
AECOM
Wellington Public
Transport Spine Study
RAILWAY STATION TO HOSPITAL
Option Evaluation - Medium List
Technical Note

Wellington Public Transport Spine Study

Medium List Technical Note

Prepared for

Greater Wellington Regional Council

Prepared by

AECOM New Zealand Limited
Level 10, 135 Victoria Street, Te Aro, Wellington 6011, PO Box 27277, Wellington 6141, New Zealand
T +64 4 382 2999 F +64 4 382 2998 www.aecom.com

In association with

Incite Ltd

27 July 2012

Quality Information

Document	Wellington Public Transport Spine Study
Ref	
Date	27 July 2012
Prepared by	Rob Napier, Andrew Foy, Simon Lusby, Adam Ashford
Reviewed by	Shaun Hubbard, Denis Leviny, Rob Whight

Revision History

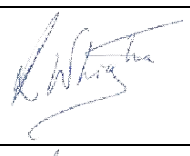
Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
Rev A	06-Jul-2012	Client Issue	Rob Whight Project Director	
Rev B	24-Jul-2012	Client Issue	Rob Whight Project Director	

Table of Contents

List of Tables

List of Figures

Glossary

Abbreviation	Definition
BBC	Treasury's Better Business Case Framework
BCR	Benefit Cost Ratio
BRT	Bus Rail Transit
CBD	Central Business District
EEM	Economic Evaluation Manual
EMME/2	Multimodal Equilibrium (Modelling Package)
GIS	Geographical Information Systems
GPS	Government Policy Statement
Greater Wellington	Greater Wellington Regional Council
HOV	High-Occupancy Vehicle
ILM	Investment Logic Map
KPI	Key Performance Indicator
LOS	Levels of Service
LRT	Light Rail Transit
LTMA	Land Transport Management Act
LU	Land Use
MCA	Multi-Criteria Assessment
MoT	Ministry of Transport
MRT	Mass Rail Transit (e.g. heavy rail)
N2A	Ngauranga to Airport Corridor Plan
NZTA	New Zealand Transport Agency
NZTS	New Zealand Transport Strategy
PT	Public Transport
PTSS, the Study	Public Transport Spine Study
RLTS	Regional Land Transport Strategy
RMA	Resource Management Act 1991
RoNS	Roads of National Significance
RPTP	Regional Public Transport Plan
RTN	Rail Transit Network
SATURN	Simulation and Assignment of Traffic to Urban Road Networks

Abbreviation	Definition
SES	Social Environmental Screen
SWOT	Strengths, Weaknesses, Opportunities, Threats
TDM	Travel Demand Management
TOD	Transit Orientated Development
TSD	Transit-Supportive Development
TWG	Technical Working Group
UD	Urban Design
ULT	Urban Light Transit
WCBR	Wellington City Bus Review
WCC	Wellington City Council
WPTM	Wellington Public Transport Model
WTSM	Wellington Transport Strategy Model

Executive Summary

Purpose and context

This report is a technical report which explains in detail the medium list evaluation process and results used to select a short list of options for the Wellington Public Transport Spine study area.

The medium list evaluation is the second of three stages in the evaluation process. A previous report, titled AECOM's *Option Evaluation – Long-List Technical Note, April 2012* explains the first stage of the evaluation. It describes how a long list of 88 potential mode and route options were reduced to eight options. These eight options are evaluated and reported on in this report. A short list evaluation, Stage 3, will proceed once the recommendations of this report have been endorsed by Greater Wellington Regional Council.

The Medium List Options

The Base Case and eight medium list options are:

Option	Definition
Base Case	This is the base line against which the other options are compared. It involves only minor and already committed projects in the study area.
1) Bus Priority Central alignment	This option builds on the Base Case through maximising the provision of bus priority lanes along the Golden Mile, Kent and Cambridge Terrace and Adelaide road.
2) Bus Priority Waterfront alignment	As per the previous option except the route follows the waterfront instead of the Golden Mile.
3) Bus Rail Transit (BRT) Central alignment	This option is Bus Rail Transit along the Golden Mile, Kent and Cambridge Terrace and Adelaide Road. This option provides a separate right of way for buses only.
4) Bus Rail Transit (BRT) Waterfront alignment	As per the previous option except the route follows the waterfront.
5) Light Rail Transit (LRT) Central alignment	This option is light rail transit along the Golden Mile. Light rail vehicles (or trams) run on steel rail tracks laid in the road. The degree of separation from cars, buses and pedestrians can be varied to suit the particular situation.
6) Light Rail Transit (LRT) Waterfront alignment	As per the previous option except the route follows the waterfront.
7) Heavy Rail Extension (HRE) Underground alignment	This option extends the existing heavy rail lines southwards from the current terminus at Wellington Railway Station in an underground tunnel. The route would have stops at the BNZ Centre and at Courtenay Place. The remainder of the route to the hospital would be served by buses.
8) Heavy Rail Extension (HRE) Waterfront alignment	As per the previous option except the trains would be at ground level rather than underground.

Evaluation Scoring Outcomes

The final outcome from the scoring process was as follows:

Rank	Option	Reference	Score
1	Bus Rail Transit (BRT) Central	BRT C	0.4
2	Light Rail Transit (LRT) Central	LRT C	0.3
3	Bus Priority Central	BUS C	0.2
4	Bus Priority Waterfront	BUS WF	0
5	Bus Rail Transit (BRT) Waterfront	BRT WF	-0.1
6	Light Rail Transit (LRT) Waterfront	LRT W	-0.2
7	Heavy Rail Extension (HRE) Underground	HRE UG	-0.5
8	Heavy Rail Extension (HRE) Waterfront	HRE WF	-0.7

As can be seen in the above Table, three ranked options scored better than the Base Case, whilst four options scored worse than the Base Case.

Options Recommended for Short Listing

The three options, along with the Do Minimum, with the highest overall average scores recommended for more detailed consideration during the remainder of the Study are:

Bus Rail Transit, Along a Central Alignment

BRT meets the goal of high quality PT. It also has plenty of scope to increase capacity once signal prioritisation and an exclusive bus right-of-way is established as part of the BRT options. For these reasons it scores positively relative to the Base Case.

For BRT Central, with the segregation of the bus route there will be implications for existing levels of cyclist and pedestrian movements. Whilst these may be considered minor, they must be investigated further.

Sub options that will be considered, which may lead to option refinements, include:

- Route sub options including along Stout Street, Featherston Street;
- PT Network options of BRT only services or mix BRT and normal bus services along the spine;
- Different BRT service frequencies;
- Different capacity of BRT buses including double deck, articulated bus; and
- Different bus technologies including O Bahn and electric buses.

It will also be important to further consider the extent of anticipated disruptions to general traffic movement through intersections and accessibility for serving CBD properties.

Overall this option ranks within the top three options recommended to be taken forward in the remainder of the Study.

Bus Priority option, Along a Central Alignment

This option provides strong consistency with the Base Case option in terms of the employment and population catchment numbers, and associated with the flexibility of providing stops along a similar alignment. In all other respects, there is strong similarity to the impacts of the current Base Case, and additional priority measures are not considered to offer any significant challenges. The option ranks within the top three options recommended to be taken forward in the remainder of the study.

Sub options that will be considered, which may lead to option refinements, include:

- Route sub options including along Stout Street, Featherston Street;
- Different bus service frequencies;

- Different capacity of buses including double deck, articulated bus;
- Different bus technologies including electric buses; and
- Buses only on sections of the Golden Mile.

Light Rail along a Central Alignment

LRT is similar to BRT in that it meets the goal of high quality PT but it also has plenty of scope to increase capacity once signal prioritisation and an exclusive right of way is established. For these reasons it scores positively relative to the Base Case.

Regarding the Environment and Safety criteria, this option is likely to create a low level of severance on Lambton Quay. Pedestrians may not be able to cross the alignment as they do currently with the LRT route being physically segregated mid-block. This is however a design consideration and has successfully been addressed in other locations e.g. Bourke and Swan Street Malls in Melbourne. Furthermore, rail tracks may cause a hindrance to cyclists on Lambton Quay and they may prefer to use alternative routes.

Sub options that will be considered, which may lead to option refinements, include:

- Route sub options including along Stout Street, Featherston Street;
- PT Network options of LRT only services or mix LRT and normal bus services along the spine;
- Different LRT service frequencies;
- Different capacity of LRT vehicles; and
- Different numbers of stops.

Further investigations are required to understand the change to the existing traffic system configuration with a number of altered intersections, establishment of dedicated LRT lanes, removal of parking and loss of traffic lanes requiring consultation or specific consent. In light of the complexity of the physical changes consentability and gaining public support for the option is considered to be moderately difficult.

Overall this option ranks within the top three options recommended to be taken forward in the remainder of the Study.

1.0 Overview

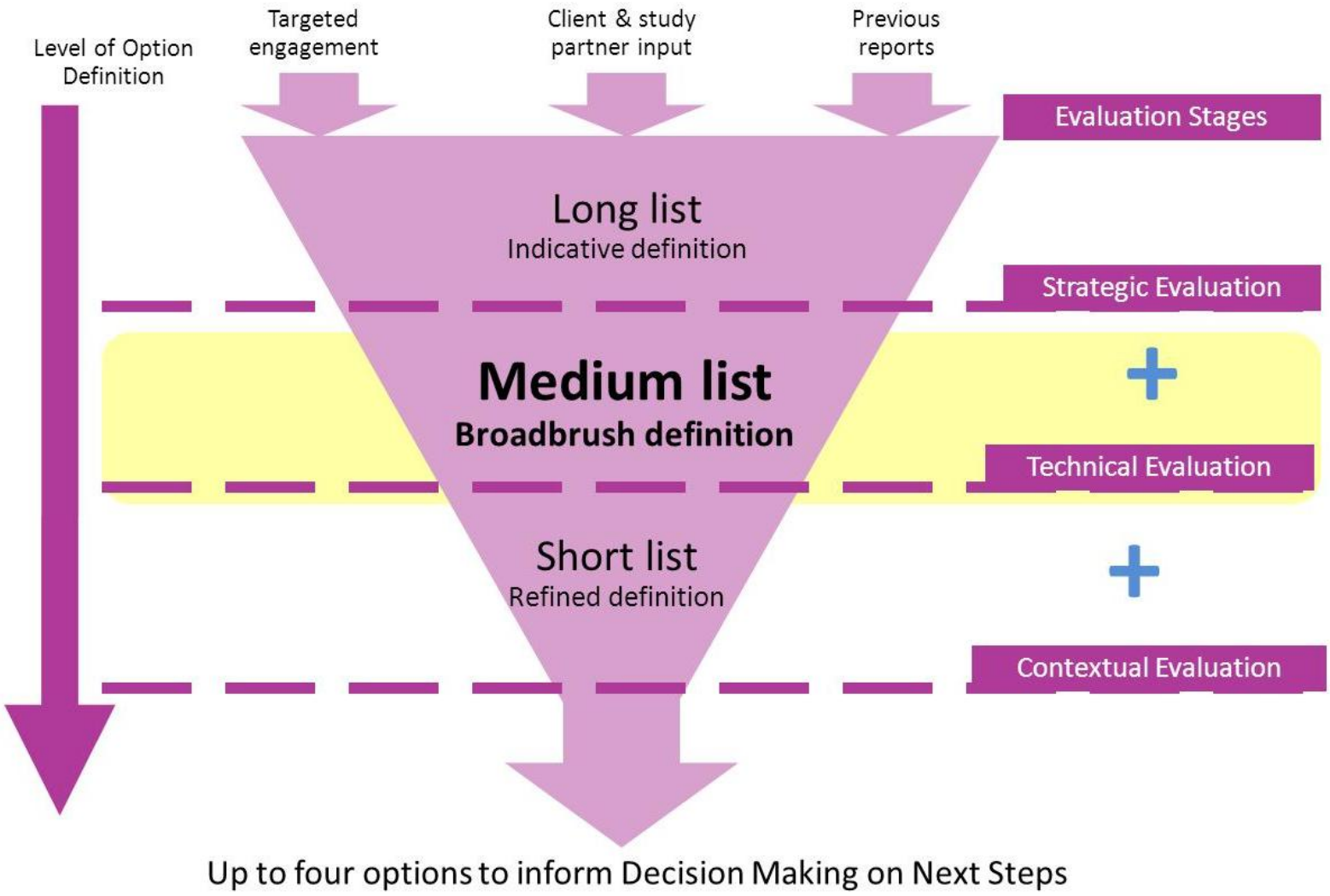
This report forms part of a suite of documents for the Wellington Public Transport Spine Study. It outlines the medium list evaluation process and results to reduce eight options to a maximum of four shortlisted options.

1.1 Overall Study Process

The overall study process is explained in the Inception and Scoping Report and summarised in Figure 1. Essentially, the approach is to progressively narrow-down (or funnel) the number of options through three stages:

- A long-list evaluation, which reduced a long list of 88 options to eight options. This is reported in the *Option Evaluation – Long-List Technical Note, April 2012.*
- A medium-list evaluation, which is the focus of this report, reduces eight to up to four options.
- A short list evaluation, which is yet to be undertaken and will evaluate the short-listed options in detail.

Figure 1 Funnel Approach for Option Evaluation



1.2 The Medium List Process

The process required to reduce the Medium List options to the recommended short-list options was underpinned by a number of assessments:

- Engineering assessment, which looks at the impacts of the various options from a design perspective, including the footprint of the vehicles, and how typical bus/train stops will impact on the corridors;
- Social and Environmental assessment, which assesses the impact from the perspective of the built and natural environment, but also on the cultural and social aspects including the movement of people;
- Urban Planning/ Design assessment, which assesses the suitability of the options against the visions, strategies and plans for Wellington, including the “look and feel” and the functionality of the options;
- Statutory Planning assessment, which considers legislative issues and associated consenting requirements;
- Transport Modelling, which forecasts demand expectations for public transport services in the future years; and
- Operational and Capital Cost estimates which provide an indicative cost range the options based on the cost of similar projects considered in the PTSS International Review.

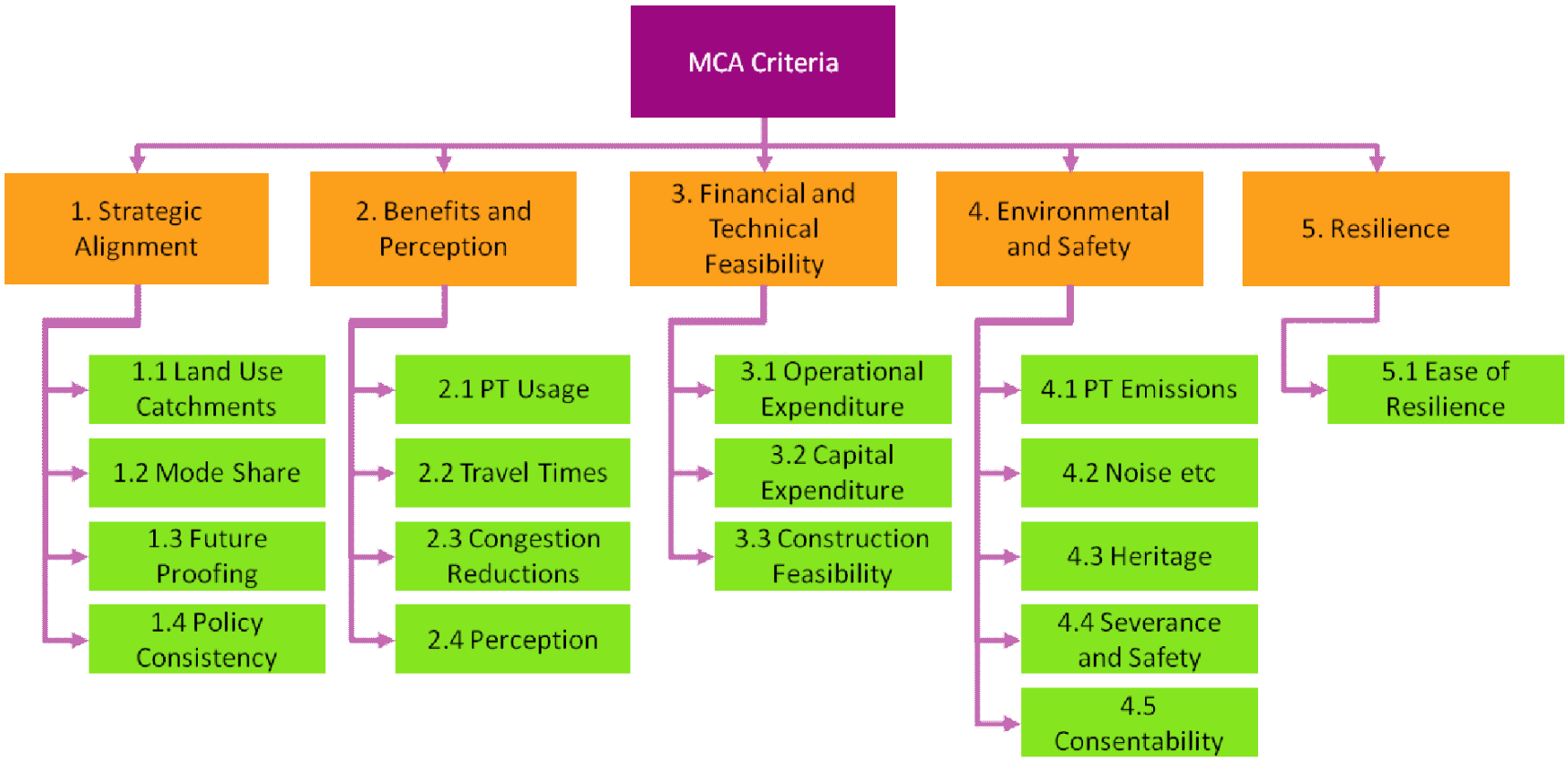
The medium list analysis is a high level assessment which has been carried out part way through the feasibility phase. Given the preliminary nature of the information available to the study at this stage the analysis is therefore inevitably coarse. For example the transport modelling done to date has used the WTSM strategic model only which is a high level strategic model. At the short list stage the WPTM modelling and SATURN modelling will be available which will enable the short list options to be refined in more detail. (for example in relation to walking catchments and costs).

Once these assessments were complete, the options were scored against multi-criteria criteria as described below.

1.3 Medium List Criteria and Performance Measures

The set of criteria and supporting performance measures, used to evaluate the eight medium list options, are illustrated in Figure 2. These criteria were specifically developed with the Technical Working Group and endorsed by the Steering Group to capture key strategic, customer, financial, technical, environmental, safety and resilience factors deemed important for the City. These criteria are explained in further detail in Chapter 2.0.

Figure 2 Multi-Criteria Assessment Tree



1.4 The Medium List Scoring

The score for each of the eight options has been assigned relative to the Base Case option. So, within each of the technical assessments, each of the eight options were scored using the following five-point scale:

- Significant Positive Effects; scored +2;
- Minor Positive Effects ; scored +1;
- Neutral Effects or Not Applicable; scored 0;
- Minor Negative Effects; scored -1; and
- Significant Negative Effects; scored -2.

The Do-minimum case was scored zero.

1.5 The Options

1.5.1 Medium List

The eight medium list options evaluated are:

Option	Definition
Base Case	This is the base case against which the other options are compared. It involves only minor and already committed projects in the study area.
Bus Priority Central alignment	This option builds on the Base Case through maximising the provision of bus priority lanes along the Golden Mile, Kent and Cambridge Terrace and Adelaide road.
Bus Priority Waterfront alignment	As per the previous option except the route follows the waterfront instead of the Golden Mile.
Bus Rail Transit (BRT) Central alignment	This option is Bus Rail Transit along the Golden Mile, Kent and Cambridge Terrace and Adelaide Road. This option provides a separate right of way for buses only.
Bus Rail Transit (BRT) Waterfront alignment	As per the previous option except the route follows the waterfront.
Light Rail Transit (LRT) Central alignment	This option is light rail transit along the Golden Mile. Light rail vehicles (or trams) run on steel rail tracks laid in the road. The degree of separation from cars, buses and pedestrians can be varied to suit the particular situation.
Light Rail Transit (LRT) Waterfront alignment	As per the previous option except the route follows the waterfront.
Heavy Rail Extension (HRE) Underground alignment	This option extends the existing heavy rail lines southwards from the currently terminus at Wellington Railway Station in an underground tunnel. The route would have stops at the BNZ Centre and Courtenay Place. The remainder of the route to the hospital would be served by buses.
Heavy Rail Extension (HRE) Waterfront alignment	As per the previous option except the trains would be at ground level rather than underground.

The options have sub-options around route and technology. For example central routes have sub options that include Featherston and Stout Street. LRT and BRT could consider tunnels or grade separation if the modelled demand warrants. BRT options have sub options around different vehicle capacity, electric v diesel and O Bahn. However, the medium list assessment is at a higher level and refinement and consideration of sub-options will take place at the short list stage. The eight options have been assessed against a Base Case and evaluated over a 30 year period to a 2041 future year.

1.5.2 Do Minimum

Capital projects are included in the Base Case if they are 1) outside the PT Spine study area, [1] 2) already committed, or 3) are needed to maintain a minimum level of service over the evaluation period of 30 years. These committed and minor improvements are to make sure that the transport system in the model does not show excessive and unrealistic delays and continues to provide a minimum level of service for underlying increases in transport demand, for example due to growth in population. Further detail on the capital projects included in the Base Case is provided in Appendix A.

1.6 Investment Logic Map (ILM) Process and Weightings

As part of the Treasury's Better Business Case process followed in the study, a series of workshops were held which identified the "problem" the study is addressing as well as the "benefits" that would result from addressing the "problem". The "problem" was the fact that the PT Spine will constrain economic growth if it does not meet its share of future demand and that because PT shares a constrained corridor this limits future network growth.

The "benefits" of addressing the "problem" and the weightings assigned to them are as follows:

- Travel time along the spine is reduced (25%);
- There is potential to make the spine more resilient (15%);
- There is an opportunity to make smart investment an optimised travel system (30%); and
- Choice and accessibility for users could be improved. (30%).

The weights in the ILM are considered an appropriate starting point for setting the primary weightings used in this MCA. The primary MCA criteria weightings were derived from the ILM weightings rather than set by it.

A series of sensitivity tests were carried out to ensure that the final result has not been dictated by the ILM weightings. The tests were:

- **Equal weighting** – All performance measures have equal weighting.
- **Excluding Costs** – The cost measure is excluded and all other performance measure have equal weighting. This provides the opportunity to consider what option would be chosen if cost were not a deciding factor.
- **Excluding Resilience** – The resilience measure is excluded and all other performance measures have equal weighting. This provides the opportunity to understand whether an option which is less resilient to natural disasters and other impacts on operation would be chosen.

The conclusion of the sensitivity testing was that the STET of shortlisted options was not sensitive to the weightings.

[1] The core study area is **ketinea** Wellington Railway Station and the Wellington Regional Hospital. The study area is boarded by the Terrace and Wallace Street in the west and the waterfront, Kent Terrace and Adelaide Road in the east.

-

2.0 Scoring and Rationale

This Chapter of the report describes the outcomes of the medium-list scoring process, using the Multi-Criteria Analysis (MCA) framework, and the rationale for awarding the scores to the options.

The weightings of the performance measures under the five assessment criteria was considered at a TWG workshop and it was considered that equal weightings were appropriate in the absence of justification to give some performance measures higher weighting than others. An average score for each criteria was calculated to one decimal point to ensure that the differences in scoring between the options was not lost though rounding of the numbers.

2.1 Strategic Alignment Criteria

Table 1 Strategic Alignment– Criteria Summary Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
1.1 Land Use Catchments	0	0	-1.5	0	-2	0	-2	-2	-2
1.2 Mode Share	0	0	0	0	0	0	0	0	0
1.3 Future Proofing	0	1	1	2	2	2	2	2	2
1.4 Policy Consistency	0	0	0	2	-2	2	-2	-1	-2
Average Score	**0**	**0.3**	**-0.1**	**1**	**-0.5**	**1.0**	**-0.5**	**-1.3**	**-1.5**

This criterion assesses how the option meets public transport objectives. These include catchments, mode share, future proofing and consistency with Wellington and Government transport policies.

Performance measures include:

- Land Use Catchments (25% weighting);
- Mode Share (25% weighting);
- Future Proofing (25% weighting); and
- Policy Consistency (25% weighting).

The summary scores for this criteria are as follows and a more detailed explanation of the scoring is given below.

2.1.1 Land Use Catchments

Table 2 Land Use Catchments– Performance Measure Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
1.1.1 Employment Catchment	76,200	76,200	71,000	75,600	59,800	75,600	59,800	52,400	43,800
	0	0	-1	0	-2	0	-2	-2	-2
1.1.2 Population Catchments	9,900	9,900	5,800	8,700	3,900	8,700	3,900	5,000	2,700
	0	0	-2	0	-2	0	-2	-2	-2
Average Score	**0**	**0**	**-1.5**	**0**	**-2**	**0**	**-2**	**-2**	**-2**

Explanation of Performance Measures

This performance measures assesses the potential number of jobs and resident population (catchment area) within a typical walking distance to stops / stations along the PT-Spine (Wellington Station to Courtenay Place). The walking distance used is 400 metres for all modes, as this seeks to provide consistency, meaning walk distance is perceived on an equal basis by passengers regardless of the mode. The measure of 400m is based upon the international review which found that 400m was an acceptable distance in which to access public transport in a walkable city. This is further supported by reviewing current LRT walking distance guidelines from Canadian and American cities which suggest an acceptable range between 300m and 600m. The population and employment forecasts are those used in the transport model for a 2041 medium projection.

The weighting given to each walk up catchment measure is split evenly between Employment Catchments and Population Catchments

Explanation of Scoring

- **Bus Priority Central, LRT Central and BRT Central** options have similar employment and population catchment numbers to the Base Case and therefore score 0. This is due to these modes having similar alignments and the inclusion of multiple stops or stations along the route, although it is noted there are minor differences due to the consolidation of bus stops with BRT and LRT. This suggests that the number of bus stops within the CBD could be consolidated with minimal impacting on the walk up catchments.
- The **Bus Priority Waterfront** option alignment moves services away from the central alignment; therefore the walking catchment does not extend as far into the dense employment areas within the CBD. Whilst multiple bus stops provided by this option help to mitigate this, the option has a smaller catchment and therefore has lower scores at -1 for employment and -2 for population catchments.
- **LRT Waterfront and HRE Underground and Waterfront** options have significantly smaller employment and population catchment numbers. The waterfront option alignments are further from the centre of the CBD and in the case of HRE this is compounded by having only two stations. HRE Underground also includes the vertical separation of the station from the street, requiring passengers to use escalators, stairs or lifts to access underground stations. Therefore these options are scored at -2.

2.1.2 Mode Share: Public Transport Mode Share in 2041

Table 3 Mode Share – Performance Measure Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
1.2.1 Mode Share (Region)	14.2% 0	14.3% 0	14.3% 0	14.4% 0	14.4% 0	14.1% 0	14.1% 0	14.3% 0	14.3% 0
1.2.2 Mode Share (to CBD)	34.6% 0	34.9% 0	34.9% 0	35.0% 0	35.0% 0	34.2% 0	34.2% 0	34.8% 0	34.8% 0
Average Score	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Explanation of Performance Measures

This performance measure assesses the proportion of total all trips made on passenger transport during the 2041 morning peak period. Other modes include walking, car and heavy vehicles. This criterion is split into two sub categories and assesses the entire demand for travel within the region by mode not by service or alignment. Due to the volume of total trips within the region during the morning peak period it is unlikely these mode shares will vary by more than a few percentage points because the options affect only a short section of the PT network within the Wellington region. The two sub categories are:

- Total region, which identifies wider benefits provided by the public transport services, which could be influenced by improved connectivity for example. (50% weighting); and
- Wellington CBD which identify benefits for trips to the study area, which could be influenced by reduced walking distances or increased frequency. (50% weighting).

Explanation of Scoring

- **Bus Priority and BRT** options produce slightly higher mode shares compared to the Base Case over the region and mode share to Wellington CBD. These increases are caused by the additional priority given to bus services in these options.
- **LRT and HRE** options reduce mode share by PT and increase CBD walking trips. For LRT, the need to transfer could be addressed through the development of a better integrated service plan providing more of a network solution to connect with revised bus services. Modelling using the Wellington Passenger Transport Model (WPTM) can be used to test these initial modelling results further if these options progress to the 'Short List'. HRE does not require transfer as trains arriving at Wellington would continue into the tunnel.
- The differences in forecast mode share for options are not large enough to allow for differentiation between modes. This is due to the options only representing minor changes to modes within the CBD, for short list testing a full review of the public transport network is recommended. It has therefore been decided that all

modes should be scored equally at 0 and that a detailed review of services, networks and frequencies will be carried for the short list assessment to differentiate the modes.

2.1.3 Future Proofing: Ease by Which Additional Capacity can be Provided

Table 4 Future Proofing – Performance Measure Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
1.3.1 Future Proofing	0	1	1	2	2	2	2	2	2
Average Score	**0**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**

Explanation of Criteria

This performance measure assesses the ease by which additional capacity can be added by the mode based on typical capacities from the international review as applicable to the PT Spine (International Review).

Explanation of Scoring

- **The Bus Priority** options has very limited ability to add to additional capacity as the number of buses per hour using the golden Mile already exceeds the desirable maximum bus per hour at peak time and bus congestion is an existing issue. Bus options provide flexibility in both ease of moving alignment and the speed in which additional capacity can be provided through increased frequency of services. However, providing additional capacity within the existing corridor may be difficult and so the option does not score maximum points but scores +1.
- **BRT** has scope to increase capacity once signal prioritisation and an exclusive right of way are established as part of the BRT options. Additional capacity can be created by increasing frequency, adding additional services or optimising the use of existing buses. This options scores +2.
- **LRT** has scope to increase capacity once signal prioritisation and an exclusive light rail or tram right of way are established as part of the LRT options. This options scores +2.
- **HRE Underground and HRE Waterfront** could potentially provide the highest capacity system and is scored at +2.

2.1.4 Consistency of Option with Agreed Policy Positions

Table 5 Policy Consistency – Performance Measure Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
1.5.1 Policy Consistency	0	0	0	2	-2	2	-2	-1	-2
Average Score	**0**	0	0	2	-2	2	-2	-1	-2

Explanation of Performance Measures

This performance measures assesses whether the option is consistent with published strategies and policy documents. These include: Regional Land Transport Strategy 2010-2040 (RLTS), Wellington Towards 2040, Nguaranga to Airport Corridor Plan 2008 (N2A), Wellington Regional PT Plan 2011-2021, Wellington Regional Strategy 2007

Explanation of Scoring

- **The Bus Priority** options are a continuation of the existing approach to public transport though the provision of bus services similar to the Base Case and therefore scores 0. This would not meet the strategic (RLTS, N2A) goals of a high quality high frequency system if buses are congested.
- **BRT and LRT** options in the central corridor meet the goal of high quality PT and therefore score positively relative to the Base Case and score +2. However, waterfront routes do not align with N2A and WCC land use policy and therefore scores -2.
- **HRE Underground** does not align to N2A and the RLTS. It over provides on capacity which is not envisaged in the RLTS as necessary under future demand forecasts and scores -1.
- **HRE Waterfront** lack of consistency with strategy due to further severance of the CBD from the waterfront. Extension of the heavy rail system is not consistent with current RLTS and could have significant cost and

operational implications for the Wellington Railway station at which trains currently terminate and therefore scores -2.

2.2 Benefits and Perception Criteria

Table 6 User and Non-User Benefits Criteria– Summary Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
2.1 PT Usage	0	0	0	0	0	0	0	0	0
2.2 Travel Times	0	0	0	0	0	0	0	0	0
2.3 Congestion Reductions	0	1	1	1	1	0	0	1	1
2.4 Perception	0	0	0	1	1	2	2	2	1
Average Score	**0**	**0.3**	**0.3**	**0.5**	**0.5**	**0.5**	**0.5**	**0.8**	**0.5**

This criterion assesses the perceived benefits of each option by users. This includes reductions in congestion for all motor vehicle users and public transport benefits such as travel time.

Performance measures include:

- Patronage and Distance Travelled (25% weighting);
- Travel Times (25% weighting);
- Congestion Reductions (25% weighting); and
- Perception (25% weighting).

The summary scores for this criteria are as follows and a more detailed explanation of the scoring is given below.

2.2.1 PT Usage

Table 7 PT Usage – Performance Measure Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
2.1.1 Patronage	35,200 0	35,500 0	35,500 0	35,700 0	35,700 0	35,600 0	35,600 0	35,600 0	35,600 0
Average Score	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Explanation of Performance Measures

This performance measure assesses the number of passengers who travel in buses, ferries and trains for each of the options relative to the Base Case. Patronage represents all passengers during the 2041 two hour AM peak period.

Explanation of Scoring

- **Bus and BRT options show** slight increases in patronage which is due primarily to buses entering and travelling through the CBD in less congested corridors resulting in faster trip times than the Base Case. These options have not changed the bus network so passengers experience a quicker trip on the existing network.
- **LRT and HRE** options have fewer passengers, this is most likely due to bus services from the south being terminated at Courtney Place and requiring passengers to transfer, some previously remained on the bus until they reached their destination.
- Similar to forecast mode share the differences between options are not large enough to allow for differentiation between modes. It has therefore been decided that all modes should be scored equally at 0 and that at the short list option development phase a system wide review will be undertaken.

2.2.2 Public Transport Travel Time: To Wellington CBD

Table 8 Public Transport Travel Time – Performance Measure Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
2.2.1 Travel Times (Average Travel Time in Minutes)	41	40	40	39	39	40	40	40	40
	0	0	0	0	0	0	0	0	0
Average Score	**0**	0	0	0	0	0	0	0	0

Explanation of Performance Measures

This performance measure assesses the travel times for passenger transport trips between selected regions and the Wellington CBD. This incorporates walking, waiting and in-vehicle travel times (without factoring for generalised cost). Waiting time will be influenced by frequency of direct services. Walking time relates to the effectiveness/ competitiveness of alternatives, therefore a passenger may choose to walk as opposed to transfer. In-vehicle time relates to improved priority as well as the extension of services.

Explanation of Scoring

- Northern Hutt and Porirua Suburbs have similar travel times for all scenarios (+/- 1 minute). Western Suburbs in the Base Case and all bus options have a shorter trip than for the **LRT and HRE** Options.
- Southern Suburbs are better in all Options compared to the Base Case with the best options being the BRT due connectivity and priority of these Options. Northern suburbs have reduced travel times to the CBD in the HRE options.
- Similar to forecast mode share the differences between options are not large enough to allow for differentiation between modes. It has therefore been decided that this criteria should be removed from the assessment by scoring 0.

2.2.3 Reduced Congestion Impacts on General Traffic

Table 9 Congestion – Performance Measure Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
2.3.1 Congestion ('000 Car Hours Travelled)	2,333	2,323	2,323	2,322	2,322	2,330	2,330	2,324	2,324
	0	1	1	1	1	0	0	1	1
Average Score	**0**	1	1	1	1	0	0	1	1

Explanation of Performance Measures

This performance measure assesses the congestion of each scenario based on how long vehicles are on the network, compared to the Base Case (WTSM). The results represent the outcome of morning peak period forecasts and represent car hours travelled over a two hour period.

Explanation of Scoring

- **LRT options** are similar to the Base Case, this is because the LRT option has not increased the number of passengers and therefore not reduced the number of vehicles on the network and scores 0.
- **HRE options** have reduced congestion because they provide additional route capacity into the CBD without the need to reallocate further road space and therefore have been scored equally at +1 and as an improvement when compared to the Base Case.
- **Bus Options** may have both a positive effect on congestion through increased PT mode share and a reduction in car travel and also negative effects on congestion due to the space requirements of each option and the changes needed to the traffic network to accommodate this. In particular bus priority measures could be provided at the expense of general traffic lanes. This can be modelled in more detail at the 'short list' stage.

2.2.4 General Perception toward the Mode e.g. Safety, Comfort

Table 10 Mode Perception – Performance Measure Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
2.4.1 Perception	0	0	0	1	1	2	2	2	1
Average Score	**0**	0	0	1	1	2	2	2	1

Explanation of Performance Measures

This performance measure assesses the public's perception of what a high quality PT system should look like. This was tested through targeted engagement with user groups and public surveys.

Explanation of Scoring

- **The Bus Priority** options are essentially continuation of the current system and scores 0. There are some concerns about the quality of the buses and reliability issues caused by bus congestion. Increasing the number of buses which are already congested would be perceived negatively.
- **The BRT** mode is perceived as a higher quality PT system with greater speed and reliability, with high quality stations and a dedicated right of way giving good reliability and journey times and is scored +1.
- **LRT and HRE UG** have the highest perception of safety and comfort. Modern systems have level boarding and high quality design both internally and externally and are scored +2. HRE WF is perceived as higher quality PT than the Base Case but nevertheless not as highly a modern underground system and are scored at +1.

2.3 Financial and Technical Feasibility Criteria

Table 11 Feasibility Criteria – Summary Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
3.1 Operational Expenditure	0	0	0	0	0	-1	-1	-1	0.5
3.2 Capital Expenditure	0	0	0	-1	-1	-1	-1	-2	-1
3.3 Construction Feasibility	0	0	0	-1	-1	-1	-1	-2	-1
Average Score	**0**	**0**	**0**	-0.7	-0.7	-1	-1	-1.7	-0.5

This criterion assesses each option in terms of its overall cost and constructability. This includes the one off capital cost as well as ongoing operational cost.

Performance measures are:

- Operational Expenditure (33% weighting);
- Capital Expenditure (33% weighting); and
- Construction Feasibility (33% weighting).

Explanation of Scoring

The summary scores for this criteria are as follows and a more detailed explanation of the scoring is given below.

2.3.1 Operational Expenditure (OPEX)

Table 12 OPEX – Performance Measure Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
3.1.1 Operational Expenditure (M/annum)	$146 0	$146 0	$146 0	$146 0	$146 0	$151 -1	$151 -1	$149 -1	$145 1
3.1.2 Operational Expenditure (per trip)	$4.14 0	$4.12 0	$4.12 0	$4.09 0	$4.09 0	$4.39 -1	$4.39 -1	$4.32 -1	$4.18 0
Average Score	0	0	0	0	0	-1	-1	-1	0.5

Explanation of Performance Measures

This performance measure assesses the operating cost of the option relative to the Base Case. Regional operating costs for rail and bus have been estimated from subsidy levels published in the NLTP and farebox recovery levels published by NZTA for the Wellington region. Further refinement of these estimates may be possible from operating costs data held by Greater Wellington although detailed actual operating costs are unlikely to be available due commercial confidentiality restrictions.

Changes to the operating costs for Bus and Rail have been estimated by adjusting the Base Case operating cost pro rata on the change in vehicle km for the option versus the Base Case. Operating costs for LRT were estimated using Australian Transport Council (ATC) Guidelines. The operating cost of the underground option assumed a notional 0.5% of CAPEX cost to cover tunnel and station operating costs. These costs will be further refined at the 'Short List' stage.

Performance measures include:

- Operational Expenditure per annum (50% weighting); and
- Operational Expenditure per passenger trip (50% weighting).

Explanation of Scoring

- The Do-Minimum estimated operating costs for the whole region is $146M per annum ($4.14 per trip).
- **The Bus Priority** BRT options has similar operating costs to the Base Case and scores 0.
- **The LRT** options marginally increase region wide operating costs due to higher operating cost estimates for LRT. Operating costs increase from $4.14 to $4.39 per trip. International experience would suggest that the per passenger km operating costs for light rail are less than for buses due to lower energy costs, less drivers etc. However a short system such as the Wellington PT spine will have to bear higher overheads per km than would a larger system and this option is scored at -1.
- **The HRE Underground** option increased operating cost due to operating costs associated with a tunnel and is scored at -2. These costs need to be further refined in the next stage.
- **The HRE Waterfront** option decreased overall PT operating costs significantly as the rail system already exists and the cost of running a further 2km is low. Also, the HRE option decreases bus passenger km in the CBD (as some potential bus passengers stay on the train) and overall PT OPEX decreases.

2.3.2 Capital Expenditure (CAPEX)

Table 13 CAPEX Performance Measure Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
3.2.1 Capital Expenditure ($M)	0	16-35 0	23-45 0	98-319 -1	94-306 -1	172-392 -1	165-376 -1	625-1125 -2	250-425 -1
Average Score	**0**	0	0	-1	-1	-1	-1	-2	-1

Explanation of Performance Measure

This performance measure assesses the capital cost (including staging and land-take considerations) estimates of the options relative to the Base Case acknowledging the estimates are pre-feasibility and the options have yet to be fully scoped.

Explanation of Scoring

- **The Bus Priority** options assume minimal expenditure on an additional 50 buses to cater for forecast increases in demand. Some lane marking and carriageway strengthening has been assumed on the waterfront. This minimum CAPEX is assumed to score 0, the same as the Base Case.
- **The HRE Waterfront** is based on the range of rates from the international review, per kilometre costs published by the World Bank and a previous study carried out for Greater Wellington. An allowance of $100M has been made for rolling stock based on 4 extra six car trains. This estimate will be further refined at the short list. No allowance is required for undergrounding new stations, underground connections to the existing rail station. Land acquisition costs will be considered at the short-list stage.

- **The BRT and LRT** options assume infrastructure upgrades and additional buses/rolling stock in line with the range of rates from the international review and per kilometre costs published by the World Bank. Given that the at grade options cost estimates are approximately midway between the underground option and the bus options, these options have been scored at -1.
- The HRE Underground option is based on the range of rates from the international review and per kilometre costs published by the World Bank. Considerable cost would be involved in underground tunnels due to high seismic risks and potential for liquefaction as the route is generally on reclaimed land. Due to the high capital cost of this option it scores negatively in comparison to the Base Case and is scored at -2.

2.3.3 Construction Feasibility/Risk

Table 14 Feasibility and Risk – Performance Measure Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
3.3.1 Construction Feasibility	0	0	0	-1	-1	-1	-1	-2	-1
Average Score	0	0	0	-1	-1	-1	-1	-2	-1

Explanation of Performance Measures

This performance measures assesses the construction feasibility/risk and stageability of the options relative to the Base Case.

Explanation of Scoring

- **The Bus Priority** options involve only minimal CAPEX and construction work relative to the Do-minimum and therefore score the same as the Base Case at 0.
- **BRT, LRT and HRE (Waterfront)** options do involve some risks including turning radii, service relocation and dislocation of existing traffic. However the options are all at grade and less complicated compared to the HRE Underground. BRT and LRT could both be staged, for example from the Station to Courtenay Place. For HRE waterfront It has been assumed that rail would only be constructed as far as Courtenay Place and that a second stage to the hospital would be overprovision of capacity and this stage could be adequately covered by bus services. The feasibility/risk and stageability is scored at -1.
- **The HRE Underground** involves risk due to the seismic hazard of building underground in a potentially liquefaction zone (made ground). Ground water issues next to the harbour including the risk of flotation caused by uplift forces would also be expensive to deal with. Stageability is similar to HRE waterfront as it has been assumed the tunnel would be constructed to Courtenay Place in one stage and that a second stage to the hospital would be overprovision of capacity and this stage could be adequately covered by bus services This option is scored at -2.

2.4 Environmental and Safety Criteria

Table 15 Environmental and Safety – Summary Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
4.1 PT Vehicle Emissions	0	0	0	0	0	1	1	0	0
4.2 Noise etc.	0	0.3	0	0.3	0.3	0.7	0.7	1	-0.3
4.3 Heritage	0	0	-0.5	-0.5	-0.5	-0.8	-0.8	0.3	-1.3
4.4 Social Severance and Safety	0	0	-1.2	-0.4	-1.2	0	-1.4	-0.6	-1.4
4.5 Consentability	0	0	0	0	0	-1	-1	-2	-2
Average Score	**0**	**0.1**	**-0.3**	**-0.1**	**-0.3**	**0**	**-0.3**	**-0.3**	**-1.0**

This criterion assesses the environmental and safety effects of each option. Performance measures include:

- PT Emissions (20% weighting);
- Noise, Air Quality and Vibrations (20% weighting);
- Heritage (20% weighting);

- Social severance and safety(20% weighting); and
- Consentability (20% weighting).

The summary scores for this criteria are as follows and a more detailed explanation of the scoring is given below.

2.4.1 PT Vehicle Emissions

Table 16 Emissions – Performance Measure Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
4.1.1 Bus (km)	4,170	4,170	4,170	4,170	4,170	3,880	3,880	3,950	3,950
4.1.2 LRT (km)	0	0	0	0	0	120	120	0	0
4.1.3 HRE (km)	1,490	1,490	1,490	1,490	1,490	1,490	1,490	1,540	1,540
4.1 Total PT Emissions (kg CO2)	125	125	125	125	125	116	116	119	119
Average Score	**0**	0	0	0	0	1	1	0	0

Explanation of Performance Measures

This performance measure assesses the distance travelled by each mode assuming that this causes proportional emissions. Each of the vehicle types have assumed efficiency and emissions per kilometre (Bus: 0.75 TCO^2 /km, Rail: 0.17TCO^2 /km^2). Emissions from General traffic have not been included in the measure as this would overwhelm the result and not allow for meaningful comparison.

The emissions assessment excludes consideration of the original power source. Marginal generation is likely to be from non-renewables, however only local emissions have been considered in this criteria.

Explanation of Scoring

- **Bus Priority and BRT** options are the same as the Base Case and scored 0. The evaluation takes account of the fact that the existing bus fleet has a large number of trolley buses that are electric powered, not diesel.
- **LRT options** increase LRT kilometres, but reduce bus kilometres. The LRT options have the lowest public transport emissions locally as LRT is assumed to be electric and there is a reduction in overall bus travel. This is scored +1.
- **HRE options** increase rail kilometres, but reduce bus kilometres leading to an overall reduction in emissions. Assuming that HRE is electric or diesel does not affect the final scores as all options including the Base Case reduce by approximately the same amount and scored +1.

2.4.2 Noise, Air Quality, Vibration

Table 17 Noise, Air Quality and Vibration – Performance Measure Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
4.2.1 Noise	0	0	0	0	0	1	1	2	-1
4.2.2 Air Quality	0	1	0	1	1	1	1	1	1
4.2.3 Vibrations	0	0	0	0	0	0	0	1	-1
Average Score	0	**0.3**	**0**	**0.3**	**0.3**	**0.7**	**0.7**	**1.3**	**-0.3**

Explanation of Performance Measure

This performance measure includes the assessments for:

- **Noise** – e.g. construction noise, traffic noise, maintenance noise, presence of sensitive receivers (homes, schools, hospitals). (33% weighting).
- **Air Quality** - e.g. dust, air pollution, greenhouse gas emissions, odour (33% weighting).

[2] Copenhagen Resource Institute (CRI)

- **Vibration** - e.g. construction and maintenance vibration, pavement surface, heavy traffic vibration, presence of sensitive receivers including historic buildings and features (33% weighting).

Explanation of Scoring

- **The Bus Priority Central** is the status quo and therefore scored 0 (neutral effects).
- **For Bus Priority and BRT** options the addition of scheduled bus services will add little additional operational noise, however some additional short-term construction noise. These options are scored at 0. As with noise, air quality along the routes is unlikely to be affected by the addition of buses. Some small improvements to the central route may arise from the removal of some diesel buses for the waterfront options. The introduction of buses along the general traffic route will not add additional vibration effects and these are scored at +1.
- **For LRT** options it is assumed that noise from these units would be lower than noise from buses as they are electrically powered. Noise and air quality improvement may occur from the removal of diesel buses, notably along Golden Mile and are scored +1. LRT may have additional vibration effects, depending on the track design but this would need to be investigated and are scored 0.
- **For the HRE Underground** option, operational noise will be minimal. On the basis of sound engineering practices it can be assumed that the vibration effects will be minimised and this option is scored +2.
- **For HRE Waterfront**, it's assumed that an above ground rail line will be noisier than currently exists and also that the potential for vibration is higher than exists currently, although the extent to which these are issues would depend on the train frequency and track design and would probably be minor. These aspects are scored at -1.

2.4.3 Heritage and Open Space Impacts

Table 18 Heritage and Open Space- Performance Measure Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
4.3.1 Culture and Heritage	0	0	0	0	0	0	0	0	0
4.3.2 Ecological Resources	0	0	0	0	0	-1	-1	0	-1
4.3.3 Visual Quality	0	0	-1	-1	-1	-1	-1	1	-2
4.3.4 Urban Design	0	0	-1	-1	-1	-1	-1	0	-2
Average Score	**0**	**0**	**-0.5**	**-0.5**	**-0.5**	**-1**	**-0.8**	**0.3**	**-1.3**

Explanation of Performance Measure

This performance measure includes the assessments for:

- **Culture and Heritage** – e.g. wahi tapu and Statements of Identified Maori Interests, archaeological sites, historic buildings, places, trees and special features (25% weighting).
- **Ecological Resources** – e.g. significant vegetation, fauna passage, habitat protection, special trees, reinstatement of vegetation, slope stabilisation, use of low-growth vegetation to reduce maintenance costs (25% weighting).
- **Visual Quality** – e.g. landscaping, retaining walls, noise walls, views from roads neighbouring properties (25% weighting).
- **Urban Planning/Design** - e.g. context sensitive design, including aesthetics of structures (refer PSG/12 for guidance). (25% weighting).

Explanation of Scoring

The Bus Central is the status quo and therefore scored 0 (neutral effects).

- **For Bus Priority Waterfront and BRT Waterfront,** the waterfront already has one northbound trolley bus overhead line. There is currently no southbound provision where one would be required. Locations of bus stops and bus shelters would need to be confirmed and any effects on Lambton Harbour area and its ongoing development would need to be established particularly if three through lanes of traffic are to remain on both sides of the Quays. Some limited visual effects but from a social perspective the transport spine is not located where the majority of employment is. Some new bus stops and bus shelters that would need to integrate with the existing Lambton Harbour development.

- **For BRT Central,** some loss of visual quality through the introduction of segregation presumably via fencing to limit pedestrian crossing points. Introduction of barriers to movement and some potential loss of visual quality.
- **For LRT Central,** the option appears close to the Maori heritage site in the central median of Kent and Cambridge Terrace at the intersection with Courtenay Place but assumed that this can be avoided. Some loss of visual quality through the introduction of new fixed infrastructure. Assume that pedestrian segregation will be less than BRT as LRT movements will be less. Overhead lines are similar in appearance to overhead trolley wires but may need to be higher. Introduction of barriers to movement may or may not be required and some loss of visual quality.
- **For LRT Waterfront,** the loss of three traffic lanes on the Quays may mean the loss of the planted central reservation. Some loss of visual quality through the introduction of segregation presumably via fencing to limit pedestrian crossing points and segregate the traffic on the Quays. Overhead lines are similar in appearance to overhead trolley wires but may need to be higher. Any effects on Lambton Harbour area and ongoing development would need to be established particularly if three through lanes of traffic are to remain on both sides of the Quays. Introduction of barriers to movement and some loss of visual quality. From a social perspective the public transport spine on the waterfront is not located where the majority of employment or social activity is.
- **For HRE Underground,** on the basis that the route is clear of existing building footprints during construction there is unlikely to be any effects. If any street trees or landscaping are affected they can be replaced. No impacts post construction. No impacts except in respect of the location of the stops and where users need to return to ground level.
- **For HRE Waterfront,** the loss of three traffic lanes on the Quays may mean the loss of the planted central reservation. New fixed rail, barriers and overhead transmission will be a significant change to existing and will affect the visual qualities of the Lambton Harbour Area. Introduction of barriers to movement and some loss of visual quality. From a social perspective the public transport spine on the waterfront is not located where the majority of employment or social activity is. Will inhibit greater accessibility to the Waterfront from the CBD.
- **Culture and Heritage**. All options are assessed to have no significant effect compared to the Base Case and are therefore scored at zero.
- **Ecological resources**. LRT options and Heavy Rail Waterfront may result in loss of planting in central reserves in order to maintain traffic lanes. These options have therefore been scored at -1.
- **Visual Quality.** Waterfront options, BRT and LRT Central will require the introduction of some fixed items such as bus shelters and raised kerbs for bus options and overhead wires for LRT. These have been scored at -1. Heavy Rail waterfront would involve significant new infrastructure along the waterfront and has been scored at -2.
- **Urban Design**. Waterfront options, BRT and LRT Central will require the introduction of some fixed items such as bus shelters and raised kerbs for bus options and overhead wires for LRT. These have been scored at -1. Heavy Rail waterfront would involve significant new infrastructure along the waterfront and has been scored at -2. Heavy Rail underground would have no significant scored at 0.

2.4.4 Social Severance and Safety

Table 19 Social Severance and Safety – Performance Measure Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
4.4.1 Land Use Integration	0	0	-2	0	-2	-1	-2	-1	-2
4.4.2 Public Health	0	0	-1	0	-1	0	-1	0	-1
4.4.3 Cycling	0	0	0	0	0	-1	-1	0	0
4.4.4 Pedestrian Safety	0	0	-1	-1	-1	1	-1	0	-2
4.4.5 Social Severance	0	0	-2	-1	-2	1	-2	-2	-2
Average Score	**0**	**0**	**-1.2**	**-0.4**	**-1.2**	**0**	**-1.4**	**-0.6**	**-1.4**

Explanation of Performance Measures

This performance measure includes the assessments for:

- **Social Responsibility** – e.g. social severance, social interaction, connectivity (20% weighting);
- **Land use and transport integration** – e.g. integration of land use and development with transport networks, reverse sensitivity, access management (20% weighting);
- **Public Health** – e.g. stress to individuals and community, personal security, cycling and walking opportunities (20% weighting);
- **Cycling infrastructure and cycle crossing facilities** – e.g. on highway cycle lanes, segregated cycle path adjacent to SH, links into local cycling network; shared cycle/pedestrian crossing at traffic signals, widened traffic island to accommodate cyclists where cycle route crosses SH, dropped crossings (20% weighting); and
- **Walking infrastructure / pedestrian crossing facilities** - e.g. new or widened footway, connections to local road footways; signalised crossings, traffic islands, dropped crossings, pedestrian desire lines.

The Waterfront options generally do not necessarily promote land use and transport integration. The higher height limits and as a consequence the higher density of employment, are located either side of the existing public transport spine. On the eastern side of the waterfront large amounts of additional employment are not envisaged.

Explanation of scoring

- **The Bus Priority Central**, is similar to the status quo and therefore scored 0 (neutral effects).
- **For Bus Priority and BRT Waterfront,** may be of benefit to the overall usability of the waterfront as a destination with an increase in pedestrians accessing public transport. Possible increases to severance across the waterfront from the introduction of buses. Pedestrian sheltering is an issue that needs to be considered.
- **For BRT Central,** with the segregation of the bus route there will be implications for existing levels of pedestrian movement. For example the mid-block crossings of Lambton Quay that are available currently will not be possible to the extent they are currently. Some disruption to general traffic movement through intersections and accessibility for serving CBD properties. Cycling in general traffic lanes can continue or use alternatives. Pedestrians will not be able to cross the alignment as they do currently with the BRT route being physically segregated mid-block. As a consequence pedestrians will need to cross at specific points. The degree of severance for BRT options will largely be a design consideration.
- **For LRT Central,** LRT will have a much lesser severance impact than BRT because it can operate in mixed pedestrian environments and would require fewer vehicle movements per hour than BRT. The degree of severance for LRT options will largely be a design consideration.
- **For LRT Waterfront,** the public transport spine would be removed from the central city to an edge location potentially leading to longer walking distance for many users from their origins and to their destinations. Pedestrians will not be able to cross the alignment as they do currently with the LRT route being physically segregated mid-block. As a consequence pedestrians will need to cross at specific points. A number of intersections may require restrictions on movements including pedestrian movements.
- **For HRE Underground,** would consolidate public transport to three locations (Railway Station, Courtenay Place and one mid- block) to access public transport. As with all waterfront routes this generally does not promote land use and transport integration along the Waterloo, Customhouse and Jervois Quay areas. No additional negative effects on public health, walking and cycling infrastructure.
- **For HRE Waterfront,** fixed infrastructure may create a psychological barrier to movement. Assume that this can be accommodated elsewhere on the network. Additional at grade crossing required at Waterloo Quay and significant restrictions of pedestrian movements to designated crossing points.
- **Land Use Integration,** The Waterfront options do not necessarily promote land use and transport integration and are scored at -2. The underground option could potentially be better integrated with existing buildings and is scored at -1. For LRT Central there may be some additional effects to existing as the location of the interchanges and their form at the Railway Station and Hospital are not yet known and therefore scored at -1.
- **Public Health** At grade waterfront options could create a barrier to movement and are therefore scored at -1. Emissions from diesel buses have negative health effects due to particulates.

- **Cycling Safety,** For LRT options the loss of road space and parking from Courtenay Place to the Hospital may impact on existing cycling movements and cycle safety and are scored at -1. This will need to be considered and confirmed.
- **Pedestrian Safety,** BRT tracks would also impact cycle safety. For BRT options barriers may be required to address pedestrian safety and are therefore scored at -1. HRE Underground would be similar to status quo. HRE Waterfront would have significant severance effects and is scored at -2. For Bus Waterfront there would be significantly more pedestrians that need to access the waterfront, the location of crossings and the phasing of traffic signals may need to be changed to address pedestrian safety. Pedestrian shelter is also an issue that needs to be considered. This option is scored at -1. For LRT C, LRT can operate in mixed pedestrian environments and would require fewer vehicle movements per hour than BRT This option scored at +1.
- **Social Severance,** for waterfront options public transport spine would be removed from the central city to an edge location potentially leading to longer walking distance for many users from their origins and to their destinations. In addition the lack of pedestrian cover such as verandahs across the route is an issue. However, may be of benefit to the overall usability of the waterfront as a destination with an increase in pedestrians accessing public transport. Possible increases to severance across the waterfront from the introduction of buses. Waterfront options scored at -2. For BRT C with the segregation of the bus route there will be implications for existing levels of pedestrian movement. For example the mid-block crossings of Lambton Quay that are available currently will not be possible to the extent they are currently. Some disruption to general traffic movement through intersections and accessibility for serving CBD properties. This option scored at –1. For LRT C, LRT can operate in mixed pedestrian environments and would require fewer vehicle movements per hour than BRT. This option scored at +1.

2.4.5 Consentability

Table 20 Consentability – Performance Measure Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
4.5.1 Consentability	0	0	0	0	0	-1	-1	-2	-2
Average Score	**0**	**0**	**0**	**0**	**0**	**-1**	**-1**	**-2**	**-2**

Explanation of Performance Measures

This performance measure is from the perspective that some options will require little or no work beyond the existing road reserve (i.e. from private property boundary to private property boundary) but others may. Several statutes that may require consideration for the options include RMA1991, LTMA 2003, LGA1974, LGA2002, Reserves Act 1977, Railways Act 2005 and Historic Places Act 1993.

Explanation of Scoring

- **For Bus Priority Central,** this option effectively represents the status quo similar to the Base Case. It is considered that there are no particular consent issues with its implementation. **For Bus Waterfront,** this includes the possible location of bus stops on road reserve. Bus shelters on legal road can be established as of right within the central area and in suburban centres. However, consentability is considered reasonably straightforward. Reconfigurations will be of public interest, consentability or public support for the option is considered straightforward but not to the same degree as Bus Central and scored at 0.
- **For BRT Central** may result in loss of a limited amount of car parking and intersection capacity. **For BRT Waterfront,** the separate busway, loss of a limited amount of carparking and intersection reconfigurations will be of public interest. The location of bus stops and bus shelters will require assessment, particularly if they need to be located on private land. Consentability or public support for the option is considered straightforward and therefore scored at 0.
- **For LRT Central**, there is considerable change to the existing configuration with a number of altered intersections, establishment of dedicated LRT lanes, removal of parking and loss of traffic lanes requiring consultation or specific consent from NZTA. In light of the complexity of the physical changes, consentability or gaining public support for the option is considered moderately difficult. **For LRT Waterfront,** there is considerable change to the existing layout and function of the waterfront routes and on Kent and Cambridge Terraces. There is the introduction of new and higher overhead facilities. There are a number of altered intersections, establishment of dedicated LRT facilities, removal of parking and the loss of traffic lanes

requiring at least consultation or specific consent. In light of the complexity of the physical changes, consentability or gaining public support for the option is considered moderately difficult and scored at -1.

- **For HRE Underground,** a connecting station at the Railway terminus, one station at a midpoint and the terminating station at Courtenay Place are proposed. How the stations may integrate back to surface level is yet to be determined. Most environmental effects are contained within the tunnels. In terms of consentability regional resource consents are required for earthworks and discharges during construction. Subject to sound engineering practices, on environmental grounds this option is seen to be straightforward from a consentability perspective and is scored at -2.
- **For HRE Waterfront,** there is proposed to be a connecting station at the Railway terminus, one station at a midpoint and the terminating station at Waitangi Park. All other railway lines in the region are designated for rail purposes and the support of Kiwirail to operate and maintain a designation will be required. This option has a number of issues particularly in respect of severance and amenity (see 4.3). There may be a significant consent process if the rail line is designated. As such consentability and receiving public support for the option is foreseen as a barrier and scored at -2.

2.5 Resilience Criteria

2.5.1 Ease of Recovery from Natural Disaster and Service Disruption

Table 21 Resilience Criteria - Summary Scoring

Performance Measure	Base Case	Bus		BRT		LRT		HRE	
		C	WF	C	WF	C	WF	UG	WF
5.1 Ease of Recovery	0	0	0	0	0	-1	-1	-2	-1
Total Score	**0**	**0**	**0**	**0**	**0**	**-1**	**-1**	**-2**	**-1**

Explanation of Criteria

This criterion assesses the potential recovery of the PT system relative to the Base Case from both natural disasters and service disruption. The recent Christchurch earthquakes and Japanese tsunami have highlighted the risks of natural disasters in seismic areas and prove a context for this criterion.

In Wellington it is anticipated that it could take 42 days to provide emergency supplies to the city. If a major earthquake occurs in Wellington widespread damage is likely in the CBD from falling masonry and glass meaning roads could take weeks/months to reopen. Given the narrow strip of land between the hills and the harbour it could be many months before businesses are up and running.

This criteria also covers planned service disruptions. e.g. the Hobbit film premiere will require the closure of Courtenay Place to buses.

Explanation of Scoring

As noted above the CBD could be closed for weeks/months and therefore buses would need to reroute possibly terminating outside the CBD if road access to the CBD is not possible. Buses are clearly flexible but rely on roads being open to run. Buses can recover within hours from a service disruption caused by road closure or power supply as seen on a number of occasions in recent years.

- **The BRT** options have the same issue as needing roads to be open for access. However it is assumed the BRT buses could be rerouted in the same way as the bus options and therefore scores the same as the Base Case. Service disruption recovery, planned or un-planned, as per buses.
- **The LRT and HRE Waterfront** options also require road access but the infrastructure has a higher degree of complexity and would take longer to reinstate as seen in Christchurch. Recovery from service disruption e.g. from loss of from power supply can be achieved within hours as seen on similar events on Wellington rail network.
- **The HRE Underground** option is the most complex and most costly to repair and scored the lowest of the options. Liquefaction of the ground surrounding the tunnel could occur. Inundation from tsunami or seismic activity in the harbour is also a risk. This option was considered to be significantly more at risk than at grade solutions.

The summary scores for this criteria are as follows and a more detailed explanation of the scoring is given below.

2.6 Summary of Scoring Outcomes

The overall scoring for all criteria is presented in Table 25, and also depicted graphically in Figure 5 below. These scores are the average values of the performance criteria detailed throughout this document. These scores have been combined using the primary weightings based on ILM weightings.

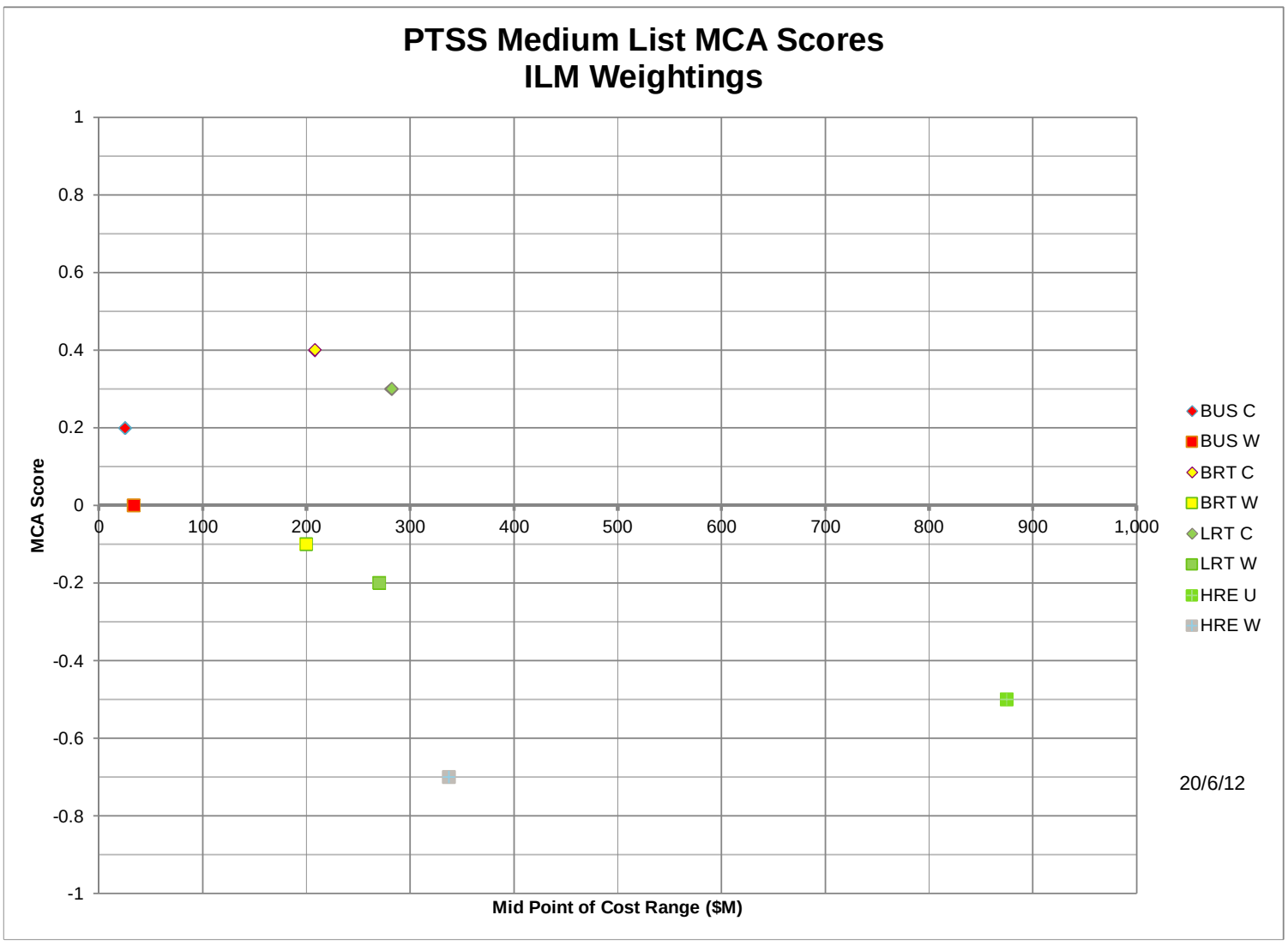
Table 22 MCA Criteria – Final Scores

Criteria	Base Case	Bus C	Bus WF	BRT C	BRT WF	LRT C	LRT WF	HRE UG	HRE WF
1 Strategic Alignment	0	0.3	-0.1	1	-0.5	1	-0.5	-0.3	-1.5
2 Benefits and Perception	0	0.3	0.3	0.5	0.5	0.5	0.5	0.8	0.5
3 Financial and Technical Feasibility	0	0	0	-0.7	-0.7	-1	-1	-1.7	-0.5
4 Environmental and Safety	0	0.1	-0.3	-0.1	-0.3	0	-0.3	0	-1
5 Resilience	0	0	0	0	0	-1	-1	-2	-1
Total Score	0	**0.2**	**0**	**0.4**	**-0.1**	**0.3**	**-0.2**	**-0.2**	**-0.7**

Financial and Technical Feasibility including cost is considered too important to be combined with the other criteria and is therefore considered separately in its own right. Also the other criteria are more akin to benefits therefore plotting MCA scores excluding cost against cost starts to give a picture of value for money and the level of benefits achieved at a given cost. The costs and benefits will be looked at in greater detail at the short list stage when monetised benefits will be quantified in accordance with NZTA's Economic Evaluation Manual.

Figure 3 gives a graph of MCA scores (excluding cost) versus cost.

Figure 3 MCA Scores

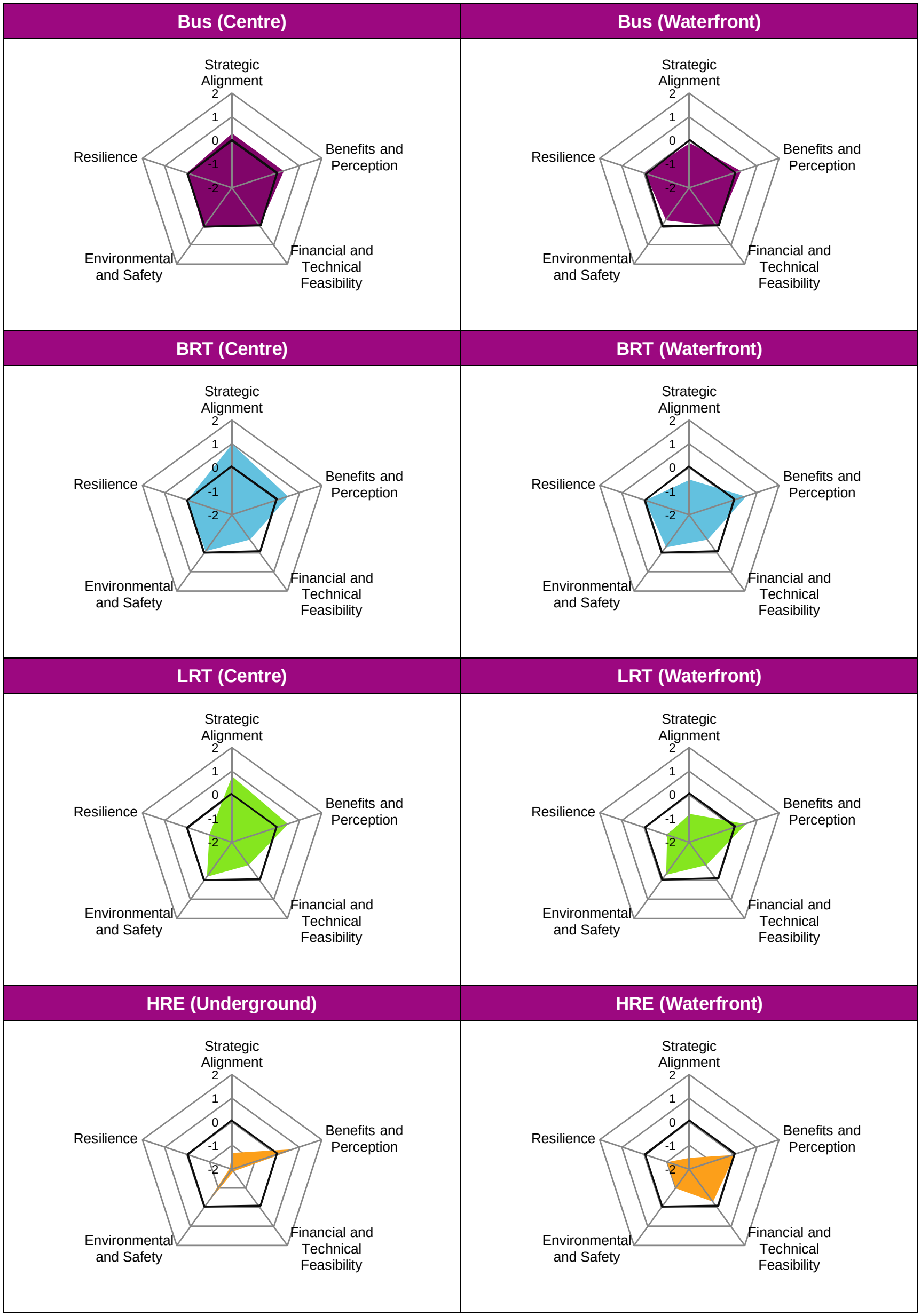


The graph shows there are three options with MCA scores better than the Base Case and also the relative estimated capital cost of the options. At this stage only capital costs are shown in the above graph. Whole of life costs that combine capital and operational cost will be estimated at the short list stage. .

The above scores are illustrated graphically in the following spider diagrams. There is one diagram for each of the options. Each diagram has 5 axes (or dimensions) which represent the 5 headline criteria. The concentric lines represent the 5-point scoring system and so this presents a simple picture of how each of the eight options

fare on the criteria. The size of the shaded area indicates how well each option performs against the MCA performance measure.

Figure 4 Spider Diagrams Representing Summary Scores of Options



3.0 Sensitivity Tests

The MCA process has provided a framework which allows the assessment of a number of criteria representing both technical and perceptive measures to be evaluated on an equal basis. These criteria are then weighted to provide a final result. The weightings used in this assessment are consistent with the ILM and are considered appropriate for use. To understand the robustness of the result of the MCA a series of sensitivity tests have been carried out to ensure that the final result has not been dictated by the ILM weightings. Table 23 displays the ILM weightings and the 3 sensitivity tests. The tests include:

- **Equal weighting** – All performance measures have equal weighting.
- **Excluding Costs** – The cost measure is excluded and all other performance measures have equal weighted. This provides the opportunity to consider what option would be chosen if cost were not a deciding factor.
- **Excluding Resilience** – The resilience measure is excluded and all other performance measures have equal weighting. This provides the opportunity to understand whether an option which is less resilient to natural disasters and other impacts on operation would be chosen.

Table 23 MCA Sensitivity Test Weightings

Performance Measure	Weighting			
	ILM	Equal	Excluding Costs	Excluding Resilience
Strategic Alignment	30%	20%	25%	25%
Benefits and Perception	30%	20%	25%	25%
Financial and Technical Feasibility	0%	20%	0%	25%
Environmental and Safety	25%	20%	25%	25%
Resilience	15%	20%	25%	0%

Table 24 displays the results of the sensitivity tests:

Table 24 MCA Sensitivity Test Results

Scenario	Weighting			
	ILM	Equal	Excluding Cost	Excluding Resilience
Bus Central	0.2	0.1	0.2	0.2
Bus Water Front	0	0	0	0
BRT Central	0.4	0.1	0.4	0.2
BRT Water Front	-0.1	-0.2	-0.1	-0.3
LRT Central	0.2	-0.1	0	0.1
LRT Water Front	-0.3	-0.5	-0.4	-0.4
HRE Underground	-0.5	-1	-0.7	-0.7
HRE Water Front	-0.9	-0.8	-0.9	-0.7

These results show that the three options identified as preferred through the medium list MCA process remain unchanged. The analysis shows that even through the sensitivity, tests the four worst performing options remain unchanged. Of note from this analysis is that Bus and BRT Central options are superior to the Base Case for all sensitivity tests and Bus Water Front is as good as the Do Minimum Case. LRT central performs worse when weightings are equal and is sensitive to resilience and cost weighting.

The results of the MCA sensitivity tests provides comfort that a robust result has been achieved. Varying the weightings given to the performance criteria has not changed the overall result.

4.0 Conclusion

This Chapter presents the medium list evaluation conclusions. The three options that score greater than the Do-Minimum case are illustrated in Figure 5, described further below.

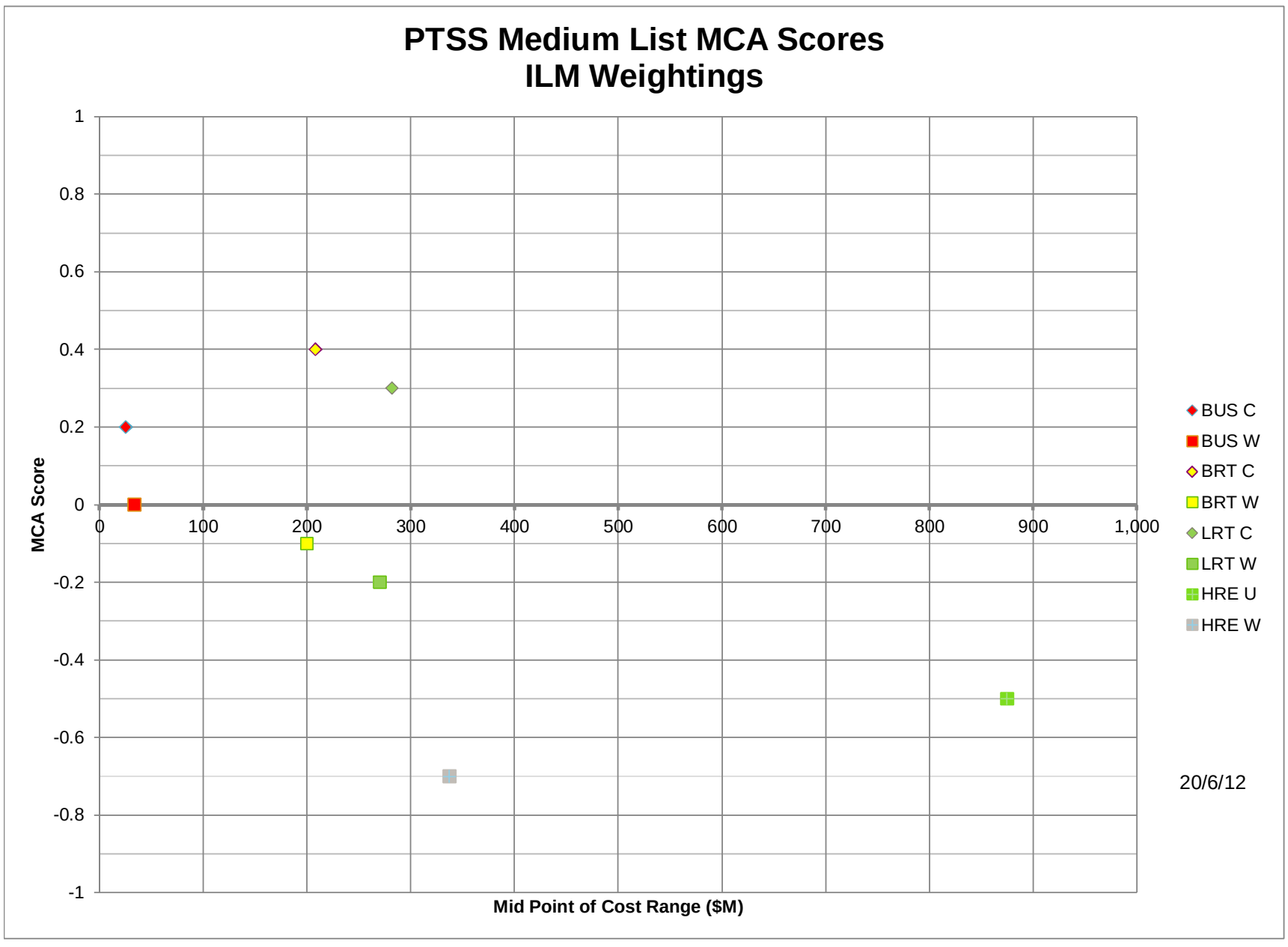
- Bus rail transit, along a central alignment;
- Bus priority option, along a central alignment; and
- Light rail transit, along a central alignment.

These three options have been sensitivity tested with three different weightings of the MCA criteria:

- **Equal weighting** – All performance measures have equal weighting.
- **Excluding Costs** – The cost measure is excluded and all other performance measures have equal weighting. This provides the opportunity to consider what option would be chosen if cost were not a deciding factor.
- **Excluding Resilience** – The resilience measure is excluded and all other performance measures have equal weighting. This provides the opportunity to understand whether an option which is less resilient to natural disasters and other impacts on operation would be chosen.

The results tested against these weightings provide the same results in that bus priority central, BRT central and LRT central scored greater than the Do-minimum. This provides a level of comfort that these are the three most beneficial options to proceed to the short list evaluation.

Figure 5 Medium List MCA scores



Note: Do-Minimum is scored zero on the graph for comparative purposes.

4.1 Recommended Options

The following options are recommended for further, more detailed, consideration during the remainder of the Study:

4.1.1 Base Case

This is the base case against which the other options are compared. It involves only minor and already committed projects in the study area.

The Base Case option assumes that all committed Public Transport services and committed road network improvements will continue much as they do at present, and that this will maintain a minimum level of service over the evaluation period of 30 years. Benefits over and above the Base Case, which some of the options may present, can then be investigated further, according to these criteria.

Capital projects are included in the Base Case if they are 1) outside the PT Spine study area, [1] 2) already committed, or 3) are needed to maintain a minimum level of service over the evaluation period of 30 years. These committed and minor improvements are to make sure that the transport system in the model does not show excessive and unrealistic delays and continues to provide a minimum level of service for underlying increases in transport demand, for example due to growth in population.

The Base Case is based on the Wellington City Bus Review network and the transport modelling will provide an understanding of how it will perform in the modelled year 2041.

4.1.2 Bus Priority Option, Along a Central Alignment

This option provides strong consistency with the Base Case option in terms of the employment and population catchment numbers and associated with the flexibility of providing stops along a similar alignment. In all other respects, there is strong similarity to the impacts of the current Base Case, and additional priority measures are not considered to offer any significant challenges. The option ranks within the top three options to be taken forward in the remainder of the study.

4.1.3 Bus Rail Transit, Along a Central Alignment

BRT meets the goal of high quality PT but it also has plenty of scope to increase capacity once signal prioritisation and an exclusive bus right of way are established as part of the BRT options. For these reasons it scores positively relative to the Base Case.

For BRT Central, with the segregation of the bus route, there will be implications for existing levels of cyclist pedestrian movement. Whilst these may be considered minor, they must be investigated further.

It will be important to further consider the extent of anticipated disruption to general traffic movement through intersection changes and accessibility for serving CBD properties.

Overall this option ranks within the top three options to be taken forward in the remainder of the Study.

4.1.4 Light Rail, Along a Central Alignment

LRT is similar to BRT in that it meets the goal of high quality PT but it also has plenty of scope to increase capacity once signal prioritisation and an exclusive right of way is established as part of the LRT options. For these reasons it scores positively relative to the Base Case.

Regarding the Environment and Safety, this option would create a low level of severance on Lambton Quay, with the result that pedestrians may not be able to cross the alignment as they do currently with the LRT route being physically segregated mid-block. Rail tracks may cause a hindrance to cyclists on Lambton Quay and they may prefer to use alternative routes.

Further investigations are required to understand the change to the existing traffic system configuration with a number of altered intersections, establishment of dedicated LRT lanes, removal of parking and loss of traffic lanes requiring consultation or specific consent from NZTA. In light of the complexity of the physical changes consentability and gaining public support for the option is considered to be moderately difficult.

Overall this ranks within the top three options to be taken forward in the remainder of the Study.

[1] as in Executive Summary

4.2 Rationale for Options Recommended to be Dismissed

With reference to the scores and spider diagrams referred to in Chapter 2.0, the following options are considered to have insufficient merit for further evaluation:

4.2.1 Base Case option

This is the base case against which other options are compared and is therefore automatically included in the short list for further consideration.

4.2.2 Bus Priority Option, Along a Waterfront Alignment

Whilst comparable to the Bus Central option and the Base Case option in almost all regards, this option does attract a slight negative in the sense that its walking catchment along the Waterfront does not cover the whole CBD.

4.2.3 Bus Rail Transit, along a Waterfront alignment

As a mode option, BRT meets the goal of high quality PT and therefore scores positively relative to the Base Case.

However, the waterfront alignment generally does not align with N2A and WCC land use policy.

On balance, the score for this option does not allow it to rank within the top three and consequently should be dismissed from any further investigation.

4.2.4 Light Rail, along a Waterfront Alignment

As a mode option, LRT also meets the goal of high quality PT and therefore scores positively relative to the Base Case.

However, the waterfront alignment generally does not align with N2A and WCC land use policy.

The fixed nature of this mode makes it relatively more difficult to reroute than say BRT, in the event of a natural or service disruption.

On balance, the score for this option does not allow it to rank within the top three and consequently should be dismissed from any further investigation.

4.2.5 Heavy Rail Extension, Along an Underground Alignment

A benefit of this option is that it provides a higher capacity and this is likely to increase average travelled distance and reduce travel times. This mode is perceived as one of the best options from this perspective.

However, from the other perspectives considered, this option is not favourable. It is considered to have significantly smaller employment and population catchment numbers due to the alignment being further from the centre of development and only two stations. This option also does not align to N2A and the RLTS.

In terms of cost and construction feasibility, the HRE Underground option increases costs significantly due to tunnelling, seismic considerations, and lighting and ventilation requirements.

This option involves high risk due to the seismic hazard of building underground in a potential liquefaction zone (made ground), and ground water issues next to the harbour including the risk of flotation caused by uplift forces.

Finally, from a resilience perspective, this underground option is the most complex and most costly to repair and scored the lowest of the options. This option was considered to be significantly more at risk than at grade solutions.

On balance, the score for this option does not allow it to rank within the top three and consequently should be dismissed from any further investigation.

4.2.6 Heavy Rail Extension, Along a Waterfront alignment

As with the underground option, a benefit of this option – though at grade - is that it provides a higher capacity and this is likely to increase average travelled distance and reduce travel times. This mode is perceived as one of the best options from this perspective.

Furthermore, although perceived to be an expensive option, the relative operational costs for the HRE Waterfront option are not significantly high as the rail system already exists and the cost of running a further 2km is low. From a capital cost perspective, the rolling stock fleet already exists, and the allowance required for new rolling stock is relatively small.

However, the HRE Waterfront alignment has a lack of consistency with strategy due to further severance of the CBD from the waterfront. Extension of the heavy rail system is not consistent with current RLTS and could have significant cost and operational implications for the Wellington Railway station at which trains currently terminate.

There may be a significant consent process if the rail line is designated. As such consentability and receiving public support for the option is foreseen as a barrier.

On balance, the score for this option does not allow it to rank within the top four and consequently should be dismissed from any further investigation.

5.0 Next Steps

On Greater Wellington endorsement that the above options should proceed to the Short List evaluation, additional analyses will be undertaken. There will be opportunities to review and provide input throughout, primarily facilitated through TWG and SG meetings.

The approach for this will be subject to agreement with GWRC. However the tasks listed below are considered the key elements.

Approach Confirmation

- The proposed short list evaluation approach will be supplied to client partners to allow for reviews and consolidated feedback. The shortlist evaluation approach can then be agreed.

Concept Designs

- Initially the underlying PT network will be defined in further detail to identify base characteristics such as integration and transfers. This will be followed by MRC reviews in light of their land use findings earlier in the Study;
- Following the initial definition of the PT network the concept scope of all four options will be prepared in a design brief. This will include: route analysis with identification of main routes and all possible sub-options to be considered; confirmation of priority for bus and LRT; definition of base assumptions in further detail; and identification of specific differences between bus and BRT options.
- Once agreement on the scope of works is gained, geometric alignment and cross sectional sketches will be completed along with preparation of a design philosophy for each of the three options. The design philosophy note will also include the outline Treasury Better Business Management Case and sequencing plan for all options.

Option Impact Assessment

- In parallel to the geometric alignment and cross section development, detailed impact assessments will be undertaken, including: transport integration; network and PT integration; land use evaluation; social, environmental and planning assessment. These will be similar in approach to the medium list but in more detail.

Cost estimation

- The Capital and Operational costs for each of the options will be developed to Feasibility level.

Modelling

- Once the service specification for each of the short list options has been defined, additional PT modelling and SATURN runs will be undertaken. These provide inputs to the economic evaluation in terms of benefits and dis-benefits. Sensitivity tests will be conducted by GWRC to form part of the overall understanding of the robustness of the option impacts on the network.

Economic evaluation

- This evaluation will allow for a more comparative assessment to be made of the four options. The benefits and costs will be estimated based on NZTA's Economic Evaluation Manual, as stipulated in the Inception and Scoping Report.

Appendix A

Option Descriptions

Appendix A Option Descriptions

1.0 Option Descriptions

1.1 Overview of Options

The short list assessment evaluated 88 options; these options included concepts of mode and alignment. The outcome of the assessment was confirmation of eight options to be taken forward to medium list testing. The medium list options include three different modes on two alignments with alternative infrastructure requirements. The modes are bus, light rail and heavy rail, with the alignments on the Golden Mile or along the waterfront for travel between the Wellington Rail Station and Courtenay Place. Infrastructure requirements range from bus priorities through to underground rail.

Table 25 displays how mode, alignment and infrastructure are combined to create the options.

Table 25 Medium List Option Overview

Option	Definition
Base Case	Involves only minor and already committed projects in the study area. Services and frequencies based on Wellington Bus Review.
Bus Priority Central	Bus priority lanes along the Golden Mile, Kent and Cambridge Terrace and Adelaide road where necessary.
Bus Priority Waterfront	Bus priority lanes along the waterfront, includes realigning bus routes from the Golden Mile onto the waterfront where necessary.
Bus Rail Transit (BRT) Central	Bus Rail Transit along the Golden Mile, Kent and Cambridge Terrace and Adelaide Road providing a separate right of way for buses only.
Bus Rail Transit (BRT) Waterfront	Bus Rail Transit along the waterfront, includes realigning bus routes from the Golden Mile onto the waterfront providing a separate right of way for buses only.
Light Rail Transit (LRT) Central	Light rail vehicles travel along the Golden Mile on steel rail tracks laid in the road. Degree of separation from cars, buses, cyclists and pedestrians varied to suit the particular situation.
Light Rail Transit (LRT) Waterfront	As per the previous option except the route follows the waterfront.
Heavy Rail Extension (HRE) Underground	Extends existing heavy rail lines southwards from Wellington Station in an underground tunnel. The exact route has not been confirmed but stations are assumed at the BNZ centre and Courtenay Place.
Heavy Rail Extension (HRE) Waterfront	As per the previous option except the trains would travel at ground level along the waterfront, rather than underground.

1.2 Option Definition

The following sections discuss each option in detail. Table 27 displays the assumptions and key parameters for the options and **Figure 13** - **Figure 18** display the potential alignments of the medium list options.

1.2.1 Base Case

The Base Case provides a base line as to the future level of service which might eventuate should current day assumptions on improvements to the PT and vehicle network continue. It also provides a base line against which the other options can be assessed. Benefits over and above the Base Case reveal how potential options may provide a superior level of service compared to the minimum levels provided. The Base Case includes future capital projects which are already committed, or are needed to maintain a minimum level of service over the evaluation period of 30 years. These improvements ensure that the transport system continues to provide a minimum level of service for underlying increases in transport demand. Table 26, details the capital projects included in the Base Case and the other improvements or assumptions related to trip making.

Table 26 Base Case Transport Network for Medium List

	Network Changes 2006 to 2011	Network Changes 2011 to 2041
Wellington Roads of National Significance changes		1) Basin Reserve (grade separation) 2) Inner City Bypass Upgrade and Ruahine Street Improvements 3) Aotea to Ngauranga Gorge
Roading Changes	1) Inner City Bypass 2) Rugby Street/Adelaide Road intersection 3) Dowse to Petone Interchange 4) MacKays Crossing overbridge 5) Otaki Roundabout 6) Lindale Grade Separation 7) Waiohine Bridge	1) Petone to Grenada 2) Rimutaka (Muldoon's) Corner Easing (modelled as a speed increase) 3) SH2/58 Grade Separation
Public Transport Changes	1) Rail extension to Waikanae and station upgrade 2) Muri Station closed 3) Bus lanes and priority (Adelaide Road, Karori Tunnel, Ngaio lights, parts of Willis Street and Lambton Quay, Manners Mall and priority at Courtenay Place) 4) 20% public transport fare increase (to reflect the observed increase in fares at 2006)	1) Implementation of Wellington City Bus Review (2011) routes 2) The effects of rail station upgrades, park-and-ride car parks, integrated ticketing, real time information systems 3) Bus lanes (those likely to be completed by 2026) 4) Improved rail rolling stock with higher speeds 5) Train services at 4 trains/hour in peaks and 2 trains/hour in inter-peak, except Wairarapa the same as existing
Other Changes		Effects of TDM include a 5% reduction in commuting trips by car to Wellington CBD, and of which 90% transferred to PT

The bus network comprised of routes and the frequencies they operate have been taken from the Wellington City Bus Review (2011). This review proposed an overlay of services based upon the frequency of services. The "Core" network comprises routes that run every 15 minutes throughout the day. The "Secondary" services fit around the Core but do not duplicate it and the "Peak" services support morning and evening peak commuter and education travel. Figure 10 displays the Core and Peak services that are included in the Base Case.

The medium list options are based upon Base Case assumptions but include the changes to infrastructure, services and public transport routes required to give effect to each option.

1.2.2 Bus Priority options

The Bus Priority option seeks to improve the travel time of buses through the study area through the provision of bus lanes and bus priorities at intersections where required. Figure 6 displays the proposed alignments and sections where continuous bus priorities are required. The provision of bus Priorities between the Wellington Rail Station and Vivian Street is based upon the identification of where buses are delayed on the network. The continuous bus priority terminates at Vivian Street because over 20 services per hour separate off to use the Victoria bus tunnel and there is less general traffic between Vivian Street and the Basin Reserve.

Bus Priority - Central Alignment

The main features of this option are:

- The option is provided within the existing roadway and follows the Golden Mile as currently used.
- There is only partial separation from other traffic through the use of bus priority lanes.
- Only partial intersection priority is allowed for over the majority of the route. Priority is provided on the basis of need.

- Bus stops are based on the existing spacing and locations with stations at the Wellington Rail Station and Newtown.

It is noted that whilst this assumes a core bus spine, it would not negate buses from using other routes in the City, as proposed in the Wellington City Bus Review.

Bus Priority - Waterfront Alignment

The main features of this option are:

- The option is provided within the existing roadway, travelling via the Waterfront.
- There is only partial separation with other traffic through the use of bus priority lanes.
- Only partial intersection priority is allowed for over the majority of the route. Priority is provided on the basis of need.
- Indicative bus stops are based on 250m – 400m spacing with stations at the Wellington Rail Station and Newtown.

It is noted that whilst this assumes a core bus spine, it would not negate buses from using other routes in the City, as proposed in the Wellington City Bus Review.

1.2.3 Bus Rail Transit

The BRT option provides priority and segregation for buses for the full length of the PT-Spine. Figure 7 displays the potential alignments. The central and waterfront alignments differ only between Courtenay Place and the Wellington Rail Station. At the medium list level, no decision has been made as to whether buses will travel on an entirely segregated route, or on a series of permanent bus lanes with full bus priority at intersections. Although, through the city centre it is likely that buses would travel on the local road network which could be converted to bus only. The benefit of a BRT is that services can join at multiple locations and are not constrained to terminate at the extent of the BRT corridor.

The BRT and Bus Priority options are similar in many aspects. They use the same vehicle types, routes can be the same, provide flexibility and can service the same catchments with the same level of accessibility. There is however a fundamental difference in the philosophy of the options. The BRT option is envisaged to include segregated or permanent bus lanes and priorities which operate throughout the day providing for an uncongested journey and provides a greater reliability of travel time. The Bus Priority option uses the local street network with bus lanes and bus priorities at intersections during peak periods to bypass congestion. In general bus priorities are provided in the peak direction of travel and may either revert to general traffic or parking during off peak periods.

BRT – Central Alignment

The main features of this option are:

- The option may be provided within the existing roadway and follows the Golden Mile as currently used through the CBD.
- Where a separate carriageway is provided there will be separation from other traffic/pedestrians via kerbs and fences through mid-block sections. The degree of separation will be a design issue.
- Intersection bus priority would be provided at all intersections.
- Indicative bus stops are based on 500m spacing.

BRT – Waterfront Alignment

The following base design assumptions have been established for the BRT waterfront alignment:

- The option may be provided within the existing roadway and follows the Golden Mile as currently used through the CBD.
- Where a separate carriageway is provided there will be separation from other traffic/pedestrians via kerbs and fences through mid-block sections. The degree of separation will be a design consideration
- Intersection bus priority would be provided at all intersections.
- Indicative bus stops are based on 500m spacing.

Both options are able to use the services specified in the Wellington City Bus Review. A complete review of services has not been included in the medium list assessment but should be undertaken to provide an input into short list testing.

1.2.4 Light Rail Transit

The LRT scenario provides a light rail line for the length of the PT-Spine. Figure 8 displays the potential alignments and indicative locations for stops and stations providing for transfers. The LRT options require a review of the proposed bus services and network to make best use of the capacity provided. This will include consideration of how services should change, where transfers take place and where there might be conflicts between the provision of LRT and bus services. This optimisation of services will be required as an input into short list testing.

LRT – Central Alignment

The following base design assumptions have been established for LRT:

- The option allows for as a minimum a LRT double track along the entire length through the Central Alignment.
- There is separation from other traffic/pedestrians via kerbs and fences through mid block sections outside the CBD. The degree of separation will be a design consideration. LRT has fewer vehicle movements than BRT and a mixed environment with pedestrians in the CBD will be considered.
- A station with mode transfer facilities is located to the north (Wellington Railway Station), Central (Courtenay Place) and south (Wellington Regional Hospital/Newtown).
- All stops are raised platforms.

LRT – Waterfront Alignment

The following base design assumptions have been established for LRT:

- The option allows for as a minimum a LRT double track along the entire length through the Waterfront Alignment.
- A station with mode transfer facilities is located to the north (Wellington Railway Station), Central (Courtenay Place) and south (Wellington Regional Hospital/Newtown).
- The northern station is located to the west of the Wellington Railway Station to facilitate transfers to existing bus station.
- There is separation from other traffic/pedestrians via kerbs and fences through mid block sections. The degree of separation will be a design consideration.
- All stops are raised platforms

Figure 11 displays changes to services that have been used in the LRT option development. Specific changes relate to the removal of bus services through the study centre and the requirement to transfer. Specific changes are that core and secondary services will terminate requiring a transfer onto the LRT to reduce duplication:

- Service A1 and A2 from Island Bay and wellington Zoo respectively will terminate at Newtown.
- Service B from Miramar (now called B2) will terminate at Courtenay Place.
- Service B from Karori (now called B1) and H from Newlands will terminate at the Wellington Railway Station.
- Service 32 and 34 from Houghton Bay and Owhiro Bay respectively will terminate at Newtown
- Service 30, 31, 36 from Breaker Bay, Miramar and Lyall Bay respectively will terminate at Courtenay Place.
- Service 12 (Secondary Service) from Khandallah and Newlands services 61, 62, 67, 68 will terminate at the Wellington Railway Station. Future tests may terminate these services at Johnsonville.

1.2.5 Heavy Rail Extension

The Heavy Rail Extension (HRE) scenario shown in Figure 9 extends selected rail lines through Wellington CBD via a station near the BNZ Centre to Courtenay Place. The HRE option does not extend through to Newtown and therefore provides only a minimal extension to the rail network. The remainder of the corridor from Courtenay Place to Newtown would be serviced by bus.

HRE – Underground

The following base design assumptions have been established for the HRE underground Option:

- The option allows for a double track along the entire length.
- HRE will extend existing selected services
- The alignment will follow the road reserve so as to have a lower impact on building structures, in terms of undermining their footings/foundations.
- The alignment will travel underground from the Wellington Railway Station requiring underground stations at the BNZ centre and Courtenay Place.

HRE – Waterfront

The following base design assumptions have been established for HRE through the Waterfront Alignment:

- The option allows for double track along the entire length.
- There is full separation from other traffic along entire length.
- Controlled pedestrian crossings will be provided at specific locations.
- A level crossing will be required on Waterloo Quay adjacent to the existing station.

Figure 11 displays changes to services that have been used in the HRE option development. Specific changes relate to the removal of bus services through the Golden Mile and the requirement to transfer. Specific changes are that core and secondary services will terminate at Courtenay Place requiring a transfer onto the HRE as follows:

- Service A1 and A2 from Island Bay and wellington Zoo respectively will terminate Courtenay Place.
- Service B from Miramar (now called B2) will terminate at Courtenay Place.
- Service B from Karori (now called B1) and H from Newlands will terminate at the Wellington Railway Station.
- Service 32 and 34 from Houghton Bay and Owhiro Bay respectively will terminate at Courtenay Place.
- Service 30, 31, 36 from Breaker Bay, Miramar and Lyall Bay respectively will terminate at Courtenay Place.
- Service 12 (Secondary Service) from Khandallah and Newlands services 61, 62, 67, 68 will terminate at the Wellington Railway Station.

As neither option reduces traffic capacity through the Golden Mile, the above proposed changes are not a requirement of delivering the options.

Figure 6 Bus Priority Scenario Alignments

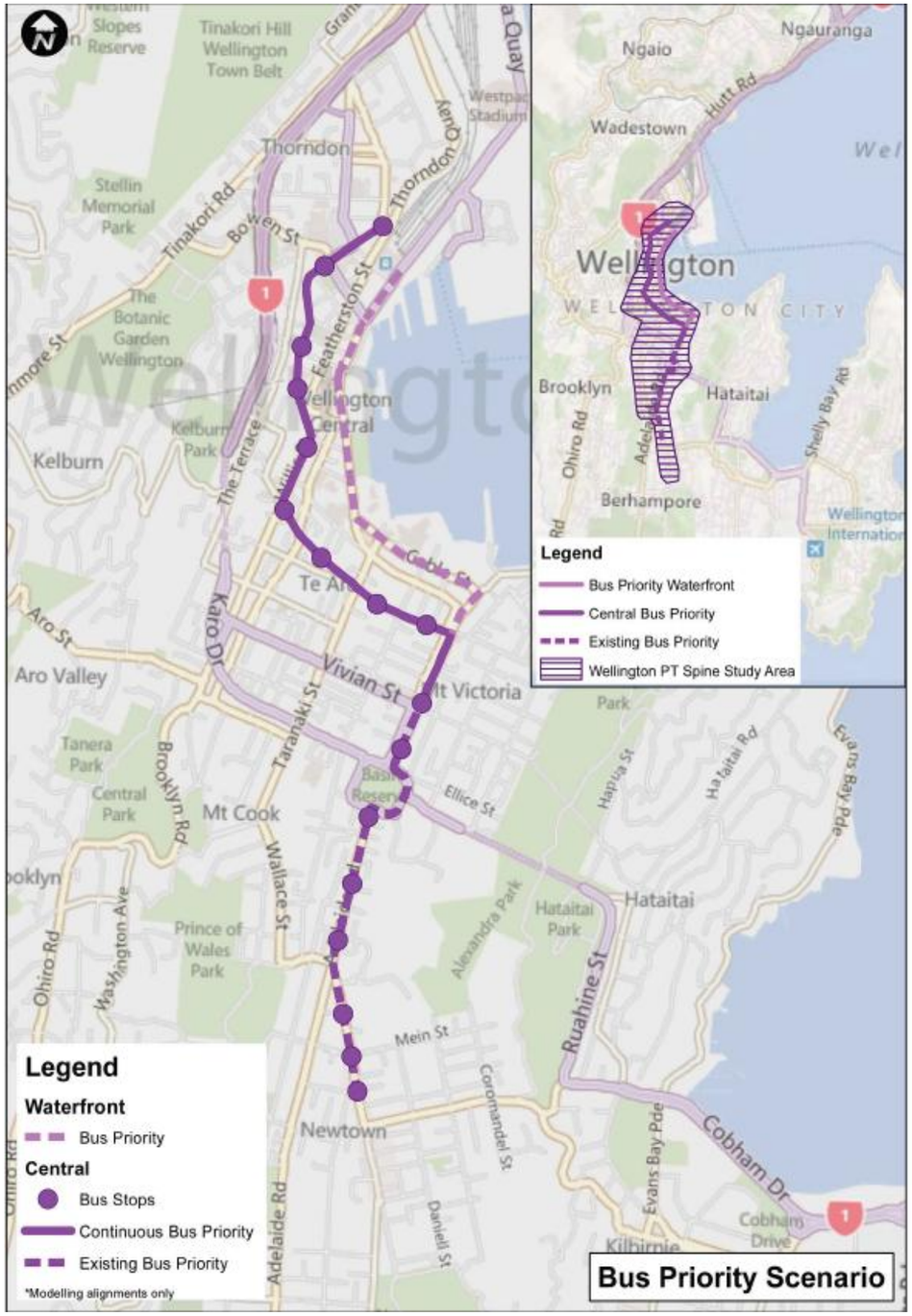


Figure 7 Bus Rail Transit Scenario Alignments

Figure 8 **Light Rail Transit Scenario Alignments**

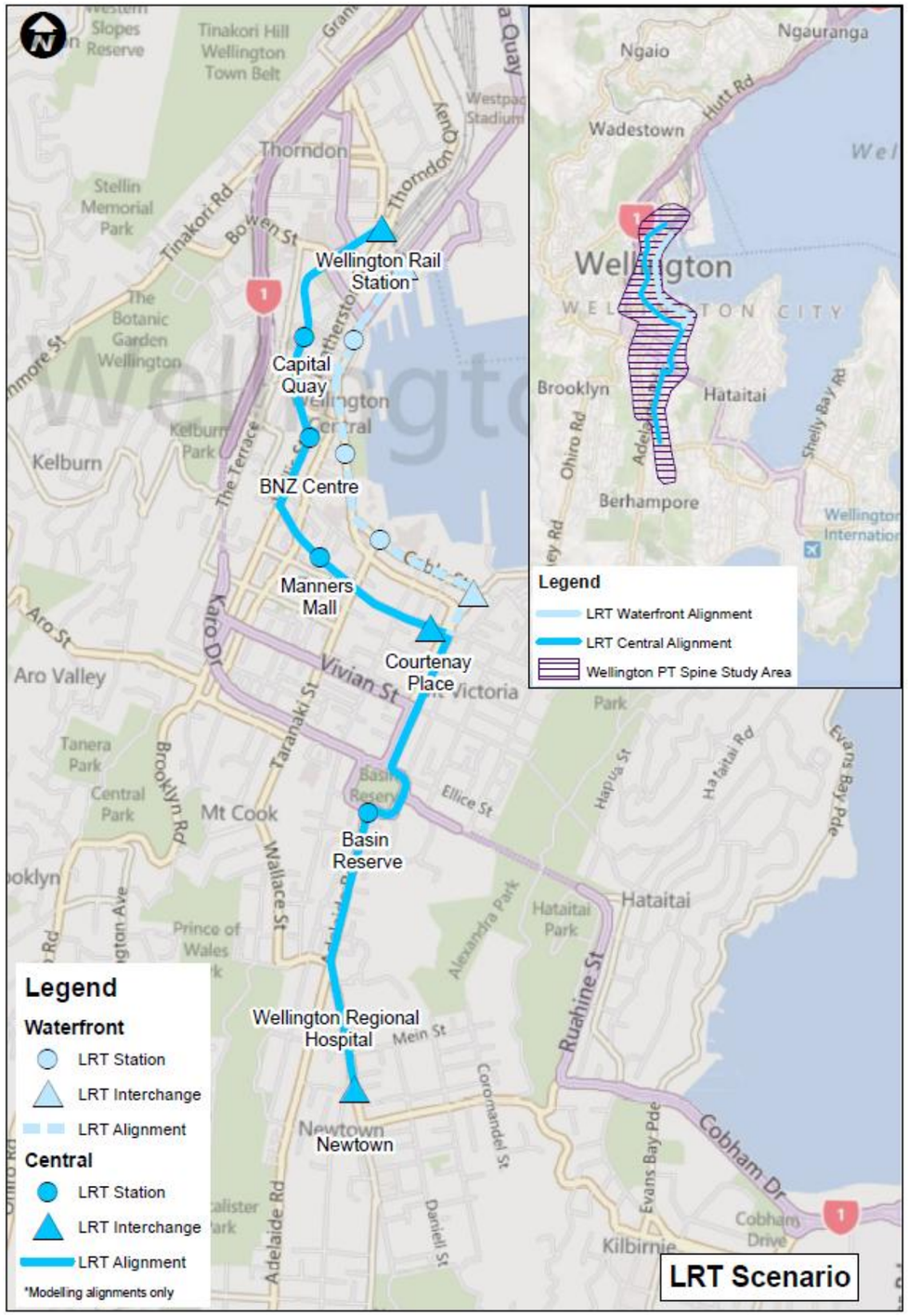


Figure 9 **Heavy Rail Extension Scenario Alignments**

1.3

Figure 10 Wellington City Bus Review Routes

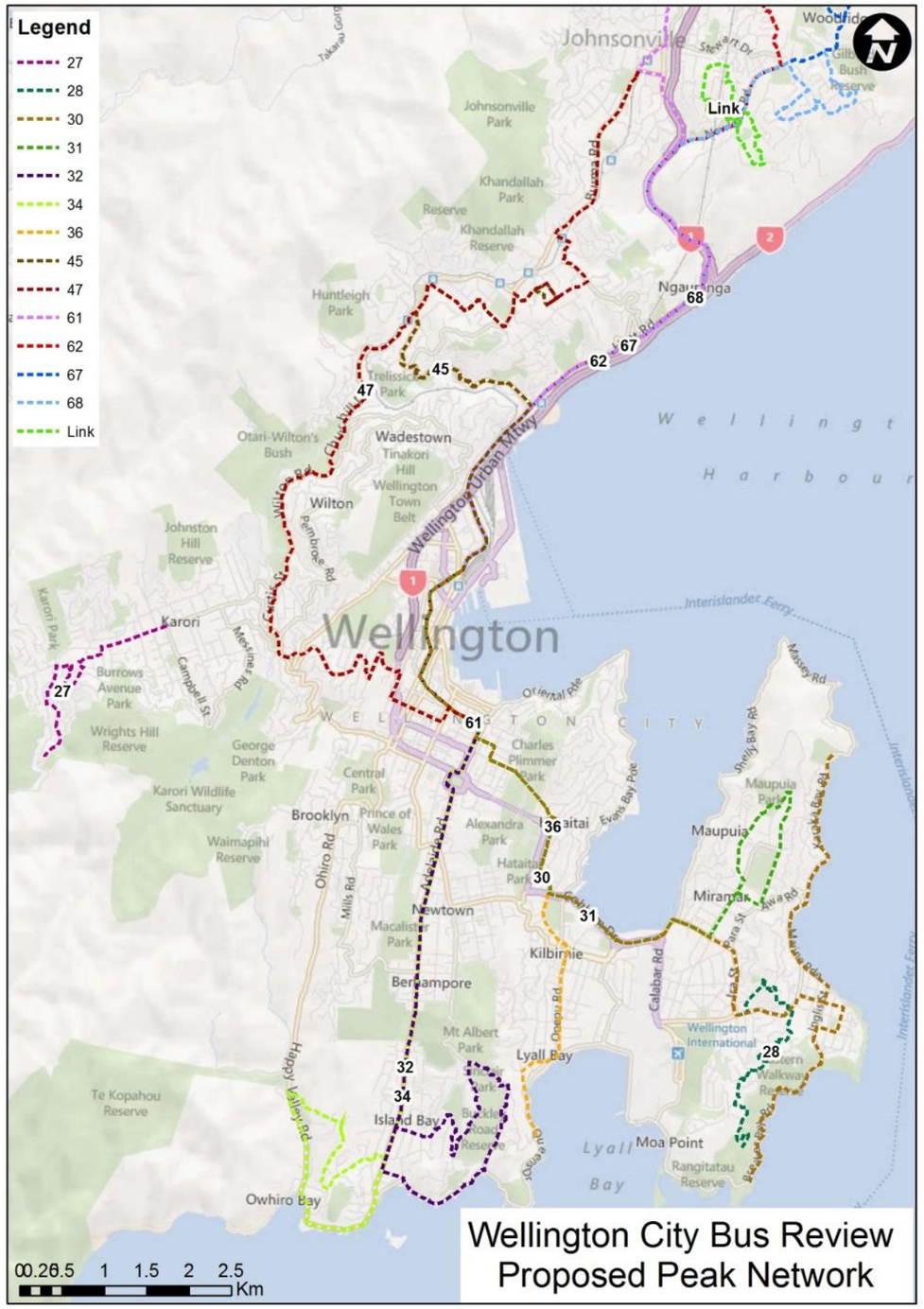
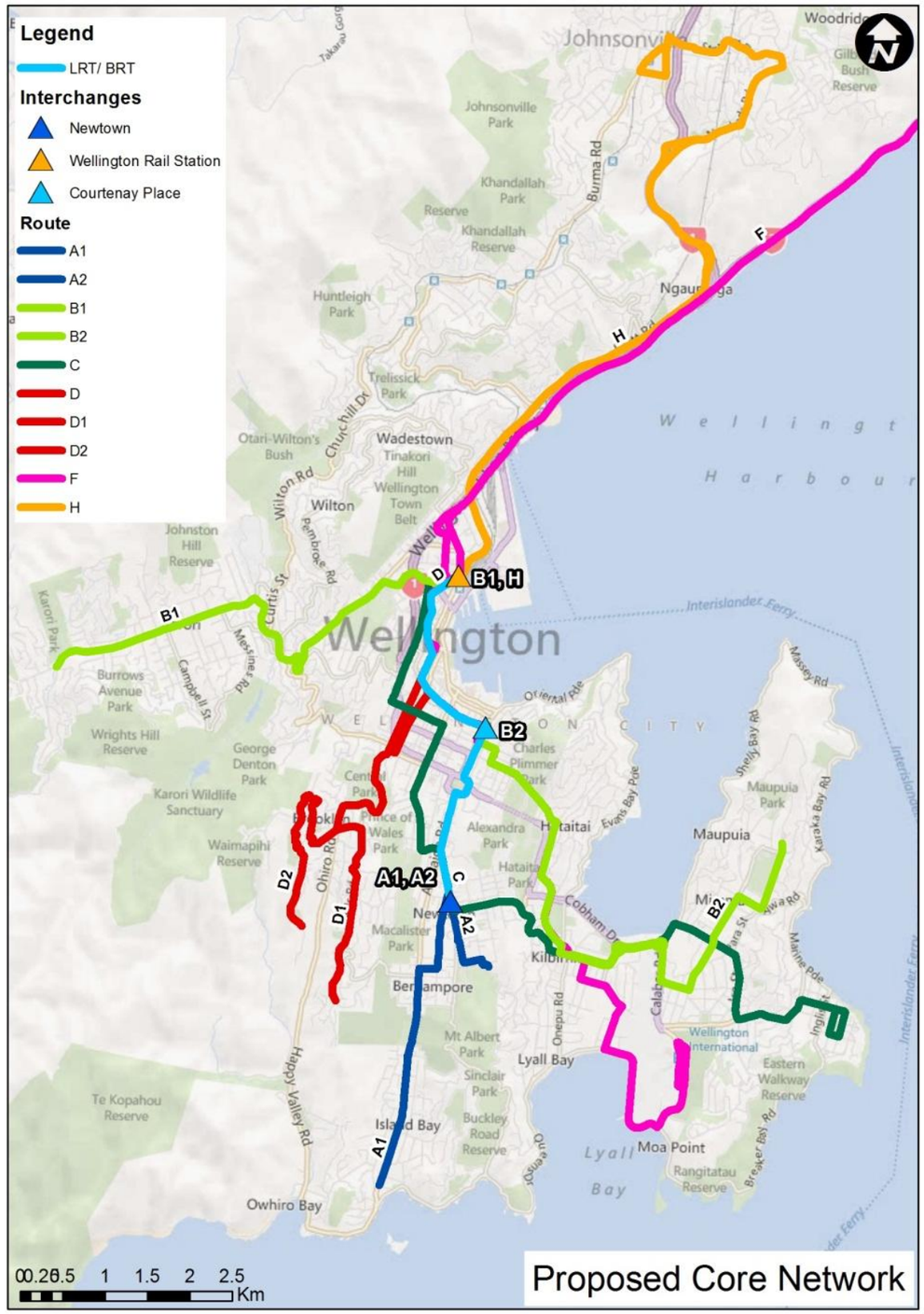


Figure 11 BRT, LRT and HRE Routes



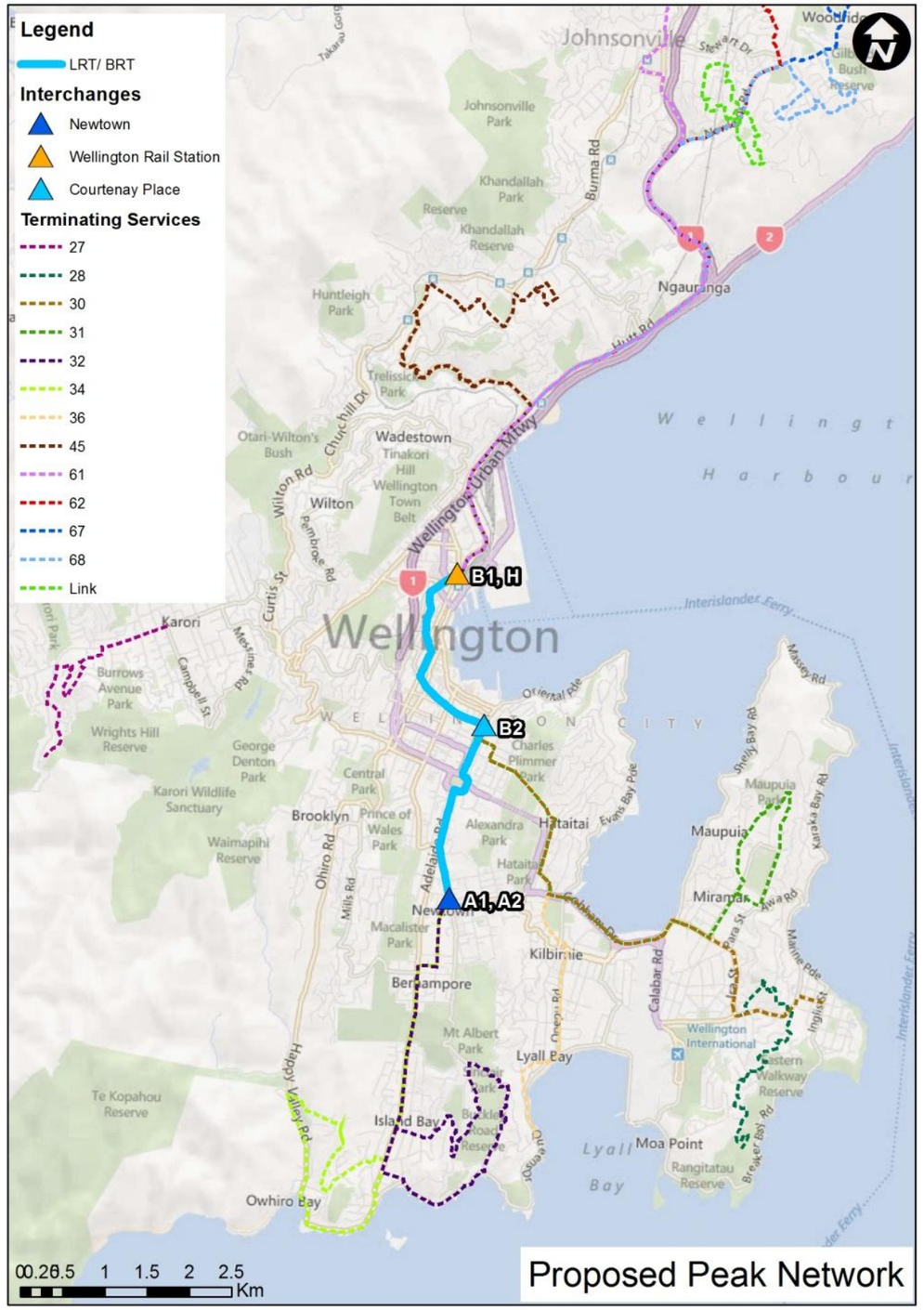


Table 27 Key Parameters and Assumptions for Medium List Evaluation (on PT Spine)

No.	Item	Unit	Base Case	Bus – Central	Bus – Waterfront	BRT – Central	BRT – Waterfront	: LRT – Central[10]	LRT – Waterfront[10]	HRE (Heavy rail extension) – Underground	HRE (Heavy rail extension) – Waterfront	Where Assumption will be used
Operational Assumptions												
1	Fare level	-	Flat rate	Flat rate	Flat rate	Flat rate	Flat rate	Flat rate	Flat rate	Flat rate	Flat rate	WTSM
2	Vehicle Operating Capacity (seated and standing)[1]	No.	75	75	75	60-150	60-150	110-350	110-350	206 per 2 car / 824 per 8 car[6]	206 per 2 car / 824 per 8 car[6]	Analysis to assist MCA
3	Vehicle Width	m	2.5m	2.5m	2.5m	2.5m	2.5m	2.3m - 2.7m	2.3m - 2.7m	2.7m	2.7m	Concept Design
4	Peak capacity est. /hour[2]	pphpd	Up to 6,000	Up to 6,000	Up to 6,000	Up to 9,000	Up to 9,000	Up to 10,500	Up to10,500	Up to 10,000[7]	Up to 10,000[7]	MCA
5	Station/ Stop dwell times[3]	s	30	30	30	30	30	30	30	48	48	WTSM
6	Operational costs per annum[8]	$/annum	146M	147M	147M	148M	148M	153M	153M	157M	138M	MCA
Design Principles / Assumptions												
7	Length of option	m	4700m	4700m	4500m	4700m	4500m	4700m	4500m	2100m	2100m	Concept Design
8	PT Spine Minimum Corridor Width	m	6.0m (two way between kerbs)	6.0m (two way between kerbs)	6.0m (two way between kerbs)	6.0m (two way between kerbs)	6.0m (two way between kerbs)	6.8m (two way between kerbs)	6.8m (two way between kerbs)	10.6m between structures	10.6m between structures	Concept Design
9	Minimum Corridor Width at stops	m	9.0m (Two 1.5m wide footpaths)	9.0m (Two 1.5m wide footpaths)	9.0m (Two 1.5m wide footpaths)	9.0m (Two 1.5m wide footpaths)	9.0m (Two 1.5m wide footpaths)	14.3m (8m wide platform)	14.3m (8m wide platform)	17.5m (8m wide platform)	17.5m (8m wide platform)	Concept Design
10	Designated segregation[4]	None/ Partial/Full	None	None	None	Partial	Partial	Partial	Partial	Full	Full	WTSM
11	Design minimum radii[5]	m	10.0m	10.0m	10.0m	13.0m	13.0m	25.0m	25.0m	350.0m	350.0m	Concept Design
12	Max grades allowed	%	30%	30%	30%	30%	30%	8% (ideally max 1% in stations)	8% (ideally max 1% in stations)	3% (ideally max 1% in stations)	3% (ideally max 1% in stations)	Concept Design
13	Power Source	-	Diesel, electric	Diesel, electric	Diesel, electric	Diesel, electric	Diesel, electric	Diesel, Electric	Diesel, Electric	Electric	Electric	MCA
14	Range Capital expenditure[9]	NZ$	0 Base Case	16M - 35M	23M - 45M	98M-319M	94M-306M	172M-392M	165M-376M	625M-1125M	250M-425M	Concept Design

Footnotes

General footnotes

The Medium List options are to be scoped at a high level based on the key criteria derived from the International Review and local data. This will provide broad alignments to be tested through multi criteria assessments and local data and allow comparative capital and operational costs to be performed. This Table sets out the key parameters and assumptions for the Medium List Assessment and has been referenced from the following sources:

- Option 7 and Option 8 design criteria referenced from the KiwiRail Standard Tranz Rail T:200 Infrastructure Engineering handbook or based on existing Matangi Electric Multiple Unit dimensions and infrastructure requirements.
- Option 1 - 6 design criteria referenced from Urban Transit Systems and Technology by Vukan R. Vuchic, Published by John Wiley & Sons, Inc.

Specific Footnotes

- Footnote 1 – Vehicle operating capacity (apart from HRE, refer footnote 6) is sourced from Wellington Public Transport Spine Study, International Review.
- Footnote 2 – Peak hour capacity estimates are preliminary estimates only and are to be refined at the short list stage. Bus and bus priority based on 80 buses per hour (desirable maximum) x 75 passengers. BRT based on 120 buses per hour per direction x 75 passengers. LRT based on 30 LRT vehicles per hour x 350 passengers sourced from Wellington Public Transport Spine Study, International Review.
- Footnote 3 – Item No. 5 (Station/Stop dwell times). The WTSM has been calibrated with these dwell times included.
- Footnote 4 – Segregation is defined as a physical separation of PT from other vehicles and pedestrian. None refers to PT sharing road space with other vehicles and includes bus priority lanes. Partial segregation refers to physical separation along part of the route, i.e. midblock but not at intersections. Full segregation refers to physical separation along the entire route, i.e. midblock and grade separation at intersections.
- Footnote 5 – Conservative minimum radii assumptions have been used. Minimum radii are based on the average or standard vehicle minimum radii in order to no exclude standard vehicle configurations. LRT radii of 11m -13m are physically possible.
- Footnote 6 – HRE vehicle operating capacity based on 2 car Matangi Electric multiple unit configurations with seating standing ratio of 1.4 (4 standing for every 10 seated).
- Footnote 7 – HRE peak hour capacity based on 8 car Matangi EMUs operating at 5 minute intervals; which would provide approximately10000 pax per hour per direction.
- Footnote 8 – Base Case Opex costs for bus and rail are for whole region and are based on the subsidy and farebox recovery ratios published by NZTA. Option Bus and Rail opex estimates are the Base Case opex adjusted pro rata on WTSM passenger km. LRT opex is based parameter costs in Australia Transport Council (ATC) Guidelines. HRE Opex includes reduction in bus Opex from reduction in bus passenger km for this option.
- Footnote 9 – CAPEX ranges are based on per km rates sourced from Wellington Public Transport Spine Study, International Review, local rates for specific items, generic rates from Australian projects, and other local similar project costings.
- Footnote 10 – LRT is modelled with priority at intersections only (due to model limitations). Cost estimates will be further refined at the short list stage.

Appendix B

Modelling Assumptions

1.0 Introduction

Appendix B sets out the eight options which are to be modelled for Medium List testing and the implications of the options on services, alignments and potential infrastructure changes. This appendix sets out how these options will be tested using transport modelling, including a description of the modelled scenarios and the assumptions used for each option. A single model forecast year of 2041 was used to test Scenarios based on the medium land use forecasts.

The Wellington Strategy Transport Model (WTSM) was used for option testing and to provide inputs into the Multi Criteria Assessment (MCA) to refine a 'Short List'. Bus services, station locations, alignments and some modelling parameters for these tests are preliminary and will need further refinement before being taken forward to the 'Short List' testing.

2.0 Modelling Characteristics of Scenarios

This section provides a comparison of the options on the basis of how the model will represent the modes and the basis for which options will be tested.

2.1 Operational Differences Between Modes

There are four modes to be modelled, whilst the service (in the model) provided by modes may be comparable there are distinct differences in the operation of the modes. Table 28 compares the modes and the aspects of differentiation they would need to represent within the model.

Table 28 Modelling Operational Differences between Modes

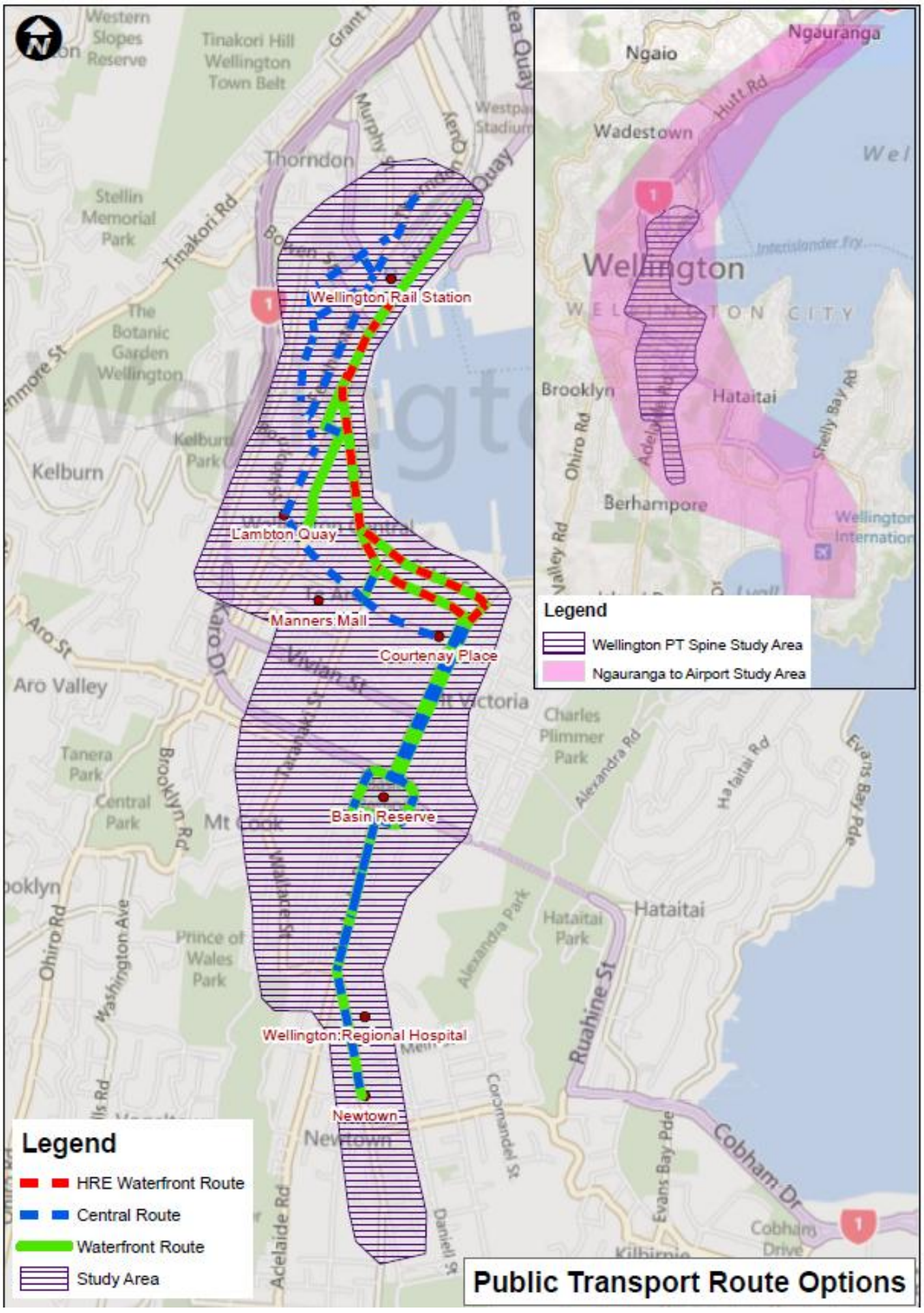
Comparison	Similarities	Differences
Bus Vs BRT	- Use same vehicles - Can provide seamless service from wider catchment to destination - Vehicles to use full network rather than dedicated corridor - Provide access to same catchments	- Bus (priority) Scenario uses local street network with bus priorities where required compared to segregated BRT. - Buses are predominantly combined with general traffic with some sections of the network bus only - There are many bus stops providing access/egress compared to bus stations with BRT
BRT Vs LRT	- Travel in segregated corridor with managed speed. - Generally not affected by traffic congestion - Limited number of access/egress points at stations	- Need to interchange for catchment serviced outside of the study area, unless the LRT line extends beyond the CBD then transfers required. - LRT - Requires a transfer onto alternate mode to travel beyond a narrow corridor. - BRT - Provides integration with existing services. - BRT - Can provide better frequency
HRE Vs LRT	- Both use similar infrastructure /corridor.	- HRE have lower frequency and fewer stations.

This analysis shows that each of the modes must be modelled separately. For example whilst there are similarities between LRT and BRT modes, the requirement for transfer with LRT and the question of how LRT could extend beyond the study area means they require separate consideration.

2.2 Differences Between Alignments

Figure 12 displays a comparison of the alignments for all modes through the study area, there are similarities between the alignments, starting at the rail station and with the exception of HRE (which ends at Courtenay Place) travelling on Adelaide Road to Newtown. The difference in alignments in the CBD is generally between two parallel roads, it is unlikely that this separation in alignment over a short distance will create a significant difference in the WTSM model results. Therefore for each mode a single alignment representing the central alignment will be used.

Figure 12 Alignments



3.0 Model Scenario Specification

3.1 Confirmed Scenarios

The differences in operating characteristics mean that each mode is able to be differentiated within the model and therefore should be modelled separately. The comparison of alignments within the study area shows that the WTSM is not of sufficient detail to differentiate the benefits of the different alignments therefore a single alignment is to be modelled. This means that to test the core Medium List options 5 scenarios must be modelled (including Base Case).

Table 29 displays the characteristics of the resulting scenarios, issues related to competition between modes and the requirement to transfer at key locations. This is not a definitive representation of scenarios but rather a stylised representation of how the Scenarios operate. This shows that if LRT is provided only between the Wellington Rail Station and the Hospital that bus passengers to/from the south and rail passengers from the north will be required to transfer to LRT to complete their journey. To test the sensitivity of extending the LRT beyond the study area a further two scenarios have been added. These scenarios extend LRT north to Johnsonville and south to Island Bay.

Table 29 Characteristics of Options

Scenario	North of CBD	Study Area			South of CBD
		Rail Station	CBD	Hospital	
Base Case	Rail				
	Bus				
Bus Priority	Rail				
	Bus	Bus Priority			Bus
BRT	Rail				
	Bus				Bus
	BRT (North) Only	Buses use BRT Infrastructure			
LRT	Rail				
	Bus	Reduced buses through centre			Bus
	LRT (North) Only	LRT			
		LRT			LRT (South) Only
HRE	Rail	Extended			
	Bus	Reduced Buses			Bus

◆ Transfer Points

3.2 Model Scenario descriptions

Table 30 lists the seven scenarios selected for modelling in in Medium List testing. The alignments for each of the options are detailed in Figure 13 to Figure 18. Summaries of the changes to the model to represent each model accurately are provided in Table 31 to Table 33. For consistency purposes as few changes as possible have been made to existing model parameters/coding.

Table 30 Modelling Scenario List

Mode	Scenario	Description
Base	Base Case	Agreed Future WTSM
Bus	Bus Priority	Bus priority from Newtown to Wellington Railway Station.
BRT	CBD	BRT from Newtown to Wellington Railway Station.
LRT	CBD	LRT from Newtown to Wellington Railway Station.
	North	LRT from Newtown to Johnsonville and replacing the Johnsonville Rail line.
	South	LRT from Island Bay via Newtown to Wellington Railway Station.
HRE	Extension	Extending heavy rail through to Courtenay Place from Wellington Railway Station.

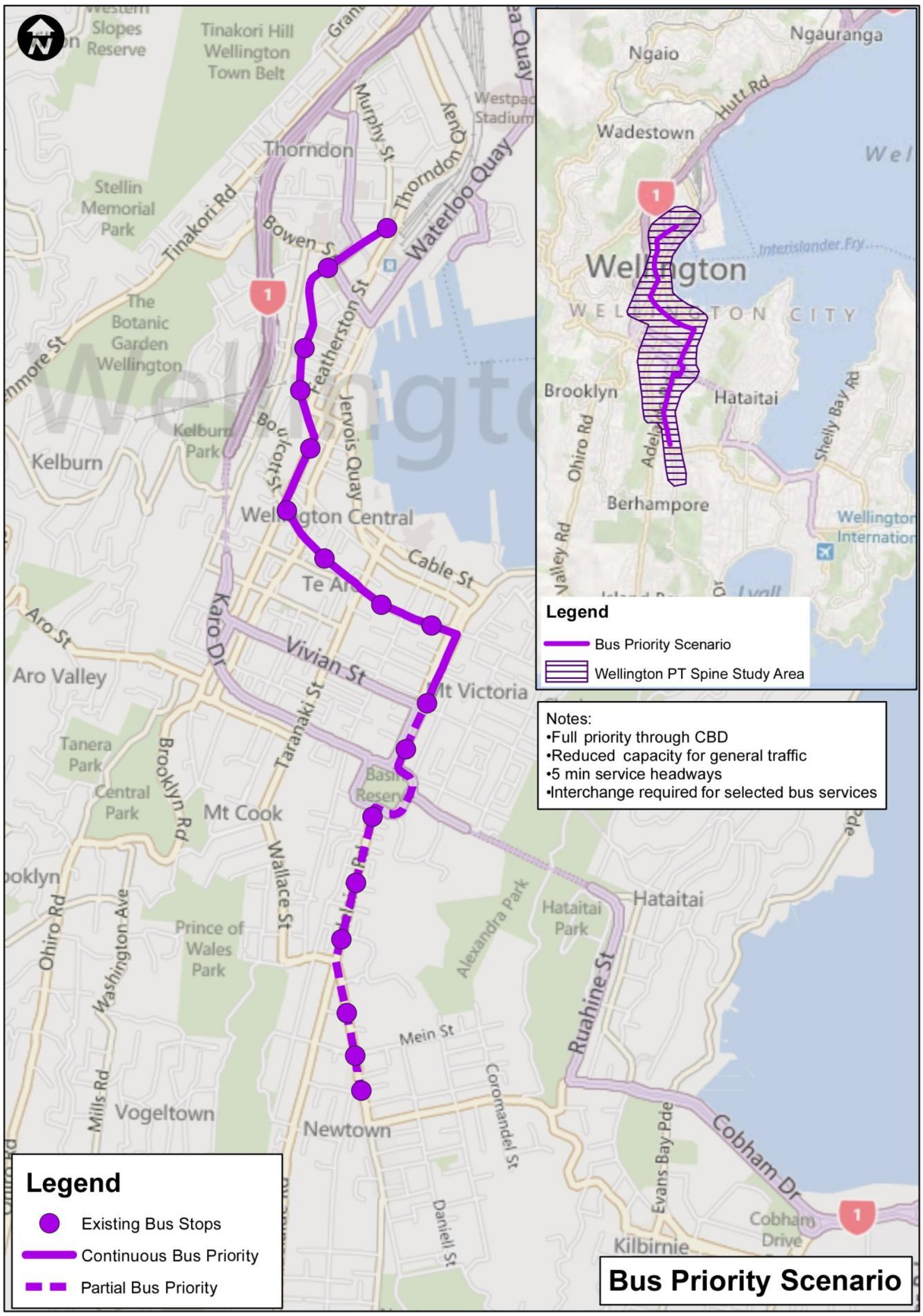
Major considerations which have been assumed and will require further consideration for the 'Short List' include:

- The extent to which existing bus routes compete with scenarios within the CBD. All options will provide access to the same catchments as existing bus services. An issue is which existing services travelling from beyond the study area will continue into the CBD to provide access.
- The necessity to transfer between modes and the locations for transfers. LRT and HRE require definition as to how and where transfers will take place, whilst bus and BRT provide a seamless journey.
- The extent to which scenarios will extend and have an impact beyond the study area.

Bus Priority

The necessity for Bus Priority between Wellington Rail Station and Vivian Street (shown in Figure 13) is based on analysis of travel speeds from the 2041 AM peak Base Case model.

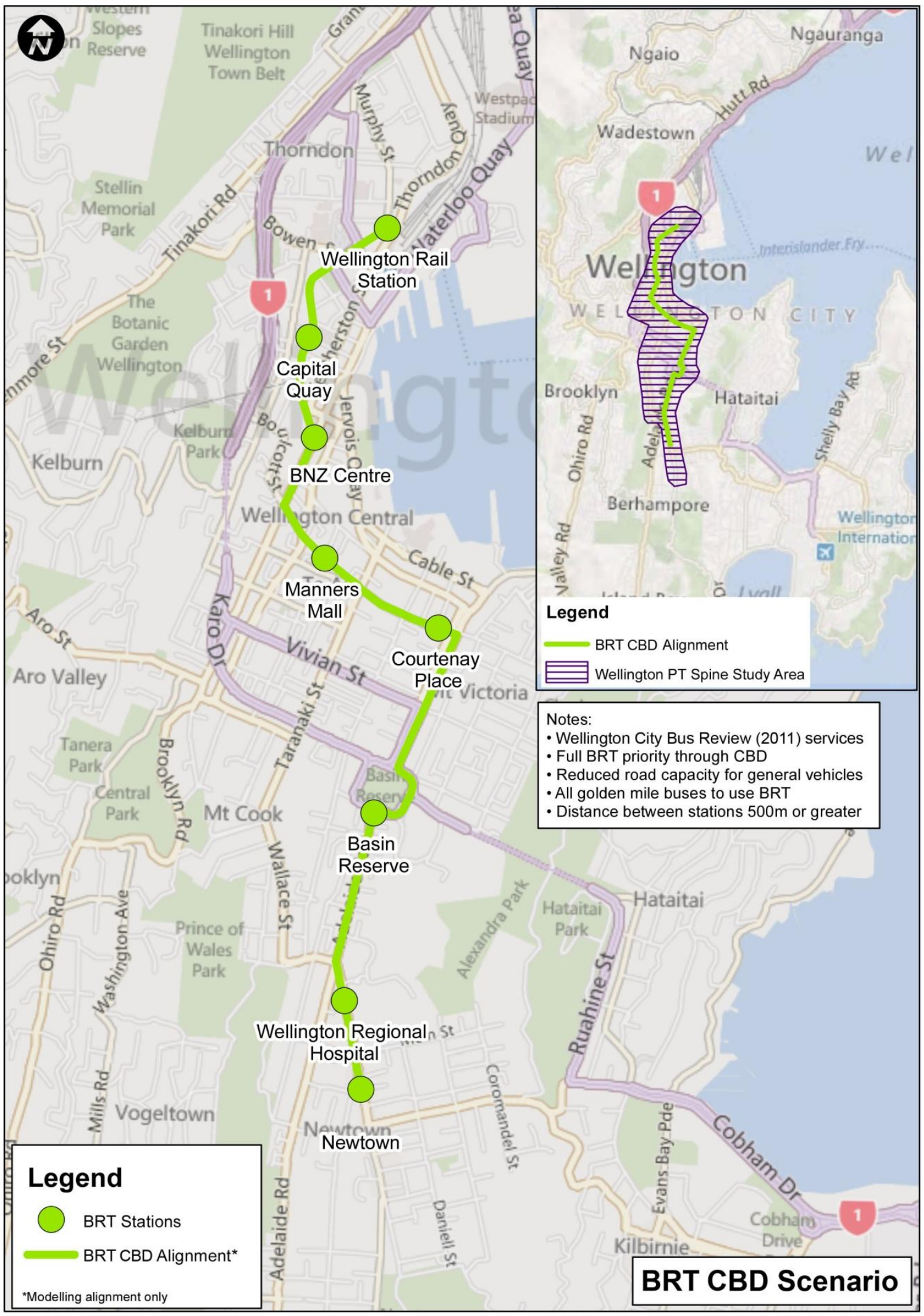
Figure 13 Bus Priority



Bus Rail Transit

The BRT scenario provides priority and segregation for buses for the full length of the PT-Spine. As shown in Figure 14, stops have been consolidated to reduce delays along the corridor.

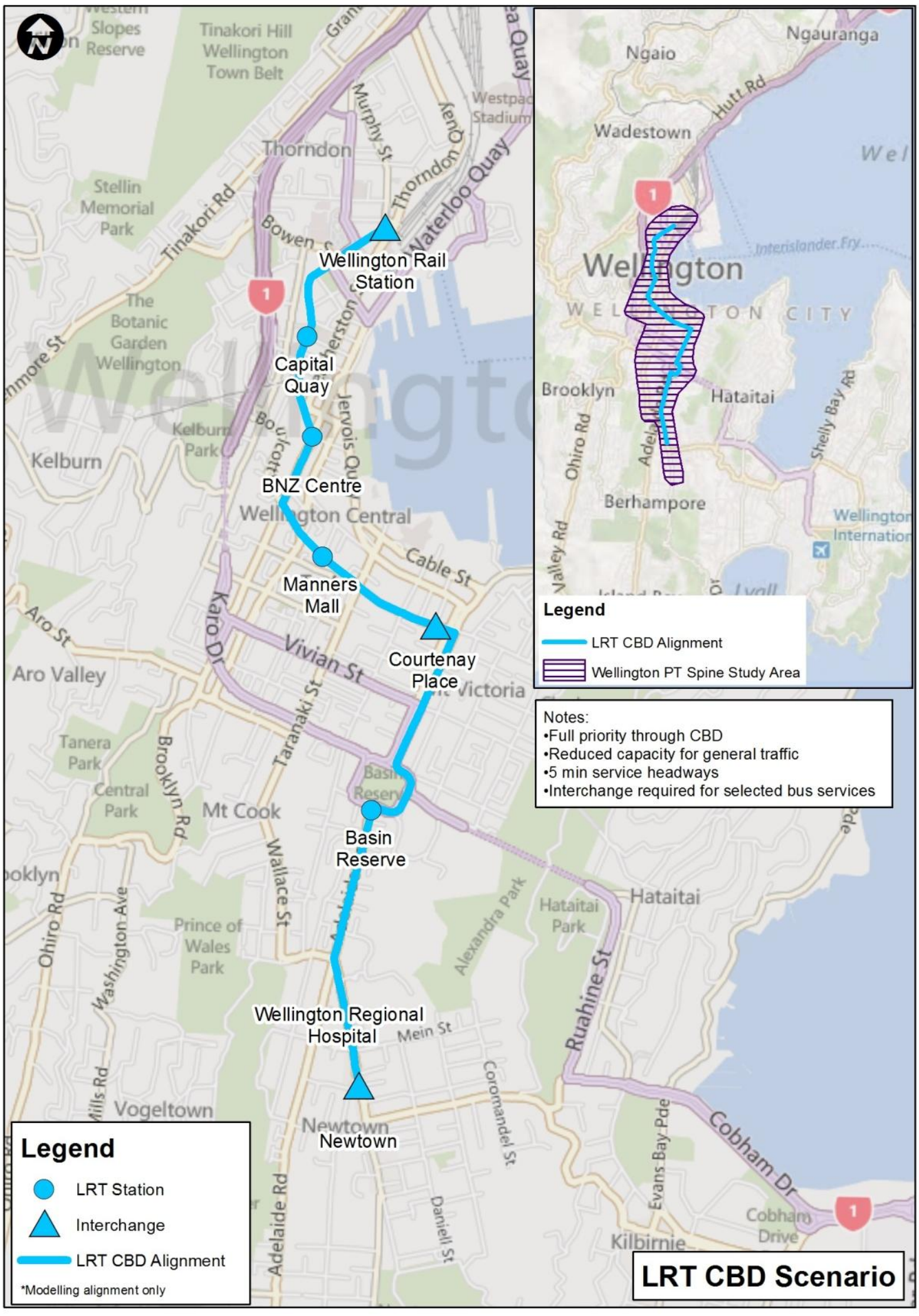
Figure 14 BRT (CBD)



Light Rail Transit

The LRT scenario provides a light rail line for the length of the PT-Spine. This scenario requires passengers to transfer onto other modes at the locations marked below in Figure 15. The LRT stations are positioned to assess demands prior to definitive testing of the 'Short List'.

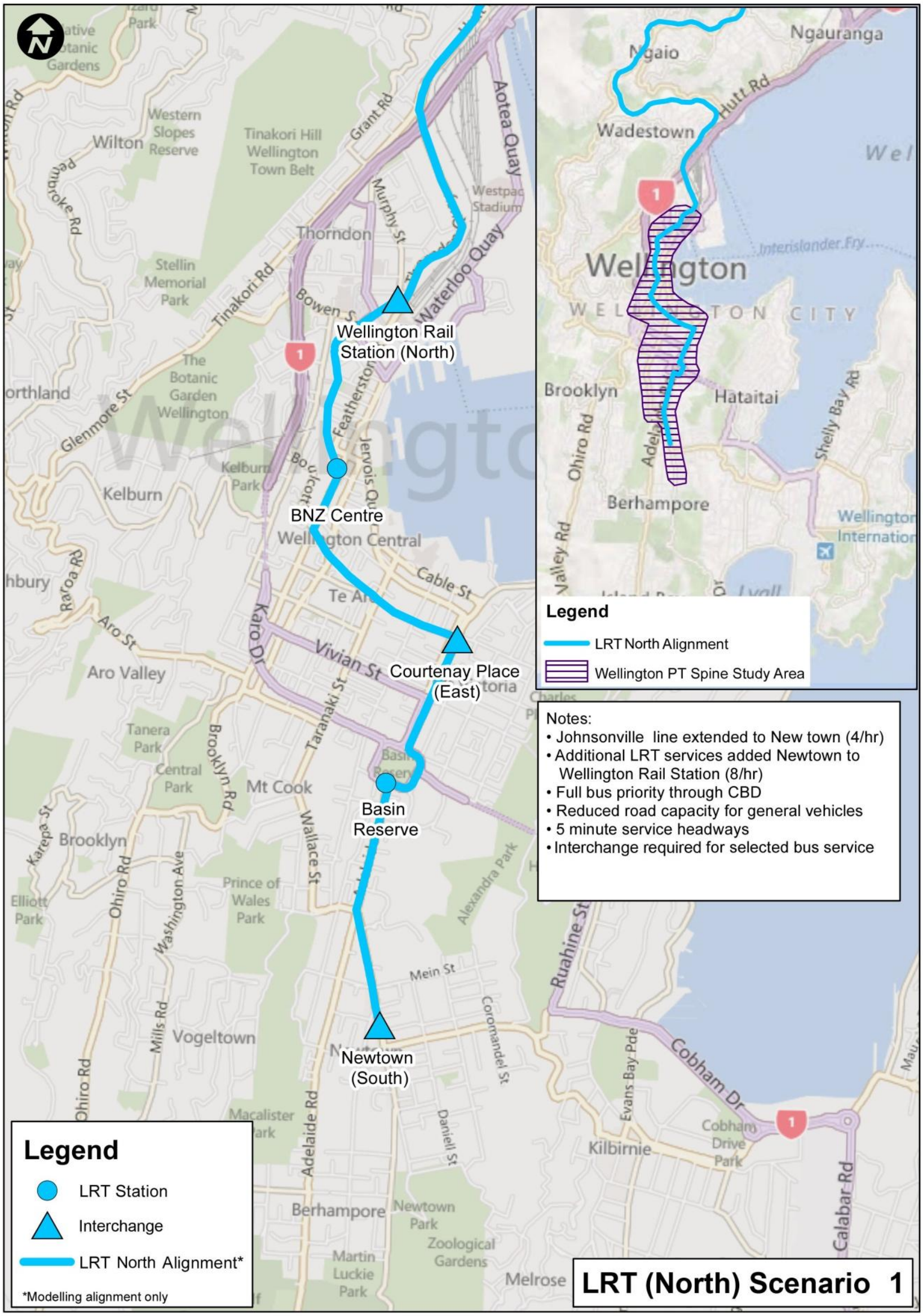
Figure 15 LRT (CBD)



LRT - North

The LRT (North) scenario shown in Figure 16 extends the LRT north of the CBD by utilising the Johnsonville rail line.

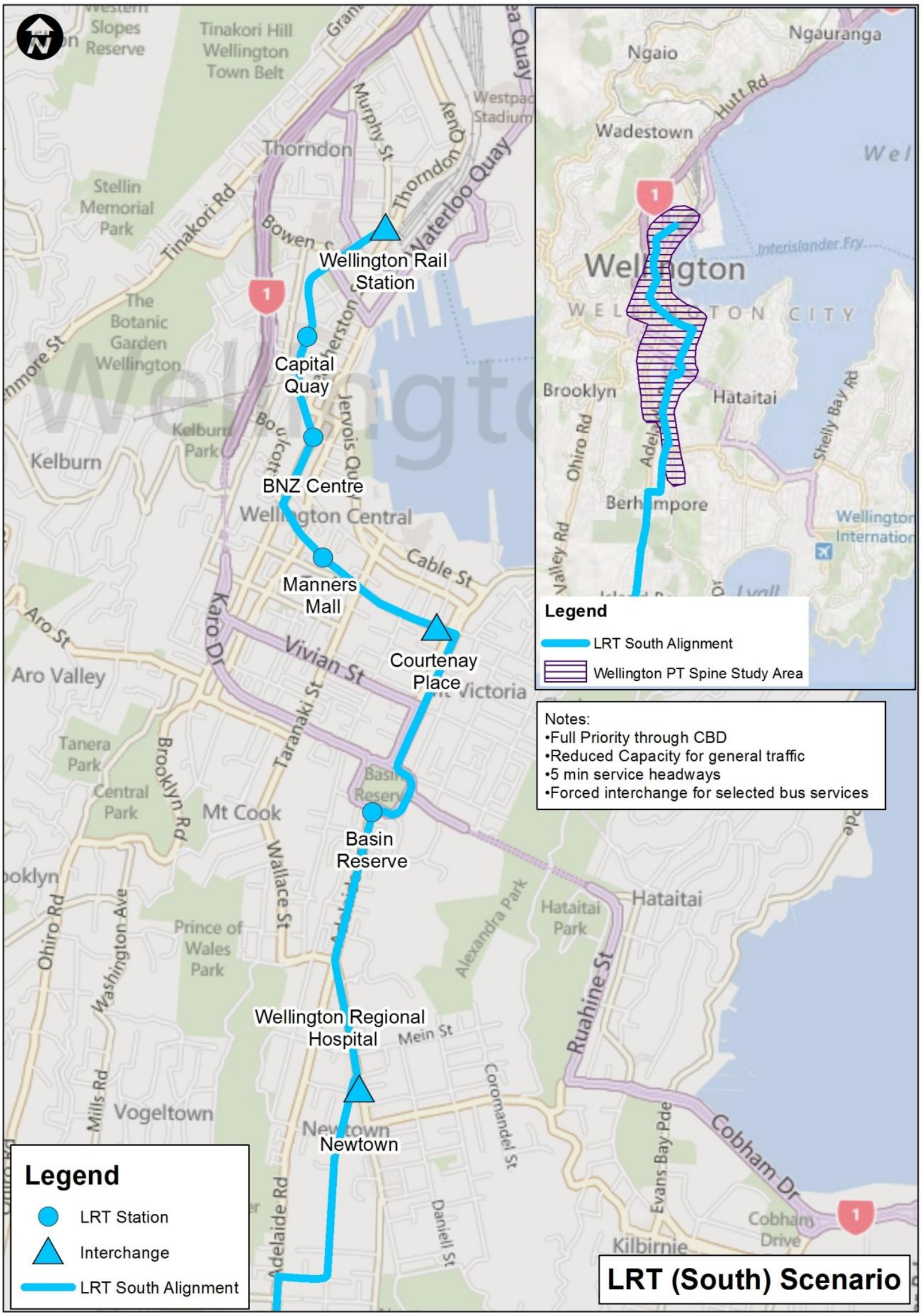
Figure 16 LRT (North)



LRT – South

The LRT (South) scenario shown in Figure 17 extends the LRT (CBD) south to Island Bay. This scenario was included into the modelling by the project steering group.

Figure 17 LRT (South)



Heavy Rail Extension

The HRE scenario shown in Figure 18 extends selected rail lines through Wellington CBD via a station near the BNZ Centre to Courtenay Place. The stations are positioned to assess demands prior to definitive testing of the 'Short List'.

Figure 18 HRE

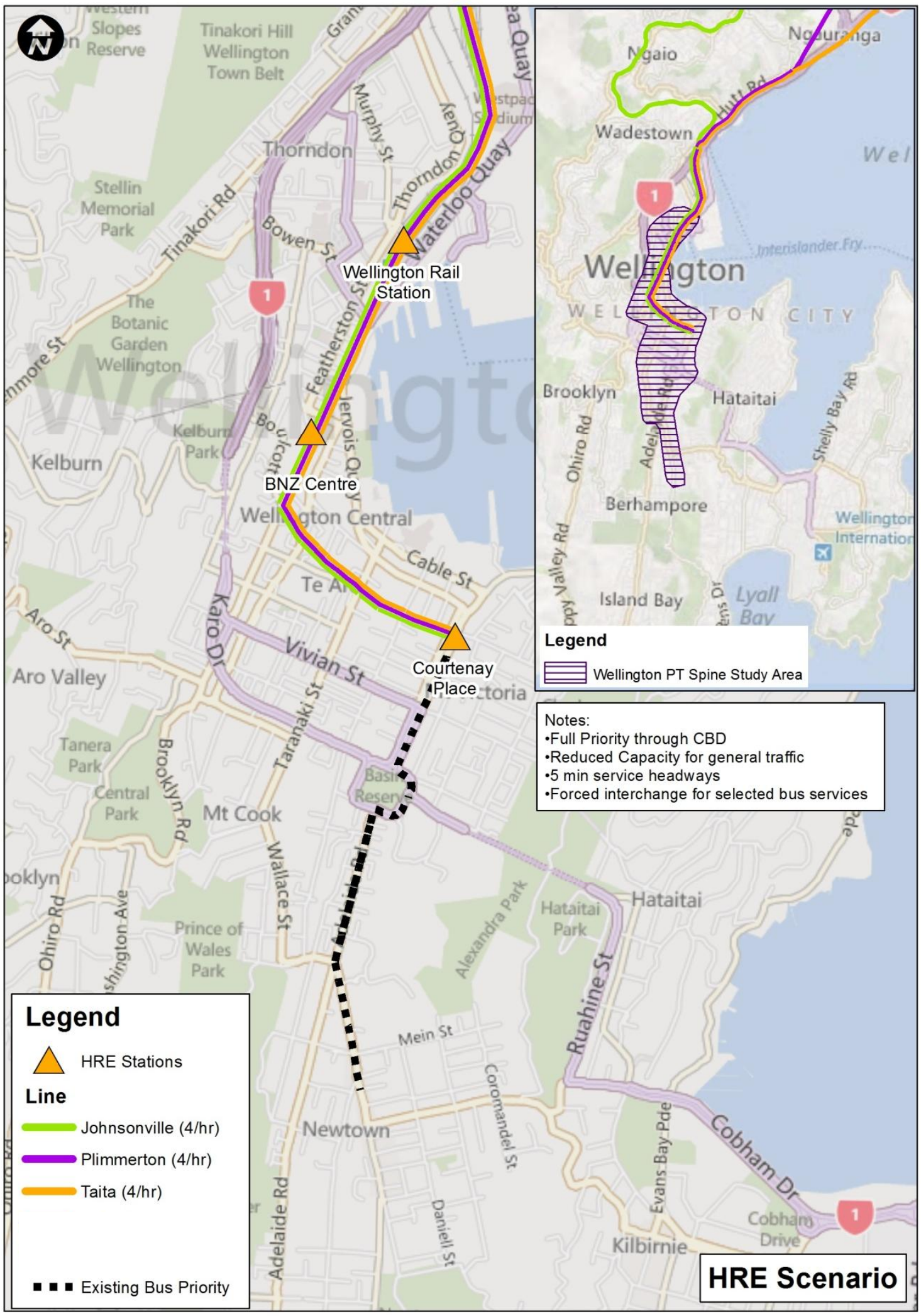


Table 31 details the design principles and assumptions for each of the 'Medium List' scenarios. Alignments, stations, impact on general vehicles and termination points of bus services are all indicative at this stage and to be confirmed in 'Short List' testing. Therefore the main focus of these 'Medium List' tests is to assess the network impacts of each mode with the aim of reducing to a 'Short List' of around four scenarios.

Table 31 Design Principles\Assumptions

	Base Case	Bus Priority	BRT (CBD)	LRT (CBD)	LRT (North)	LRT (South)	HRE
Description	**Agreed Future WTSM**	**Bus priority from Newtown to Wellington Railway Station.**	**BRT from Newtown to Wellington Railway Station.**	**LRT from Newtown to Wellington Railway Station.**	**LRT from Newtown to Johnsonville and replacing the Johnsonville Rail line.**	**LRT from Island Bay via Newtown to Wellington Railway Station.**	**Extending heavy rail through to Courtenay Place from Wellington Railway Station**
Alignment (indicative)	Future base service alignments		- Cambridge Terrace - Courtenay Place - Willis Street - Lambton Quay	- Cambridge Terrace - Courtenay Place - Willis Street - Lambton Quay	- Cambridge Terrace - Courtenay Place - Willis Street - Lambton Quay - J'ville Rail line	- Adelaide Road - Cambridge Terrace - Courtenay Place - Willis Street - Lambton Quay - J'ville Rail line	- Courtenay Place - BNZ Centre - Railway Station
Priority (indicative)	As Current	Partial PT Priority through CBD	Full PT Priority through CBD	Full PT Priority	Full PT Priority	Full PT Priority	Fully Segregated
Impact on general traffic (indicative)	As Current	Partial	Yes	Yes	Yes		
Changes to Bus Services (indicative)	Future base services		Bus services to use BRT through CBD.	Terminate bus services: South - Newtown East – Courtenay Pl North – Railway Station	Terminate bus services: South - Newtown East – Courtenay Pl North – Railway Station	Terminate bus services: South - Newtown East – Courtenay Pl North – Railway Station	Terminate bus services: South and East – Courtenay Pl North – Railway Station
Frequency (indicative)	Future base services			+12 services per hour	+8 services per hour +4 J'ville services	+8 services per hour +4 J'ville services	+4 J'ville services +4 Taita services +4 Plimmerton services
Stations (indicative)	As Current		- Newtown - WGTN Hospital - Basin Reserve - Courtenay Place - Manners - BNZ Centre - Capital Quay - WGTN Station	- Newtown - WGTN Hospital - Basin Reserve - Courtenay Place - Manners - BNZ Centre - Capital Quay - WGTN Station	- Newtown - WGTN Hospital - Basin Reserve - Courtenay Place - Manners - BNZ Centre - Capital Quay - WGTN Station - All stations to Johnsonville	- Current Island Bay bus stops - Newtown - Basin Reserve - Courtenay Place - BNZ Centre - WGTN Station	- Courtenay Place - BNZ Centre - WGTN Station - All stations to Johnsonville - All stations to Taita - All stations to Plimmerton
Transfers (indicative)	Bus stops as current.		Assume favourable transfers. Reduced bus stops.	Assume favourable transfers. Buses terminate at rail stations for transfers.	Assume favourable transfers. Buses terminate at rail stations for transfers.	Assume favourable transfers. Buses terminate at rail stations for transfers.	Assume favourable transfers. Buses terminate at rail stations for transfers.

Table 32 displays the assumptions used to model each of the medium options. All options are versions of the 'Base Case' with as many factors as possible keep constant throughout this process. The In Vehicle Time Factor and transfer penalties will be considered in more detail for the 'Short List' tests, when the more detailed public transport model is used.

Table 32 Modelling Assumptions

	Base Case	Bus Priority	BRT (CBD)	LRT (CBD)	LRT (North) x2	LRT (South)	HRE
Description	**Agreed Future WTSM**	**Full bus priority from Newtown to Wellington Railway Station.**	**BRT from Newtown to Wellington Railway Station.**	**LRT from Newtown to Wellington Railway Station.**	**LRT from Newtown to Johnsonville and replacing the Johnsonville Rail line.**	**LRT from Island Bay via Newtown to Wellington Railway Station.**	**Extending heavy rail through to Courtenay Place from Wellington Railway Station**
Free Flow Vehicle Speed: Outside CBD	As Current		As per speed limit Newtown to CBD	As per free flow rail speeds	As per free flow rail speeds	As per free flow rail speeds	As per free flow rail speeds
CBD Vehicle Speed	As Current	25 km/h for sections of road with bus priorities	30 km/h	30 km/h	30 km/h	30 km/h	As per rail speeds (Assumed grade separated)
In Vehicle Time Factor	Bus (ft11) = 1.00 Rail (ft12) = 0.90		Bus (ft11) = 1.00 Rail (ft12) = 0.90 BRT (ft14) = 0.92	Bus (ft11) = 1.00 Rail (ft12) = 0.90 LRT (ft13) = 0.80	Bus (ft11) = 1.00 Rail (ft12) = 0.90 LRT (ft13) = 0.80	Bus (ft11) = 1.00 Rail (ft12) = 0.90 LRT (ft13) = 0.80	Bus (ft11) = 1.00 Rail (ft12) = 0.90
Dwell Time at Stations	As Current		0.5 minutes / station	0.5 minutes / station	0.5 minutes / station	0.5 minutes / station	
Dwell Time at Wellington Railway Stations					0.5 minutes / station		0.8 minutes / station (Wellington Station and BNZ Centre)
Reduced Road Capacity	As Current	Reduced vehicle lanes for bus priority in each direction in CBD	Reduced vehicle lanes for bus priority in each direction in CBD	Reduced vehicle lanes in each direction in CBD	Reduced vehicle lanes in each direction in CBD	Reduced vehicle lanes in each direction in CBD	No
Transfer Penalty on PT Spine	Calibrated Model 21.5 minutes for boarding and transfer penalty		High Quality Stops 15 min for boarding and transfer penalty)	High Quality Stops 15 min for boarding and transfer penalty)	High Quality Stops 15 min for boarding and transfer penalty)	High Quality Stops 15 min for boarding and transfer penalty)	High Quality Stops 15 min for boarding and transfer penalty)
Fares	Zoned						NB: No additional charge for rail to travel additional distance.

Table 33 Scenario Public transport Services

	Base Case	Bus Priority	BRT (CBD)	LRT (CBD)	LRT (North) x2	LRT (South)	HRE
Description	**Agreed Future WTSM**	**Full bus priority from Newtown to Wellington Railway Station.**	**BRT from Newtown to Wellington Railway Station.**	**LRT from Newtown to Wellington Railway Station.**	**LRT from Newtown to Johnsonville and replacing the Johnsonville Rail line.**	**LRT from Island Bay via Newtown to Wellington Railway Station.**	**Extending heavy rail through to Courtenay Place from Wellington Railway Station**
Core Services on PT Spine*	Future base services		D - Brooklyn F – Airport Service	D - Brooklyn F – Airport Service	D - Brooklyn F – Airport Service	D - Brooklyn F – Airport Service	D - Brooklyn F – Airport Service
Extend on PT Spine	N/A			New LRT Service	New LRT Service J'ville Rail services	New LRT Service	J'ville Rail services Taita Rail services Plimmerton Rail services
Services replaced by new mode						A1 – Island Bay A2 – Zoo	
Services to Terminate at Newtown	N/A			A1 – Island Bay A2 – Zoo 32 – Houghton Bay 34 – Owhiro Bay	A1 – Island Bay A2 – Zoo 32 – Houghton Bay 34 – Owhiro Bay	32 – Houghton Bay 34 – Owhiro Bay	
Services to Terminate at Courtenay Place	N/A			B – east to Miramar 30 – Moa Point 31 - Miramar 36 – Llyal Bay	B – east to Miramar 30 – Moa Point 31 - Miramar 36 – Llyal Bay	B – east to Miramar 30 – Moa Point 31 - Miramar 36 – Llyal Bay	A1 – Island Bay A2 – Zoo B – east to Miramar 30 – Moa Point 31 - Miramar 32 – Houghton Bay 34 – Owhiro Bay 36 – Llyal Bay
Services to Terminate at Wellington Railway Station	N/A			B – west to Karori H / 67 / 68 - Newlands 12 – Khandallah 61 –Churton Park 62 – Granada Village	B – west to Karori H / 67 / 68 - Newlands 12 – Khandallah 61 –Churton Park 62 – Granada Village	B – west to Karori H / 67 / 68 - Newlands 12 – Khandallah 61 –Churton Park 62 – Granada Village	B – west to Karori H / 67 / 68 - Newlands 12 – Khandallah 61 –Churton Park 62 – Granada Village
Remain Unchanged	All bus services All rail services			C – Cross-town D - Brooklyn F – Airport Service All other bus services All other rail services	C – Cross-town D - Brooklyn F – Airport Service All other bus services All other rail services	C – Cross-town D - Brooklyn F – Airport Service All other bus services All other rail services	C – Cross-town D - Brooklyn F – Airport Service All other bus services All other rail services
Peak Hour Bus Frequency on PT Spine	34x Core Buses 15x Secondary Buses 22x Peak Buses **Total = 71 (each way)**			8x Core Buses 11x Secondary Buses 0x Peak Buses **Total =19 (each way)**	8x Core Buses 11x Secondary Buses 0x Peak Buses **Total =19 (each way)**	8x Core Buses 11x Secondary Buses 0x Peak Buses **Total =19 (each way)**	8x Core Buses 11x Secondary Buses 0x Peak Buses **Total =19 (each way)**
Additional potential stations outside PT Spine (not modelled):	N/A		- Zoo - Picton Ferry Terminal - WestPac Stadium		- Picton Ferry Terminal - Wadestown - Broadmeadows - Churton Park - Tawa		- Picton Ferry Terminal - Wadestown - Broadmeadows - Granada Village

Currently express bus services and trains from the north terminate at the Wellington Railway Station. This philosophy would be reapplied by terminating services from the east (and some from the south) at Courtenay Place (and Newtown) to reduce duplication of services on the PT Spine. The Golden Mile would instead be catered for with the PT Spine services. The Hutt to Airport service would be retained under all options. Secondary services other than the 12 remain as proposed, core and peak services are truncated to cater for the PT Spine. Potential additional stations have also been listed, to show the potential coverage of these options, outside of the PT spine, for example a Wadestown or Broadmeadows station on the Johnsonville rail line. The interaction of bus routes within in the model runs, will be considered in greater detail at the short list stage

Appendix C

Modelling Results

Appendix C Option Modelling Results

1.0 Background

The Wellington Public Transport Spine Study (PTSS) has been commissioned by Greater Wellington Regional Council to assess the feasibility and merits of a range of long term options for providing a high frequency and high quality public transport system between the Wellington Railway Station and the Wellington Regional Hospital.

For the Multi Criteria Assessment (MCA), eight 'Medium List' options have been assessed against a Base Case and evaluated for the 2041 year. These options covered two alignments for each of the four modes (Bus, Bus Rail Transit, Light Rail, and Heavy Rail). The Wellington Strategy Transport Model (WTSM) was used to test options based on these four modes and provide an input into the MCA to refine a 'Short List'. Bus routing, station locations, alignments and some modelling parameters for these test were provisional and will need further refinement before being taken forward to the 'Short List' testing.

This document reports on the results of the 'Medium List' modelling tests for the PTSS focusing on the MCA Criteria Options and two additional sensitivity tests for the Light Rail Transit (LRT) option. All of the assumptions included in the transport modelling are fully detailed in the transport modelling assumptions technical note (29 March 2012).

These tests are listed in Table 34, and are further described below. All results are for the 2041 morning 2 hour peak period, as extracted from the Wellington Regional Transport Model.

Table 34 Medium List Tests (For MCA)

Tests	Description
Base Case	Agreed Future WTSM
Bus Priority	Full bus priority from Newtown to Wellington Railway Station.
Bus Rail Transit (BRT)	BRT from Newtown to Wellington Railway Station.
Light Rail Transit (LRT)	LRT from Newtown to Wellington Railway Station, replacing bus services on the PT Spine.
Heavy Rail Extension (HRE)	Extending heavy rail through to Courtenay Place from Wellington Railway Station, replacing bus services on the PT Spine.
LRT (North) (Additional LRT Option)	LRT from Newtown to Johnsonville and replacing the Johnsonville Rail line and replacing bus services on the PT Spine.
LRT (South) (Additional LRT Option)	LRT from Island Bay via Newtown to Wellington Railway Station, replacing bus services on the PT Spine and between Newtown and Island Bay.

Major assumptions which will require further consideration for the 'Short List' include:

- The extent to which existing bus routes compete with scenarios within the CBD. All options will provide access to the same catchments as existing bus services. The issue is which existing services travelling from beyond the study area will continue into the CBD to provide access.
- The necessity to transfer between modes and the locations for transfers whilst bus and BRT provide a seamless journey, LRT and HRE require definition as to how and where transfers will take place.
- The extent to which scenarios will extend and have an impact beyond the study area, e.g. the additional LRT options.

2.0 Medium List Tests

2.1 Base Case

The Base Case provides a base line for tests formulated from the agreed future WTSM. Capital projects are assumed in the Base Case if they are 1) not on the PT Spine, 2) already committed or 3) are needed to maintain a minimum level of service over the evaluation period of 30 years. The Public Transport network is assumed to include the Wellington City Bus Review. These committed and minor improvements ensure the transport system in the model does not show excessive or unrealistic delays and continues to provide a minimum level of service for underlying increases in transport demand, for example due to growth in population.

Figure 19 displays the output plots for the Base Case including public transport frequencies (vehicles per hour) and passenger volumes from the 2041 morning 2 hour peak period. The plots of bus frequencies provide a colour coded range to indicate a volume of buses, the width of the lines on the network plot also indicate volume so as to provide a comparative scale within each off the bands.

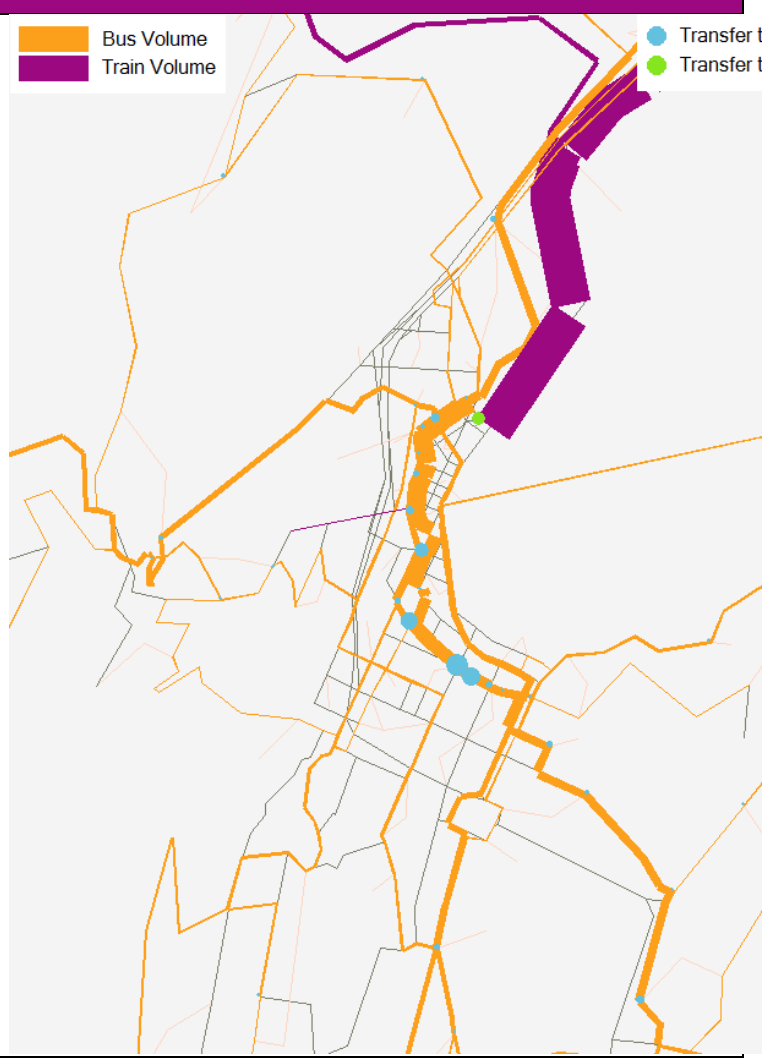
These plots show that the main public transport corridors into the Wellington CBD are the rail lines from the north Karori bus services from the west and Mirimar bus services from the east. These bus services converge with others through the Golden Mile (Lambton Quay, Willis Street and Courtenay Place) to provide frequencies of 40 – 60 northbound and 60-80 southbound services per hour. There are also express services travelling northbound parallel along the water front route, to relieve pressure on the Golden Mile.

Passenger volumes are largest on the rail services from Porirua and Hutt Valley. The majority of transfers occur to bus services along the Golden Mile, particularly around Courtenay Place. Similar plots for the other options are displayed in Figure 20 and Figure 22.

Figure 19 Output Plots – Base Case

- **Vehicle Frequencies**

- **Passenger Volumes**



2.2 Summary of Modelling results

2.2.1 Public Transport Vehicles

Table 35 displays the frequencies of selected services into and within the Wellington CBD. Rail frequencies per hour into the CBD are the same for all options, similar to the current rail frequencies. Bus services are the same on Adelaide Terrace from Newtown, with the exception of the LRT option where buses are replaced by light rail. Through the PT Spine (Lambton Quay and Customhouse Quay) there are approximately 75 buses in each direction per hour (consistent with Wellington Bus Review). The volume of buses is greatly reduced in the LRT and HRE options, where all non-peak services are replaced by rail (or light rail) services, these options would r the density of vehicles on the Golden Mile.

Table 35 Public Transport Vehicles (per hour)

Performance Measure	Base Case	Bus	BRT	LRT	HRE
Rail Inbound					
Porirua	9	9	9	9	9
Hutt Valley	14	14	14	14	14
Johnsonville	4	4	4	4	4
PT Spine					
Northbound Bus	75	75	75	21	21
Northbound Rail	-	-	-	12	12
Southbound Bus	77	77	77	29	29
Southbound Rail	-	-	-	12	12
Newtown Services					
Northbound	20	20	26	12 (Rail)	26

Figure 20 displays the public transport frequencies through Wellington CBD for the bus options (Bus Priority and BRT) and rail options (LRT and HRE). These show that for the rail option there are lower frequencies through (or under) the CBD, as rail has higher seating capacities then bus per vehicle so a lower frequency can be used.

Figure 20 Output Plots – Public Transport Vehicles (per hour)

- **Bus Options**

- **Rail Options**

2.2.2 Passenger Volumes

Table 36 displays patronage along selected corridors into and within Wellington CBD, from the 'Medium List' model tests. These results show that inbound rail patronage increases for the LRT (+45%) and HRE (+90%) options on the Johnsonville rail line. Patronage on the Golden Mile increases slightly for the BRT option in each direction, but reduces for the LRT option (-15%). The HRE option increases patronage on the PT Spine (+50%) in the southbound direction, these passengers are believed to have previously walked.

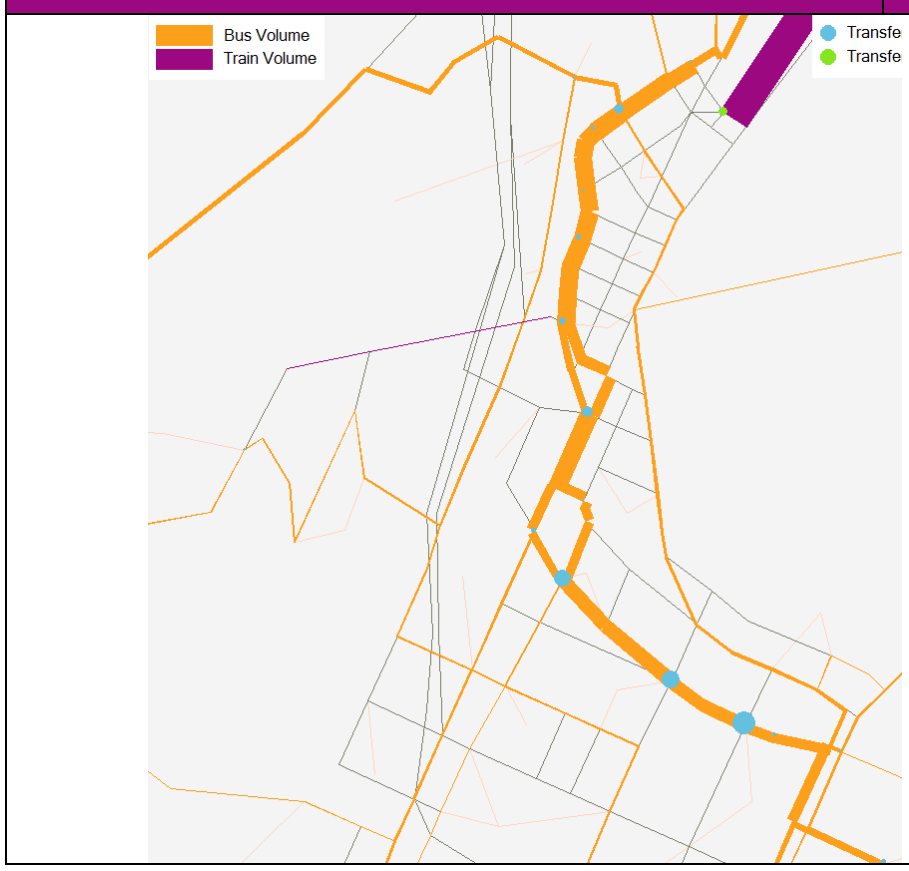
Table 36 Patronage (Passenger Volumes)

Performance Measure	Base Case	Bus	BRT	LRT	HRE
Rail Inbound					
Porirua	6300	6300	6400	6400	6500
Hutt Valley	6300	6300	6400	6500	6700
Johnsonville	1600	1600	1800	2300	3000
PT Spine					
Northbound Bus	3500	3800	4200	1900	2700
Northbound Rail	-	-	-	1700	900
Southbound Bus	5800	5900	6100	1900	1100
Southbound Rail	-	-	-	2600	7500
Newtown Services	**Bus**	**Bus**	**Bus**	**Rail and Bus**	**Bus**
Northbound	2900	2900	3600	2200	3300
Southbound	400	400	700	400	500

Figure 21 displays the public transport patronage through Wellington CBD and the location of transfers for each of the MCA options (Bus Priority, BRT, LRT and HRE). These show that patronage is moderately consistent in all options. The HRE and BRT options have the most transfers at Courtenay Place. The Bus Priority and LRT options have few transfers.

Figure 21 Output Plots – Passenger Volumes

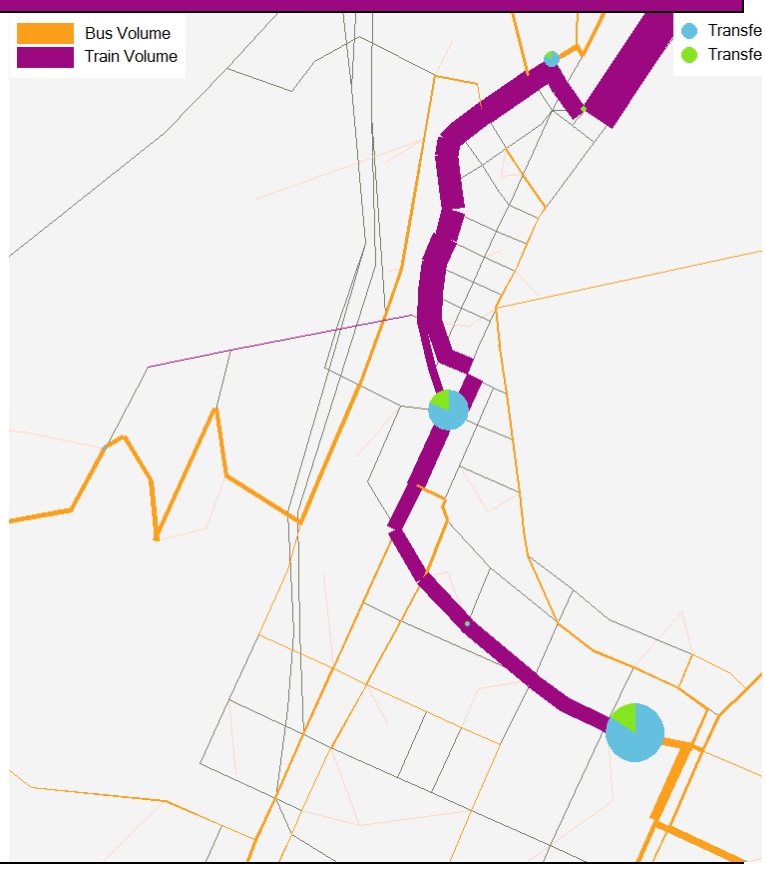
- **Bus**
- **BRT (CBD)**



Output Plots – Passenger Volumes (Continued)

- **LRT (CBD)**

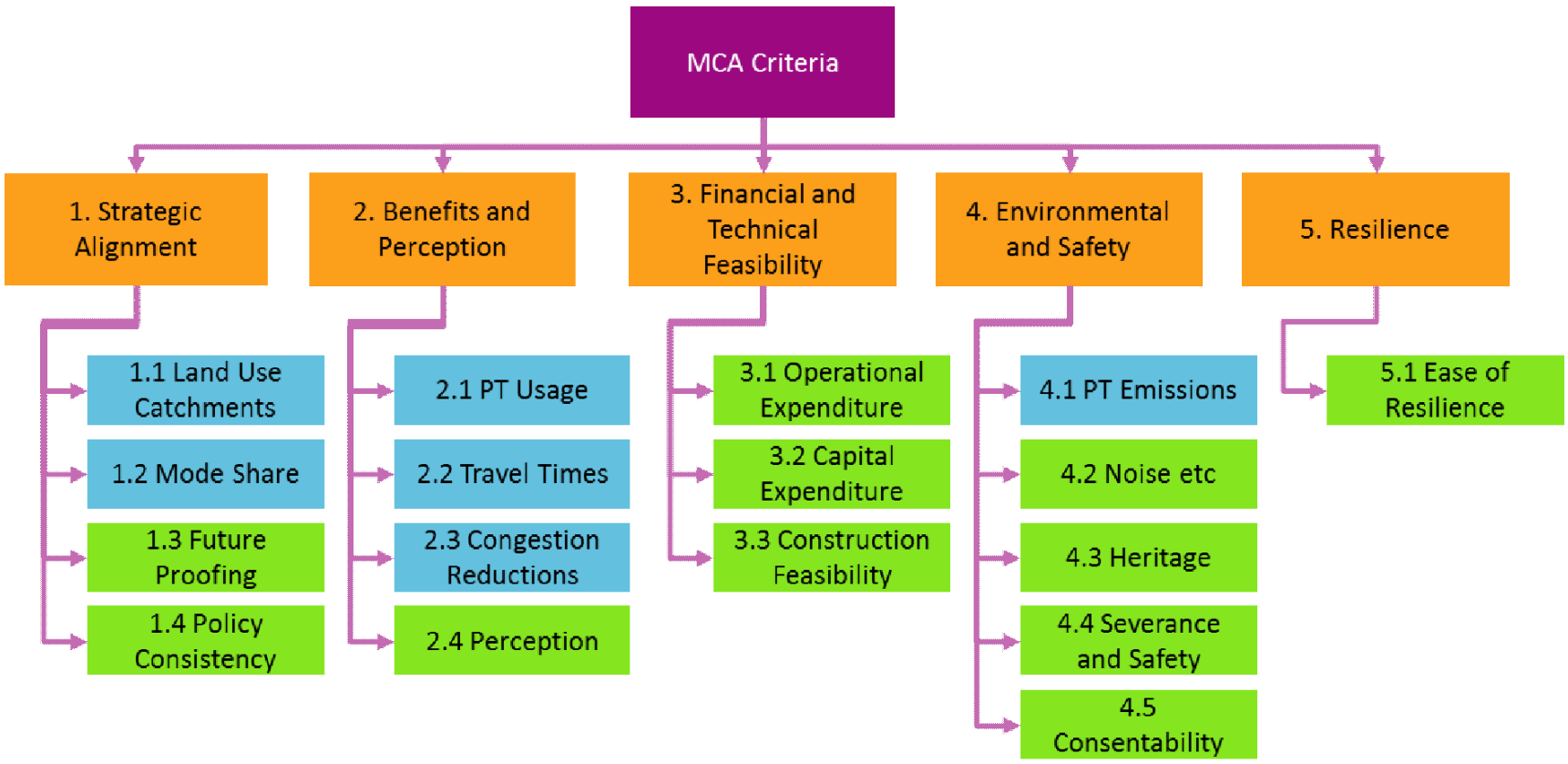
- **HRE**



3.0 Transport Modelling Metrics (Medium List)

This analysis has been conducted to provide commentary for the MCA assessment by providing additional detail of each of the modelling results, including extraction, meaning and relevance to the overall MCA decision. The criteria highlighted (blue) in Figure 22 represent the MCA criteria based on transport modelling outputs. This commentary does not discuss the scoring of each mode as this is provided in the main MCA documentation.

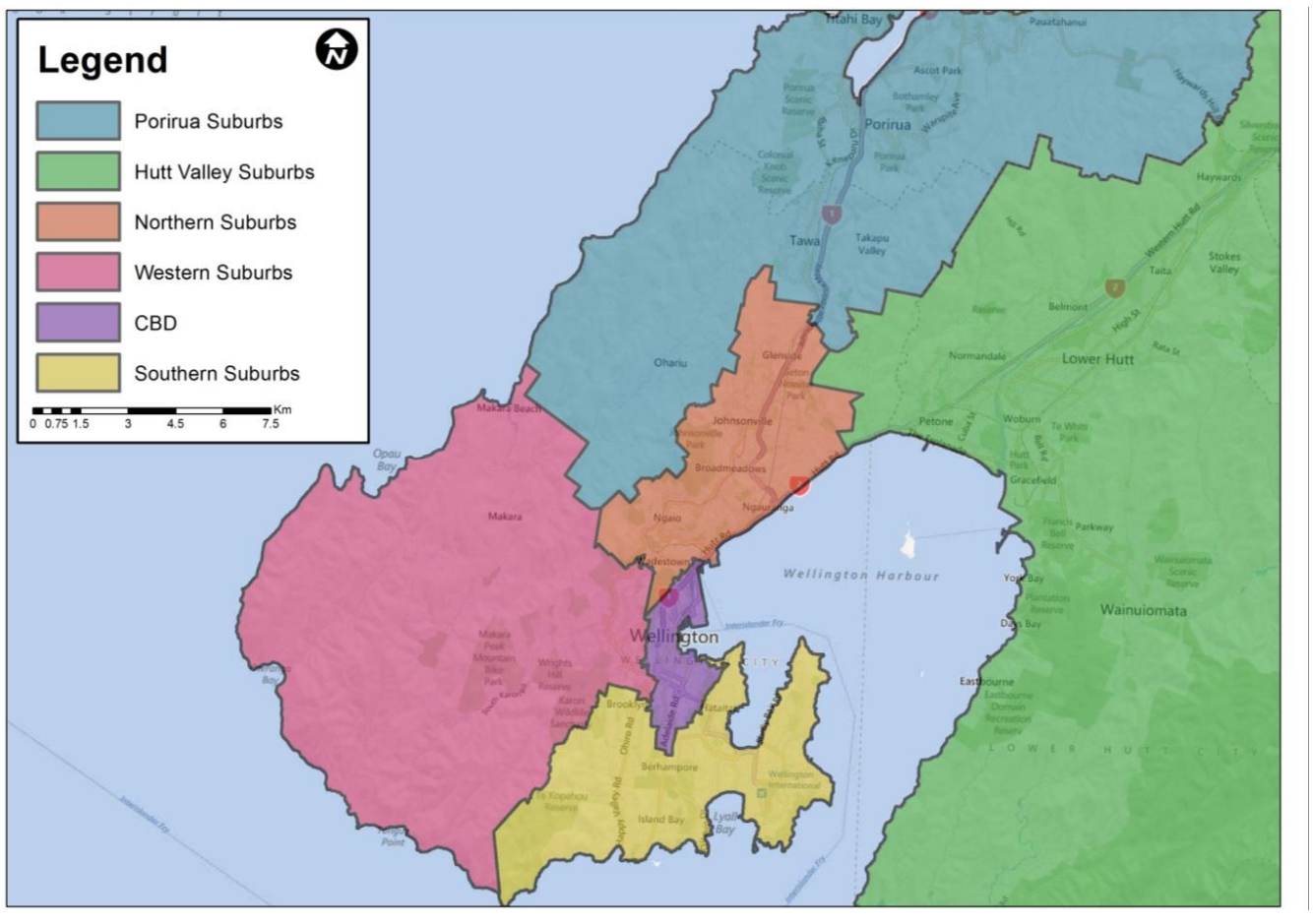
Figure 22 MCA Option Tree



Although not used in the MCA process there are other relevant modelling outputs such as the number of transfers taken to make a trip. For completeness this additional information has been provided.

For some of these criteria Wellington City has been divided into suburban groups, these are displayed in Figure 23

Figure 23 Suburban Groups



3.1 Employment and Population within Stop Catchment

3.1.1 Transport Modelling Calculations

This criterion assesses the potential number of jobs and population (catchment area) within a typical walking distance to stops / station along the PT-Spine (Wellington Station to Courtenay Place) (see Figure 25**Error! Reference source not found.**). This will vary by mode (based on the number of stops or stations) and alignment of the route (i.e. a waterfront route would have less of a catchment area as the area to the east is the sea). Land use catchments (employment and Population) were extracted by aggregating census mesh blocks within 400m of stops using GIS. The measure of 400m is based upon the international review which found that 400m was an acceptable distance in which to access public transport in a walkable city. This is further supported by reviewing current LRT walking distance guidelines from Canadian and American cities which suggest an acceptable range between 300m and 600m. For this study a radius of 400m was considered suitable.

Future year forecasts were applied by factoring 2006 mesh block totals by the increase in development between 2006 and 2041. Employment grew by 133% and population by 124% between 2006 and 2041.

Figure 25 displays the 400 m catchments for each of the options. This is a simplified analysis which considers a radius of 400 m radius rather than walking distance. This approach was taken as the potential location of stops have not been finalised and in the case of HRE option access to underground stations have not been confirmed. This figure clearly shows that the options with fewer potential stops have much reduced catchments.

Table 37 displays the results of the analysis, this shows the population and employment within a practical walking distance of the 'Medium List' alignments. This statistic is relevant as it identifies the potential users of the facilities. Due to the reduced number of stops and assuming a 400m catchment HRE has a significantly smaller catchment. By comparison Bus, BRT and LRT have similar catchments to the Base Case.

Table 37 Land Use Catchments – 400m Catchments

Performance Measure	Base Case	Bus		BRT or LRT		HRE	
		Centre	Water	Centre	Water	Under	Water
2006 Employment Catchment	61,400	61,400	57,300	61,000	48,300	42,300	35,300
2041 Employment Catchment	76,200	76,200	71,000	75,600	59,800	52,400	43,800
2006 Population Catchment	8,000	8,000	4,700	7,000	3,200	4,000	2,100
2041 Population Catchment	9,900	9,900	5,800	8,700	3,900	5,000	2,700

Figure 24 Mode Share (Region) - Graph

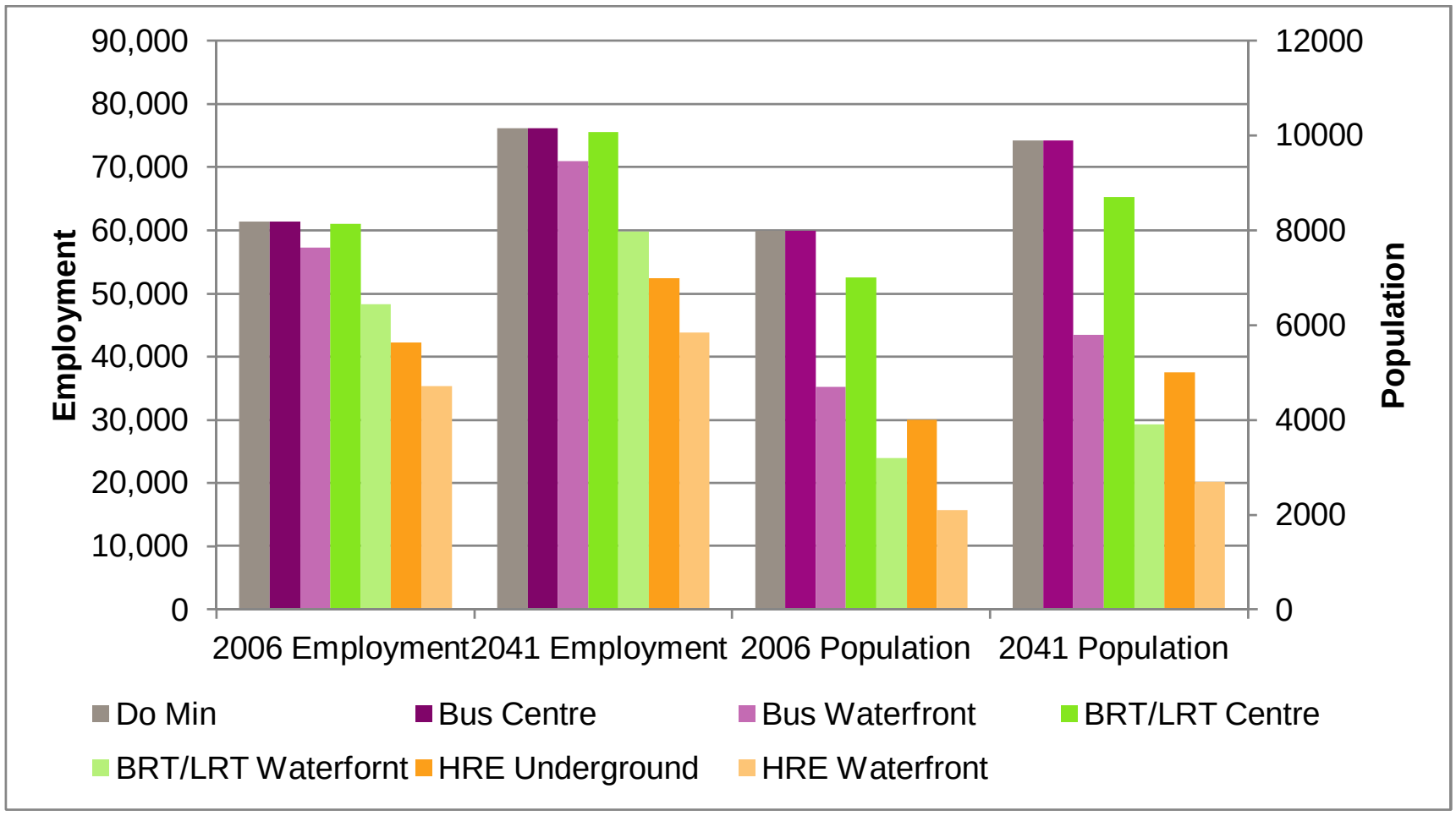
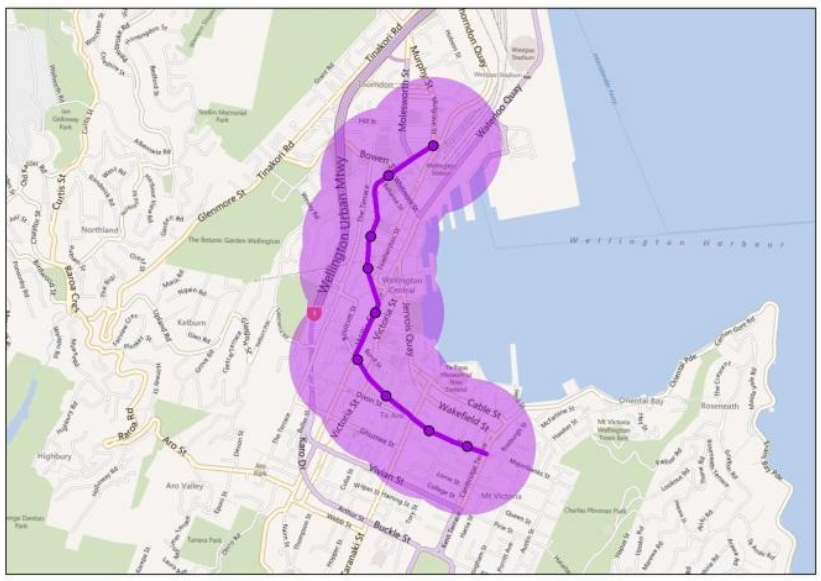
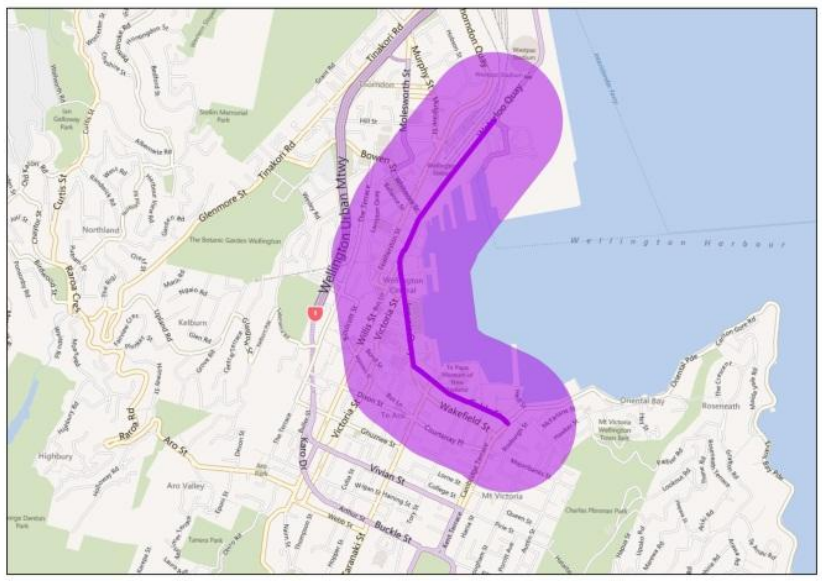
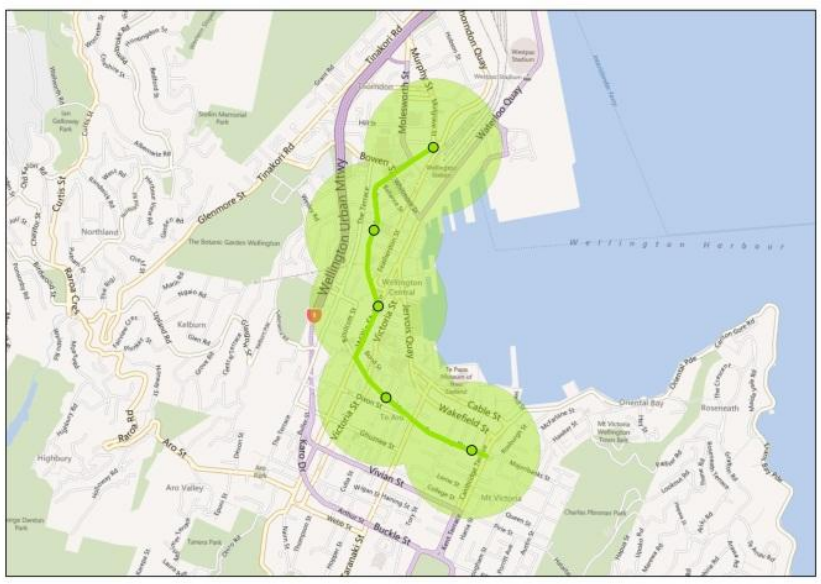
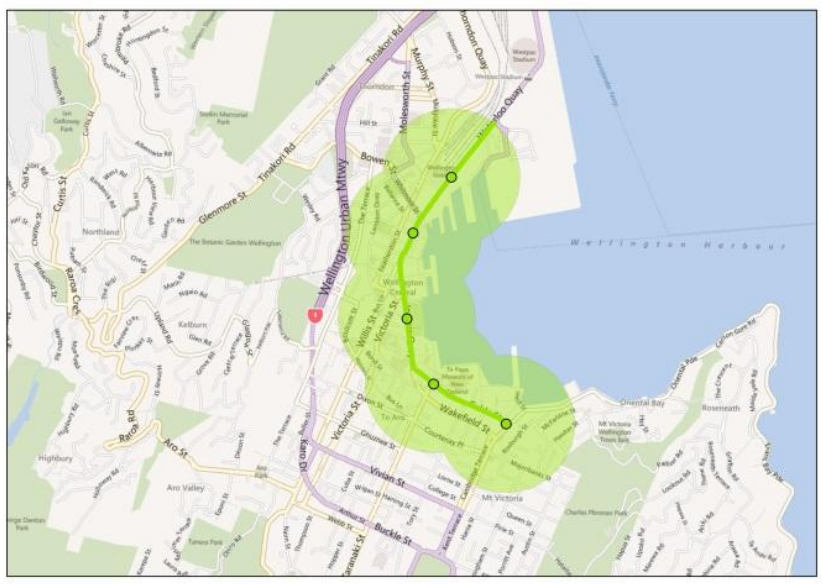
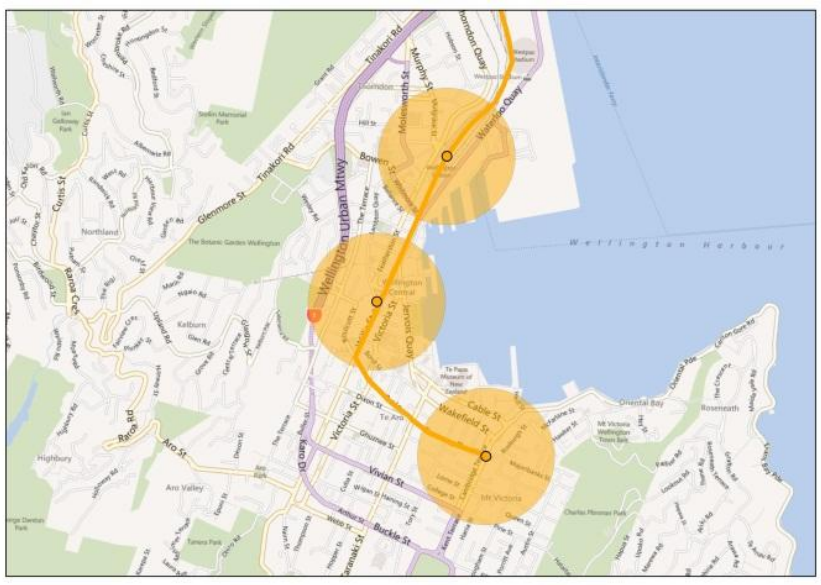
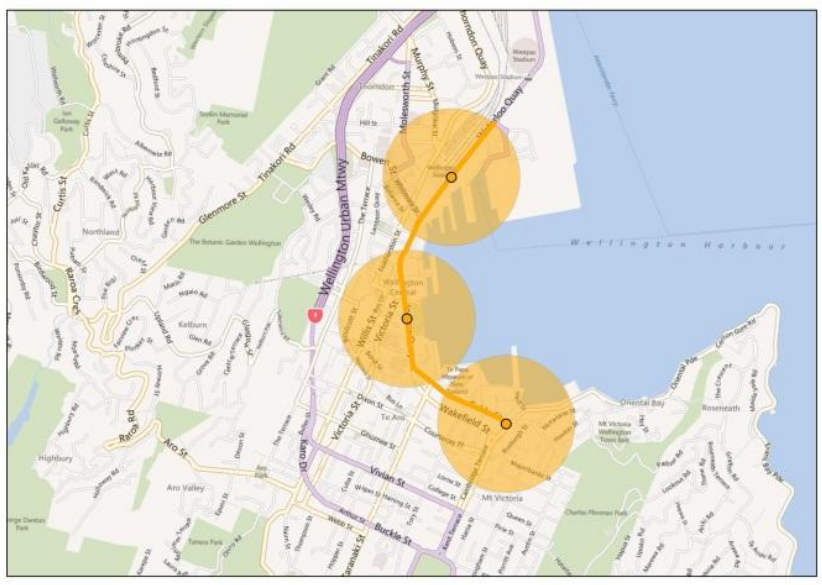


Figure 25 Passenger Transport Stop Catchments

Base Case & Bus Centre	Bus Waterfront
	
BRT or LRT Centre	**BRT or LRT Waterfront**
	
HRE Centre	**HRE Waterfront**
	

3.2 Mode Share

This criterion assesses the proportion of total all-purpose trips made on passenger transport. Other modes include walking, car and heavy vehicles. Due to the volume of total trips it is unlikely these mode shares will vary by more than a few percentage points. This criteria is shown in two sub categories and assessment is made by mode not by route alignment.

- Total region, which identifies wider benefits provided by the public transport services, which for example could be influenced by improved connectivity.
- Wellington CBD which identify benefits for trips to the study area, which could be influenced by reduced walking distances or increased frequency.

Mode Share was extracted by aggregating the trip matrix and separating the public transport trip matrix out into walking trips (boardings = 0) and passenger transport trips (boardings ≥ 1). Public transport trips were then divided by the total number of trips to obtain a percentage. As mode share will vary depending on geographic region the Wellington Region has been aggregated into suburban groups based upon the public transport service corridors as shown in Figure 23.

These results show the percentage of all trips made by public transport. This highlights that on average there is little difference between the options and the Base Case, although the LRT and HRE have a reduced mode share for the Western and Southern Suburbs.

Table 38 Mode Share (Region)

Performance Measure	Base Case	Bus	BRT	LRT	HRE
Trips from Western Suburbs	14.1%	14.2%	14.2%	13.6%	13.5%
Trips from Southern Suburbs	18.0%	18.4%	18.6%	17.6%	18.0%
Trips from Northern Suburbs	19.2%	19.3%	19.3%	19.0%	19.6%
Trips from Hutt Valley Suburbs	14.6%	14.6%	14.7%	14.8%	15.0%
Trips from Porirua Suburbs	15.5%	15.5%	15.6%	15.7%	15.8%
Mode Share (Whole Region)	**14.2%**	**14.3%**	**14.4%**	**14.1%**	**14.3%**

Figure 26 Mode Share (Region) - Graph

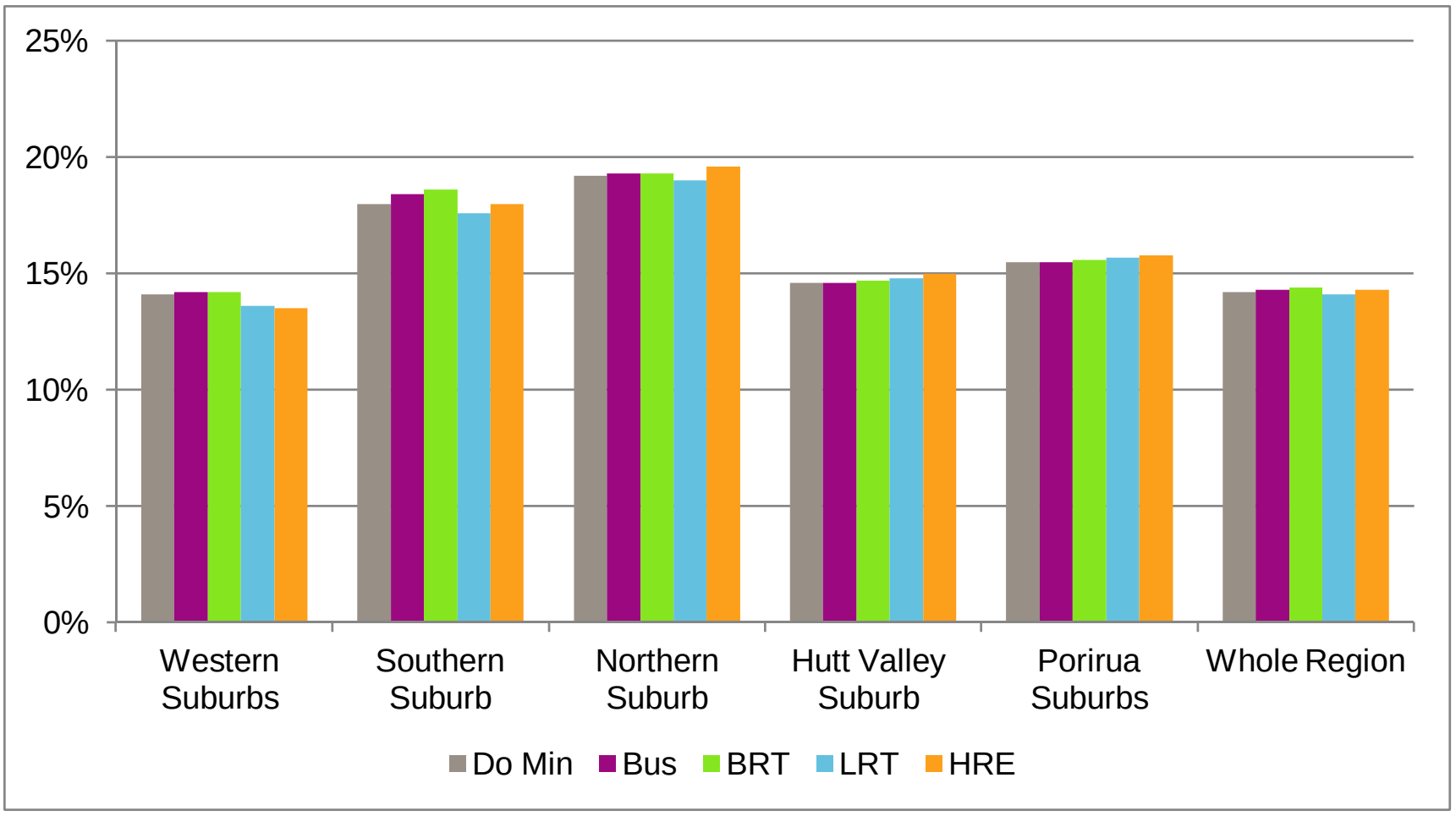


Table 39 Mode Share (to CBD)

Performance Measure	Base Case	Bus	BRT	LRT	HRE
Western Suburbs to CBD	25.5%	25.7%	25.3%	24.0%	23.8%
Southern Suburbs to CBD	33.7%	34.5%	34.9%	32.6%	33.1%
Northern Suburbs to CBD	46.6%	46.7%	46.5%	45.9%	47.2%
Hutt Valley Suburbs to CBD	56.1%	56.1%	56.3%	56.7%	57.8%
Porirua Suburbs to CBD	57.0%	57.0%	57.4%	57.7%	58.2%
Mode Share (to CBD)	**34.6%**	**34.9%**	**35.0%**	**34.2%**	**34.8%**

Figure 27 Mode Share (To CBD) - Graph

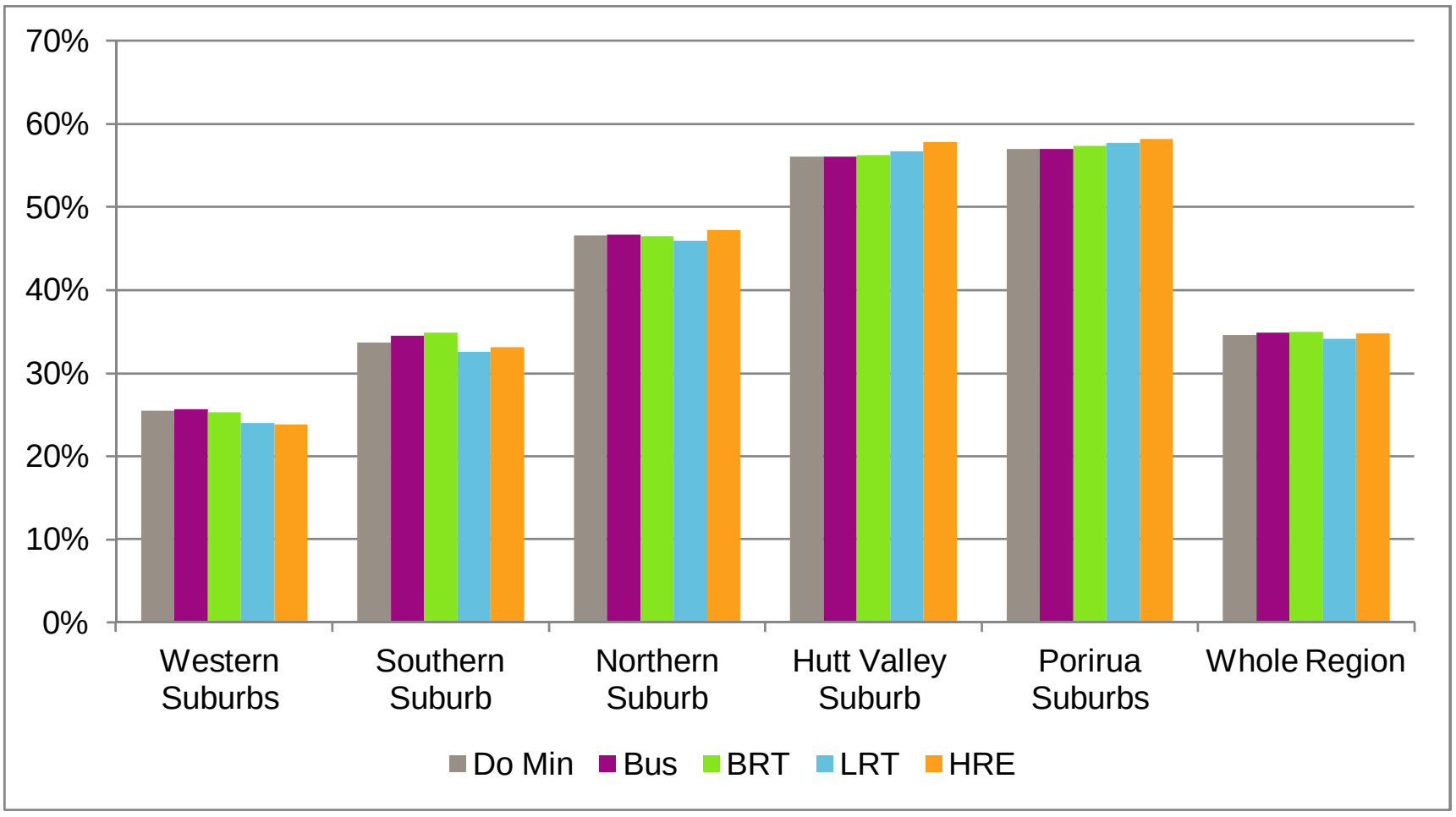
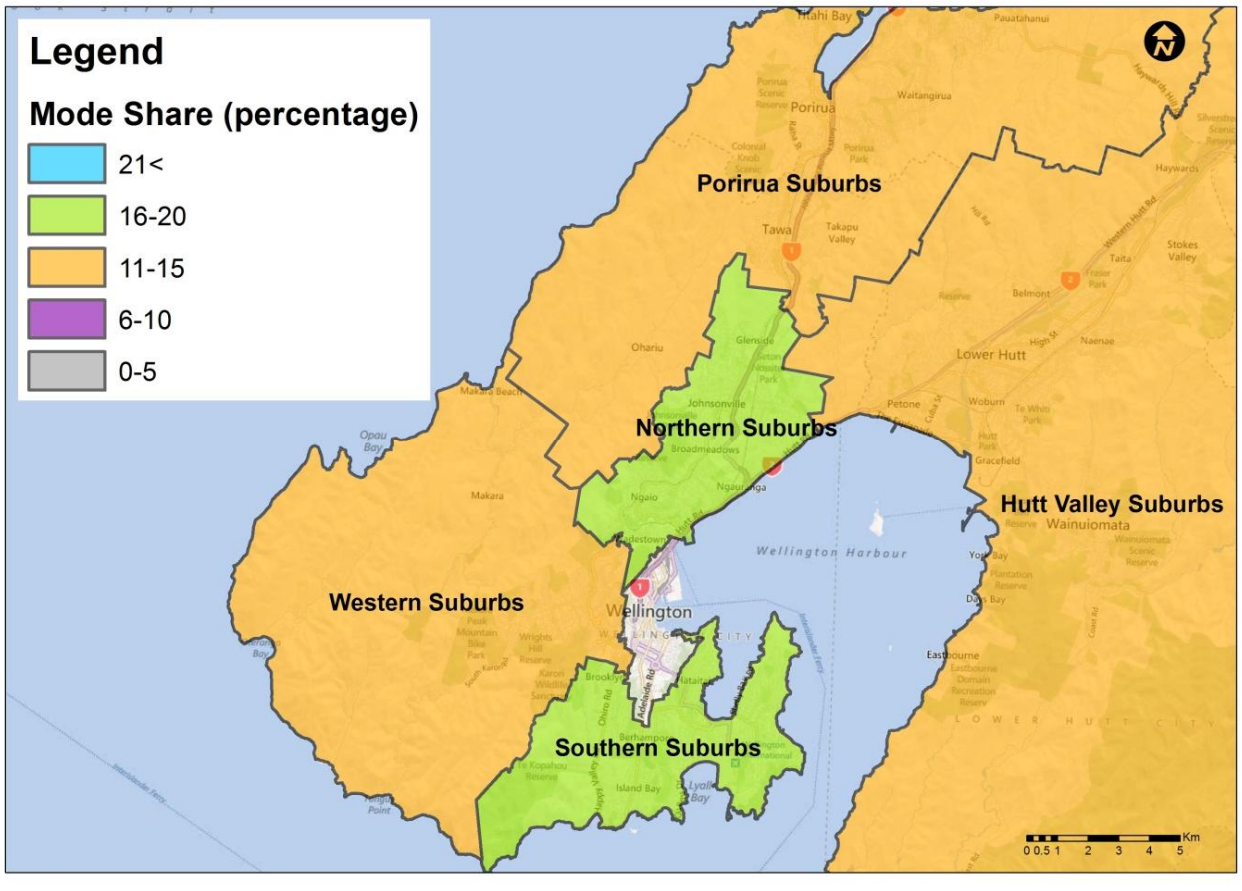


Figure 28 Mode Share (Region) - Maps (Base Case)



3.3 Integration with Wider PT Network: Number of Transfer per 100 Trips

This measure assesses the average number of transfers made to travel from outer regions into the Wellington CBD zones. Internal Wellington CBD trips require few transfers. This shows how the scenario affects the need to transfer travelling into the CBD. Assessing transfers provides a better understanding of the integration of each mode. The average number of transfers required was extracted by aggregating the public transport trip matrix multiplied by the boardings matrix. This automatically removed walking trips (boardings = 0) and therefore only counted true passenger transport trips (boardings ≥ 1). The result was divided by the total number of trips for that area and the first boarding was removed and divided by 100 to obtain the average number of transfers per 100 trips.

Equation 1 Transfer Calculations

$$\left(\left(\frac{\sum_A (PTtrips \times Boardings)}{\sum_A PTtrips}\right) - 1\right) / 100$$

These results therefore show the transfers required by public transport trips and how well the network is integrated. This highlights that the LRT and HRE require additional transfers from the Southern and Northern (LRT Only) Suburbs. This statistic is relevant to the MCA although most options would score the same as the Base Case as there is little change in required transfers. The LRT would score poorly due to the additional transfers required. Although the HRE increases transfers from the Southern Suburbs it decreases the required transfers from the Northern (-100%), Hutt Valley (-50%) and Porirua (-80%).

Table 40 PT Network Integration- Transfers per 100 trips

Performance Measure	Base Case	Bus	BRT	LRT	HRE
Western Suburbs to CBD	2	2	2	10	7
Southern Suburbs to CBD	0	0	0	24	15
Northern Suburbs to CBD	8	8	11	27	0
Hutt Valley Suburbs to CBD	18	19	21	21	9
Porirua Suburbs to CBD	21	21	22	22	2
Average to CBD	10	11	12	22	10

Figure 29 Average Transfers (To CBD) per 100 trips - Graph

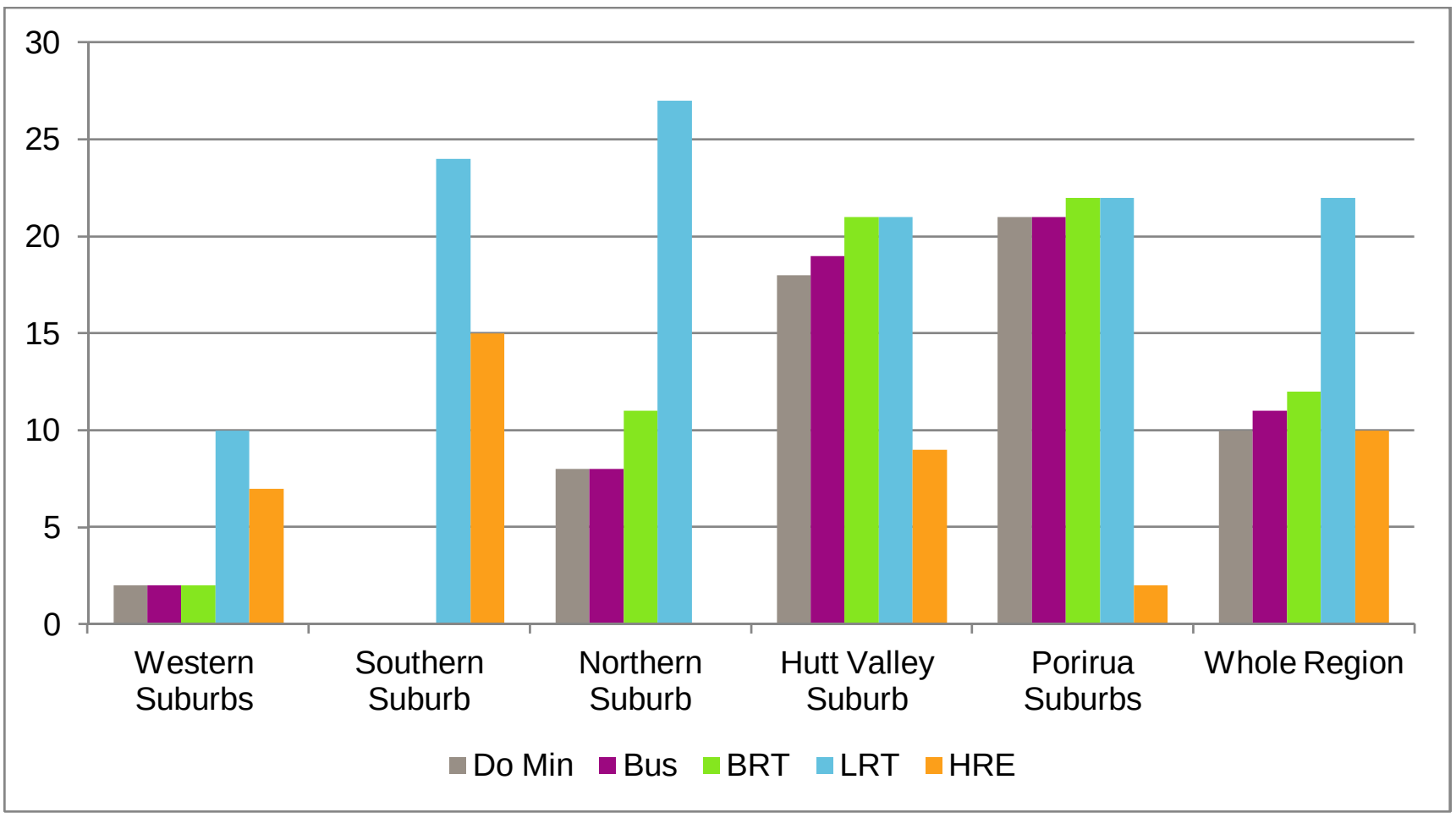
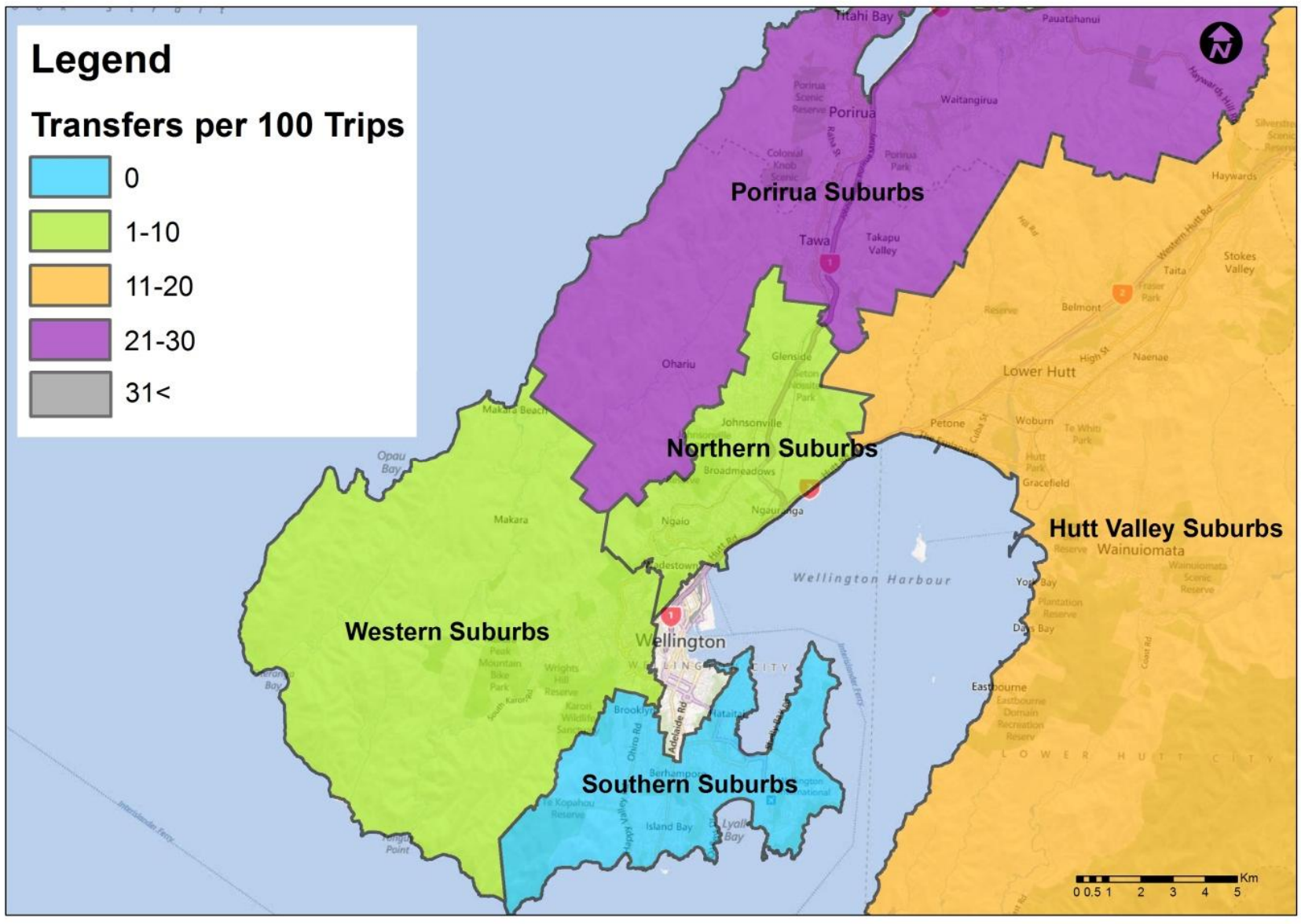


Figure 30 Average Transfers (To CBD) per 100 trips - Map (Base Case)



3.4 PT Usage: Total Passengers and Passenger km

This criterion assesses the number of passengers and distance they travel in buses, ferries and trains of the options relative to the Base Case. Additional average distance suggests passengers are travelling closer to their destination as opposed to having to walk (e.g. from Wellington Station).

Patronage was extracted by summing the public transport trip matrix and removing walking trips (boardings = 0). Average travel distance was calculated by multiplying the distance travelled matrix through by the public transport trip matrix and dividing by the total number of trips.

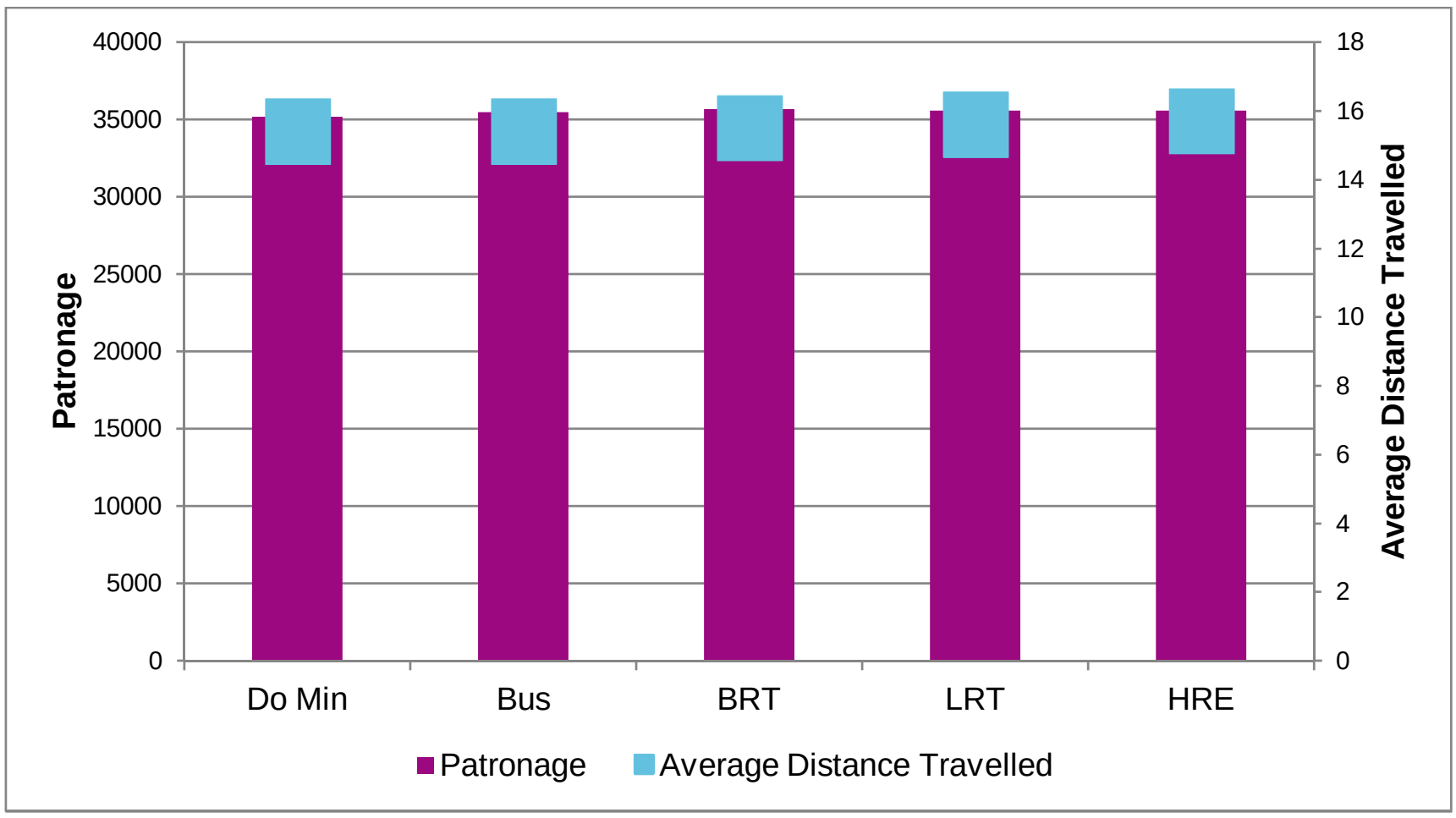
These results therefore show the total number of public transport trips, which replicates the mode share calculation and again is fairly similar for all options. This highlights that the LRT and HRE options slightly increase the distance that passengers travel, this is as they stay on their vehicles longer.

Patronage is relevant to the MCA although it replicates mode share, and therefore has the potential to be double counted. From these tests there is little difference in results, so this statistic will not assist in selecting options. The average distance would usually show that services are detouring to reach their destination which is not the case for these options as they instead show increased convenience as passengers travel further.

Table 41 PT Usage

Performance Measure	Base Case	Bus	BRT	LRT	HRE
Patronage	35,200	35,500	35,700	35,600	35,600
Average Distance Travelled	15.4	15.4	15.5	15.6	15.7

Figure 31 PT Usage - Graph



3.5 Public Transport Travel Time: To Wellington CBD

This criterion assesses the travel times for passenger transport trips between selected regions and the Wellington CBD. This incorporates walking, waiting and in-vehicle travel times (without factoring for generalised cost). Waiting time will be influenced by frequency of direct services. Walking time relates to the effectiveness/ competitiveness of alternatives, therefore a passenger may choose to walk as opposed to transfer. In-vehicle time relates to improved priority as well as the extension of services.

Average Travel Time was extracted by adding the walking time matrix in vehicle time matrix and waiting time matrix together to obtain a travel time (in minutes) for each origin - destination pair. These travel times were then multiplied by the number of trips (Total trip time) and aggregated into suburbs. Total trip time was divided by the number of trips to obtain an average travel time from each suburb to the CBD.

In most cases the options have a shorter travel time then the Base Case as they have additional priority. The LRT and HRE options have an increased travel times from the Western Suburbs as bus services are shortened and transfers are required to access some destinations. Overall this has not affected the overall average travel time.

This statistic is relevant to the MCA, however all options would score the same as the Base Case as there is little change in overall travel time.

Table 42 Public Transport Travel Time (Minutes to CBD)

Performance Measure	Base Case	Bus	BRT	LRT	HRE
Western Suburbs to CBD	34	33	33	39	39
Southern Suburb to CBD	34	31	30	31	32
Northern Suburb to CBD	36	35	35	35	34
Hutt Valley Suburb to CBD	44	44	44	44	43
Porirua Suburbs to CBD	44	43	43	43	43
Average Travel Time in Minutes	41	40	39	40	40

Figure 32 Average Travel Time to CBD - Graph

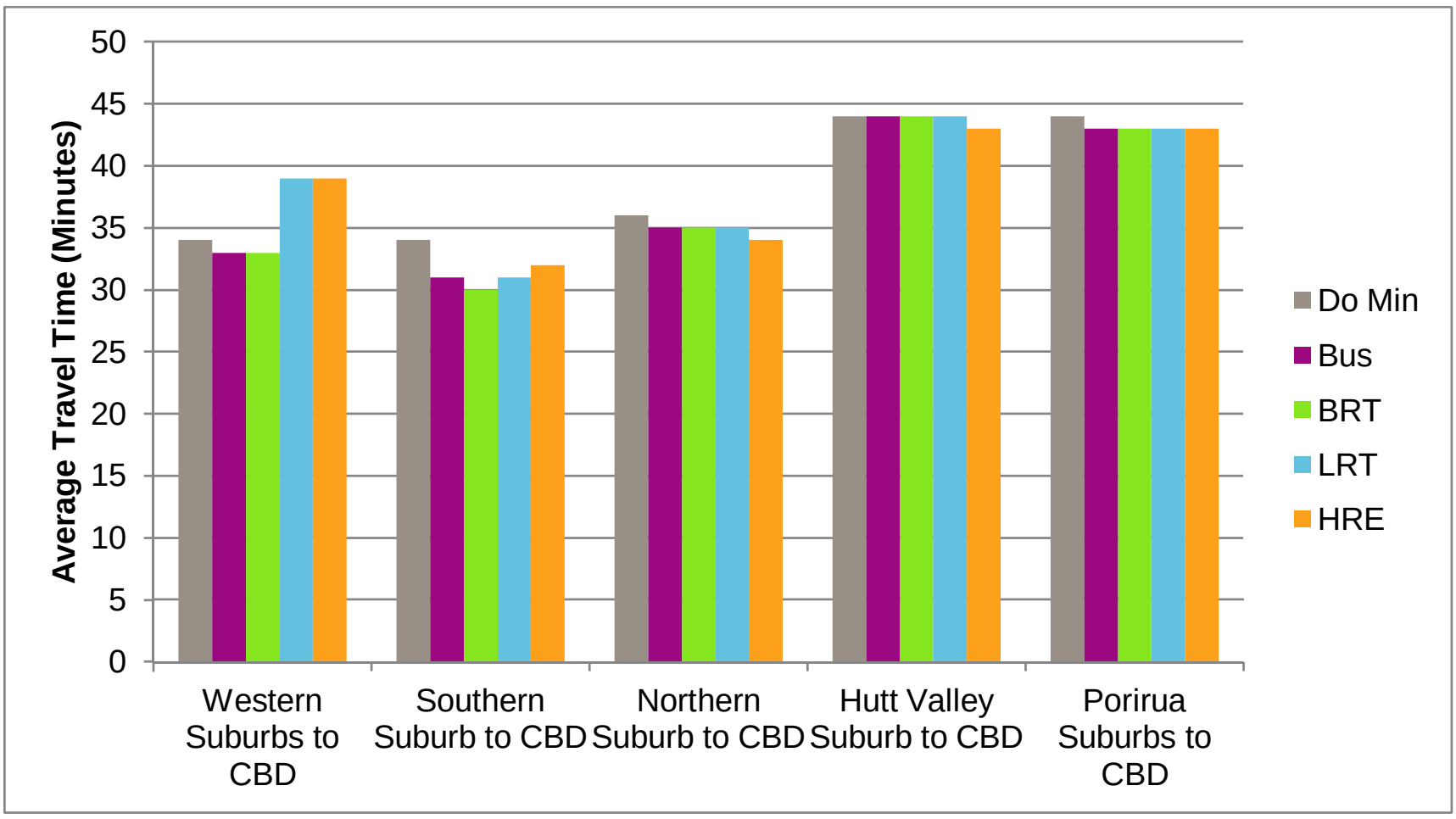
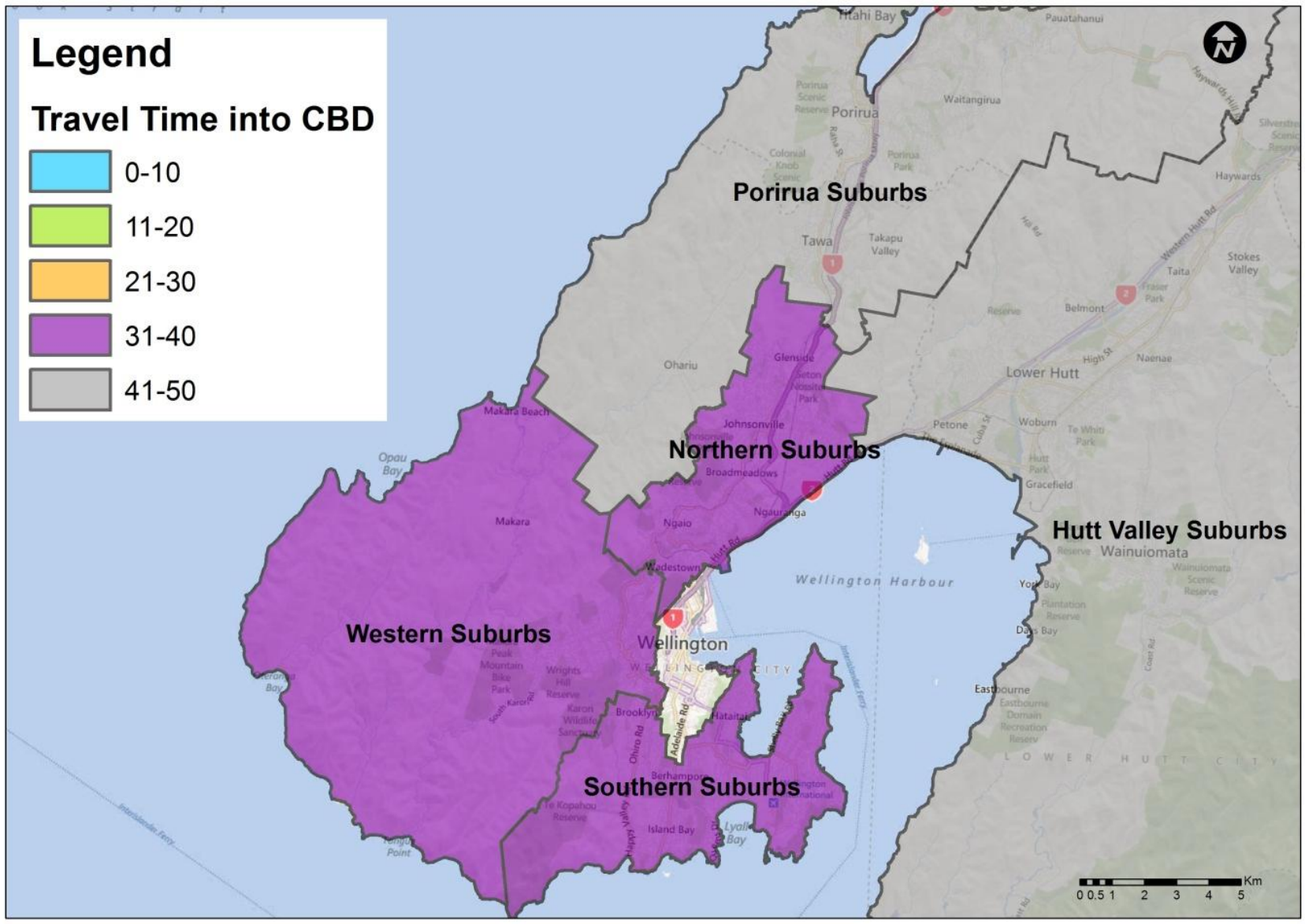


Figure 33 Average Travel Time to CBD – Map (Base Case)



3.6 Reduced Congestion Impacts on General Traffic

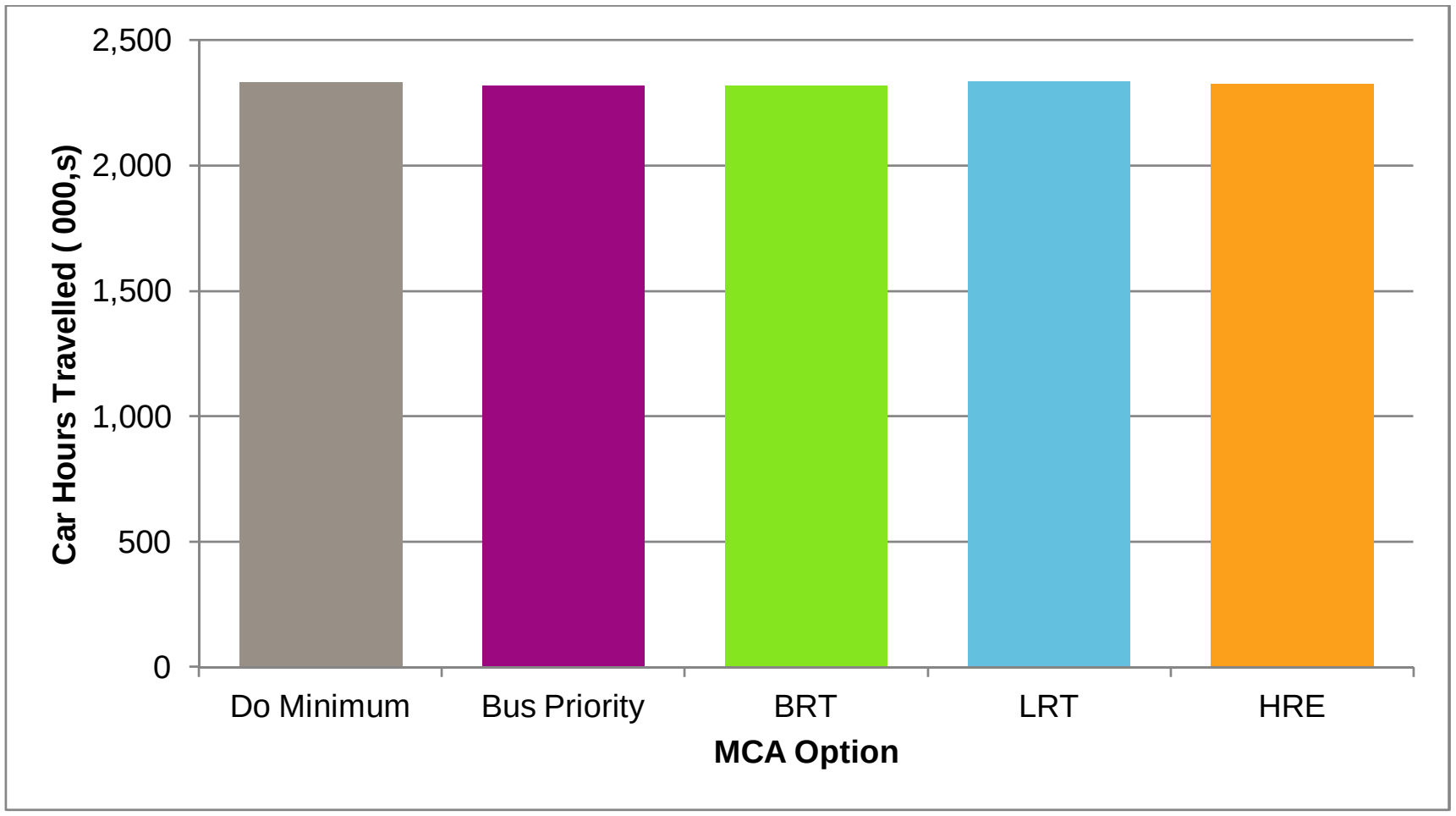
This criteria assesses the congestion of each scenario based on how long vehicles are on the network, compared to the Base Case (WTSM). Options may have both a positive effect on congestion through increased PT mode share and a reduction in car travel and also negative effects on congestion due to the space requirements of each option and the changes needed to general traffic to accommodate this. This can be modelled in more detail at the 'short list' stage.

Car hours travelled was extracted by multiplying the car trip matrix and the car distance matrix. This statistic is relevant to the MCA, however all options would score the same as the Base Case as there is little change in overall congestion from hours travelled.

Table 43 Congestion

Performance Measure	Base Case	Bus	BRT	LRT	HRE
Congestion (Car Hrs Travelled)	2,333,000	2,320,000	2,318,000	2,334,000	2,324,000

Figure 34 Congestion - Graph



3.7 PT Network Vehicle Emissions

This criterion assesses the distance travelled by each mode assuming that this causes proportional emissions. Each of the vehicle types have different efficiency and emissions per kilometre. This measure considers only local vehicle emissions, meaning that electric HRE and LRT vehicles are assumed to generate no local vehicle emissions. The bus fleet is currently comprised of diesel and electric buses. Given potential changes to the fleet type in the future two scenarios for emissions are considered. The first is if the existing ratio of diesel to electric vehicles continues (approximately 50%), the second is if the entire vehicle fleet is diesel. An option with the entire fleet being electric has not been considered, if it were then this would nullify this measure.

Public Transport emissions were calculated by extracting the kilometres travelled and multiplying that by a CO^2 factor. Table 44 shows that the distance travelled for all options are quite similar, however because emissions have been calculated based on bus kilometres travelled the total emissions are lower for the HRE and LRT options which reduce bus services.

Table 44 Emissions

Performance Measure	Base Case	Bus	BRT	LRT	HRE
Bus Kilometres [Bus kg CO^2] 100% Diesel [Bus kg CO^2] 50% Diesel	4,170 [125] [63]	4,170 [125] [63]	4,170 [125] [63]	3,880 [116] [58]	3,950 [119] [58]
LRT Kilometres [LRT kg CO^2]	0 [0]	0 [0]	0 [0]	120 [0]	0 [0]
HRE Kilometres [HRE kg CO^2]	1,490 [0]	1,490 [0]	1,490 [0]	1,490 [0]	1,540 [0]
Total PT Emissions [kg CO^2]	125	125	125	116	119

Figure 35 Public Transport Kilometres

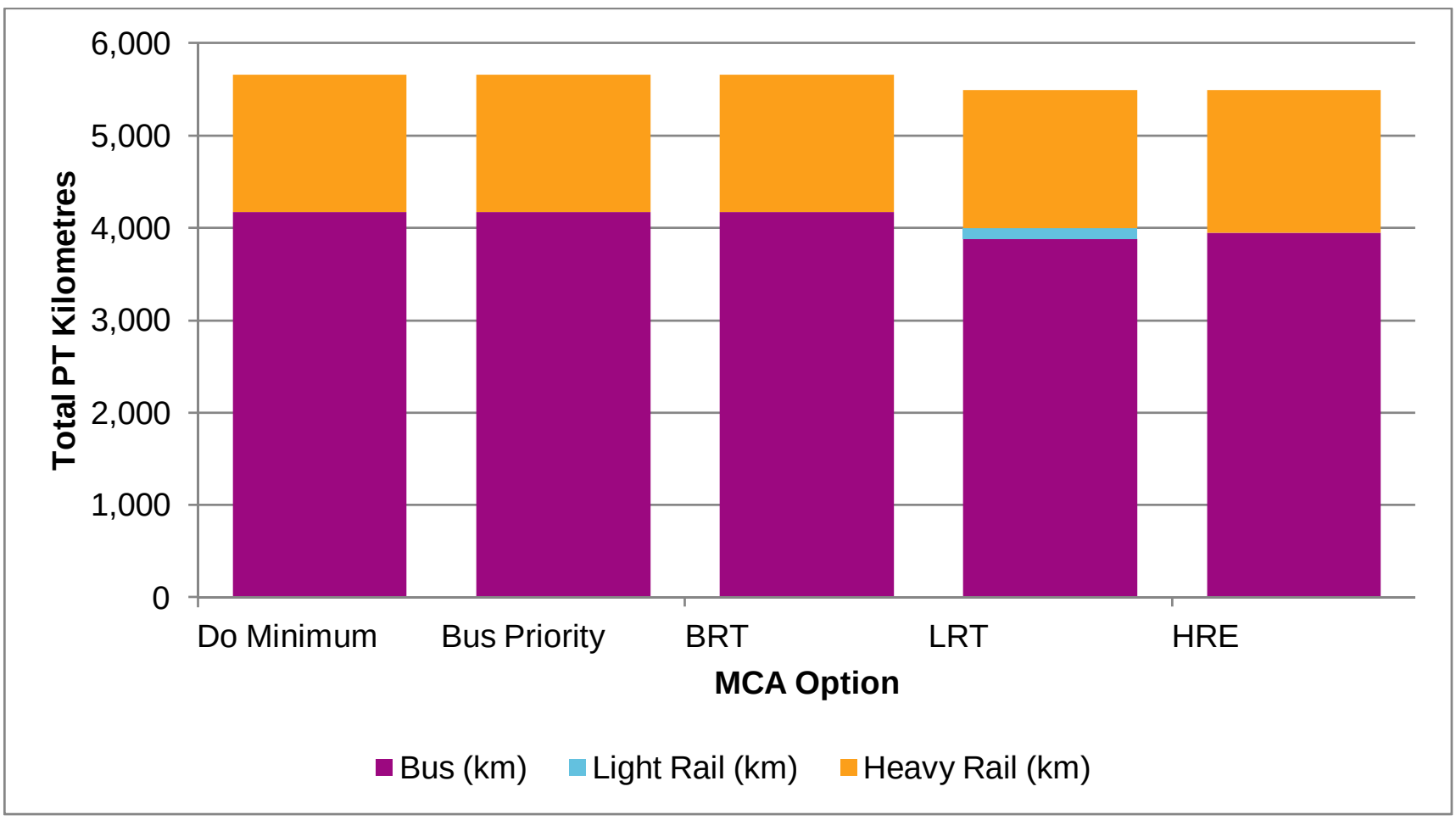
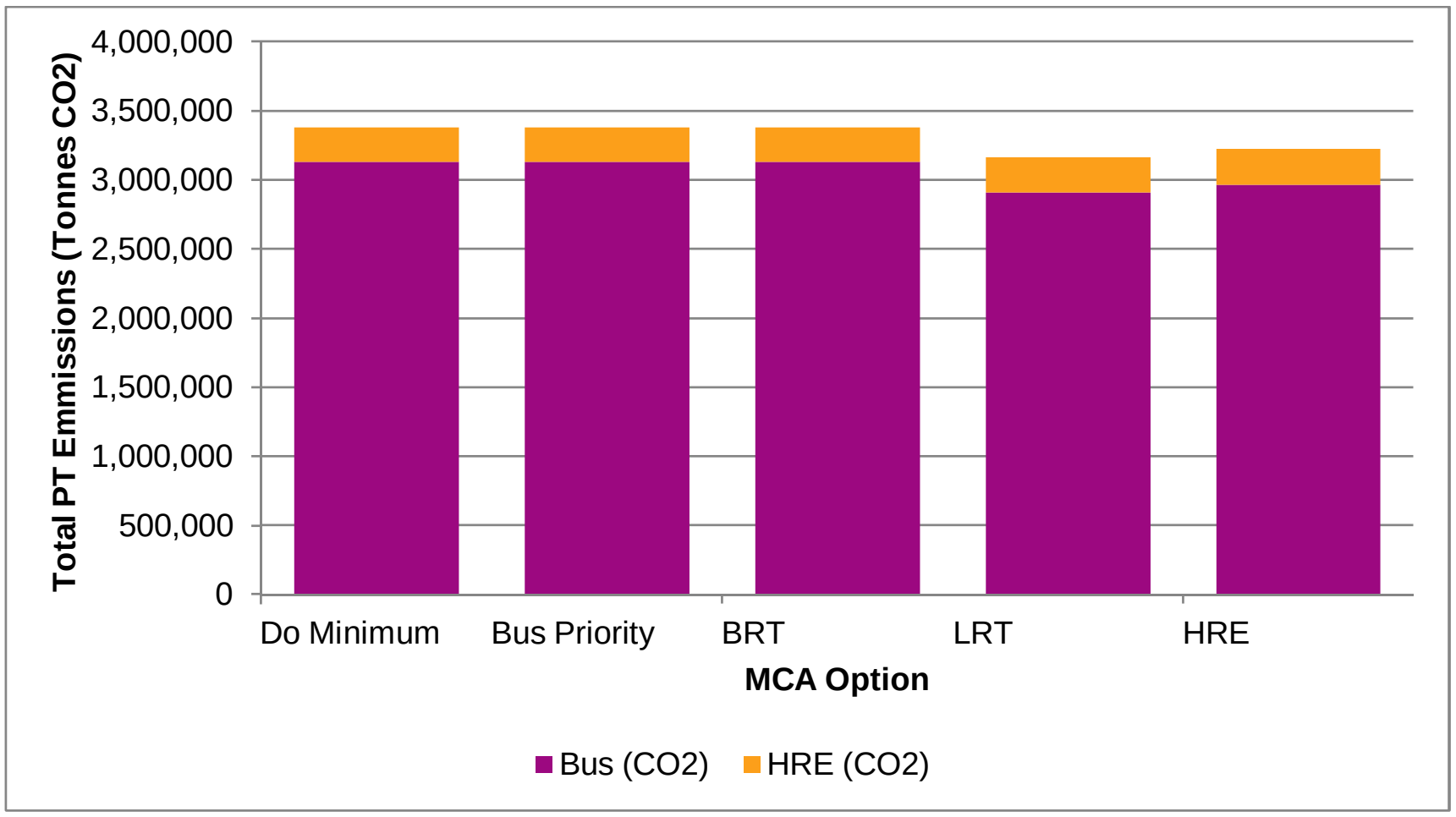


Figure 36 Total Emissions of CO^2

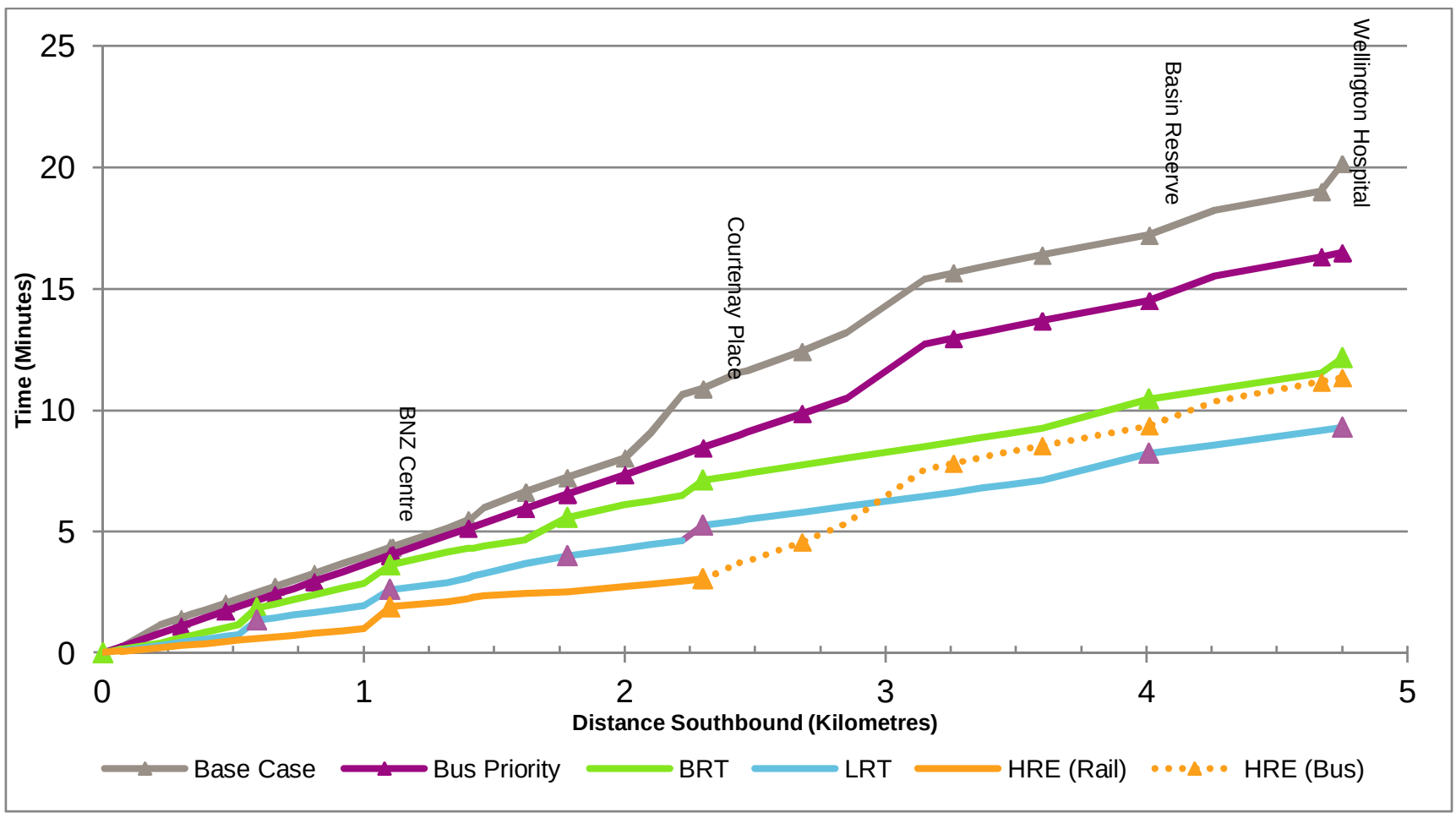


3.8 Travel Time Along Corridor

Figure 37 displays the southbound travel time for each option along the Golden Mile and beyond, from the Wellington Rail Station in the north to the Hospital in the south. The travel time has been extracted from the WTSM for the 2041 morning peak, for HRE and LRT the travel time is based upon standard speeds as specified in the model assumptions (see Appendix B). This compares the cumulative time along the route for each option.

This shows that there are significant differences between the options along the entire route with LRT being the fastest of the options and Bus Priority the slowest. LRT performs best as it will be the option most segregated from general traffic with priorities where necessary. HRE provides a fast travel time to Courtenay Place but requires passengers to transfer to buses beyond Courtenay Place.

Figure 37 Travel Time Between the Rail Station and Hospital



4.0 LRT Sensitivity Tests

Two sensitivity tests were undertaken for the LRT extensions. The LRT (North) scenario (shown in Figure 38) extends the LRT north of the CBD by utilising the Johnsonville rail line. The LRT (South) scenario (shown in

Figure 39) extends the LRT south to Island Bay. This scenario was added to the modelling by the project steering group.

4.1 Light Rail Transit - Summary

Table 45 displays the patronage for LRT options compared to the Base Case option. These results show an increase in patronage on the Johnsonville rail line for LRT (+50%), LRT (South) (+50%) and LRT (North) (+100%). The first two are due to the Newlands and Johnsonville bus services being terminated at Wellington Railway Station, making the bus services and rail services more comparable, the LRT (North) is caused by continuing the Johnsonville rail line through to Courtenay Place. On Newtown services there is an increase in the LRT (South) option (+50%), as a result of providing a seamless service through to Wellington Railway Station from Island Bay.

These LRT extensions provide more of a network of LRT then the short LRT option, by merging it with a current rail service in the LRT (North) option or extending it an additional 3 km in the LRT (South) option. Theoretically if the LRT were extended from Johnsonville to Island Bay both of these patronage increases would occur simultaneously, resulting in around 2500 additional public transport passengers. Such options are where the LRT can start to provide benefits whereas if retained only on the PT Spine it has a negative impact on patronage as it forces passengers to transfer on the boundaries of the CBD.

Table 45 Patronage

Performance Measure	Base Case	LRT	LRT North	LRT South	Frequency
Rail Inbound					
Porirua Rail Line	6300	6400	6400	6400	**9**
Hutt Valley Rail Line	6300	6500	6500	6500	**14**
Johnsonville Rail Line	1600	2300	3300	2400	**4**
PT Spine					
Northbound Bus	3500	1900	1900	1600	**21**
Northbound Rail	-	1700	1600	2000	**12**
Southbound Bus	5800	1900	2100	2600	**29**
Southbound Rail	-	2600	3800	1800	**12**
To Newtown		**Rail and Bus**	**Rail and Bus**	**Rail and Bus**	
Northbound	2900	3000	3000	3600	**12**
Southbound	400	500	500	600	**12**

Table 46 displays the patronage to the CBD for each of the LRT options. These show a decrease in patronage from the western and southern suburbs (Karori) due to the termination of these services at the Wellington Railway Station.

Table 46 Patronage to CBD

Performance Measure	Base Case	LRT	LRT North	LRT South	Variation
From Western Suburbs	2100	1700	1700	1700	-19%
From Southern Suburb	4900	4600	4600	4800	-2% to -6%
From Northern Suburb	4100	4000	4200	4000	+/-2%
From Hutt Valley Suburb	4700	4800	4800	4800	+2%
From Porirua Suburbs	2000	2100	2100	2100	+5%

Figure 38 LRT (North)

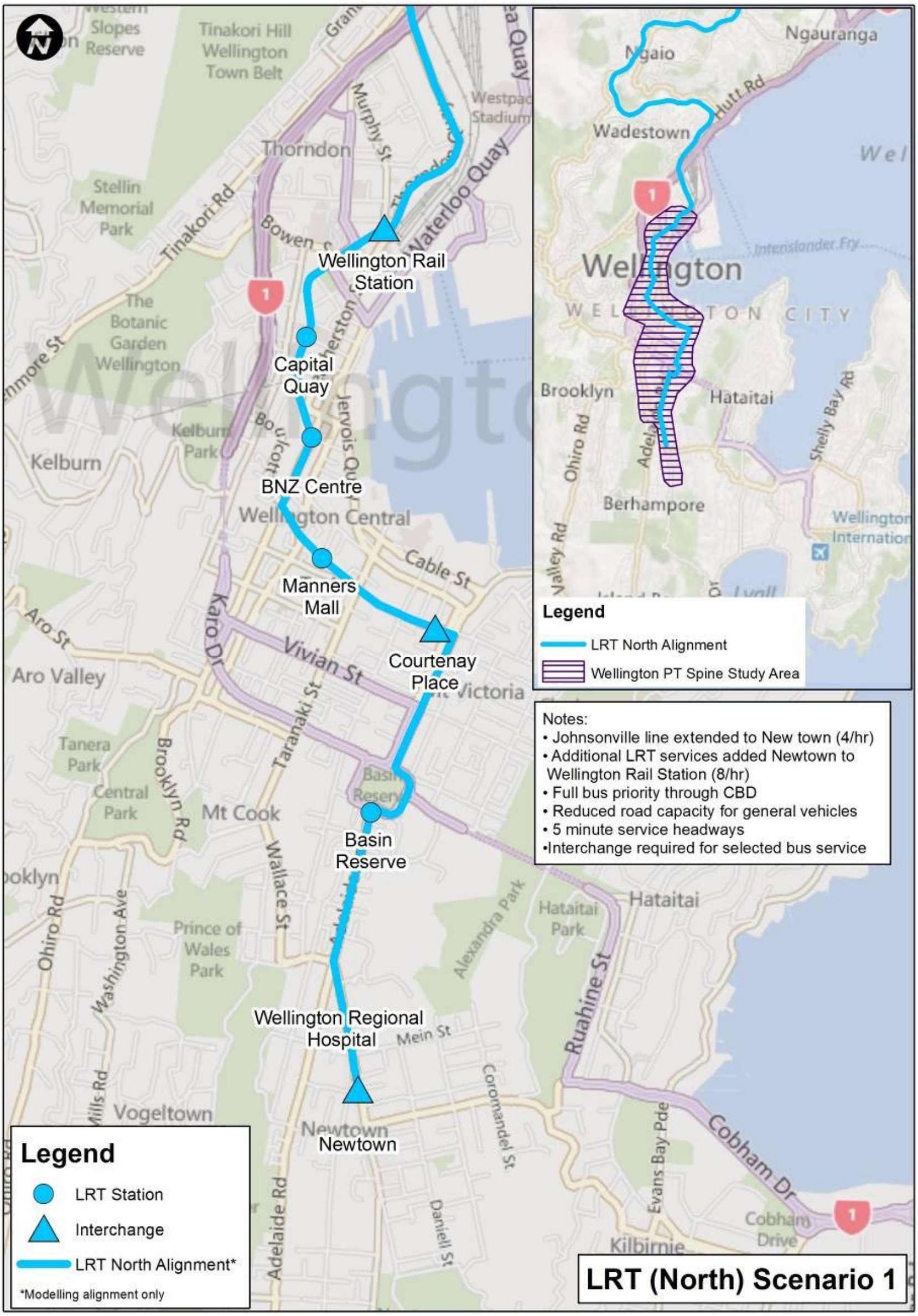
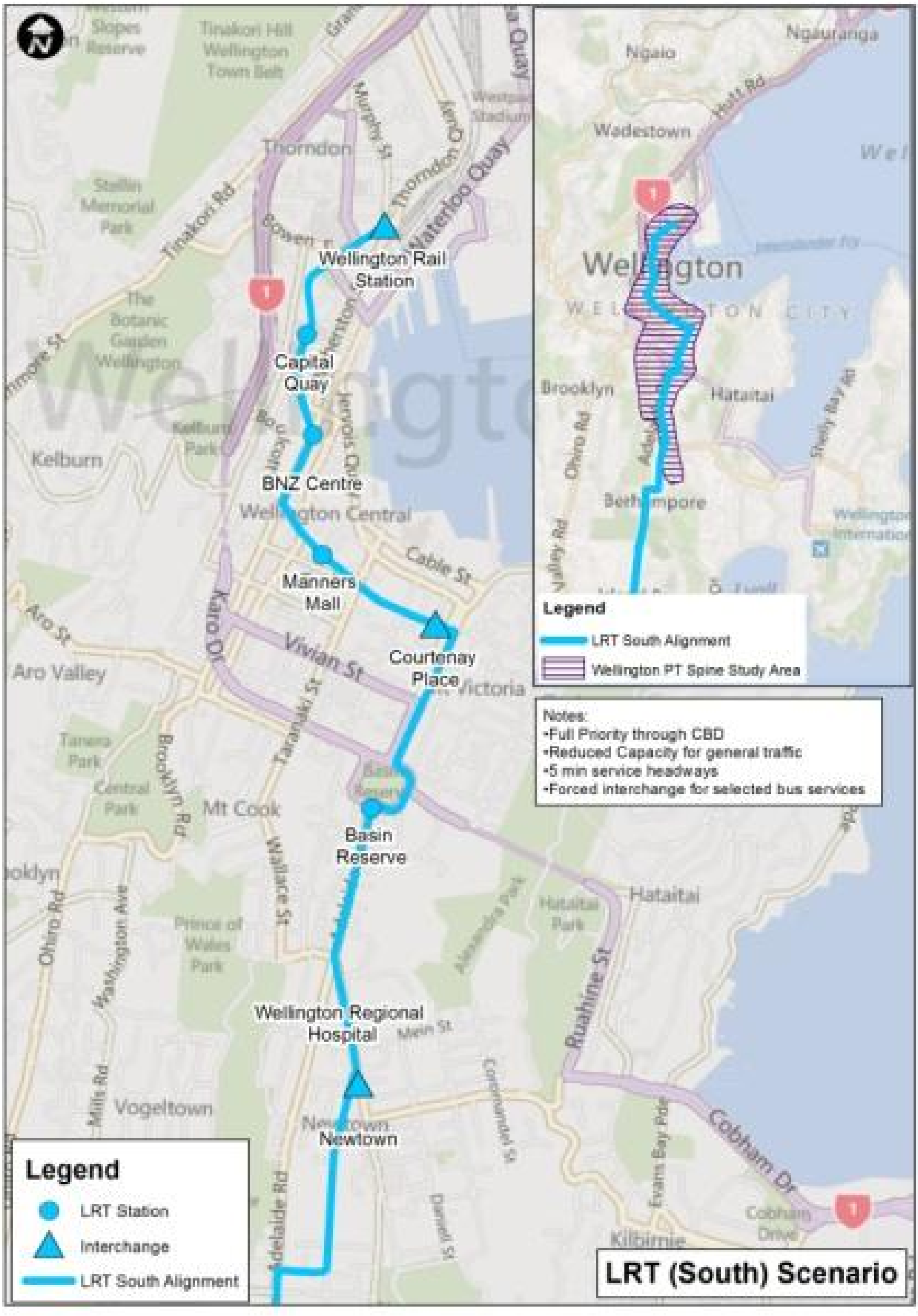


Figure 39 LRT (South)



5.0 Conclusion

A robust methodology has been followed in modelling PTSS 'Medium List' options using the WTSM for a future year of 2041. Key metrics have been extracted from the morning peak period model to provide the technical inputs required for the MCA evaluation process. These metrics are fully described in this memorandum. A key finding of the modelling has been that it is difficult to discern significant differences between options. This is as the options have been limited to changes within the CBD between the Wellington Railway Station and Wellington Regional Hospital.

It is recommended that at the next stage of option assessment a full review of bus routes be completed to identify how the existing routes can be amended to provide a more integrated network.