	24	92%	71%
Taranaki Street – Willis Street	32	40	24	24	75%	60%
Willis Street – Lambton Quay	46	54	24	24	52%	44%
Lambton Quay – Bowen Street	46	54	24	24	52%	44%

Table 7.7 LRT Option Vehicle Frequencies along Golden Mile, Inter-peak

	Total Vehicles per Hour		LRT Vehicles per Hour		% LRT	
Section	**NB**	**SB**	**NB**	**SB**	**NB**	**SB**
Courtenay Place – Taranaki Street	14	16	12	12	86%	75%
Taranaki Street – Willis Street	16	18	12	12	75%	67%
Willis Street – Lambton Quay	23	25	12	12	52%	48%
Lambton Quay – Bowen Street	23	25	12	12	52%	48%

Compared to the reference case and BP frequencies, the LRT option results in a drop in the number of PT vehicles travelling along the Golden Mile. This is likely to improve PT service reliability.

The majority of vehicles along the Golden Mile are LRT vehicles. The Airport Flyer still runs along the entire length of the Golden Mile, whilst select services from the inner southern suburbs run along the Golden Mile from Willis Street to Wellington Station as they cannot be easily moved onto the secondary spine:

- **Service 7** – Brooklyn to Newlands;
- **Service 8** – Kowhai Park to Grenada;
- **Service 19** – Aro Valley to Khandallah; and
- **Service 26** – Highbury to Ngaio.

7.9 Future Highway Infrastructure Assumptions

The following road schemes were implemented in all scenarios and for all years (2021,2031,2041). The RoNS schemes in particular were based on the latest information from NZTA.

- **SH1 Basin Reserve Bridge and associated improvements (RoNS):** a bridge to the north of the Basin Reserve, with an Eastbound link between Kent Terrace and Mt Victoria tunnel and a westbound link between Mt Victoria tunnel and Buckle St. Local improvements to the Basin Reserve roundabout;
- **SH1 Ruahine St double-laneing (RoNS, part of Airport to Mt Victoria Tunnel project):** double laneing of Ruahine St and Wellington St;
- **SH1 Inner City Bypass Improvements (RoNS):** additional capacity through clearway lanes and upgrades to key intersections; and
- **SH1 Ngauranga to Aotea 4-laning:** Increased capacity to four lanes per direction on SH1 between Ngauranga interchange and Aotea Quay off/on ramp;

- **SH1 Memorial Park Underpass (RoNS):** Underground section of Buckle St between Tory St and Taranaki St;

- **Adelaide Road Improvement:** 4-laning of Adelaide Rd between Basin Reserve and John St, with one lane for general traffic and one bus lane in each direction (modified for PTSS layout in options);

- **SH1 Mackays to Peka Peka (RoNS):** New SH1 link between McKays Crossing and Peka Peka, with two lanes per direction and two interchanges with the local network;

- **SH1 Peka Peka to Otaki (RoNS):** New SH1 link between Peka Peka and Otaki with two lanes per direction; and

- **SH58/SH2 Interchange:** Grade separation of SH2 / SH58 interchange with on/off ramp in both directions on SH2.

The following schemes have been implemented from 2031 onwards as they were not planned to be completed by 2021:

- **Mt Victoria Tunnel duplication (RoNS, part of Airport to Mt Victoria Tunnel project):** two lanes each way in Mt Victoria tunnel, complementing Ruahine St Duplication;

- **Transmission Gully (RoNS):** 27km motorway link between Linden and McKays Crossing with two lanes in each direction and interchange with SH58; and

- **Petone to Grenada Link**: new motorway link connecting SH1 at Grenada to SH2 at Petone, with connections to the planned Lincolnshire Farm developments.

7.10 Highway Modifications for the PTSS

Changes have been made to the number of lanes, permitted turning movements and capacities at certain intersections along the core route to model the reduction in capacity for general traffic that would be created by constructing segregated BRT and LRT corridors.

Apart from the aforementioned restrictions to general traffic along the Golden Mile – which will apply to the BRT / LRT options - small reductions in capacity for general traffic are made along Riddiford Rd and Constable Street in the BP option as it is assumed that all other bus lanes can be accommodated within the existing road space by the removal of parking.

No detailed intersection design has been undertaken at this stage for any of the options. Below is a first estimate of what might need to be done at various locations on the network to provide PT with adequate priority measures. Should any PTSS option be progressed, more detailed intersection design would be a required.

Alterations were made to WTM in order to generate intersection capacities that were then input to WTSM. Where a change in the number of lanes occurs, this was also coded into WTSM unless otherwise stated along with the revised intersection capacities:

- Lambton Quay – BRT / LRT will run on the western side of Lambton Quay, with general traffic running down the eastern side. In modelling terms this has been represented by reducing the number of lanes available for general traffic along Lambton Quay in both directions from 2 to 1. Side road saturation flows are also reduced accordingly;

- Featherston Street – buses will run down Featherston Street as they are been diverted onto the second spine. Saturation flows for general traffic have been reduced by 25% along Featherston Street between Whitmore Street to represent this;

- Customhouse Quay – as a proxy for the impact that buses and bus lanes might have on general traffic, saturation flows along this stretch of road have been reduced by 20%;

- Willis Street – Wills Street is closed to traffic between the junction with Boulcott Street / Manners Mall and BNZ Centre. This is effective throughout the day and is not confined to peak periods;

- Courtenay Place – the stretch of Courtenay Place between Kent / Cambridge Terrace and Taranaki Street is transit only during the AM peak and PM peak;

- Kent / Cambridge Terrace – all junctions along Cambridge / Kent Terrace have general traffic capacities reduced by around 15% as a proxy for public transport priority measures. In addition, the inbound capacity from the Basin Reserve to Kent / Cambridge Terrace will be reduced by around 40% as one lane of general traffic will be lost and replaced by a segregated PT corridor, with the second lane required for PT coming from the removal of parking spaces;

- Adelaide Road – along Adelaide Rd the current proposed layout will effectively remain, with one lane in each direction designated for general traffic and another lane for the segregated PT corridor.

- Adelaide Rd / John Street / Riddiford Road – capacity at this busy junction is reduced by between 25% and 50% to accommodate a segregated PT corridor in both directions along with accompanying priority measures;

- Newtown – the junctions of Mein Street / Riddiford Rd and Riddiford Rd / Rintoul Street have their capacities reduced by 20% and 50% respectively to accommodate full bus lanes running up to the signal stop lines;

- Constable Street – no change along Constable Street;

- SH1 / Ruahine Street – right / left turns for general traffic off SH1 to the netball centre are banned (and therefore in the options accessed from Goa Street) so that a segregated PT corridor can be accommodated and run at the same time as the dominant CBD-Kilbirnie SH1 traffic;

- SH1 / Ruahine Street – Segregated PT corridor in both directions, plus two lanes for general traffic; and

- SH1 / Wellington Street – a slight reduction in intersection capacities to accommodate signal priority measures for BRT / LRT. Two lanes in both direction – removal of left filter for traffic heading northbound on SH1 and running left up Wellington Street towards Constable Street and Newtown;

Figures 7.10 to 7.12 below shows the percentage change in available capacity in the centre of the study area during the AM peak as a result of the alterations to the highway network documented above.

Further screenshots showing these changes across the remainder of the study areas are shown in **Appendix 7 – WTM Highway Capacities**, together with plots showing capacities at key intersections in the AM peak for both the reference case and BRT / LRT option to give an indication of the changes that have been made to intersection capacities to reflect improved PT infrastructure and priority measures

Figure 7.10 – AM peak 2031 – Percentage Change in Highway Link Capacity between Reference Case and BRT / LRT SATURN Option – Northern CBD

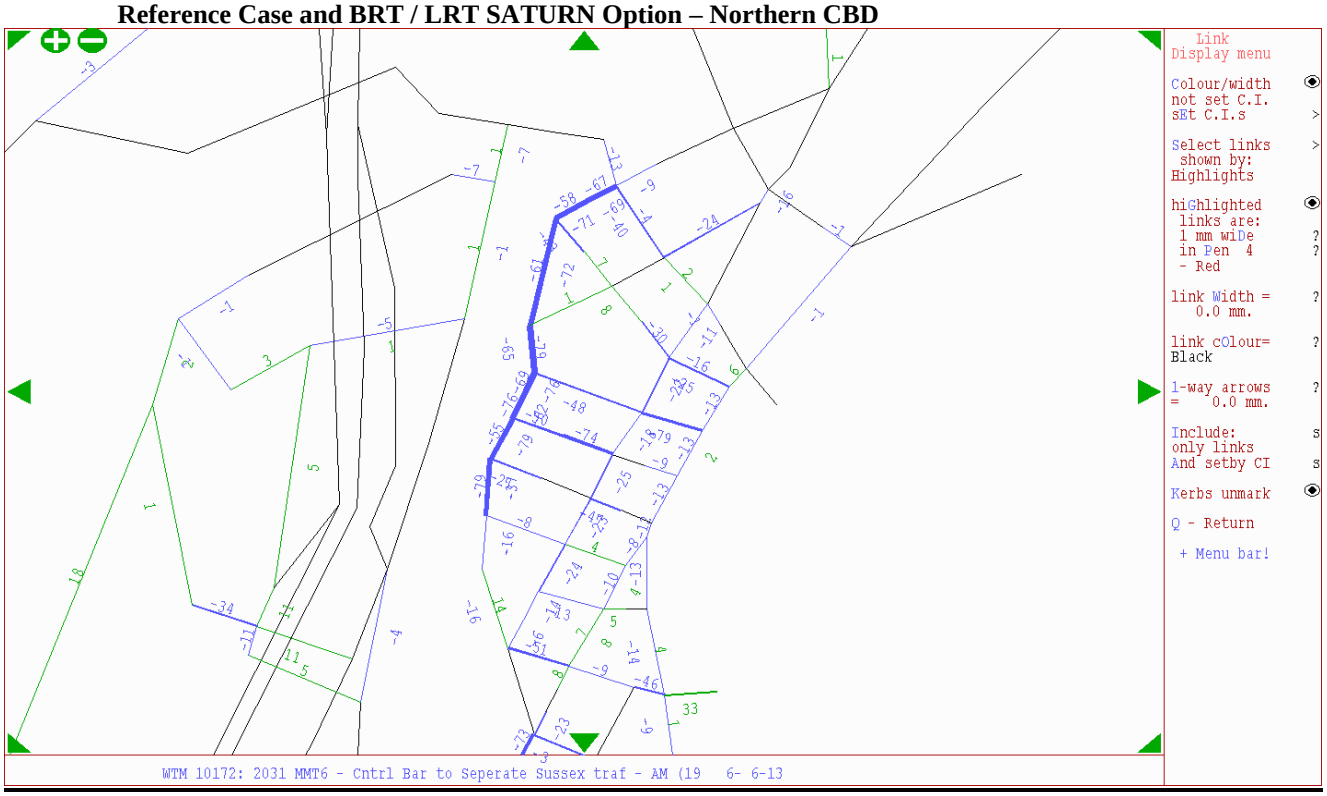


Figure 7.11 – AM peak 2031 – Percentage Change in Highway Link Capacity between Reference Case and BRT / LRT SATURN Option – Central CBD

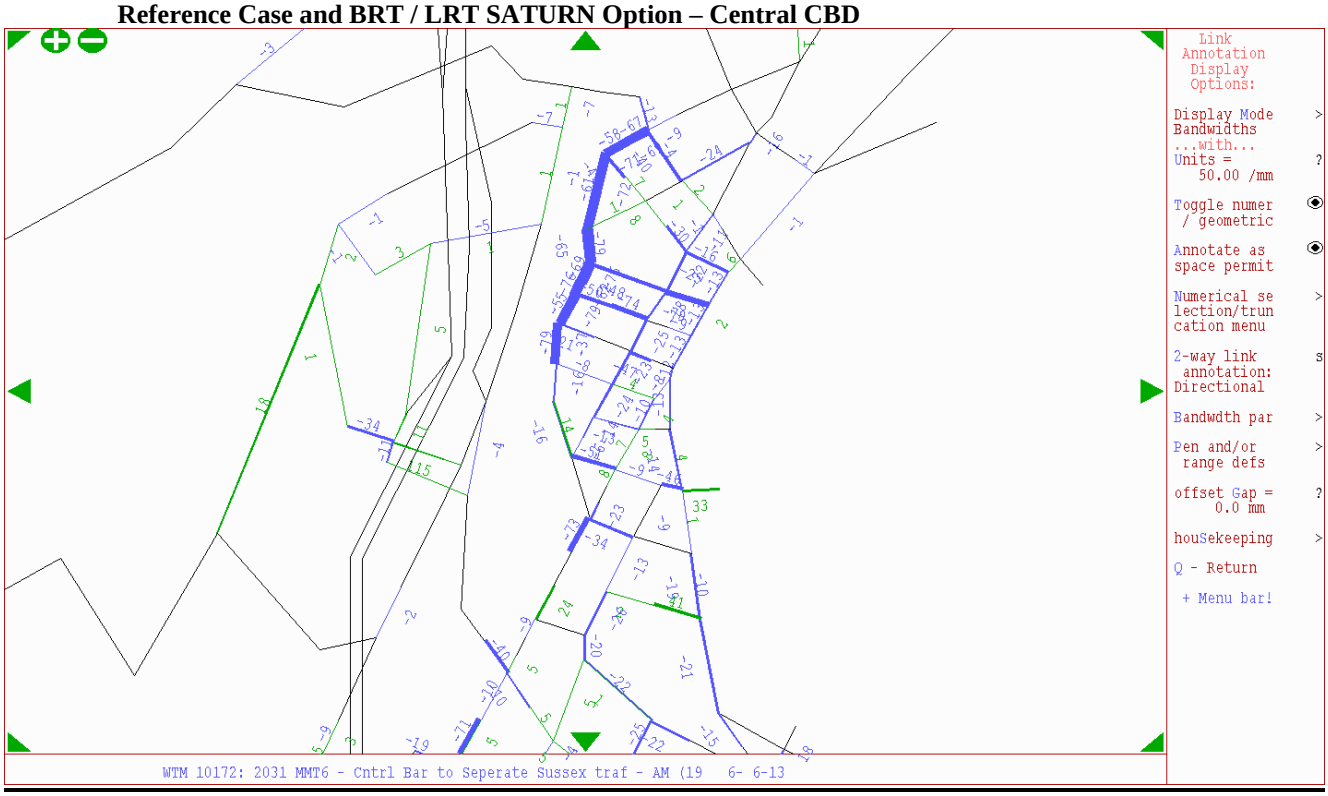
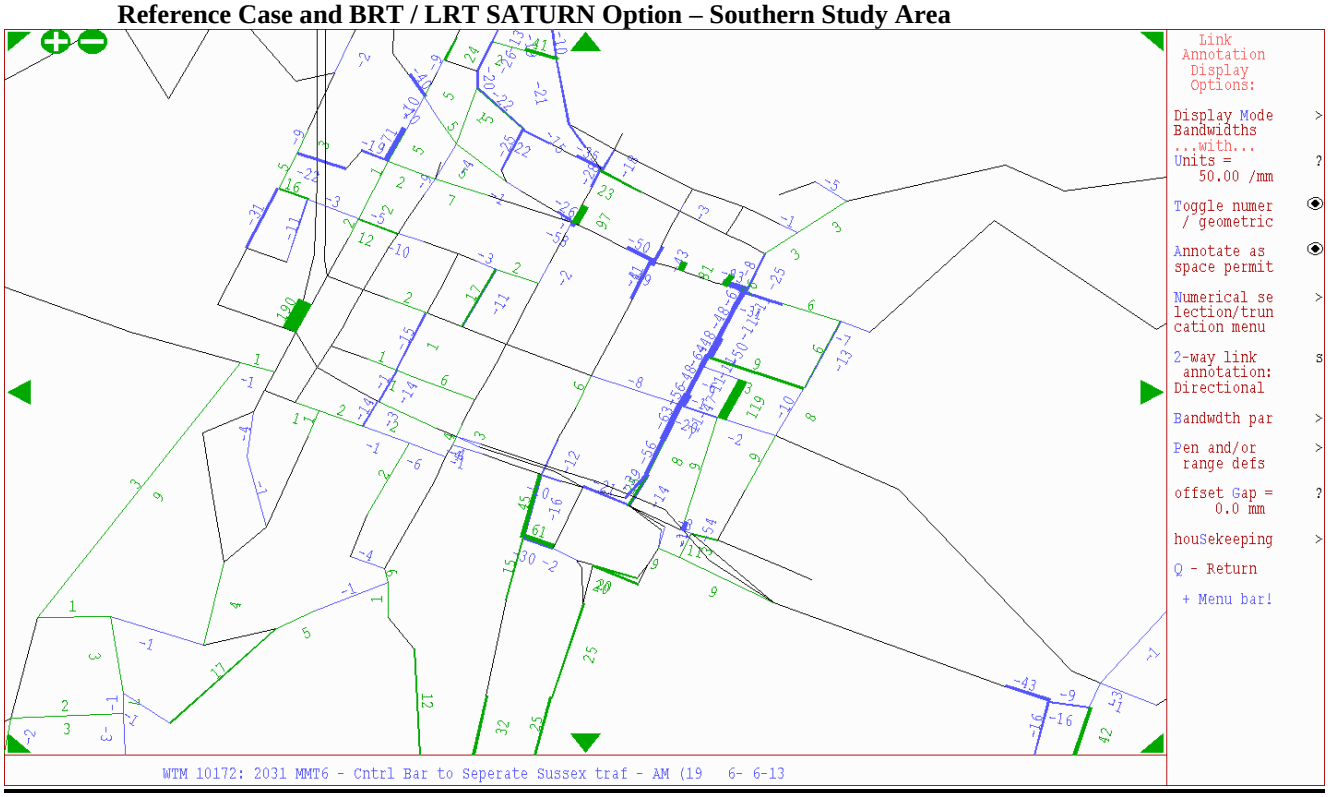


Figure 7.12 – AM peak 2031 – Percentage Change in Highway Link Capacity between Reference Case and BRT / LRT SATURN Option – Southern Study Area



The SATURN capacities are extracted for intersections shown in red in **Figure 7.13** below and input into WTSM.

Figure 7.13 – WTSM Intersections that use SATURN Model Intersection Capacities

7.11 Summary

PT Infrastructure and Services

- **general traffic will be banned from the Golden Mile** in the BRT/ LRT options between 7am and 7pm, apart from the northern section of Lambton Quay where general traffic is to the east of the central reserve and Courtenay Place where general traffic is allowed on the southern side in the inter-peak;
- **Willis Street is closed to general traffic all day** between the Majestic Centre and BNZ Centre **for the BRT/ LRT options;**
- **The number of bus stops along the Golden Mile is reduced from 8 to 5** to improve PT travel times;
- **for modelling purposes it has been assumed that buses, BRT and LRT will share the same stops** along the Golden Mile;
- around **30 southbound buses per hour will be diverted onto a secondary spine in the AM peak** to relieve pressure along the Golden Mile and improve PT travel times and service reliability for BRT and LRT options;

- the **BP option involves additional bus lanes and bus priority measures at intersections** along the core route (defined as Kilbirnie to Wellington Station via Mt Vic and Newtown to Wellington Station) and along Constable street between Kilbirnie and Newtown;

- the BRT and LRT options involve services running along **fully segregated corridors along the core route**;

- **BRT and LRT will receive greater priority at signals** along the Golden Mile than the bus priority option, resulting in improved travel times;

- BRT and LRT services have the same network of stops. The distance between BRT / LRT stops is increased compared to the BP and reference case;

- in the BRT option and, to a much greater extent, the LRT option, **existing bus services are split or terminated at interchange points** – Kilbirnie, Newtown, Courtenay Place, Wellington Station, Miramar – to feed passengers onto the BRT and LRT networks and optimise BRT/ LRT travel time savings and benefits;

- whilst precise details regarding which services are to be truncated/ changed could be discussed and debated, the most important thing is the **principle whereby services need to be changed in order to optimise both the BRT and LRT options**; and

- both the **BRT and LRT options result in fewer peak vehicles** travelling along the Golden Mile;

Highway Modifications

- the assumed timing of all **committed highway infrastructure schemes**, including all the Wellington RoNS, is documented;

- **capacity available to general traffic has been reduced** in a number of locations to model the potential impact of implementing PT priority measures;

- **reductions in capacity** are mainly a result of **the removal of one or more lanes of general traffic** to accommodate bus lanes and **a reduction in signal green times** to give PT services greater priority at intersections, leading to a consequent reduction in capacity for general traffic; and

- no detailed intersection design has been undertaken for this stage of the project – what has been presented is a first estimate. Should an option be chosen and progressed, such detailed intersection design would be required.

8. Modelling Assumptions

Chapter 3 outlined the structure of the modelling system.

This chapter describes the assumptions that underpin WTSM and WPTM and also documents changes that have been made to the models for the PTSS short list testing.

If the reader requires further information relating to both WTSM and WPTM, a full set of documentation relating to the most recent update of both models is available on request from GWRC. Both models were calibrated and validated in 2011 and peer reviewed to confirm their suitability.

8.1 Principles of Modelling

The costs of a particular highway or PT journey are represented in units of generalised time, with any non-time components converted by applying relevant values of time.

Table 8.1 below shows the values of time used in WTSM to convert fares and distances into time. Captive/competition and choice relate to the car availability for a trip where:

- captive trips are trips by residents of non car owning households
- competition is for households where the number of cars is inferior to the number of adults
- choice is for households where the number of cars is superior. to the number of adults

Table 8.1 – WTSM 2031 Values of Time (in $2011)

Purpose	Car Availability	2031 VOT ($/hr)
Home Based Work	Captive	**10.64**
	Competition and Choice	**14.27**
	All	**14.20**
Home Based Education	Captive	**6.61**
	Competition and Choice	**10.03**
	All	**9.90**
Employer Business	All	**45.44**
Other	Captive	**8.56**
	Competition and Choice	**12.17**
	All	**12.03**

The values of time used in WPTM have been directly derived from these, with a model scaling factor of 0.6 applied to replicate observed behaviour.

Every journey comprises a number of components, such was walking time (to access PT) waiting time (for a PT service), actual travel time (driving or by PT), parking costs and fuel costs (car) and fares (PT).

Perception factors are applied to certain components of a PT journey to account for the fact that people would perceive, for example, 10 minutes waiting for a bus service to be more onerous than 10 minutes spent travelling on the bus. These perceptions affect people's choice of journey – i.e do they wait a shorter time for a slower bus or wait longer for a faster, more direct service?

Table 8.2 shows the generalised time components that make up car and PT journeys in WTSM and WPTM, noting whether the original units are time-based and whether perception factors are applied when calculating the generalised time.

Table 8.2 – Time Components of Car and PT Journeys in WTSM and WPTM

Component	Original Unit	Weighting Applied
PT Walk time	Time	Yes
PT In-Vehicle time	Time	Yes (varies by mode)
PT Wait time	Time	Yes (varies by mode in WPTM)
PT Fare	Dollars	No
PT Boarding Penalty	Time	No, but vary by mode
PT Transfer Penalty	Time	No
Highway Travel Time	Time	No
Parking Costs	Dollar	No
Vehicle Operating Costs (Distance / Speed)	Dollar / km	No

The individual time components are aggregated to obtain a total generalised travel time by car and PT for trips between every O-D pair in the model. WTSM uses the relative difference between the generalised time of travelling by car and by PT to work out the modal split.

Once the mode split has been calculated, PT and car demand is generated between each O-D pair.

The respective highway and PT assignment modules of each model then work out the cost (time) for a series of routings between origin-destination pairs and assign trips to these routings depending on the relative difference between costs using a logit choice model.

In simple terms, if one route between an O-D pair takes 50 generalised minutes and another route takes 55 minutes then demand would not all be assigned to the fastest route, as in reality some people would likely take the slower route as there is little difference between the travel times. The logit choice model will

distribute trips between attractive routes according to the relative attractiveness of each route.

If highway travel times do improve, as is the case when the RoNS schemes are built, then the balance shifts a little from PT to car, resulting in a decrease in PT mode share that is most pronounced for areas that will benefit the most from such schemes (for the RoNS this is evident for trips from Kapiti to Wellington CBD).

If a scheme such as the PTSS improves PT travel times relative to car travel times, then this will result in a shift in trips from car to PT, increasing the PT mode share from areas that benefit the most e.g southern and eastern suburbs.

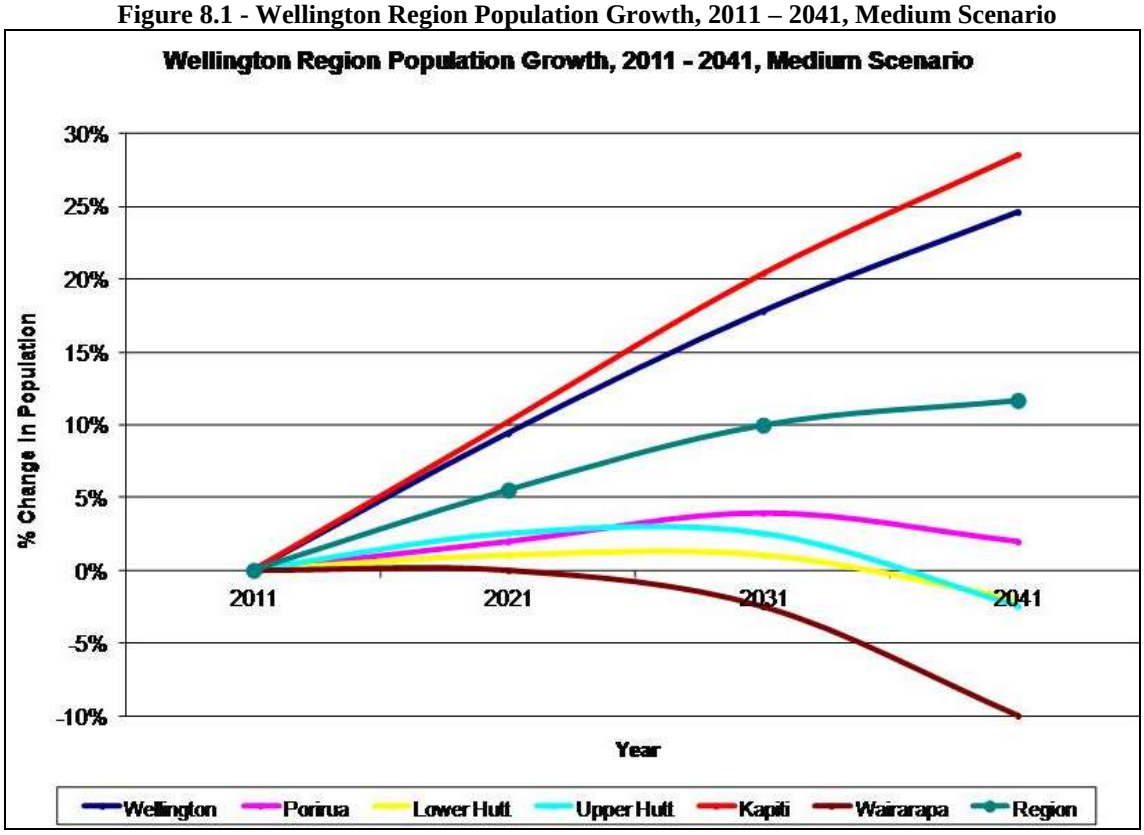
8.2 Land Use

WTSM uses land use projections – numbers of households, number of jobs and population – to generate estimates of the number of trips to / from a particular zone.

Changes in land use between 2011 and any forecast year will result in changes in travel demand patterns.

Between 2011 and 2041, population and employment growth in the Wellington Region is forecast to be 12% and 15% percent respectively. As **Figure 8.1** shows, however, the pattern of growth across the region is varied – Wellington City TA and Kapiti TA are forecast to see the highest growth rates, with other TAs experiencing lower growth rates. These are 'WTSM Medium' forecasts prepared as part of the WTSM model update in 2011.

Figure 8.1 - Wellington Region Population Growth, 2011 – 2041, Medium Scenario



Whilst the overall level of growth will lead to an increase in trips, the precise location and concentration of this growth will affect trip patterns at a more local level.

Following consultation with project partners, it was decided that a variant of the medium land use scenario should be used for the PTSS, to ensure consistency with "Growth Spine" which reflects the plans and policies of Wellington City Council.

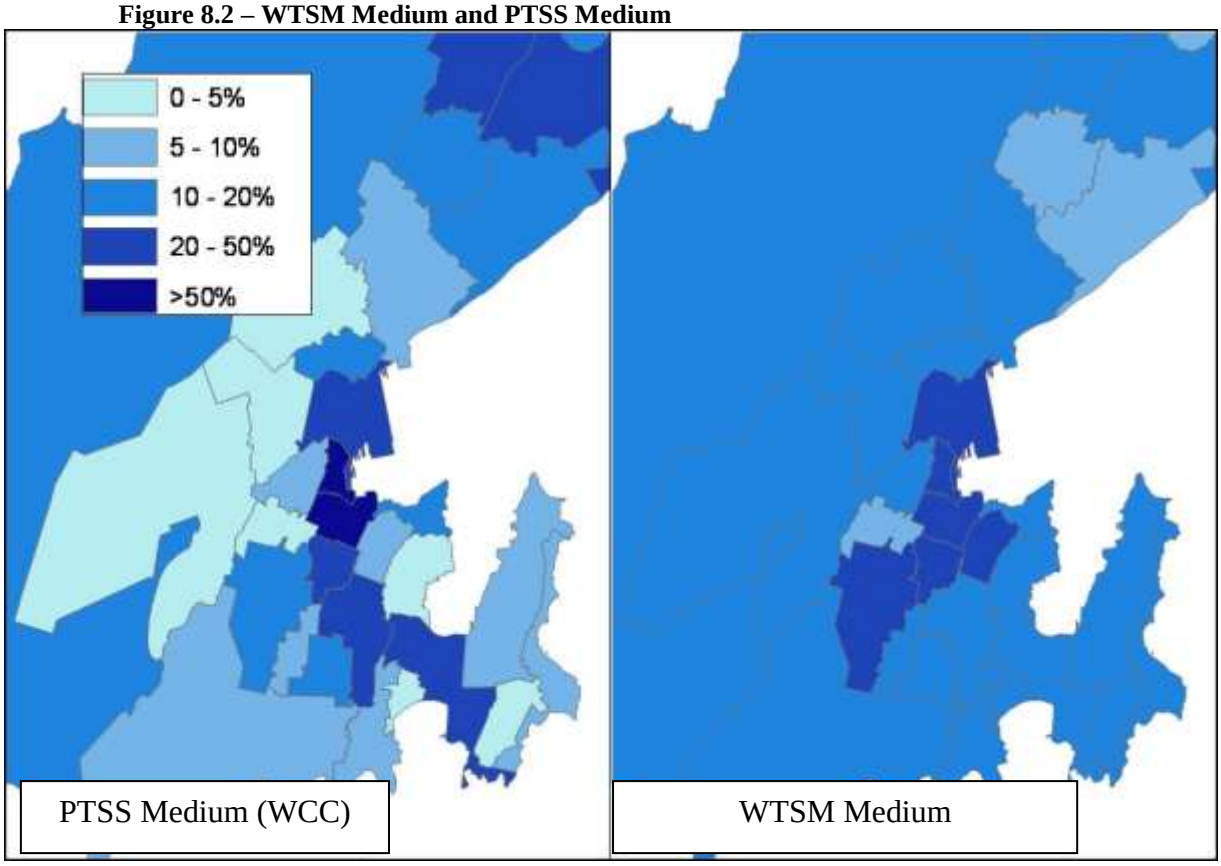
Table 8.3 shows the population growth rates for the PTSS area and the rest of Wellington City TA for the original WTSM land use, the Wellington City Council (WCC) forecast, and the new PTSS Medium land use. It shows that whilst the overall Wellington wide growth totals are maintained, the 'PTSS Medium' scenario focuses growth on the Spine corridor, replicating the forecast from WCC.

Table 8.3 – Forecast Population Growth – 2011 to 2031

2011 – 2031 Population Increase	PTSS Area (S + E)		Rest of City	
WTSM Medium Land Use	12,306	*37%*	21,348	*63%*
WCC Forecast	17,667	*55%*	14,204	*45%*
New PTSS Medium Land Use	18,655	*55%*	14,999	*45%*

Figure 8.2 shows the change in population at a zonal level for the PTSS Medium and WTSM Medium scenarios, focussing on Wellington TA It clearly shows that growth is more concentrated in Wellington CBD in the PTSS Medium scenario, with slightly lower growth rates in outlying suburbs.

Figure 8.2 – WTSM Medium and PTSS Medium



8.3 Economic Parameters

The cost of car and PT travel is governed by a number of parameters:

- fuel cost and vehicle operating costs;
- public transport fares;
- values of time; and
- parking costs.

Changes in these costs over time and, more importantly, changes in the relative costs over time, will lead to changes in travel patterns and changes in the PT mode share.

Figure 8.3 shows the forecast parameters that are used for the core PTSS modelling. This information was prepared as part of the 2011 model update programme using the following methodology:

- Fuel Costs - increase each year using factors derived from Ministry for Transport and Ministry of Economic Development relating to forecast changes in fuel prices and vehicle operating costs;
- PT Fares - increase with respect to GDP / capita growth (1.8% pa) with an elasticity of 0.25. ;

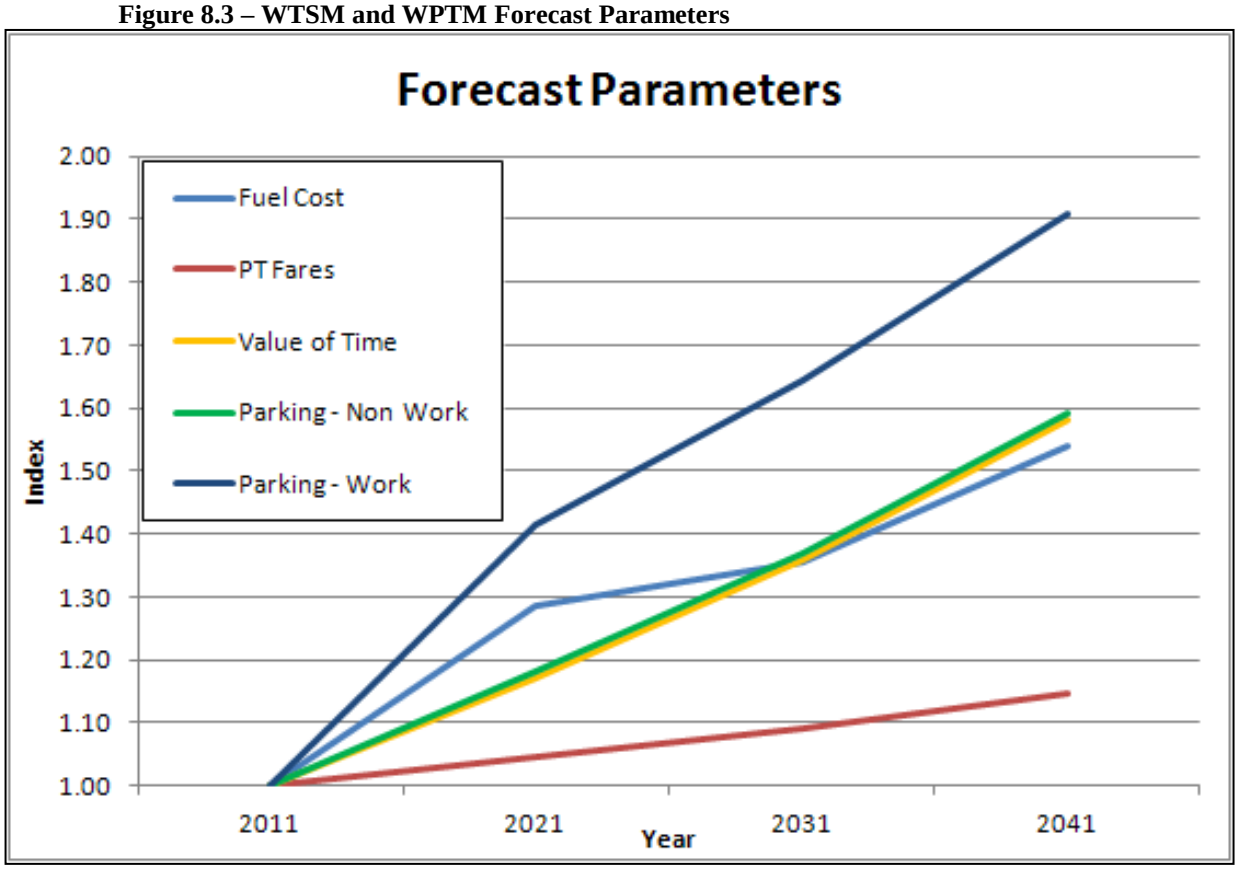
- Parking Costs - increase with respect to GDP / capita growth (1.8% pa) with an elasticity of 1.2 (work) and 1.0 (non-work).; and

- Values of Time - increase with respect to GDP / capita growth (1.8% pa) and with an elasticity of 1.0.

This methodology was agreed upon following discussions with NZTA and transport modelling professionals in Auckland and Wellington.

Sensitivity tests reported in Chapter 11 assess the impact that changing some of these assumptions has on the PTSS results.

Figure 8.3 – WTSM and WPTM Forecast Parameters



8.4 Modifications to the Modelling System for PTSS

This section details other modifications that have been made to the modelling system in order to model and assess the PTSS.

Changes relating to infrastructure (highway capacity, segregated bus corridors, stop locations) and services (new LRT / BRT services, amendments made to existing services) have been documented in **Chapter 7.** Amendments made to the model parameters are detailed in **Section 8.6**.

8.4.1 PT Services Travel Time Functions

Given that BRT and LRT schemes are proposed, with segregation from traffic and enhanced priority measures over and above standard BP, a method had to be developed to refine the existing travel time functions to provide realistic

travel times for BRT/ LRT. This was done by estimating average running speeds along the various sections of the Spine corridor inclusive of junction delay, based on the characteristics of these sections (urban or open environment, pedestrian traffic, topography, etc) and international guidelines. A comparison of the final achieved speeds with other BRT/ LRT schemes in other countries is shown in Section 9.6;

8.4.2 Interchanging and Integrated Ticketing

Given that a central component of a BRT/ LRT system will be free transfers between services/ modes at key interchange points (this is assumed for the reference case and all options) then a method of accurately representing integrated ticketing and high quality interchange hubs in both models had to be developed. The following is a brief summary of the methodology used - more details can be found in **Appendix 8 – Modelling of Interchanges in WTSM and WPTM**.

The fare calculation process in WTSM was altered to include integrated ticketing in the whole region, so that for all trips the boarding component of a fare was discarded for any additional boarding after the initial service used.

In WPTM this approach is not possible for the whole region due to different process used in the model, but the PT network was modified to allow integrated ticketing at the main modal interchange hubs were most of the transferring would occur. These interchanges are the following:

- Bus/Rail station;
- Courtenay Place;
- Newtown;
- Kilbirnie; and
- Miramar.

The same network modifications for these five hubs were used to model reduced transfer penalty at these location in WTSM (reduced from 10min to 2.5min), to represent high quality facilities, potential coordinated services, etc.

8.5 Public Transport Assignment – WTSM and WPTM

This section outlines the principles of PT modelling, including changes that have been made to model parameters and constants for the PTSS.

WPTM is a bespoke public transport model that is used for the assessment of the PT impacts and benefits of the PTSS. The demand used in WPTM is obtained from the WTSM by applying differences between the base year (2011) and forecast year demand in WTSM to the base year demand in WPTM.

This process is done at a zonal level using a sophisticated process that involves taking demand from the WTSM zone system and applying a combination of

absolute and percentage growth rates depending on the individual zonal characteristics.

Whilst WTSM and WPTM share a common PT network, PT travel time functions and zone system, subtle differences exist in the way that both models operate.

This short section runs through the components of a typical PT journey, noting differences between the two models.

Existing differences between both models are noted in red, with changes made for the purpose of the PTSS noted in blue.

(a) Walk access / egress

Walk access and egress to / from PT is a function of the distance and speed (walking speed is assumed to be 5kph).

Both WPTM and WTSM use behavioural weights that are applied to walk time to convert from 'actual' to 'perceived' values. These weight reflect the fact that users perceive certain elements of a journey to be more onerous than others.

All behavioural weights are expressed relative to the value applied to standard bus in-vehicle time which is 1.0.

In WPTM the walk time behavioural weight is 1.8, meaning that an actual 10 minute walk time is perceived as taking 18 minutes. In WTSM the value is 2.0, meaning that a 10 minute walk is perceived as taking 20 minutes.

Differences between values used in WTSM and WPTM are a result of different approaches taken whilst calibrating the models.

Summary: Slight differences in walk time weights between both models.

For the PTSS, no change is made to the calculation of walk time.

(b) Waiting time

Wait time is the time spent waiting for a public transport service.

In WPTM it is defined as being equal to half the headway up to 15 minutes, and then a factor of 0.22 gets applied to any additional wait time. I.e. if a service runs every 5 minutes, then the wait time is 2.5 minutes, for a service running every 20 minutes the wait time is 8.6 minutes.

In WTSM it is defined as being equal to a quarter times the headway I.e. if a service runs ever 5 minutes, then the wait time is 1.25 minutes.

Behavioural weights are also applied to the wait times. The weights are 2 for WTSM (all modes), 1.4 for WPTM (rail) and 1.8 for WPTM (bus).

Summary: The use of service headway for the calculation of waiting time differs between both models. There are some small differences in wait time weights between models.

For the PTSS, BRT and LRT both have behavioural weights of 1.6 in WPTM, meaning that they are perceived as more attractive than bus but less attractive than rail. The relationship between headway and wait time is maintained in both models.

(c) In-vehicle time

In-vehicle time is a function of highway travel time, stop dwell time and a calibrated factor called a travel time function that is applied in both models to convert highway travel times to PT travel times.

The travel time functions have been calibrated against observed bus travel times in the base year. These same functions are then applied in future years.

Where bus lanes and/ or signal priority is in operation, the travel time functions are modified accordingly to represent these measures both in the base model and future forecast models.

Behavioural weights are applied to rail trips to reflect the perceived attractiveness of rail relative to bus.

- AM peak = 0.88 (WPTM), 0.9 (WTSM); and
- Inter-peak = 0.84 (WPTM), 0.9 (WTSM).

Summary: Slight differences between rail in-vehicle factors between models.

For the PTSS, the in-vehicle time factors are as follows:

- AM peak LRT = 0.88 (WPTM), 0.9 (WTSM);
- Inter-peak LRT = 0.88 (WPTM), 0.9 (WTSM);
- AM peak BRT = 0.88 (WPTM), 0.95 (WTSM); and
- Inter-peak BRT = 0.88 (WPTM), 0.95 (WTSM).

(d) Boarding penalties

Boarding penalties are used in both models. They are calibrated constants that are meant to reflect the perceived inconvenience of both boarding and transferring between PT services.

Both WTSM and WPTM apply boarding penalties in a similar way, with the values shown in **Table 8.1** below for both existing and new (PTSS) modes.

Table 8.4 – Boarding Penalties applied in WTSM and WPTM

Mode	Interchange	WTSM Penalty	WPTM Penalty
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
BRT	Standard		
	Purpose Built		
	High Quality	5.5	3
LRT	Standard		
	Purpose Built		
	High Quality	5.5	3

Summary: Differences in boarding penalties exist between both models.

In the PTSS, BRT and LRT are assumed to have low boarding penalties, reflecting the fact that both are high quality, premium services that operate from dedicated, high quality stops and interchanges.

(e) Transfer penalties

As several of the PTSS options require additional transfers to be made between PT services it was important that the models accurately represent the costs associated with transferring, namely:

- Additional waiting time;
- Walk time between stops (in reality this is small); and
- The inconvenience of transferring and boarding another service.

The response of WTSM to transfer penalties will govern the modal shift from car to PT as they will affect the relative attractiveness of car and PT.

In WPTM the transfer penalties will affect the chosen routing – i.e. does someone take a direct but slow route involving only one service or do they take a faster route that involves a transfer? In reality the choices are limited as both the BRT and LRT networks have been rationalised such that bus services feed into and compliment the BRT/ LRT services rather than compete against each other.

(i) Modelling of transfer penalties

To illustrate how transferring is modelled in WTSM and WPTM, **Table 8.5** below shows an example of how the total costs (in generalised minutes) incurred by having to transfer between services would be calculated in both models (for a trip to work, AM peak 2031):

- first for a passenger travelling by bus and then transferring to another bus service at a normal interchange; and
- secondly for a passenger travelling by bus and then transferring to LRT at a high quality interchange.

The greyed out figures in this table relate to the access, first bus boarded and egress legs of the trip and are therefore identical for both examples. Only the figures relating to the second services change.

These figures correspond to a bus to BRT/ LRT transfer in WTSM and WPTM.

Table 8.5 – Worked Example showing derivation of Transfer Penalties in the Modelling System

	WTSM (Distribution / Mode Split Stage)		**WPTM**	
	Example 1 - Bus to Bus	Example 2 - Bus to LRT at Interchange	Example 1 - Bus to Bus	Example 2 - Bus to LRT at Interchange
	Walk Time from Origin to 1st Service		*Walk Time from Origin to 1st Service*	
	Wait Time		*Wait Time*	
	Fare (Flagfall + Zonal) 1st Service		*Fare (Flagfall + Zonal) 1st Service*	
	In-vehicle Time 1st Service		*In-vehicle Time 1st Service*	
2nd Wait Time (headway=5min)	2.5	2.5	5	4
2nd Flagfall Fare (Zero due to integrated ticketing)	0	0	0	0
2nd Boarding Time	3	3	5.5	3
Transfer Penalty	10	2.5	-	-
Total Interchange time inc Wait (min)	**15.5**	**8.0**	**10.5**	**7.0**
Overall Transfer Penalty (excluding wait time)	**13**	**5.5**	**5.5**	**3**
	IVT 2nd Bus	*IVT LRT*	*IVT 2nd Bus*	*IVT LRT*
	Fare (Zonal) 2nd Service		*Fare (Zonal) 2nd Service*	
	Walk Time to Destination		*Walk Time to Destination*	

In summary, the transfer penalty is **5.5** in WTSM and **3** minutes in WPTM for a bus to BRT/ LRT transfer at a high quality interchange.

(ii) International guidelines relating to transfer penalties

Many international studies have looked at how people perceive transferring between services/ modes. These studies are often specific to certain cities and

involve comprehensive stated preference surveys – therefore the findings and conclusions should not be automatically applied to other cities that might have different PT networks, demographics and income structures.

The Australian Transport Council "2006 National Guidelines for Transport System Management in Australia"[2] suggests that "**an interchange that is between-mode (BRT/LRT-bus) but at the same facility has a value of seven minutes**". This value includes just the transfer penalty (people's reluctance to transfer) and no wait time penalties associated with transferring.

These guidelines note that a wide range of transfer penalties are used across different models and that when looking farther afield, international studies suggest a higher penalty of around 9 minutes.

(iii) Summary

The modelled WTSM transfer penalty of 5.5 minutes, whilst slightly less than the recommended value of 7.0 taken from the ATC guidelines, is still close enough to allow us to conclude that transfers are adequately represented in WTSM. Any difference is due to the characteristics of the modelling system and is not great enough to have a significant impact on any conclusions that might get drawn from this study.

Whilst the WPTM value (3 minutes) is lower than the WTSM and ATC values, this will not affect trips from the study area to the CBD as most transfers are effectively 'forced' transfers as competing buses have been withdrawn to optimise BRT/ LRT benefits.

The only effect that the low transfer penalty in WPTM might have is to attract more people onto BRT/ LRT services along the Golden Mile after arriving into Wellington by train than might be the case in reality.

(f) Comparison of travel times from both models

Figure 8.4 shows a comparison of travel times from both WTSM and WPTM for a selection of journeys, showing how the differences outlined in this section appear when aggregated.

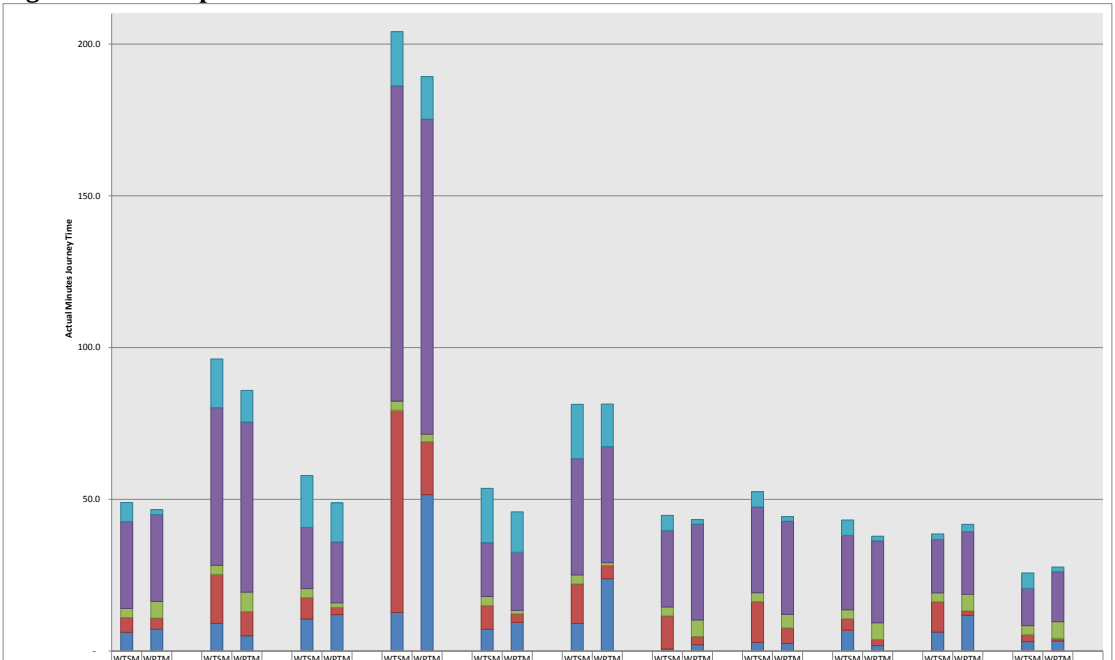
In broad terms, WPTM and WTSM produce largely similar travel times, showing that both models can be used in combination to produce meaningful analysis of the PT impacts and benefits associated with the PTSS options.

[2] The ATC Guidelines can be found here

http://www.atcouncil.gov.au/documents/files/National_Guidelines_Volume_4.pdf

Transfer penalties are discussed on page 74.

Figure 8.4 – Comparison of WTSM and WPTM Travel Times



	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

8.6 Summary

- model values of time change according to journey purpose (work, education, business) and whether a choice is available (i.e. PT, car);
- **values of time** are used to convert non-time based components of a journey – fares, fuel costs – into time values**;**
- car and PT travel times are modelled in terms of **'generalised time'**, accounting for all time based and non-time based components of a journey;
- both WPTM and WTSM use 'perceived' rather than 'actual' time when calculating total generalised time, to reflect the fact that people perceive certain components of a journey to be more onerous than others;
- **employment and population growth** in the future is largely concentrated in Kapiti and Wellington;
- a **PTSS Medium land use** scenario, **focussing growth in Wellington CBD**, has been used;
- **forecast economic parameters** are based upon agreed practice and are linked to GDP / per capita growth;
- **whilst differences exists between WTSM and WPTM** in terms of how they represent wait time, walk time and in-vehicle time, these differences are minor and **do not materially affect the modelling system nor any results** coming out of it;

- given that both the BRT and LRT options requires people to transfer between services, it is **important that both models accurately represent the costs associated with transferring between modes**;

- therefore a number of **modifications and improvements** were made to the modelling system **for the PTSS**, mainly to do with the representation of between-mode transfers and the modelling of integrated ticketing; and

- compared against current Australasian Guidelines, the **representation of transfers in both WTSM and WPTM is deemed realistic**.

9. Model Results

This section presents results from the modelling that has been undertaken to inform the assessment of the PTSS options.

The Option Evaluation Report used AECOM presented data from the model plus other sources to undertake a detailed evaluation of all the options.

This report presents Transportation Modelling results in a greater level of detail.

9.1 Points of Clarification

9.1.1 Modelled Year

The results under each of the sub-headings are presented in a tabular format for the AM peak in 2031, with the inter-peak only reported for some of the key indicators.

No results are presented for the PM peak since WPTM does not model the PM peak and PM peak results were not used in the economic evaluation

9.1.2 Appendices

This chapter should be read in conjunction with the following appendices:

- **Appendix 9.1 –Additional Model Results** - contains inter-peak analysis for certain indicators and AM peak / inter-peak analysis for minor indicators;
- **Appendix 9.2 – PT Indicators** – contains a visual representation of changes in PT demand, car demand and mode share that are commented upon in this chapter, together with GIS difference plots for all options showing changes in volumes, capacity, spare-capacity, volume-capacity ratios and speed, all relative to the reference case;
- **Appendix 9.3 – WTM Highway Indicators** - contain difference plots for the AM peak and inter-peak showing changes in traffic volumes, delays, capacities and VC ratios.

The relevant appendices are referenced in blue at the start of each sub-section.

9.1.3 Reporting of Data

As a general rule, absolute numbers are only reported for the reference case scenario, with changes reported for BP, BRT and LRT scenarios relative to the reference case.

The changes are colour coded – green showing an increase in a particular indicator, but not necessarily an improvement (e.g volume, travel time, speed) and red showing a decrease, but not necessarily a decline or worsening.

9.1.4 Use of WTSM, WPTM and WTM

Data from WTSM and WPTM is used for most of the analysis, with WTM data used to look at specific highway indicators.

Which model is used and whether the data relates to an average AM peak hour or the AM peak two hour period (7am to 9am) is stated in blue at the start of each section.

9.2 Change in Demand and Travel Time between 2011 and 2031

AM peak two hour period, WTSM.

Read with Appendix 9.1, Section 9.1.1 – inter-peak results.

Between 2011 and 2031, forecast changes in land use, input parameters and highway infrastructure projects affect car and PT demand within the region.

9.2.1 Change in Demand – 2011 to 2031

Table 9.1 below summarises the change in car and PT demand between 2011 and 2031.

Table 9.1 AM peak – PT, Car and Combined (Car plus PT) Growth Rates – 2011 to 2031

Origin Sector	2011 PT	2031 PT	% Inc	2011 Car	2031 Car	% Inc	2011 Comb	2031 Comb	% Inc
CBD	2,548	3,315	30%	20,973	26,859	28%	23,521	30,174	28%
Northern Suburbs	3,808	5,013	32%	16,757	20,530	23%	20,565	25,543	24%
Western Suburbs	2,058	2,201	7%	7,601	8,524	12%	9,659	10,725	11%
Southern Suburbs	2,474	3,154	27%	9,581	11,744	23%	12,056	14,898	24%
Eastern Suburbs	3,277	3,682	12%	13,508	16,424	22%	16,785	20,105	20%
Rest of Region	15,517	16,629	7%	99,713	113,981	14%	115,230	130,609	13%
Total	**29,683**	**33,994**	**15%**	**168,133**	**198,061**	**18%**	**197,816**	**232,055**	**17%**

Results show that PT growth rates lag behind car growth rates (15% compared with 18%) in the period 2011 to 2031, despite the forecast increase in PT fares being lower than the forecast increase in vehicle operating costs (see **Chapter 8**).

The separate growth rates for the five Wellington City suburbs and the rest of the region vary quite widely. Wellington CBD, northern and southern suburbs have high PT growth rates and lower (relative) car growth rates. Western suburbs, eastern suburbs and the rest of the region have lower growth rates and also have higher car than PT growth rates.

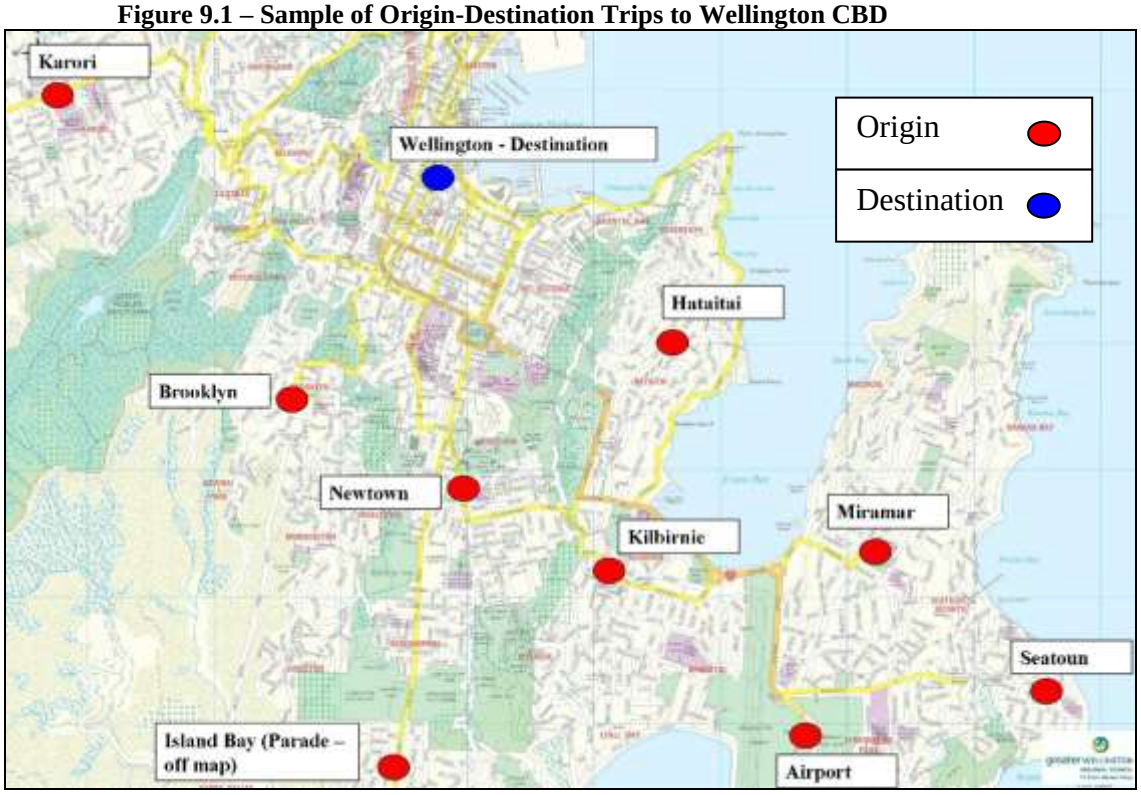
The difference between car and PT growth rates, and the resulting drop in PT mode share between 2011 and 2031, is largely driven by the RoNS projects increasing highway capacity. This reduces car travel times and attracts

additional car trips (either new trips or persons switching from rail and to some extent bus).

9.2.2 Change in Travel Times – 2011 to 2031

Table 9.2 below shows highway travel times, PT travel times and the difference between the two for trips into Wellington CBD in the AM peak from a selection of suburbs within the study area (shown in **Figure 9.1**).

Figure 9.1 – Sample of Origin-Destination Trips to Wellington CBD



The PT travel times include all 'actual' time components of a journey – walking time (to / from stop), waiting time (for BP, BRT, LRT) and actual in-vehicle time – plus an additional 5 minute time penalty for every journey that involves a transfer.

Car travel times include a 10 minute additional time penalty to represent the average time that people take to walk from where they park in the CBD to their place of work.

The 5 minute time penalty for persons interchanging between services is specified in the NZTA Economic Evaluation Manual (EEM) to reflect the perceived inconvenience of transferring between services, and is included on top of any additional waiting time that may be incurred when interchanging.

As transfer penalties are included in the evaluation of scheme benefits, then for consistency they should also be included when assessing travel times between options and modes.

Table 9.2 Highway and PT Travel Times to Wellington CBD, AM peak, 2031

	Highway Travel Time (in minutes)		PT Travel Time (in minutes)		Difference between Highway and PT travel Time (in minutes)	
Origin Suburb	**2011**	**Change: 2011 to 2031**	**2011 Travel Time**	**Change: 2011 to 2031**	**2011**	**Change: 2011 to 2031**
Miramar	27.2	-0.6	32.6	0.9	5.4	1.5
Seatoun	28.1	-0.6	32.2	0.9	4.1	1.5
Airport	26.4	-0.8	38.3	2.6	11.9	3.4
Island Bay	24.1	-0.2	35.9	-0.5	11.7	-0.2
Newtown	20.8	0.8	27.6	-2.3	6.9	-3.1
Hataitai	19.6	0.3	30.2	-1.0	10.5	-1.3
Kilbirnie	24.3	-1.7	30.4	-0.0	6.2	1.7
Karori	22.8	1.4	31.4	-1.2	8.6	-2.6
Brooklyn	18.7	2.0	22.3	1.2	3.6	-0.8

Eastern suburbs such as Miramar, Seatoun, Airport and Kilbirnie show a decrease (improvement) in highway travel times between 2011 and 2031 and an increase in PT travel times over the same period, resulting in a net increase in the difference between car and PT travel times. The improvement in car travel times is due to the duplication of Mt Victoria tunnel.

Suburbs such as Karori, Brooklyn and Newtown show an increase (worsening) in car travel times to Wellington CBD between 2011 and 2031, due to road closures to general traffic in the CBD, whilst PT travel times decrease (improve) over the same period.

In summary, highway infrastructure schemes planned for construction between 2011 and 2031 result in improved travel times and highway capacities for people wishing to travel between the study area and Wellington CBD, whilst the lack of PT infrastructure investment in the study area results in little change to PT travel times and a slight worsening of the PT mode share.

As WTSM allocates demand depending on the relative attractiveness of each mode., Improving the attractiveness of PT will decrease relative attractiveness of the car and improve PT use.

9.3 PT and Highway Travel Times

AM peak two hour period, WTSM.

Increased priority measures for public transport – which depending on the option means additional bus lanes, fully segregated PT corridors and traffic signal priority measures result in substantial improvements to public transport travel times along the routes to Wellington Station.

These improvements benefit all passengers travelling from the southern and eastern suburbs into Wellington and, to a lesser extent, passengers for whom part of their journey takes them along the Golden Mile (e.g. trips from Brooklyn to Wellington Station or Khandallah to Courtenay Place).

Highway travel times will also change due to:

- a reduction in highway capacity for general traffic as road space is removed and allocated to PT (bus lanes, segregated corridors), potentially increasing congestion and travel times; and

- fewer cars on the road as people will be encouraged to switch modes from car to PT as a result of improved PT travel times, potentially resulting in less congestion.

AM peak 2031 PT and highway travel times were extracted for the same routes and using the same methodology as was used for the 2011 / 2031 comparisons presented in section 9.3.

9.3.1 Car travel times

Table 9.3 shows the changes in car travel times between options in the AM peak:

Table 9.3Change in Car Travel Time (in minutes) to Wellington CBD for Selected Journeys, AM peak, 2031

Origin Suburb	Reference	BP: Change from Ref	BRT: Change from Ref	LRT: Change from Ref
Miramar	26.6	-0.3	-0.9	0.2
Seatoun	27.4	-0.3	-0.9	0.2
Airport	25.7	-0.3	-0.9	0.2
Island Bay	23.9	0.0	0.5	0.6
Newtown	21.6	1.0	0.8	1.1
Hataitai	20.0	-0.3	0.5	0.6
Kilbirnie	22.6	0.2	-0.1	0.1
Karori	24.2	1.3	1.0	1.2
Brooklyn	20.8	0.0	0.8	1.1

Table 9.3 shows that:

- for all options, the change in car travel time is minimal (less than 1 minute in most instances), showing that the impact of reduced highway capacity and fewer car trips appear to largely cancel each other out; and

- the greatest increases in car travel times to Wellington CBD (around 1 minute) are from Newtown, Karori and Brooklyn in both the BRT and LRT options. These increases will be due to capacity reductions at intersections

in Newtown and the closure of the Golden Mile to general traffic, affecting trips from northern and western suburbs to the CBD.

9.3.2 PT travel times

Table 9.4 shows the changes in PT travel times between options in the AM peak:

Table 9.4 Change in PT Travel Time (in minutes) s to Wellington CBD for Selected Journey, AM peak, 2031

Origin Suburb	Reference	BP: Change from Ref	BRT: Change from Ref	LRT: Change from Ref
Miramar	33.5	-2.7	-4.0	2.0
Seatoun	33.0	-2.7	-4.0	3.4
Airport	40.9	-1.9	-5.5	-4.5
Island Bay	35.4	-1.0	-4.8	1.4
Newtown	25.4	-2.7	-6.7	-4.2
Hataitai	29.2	-0.9	3.8	3.9
Kilbirnie	30.4	-4.5	-10.8	-10.6
Karori	30.1	-0.4	0.3	1.2
Brooklyn	23.5	0.0	0.2	0.3

Table 9.4 shows that:

- the BP option results in small decreases (1 to 4 minutes) in PT travel times for trips originating in all suburbs, with Kilbirnie (4.5 minutes) showing the greatest increase;
- the BRT option results in larger improvements in PT travel times from southern and eastern suburbs, ranging from a 4 to a 11 minute improvement. The greatest improvements (over 10 minutes) are from Kilbirnie and Newtown, due to a combination of increased service frequencies and segregated running between these two suburbs and Wellington CBD;
- the BRT option results in a slight increase in travel time from Karori to the CBD as the current high frequency service is replaced by a BRT standard service that has a slightly lower service frequency but a larger and superior standard of vehicle;
- in both the BRT and LRT options, travel times from Hataitai worsen as people have to walk further to catch fast city bound PT services;
- the LRT option results in substantial improvements to travel times between Newtown, Kilbirnie and Wellington CBD, as these areas have the most to gain from travel time improvements associated with the LRT;

- from Miramar, the LRT provides a 6 minute slower travel time compared with the BRT. This is solely due to the need to transfer between bus and LRT at Kilbirnie, adding additional waiting time and a transfer penalty to the overall travel time;

- from Island Bay, the transfer penalty and additional wait time associated with switching between bus and LRT at Newtown actually outweighs any travel time savings from the LRT leg of the journey, resulting in a slight worsening of travel times relative to the reference case situation.

9.3.3 Difference between Car and PT Travel Times

Table 9.5 shows the change in the difference between car PT travel times for trips to Wellington CBD in the AM peak. A negative value signifies a narrowing of the difference between car and PT travel times (an improvement) while a positive value show an increase in the difference (a worsening).

Table 9.5 Change in Difference between Car and PT Travel Times to Wellington CBD for Selected Journeys, AM peak, 2031

Origin Suburb	Reference	BP: Change from Ref	BRT: Change from Ref	LRT: Change from Ref
Miramar	6.9	-2.4	-3.1	1.8
Seatoun	5.6	-2.4	-3.1	3.2
Airport	15.2	-1.5	-4.6	-4.7
Island Bay	11.5	-1.0	-5.4	0.7
Newtown	3.8	-3.7	-7.6	-5.3
Hataitai	9.2	-0.6	3.2	3.2
Kilbirnie	7.8	-4.7	-10.8	-10.7
Karori	6.0	-1.7	-0.7	0.0
Brooklyn	2.7	0.0	-0.6	-0.9

From **Table 9.5** the following points can be made:

- the BP option results in a slight improvement (1 to 4 minutes);

- the BRT option results in a large improvement, particularly for southern and eastern suburbs (3 to 11 minutes);

- the BRT option results in a slight worsening for passengers from Hataitai as they have to walk slightly further to catch the BRT;

- suburbs benefiting from a direct LRT service to the CBD show a substantial improvement, such as Kilbirnie (11 minute improvement); and

- suburbs such as Seatoun and Island Bay, from where people have to interchange under BRT/ LRT in order to access the CBD, show a slight

increase in the difference between PT and car travel times (between 1 and 3 minutes).

9.3.4 Inter-peak travel times

Inter-peak travel times (not reported) are very similar to AM peak PT travel times, especially along the PT spine, as the priority measures and segregation (BRT, LRT options only) will provide benefits in both the AM peak and inter-peak periods. Inter-peak travel times are slower than AM peak travel times in the BP option because the BP measures (bus lanes, signal priority) are only operational in the AM peak.

Highway travel times are lower in the inter-peak, due to less congestion. The net result is that the difference between PT and car travel times is slightly greater in the inter-peak as the advantages that PT gets in terms of priority measures are largely the same between the AM peak and inter-peak but the corresponding level of congestion experienced by car users is generally lower. This helps to partly explain the low PT mode share in the inter-peak compared with the AM peak.

9.4 Travel Times and Speeds along the PT Spine

AM peak two hour period, WPTM.

Read with Appendix 9.2, Figures 9.2.8 to 9.2.13 – actual vehicle speed and change in speed between options

Figure 9.2 shows the PT spine broken down into a number of distinct sections. Travel times (including stop dwell times) have been extracted from the model for all of these sections.

Figure 9.2 – PT Spine Sections

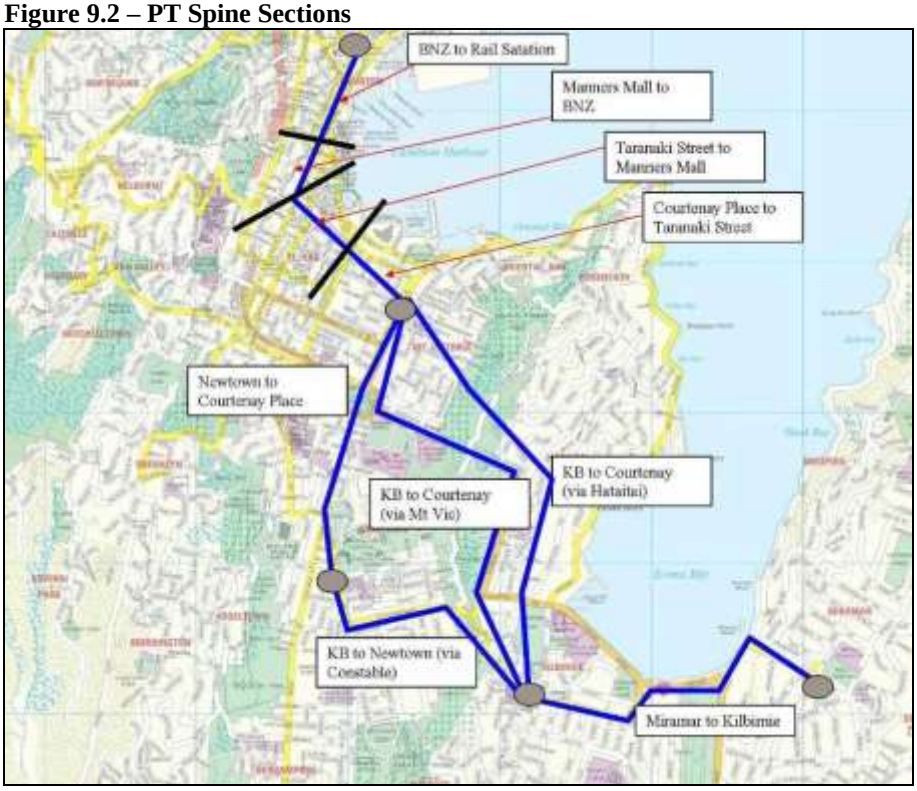


Table 9.6 below shows the change in PT travel time and speed by section for the AM peak.

Table 9.6 Change in PT Travel Time (in minutes) by Section, AM peak, 2031

		PT Travel Time (minutes)				Change from Ref (minutes)		
Description	**Dist (km)**	**Ref**	**BP**	**BRT**	**LRT**	**BP**	**BRT**	**LRT**
Miramar Shops to Kilbirnie	2.0	7	7	7	7	0	0	-0
Kilbirnie to Courtenay Place via Moxham (BP), Mt Vic (BRT / LRT)	3.5	15	14	7	6	-1	-8	-8
Kilbirnie to Newtown	1.7	7	6	7	7	-2	0	0
Newtown to Courtenay Place via Basin Reserve	2.3	9	7	5	5	-1	-4	-4
Courtenay Place to Wellington Station	**2.2**	**10**	**8**	**7**	**7**	**-2**	**-3**	**-3**
Courtenay Place - Taranaki	*0.4*	*3*	*3*	*2*	*2*	*0*	*-1*	*-1*
Taranaki - Willis	*0.5*	*2*	*1*	*2*	*2*	*0*	*-1*	*0*
Willis - BNZ	*0.3*	*2*	*1*	*1*	*1*	*-1*	*-1*	*-1*
BNZ - Station	*0.9*	*4*	*3*	*2*	*2*	*-1*	*-1*	*-1*

Table 9.6 shows that:

- the current 2031 modelled travel time of 15 minutes between Kilbirnie and Courtenay Place is cut to 7 minutes in the BRT and LRT options, a reduction of 8 minutes;

- in the BP option the current travel time from Kilbirnie to Courtenay Place is reduced from 15 to 14 minutes;

- current travel times between Newtown and Courtenay Place are reduced from 9 minutes to 7 minutes in the BP option and are nearly halved to 5 minutes in the BRT and LRT options;

- along the whole length of the Golden Mile, modelled travel times are reduced from 10 minutes (reference case) to 8 minutes in the BP and 7 minutes in the BRT and LRT options.

Table 9.7 below shows how these travel time savings translate into higher average speeds.

Table 9.7Change in PT Travel Speed (in kph) by Section, AM peak, 2031

		PT Travel Speed (kph)				Change cf Ref (kph)		
Description	**Dist (km)**	**Ref**	**BP**	**BRT**	**LRT**	**BP**	**BRT**	**LRT**
Miramar Shops to Kilbirnie	2.0	17	17	17	17	0	0	0
Kilbirnie to Courtenay Place via Moxham (BP), Mt Vic (BRT /	3.5	14	15	34	35	1	19	21
Kilbirnie to Newtown	1.7	14	18	14	14	4	0	0
Newtown to Courtenay Place via Basin Reserve	2.3	16	19	26	30	3	10	14
Courtenay Place to Wellington Station	**2.2**	**13**	**16**	**19**	**19**	**3**	**6**	**6**
Courtenay Place - Taranaki	*0.4*	*9*	*9*	*16*	*16*	*0*	*7*	*7*
Taranaki - Willis	*0.5*	*17*	*22*	*20*	*20*	*5*	*3*	*3*
Willis - BNZ	*0.3*	*11*	*16*	*18*	*17*	*5*	*6*	*6*
BNZ - Station	*0.9*	*15*	*19*	*22*	*21*	*4*	*7*	*7*

Table 9.7 above shows that the improvements in PT travel times result in increased PT operating speeds. The BRT and LRT improvements result in speeds of between 25 – 35kph on sections leading to Courtenay Place, with an average speed of 19kph achieved along the Golden Mile. BP results in small improvements in travel speeds on sections leading to Courtenay Place and a small increase in travel speeds along the Golden Mile from 13kph to 16kph.

Current bus travel times along the Golden Mile vary throughout the AM peak and from one day to another, due to the seemingly unpredictable nature of delays experienced by buses. For example, an 8am journey into the CBD on a Monday could take 20 minutes whereas the same journey made on a Tuesday could take 30 minutes for no apparent reason. Passengers account for such variability in travel times by changing travel patterns so they allow enough time for potential delays to their journey.

Given the reduction in the number of vehicles along the Golden Mile and elsewhere in the network in the BRT and LRT options (and, to much lesser extent, BP) and associated priority measures along this corridor, travel time

variability should also reduce dramatically. Whilst it is hard to quantify these reliability benefits, they are likely to be positive across all options.

The individual segments can be aggregated to determine end to end travel times for the core PTSS routes shown in **Figure 9.3**

Figure 9.3 – Core PTSS Routes

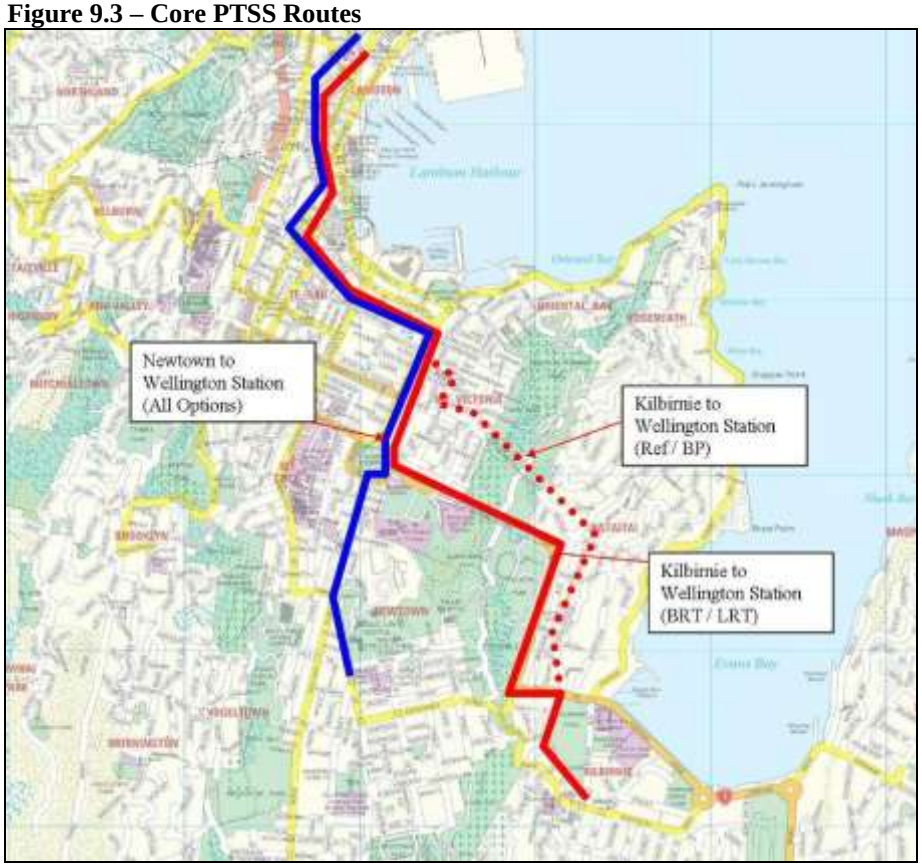


Table 9.8 below shows end to end travel times for all options between Kilbirnie / Newtown and Wellington Station in both the AM peak and inter-peak.

Table 9.8 Change in PT Travel Time (in minutes) by Route, AM peak and inter-peak, 2031

		PT Travel Time by Route (minutes)				Change cf Ref (minutes)		
AM peak	**Dist (km)**	**Ref**	**BP**	**BRT**	**LRT**	**BP**	**BRT**	**LRT**
Kilbirnie to Wellington Station	5.4	24	21	13	13	-3	-11	-11
Newtown to Wellington Station	4.2	18	15	12	11	-3	-6	-7
Inter-peak	**Dist (km)**	**Ref**	**BP**	**BRT**	**LRT**	**BP**	**BRT**	**LRT**
Kilbirnie to Wellington Station	5.4	25	25	13	13	0	-12	-12
Newtown to Wellington Station	4.2	18	18	12	11	0	-7	-7

Table 9.8 shows that PT travel times between Kilbirnie / Newtown and Wellington Station show a marginal improvement (3 minutes) in the AM peak BP option and no change in the inter-peak.

Looking at the BRT and LRT options, they provide similar travel time savings in the AM peak and inter-peak relative to the reference case:

- travel times between Kilbirnie and Newtown are reduced by 11 minutes from 24 to 13 minutes; and
- travel times between Newtown and Wellington Station are reduced by 7 minutes from 18 to 11 minutes.

Figures 9.4 and **9.5** below summarise travel times between Kilbirnie / Newtown and Wellington Station for the three options plus the reference case.

Figure 9.4 – Change in PT Travel Time (in minutes) between Kilbirnie and Wellington Station

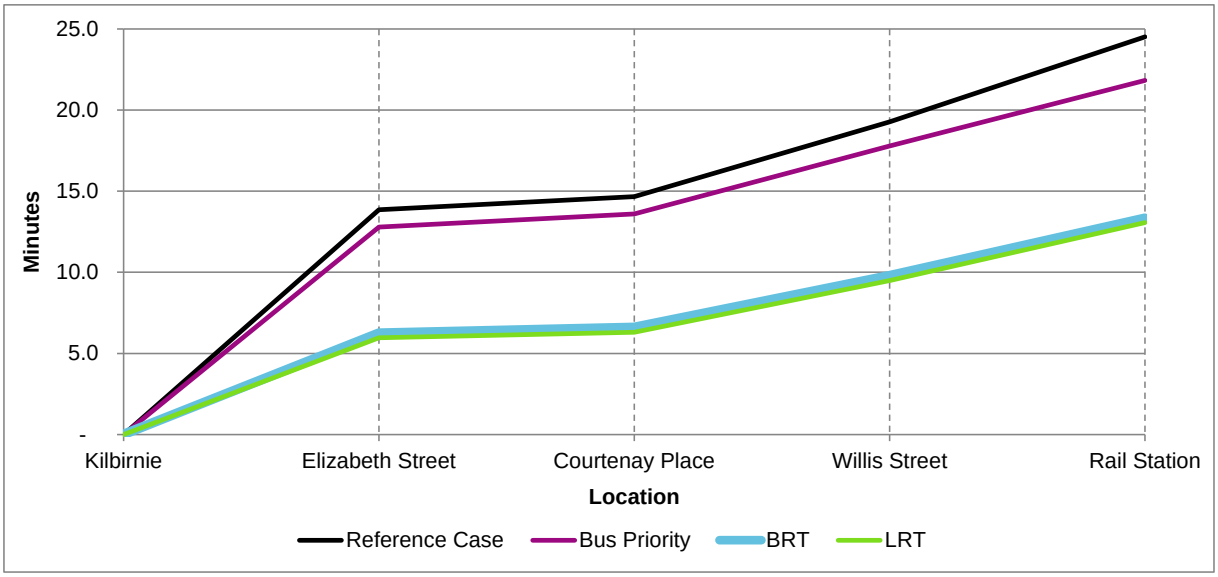


Figure 9.5 – Change in PT Travel Time (in minutes) between Newtown and Wellington Station

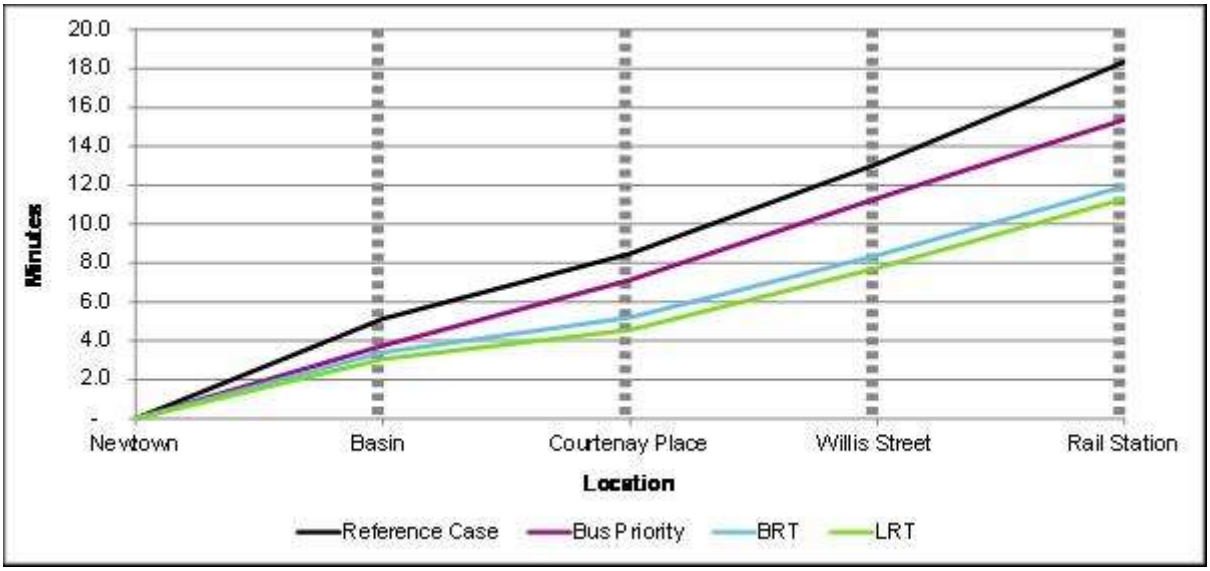


Table 9.9 below shows how the travel time savings in **Table 9.8** translate into improvements in travel speeds

Table 9.9 Change in PT Travel Speed (in kph) by Route, AM peak, 2031

		PT Travel Speed by Route (kph)				Change cf Ref (kph)		
AM peak	**Dist**	**Ref**	**BP**	**BRT**	**LRT**	**BP**	**BRT**	**LRT**
Kilbirnie to Wellington Station	5.4	13	13	25	25	-0	12	13
Newtown to Wellington Station	4.2	14	14	22	23	-0	8	9
Inter-peak	**Dist**	**Ref**	**BP**	**BRT**	**LRT**	**BP**	**BRT**	**LRT**
Kilbirnie to Wellington Station	5.4	14	16	25	26	2	11	12
Newtown to Wellington Station	4.2	14	17	22	23	3	7	9

Travel speeds increase from an average of 13 to 16 kph in the reference and BP options to between 22 kph and 26 kph in the BRT and LRT options. These travel times are end to end travel times and include stop dwell times and time waiting at signals.

Average speeds for the BRT are 22kph over the BRT section for services to/from Newtown and 25kph for services to/from Kilbirnie. In the USA, 24kph is typically what is aimed for when designing full priority BRT. As such the average speeds over the BRT sections seem plausible. It is also encouraging that the BRT and LRT have similar run times for the BRT/LRT sections as this would be expected when designing full priority BRT.

The LRT speeds are in the range 23 to 26 kph. French tramways with no segregation achieve speeds in the range 17 to 20 kph. Newer systems in Nantes (Line 1), Orleans and Strasbourg with full traffic priority but no segregation achieve around 22 kph. Sheffield is the slowest British system at 26 kph and is 40% segregated. Croydon is 86% segregated and achieves 27 kph, and Manchester Phase 1 which is 90% segregated with wide stop spacing achieves 36 kph.

On this basis, the speeds coded for PTSS LRT and BRT appear reasonable for a segregated system with typical stop spacing.

9.5 PT and Car Demand

AM peak two hour period, WTSM.

Each of the three options being evaluated – BP, BRT and LRT – result in improved PT travel times, both in absolute terms and relative to highway travel times.

Improved PT travel times provide benefits to existing users and will also help to generate new trips as people shift from car to PT.

A further incentive to change from car to PT might be that, along with improved PT travel times, highway travel times worsen due to additional congestion caused by capacity being removed for general traffic to allow PT infrastructure improvements associated with each scheme.

9.5.1 PT Demand

Read with Appendix 9.1, Section 9.1.2, for inter-peak results

Read with Appendix 9.2, Figure 9.2.1 and Figure 9.2.2, for GIS plots showing absolute change in PT demand

Table 9.10 below shows the change in the number of PT trips for each option in the AM peak, relative to the reference case.

Table 9.10 Change in PT Demand, AM peak, 2031

	PT Demand	Change in PT Demand cf Reference					
Origin Suburb	**Ref**	**BP**	**% Diff cf Ref**	**BRT**	**% Diff cf Ref**	**LRT**	**% Diff cf Ref**
Miramar	1,620	63	4%	176	11%	-57	-4%
Kilbirnie	850	41	5%	89	10%	101	12%
Mt Vic /Hataitai	950	19	2%	-37	-4%	-38	-4%
Island Bay	1,370	24	2%	112	8%	-63	-5%
Newtown	977	39	4%	112	12%	48	5%
CBD	3,315	35	1%	105	3%	60	2%
Rest of Wellington	8,350	63	1%	146	2%	83	1%
Rest of Region	16,561	-3	0%	141	1%	192	1%
Total	**33,994**	**280**	**1%**	**844**	**2%**	**325**	**1%**

At a region-wide level, the BP (280) and LRT (325) options result in a similar number of additional PT trips, while the BRT (844) generates nearly three times as many new trips. The majority of these new trips are heading towards Wellington CBD.

At a sector level, the new trips are spread evenly across all sectors in the BP option, except from the rest of the region where there are no new trips. In the BRT option, Kilbirnie, Miramar, Newtown and Island Bay gain the most new trips when figures are expressed as a percentage of existing trips. This result is expected as these areas see the greatest improvements in travel times.

In the LRT option, several areas, including Miramar and Newtown, show an increase in trips. Island Bay/ Miramar actually show a decrease, as the need to transfer results in increased end-to-end travel times and a consequent decrease in demand.

Over 50% of new trips in the LRT option originate from outside of Wellington City. This is due to improved travel times along the Golden Mile and more attractive modal interchange at Wellington Station, encouraging people from Hutt Valley and Kapiti to switch from driving into Wellington to getting the train / LRT.

In both options, the Mt Victoria/ Hataitai sector shows a slight decrease in trips because:

- some bus services now terminate at Courtenay Place in the BRT / LRT option, requiring a transfer to then proceed further along the Golden Mile; and

- people have to walk further to access their nearest BRT / LRT stop.

9.5.2 Car Demand

Read with Appendix 9.1, Section 9.1.3, for inter-peak results

Read with Appendix 9.2, Figure 9.2.3 and Figure 9.2.4, for GIS plots showing absolute change in car demand

Table 9.11 below shows the change in car trips for each of the options for the AM peak, relative to the reference case.

Table 9.11 Change in Car Demand, AM peak, 2031

	Car Demand	Change in Car Demand cf Reference, AM peak					
Origin Suburb	**Ref**	**BP**	**% Diff**	**BRT**	**% Diff**	**LRT**	**% Diff**
Miramar	7,502	-55	-1%	-121	-2%	39	1%
Kilbirnie	4,647	-43	-1%	-77	-2%	-88	-2%
Mt Vic /Hataitai	3,355	-20	-1%	37	1%	33	1%
Island Bay	4,333	-22	-1%	-92	-2%	52	1%
Newtown	4,548	-30	-1%	-76	-2%	-30	-1%
CBD	26,859	-90	0%	-25	0%	-8	0%
Rest of Wellington	34,171	-75	0%	-59	0%	-14	0%
Rest of Region	116,266	-31	0%	-51	0%	-14	0%
Total	**201,681**	**-365**	**0%**	**-465**	**0%**	**-30**	**0%**

The reduction in car trips roughly mirrors the corresponding increase in PT trips reported in section 9.6.1, with the greatest absolute decreases in car trips occurring in the sectors where the increase in PT trips is greatest:

- Miramar (BRT);

- Island Bay (BRT);

- Kilbirnie (BRT and LRT); and

- Newtown (BRT and LRT).

The relationship between changes in PT and car trips is not a simple one-to-one relationship because:

- each car contains an average of between 1.2 and 1.5 persons depending on the journey purpose. Therefore, a 10 car decrease might equate to a corresponding 12 to 15 person increase in PT trips; and

- a reduction in AM peak car trips does not necessarily mean that the occupants transfer to PT. They might delay their journey until the inter-peak when there is less congestion.

9.5.3 PT Mode Share to Wellington CBD

Read with Appendix 9.1, Section 9.1.4, for Inter-peak results

Read with Appendix 9.2, Figure 9.2.5 and Figure 9.2.6, for GIS plots showing the PT mode share for the AM peak and inter-peak

Changes in PT and car demand will affect the PT mode share.

The spatial variation in the change in PT and car demand across the region was highlighted in sections 9.5.1 and 9.5.2, showing that the growth in PT trips (and consequent reduction in car trips) is greatest in areas that benefit the most in terms of travel time savings from the various options.

Table 9.12 show the PT mode share to Wellington CBD in the reference case and the change relative to the reference case for the three options.

Table 9.12 Change in PT Mode Share between Options, AM peak, Trips to CBD

	Mode Share to Wellington CBD and Diff from Ref, AM peak						
Origin Suburb	**Ref**	**BP**	**Diff**	**BRT**	**Diff**	**LRT**	**Diff**
Miramar	42.9%	44.5%	1.6	46.9%	4.0	41.6%	-1.2
Kilbirnie	35.6%	37.6%	2.0	39.5%	3.8	39.7%	4.1
Mt Vic /Hataitai	33.1%	33.8%	0.7	31.6%	-1.5	31.7%	-1.3
Island Bay	43.2%	44.0%	0.8	46.4%	3.1	41.8%	-1.4
Newtown	30.5%	31.8%	1.2	33.9%	3.3	32.2%	1.7
CBD	11.0%	11.1%	0.1	11.2%	0.3	11.3%	0.3
Rest of Wellington	37.4%	37.7%	0.4	37.9%	0.5	37.7%	0.3
Rest of Region	55.5%	55.5%	0.0	55.8%	0.4	55.9%	0.5
Total	**34.7%**	**35.1%**	**0.4**	**35.5%**	**0.8**	**35.1%**	**0.3**

Table 9.12 shows that, in terms of the percentage point (pp) change in mode share:

- PT mode share to the CBD increases by around 0.8 pp for the BRT option, 0.4pp for BP and 0.3pp for LRT;

- Looking at the origin sectors, PT mode share to the CBD increases by up to 2.0% in the BP option, with Kilbirnie (2.0) and Miramar (1.7) showing the greatest increases;

- PT mode share to Wellington CDB increases by over 3%, for trips originating from Miramar (4.0), Newtown (3.3), Kilbirnie (3.8) and Island

Bay (3.1) in the BRT option, with smaller increases seen across other sectors;

- the LRT option sees an increase in PT mode share for Kilbirnie (4.1) and Newtown (1.7) but a decrease for Island Bay (-1.4), Mt Victoria / Hataitai (-1.3) and Miramar (-1.2); and

- when focussing on the study area and excluding the rest of Wellington and rest of the region, BRT results in a near 4 percentage point increase in PT mode share whilst the comparable figure for LRT and BP is nearer 2.0

9.6 PT Patronage along PTSS Corridors

AM peak average hour, WPTM.

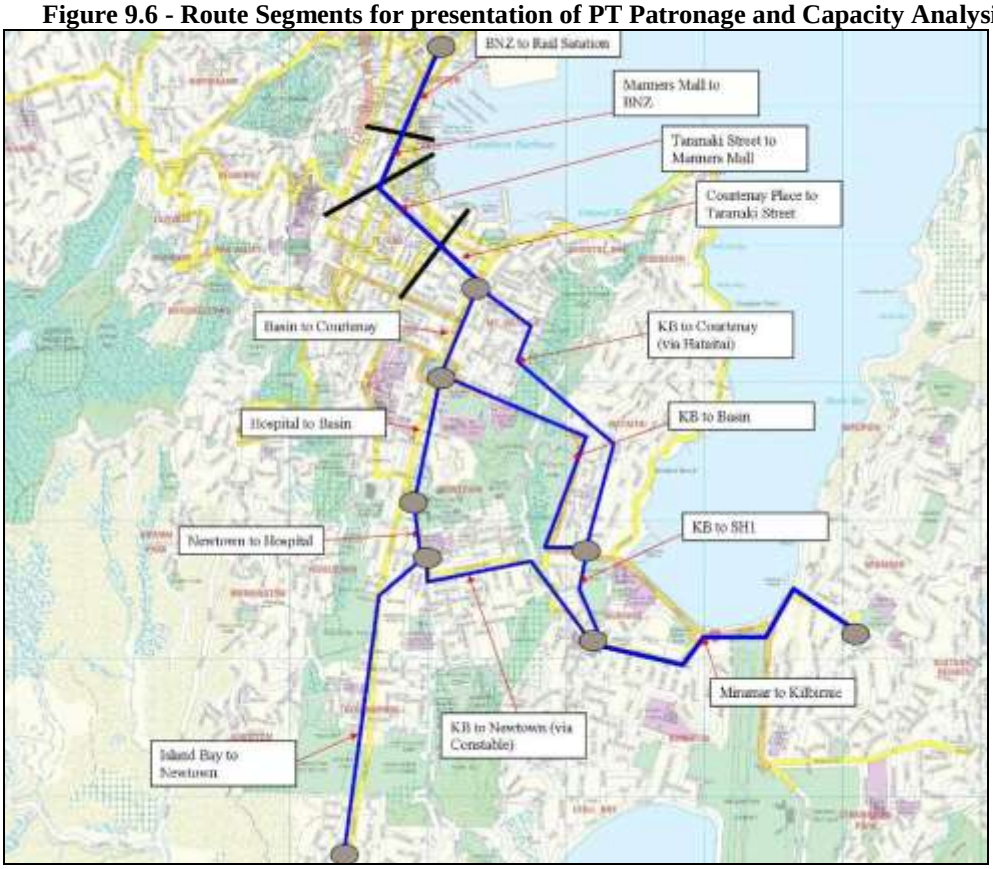
Read with Appendix 9.1, section 9.1.5 – inter-peak patronage.

Read with Appendix 9.2, Figures 9.2.14 to 9.2.16 – change in AM peak patronage.

An alternative means of looking at patronage and capacity is to split the network up into specific segments and look at average values along these segments.

Figure 9.6 shows the segments that have been used for the analysis presented in the next few sections.

Figure 9.6 - Route Segments for presentation of PT Patronage and Capacity Analysis



The average patronage / capacity / spare capacity is calculated along each section, weighted by distance. This indicates differences and changes between options.

The disadvantage of looking solely at an average figure is:

- they will smooth out any spikes in patronage and mask potential capacity issues that may occur at the 'peak of the peak'; and
- average figures along a long segment would not identify peak loading locations and capacity issues at these locations.

Therefore, a further piece of analysis is presented later in this chapter looking at peak loadings.

Table 9.13 shows the change in patronage by segment. Note that the alternative routes between SH1 (Kilbirnie) and Courtenay Place via Hataitai (Ref, BP) and Mt Victoria Tunnel (BRT and LRT) have been combined and shown as one single entry so that differences can be calculated at this location between the reference case/BP and BRT / LRT options.

Table 9.13 Change in PT Patronage, By Segment, AM peak, 2031

	PT Pax	Absolute and Percentage change in PT Patronage cf Ref					
Segment	**Ref**	**BP**	**% Diff**	**BRT**	**% Diff**	**LRT**	**% Diff**
Miramar to Kilbirnie	363	14	4%	172	47%	107	29%
Kilbirnie to SH1	482	17	4%	481	100%	384	80%
SH1 to Courtenay Place (Hat / Mt Vic)	942	28	3%	393	41%	298	31%
Basin to Elizabeth Street	813	59	7%	1,306	161%	1,094	135%
Kilbirnie to Newtown	242	28	12%	-178	-74%	-179	-74%
Island Bay to Newtown	277	5	2%	78	28%	11	4%
Newtown to Hospital	1,040	65	6%	-57	-6%	-157	-15%
Hospital to Basin	807	59	7%	172	21%	17	2%
Cambridge to Taranaki (GM)	2,019	102	5%	542	27%	331	16%
Taranaki to Willis (GM)	2,058	104	5%	479	23%	296	14%
Manners to Lambton (GM)	2,240	116	5%	396	18%	249	11%
Willis to Bowen (GM)	1,498	84	6%	167	11%	84	6%

Table 9.13 shows that:

- in the BP option, patronage on the individual segments increases by between 2% and 12% across the network. On average, around 100 extra passengers travel along the Golden Mile in the AM peak hour;

- in the BRT option there is a reduction of 178 passengers travelling between Kilbirnie and Newtown, as they re-route and use alternative services through Mt Victoria tunnel;

- the patronage between SH1 (Kilbirnie) and the Basin via Mt Victoria increases to 1,331 from 942 in the reference case, an increase of 393;

- there is a 21% increase in patronage along the segment between the Hospital and the Basin Reserve;

- in the BRT option, average hourly patronage along the Golden Mile is around 400-500 (20%) greater compared with the reference case;

- the pattern for the LRT option is similar to that for the BRT, except the absolute increase in PT patronage is roughly a third to a half lower than what is seen in BRT option, due to fewer new PT trips being generated; and

- for both BRT and LRT, the absolute increase in PT patronage is greatest for the segments between Kilbirnie and the CBD drawing most of their patronage from the eastern suburbs.

9.7 PT Capacity

AM peak average hour, WPTM.

Read with Appendix 9.2 and Appendix 9.1, Section 9.1.6

Read with Appendix 9.2, Figures 9.2.17 to 9.2.19 – change in AM peak capacity.

Table 9.14 shows the change in available PT capacity across all options, expressed in passengers / hr.

Table 9.14 Change in PT Capacity, By Segment, AM peak, 2031

	Capc	Absolute and Percentage change in PT Capacity cf Ref					
Segment	**Ref**	**BP**	**% Diff**	**BRT**	**% Diff**	**LRT**	**% Diff**
Miramar to Kilbirnie	1,385	0	0%	-12	-1%	155	11%
Kilbirnie to SH1	1,491	0	0%	472	32%	1,132	76%
SH1 to Courtenay Place (Hat / Mt Vic)	1,695	0	0%	78	4%	748	44%
Basin to Elizabeth Street	1,238	0	0%	1,502	121%	2,564	207%
Kilbirnie to Newtown	384	0	0%	0	0%	0	0%
Island Bay to Newtown	731	0	0%	946	129%	123	17%
Newtown to Hospital	1,536	0	0%	448	29%	1,008	66%
Hospital to Basin	1,248	0	0%	352	28%	912	73%
Cambridge to Taranaki (GM)	3,688	0	0%	-300	-8%	920	25%
Taranaki to Willis (GM)	4,139	0	0%	-527	-13%	693	17%
Manners to Lambton (GM)	5,035	0	0%	-527	-10%	693	14%
Willis to Bowen (GM)	5,035	0	0%	-610	-12%	693	14%

There is no change in capacity between the reference case and BP as both options use the same underlying PT services.

Along the SH1 to Courtenay Place (via Mt Victoria/ Hataitai) segment, the available capacity is similar between the reference case and BRT option. The LRT option results in a considerable increase in capacity.

Elsewhere on the network, the BRT option results in an increase in capacity between Island Bay and Courtenay Place, but a slight reduction in capacity along the Golden Mile compared with the reference case. This is because some existing services that travel along Oriental Parade and down Palliser Road will terminate at Courtenay Place in the BRT option, requiring passengers to transfer onto BRT services to then travel along the Golden Mile. This reduces the number of normal buses running along the BRT corridor to ensure that superior BRT travel times and improved service reliability is achieved.

The LRT provides a significant increase in capacity compared with the Ref, BP and BRT options.

9.8 PT Spare Capacity

AM peak average hour, WPTM.

Read with Appendix 9.2, Figures 9.2.20 to 9.2.22 – change in AM peak spare capacity.

Spare capacity gives an indication of whether there is enough capacity to cater for any increase in patronage over and above what has been predicted. It will

also indicate if there is too much or too little capacity at certain points in the network, so that services can be refined and modified accordingly.

Table 9.15 overleaf shows the change in spare PT capacity by segment, relative to the amount of spare capacity available in the reference case.

It shows that average spare seat capacity (passengers / hr) in the reference case appears to indicate that adequate capacity exists across the current network (although these figures are averages and will smooth out any peaks / troughs).

Table 9.15 Change in PT Spare Capacity, By Segment, AM peak, 2031

	Sp Capc	Absolute and Percentage change in PT Spare Capacity cf Ref					
Segment	**Ref**	**BP**	**% Diff**	**BRT**	**% Diff**	**LRT**	**% Diff**
Miramar to Kilbirnie	1,022	-14	-1%	-184	-18%	48	5%
Kilbirnie to SH1	1,009	-17	-2%	-9	-1%	748	74%
SH1 to Courtenay Place (Hat / Mt Vic)	753	-28	-4%	-305	-40%	450	60%
Basin to Elizabeth Street	425	-59	-14%	196	46%	1,470	346%
Kilbirnie to Newtown	142	-28	-20%	178	125%	179	126%
Island Bay to Newtown	454	-5	-1%	869	191%	112	25%
Newtown to Hospital	496	-65	-13%	505	102%	1,165	235%
Hospital to Basin	441	-59	-13%	180	41%	895	203%
Cambridge to Taranaki	1,669	-102	-6%	-842	-50%	590	35%
Taranaki to Willis	2,081	-104	-5%	-1,006	-48%	397	19%
Manners to Lambton	2,794	-116	-4%	-922	-33%	444	16%
Willis to Bowen	3,537	-84	-2%	-776	-22%	609	17%

The BP option results in a slight reduction in available spare capacity, purely because there is a slight increase in patronage.

The BRT option results in some increases in spare capacity and some decreases, with the decreases most notable along the Golden Mile. There is very little spare seat capacity through Mt Victoria tunnel in the BRT option, while the same option provides a sizeable increase in spare capacity between Island Bay and Newtown.

The LRT option provides a step change in capacity. Arguably it over provides, although if available capacity were lowered by reducing service frequencies then this would adversely affect travel times, given that waiting time is one component of a person's total travel time.

9.9 Volume / Capacity Ratios

AM peak average hour, WPTM.

Read with Appendix 9.2, Figures 9.2.23 to 9.2.25 – actual AM peak volume-capacity ratios.

Volume over capacity (V/C) ratios are a measure of how full, on average, services are on a particular link.

The capacities used for this assessment are the standard design capacities used by AECOM:

- Bus (64 pax);
- BRT (100 pax); and
- LRT (180 pax).

These capacities are 'total' capacities that allow for a certain number of standees but no so many standees that the vehicle would be considered overloaded and at 'crush capacity'.

As a general rule, any VC ratio over 75% will start to signify that the service is approaching capacity and that people might start to experience deterioration in their travel experience as a result. International research suggests that when waiting for PT services, passengers perceive a service to be crowded when it is actually at around 75% of capacity.

Both the demand and capacity figures represent an average hour between 7am and 9am. Therefore the demand and capacity profiles are smoother than might be the case in reality, where demand is greatest in the 'peak of the peak' and capacity is, to a certain extent, matched accordingly against this demand.

Table 9.16 below details the change in PT V/C ratios by segment, relative to the reference case. It shows that in the BP option no segments have average VC ratios greater than 75%. In the BRT option, a number of segments have VC ratios greater than 75% and may therefore be perceived as being crowded.

Table 9.16 Change in PT Volume-Capacity Ratios, By Segment, AM peak, 2031

	VC	Volume-Capacity Ratios and change cf Ref					
Segment	**Ref**	**BP**	**Change**	**BRT**	**Change**	**LRT**	**Change**
Miramar to Kilbirnie	26%	27%	1	39%	13	31%	4
Kilbirnie to SH1	32%	33%	1	49%	17	33%	1
SH1 to Courtenay Place (Hat / Mt Vic)	56%	57%	2	89%	89	57%	57
Basin to Elizabeth Street	66%	70%	5	77%	12	50%	-16
Kilbirnie to Newtown	63%	70%	7	17%	-46	16%	-47
Island Bay to Newtown	38%	39%	1	21%	-17	34%	-4
Newtown to Hospital	68%	72%	4	50%	-18	35%	-33
Hospital to Basin	65%	69%	5	61%	-3	38%	-27
Cambridge to Taranaki	55%	58%	3	76%	21	51%	-4
Taranaki to Willis	50%	52%	3	70%	21	49%	-1
Manners to Lambton	44%	47%	2	58%	14	43%	-1
Willis to Bowen	30%	31%	2	38%	8	28%	-2

In the BRT option between SH1 (Kilbirnie) and the Basin Reserve, through Mt Vic tunnel, the VC ratio is 89%.

The LRT VC ratios are nearly all below 50% and show that this option provides more than enough capacity on both the core spine (Kilbirnie / Newtown to Wellington CBD) and feeder services (e.g. Miramar to Kilbirnie, Island Bay to Newtown) linking into the LRT network, where service frequencies have been increased to make up for the need to interchange between bus and LRT at Kilbirnie and Newtown.

VC ratios on the Island Bay to Newtown branch are 21% and 34% respectively in the BRT and LRT options, indicating that a lot of spare capacity is present which could be reduced.

9.10 Vehicles per hour

Chapter 7 tabulated the number of vehicles per hour travelling along the Golden Mile in the reference case and the three options. This analysis showed that the BRT & LRT options both result in lower frequencies along the Golden Mile due to:

- larger BRT and LRT standard vehicles offering greater capacity, mean that service frequencies can be lowered accordingly;

- some existing bus services now terminate at interchange points such as Courtenay Place and Wellington Station in the BRT and LRT options, further reducing the number of vehicles along the Golden Mile; and

- services from the northern suburbs and the Hutt Valley are routed onto the secondary spine.

Figures 9.2.26 to 9.2.28 in Appendix 9.2 show the change in Am peak vehicles per hour travelling on the core network relative to the reference case for all three options.

These figures highlight the reduction in service frequencies between Kilbirnie and the Basin Reserve, Newtown and the Basin Reserve and along the Golden Mile for both BRT and L:RT options.

The number of vehicles per hour travelling from Island Bay and Miramar to Newtown and Kilbirnie interchanges respectively increase for both the BRT and LRT option.

The increase in vehicles per hour between the Basin Reserve and Courtenay Place is a little misleading as it is due to BRT and LRT services from Kilbirnie to Courtenay Place now using this stretch of road instead of travelling through the bus tunnel as is the case in the Ref and BP option.

9.11 Peak Loadings

AM peak average hour, WPTM.

AM peak 'peak 30 minute patronage' derived from WPTM.

As mentioned in the previous section, VC ratios use average volumes and average capacities, whereas in reality volumes and, to a lesser extent, capacities will vary along these sections throughout the 2hr peak period to try and best match demand and supply.

Local knowledge and modelling that has been undertaken for the PTSS, have identified the following sections on the approach to the CBD as the peak loading locations. The VC ratios will be at their highest at these locations and therefore they are good locations for assessing whether the network can cope with the forecast demand.

The peak loading points form three screenlines:

- **Screenline 1**
    - BRT / LRT (from Kilbirnie) – Exit from Mt Vic tunnel; and
    - Ref / BP (from Kilbirnie) – Bottom of Elizabeth Street.
- **Screenline 2**
    - Ref / BP / BRT / LRT (from Newtown) – Approach to Basin Reserve; and
    - Ref / BP / BRT / LRT (from Newtown) – Wallace Street approach to Taranaki Street.

- **Screenline 3**
  - Ref / BP / BRT / LRT (CBD) – Start of Courtenay Place.

Figure 9.7 overleaf shows the peak loading points and screenlines.

Figure 9.7 - Peak Loading Locations and Screenlines

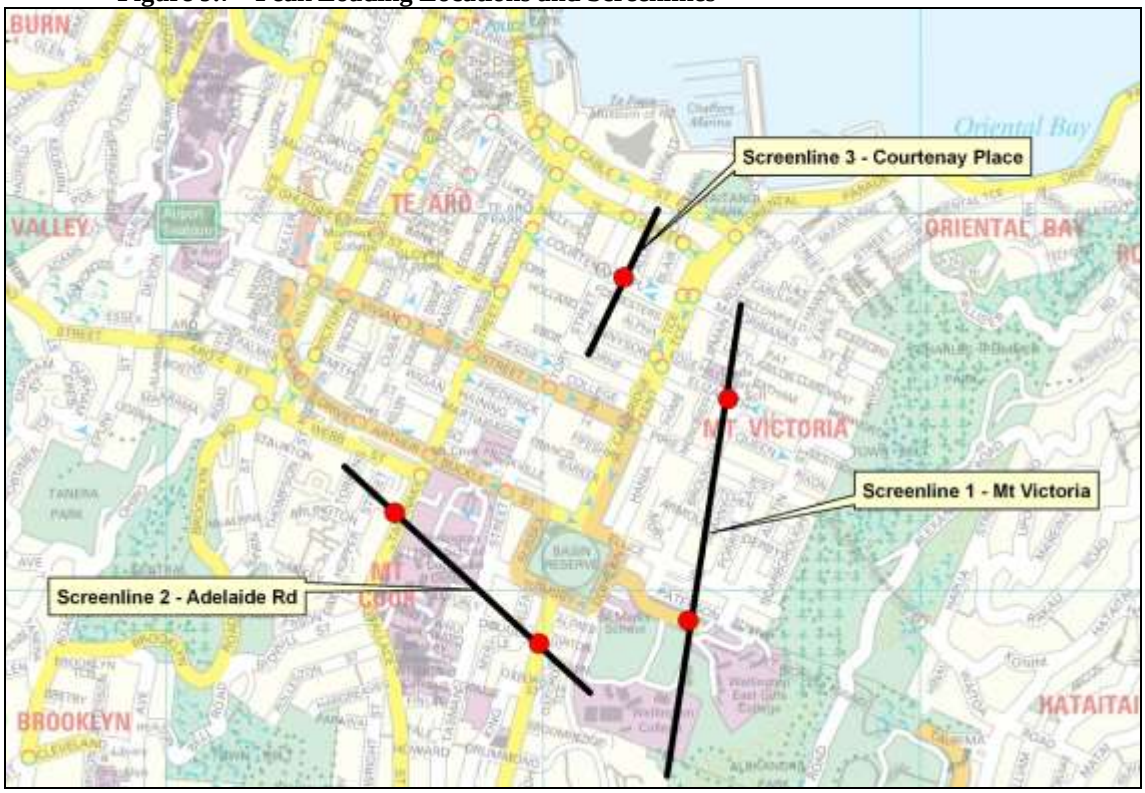


Table 9.17 shows the change in average PT hourly volumes at these locations, together with the VC ratio for each of the options.

Table 9.17 Average VC Ratios at Peak Loading Points, AM peak, 2031

	PT Volumes	Change in PT Volumes cf Ref			VC Ratio			
Screenline	**Ref**	**BP**	**BRT**	**LRT**	**Ref**	**BP**	**BRT**	**LRT**
1 - Mt Victoria Tunnel / Bus Tunnel	1,063	34	448	360	69%	71%	101%	66%
2 - Adelaide Rd / Wallace Street	1,198	65	-145	-269	59%	63%	44%	32%
3 - Courtenay Place	1,966	96	562	343	57%	60%	64%	45%

Looking at the VC ratios above:

- the VC ratio at Screenline 1 (Mt Victoria) increases from around 70% in the reference case / BP to over 100% in the BRT option, signifying that capacity is being exceeded at this location throughout the whole of the average peak hour. The corresponding LRT VC ratio is 66%, indicating that spare capacity still exists at this location;

- PT volumes crossing Screenline 1 increase by 450 and 360 respectively across the average AM peak hour between the reference case and BRT/ LRT options;

- the VC ratio for services crossing Screenline 2 is much lower in the BRT and LRT options (44% and 32% respectively) than in the reference case (59%) and BP (63%);

- from this analysis it could be possible to reduce capacity on the Newtown BRT branch and increase it on the Kilbirnie BRT branch;

- LRT frequencies could also be reduced on the Newtown branch as the VC ratio (32%) is low; and

- peak VC ratios on the northbound approach to the first stop on Courtenay Place are around 60% for reference, BP and BRT, dropping to 45% for the LRT.

Analysis of data from the Wellington CBD PT Cordon Survey (2011) found peak loadings on high frequency services (the 30 minute 'peak of the peak') to be around 60% greater than average loadings across the whole time period for the service in question.

Table 9.18 below shows, for the peak 30 minutes during the AM peak, an estimate of PT patronage and VC ratios at peak loading screenlines.

Table 9.18 Estimated Maximum 'Peak of the Peak' PT patronage and VC Ratios at Peak Loading Points, AM peak, 2031

	PT volumes	Change in PT volumes cf Ref			VC Ratio			
Screenline	**Ref**	**BP**	**BRT**	**LRT**	**Ref**	**BP**	**BRT**	**LRT**
Mt Vic Tunnel / Bus Tunnel	881	28	358	256	102%	105%	155%	105%
Adelaide Rd / Wallace Street	968	53	-126	-225	89%	94%	71%	51%
Courtenay Place	1,610	78	440	236	87%	91%	99%	70%

The trends in **Table 9.18** are similar to those in **Table 9.17**, although the VC ratios are higher across the board as 'peak loadings' are used as opposed to average loadings.

Both the reference case and BP option show peak VC ratios in excess of 85% across all three screenlines.

Table 9.18 further highlights the fact that additional capacity may be required between the southern/ eastern suburbs and Wellington CBD as the peak VC ratios crossing Screenline 1 (Mt Victoria) exceed 100% in all options . Screenline 2 shows that the part of the network from Island Bay/ Newtown appears to be operating under capacity in the BRT and LRT options even when peak loads are considered.

These issues can be resolved at any later detailed design stage.

9.12 Boardings by Sector

AM peak average hour, WPTM.

Read with Appendix 9.1, Section 9.1.7 (Inter-peak boardings by sector), Section 9.1.8 and Section 9.1.9 (boardings by stop in AM peak and inter-peak)

A change in the number of PT boardings between options will be due to either increased demand or the need to transfer between services (creating additional boardings) compared to the reference case.

Table 9.19 below shows the change in total boardings between the reference case and the three options.

Table 9.19 Change in Total Boardings by Sector, AM peak, 2031

Sector	Boardings	Absolute and Percentage change in Total PT Boardings cf Ref					
	Ref	BP	% Change	BRT	% Change	LRT	% Change
Miramar	595	23	4%	111	19%	-35	-6%
Kilbirnie	538	24	5%	79	15%	648	120%
Mt Vic /Hataitai	443	7	2%	110	25%	103	23%
Island Bay	591	13	2%	53	9%	-54	-9%
Newtown	564	47	8%	7	1%	415	74%
CBD	5,166	-24	0%	665	13%	893	17%
Rest of Wellington	3,854	48	1%	59	2%	44	1%
Rest of Region	8,098	-20	0%	53	1%	83	1%
Total	19,846	118	1%	1,137	6%	2,097	11%

All three options result in an increase in boardings across the region.

Relative to the previously reported increase in demand across the region (**Table 9.5** - between 1.0% and 2.0% across all options), BP shows an increase in boardings that is in-line with the increase in demand, showing that no extra transfer boardings are having to be made.

In both the BRT (6% cf 2%) and LRT (11% cf 1%) options the increase in boardings is considerably greater than the increase in trips, signifying that additional transfers are being made.

In the BRT option, small increases in the number of boardings occur in Miramar, Kilbirnie and Newtown, due to people transferring from feeder bus services to the BRT.

The LRT option results in a substantial increase in boardings in Newtown and Kilbirnie, as people transfer off feeder bus services onto the LRT.

The increase in boardings in the CBD is due to additional people who currently walk to their final destination after alighting from rail services at Wellington station deciding to take the BRT/ LRT due to the enhanced travel times and service frequencies.

9.13 Journeys requiring a transfer to reach Wellington CBD

AM peak average hour, WPTM.

Read with Appendix 9.2, Figure 9.2.7, for a GIS plot showing journeys requiring a transfer to reach the CBD

Analysis of boardings highlights the sector within which additional boardings take place – it does not identify the origin sector for these trips. For example, Kilbirnie shows a big increase in boardings under the LRT option. This is due to passengers from Miramar to the CBD needing to change between bus and LRT.

Table 9.20 below shows the PT demand originating from each sector in the AM peak and the percentage of journeys originating from each sector that require a transfer.

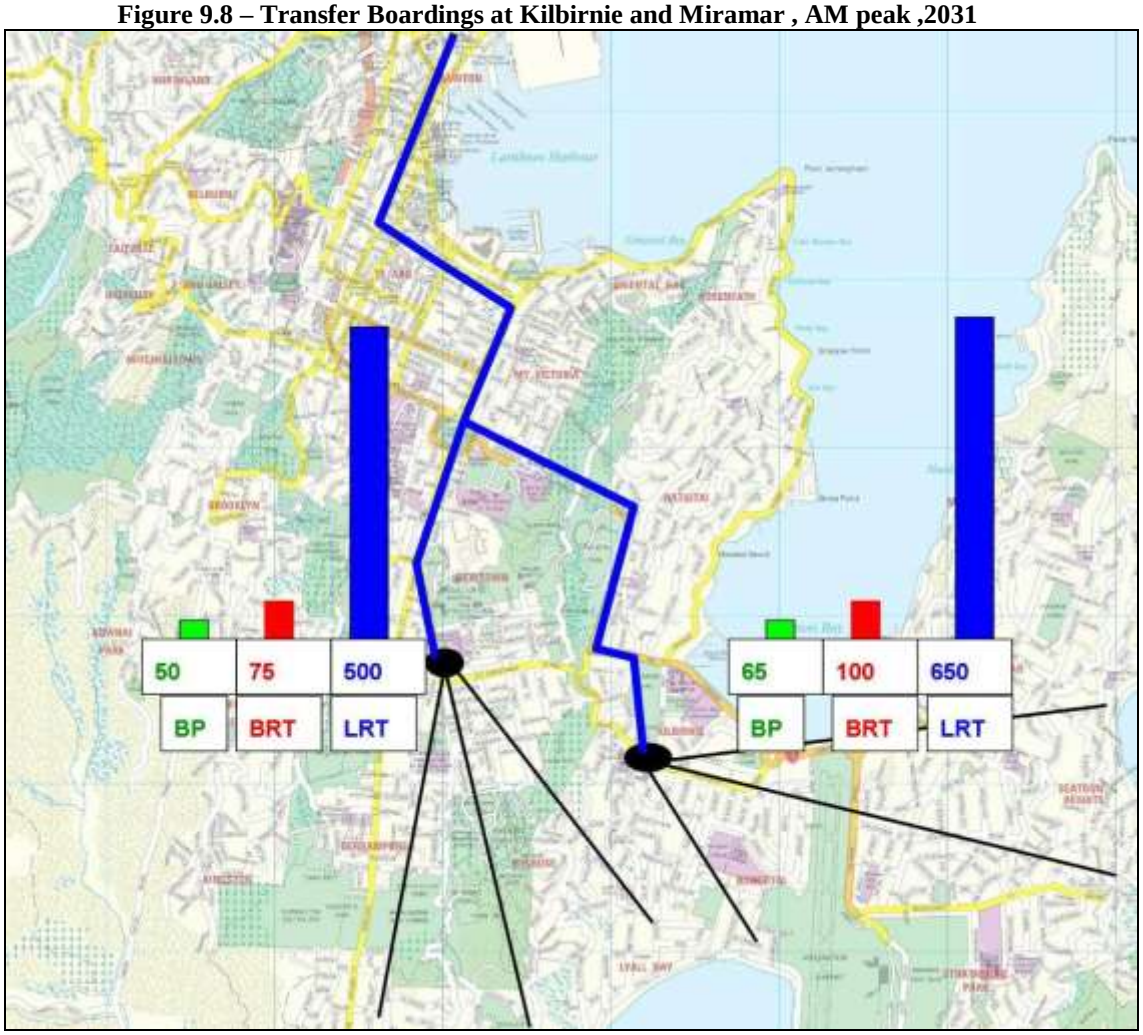
Table 9.20 Percentage of Journeys Requiring a Transfer to reach Destination in the CBD, AM peak, 2031

Origin Sector	PT trips	% of PT trips requiring a transfer to reach CBD			
	Reference	Ref	BP	BRT	LRT
Miramar	481	11%	17%	21%	89%
Kilbirnie	407	2%	8%	36%	46%
Mt Victoria /Hataitai	421	3%	5%	4%	5%
Island Bay	498	8%	11%	29%	90%
Newtown	512	0%	4%	14%	6%
CBD	1,074	0%	0%	0%	0%
Rest of Wellington	3,648	17%	17%	25%	31%
Rest of Region	5,795	57%	57%	62%	66%
Total	**12,834**	**29%**	**30%**	**36%**	**45%**

Table 9.20 above demonstrates quite clearly how the percentage of passengers needing to transfer between services in order to reach a final destination in the CBD increases in the LRT and, to a lesser extend, BRT scenarios.

Figure 9.8 shows transfer boardings at Miramar and Kilbirnie Interchanges in the AM peak. Again, it shows quite clearly the large number of transfers generated by the LRT scenario.

Figure 9.8 – Transfer Boardings at Kilbirnie and Miramar , AM peak ,2031



9.14 Wellington Rail Station – Walk vs PT Egress

AM peak average hour, WPTM.

Currently around 6,250 passengers arrive into Wellington station by rail in the AM peak average hour. Of these passengers, relatively few complete their journey to their final destination by PT; the majority (90%) walk to their final destination.

By improving travel times along the Golden Mile and introducing a superior level of service, it is possible that the walk/ PT mode share might shift slightly in favour of bus.

Table 9.21 shows that of the 3,500 PT boarding's at Wellington Bus Station in the AM peak 2031 reference case, 99% are transfer boardings, with all of these transfers coming from rail services terminating in Wellington.

Table 9.21 PT Boardings and Transfer Boardings at Wellington Bus and Rail Stations, AM peak, 2031

	PT Boardings		Change in Boardings cf; Reference Case and % of Transfer Boardings					
	Ref	% Trans	BP	% Trans	BRT	% Trans	LRT	% Trans
Wellington Bus Station	3,594	99%	-40	99%	664	98%	934	98%
Wellington Rail Station	313	72%	-23	72%	-4	74%	-4	74%

In the BRT and LRT options, 650 and 900 additional transfer boardings are generated due to improvements in PT travel times between Wellington Station and stops along the Golden Mile resulting in people taking PT instead of walking to reach their final destination.

Whilst it is considered reasonable that the BRT and LRT travel time improvements will result in more rail passengers using PT to reach their final destination along the Golden Mile (and beyond), the baseline figure (7,000 rail-bus transfer trips at Wellington Station) should be treated with a degree of caution as we believe this is an over-estimate and in reality more people would actually walk over short distances than predicted by WPTM in 2031.

In the base (2011) version of WPTM, around 550 passengers transfer from rail services onto buses at Courtenay Place, mirroring results from the 2011 rail passenger survey.

Integrated ticketing is assumed to be operational for the PTSS, essentially making it free for someone to travel from Wellington Station to anywhere along the Golden Mile if they arrive in Wellington by train.

This results in a perhaps unrealistically large number of people switching from walking to their final destination to taking a bus/ BRT/ LRT.

Whilst the absolute numbers should be treated with caution, the PTSS is more concerned by relative differences between options rather than absolute numbers. Therefore this issue will not materially affect the assessment of the PTSS options and the estimation of scheme benefits.

9.15 Southbound and Outbound Trips

AM peak average hour, WPTM.

Most analysis presented in this chapter relates to inbound trips to Wellington and northbound trips along the Golden Mile as:

- Inbound trips comprise over 90% of total inbound PT demand in the AM peak; and
- When looking at the study area, most inbound trips to the CBD need only travel northbound along the Golden Mile due to employment being centred there

Each of the options do, however, provide additional capacity and service frequencies in the southbound direction along the Golden Mile.

Table 9.22 below shows changes in capacity and patronage along the various route segments as shown previously in **Figure 9.7**:

Table 9.22 Southbound Patronage and Capacities along the Golden Mile and Study Area, AM peak, 2031

	Patronage				Capacities			
Segment	**Ref**	**BP**	**BRT**	**LRT**	**Ref**	**BP**	**BRT**	**LRT**
Kilbirnie to Miramar	62	1	24	11	946	0	535	138
SH1 to Kilbirnie	120	2	53	31	1,374	0	798	1,452
Courtenay Place to SH1 (Hat/Mt Vic)	114	1	59	37	1,110	0	798	1,452
Basin to Elizabeth Street	196	1	353	344	1,004	0	1,303	3,317
Newtown to Kilbirnie	65	3	-32	-24	384	0	0	0
Newtown to Island Bay	9	-0	3	-3	553	0	313	45
Hospital to Newtown	112	0	-20	-19	1,536	0	-352	1,008
Basin to Hospital	121	1	39	69	981	0	-181	1,179
Taranaki St to Cambridge Terrace	584	8	223	217	3,961	0	-971	1,043
Wills Street to Taranaki Street	1,015	11	158	256	5,106	0	-1,443	571
Lambton Q to Willis	2,258	27	65	112	5,687	0	-1,470	544
Bowen St to BNZ	3,734	62	-2	78	5,755	0	-1,212	802

In terms of patronage, both the BRT and LRT options result in increases in southbound patronage along the Golden Mile and elsewhere throughout the study area. The BP options results in no change in capacity and little change in patronage.

The southbound patronage along the Golden Mile is slightly skewed as around 1,000 trips that are present along this section in the reference case and BP options are now routed onto the secondary spine in the BRT and LRT options. Adjusting the figures accordingly, the BRT and LRT options result in around 500 - 1,000 additional southbound PT trips along the Golden Mile – as documented in the previous section, these trips are mostly rail transfer trips as passengers alighting at Wellington Railway Station now take the BRT/ LRT to access their final destination off the Golden Mile rather than walk as was the case in the reference case / BP options.

Whilst the capacity figures along the Golden Mile are similarly skewed by the rerouting of services onto the secondary spine, the figures show that the LRT option provides a step change in passenger capacity through the study area.

9.16 Through Trips

AM peak two hour period, WTSM.

Table 9.23 below shows the change in through trips between the AM peak 2031 reference case and the three options. **Section 5.2.1** and **Figure 5.1** previously explained what is considered a through trip.

Table 9.23 Change in Through Trips, AM peak, 2031

Origin	Reference Case		Change in Through Trips		
	Through Trips	Through Trips (% of Total Trips from Sector)	BP	BRT	LRT
CBD	-	0%	-	-	-
Northern	119	2%	1	28	12
Western	73	3%	1	7	-10
Southern	259	8%	5	28	3
Eastern	258	7%	10	24	8
Rest	209	1%	1	59	28
Total	**919**	**3%**	**19**	**145**	**42**

It shows that some new through trips are generated in the BRT option, with hardly any generated in the other two options. Not enough new trips are generated to change the percentage of through trips, relative to the total number of trips originating from each of the sectors.

9.17 PT Vehicle Kilometres Travelled and Passenger Load Factors

AM peak average hour, WPTM.

Vehicle kilometres travelled is a measure used to look at operational expenditure relating to PT networks. As both fixed (vehicle) and variable (fuel) costs are associated with running PT services, it is in the operators' interests to optimise vehicle kilometres travelled to reduce operating costs whilst continuing to provide a good level of service..

Table 9.24 shows the change in vehicle kilometres travelled for all sectors within Wellington City TA, excluding rail services as these do not change between options and will dilute any changes between options.

Table 9.24 Change in Vehicle Kilometres Travelled between Options

	AM peak			
	Veh Km	Change in Vehicle Km Travelled		
Sector	Ref	BP	BRT	LRT
Miramar	226	0	15	5
Kilbirnie	153	0	-13	-4
Mt Vic /Hataitai	128	0	-18	-25
Island Bay	153	0	19	-1
Newtown	106	0	-8	-11
CBD	942	0	-81	-107
Rest of Wellington	1,686	0	10	-2
Total	**3,393**	**0**	**-76**	**-144**

AM peak vehicle kilometres travelled show a slight reduction between reference case and BRT/ LRT options as normal bus services are truncated at interchange locations, being replaced along the core spine by BRT and LRT vehicles providing greater capacity but a marginally lower service frequency.

Table 9.25 presents the average passenger load by vehicle for all options.

Table 9.25 Change in Average Passenger Load per Vehicle, by Sector

	AM peak			
	Pax Load	Change in Average Load		
	Ref	BP	BRT	LRT
Miramar	13.9	0.5	-0.7	-1.5
Kilbirnie	20.2	0.8	7.1	2.9
Mt Vic /Hataitai	26.1	0.6	1.6	0.9
Island Bay	13.5	0.3	-0.7	-1.0
Newtown	42.6	2.6	-0.5	-4.3
CBD	66.7	1.3	12.0	12.7
Rest of Wellington	71.6	0.1	0.4	1.0
Total	**58.9**	**0.6**	**3.3**	**3.7**

It shows that the average load increases by upto 3 passengers in the BP option due to increases patronage and no change in capacity resulting in an increase in average load.

In the BRT option, average loads increase by 12 persons in the CBD and 7 passengers in Kilbirnie, whilst they decrease slightly in Miramar (-0.7), Island

Bay (-1) and Newtown (-1). The increase is due to larger vehicles operating at lower frequencies through the CBD, whilst the decrease is due to the increased frequencies provided by feeder services in the outlying suburbs resulting in slight decreases in average passenger load factors.

In the LRT option, average loads increase by 13 passengers in the CBD, again due larger but less frequent vehicles, whilst decreases in Miramar (-2), Island Bay (-1.0) and Newtown (-4) are due to increased service frequencies in these areas.

9.18 Highway Indicators (WTM 2009)

AM peak hour (8am to 9am), WTM. Read with Appendix 9.3.

The highway impacts of the BRT and LRT PTSS options is briefly assessed below using the following indicators from WTM.

- flow change plots – showing where traffic flows increase / decrease;
- capacity change plots – showing where capacities increase / decrease;
- delay change plots – showing where delays have increased and decreased; and
- V/C plots – shows links where the link volume / capacity ratio, an indicator for congestion, is over 85% (and agreed threshold).

Figures 9.9 to 9.12 below show flow, capacity, delay and V/C indicators for the AM peak 2031 scenario looking at Wellington CBD, with further plots covering other time periods and the wider network contained in **Appendix 9 – WTM Highway Indicators.**

The quantitative assessment of highway benefits is undertaken in WTSM and feeds into the final benefits calculations. The purpose of this qualitative assessment is to describe how the BRT and LRT options affect traffic volumes, capacities, delays and volume / capacity ratios in the vicinity of the scheme.

Figure 9.9 –Change in Highway Capacity, AM peak, 2031

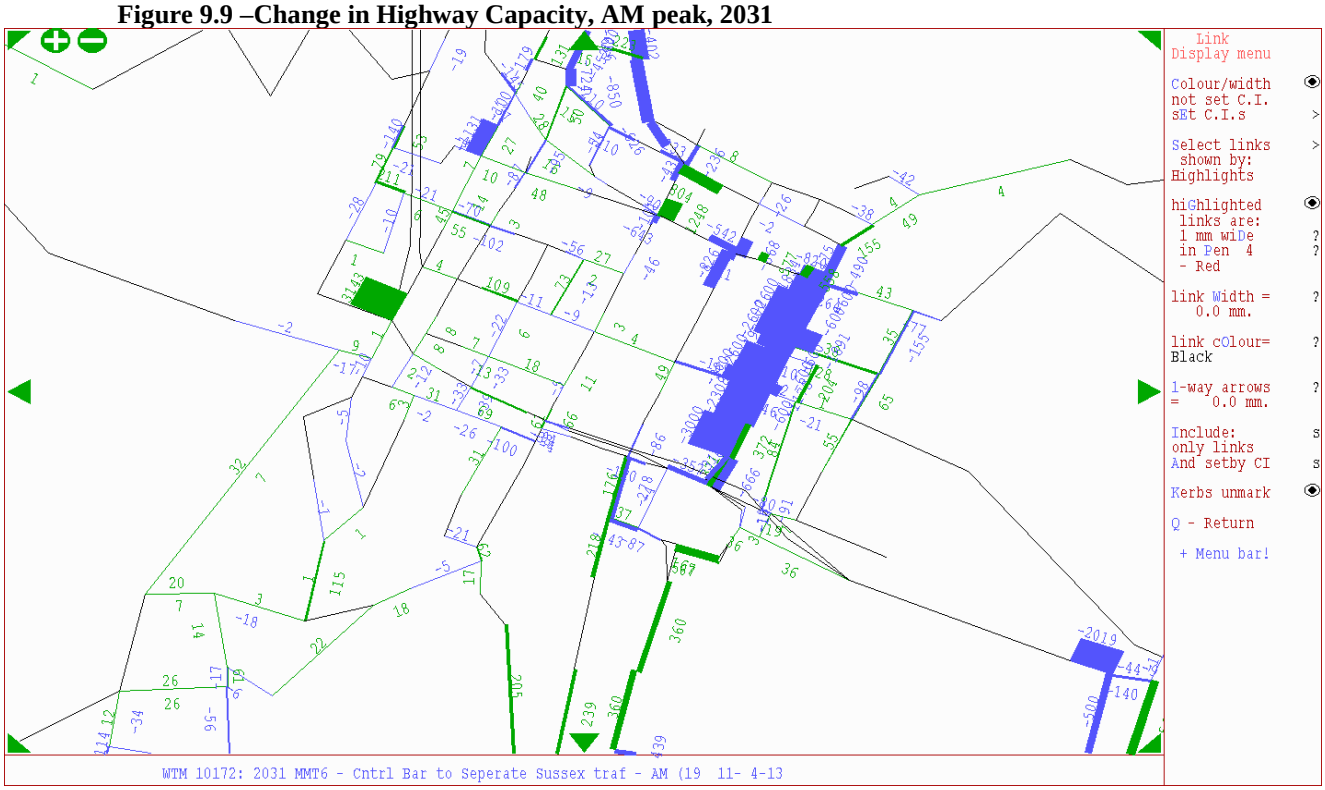


Figure 9.9 shows:

- capacity is reduced along Riddiford Road as one lane in each direction removed to accommodate the segregated rapid transit corridor;
- Wellington Road and along Ruahine Street has 2 traffic lanes in both direction for general traffic along SH1 which is consistent with NZTA's latest scheme design for the Ruahine Street upgrade to accommodate the segregated rapid transit corridor. ;
- two lanes are removed from Cambridge/ Kent Terrace reducing capacity along this stretch of road;
- small decreases in capacities occur along Featherston Street and Customhouse / Jervois Quay as bus lanes and signal priority are introduced along the secondary spine; and
- 50% of capacity along Lambton Quay is lost as general traffic is moved to the eastern side of the current central reserve.

Figure 9.10 –Change in Traffic Volumes, AM peak, 2031

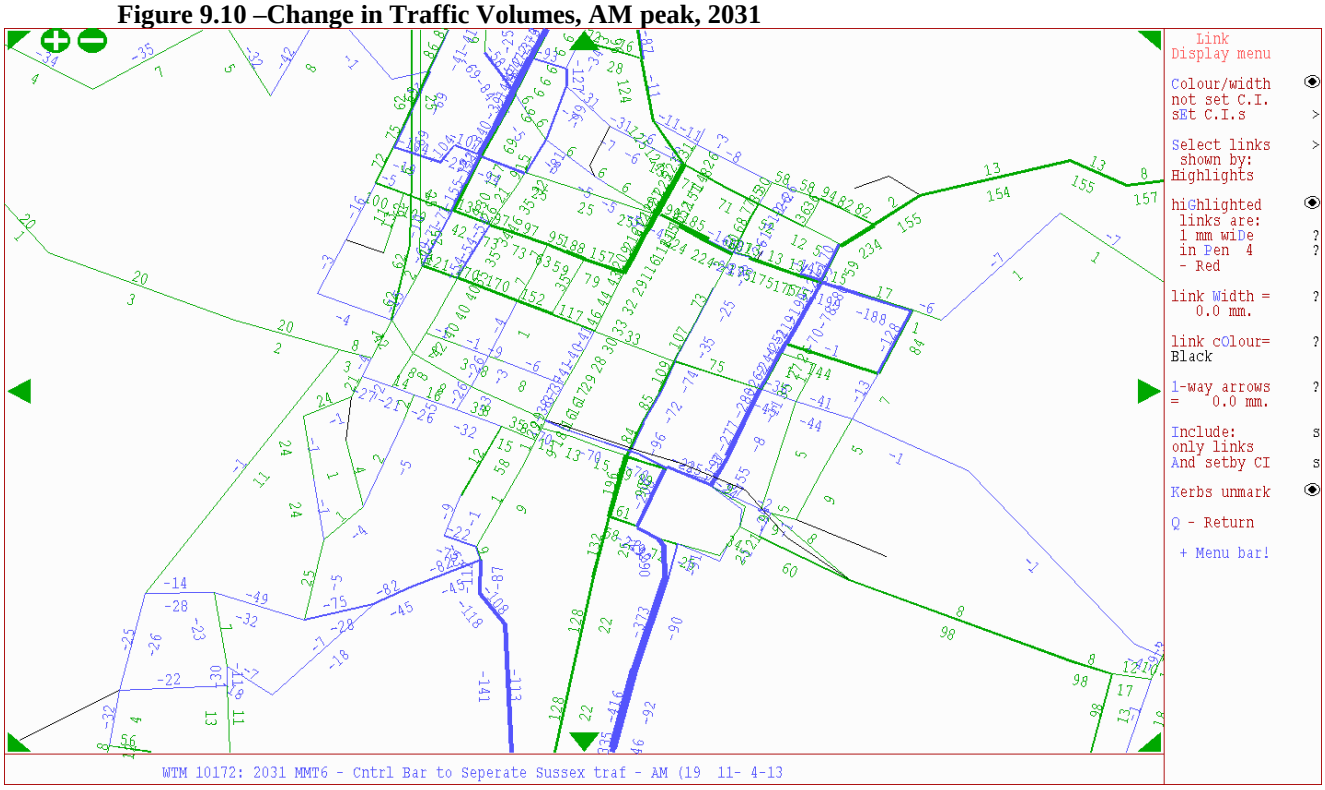


Figure 9.10 shows:

- a decrease in traffic volumes through Newtown of between 300 and 500 vehicles per hour due to reduced capacity for general traffic at the John St / Adelaide Rd, Riddiford Rd / Rintoul Rd and Constable St / Riddiford Rd intersection;
- a consequent reduction in traffic volumes of between 300 and 400 vph along Adelaide Road;
- a reduction in traffic volumes along Cambridge / Kent terrace of around 300 vph, due to upstream capacity reductions and fewer lanes along Cambridge/ Kent Terrace;
- increased traffic flows on Ghuznee / Taranaki Street, as vehicles re-route due to the closure of Willis Street to general traffic; and
- decreases in traffic volume of around 300 vph along Willis Street and Lambton Quay due to the closure of Willis Street and knock-on effect that this has along Lambton Quay.

Figure 9.11 –Change in Delays, AM peak, 2031

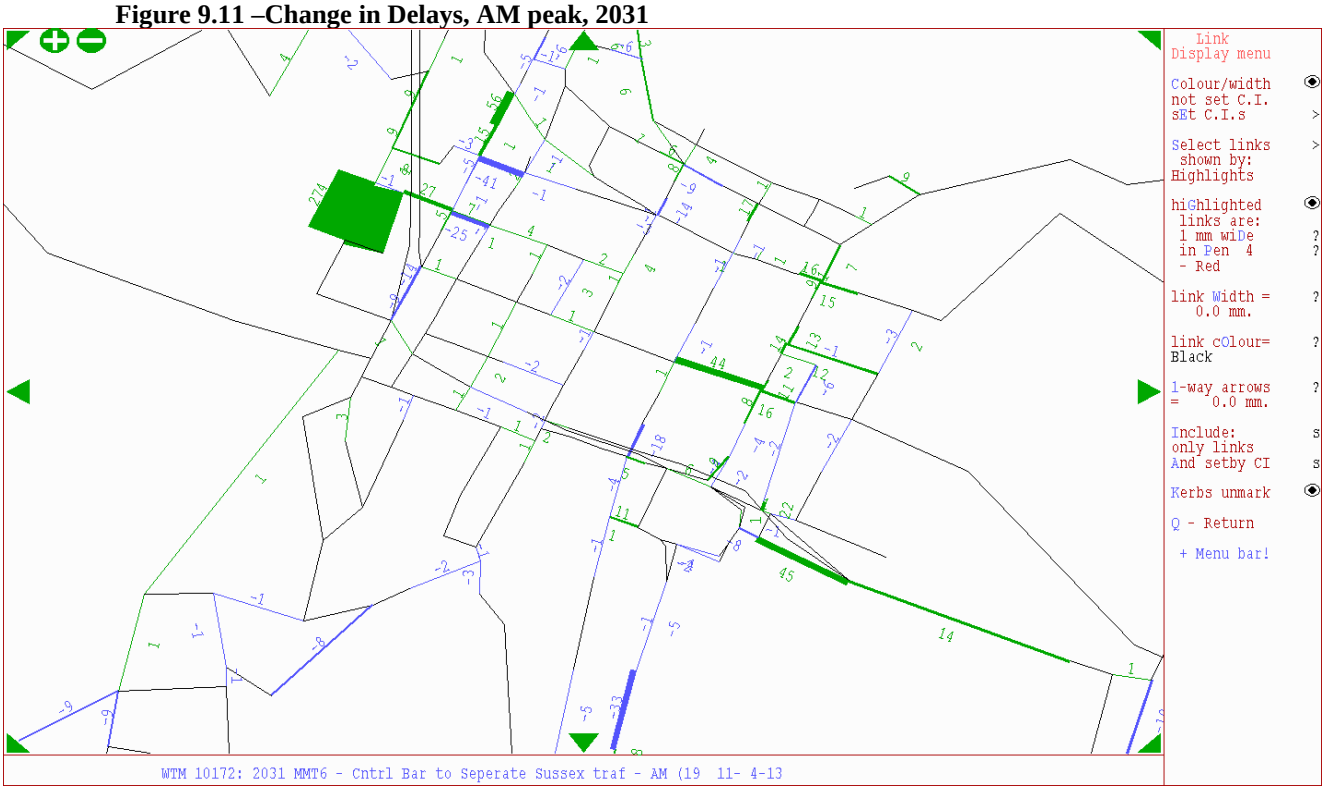


Figure 9.11 shows:

- an increase in delays on the northbound approach to the Adelaide Rd/ John Street and Riddiford Rd/ Rintoul Rd intersections as a result of a decrease in capacity at these intersections;
- minimal increases in delays along SH1 between Kilbirnie Crescent and the Basin Reserve;
- an increase in delay on the Vivian Street (SH1) approach to Cambridge Terrace, as the amount of signal green time for general traffic is reduced for all approach arms to this intersection as a result of priority being given to rapid transit. This Vivian Street approach is currently capacity in both 2011 and the 2031 reference case – therefore any reduction in green time will result in an increase in delays;
- small increases in delays at other intersections along Cambridge/ Kent Terrace, again due to additional priority being given to rapid transit vehicles at these locations; and
- small increases in delays for vehicles travelling along Featherston Street and Lambton Quay.

Figure 9.12 –Change in VC Ratio, AM peak, 2031

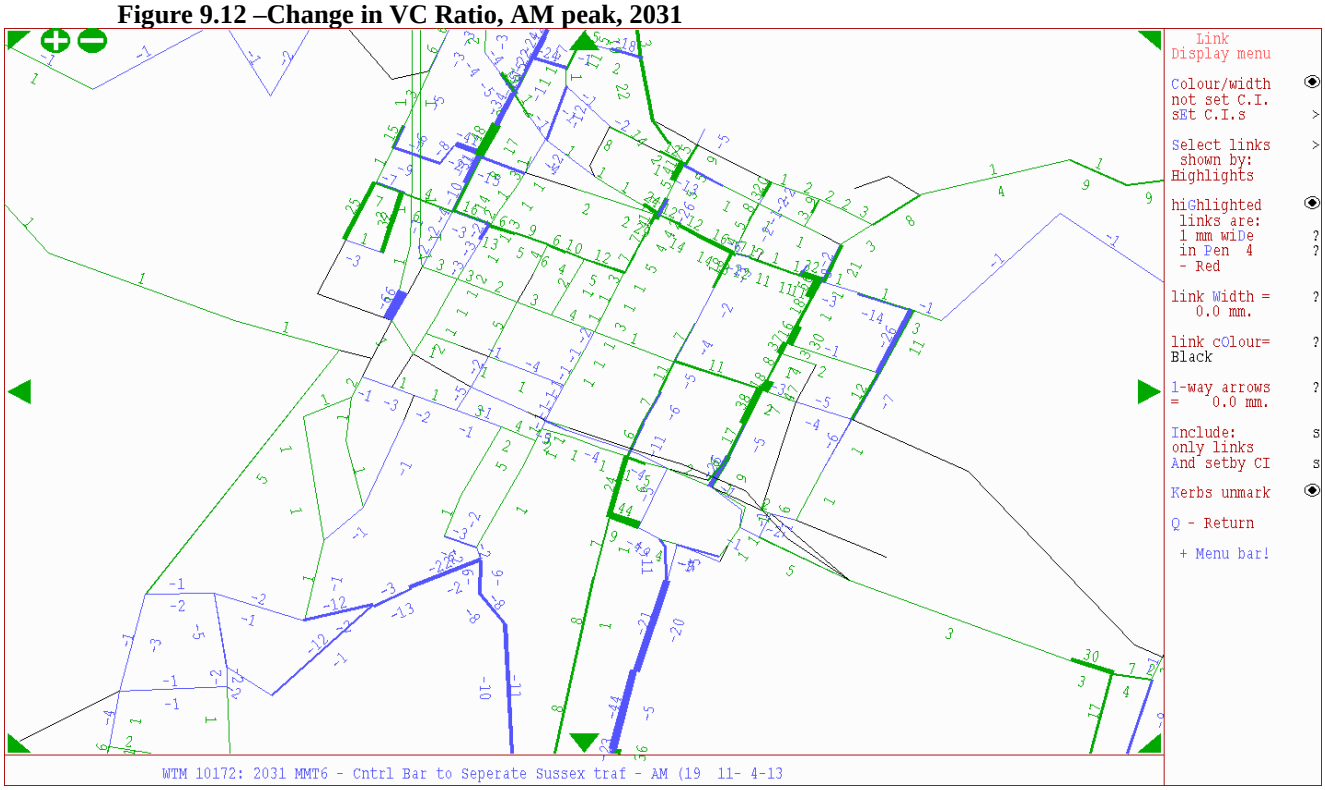


Figure 9.12 shows:

- increases in VC ratios along SH1 between Kilbirnie Crescent and Mt Vic Tunnel (although the actual VC ratios are still around 60-70%, indicating that adequate spare capacity still exists);
- increases in VC ratios on the approaches to Rintoul Rd/ Riddiford Rd and Adelaide Rd/ John Street intersections;
- the decrease in VC ratios on links in the Newtown area is a little misleading as it is due to reduced traffic volumes caused by reduced capacities at intersections within the area;
- increases in VC ratios along Cambridge/ Kent Terrace due to reduced signal green times and capacities at these intersections; and
- small increases in VC ratios along Featherston Street and Customhouse Quay due to reductions in capacities associated with the implementation of the secondary spine.

9.19 Summary

The information presented in this Chapter and the supporting appendices has been used to demonstrate the impact of the various PTSS options using a number of key indicators. The conclusions can be summarised as follows:

Change in demand and travel times between 2011 and 2031

- **growth in car trips** between 2011 to 2031 (18%) is predicted to be **greater than the growth in PT trips** (15%);
- **PT mode share remains relatively unchanged** between 2011 and 2031;
- PT growth is focussed on the northern, southern and eastern suburbs of Wellington; and
- highway travel times decrease between 2011 and 2031 whilst PT travel times generally remain flat.

Option Travel Times

- **car travel times show little variation between options**;
- **PT travel times** from selected origin zones in the study area to Wellington CBD **improve by up to 11 minutes** in the BRT and LRT options;
- PT travel times from **Miramar / Island Bay to Wellington CBD in the LRT option are 6 minutes worse than in the BRT option** due to time penalties associated with interchanging between bus and LRT at Kilbirnie/ Newtown;
- the **improvement in travel times from Kilbirnie (11 minutes) and Newtown (7 minutes)** to Wellington Station is the same for both the BRT and LRT options; and
- travel times along the **Golden Mile improve by up to 3 minutes** in all options.

PT Demand, Car Demand and Mode Share

- **the BP option results in a 4% to 5% increase** in PT demand from the study area;
- the **BRT option results in an 8% to 12% increase** in PT demand from the study area;
- the **LRT option** results in increases in demand from Kilbirnie/ Newtown but **slight decreases from Miramar and Island Bay**;
- areas that see the greatest increase in PT demand also see the greatest decrease in car demand as people change modes; and

- **PT mode share from the study area increases** by around 1% to 2% in the BP option, 3% to 4% in the BRT option and an average of 2% in the LRT option.

PT Patronage

- patronage **increases slightly in BP option**;
- an increase **in patronage of 400 is generated through Mt Vic Tunnel in the BRT option**;
- patronage does not increase between Newtown and Courtenay Place in the LRT and BRT options as any new trips are balanced by passengers shifting to the new Kilbirnie to CBD route via Mt Victoria; and
- **500 additional northbound PT trips are generated along the Golden Mile** in the **BRT option** (LRT = 300).

PT Capacity

- BP – no change
- **BRT – increase in capacity between Island Bay and Courtenay Place,** no change between Kilbirnie and Courtenay Place;
- **BRT – reduction in available capacity along Golden Mile**; and
- **LRT – large increase in capacity across the whole LRT network**. Increases in capacities for feeder services linking into Kilbirnie and Newtown interchanges.

PT Spare Capacity

- **BP – slight decrease, due to increased patronage**;
- **BRT - reduction in spare capacity from Kilbirnie via Mt Victoria** and also the Golden Mile; and
- **Increase in spare capacity** along all corridors in the **LRT option.**

PT Volume / Capacity Ratios

- **BRT VC ratios increase along the Golden Mile and through Mt Vic tunnel**;
- **A mismatch between BRT supply and demand exists at peak times**. This could be remedied by increasing frequencies on the Kilbirnie Branch and decreased on the Island Bay branch;
- **LRT VC ratios decrease due to additional capacity** provided by this option;

- Analysis of peak loadings show that the **BP and reference case operate at between 90% and 100% of capacity** at peak times;

- The **BRT operates at 155% of capacity through Mt Victoria tunnel** during the 'peak of the peak' whilst Adelaide Road operates at only 70% capacity; and

- The **LRT operates at capacity through Mt Victoria tunnel** during the 'peak of the peak' but is at only 50% capacity along Adelaide Road during the same period.

PT Boardings and Transfers

- the number of **boardings increase** slightly in the BRT option and **by a considerable amount in the LRT option**; and

- the **LRT** option requires around **90%** of persons currently travelling from Island Bay and Miramar to Wellington CBD to **interchange**.

Rail Egress Trips

- the number **persons transferring in the AM peak** from inbound rail services to an onward bus along the Golden Mile **increases from ~650 in 2011 to ~3,500 per hour as a result of integrated ticketing**;

- it is thought that WPTM is not adequately taking account of the inconvenience associated with interchanging between modes at the station – therefore **the figure of 3,500 is considered an over-estimate**; and

- the results do show, however, that the **BRT and LRT options result in a 15% and 20% increase respectively in the number of persons alighting from rail services** and travelling on PT to their final destination along the Golden Mile, due to increased travel times provided by BRT and LRT.

Through Trips

- None of the options result in any significant increase in the number of PT trips travelling through Wellington CBD.

Highway Capacity Changes

- highway **capacities** for general traffic have been **reduced** across the network **to accommodate segregated PT corridors and additional PT priority at signals**;

- **Riddiford Rd and Cambridge Terrace** show the **greatest reductions** in available capacity;

- **small capacity reductions** are made along the alignment of the proposed **secondary spine** (Featherston Street and Customhouse Quay);

- **Willis Street is closed** to general traffic 7am to 7pm; and

- **Courtenay Place is closed** to general traffic during peak periods.

Impact of Highway Capacity Changes

- Reductions in capacities result in decreases in traffic volumes and increases in V/C ratios;

- whilst **delays do increase** along affected sections of highway, **they are not substantial and unrealistic** and **do not suggest that the network will become grid-locked** as a result of the proposed capacity reductions; and

- **some re-routing of traffic occurs** as a result of the closure of Willis Street, with traffic routing via Ghuznee Street, Taranaki Street and Customhouse Quay.

10. Evaluation of Public Transport and Highway Benefits

The previous chapter focussed on the major impacts of the PTSS options upon the transport network and people's journeys.

For a scheme to be progressed and financed a business case needs to be developed and the scheme justified in terms of the cost of construction and the benefits that it would provide to society.

In simple terms, the benefits of any scheme will largely come from the following sources:

- travel time savings for existing PT users;
- travel time savings for new PT users; and
- highway travel time savings due to decongestion benefits.

This chapter is structured as follows:

- a brief outline of the chosen approach for calculating PT benefits;
- average PT travel time savings per passengers are presented for the AM peak at a sectoral and zonal level, providing an indication of the magnitude and location of benefits;
- sectored PT travel time benefits are presented by individual journey component for the AM peak, giving an indication of which components provide the greatest level of benefits for each option; and
- average highway travel time savings per vehicle and sectored highway benefits are presented for the AM peak to show the magnitude of the highway benefits and how they are spread across the region.

A full economic appraisal of the various options has been undertaken by AECOM in accordance with EEM guidelines and is reported in the Option Evaluation Report. This section takes that work and presents it in a format such that readers can easily grasp the geographic location and scale of benefits across all three options.

10.1 Appraisal Approach

As mentioned in Chapter 8, the model itself uses perceived travel times to represent certain components of a PT journey.

The EEM contains guidelines covering the economic appraisal of PT and Highway schemes to ensure consistency and comparability between schemes.

It states that 'actual' not 'perceived' times should be used for the appraisal process. The only exception to this is the application of a 5 minute transfer 'penalty' each time someone transfers between services to reflect the inconvenience that this causes.

Therefore the following actual time components of a PT journey are used to calculate the total travel time and, when comparing the option with the reference case, any travel time benefits:

- walk time – to / from PT stop;
- wait time – 0.5 * service headway for headway up to 15min, then 0.22 * additional time above 15min;
- in-vehicle time – actual time spent onboard PT service; and
- transfer penalty – 5 minutes (where applicable).

A more detailed description of the methodology is contained in the Option Evaluation Report, together with a range of BCR values that are calculated using the EEM methodology and an alternative behavioural approach to determine how changing the assessment approach might change the BCR.

All analysis reported in this chapter is for the 2031 AM peak period (7am to 9am) and uses this EEM approach. High-level comparisons between the EEM approach and an alternative 'behavioural' approach that uses perceived rather than actual time for walking, waiting and in-vehicle time and different penalties for boarding / transferring is included in the Option Evaluation Report.

10.2 Average PT Travel Time Saving per Passenger

Table 10.1 shows the average time saving per person by origin sector for trips to Wellington CBD in the AM peak. It is calculated by dividing the total time benefits by the total demand for each sector.

Table 10.1 – Average Time Savings per Passengers, AM peak, 2031, Trips to CBD

	Average Time Savings Per Passenger		
Origin Sector	**BP**	**BRT**	**LRT**
Miramar	1.9	8.1	2.2
KB Lyall Bay	2.1	9.2	8.2
Mt Vic Hataitai	1.4	4.9	4.4
Island Bay Berhampore	2.2	5.5	-0.6
Newtown	1.9	6.2	5.5
CBD	0.6	1.0	1.0
Rest of Wellington	1.1	0.8	0.5
Rest of Region	0.2	0.1	0.2
Total	**0.8**	**1.7**	**1.0**

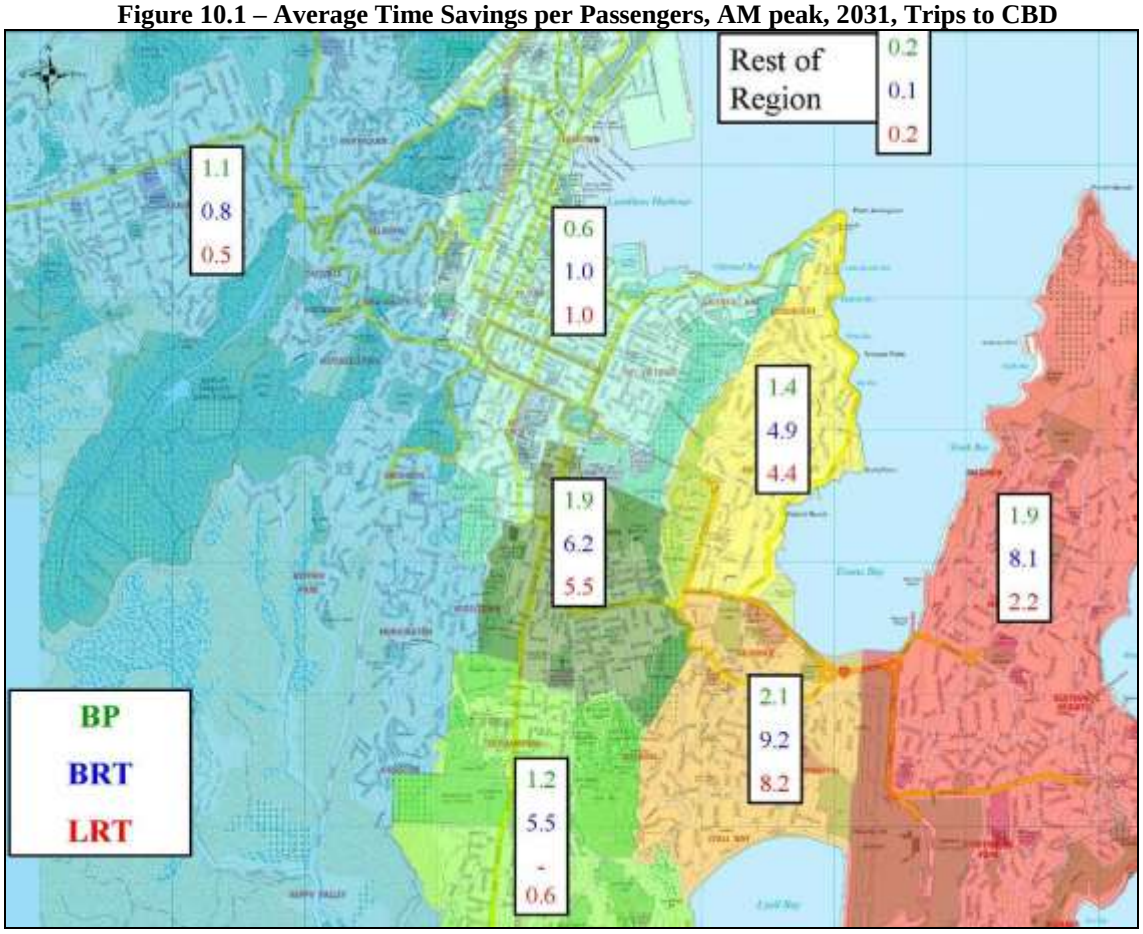
It shows that the study area as a whole experiences an approximate 1 to 2 minute improvement in travel time as a result of the BP option.

For the BRT option, the average passenger from Miramar and Kilbirnie experiences 8 to 9 minutes of travel time savings, whilst persons travelling from Mt Victoria, Newtown and Island Bay experience 5 to 6 minutes of travel time savings.

The main difference between the BRT and LRT option is that travel time savings from Miramar and Island Bay into Wellington CBD under the BRT option disappear in the LRT option, due to the 5 minute transfer penalty that will affect the majority of people coming in from these areas.

Figure 10.1 below shows the average time saving per person for trips into the CBD for all three options.

Figure 10.1 – Average Time Savings per Passengers, AM peak, 2031, Trips to CBD



10.3 Sectored PT Travel Time Benefits

This section presents time benefits for each option, by journey component – walk time, wait time, in-vehicle time and transfer 'time'. As PT fares remain constant between options, the fare benefits are minimal and have been ignored for this analysis.

GIS plots showing travel time benefits by origin zone for the four components of time (wait, walk, in-vehicle, transfer) plus total time are presented in Appendix 10.1 for all three options.

All values relate to a 2031 AM peak 2hr modelled time period (7am to 9am) and, where applicable, an average Inter-peak 2hr period between 9am and 3pm.

For each component of a typical journey the absolute value of time benefits is presented, together with the percentage of total benefits by origin sector, to give an idea of the spatial variation in time benefits.

10.3.1 Walk Time Benefits

Read with Appendix 10.1, Figures 10.1.1 to 10.1.3

Walk time is time spent:

- walking from your initial origin (e.g. home) to the point where you board public transport;
- walking from your final alighting point to your final destination (e.g. work); and
- any walking required when transferring between services.

In reality, most transfers occur at the dedicated interchanges location i.e. Kilbirnie Interchange, Newtown, and Wellington Station, where they do not involve walking between services.

Table 10.2 below shows walk time benefits by origin sector.

Table 10.2 – Walk Time Benefits by Origin Sector, AM peak, 2031

	BP - Benefits	% of Total BP Benefits	BRT - Benefits	% of Total BRT Benefits	LRT - Benefits	% of Total LRT Benefits
Miramar	69	3%	-1,982	25%	59	-1%
Kilbirnie	55	2%	-630	8%	-845	16%
Mt Vic /Hataitai	6	0%	-3,228	41%	-3,229	61%
Island Bay	39	2%	58	-1%	-114	2%
Newtown	168	7%	-1,879	24%	-3,078	58%
CBD	550	24%	-1,705	22%	-1,906	36%
Rest of Wellington	1,365	59%	-234	3%	980	-19%
Rest of Region	46	2%	1,731	-22%	2,851	-54%
Total	**2,300**	**100%**	**-7,868**	**100%**	**-5,283**	**100%**

Table 10.3 shows that:

- the BP option results in small walk time benefits, mostly associated with trips from the rest of Wellington in the AM peak;

- the BRT option results in walk dis-benefits across the study area, as passengers need to walk further to access the new BRT services to Wellington CBD; and

- the LRT option shows a very similar pattern to that observed for the BRT option.

10.3.2 Wait Time Benefits

Read with Appendix 10.1, Figures 10.1.4 to 10.1.6

Wait time is the total time spent waiting for first and subsequent PT services. In WPTM the wait time is calculated by taking half of the service headway for a particular route with headway up to 15min, and then a fraction of the additional time for headway higher than 15min.

Tables 10.3 below shows the wait time benefits by origin sector:

Table 10.3 – Wait Time Benefits by Origin Sector, AM peak, 2031

	BP - Benefits	% of Total BP Benefits	BRT - Benefits	% of Total BRT Benefits	LRT - Benefits	% of Total LRT Benefits
Miramar	8	1%	-30	-1%	-3,141	66%
Kilbirnie	13	1%	417	8%	-96	2%
Mt Vic /Hataitai	8	1%	467	8%	69	-1%
Island Bay	-16	-2%	1,159	21%	-1,575	33%
Newtown	-84	-8%	1,646	30%	1,035	-22%
CBD	155	15%	462	8%	153	-3%
Rest of Wellington	792	79%	1,304	24%	-447	9%
Rest of Region	131	13%	84	2%	-765	16%
Total	**1,006**	**100%**	**5,508**	**100%**	**-4,766**	**100%**

It shows that:

- the BP option has small wait time benefits, mostly accrued by persons whose trip originates in Wellington TA but outside of the PTSS study area;

- BRT wait time benefits are spread across three sectors – rest of Wellington, Newtown and Island Bay, the later two gain more frequent services as a result of the BRT option; and

- LRT wait time benefits are negative, with persons travelling from Miramar and Island Bay incurring the greatest negative benefits as they have to transfer between bus and LRT and therefore wait twice.

10.3.3 Transfer Time Benefits

Read with Appendix 10.1, Figures 10.1.7 to 10.1.9

Transfer 'time' is not an actual time but a notional time penalty applied every time someone transfers between services and reflects the perceived inconvenience of transferring.

The transfer penalty value used in the economic appraisal of 5 minutes comes from the EEM.

To calculate transfer benefits from WPTM, the number of transfers required for each journey is calculated and a 5 minute penalty applied if the value is greater than 1.0.

Tables 10.4 below shows the transfer time benefits by origin sector.

Table 10.4 – Transfer Time Benefits by Origin Sector, AM peak, 2031

	BP - Benefits	% of Total BP Benefits	BRT - Benefits	% of Total BRT Benefits	LRT - Benefits	% of Total LRT Benefits
Miramar	-6	-2%	229	-4%	-4,436	21%
Kilbirnie	-8	-2%	-785	12%	-1,167	6%
Mt Vic /Hataitai	-15	-4%	-332	5%	-372	2%
Island Bay	-1	0%	-538	8%	-4,788	23%
Newtown	-35	-8%	-208	3%	-165	1%
CBD	-146	-35%	-470	7%	-1,000	5%
Rest of Wellington	642	154%	-2,126	33%	-4,839	23%
Rest of Region	-12	-3%	-2,151	34%	-3,999	19%
Total	**418**	**100%**	**-6,383**	**100%**	**-20,766**	**100%**

It shows that:

- the BP option results in a very small number of transfer time benefits;
- BRT transfer time benefits are negative across the region and the study area, as more people have to transfer between services as a result of some bus routes being terminated and turned into feeder services for the BRT network; and
- LRT transfer time benefits are strongly negative, with most dis-benefits coming from Miramar and Island Bay (bus to LRT transfer now required when accessing the CBD) and Karori (Service 1 from Karori to Wellingon CBD now terminates at Wellington Station, requiring a transfer for onward travel into the CBD).

10.3.4 In-Vehicle Time Benefits

Read with Appendix 10.1, Figures 10.1.10 to 10.1.12

In-vehicle time is the actual time spent on a public transport vehicle. **Table 10.5** below shows the in-vehicle time benefits by origin sector.

Table 10.5 – In-Vehicle Time Benefits by Origin Sector, AM peak, 2031

	BP - Benefits	% of Total BP Benefits	BRT - Benefits	% of Total BRT Benefits	LRT - Benefits	% of Total LRT Benefits
Miramar	1,980	10%	11,111	19%	9,626	16%
Kilbirnie	1,910	10%	9,762	16%	9,868	16%
Mt Vic /Hataitai	1,229	6%	7,131	12%	7,163	12%
Island Bay	2,299	12%	5,686	10%	5,834	9%
Newtown	2,145	11%	7,924	13%	8,366	14%
CBD	1,489	8%	6,541	11%	6,791	11%
Rest of Wellington	5,858	31%	8,120	14%	8,865	14%
Rest of Region	2,026	11%	3,475	6%	5,185	8%
Total	**18,935**	**100%**	**59,750**	**100%**	**61,697**	**100%**

All schemes and all sectors show in-vehicle time benefits:

- apart from the Rest of Wellington (31% of total IVT benefits), the benefits are spread evenly across all sectors in the BP option;
- LRT and BRT IVT benefits are three times greater than BP IVT benefits, with Miramar, Kilbirnie, Island Bay, Newton and Mt Vic seeing around 70% of total IVT benefits in both options; and
- As LRT and BRT travel times are broadly identical then it is reasonable that the in-vehicle time benefits are also similar.

10.3.5 Total Travel Time Benefits

Read with Appendix 10.1, Figures 10.1.13 to 10.1.15

The total travel time benefits are an aggregation of the benefits from the individual components:

- walk time;
- wait time;
- transfers; and
- in-vehicle time.

Tables 10.6 shows the total time benefits by origin sector:

Table 10.6 – Total Time Benefits by Origin Sector, AM peak, 2031

	BP - Benefits	% of Total BP Benefits	BRT - Benefits	% of Total BRT Benefits	LRT - Benefits	% of Total LRT Benefits
Miramar	2,051	9%	9,327	18%	2,108	7%
Kilbirnie	1,970	9%	8,764	17%	7,760	25%
Mt Vic /Hataitai	1,228	5%	4,037	8%	3,631	12%
Island Bay	2,321	10%	6,365	12%	-643	-2%
Newtown	2,193	10%	7,483	15%	6,157	20%
CBD	2,048	9%	4,829	9%	4,038	13%
Rest of Wellington	8,657	38%	7,063	14%	4,559	15%
Rest of Region	2,191	10%	3,138	6%	3,272	11%
Total	**22,659**	**100%**	**51,007**	**100%**	**30,881**	**100%**

Table 10.6 shows that:

- when the individual components are combined, the BRT benefits are twice as high as the LRT and BP benefits;
- the majority (38%) of BP benefits are accrued by users originating from RoW. The remaining benefits are split evenly between the other sectors;
- Miramar, Kilbirnie, Island Bay and Newtown account for over 60% of total BRT benefits. All sectors benefit from the BRT scheme; and
- Kilbirnie and Newtown are the major beneficiaries from the LRT option in terms of benefits, followed by the CBD and rest of Wellington TA. Few benefits are accrued by passengers originating from Miramar and passengers originating from Island Bay actually see a small level of dis-benefits.

10.4 Sectored Highway Travel Time Benefits

This section shows the average travel time saving per vehicle for trips heading into Wellington CBD in the 2031 AM peak.

Table 10.7 shows that average travel times for vehicle trips into the CBD increase in all options relative to the reference case, the only exception being trips between Miramar and Wellington CBD in the BP and BRT options where travel times decrease slightly.

Highway travel time benefits (or dis-benefits) come from a combination of decongestion benefits due to fewer car trips (these trips are now made by PT) balanced by vehicles experiencing increased congestion due to highway capacity reductions associated with each option.

For the PTSS, increased congestion as a result of capacity reductions appears to outweigh any decongestion benefits from mode switching. As the LRT option has a lower mode shift from car to PT compared to the BRT option but a similar reduction in highway capacity, the average time dis-benefits per vehicle are greater.

The average increase in travel time is in all instances less than one minute. To place this in context, BRT and LRT users experience a decrease in travel times of between 5 and 12 minutes for trips to the CBD.

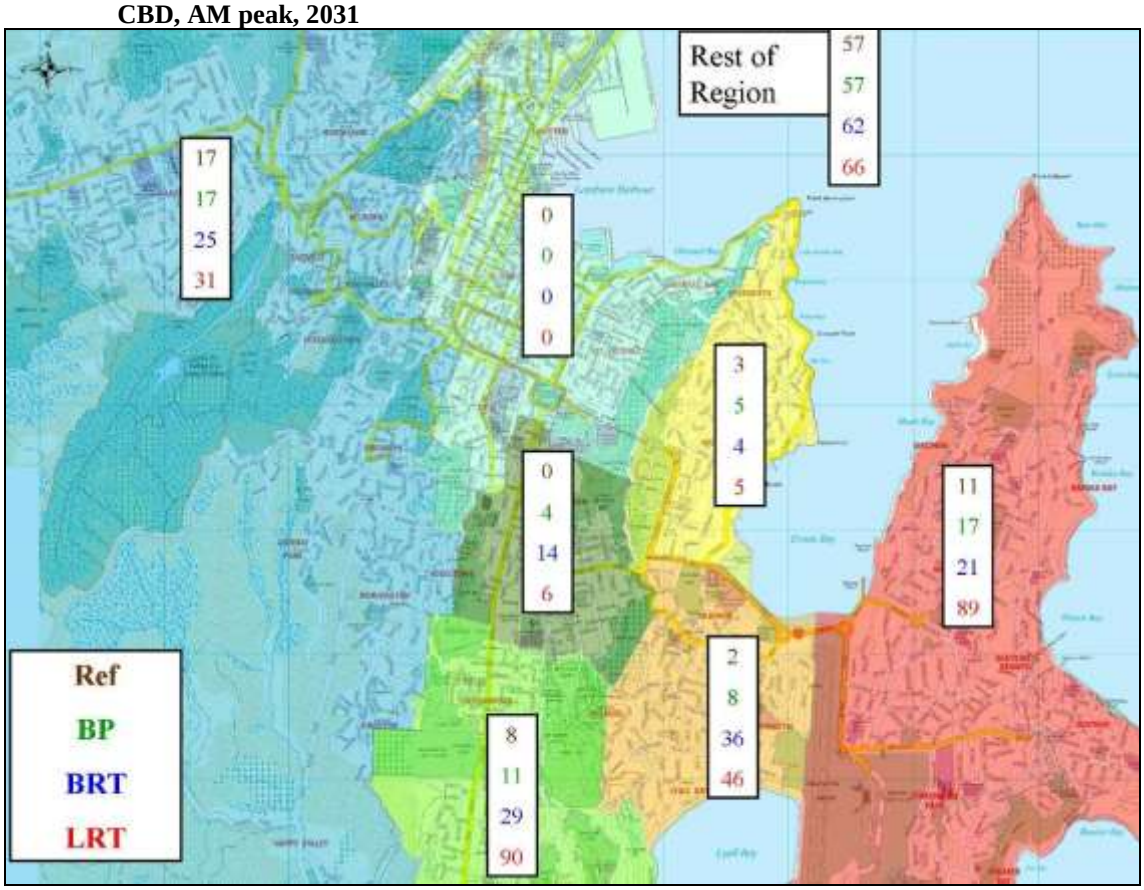
A one minute increase in vehicle travel time will likely be imperceptible to most people and is within the range of daily variability in travel times.

Table 10.7 – Average Time Saving per Vehicle for Trips heading to the CBD, AM peak, 2031

		Time Saving per Person to Access CBD (seconds)		
Origin Sector	**Demand to CBD**	**BP**	**BRT**	**LRT**
Miramar	1,756	- 5	- 31	37
KB Lyall Bay	1,231	46	17	30
Mt Vic Hataitai	1,591	1	10	15
Island Bay Berhampore	1,502	10	28	43
Newtown	1,788	23	47	54
CBD	17,288	16	21	23
Rest of Wellington	11,597	25	28	35
Rest of Region	8,084	14	10	15
Total	**44,838**	**18**	**18**	**27**

Figure 10.2 below shows the average time saving per vehicle for trips to the CBD in the AM peak (presented in Table 10.7 above) in a graphical format.

Figure 10.2 – Average Time Saving per Vehicle (in seconds) for Trips heading to the CBD, AM peak, 2031



10.5 Summary

- the average **BP and LRT user gains a 1 minute travel time saving** in the AM peak. This figure is nearer **2 minutes for the BRT** option;
- the **average travel time saving per passenger is between 6 and 9 minutes** for passenger originating from the study area in the **BRT** option, around **twice as high as similar figures from the LRT** option;
- **walk time benefits are slightly negative** for the **BRT and LRT** options, as people have to walk further to access services;
- **wait time benefits are positive for the BRT**, due to enhanced service frequencies, but **negative for the LRT due to additional waiting time required** when transferring at Kilbirnie and Newtown;
- **transfer time benefits are slightly negative for the BRT** and **largely negative for the LRT option**, again due to the additional transfers required;
- **BRT and LRT in-vehicle time savings** in the AM peak are **identical**;
- overall, BRT total time savings are twice as great as BP and LRT travel time savings;

- the **eastern branch from Kilbirnie/ Miramar have twice as many time benefits as the southern branch in both the BRT and LRT options**;
- **highway travel time savings are negative** i.e. times increase as a result of the scheme; and
- the **increases in highway travel times are small across all sectors** (less than 1 minute for the average trip).

11. Sensitivity Tests

The core tests were reported in detail, covering patronage, travel time savings and, ultimately, the level of benefits that each scheme provides.

Underpinning these tests are a series of assumptions that are either inherent to the WTSM/ WPTM modelling system or have been assumed for the PTSS model testing. Whilst all of these assumptions are grounded either in international research or work undertaken specifically for this project, it is necessary to estimate the impact that changing some of these assumptions would have on the model results and the PTSS schemes performance.

For the sensitivity testing, several assumptions were modified, the model was run for a 2031 AM peak scenario and the impact on patronage, mode share and benefits was assessed and compared against the core model runs.

Five sensitivity tests were undertaken:

- CBD parking charge increase;
- non inclusion of some of the RoNS (Roads of National Significance);
- PT fares increase/ decrease (+/-30%);
- transfer penalty doubled / removed at main PTSS interchanges; and
- no road capacity reduction along the PTSS corridors.

All tests were all run using WTSM as it is the model that drives change in PT patronage and in mode share.

However, the two first tests (parking charge increase and RoNS) are not merely about varying model parameters but actually about analysing the impact of policy levers and road infrastructure investments on the PTSS schemes performance. As a result, these were also run in WPTM to estimate their detailed impact on patronage and on the overall benefits brought by the schemes.

11.1 WTSM Sensitivity Tests

The following tables show the results of the sensitivity tests in WTSM. For clarity and to reduce the quantity of data presented, only high level indicators have been reported for BRT and LRT scenarios in the AM peak (BP results are in actual fact very similar to the reference case)

The tables show the indicators value in the reference case and how they change with the BRT or LRT in place, for both the Base runs and the Sensitivity Tests. The relative difference between Base and Sensitivity Tests is also shown for all scenarios.

11.1.1 Sensitivity to Parking Charge Increase

It was assumed that due to future parking constraints, the number of commuters driving to the CBD would stay constant between 2011 and 2031.

Whilst not an entirely realistic forecast, it does mean that we can assess the impact of parking charges on mode share to the CBD in relative simple way.

The resulting increase in the parking charge within WTSM necessary to keep the number of commuting car trips to the CBD constant was found to be a 14% increase (on top of the existing GDP linked increase in parking price between 2011 and 2031 that is applied in the model).

Table 11.1 below shows the results of this parking cost increase. The main impact is that the PT mode share to the CBD increases for the reference case, BRT and LRT, increasing from 33% (base) to 35.4% (sensitivity). This equates to an additional 1,300 PT trips to Wellington CBD in the AM peak. As a consequence, the number of car-kilometres travelled also decreases.

When comparing the reference case and BRT / LRT options, however, the differences are very similar for both the base and sensitivity tests. The relative performance of the BRT and LRT schemes do not change depending on whether the base or sensitivity test parking assumptions are used.

Table 11.1 – Parking Charge Sensitivity Test, AM peak, 2031

	Base			Sensitivity Tests			*Diff. Test/Base*		
	Ref	**BRT**	**LRT**	**Ref**	**BRT**	**LRT**	***Ref***	***BRT***	***LRT***
PT Trips	33,956	+2.5%	+1.0%	35,282	+2.3%	+0.9%	*4%*	*4%*	*4%*
PT share to CBD	33.0%	+3.5%	+0.8%	35.4%	+3.0%	+0.6%	*7%*	*7%*	*7%*
Car-kms	1,550,428	-0.3%	+0.1%	1,539,505	+0.2%	0.0%	*-1%*	*0%*	*-1%*

11.1.2 Sensitivity to RoNS

The purpose of this test was to estimate how the PTSS schemes would perform without some of the RoNS schemes in place. For this purpose the Mt Victoria tunnel, Ruahine Street duplication and the Petone to Grenada schemes were not included in the 2031 networks.

Table 11.2 below shows that this leads to a major increase in delay for car users for the reference case and the BRT/LRT options (+18 to 20%) and a corresponding increase in PT model share.

Removing selected RoNS schemes results in an additional 500 AM peak PT trips to Wellington CBD for the reference case and BRT / LRT options.

The differences between options, however, remains relatively unchanged between the base tests and sensitivity tests, showing that varying assumptions relating to which RoNS schemes are included does not materially affect the overall assessment of the PTSS options.

Table 11.2 – RoNS Sensitivity Test, AM peak, 2031

	Base			Sensitivity Tests			*Diff. Test/Base*		
	Ref	**BRT**	**LRT**	**Ref**	**BRT**	**LRT**	***Ref***	***BRT***	***LRT***
PT Trips	33,956	+2.5%	+1.0%	34,442	+2.4%	+0.9%	*1%*	*1%*	*1%*
PT share to CBD	33.0%	+3.5%	+0.8%	33.6%	+3.3%	+0.6%	*2%*	*2%*	*2%*
Car-kms	1,550,428	-0.3%	+0.1%	1,533,254	-0.1%	+0.0%	*-1%*	*-1%*	*-1%*
Veh-hour delay	6,610	-0.8%	+2.6%	7,845	+0.6%	+2.4%	*19%*	*20%*	*18%*

11.1.3 Sensitivity to Fare Increase

WTSM already assumes an increase in PT fares between 2011 and 2031. As this fare increase is linked to GDP it is important to assess how changing the fare increase impact on the model results.

Two tests were undertaken, with a 30% increase and decrease in PT fares respectively applied to all scenarios (including the reference case).

Results in **Table 11.3** below clearly illustrate that varying the PT fare impacts on the number of PT trips and, consequently, the PT mode share. A 30% increase results in a 5% decrease in PT trips, whilst a 30% decrease results in a 6% increase in trips.

Table 11.3 – PT Fare Increase Sensitivity Test, AM peak, 2031

	Base			Sensitivity Tests			*Diff. Test/Base*		
	Ref	**BRT**	**LRT**	**Ref**	**BRT**	**LRT**	***Ref***	***BRT***	***LRT***
	PT Fare +30%								
PT Trips	33,956	+2.5%	+1.0%	32,160	+2.5%	+0.9%	*-5%*	*-5%*	*-5%*
PT share to CBD	33.0%	+3.5%	+0.8%	31.9%	+3.7%	+0.9%	*-3%*	*-3%*	*-3%*
Car-kms	1,550,428	-0.3%	+0.1%	1,564,355	+0.2%	+0.6%	*1%*	*1%*	*1%*
Veh-hour delay	6,610	-0.8%	+2.6%	6,843	+1.7%	+6.0%	*4%*	*6%*	*7%*
	PT Fare -30%								
PT Trips	33,956	+2.5%	+1.0%	35,939	+2.3%	+0.8%	*6%*	*6%*	*6%*
PT share to CBD	33.0%	+3.5%	+0.8%	34.1%	+3.3%	+0.7%	*3%*	*3%*	*3%*
Car-kms	1,550,428	-0.3%	+0.1%	1,518,584	+0.3%	+0.8%	*-2%*	*-1%*	*-1%*
Veh-hour delay	6,610	-0.8%	+2.6%	6,104	+1.5%	+4.8%	*-8%*	*-6%*	*-6%*

The implied elasticity value is around -0.20, somewhat towards the lower end of standard elasticities that are used for the assessment of PT fare increases on patronage and revenue around the world.

A key point to make is that the fare changes do not result in changes in the relativities between schemes. Therefore whether the fare increase was higher

or lower than has been assumed would not affect the conclusions being drawn from the PTSS.

11.1.4 Sensitivity to Transfer Penalty

As explained in Chapter 8, passengers transferring between bus and BRT/ LRT experience a transfer penalty. In WTSM this penalty has been set to 2.5 minutes and represents the inconvenience of transferring between services (note: additional wait time due to transferring between services is not included in the 2.5 minutes).

It has been argued that this assumption can greatly impact on the desirability of the new modes, especially LRT where a significant amount of passengers need to transfer. For this reason, two tests were carried out for which the transfer penalty was first doubled to 5 minutes, and then discounted to 0.

The results in **Table 11.4** below show that if the transfer penalty is increased then the increase in PT trips to the CBD shows a slight fall in the BRT scenario (+2.5% in base, +2.0% in sensitivity) but a more pronounced fall in the LRT scenario (+1.0%, +0.3%).

Conversely, when the transfer penalty is removed, trips to the CDB in the BRT scenarios increase slightly (-2.5% in base, +3.1% in sensitivity) whilst in the LRT scenario the increase is more pronounced as more people transfer (+1.0%, 1.7%).

Even with a zero transfer penalty, the BRT scenario still results in a larger increase in trips to the CBD than the LRT scenario as additional waiting time at transfer locations will still be included in the ‘zero transfer penalty’ scenario.

Table 11.4 – Transfer Penalty Sensitivity Test, AM peak, 2031

	Base			Sensitivity Tests			*Diff. Test/Base*		
	Ref	**BRT**	**LRT**	**Ref**	**BRT**	**LRT**	***Ref***	***BRT***	***LRT***
	Transfer penalty x2								
PT Trips	33,956	+2.5%	+1.0%	33,956	+2.0%	+0.3%	*0%*	*0%*	*-1%*
PT share to CBD	33.0%	+3.5%	+0.8%	33.0%	+3.4%	+0.5%	*0%*	*0%*	*0%*
Car-kms	1,550,428	-0.3%	+0.1%	1,550,428	-0.2%	+0.4%	*0%*	*0%*	*0%*
Veh-hour delay	6,610	-0.8%	+2.6%	6,610	-0.3%	+4.5%	*0%*	*0%*	*2%*
Bus Boardings	24,305	-26.0%	-10.6%	24,305	-27.8%	-11.8%	*0%*	*-2%*	*-1%*
BRT Boardings	0	-	-	0	-	-	-	*-3%*	-
LRT Boardings	0	-	-	0	-	-	-	-	*-7%*
	Transfer penalty x0								
PT Trips	33,956	+2.5%	+1.0%	33,956	+3.1%	+1.7%	*0%*	*1%*	*1%*
PT share to CBD	33.0%	+3.5%	+0.8%	33.0%	+3.5%	+1.1%	*0%*	*0%*	*0%*
Car-kms	1,550,428	-0.3%	+0.1%	1,550,428	-0.5%	0.0%	*0%*	*0%*	*0%*
Veh-hour delay	6,610	-0.8%	+2.6%	6,610	-1.6%	+1.7%	*0%*	*-1%*	*-1%*
Bus Boardings	24,305	-26.0%	-10.6%	24,305	-23.5%	-6.5%	*0%*	*3%*	*5%*
BRT Boardings	0	-	-	0	-	-	-	*6%*	-
LRT Boardings	0	-	-	0	-	-	-	-	*8%*

11.1.5 Sensitivity to Road Capacity Reduction

The last test looks at varying assumptions relating to highway capacity that is taken away from general traffic and what impact this has upon highway delays and PT mode share.

For this test, the BRT and LRT road networks were kept identical to the reference case (i.e. no reduction in number of lanes and capacity), except for the sections of the Golden Mile which are closed to traffic. Whilst it is unlikely that no capacity reductions would need to be made to accommodate LRT and BRT, it was thought that an 'all-out' test would be the easiest way to assess how sensitive the model results are to changing the road capacity reduction assumptions.

Results presented in **Table 11.5** below indicate that this test leads to a decrease in the number of car drivers switching to PT with the BRT/LRT schemes in place. This is due to that fact that with no reduction in road capacity, there is less delay for car users and therefore less incentive to change modes.

The changes are relatively minor for both the BRT (+2.5% increase in trips to CBD in base, +2.2% in sensitivity) and the LRT (+1.0% in base, +0.6% in sensitivity) tests and do not affect the relative performance of both options.

Table 11.5 – Highway Capacity Reduction Sensitivity Test, AM peak, 2031

	Base			Sensitivity Tests			*Diff. Test/Base*		
	Ref	**BRT**	**LRT**	**Ref**	**BRT**	**LRT**	***Ref***	***BRT***	***LRT***
PT Trips	33,956	+2.5%	+1.0%	33,956	+2.2%	+0.6%	*0%*	*0%*	*0%*
PT share to CBD	33.0%	+3.5%	+0.8%	33.0%	+2.8%	+0.0%	*0%*	*-1%*	*-1%*
Car.kms	1,550,428	-0.3%	+0.1%	1,550,428	0.0%	+0.1%	*0%*	*0%*	*0%*
Veh-hour delay	6,610	-0.8%	+2.6%	6,610	-0.6%	+1.6%	*0%*	*0%*	*-1%*

11.2 WPTM Sensitivity Tests and Impact on Benefits

The first two tests (parking charge increase and non-inclusion of the RoNS) were then run in WPTM to estimate the impact of these measures on time benefits for PT users.

The results shown in this section show the perceived benefits (referred to in section 10) and not the benefits as calculated using EEM methodology. This approach was used to facilitate the comparison from a "modelling" oriented point of view, i.e. it shows the difference of benefits as perceived by PT users in the model, which allows for more consistency with the WTSM when assessing the results.

11.2.1 Sensitivity to Parking Charge Increase

Table 11.6 below shows that increasing the parking charge results in a 3% increase in annual benefits for both the BRT and LRT scenarios, mirroring the increase in patronage from WTSM.

Table 11.6 – Parking Charge Sensitivity Test Benefits, AM peak, 2031

Time Period	**Parking Charge Increase – Change in Annual Benefits**	
	Benefits (min)	**%**
AM peak	4%	4%
Inter Peak	3%	3%
Annual (000)	3%	3%

11.2.2 Sensitivity to RoNS

The effect of not including some of the RoNS (Mt Victoria tunnel and Ruahine St duplication, Petone to Grenada) is shown in the **Table 11.7** below. The impact is clearer in the AM peak, due to higher levels of traffic during this period. Without the increase of capacity brought by the RoNS, some car users shift to PT as shown in the WTSM test, and this translates into slightly higher benefits for PT users.

Table 11.7 – RoNS Sensitivity Test Benefits, AM peak, 2031

Time Period	Parking Charge Increase – Change in Annual Benefits	
	Benefits (min)	%
AM peak	3%	3%
Inter Peak	0%	0%
Annual (000)	1%	1%

11.3 Summary

The main findings from these sensitivity tests are the following:

- the **sensitivity of WTSM** to varying input parameters (e.g. parking costs, PT fare, etc) is **deemed reasonable** and is in line with standard range of elasticity for strategic models (see Technical Note 18 "WTSM Calibration and Validation" from the 2011 model update for more detail);

- the **impact of the sensitivity tests** on the PTSS schemes performance in terms of mode shift to PT generally ranges from **minor to moderate**, and in all cases **does not change the relative performance of the BRT and LRT options**; and

- when run in WPTM, **the impact of the two main tests** (parking charge and non-inclusion of the RoNS) **on time benefits to PT users is minor** and does not change the outcomes for both options.

12. Overall Summary

The purpose of this report has been to:

- outline the structure of the modelling system;
- document the results of a 2011 assessment and how the preferred LRT and BRT options have been developed;
- describe in detail the modelling assumptions and how they have been applied to the PTSS;
- present results of the core tests and evaluation of benefits; and
- briefly outline results from the sensitivity testing.

This chapter restates word for word the summaries presented at the end of each respective chapter and also concludes by presenting a brief paragraph summarising each of the options.

12.1 Chapter Summaries

12.1.1 Medium and Long List Summary

- the **long list evaluation considered 88 potential modal / alignment options**, selecting eight preferred options for the medium list;
- the **medium list considered these eight options** in more detail;
- the **medium list modelling assumptions** were fairly generic across all options, thus making it hard to differentiate between them;
- three central alignment options – **BP, BRT and LRT** – were selected from the medium list for **further consideration at the short list phase;** and
- **the short list modelling framework** was designed to provide sufficient detail to allow for differentiation between the options.

12.1.2 Modelling System

- the **modelling system consists of 3 models;**
- **WTM:**
  - Wellington Transport Model – a highway model of Wellington City, built to **assess the impact of highway schemes on the highway network;**
  - passes intersection data into WTSM.

- **WTSM:**
  - Wellington Transport Strategy Model - covers the whole region, uses land use and economic forecasts to generate estimates of trips. **The main model used to generate forecasts for the PTSS;**
  - provides inputs to WPTM;
  - used for the **assessment of PTSS highway impacts and benefits;**
- **WPTM:**
  - Wellington Public Transport Model – built from observed bus and rail data;
  - Used for the assessment of PT impacts and benefits for the PTSS.

12.1.3 Reporting Templates

- Two sector systems are used to present analysis in this report;
- A **six sector system** covering Wellington's suburbs and the rest of the region is used to present **high-level analysis**; and
- A **more detailed eight sector system** is used to look at how the impacts and effects of the options vary throughout the **study area** (defined as the southern and eastern suburbs of Wellington City TA).

12.1.4 2011 Assessment and Future Growth

- the AM peak region wide **PT mode share is 13%** in 2011
- the **PT mode share to Wellington CBD in 2011 is ~30%,** with the rest of the region having a higher PT mode share (40-50%) to the CBD than Wellington City TA (25-35%);
- the **PT mode share is lower in the inter-peak** compared with the AM peak;
- **PT demand is Wellington centric** – approximately 75% of PT trips in the AM peak terminate in Wellington CBD;
- **64,000 combined car and PT trips are made to Wellington CBD in the AM peak**, of which 21,000 are made by PT (these figures include trips where both the origin and destination is within Wellington CBD);
- **few through trips** are currently made by PT or by car in both the AM peak and Inter-peak;
- the **greatest differences between highway and PT travel times / speeds to Wellington CBD** are found for trips originating from the southern and eastern suburbs in the AM peak;

- **several corridors** have levels of demand that could potentially **support high quality public transport services;**
- **over 90% of rail passengers walk a short distance** from Wellington station to their final destination;
- relatively **few people currently connect from inbound rail services to onwards bus services at Wellington Rail Station;**
- the **heaviest bus boardings** in the AM peak occur in Karori, between Island Bay and Newtown, Kilbirnie, Miramar and in Hataitai;
- between 2011 and 2031, **PT and car trips to Wellington CBD are forecast to grow by 15% and 18% respectively in the AM peak;**
- between 2011 and 2031, the forecast growth in PT trips is only 3% in the inter-peak; and
- in both the AM peak and inter-peak the PT mode share does not really change between 2011 and 2031.

12.1.5 Long Route Assessment

Corridor Analysis

- a high quality transit corridor should provide a **high quality, high frequency, high capacity public transport** offering;
- service frequencies greater than **12-20 vph (dependent on vehicle capacity)** and patronage greater than **1,600 pax/ hr are guideline minimum requirements** for any such corridor;
- four possible corridors were identified within Wellington City TA - **Karori, Johnsonville, Island Bay / Newtown and Kilbirnie / Miramar**;
- **Karori** was ruled out due to **insufficient levels of demand**;
- **Johnsonville** was ruled out due to **the costs** involved with converting the current rail service to LRT and the **high current PT mode share** limiting opportunities for increasing PT mode share from the area;
- a **corridor to the south** (Island Bay/ Newtown) **and east** (Kilbirnie/ Miramar) of Wellington was chosen because:
  - potential **demand is high enough** to justify investigating BRT / LRT;
  - more people wanting to access the CBD live within 800m of this potential alignment than do so for any other potential corridor catchment;

- **PT travel times from these areas to the CBD are poor**, relative to car travel times;
- **the current mode share of between 25% - 30% is relatively low** and potential exists to improve this in the future;

LRT Route Definition

- analysis of current and potential travel times show that a high quality route between **Kilbirnie and Courtenay Place (via Mt Victoria tunnel) would provide a 6 minute improvement** over current travel times.
- a route between **Kilbirnie and Courtenay Place (via Constable Street and Newtown) would only provide a 3 minute improvement** on the current fastest travel time between these two points;
- **four potential LRT routes** were considered:
  - Kilbirnie to CBD via Mt Victoria tunnel;
  - Kilbirnie to CBD via Constable Street and Newtown;
  - Newtown to CBD;
  - Split route – Kilbirnie to CBD (via Mt Victoria tunnel) and Newtown to CBD;
- The **preferred option, a Y-shaped split route,** was chosen because:
  - A route between Kilbirnie and Wellington CBD via Constable Street and Newtown does not provide adequate travel time savings for passengers from Miramar compared with the alternative route via Mt Victoria tunnel;
  - A tunnel between Kilbirnie and Wellington Zoo was discounted, mainly on the ground of costs;
  - both the Island Bay / Newtown and Kilbirnie / Miramar catchments are large enough to justify a high quality transit service in their own right.
- single routes from **Newtown and Kilbirnie to Wellington CBD respectively would only benefit part of the combined catchment;**
- **combining the two single routes should optimise the benefits of any scheme;**
- a Y-shaped route will result in **very high frequencies along the core Golden Mile;**
- a Y-shaped route will provide **options for potential extensions** to the south and east at a later date; and

- a Y-shaped route is similar to and can **be directly compared against the BRT** option.

12.1.6 Short List Options – Infrastructure and Services

PT Infrastructure and Services

- **general traffic will be banned from the Golden Mile** in the BRT/ LRT options between 7am and 7pm, apart from the northern section of Lambton Quay where general traffic is to the east of the central reserve and Courtenay Place where general traffic is allowed on the southern side in the inter-peak;

- **Willis Street is closed to general traffic all day** between the Majestic Centre and BNZ Centre **for the BRT/ LRT options;**

- **The number of bus stops along the Golden Mile is reduced from 8 to 5** to improve PT travel times;

- **for modelling purposes it has been assumed that buses, BRT and LRT will share the same stops** along the Golden Mile;

- around **30 southbound buses per hour will be diverted onto a secondary spine in the AM peak** to relieve pressure along the Golden Mile and improve PT travel times and service reliability for BRT and LRT options;

- the **BP option involves additional bus lanes and bus priority measures at intersections** along the core route (defined as Kilbirnie to Wellington Station via Mt Vic and Newtown to Wellington Station) and along Constable street between Kilbirnie and Newtown;

- the BRT and LRT options involve services running along **fully segregated corridors along the core route**;

- **BRT and LRT will receive greater priority at signals** along the Golden Mile than the bus priority option, resulting in improved travel times;

- BRT and LRT services have the same network of stops. The distance between BRT / LRT stops is increased compared to the BP and reference case;

- in the BRT option and, to a much greater extent, the LRT option, **existing bus services are split or terminated at interchange points** – Kilbirnie, Newtown, Courtenay Place, Wellington Station, Miramar – to feed passengers onto the BRT and LRT networks and optimise BRT/ LRT travel time savings and benefits;

- whilst precise details regarding which services are to be truncated/ changed could be discussed and debated, the most important thing is the **principle whereby services need to be changed in order to optimise both the BRT and LRT options**; and

- both the **BRT and LRT options result in fewer peak vehicles** travelling along the Golden Mile;

Highway Modifications

- the assumed timing of all **committed highway infrastructure schemes**, including all the Wellington RoNS, is documented;
- **capacity available to general traffic has been reduced** in a number of locations to model the potential impact of implementing PT priority measures;
- **reductions in capacity** are mainly a result of **the removal of one or more lanes of general traffic** to accommodate bus lanes and **a reduction in signal green times** to give PT services greater priority at intersections, leading to a consequent reduction in capacity for general traffic; and
- no detailed intersection design has been undertaken for this stage of the project – what has been presented is a first estimate. Should an option be chosen and progressed, such detailed intersection design would be required.

12.1.7 Modelling Assumptions

- model values of time change according to journey purpose (work, education, business) and whether a choice is available (i.e. PT, car);
- **values of time** are used to convert non-time based components of a journey – fares, fuel costs – into time values**;**
- car and PT travel times are modelled in terms of **'generalised time'**, accounting for all time based and non-time based components of a journey;
- both WPTM and WTSM use 'perceived' rather than 'actual' time when calculating total generalised time, to reflect the fact that people perceive certain components of a journey to be more onerous than others;
- **employment and population growth** in the future is largely concentrated in Kapiti and Wellington;
- a **PTSS Medium land use** scenario, **focussing growth in Wellington CBD**, has been used;
- **forecast economic parameters** are based upon agreed practice and are linked to GDP / per capita growth;
- **whilst differences exists between WTSM and WPTM** in terms of how they represent wait time, walk time and in-vehicle time, these differences are minor and **do not materially affect the modelling system nor any results** coming out of it;

- given that both the BRT and LRT options requires people to transfer between services, it is **important that both models accurately represent the costs associated with transferring between modes**;

- therefore a number of **modifications and improvements** were made to the modelling system **for the PTSS**, mainly to do with the representation of between-mode transfers and the modelling of integrated ticketing; and

- compared against current Australasian Guidelines, the representation of transfers in both WTSM and WPTM is deemed realistic.

12.1.8 Model Results

Change in demand and travel times between 2011 and 2031

- **growth in car trips** between 2011 to 2031 (18%) is predicted to be **greater than the growth in PT trips** (15%);

- **PT mode share remains relatively unchanged** between 2011 and 2031;

- PT growth is focussed on the northern, southern and eastern suburbs of Wellington; and

- highway travel times decrease between 2011 and 2031 whilst PT travel times generally remain flat.

Option Travel Times

- **car travel times show little variation between options**;

- **PT travel times** from selected origin zones in the study area to Wellington CBD **improve by up to 11 minutes** in the BRT and LRT options;

- PT travel times from **Miramar / Island Bay to Wellington CBD in the LRT option are 6 minutes worse than in the BRT option** due to time penalties associated with interchanging between bus and LRT at Kilbirnie/ Newtown;

- the **improvement in travel times from Kilbirnie (11 minutes) and Newtown (7 minutes)** to Wellington Station is the same for both the BRT and LRT options; and

- travel times along the **Golden Mile improve by up to 3 minutes** in all options.

PT Demand, Car Demand and Mode Share

- **the BP option results in a 4% to 5% increase** in PT demand from the study area;

- the **BRT option results in an 8% to 12% increase** in PT demand from the study area;

- the **LRT option** results in increases in demand from Kilbirnie/ Newtown but **slight decreases from Miramar and Island Bay**;

- areas that see the greatest increase in PT demand also see the greatest decrease in car demand as people change modes; and

- **PT mode share from the study area increases** by around 1% to 2% in the BP option, 3% to 4% in the BRT option and an average of 2% in the LRT option.

PT Patronage

- patronage **increases slightly in BP option**;

- an increase **in patronage of 400 is generated through Mt Vic Tunnel in the BRT option**;

- patronage does not increase between Newtown and Courtenay Place in the LRT and BRT options as any new trips are balanced by passengers shifting to the new Kilbirnie to CBD route via Mt Victoria; and

- **500 additional northbound PT trips are generated along the Golden Mile** in the **BRT option** (LRT = 300).

PT Capacity

- BP – no change

- **BRT – increase in capacity between Island Bay and Courtenay Place,** no change between Kilbirnie and Courtenay Place;

- **BRT – reduction in available capacity along Golden Mile**; and

- **LRT – large increase in capacity across the whole LRT network**. Increases in capacities for feeder services linking into Kilbirnie and Newtown interchanges.

PT Spare Capacity

- **BP – slight decrease, due to increased patronage**;

- **BRT - reduction in spare capacity from Kilbirnie via Mt Victoria** and also the Golden Mile; and

- **Increase in spare capacity** along all corridors in the **LRT option.**

PT Volume / Capacity Ratios

- **BRT VC ratios increase along the Golden Mile and through Mt Vic tunnel**;

- **A mismatch between BRT supply and demand exists at peak times**. This could be remedied by increasing frequencies on the Kilbirnie Branch and decreased on the Island Bay branch;

- **LRT VC ratios decrease due to additional capacity** provided by this option;

- Analysis of peak loadings show that the **BP and reference case operate at between 90% and 100% of capacity** at peak times;

- The **BRT operates at 155% of capacity through Mt Victoria tunnel** during the 'peak of the peak' whilst Adelaide Road operates at only 70% capacity; and

- The **LRT operates at capacity through Mt Victoria tunnel** during the 'peak of the peak' but is at only 50% capacity along Adelaide Road during the same period.

PT Boardings and Transfers

- the number of **boardings increase** slightly in the BRT option and **by a considerable amount in the LRT option**; and

- the **LRT** option requires around **90%** of persons currently travelling from Island Bay and Miramar to Wellington CBD to **interchange**.

Rail Egress Trips

- the number **persons transferring in the AM peak** from inbound rail services to an onward bus along the Golden Mile **increases from ~650 in 2011 to ~3,500 per hour as a result of integrated ticketing**;

- it is thought that WPTM is not adequately taking account of the inconvenience associated with interchanging between modes at the station – therefore **the figure of 3,500 is considered an over-estimate**; and

- the results do show, however, that the **BRT and LRT options result in a 15% and 20% increase respectively in the number of persons alighting from rail services** and travelling on PT to their final destination along the Golden Mile, due to increased travel times provided by BRT and LRT.

Through Trips

- None of the options result in any significant increase in the number of PT trips travelling through Wellington CBD.

Highway Capacity Changes

- highway **capacities** for general traffic have been **reduced** across the network **to accommodate segregated PT corridors and additional PT priority at signals**;

- **Riddiford Rd and Cambridge Terrace** show the **greatest reductions** in available capacity;
- **small capacity reductions** are made along the alignment of the proposed **secondary spine** (Featherston Street and Customhouse Quay);
- **Willis Street is closed** to general traffic 7am to 7pm; and
- **Courtenay Place is closed** to general traffic during peak periods.

Impact of Highway Capacity Changes

- Reductions in capacities result in decreases in traffic volumes and increases in V/C ratios;
- whilst **delays do increase** along affected sections of highway, **they are not substantial and unrealistic** and **do not suggest that the network will become grid-locked** as a result of the proposed capacity reductions; and
- **some re-routing of traffic occurs** as a result of the closure of Willis Street, with traffic routing via Ghuznee Street, Taranaki Street and Customhouse Quay.

12.1.9 Evaluation of PT Benefits

- the average **BP and LRT user gains a 1 minute travel time saving** in the AM peak. This figure is nearer **2 minutes for the BRT** option;
- the **average travel time saving per passenger is between 6 and 9 minutes** for passenger originating from the study area in the **BRT** option, around **twice as high as similar figures from the LRT** option;
- **walk time benefits are slightly negative** for the **BRT and LRT** options, as people have to walk further to access services;
- **wait time benefits are positive for the BRT**, due to enhanced service frequencies, but **negative for the LRT due to additional waiting time required** when transferring at Kilbirnie and Newtown;
- **transfer time benefits are slightly negative for the BRT** and **largely negative for the LRT option**, again due to the additional transfers required;
- **BRT and LRT in-vehicle time savings** in the AM peak are **identical**;
- overall, BRT total time savings are twice as great as BP and LRT travel time savings;
- the **eastern branch from Kilbirnie/ Miramar have twice as many time benefits as the southern branch in both the BRT and LRT options**;

- **highway travel time savings are negative** i.e. times increase as a result of the scheme; and

- the increases in highway travel times are small across all sectors (less than 1 minute for the average trip).

12.1.10 Sensitivity Testing

- the **sensitivity of WTSM** to varying input parameters (e.g. parking costs, PT fare, etc) is **deemed reasonable** and is in line with standard range of elasticity for strategic models (see Technical Note 18 "WTSM Calibration and Validation" from the 2011 model update for more detail);

- the **impact of the sensitivity tests** on the PTSS schemes performance in terms of mode shift to PT generally ranges from **minor to moderate**, and in all cases **does not change the relative performance of the BRT and LRT options**; and

- when run in WPTM, **the impact of the two main tests** (parking charge and non-inclusion of the RoNS) **on time benefits to PT users is minor** and does not change the outcomes for both options.

12.2 Bus Priority Summary

The BP option offers incremental change on the current likely future (the reference case). The option comprises a package of peak only bus lanes and priority measures designed to improve PT travel times and reliability.

It results in small improvements in travel times from the study area into the CBD and a small change in the PT mode share.

12.3 Bus Rapid Transit Summary

The BRT option offers a high quality PT option and is a step-change in public transport infrastructure. It is a fully segregated BRT network running from Kilbirnie/ Newtown to Courtenay Place and on towards Wellington Station. On this core route, travel time savings of 11 minutes (Kilbirnie) and 7 minutes (Newtown) can be attained for journeys to the station.

The BRT vehicles offer superior comfort and capacity compared to current buses and also have the flexibility to run with normal traffic, allowing them to serve Miramar, Island Bay and Karori before feeding into the BRT corridor.

PT patronage from the southern and eastern suburbs to Wellington CBD increases by around 10%, resulting in a corresponding decrease in car trips and a 3-4% increase in PT mode share to the south and east.

An extra 500 to 600 people travel along the Golden Mile in an average AM peak hour.

In order to optimise BRT benefits, a number of existing bus services are modified so that they now feed into the BRT network at interchange points, allowing BRT vehicles to run largely unhindered by normal buses.

Whilst the PT capacity offered by the BRT system is similar to that currently offered by the bus network, larger vehicles and priority measures result in improved travel times and an enhanced user experience.

12.4 Light Rail Transit Summary

The LRT option also offers a high quality PT option and a step change in public transport infrastructure. The LRT provides a high frequency service between Kilbirnie/ Newtown and Wellington Station, offering identical travel time savings to those provided by the BRT option.

The LRT network involves a comprehensive system of feeder buses from Miramar, Karori and Island Bay that channel people onto LRT services at Kilbirnie and Newtown. The LRT will then travel into Wellington CBD along segregated corridors free from other buses.

Unlike BRT, the LRT offers a substantial step-up in capacity as each LRT unit can carry around 180 passengers.

PT patronage from suburbs such as Kilbirnie and Newtown into Wellington CBD increases by around 10% due to the LRT. Patronage growth from outlying suburbs such as Miramar and Kilbirnie is fairly flat as superior travel times offered by LRT are offset against the inconvenience of having to transfer from bus to LRT services at Newtown and Kilbirnie.

The resulting increase in PT mode share is therefore less than BRT at around 2% across the study area and around 0.5% across the region as a whole.

12.5 Summary of Highway Impacts

Each scheme, particularly the BRT and LRT, require capacity to be taken from general traffic at key points on the network to provide for PT infrastructure and priority measures.

These capacity reductions do result in slightly longer travel times for some current car users, especially from areas such as Newtown and Miramar to the CBD.

The net result, however, is that travel times for some car users will increase by up to 1 minute as a result of the BRT and LRT options. Such an increase is minimal and would be imperceptible to most road users and within the range of currently experienced day to day variability in travel times.

It is likely that if one of the options were to be progressed, more detailed design work would result in the optimisation of the highway network and a corresponding mitigation of the small increases in travel time that we estimate highway users will experience.