Additional Waitemata Harbour Crossing Network Plan

Passenger Transport

Quality Assurance Statement	Name	Signature / Date
Prepared by:	N Prosser, R Turnbull, B Smith, B McMahon	
Reviewed by:		
Approved for Issue by:		
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Executive Summary

The Additional Waitemata Harbour Crossing Passenger Transport Study informs the Additional Waitemata Harbour Crossing (AWHC) Network Plan on passenger transport issues that may affect the form of the crossing. The broad objectives of the study were to:

- Understand the physical and operational constraints of the current Busway;
- Estimate future busway demand;
- Using future demand estimates, determine when busway capacity may be reached;
- Outline operational measures and infrastructure improvements that will increase the Busway capacity and extend the life of the Busway;
- Consider the impact of the number of buses forecasted to travel through the Auckland Central Business District (CBD); and
- Investigate whether there is a likely “tipping point” at which further investment in passenger transport infrastructure for cross harbour travel might be more effectively directed towards rail rather than bus infrastructure.

Outcomes from the study will be used to inform decisions regarding the provision of rail to the North Shore and the need to incorporate a rail corridor as part of the proposed Additional Waitemata Harbour Crossing (AWHC).

This study provides an update to work undertaken in 2007 on the capacity of the Northern Busway Corridor. This corridor includes a dedicated busway and bus priority from Albany to Onewa Road; the Northern Motorway from Onewa Road to Fanshawe Street off ramps; and Fanshawe Street.

This capacity assessment has been undertaken for the entire corridor including bus services that enter the Northern Motorway from Onewa Road and services that exit Shelly Beach Road.

The Northern Busway has experienced strong growth in demand over the last five years with a corresponding significant increase in bus services during the peak hours. In 2009 a total of 185 buses operated along Fanshawe Street citybound in the 7:00 to 9:00 period – this corresponds to a peak hour flow of about 105 buses.

A strategic analysis of future demand was undertaken as part of this study and validated against recent Regional Land Transport Strategy model results. This analysis indicated that the AM peak hour bus flows into the CBD could increase to 246 buses per hour in 2041 (representing some 12,000 people).

For the purposes of this assessment, given bus flows joining at Onewa Road and exiting Shelly Beach Road, a target capacity for the Northern Busway system of 250 buses per hour has been adopted for 2041. This level is similar to that achieved on other major busway systems in the region including Brisbane’s South East Busway and Sydney’s Harbour Bridge bus lane.

Many busway systems experience the same challenge as that facing Auckland. Significant investment has been made in providing state-of-the-art dedicated bus facilities but system development is hindered by capacity constraints close to the CBD where the provision of dedicated facilities is more costly and bus volumes are at their highest. The appropriate response in these circumstances is to identify and implement measures to overcome such localised constraints to ensure that the full potential of the overall system is achieved.

While the current Northern Busway peak hour bus flows are placing considerable pressure on sections of the busway near the CBD, they are well below the recommended target capacity of 250 buses per hour. This report has identified a range of measures that could be implemented to reach the target capacity over time including:

- Introduction of express services that skip some stops – e.g. Fanshawe Street;
- Introduction of higher capacity, articulated buses;
- Improvement to dwell times through the introduction of improved ticketing systems;
- Provision of additional bus stops on Fanshawe Street;
- Extension of bus lanes east of Nelson Street after opening of Victoria Park Tunnel;
- Introduction of direct services from the North Shore to non-CBD destinations, such as Newmarket, Remuera and Ellerslie, either via the Northern Motorway or inner-city local streets; and
- Development of additional bus infrastructure capacity between the Northern Motorway and the CBD.

Of these measures, the development of additional bus infrastructure between the exit off the Northern Motorway and the CBD is the most important to ensure an extended life of the Northern Busway. The Additional Waitemata Harbour Crossing project provides the opportunity to develop such capacity by making use of the existing Harbour Bridge and the potential to provide additional direct bus access to and from the Northern Motorway either alongside current access arrangements at Fanshawe Street or a new point further south (for example Cook Street).

Auckland City Council’s recent Passenger Transport Integration Study has identified principles for routing North Shore busses through the CBD. These routes see North Shore buses circulating the CBD providing access to downtown, the Symonds Street ridge and mid-town. The routing of buses from the Northern Motorway to the CBD should therefore be as direct as possible to these identified bus corridors.

We therefore note the impact of North Shore buses on Auckland’s CBD cannot be considered in isolation. Forward projections for all bus volumes in the CBD, assuming a CBD Rail Loop, indicate that bus volumes in 2041 will exceed the capacity of the current street structure of the major bus corridors in use at present. Poor operational outcomes will result if the projected number of buses from the south, west, east and north are not provided with significant additional priority infrastructure or there is a major shift in their approach to the CBD and internal routing.

By way of example, this assessment has considered the impact of growing bus volumes on Fanshawe Street. Given maximum operational improvements, this street will have capacity to carry up to 180 buses per hour in the peak flow direction (unless activity in the Wynyard Quarter unduly impacts on bus operations). Based on current growth the capacity of Fanshawe Street will be exceeded by about 2020. Planning for increased capacity, for instance through use of the Cook Street exit as a second bus entry point to the CBD, is therefore recommended for a year 2020 commencement.

Further, this assessment observes that further consideration needs to be undertaken as to the volumes of buses that will need to access to the CBD and how these are provided for. Competing interests for available street capacity include the needs of increasing numbers of pedestrians and a likely desire to enhance the urban environment through traffic minimisation and calming.

With respect to the provision of rail to the North Shore, it should be noted that there is considerable divergence between the catchment and capacities of busway versus rail systems.

Firstly, comparing total Busway usage to possible rail usage cannot be followed. The rail catchment will most likely be represented only by the area north and east of the first station of a North Shore line, most probably at Takapuna. Projected services from this catchment in 2041 represent some 200 of the 250 buses from all of the North Shore to the CBD. The remaining 50 buses travelling from the North Shore are not replaceable by rail. These buses are from either Northcote or Birkenhead, or are travelling to areas where buses will provide quicker more convenient access (Shelly Beach Road, Ponsonby Road, Newton).

Given the catchment and passenger projections the Busway will provide ample capacity for rapid transit purposes from the North Shore to the CBD. Decisions about provision of rail to the North Shore should therefore be made on the basis of aspects other than just corridor catchment and capacity including:

- The potential for rail to connect with the rest of the Auckland rail network and provide significant improvements in cross regional travel opportunities;
- Rail’s role in shaping land use patterns within the city; and
- The impact of surface street bus movements in the CBD.

Within the later sections of this report, key factors influencing the provision of rail to the North Shore are discussed. Different service attributes of busway and rail systems are compared as well as comments made on the ability for bus and rail based systems to support higher densities and higher transit mode share. Evidence is provided from other cities to show that rail corridors typically achieve higher transit usage than bus corridors but only within a 1 to 2 km distance of stations. Rail systems perform best in corridors of moderate to high density and in connecting strong, mixed use centres.

The provision of rail to the North Shore is discussed within the context of wider regional rail network development. It is suggested that there are three main stages to the development of the Auckland regional rail network.

The first stage involves the current network upgrade program delivering major improvements in service frequency and reliability across the Western, Eastern and Southern lines.

The second stages involves completion of the CBD Rail Link which will deliver services to the heart of the CBD, unlock capacity constraints at Britomart, and support strong planned employment growth in the CBD.

The third and final stage of rail network development is beyond the timeframe of the current RLTS and involves expansion of the rail network to support regional employment growth in centres outside the CBD. A North Shore rail line would be part of such an expansion to provide stronger connections between the key centres of Albany and Takapuna and the rest of the Auckland region. During the period of the current RLTS, the Northern Busway is best positioned to provide transit connections from the North Shore to the CBD, service growth areas around Albany and support growth in the subregional centres of Albany and Takapuna.

In considering a suitable alignment for rail on the North Shore, there appears to be limited opportunity to develop a rail alignment within the existing motorway / busway corridor due to constrained widths and incompatible vertical alignment. Establishing rail lines along motorway corridors also restricts opportunities for transit oriented development to support rail usage.

Therefore the concept of North Shore rail presented uses principally an underground alignment through the North Shore linking key employment centres, residential areas where possible and interchange opportunities. Any future alignment should be reviewed as part of a wider study on the growth of the North Shore within the Auckland region.

1.0 Introduction

1.1 Study Objectives

The Additional Waitemata Harbour Crossing Passenger Transport Study informs the Additional Waitemata Harbour Crossing (AWHC) Network Plan on passenger transport issues that may affect the form of the crossing. The broad objectives of the study were to:

- Understand the physical and operational constraints of the current Busway;
- Estimate future busway demand;
- Using future demand estimates, determine when busway capacity may be reached;
- Outline operational measures and infrastructure improvements that will increase the Busway capacity and extend the life of the Busway;
- Consider the impact of a large number of buses on the Auckland Central Business District (CBD); and
- Investigate whether there is a likely “tipping point” at which further investment in passenger transport infrastructure for cross harbour travel might be more effectively be directed towards rail rather than bus infrastructure.

Outcomes from the study will be used to inform decisions regarding the provision of rail to the North Shore and the need to incorporate a rail corridor as part of the proposed Additional Waitemata Harbour Crossing (AWHC).

The capacity of the Northern Busway was assessed by Parsons Brinckerhoff in 2007 using microsimulation techniques (Northern Busway Corridor Capacity Study, May 2007) and reference here is made to the outcomes of that study – referred to here as the 2007 Capacity Study.

Additional work has been undertaken within this current study on predicting the likely growth in future demand on the busway, linking it to expected growth in Auckland CBD employment and North Shore population, as well as likely shifts in mode share.

A separate study is examining the potential impact of introducing HOVs to part of the busway system.

This study is being conducted against the background of investigations into the provision of an Additional Waitemata Harbour Crossing as well as the development of a business case for the Auckland CBD Rail Link. Every effort has been made to ensure that the underlying assumptions in this study regarding future travel demand and patterns in Auckland are consistent with those used for modelling of the AWHC and work on the CBD Rail Link.

1.2 Northern Busway Corridor Demand

The Northern Busway extends from Albany to Onewa Road but within the context of this study the full corridor is assumed to extend into the CBD through to Britomart. Thus the corridor includes a section on the Northern Motorway where buses do not have any priority, as well as bus lanes along Fanshawe Street.

Bus services and demand along the corridor are assumed to include all buses and passengers on the Harbour Bridge. On the north side of the bridge bus services from Onewa Road are included, while on the south side of the bridge services that run to non-CBD destinations on Shelly Beach Road are also included.

The capacity assessment for the Northern Busway corridor has been undertaken for travel in a typical weekday morning peak period into the CBD – that is, southbound across the Harbour Bridge. Most cities experience higher peak hour demand in the morning than the afternoon where demand is spread over a longer period. While strong population growth in the CBD and surrounding areas will contribute to some growth in trips in the opposite direction – to the North Shore – the peak flows will always be in the direction of the CBD in the morning peak.

Annual trip counts are taken around the CBD and reported for all modes of travel in the AM peak 7:00 to 9:00 period. These counts have been used as the base for forecasting demand growth and as such all of the demand figures in this report include all bus trips on the corridor in the AM peak 7:00 to 9:00 period – that is they include travel for all purposes including work, education etc. However, the forecast demand growth is based on forecasts of growth in CBD employment which is used as a measure of future travel demand. Demand for all travel into the CBD is assumed to grow at the same rate as demand for work travel into the CBD. Given that the majority of peak period demand is associated with work travel, this is put forward as a reasonable assumption. More details on the derivation of future bus travel demand is provided in Section 3 of this report.

1.3 Land Use Scenarios

Work in August 2010 on the CBD Rail Link Business Case has identified and reviewed a number of land use scenarios for the Auckland Region including consideration of different assumptions regarding CBD population and employment growth. Land use scenarios were developed by Auckland Regional Council in 2009 as part of modelling of the Regional Land Transport Strategy – these were derived from the key growth parameters outlined in the Regional Growth Strategy.

More recently, Auckland Regional Council completed a study comparing three broad alternative scenarios for growth across the Auckland Region *(Future Land Use and Transport Project - Evaluation of Future Land Use and Transport Scenarios, April 2010).* It appears that each of these scenarios had different assumptions regarding CBD population and employment growth to those used in the RLTS modelling in 2009. It is understood that none of these later forecasts have been adopted or endorsed by Council.

At the time of the preparation of this report, it appears that the RLTS land use forecasts developed in 2009 are being used for both the AWHC and CBD Rail Link modelling. Reported figures from ARTA for CBD population and employment growth under these forecasts are used within this study to develop estimates of Busway corridor demand growth – these are described in detail in Section 3 of this report.

1.4 Linkages with Current Studies

AWHC

Provision of an AWHC (road crossing) will have a major influence on travel modes and patterns across the Auckland Region. With respect to the Northern Busway corridor, peak period demand growth will be driven by overall demand for travel from the North Shore to the CBD and the proportion of that demand using bus instead of other modes – particularly car or ferry.

As described more in Section 3 of this report, ferry demand growth is assumed to be constrained by the limited catchment areas of the ferry services.

Car demand growth is assumed to be constrained by conditions in the CBD with respect to road capacity and parking rather than on cross-regional capacity. For this reason, it is argued that the provision of an AWHC will not have a major impact on the attractiveness of using car for travel from the North Shore to the CBD – there would be still be major constraints within the CBD. Thus, the strategic level demand growth estimates provided here are equally valid for scenarios with and without the AWHC.

CBD Rail Link

The CBD Rail Link project will provide direct rail access into the heart of Auckland CBD and increase the capacity and attractiveness of services on the existing rail network. While the project is expected to have a major impact on the use of bus and rail services across Western, Eastern and Southern parts of the Auckland region, it will have little impact on travel from the North Shore to Auckland CBD. The CBD Rail Link may have some benefits for the circulation of Northern Busway services within the CBD as bus volumes from other corridors are reduced (compared to a scenario of not have a CBD Rail Link). However, the demand growth estimates developed, for the North Shore, in this report can be assumed to apply to scenarios with and without the CBD Rail Link.

2.0 Busway Capacity

2.1 Overview of Capacity and Service Principles

The 2007 Capacity Study provided an extensive discussion of the important principles regarding busway infrastructure and service capacity. The key points are reproduced here.

The Northern Busway system combines the following types of facilities:

- Dedicated, off road busway;
- Shoulder lane on motorway;
- Bus lane on arterial street;
- Shared motorway lane; and
- Shared arterial street lane.

Flow along the busway is interrupted by bus stations and bus stops, signalised intersections and merging operations with general traffic.

In general, the overall capacity of a busway system is determined by the locations where vehicle flow is interrupted. A single lane of uninterrupted dedicated busway has a capacity of up to 600 buses per hour (based on a typical passenger car capacity of about 1,800 per hour and a bus being equivalent to 3 passenger cars). Capacity at bus stations, bus stops, intersections and merge points depends on local conditions.

The impact of capacity constraints on overall busway system performance is dependent on the service structure. The Northern Busway is designed to allow bus services to join at different points resulting in variations in bus volumes along the corridor. Bus services can be classified as either:

- Trunk services operating solely along the busway – e.g. the Northern Express service between Albany and the CBD;
- Feeder services that run from local streets onto the busway at different locations; and
- Cross-city services that run into busway stations but do not join the busway itself.

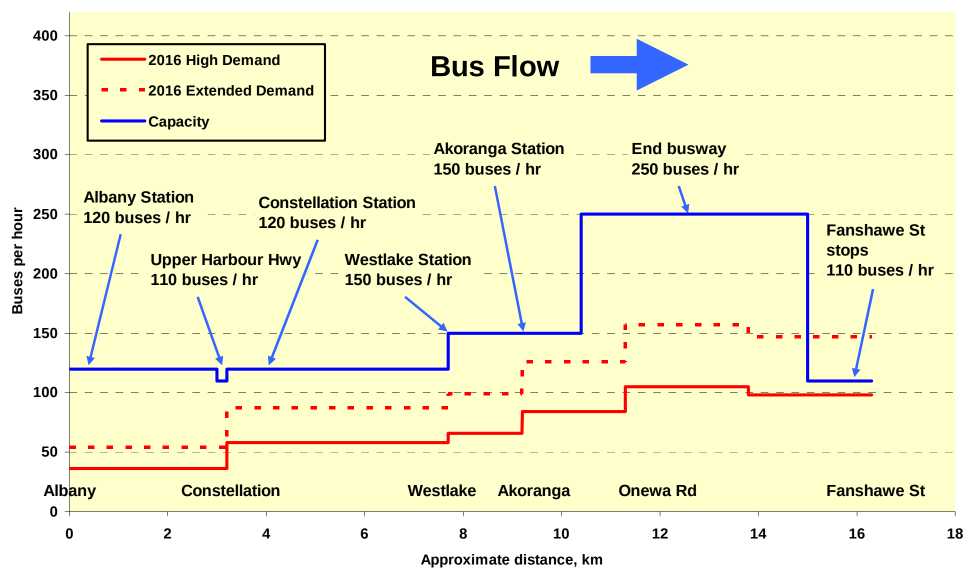
The combination of trunk and feeder services operating to and from the CBD results in a gradual build up of total bus volume on the Busway in the direction of the Harbour Bridge. Peak volumes on the busway under the current system are across the Harbour Bridge and into the CBD. The impact of capacity constraints in this section of the busway is greater than in other locations.

2.2 Outcomes from 2007 Capacity Study

Overview

The outcomes of the 2007 Capacity Study are shown in Figure 2-1 and Figure 2-2 below. These figures show the relationship between estimated capacity and forecast 2016 demand in both the inbound and outbound direction.

AM Peak Inbound



AM Peak Inbound

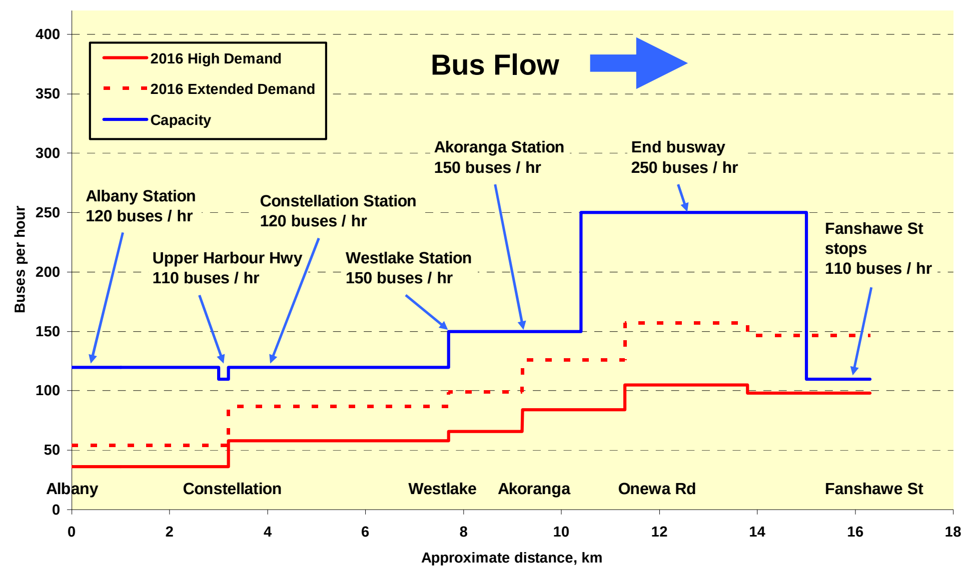
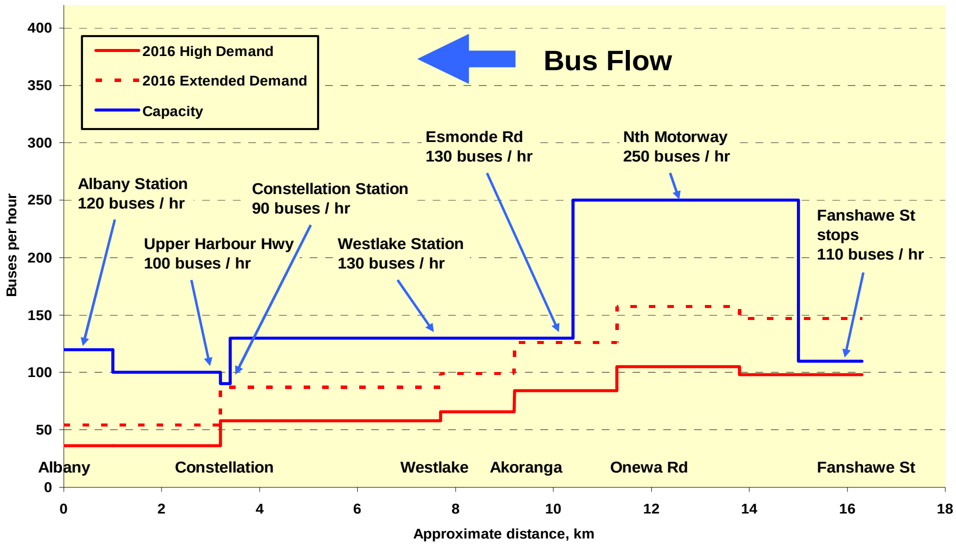


Figure 2-1 AM peak inbound capacity (2007 Capacity Study)

PM Peak Outbound



PM Peak Outbound

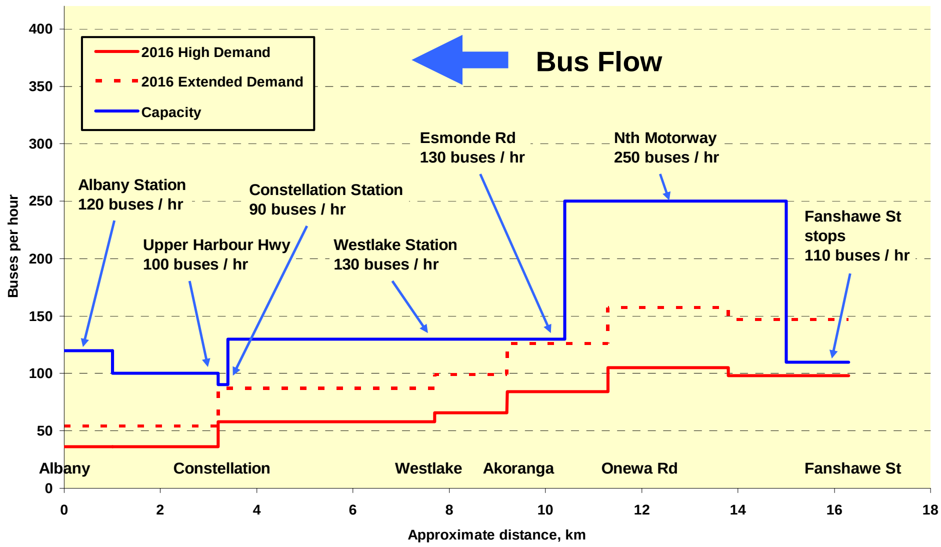


Figure 2-2 PM peak outbound capacity *(2007 Capacity Study)*

Observations were made along Fanshawe Street on Tuesday, July 2010 in the morning and afternoon peak period. These are reported in **Appendix A** and discussed below.

North of the Harbour Bridge

North of the Harbour Bridge, busway capacity is limited by the operation of the different stations, the lack of grade separation at the Upper Harbour Highway and conditions at the southern end of the busway in the vicinity of Onewa Road.

The 2007 Capacity Study estimated capacity to be limited at Upper Harbour Highway / Constellation to 110 buses per hour in the inbound direction and 90 buses in the outbound direction. Bus volumes at this location are generally 50 % of the peak volumes across the Harbour Bridge.

The Northern Busway extension project will extend the dedicated busway across Upper Harbour Highway and remove the existing capacity constraints for outbound buses.

Further south, capacity through Westlake and Akoranga stations was estimated to be in the range 130 to 150 buses per hour. Capacity across the bridge itself is estimated to be 250 buses per hour in each direction.

South of the Harbour Bridge

Capacity between the Harbour Bridge and the CBD is limited by operations on Fanshawe Street and in the vicinity of Britomart. Currently, buses use bus lanes and indented bus stops along Fanshawe Street between the motorway ramps at Beaumont Street and Nelson Street. Between Nelson Street and Britomart / Albert Street, buses share lanes with general traffic.

The 2007 Capacity Study identified limitations in the current operation of bus stops on Fanshawe Street particularly the inbound bus stop east of Beaumont Street. Observations made in July 2010 suggest that these limitations still exist with buses regularly queuing to access the indented bus bays on the north side of Fanshawe Street in the morning peak and causing delays. Queuing of buses at bus stops is less common in the afternoon peak with the Victoria Park bus bay providing space for 3 to 4 buses. The capacity of the inbound bus stops was estimated at about 110 buses per hour (near to current volumes).

Further capacity limitations exist through the signalised intersections on Fanshawe Street. Currently, Fanshawe Street through movements receive extended green times during the peak periods with side street movements experiencing extended delays. Even though there are strong measures in place to reduce traffic impacts arising from the Wynyard Quarter development, and improvements planned for many of the intersections, it is likely that through movement green times will be reduced in the future.

The 2007 Capacity Study estimated bus lane capacities through the Fanshawe Street intersections based on likely future conditions. These are summarised in Table 2-1 below.

Table 2-1: Fanshawe Street Intersection Bus Lane Capacity

Intersection	Inbound AM Peak (buses/hr)	Outbound PM Peak (buses/hr)
Beaumont Street	360	200
Halsey Street	230	180
Nelson Street	200	150

Summary

The 2009 Central Area Cordon counts showed a total of 185 buses using Fanshawe Street in the 7:00 to 9:00 peak period. This would be equivalent to between 86 to 110 buses in the peak 60 minute period[1]. Based on Figure 2-1 above, it can be concluded that the Busway is operating at its inbound capacity with respect to Fanshawe Street bus stops (up to 110 buses per hour). On this basis, consideration needs to be given immediately to measures to increase capacity of the Busway system, particularly along the Fanshawe Street section. This is discussed in the next section.

2.3 Options for Increasing Busway Capacity

Overview

The Busway has a range of options for increasing passenger and bus capacity without requiring major infrastructure investment. These include:

- Increasing bus capacity through changes to bus service structure and operations along the Busway;
- Use of higher-capacity buses to increase passenger throughput;
- Increasing bus throughput at stations by reducing passenger boarding times; and
- Modifying Busway routes within the Auckland CBD to overcome capacity constraints.

Service Structure

The 2007 Capacity Study concluded that the operation of bus stations and bus stops were a limiting factor with respect to long term capacity. In general, the capacity of a bus station or stop is determined by the volume of stopping buses, the available kerb space and the allocation of the kerb space to different services.

[1] *Note that as of September 2010 there are 86+ buses scheduled to operate on Fanshawe Street between 7.30am and 8.30am originating from the North Shore. In addition a further 15+ 'assist' buses can operate at peak months of the year to manage high passenger demands. Vagaries of weather and traffic could affect the volume arriving in any peak 60 minute period ±10%.*

As a busway system matures, there are opportunities to tailor the structure of services to meet demand and make best use of bus station and stop capacity. The underlying structure of the Northern Busway system provides a high degree of flexibility in deciding which bus services operate to different bus stations.

The current bus service structure already features some skip-stop services along the Busway, with longer-distance routes in particular (such as 893-899) offering Express (non-stop) services on some sections of the Busway. In contrast on the core Northern Express service (operating a better than one bus every five minutes frequency) all buses stop at each bus station, allowing passengers on feeder routes to transfer to Citybound services.

As bus volumes increase there is scope to adjust the bus stopping patterns along the Busway to both benefit passengers through reduced journey times and increase busway capacity by allowing some services to skip busier Busway stations (generally those closer to the CBD).

This type of service structure, common on line-haul bus corridors, would provide passengers with a choice of stopping patterns, as well as CBD and other destinations, and allow for passengers to transfer between buses along the Busway to suit their desired destination and stopping needs.

For example, a future Busway service strategy could feature:

- More buses which skip stations along the Busway (such as inner and outer Busway sections) to relieve pressure on particular stations;
- Inbound and outbound services which would not stop at particular Central Area bus stops, such as those on Fanshawe Street;
- Set-down only route sections where passengers would not be picked up at some stops or stations; and
- Buses which provide services to specific sections of the CBD and Central Area destinations – for example separate services to Britomart, to Newmarket, to Remuera, to Midtown or Auckland University, more services via Shelly Beach Road and Ponsonby etc. This would reduce pressure on CBD corridors and terminals while allowing North Shore passengers to have more direct access to Central Area destinations.

In this way bus throughput at stations can be managed within effective bus station capacity constraints while also offering passenger benefits.

2041 Projection

This assessment took into consideration the above service structure elements to confirm (or otherwise) that current bus station infrastructure would be suitable for bus flows in 2041.

The following assumptions were made in this assessment:

- AM Peak hour southbound services were considered;

- All Northern Express services observed stops at every station;
- All services entering the Busway observed the first station stop they came to and then ran express from that point (did not stop at any further stations); and
- Each Busway station has two stops for all southbound services. Local services have separate stops.

Figure 2-3 below shows the minimum number of services, given the assumptions above. The most observed stop, with 58 services in the peak hour, was at Smales Farm.

Spread over two platforms this equates to an average dwell time 'opportunity' of up to 124 seconds, or just over two minutes, per bus.

If current ticketing technology and practice was used this would allow around 20-30 passengers to board per bus per stop. If however each station was gated with ticketing undertaken 'off-bus' each bus could be loaded (assuming front and back door entry), even if from empty, and away within 60 seconds, leaving the stop empty for a further 64 seconds before the arrival of the next bus.

We therefore observe that given specific efficient operating measures, as per details in the Service Structure section page 8 and Improving Dwell Times section page 12, the busway stations have sufficient capacity to the end of the planning period (2041) to accommodate the forecasted number of buses.

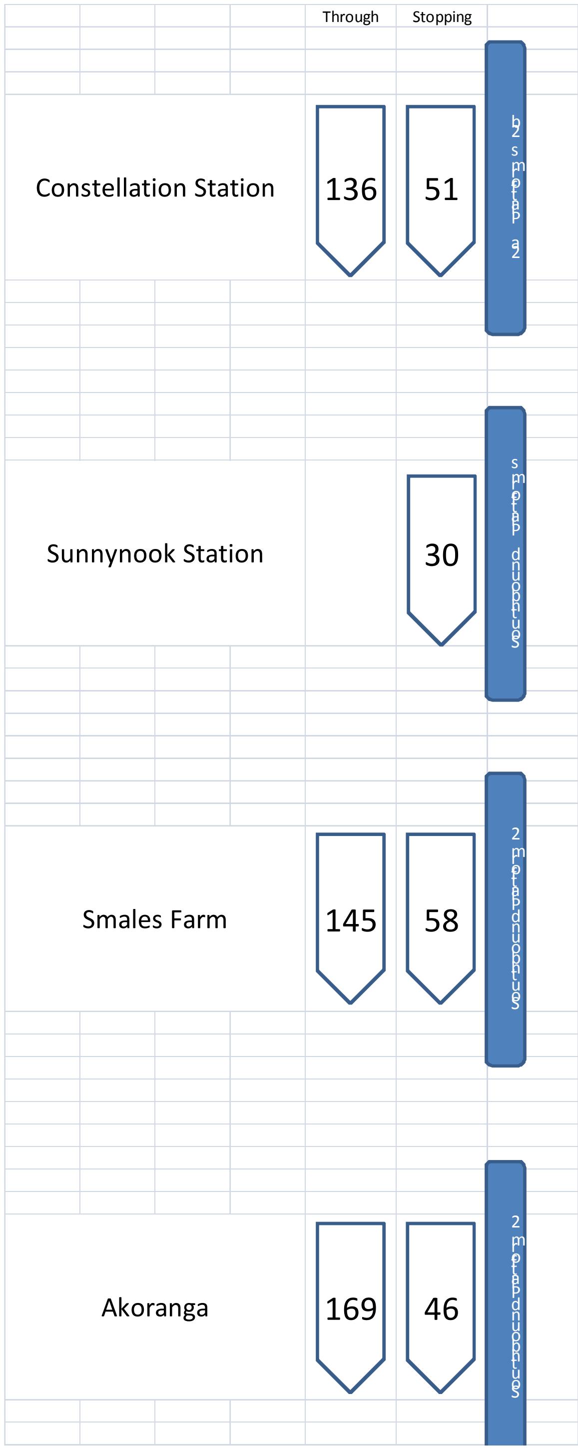


Figure 2-3 Southbound station stop observance AM peak hour 2041

Bus Fleet and Vehicle Occupancy

Data from recent bus cordon counts indicates that there are only a handful of higher capacity, articulated buses travelling into the CBD from the Northern Busway in the morning peak. As demand increases in the future, there are many benefits to be realised from introducing a higher proportion of articulated buses including reduced operating costs per passenger km and increased corridor capacity.

Assumptions are made in the following section regarding the future proportion of services operated with higher capacity buses.

Improving Dwell Times

There are opportunities within Auckland, in general, to reduce bus dwell times by way of introducing, for example, cashless express services or smart card ticketing. Many cities, including Christchurch and Sydney, have demonstrated significant improvements in bus operations arising from reducing passenger transaction times. Similar benefits would be delivered on the Northern Busway particularly where bus stops are a limiting factor on capacity – for example, on Fanshawe Street.

Introduction of an integrated smart card based ticketing system for Auckland will offer improved bus station and stop dwell times by moving to a tap-on and tap-off system. This has been proven to substantially reduce passenger boarding times.

The measures available to be introduced to reduce bus dwell times at stations and stops (and to increase bus capacity) include:

- Pre-pay only operation (in conjunction with the introduction of integrated ticketing and the smartcard, but also possible under the current ticket and fare regime) where passengers would be discouraged from making cash ticket purchases on some services or at peak times;

- Multiple-door boarding at busway stations. This is feasible with pre-pay or smart card operations, or with pre-validation of tickets, and can substantially reduce bus dwell times; and

- Pre-validation of tickets at peak times. This can be achieved through passenger marshalling with and without infrastructure such as ticketed areas or “corrals”. Passengers for some or all services at peak times would be required to pre-pay or pre-validate tickets in the Busway station or stop, allowing passengers to board buses without purchasing or validating tickets, further reducing dwell times. This approach has been in use for some time in Sydney for example, to speed boarding of high demand university express buses at a city kerbside bus stop. Additional management at peak times may be required.

Photo 2.1 Southbound platforms Sunnynook

Fanshawe Street Improvements

There is an immediate need to improve the operation of bus stops on Fanshawe Street, particularly on the north side (towards Britomart). The current stops at Beaumont Street and Halsey Street need to be split and new indented bus bays created.

The development of Wynyard Quarter will place further pressure on Fanshawe Street and increases the urgency in ensuring that bus movements are improved and not impacted by either construction activity or access to sites.

Victoria Park Tunnel Impacts

Completion of the Victoria Park Tunnel in mid-2012 will improve general traffic flow on the Northern Motorway between the Central Motorway Junction and the Harbour Bridge. The new tunnel will carry three lanes of northbound traffic while the existing viaduct will carry four lanes of southbound traffic.

At Fanshawe Street, the off ramp from the southbound carriageway will carry two lanes of general traffic and a bus lane. The modified on ramp to the northbound carriageway will be two lanes of general traffic only. Between Fanshawe Street and the Harbour Bridge there will be five lanes of general traffic in each direction with a bus lane on the southbound carriageway only. Buses will share general traffic lanes on the northbound carriageway. Traffic from the Fanshawe Street on ramp will not be required to merge with general traffic.

The intersection of Beaumont Street and Fanshawe Street will be modified as part of the Victoria Park Tunnel project – a general traffic left turn slip lane will be introduced into Beaumont Street from the Northern Motorway off ramp adjacent to a through bus lane.

Completion of the Victoria Park Tunnel is expected to reduce through traffic demand on Fanshawe Street between the Northern Motorway and the CBD – currently CBD traffic uses Fanshawe Street to avoid congestion at the Central Motorway Junction. However, reductions in through traffic are likely to be offset to some extent in the long term by increases in CBD traffic particularly from the Wynyard Quarter development as described in the next section.

The opening of the Victoria Park Tunnel therefore provides an opportunity to extend the westbound bus lane on Fanshawe Street from Nelson Street back to Hobson Street. This will increase capacity on this critical section and reduce bus delays in the PM peak.

Developing Additional Road Space for Buses into the CBD

Currently, most Northern Busway services operating to the CBD approach along Fanshawe Street, with a small number operating to Newmarket via Shelly Beach Road and Ponsonby Road. Services using Fanshawe Street travel via Britomart and Albert Street with two routes diverting via Customs Street east and the Central Connector to Newmarket; and the majority of routes continuing south on Albert Street to Midtown.

There is substantial potential to overcome identified bus capacity constraints on Fanshawe Street and Albert Street, by restructuring routes to better serve CBD destinations.

While some relief of limited Fanshawe Street capacity is possible, by not stopping a proportion of buses at Fanshawe Street stops for example, alternative routes to the CBD would offer both more direct access to the CBD core and overcome the capacity constraint of a single major approach corridor.

Assuming completion of the Victoria Park Tunnel in 2012 (which would provide the opportunity for further bus priority measures along the Nelson/Fanshawe Street corridor), the development of Wynyard Quarter and with consideration to forecast growth, additional capacity would be required by 2020.

Auckland City Council is currently giving consideration to future bus routes and bus volumes through the CBD. A summary of this study is shown in Table 2-2 below.

Table 2-2 Auckland City Council Passenger Transport Integration Study Summary

Passenger Transport Integration Study

Auckland City Council is undertaking a Passenger Transport Integration Study (PTIS). The purpose of the study is to develop a plan to accommodate bus services in the CBD as an integral part of a high quality multi-modal passenger transport system. Auckland City see's planning for integration of passenger transport as a necessity to provide future direction for supporting Auckland's development and growth as a world class city.

There are two route design principles that the PTIS is considering which affects future routing of North Shore buses in the CBD.

There are two route design principles that the PTIS is considering which affects future routing of North Shore buses in the CBD.

1. **High priority routes servicing the regional Rapid Transit Network** (rail and the Northern Express bus) and Quality Transit Network (fast, high frequency and high quality bus and ferry services) to, from and within the CBD connecting with high priority routes outside the CBD.

   High priority streets in the CBD for passenger transport are needed to:

   – Maximise the benefits of investment in regionally significant projects to achieve service operational requirements for speed, reliability and capacity for the whole of journey;

   – Improve the legibility of the network by making it obvious; and

   – Balance the needs between modes.

2. **Simplified routing** (and drop-off at key locations) would be provided to help improve legibility and maximise the efficient use of priority measures.

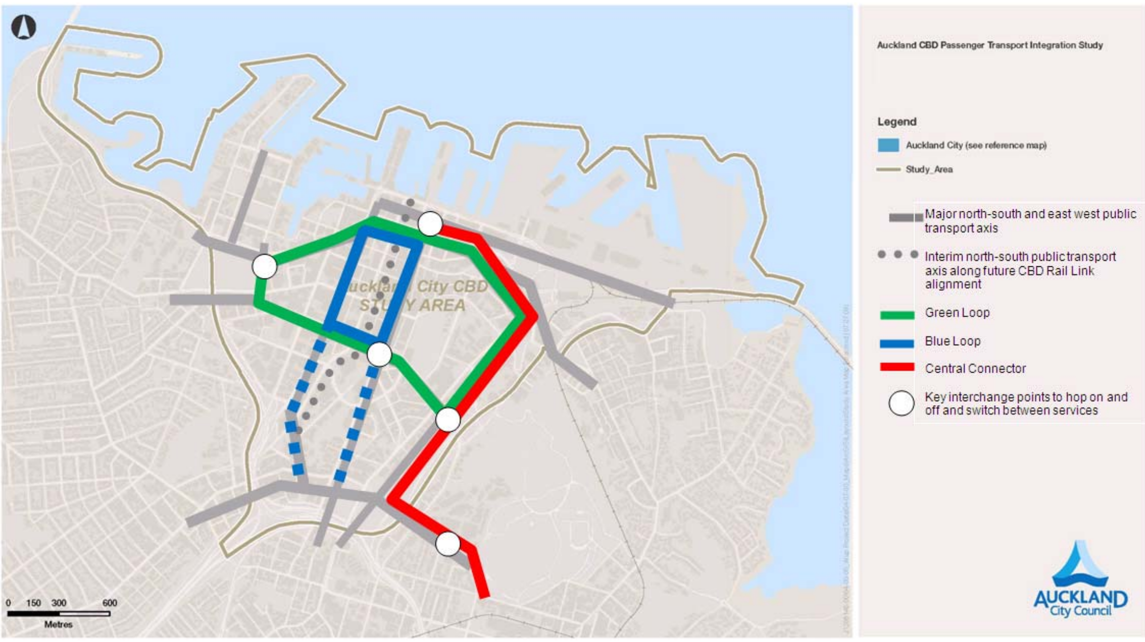
   Expanded coverage across the CBD is needed to ensure services cater for existing and future development areas, enable services to provide a simple distributor function once in the CBD, improve the level of accessibility within the CBD for trips to/from different sectors and provide ease of access and use for internal trips.

There is also a major design principle that affects future routing:

– **High quality convenient interchange** between modes and services at more than one location in the CBD.

– As the distribution of the intensity of development and activity in the CBD continues to spread and the existing and future capacity constraints at Britomart remain, additional locations (to the Britomart Transport Centre / Downtown Ferry Terminal) where people can easily access services is needed. This includes an increase in the coverage of CBD wide uniform high quality passenger information. Potential nodes include the University, Victoria Quarter, around the Civic/Aotea area and Wynyard Quarter.

Passenger Transport Integration Study
The PTIS makes the following **recommendations** for a simplified passenger transport network routing in the CBD. **East-West** – Northern Busway Rapid Transit route along Fanshawe Street through to Britomart – Quay Street (and Customs Street) – Karangahape Road – Wellesley Street **North-South** – Central Connector route (through to Britomart) – Queen Street – Albert Street (in the short-term) – Hobson Street (in the long-term).
In addition to the streets nominated, a simplified route network could also incorporate two interconnected routing circuits to provide both distribution through and circulation within the CBD. – The 'Green Loop' would operate bi-directional on Fanshawe Street, Customs Street, Symonds Street, Wellesley Street, Halsey Street to Fanshawe Street. – The 'Blue Loop' would operate bi-directional on Wellesley Street, Hobson Street, Customs Street, to Queen Street with an extension to Karangahape Road. Within these two loops, most services would operate, along part of the circuit with some services operating along the entire loop.



Considering the proposal in the Auckland City Council Passenger Transport Integration Study to route North Shore buses via Wellesley Street or Fanshawe Street, these two streets are therefore the 'target' points for any changes to North Shore bus access to the CBD.

Increase Bus Capacity on Fanshawe Street

One option is to increase capacity from the motorway along Fanshawe Street to the corner of Fanshawe and Halsey streets. This would enable the entire Busway service to use Fanshawe and then split into two routes to join the 'green loop' as detailed in the CBD PTIS study note above. (for diagram See **Appendix B**). The issues and possible means to address are as follows:

- Fanshawe / Beaumont intersection. Increase capacity by either adding an additional lane for buses or a significantly longer green cycle (this assessment understands grade separation of Fanshawe/Beaumont Street is unlikely to be feasible);

- Fanshawe Street Pedestrian Crossing (outside Air New Zealand building). Additional bus lane or grade separation (see Figure 2-4 below);

- Fanshawe Street / Halsey. Add right turn southbound (into CBD) Fanshawe into Halsey bus only lane and increase green phase on this turn or grade separate;

- Additional option. Move all buses into centre of Fanshawe Street away from kerb (as per Figure 2-5 below) but still require issues as above to be addressed.

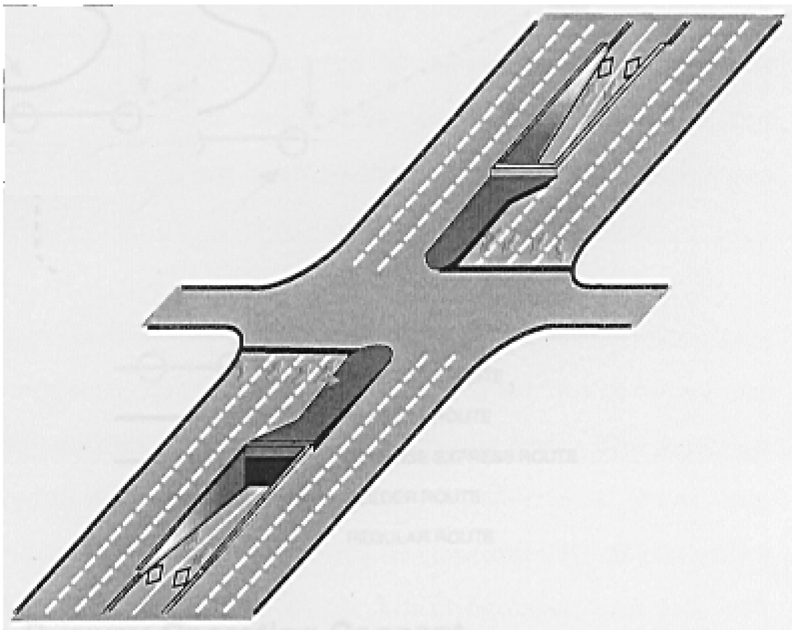


Figure 2-4 Grade Separation at intersections

Figure 2-5 Mid-street Busway extension

Expanding Fanshawe Street Capacity

Options for substantially increasing the capacity of the bus corridor along Fanshawe Street, up to the target level of 250 buses per hour, include an additional surface street bus lane and grade separation through either bus tunnels or viaducts.

An expanded bus corridor on Fanshawe Street could aim to connect to the Britomart area only or attempt to connect to Wellesley Street via Halsey Street.

Accommodating 250 buses per hour on the surface street would require extended green times for bus movements and absolute separation from conflicting vehicle movements at all intersections between the Northern Motorway and Britomart. With the development of Wynyard Quarter, it is difficult to see how this could be achieved without widening of Fanshawe Street to four lanes in each direction and substantial intersection upgrades. Further, the pedestrian connections between Wynyard Quarter and areas to the south, including the CBD, are important in achieving the targets for low car share adopted for the site. A surface street bus corridor carrying 250 buses per hour will present a major barrier between Wynyard Quarter and its surrounding area and have an impact on the amenity of the entire corridor.

Options for grade separation of the bus corridor along Fanshawe Street have not been investigated in detail but it is expected that it would be a serious undertaking. The grade separated corridor would need to run from the Northern Motorway through to the Britomart interchange or at least as far as Halsey Street (including grade separation at this intersection) where buses could split between those going to Britomart and those going to mid-City via Wellesley Street. Construction via either cut and cover or bored tunnel would be costly and have major impacts on surrounding developments.

Cook Street

Another option is use of the Cook Street off ramp. The SH1 motorway off-ramp at Cook Street presents an opportunity to divide Northern Busway routes south of the Harbour Bridge, with routes continuing to use Fanshawe Street serving the north of the CBD via Britomart (with services able to terminate there or continue via the Central Connector to other destinations such as Newmarket); and routes using the motorway off-ramp and Cook Street able to serve Midtown.

The alignment for routing buses from Cook Street to Wellesley Street has not been determined but is likely to require specifically built infrastructure such as a bus tunnel. By way of example, a direct Cook Street to Mayoral Drive connection would require a short piece of two-way bus tunnel beneath Nelson and Hobson Streets. This tunnel would both allow a more acceptable grade for buses to travel, and would reduce conflict with general traffic demands on Albert and Hobson Streets. No cost has been ascertained for such a tunnel.

Additional work would be required to determine the appropriate alignment from Cook Street to Wellesley that met Auckland Council's local and strategic objectives for Cook Street and the CBD respectively.

Routing Discussion

This study has assessed the most likely bus route pattern to best utilise the Fanshawe only and Fanshawe and Cook Street options.

This assessment proposes that all Northern Express services and Route 900's would continue to use Fanshawe Street and maintain their current routes through town (2041 estimate 85 buses in the AM peak hour).

Route 800's would use the alternative (for example Cook Street) CBD access point and travel to the Civic Centre, possibly via Mayoral Drive. (2041 estimate 161 buses in the AM peak hour).

See **Appendix B** for diagrams.

2.4 Review of Busway Capacities on Other Systems

The South East Busway system in Brisbane is reported to carry a peak hourly flow of about 340 buses on approach to the CBD on a dedicated off-street busway.[2] Bus services are split beyond this point with about 200 buses per hour entering the CBD through a set of signalised intersections with bus lanes.

[2] *Brisbane Transport, "A Tale of Three Busways".*

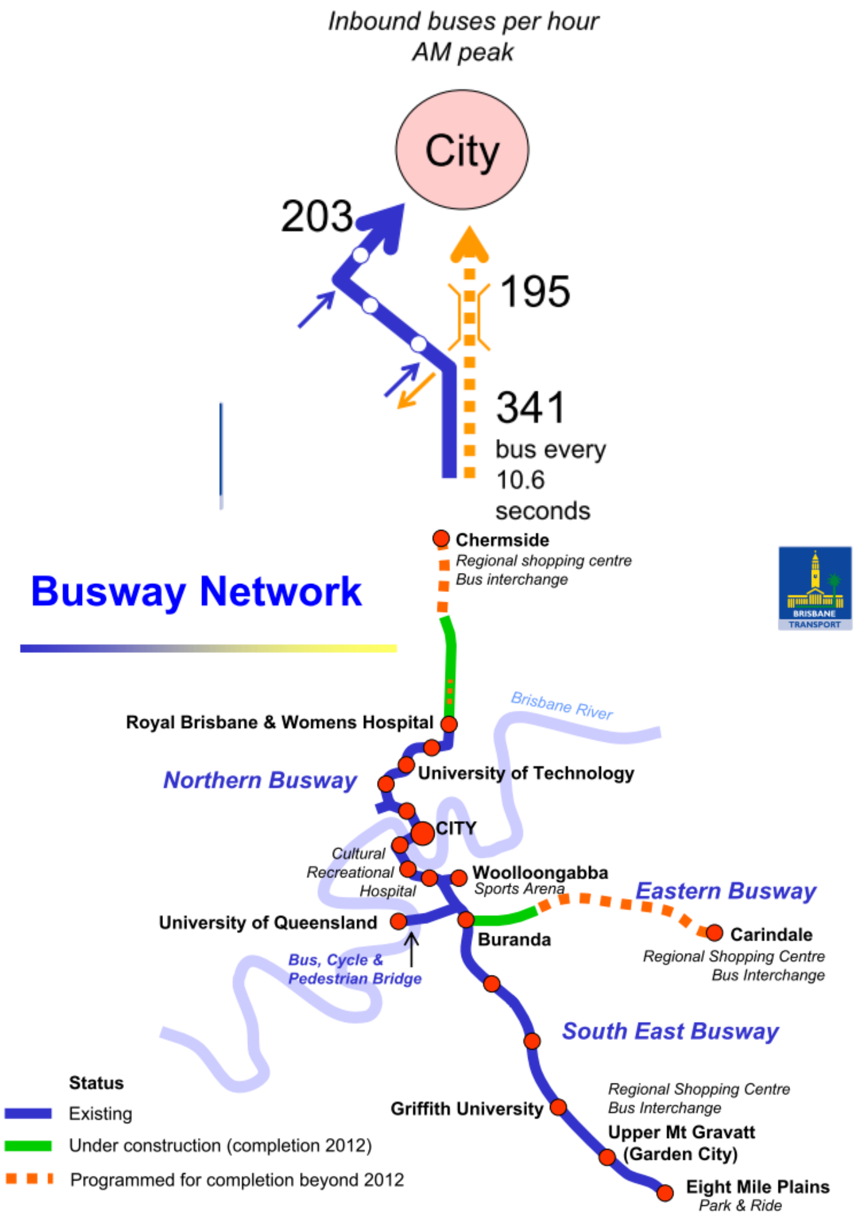


Figure 2-6 Brisbane Busway routes and Central City peak volumes

The Sydney Harbour Bridge carries about 280 buses per hour in the morning peak hour (8:00 to 9:00 am) on a 24 hour southbound bus only lane.[3]

In both Brisbane and Sydney, busway (or similar) usage exceeds 250 buses per hour, supporting the assessment of the capacity of the North Shore busway.

[3] *Hidas, P. et al, "Evaluation of Bus Operations by microsimulation in a Sydney CBD corridor", ATRF, 2009.*

3.0 Busway Demand

3.1 Future Demand Estimates

Indicative estimates of demand growth on the Northern Busway were developed based on a strategic level analysis of key demand drivers including Auckland CBD population and employment and the capacities of different modes. These indicative estimates were compared with recent forecasts from both the APT and ART3 regional models.

As reported in **Section 1.2** earlier, the demand figures reported in this section relate to total weekday morning peak for travel along the Busway corridor towards the CBD and adjacent destinations. The demand figures are at a peak across the Harbour Bridge.

Growth in CBD Travel Demand

The RLTS land use forecasts assume the following growth in CBD population and employment:

- CBD population growing from about 17,000 in 2006 to 102,000 in 2041– a growth of 500%
- CBD employment growing from about 63,000 in 2006 to 122,000 in 2041– a growth of 94%

It is assumed that the demand for work travel to CBD jobs will increase in proportion to CBD employment – that is, no significant increase in working at home for people with CBD jobs.

With population forecast to grow at a much higher rate than employment, there will be a marked increase in the number of work trips made inside the CBD. The 2006 census data indicated that about 46 % of CBD residents are in the workforce and that 45 % of these work in the CBD. As both CBD population and employment grows, it is likely that more CBD workers choose to live in the CBD. Figures of 48 % workforce participation and 55 % employed in the CBD were assumed for 2041. Applying these parameters lead to an estimated increase in internal work trips (people travelling to work within the CBD) from about 2,900 in 2006 to 23,500 in 2041 – a growth of over 700 %. This strong growth in internal work trips results in a moderation in growth for external work travel – work trips to the CBD from outside the CBD. It is estimated that external CBD work travel demand will grow by 60 % from 2006 to 2041.

The forecast growth of 60 % in external work travel demand is assumed to apply to peak period non-work trips as well as work trips.

Mode Capacities

Travel to and from the CBD from the North Shore is currently mostly undertaken using car, bus, and ferry. These modes have quite different capacities for accommodating growth.

The following assumptions were made as part of a "maximum corridor growth" scenario for different modes in the morning peak 2 hour period between 2006/07 and 2041:

- Growth in car person travel is limited to about 13 % above existing through modest increases in car vehicle occupancy and peak spreading – no increase in traffic capacity is assumed; and
- Growth in ferry person travel is limited to the growth in population in the ferry catchment areas (assumed to be the southern part of the North Shore) – a growth of no more than 36%.

Growth in Bus Travel Demand – 2041 2 Hour Peak

Under the assumptions described above for CBD travel demand growth and limits in growth for different modes, the demand for bus travel into the CBD from the North Shore in the 2 hour morning peak is estimated to increase from about 6,000 in 2007 to over 20,000 in 2041 – a growth of about 245 % or about 3.7 % p.a. This is illustrated in Figure 3-1 below that shows the recorded Fanshawe Street bus passenger counts from 2001 to 2009 and the estimated growth through to 2041. This graph demonstrates that the forecast growth is largely consistent with growth achieved on the corridor in the last 4 to 5 years.

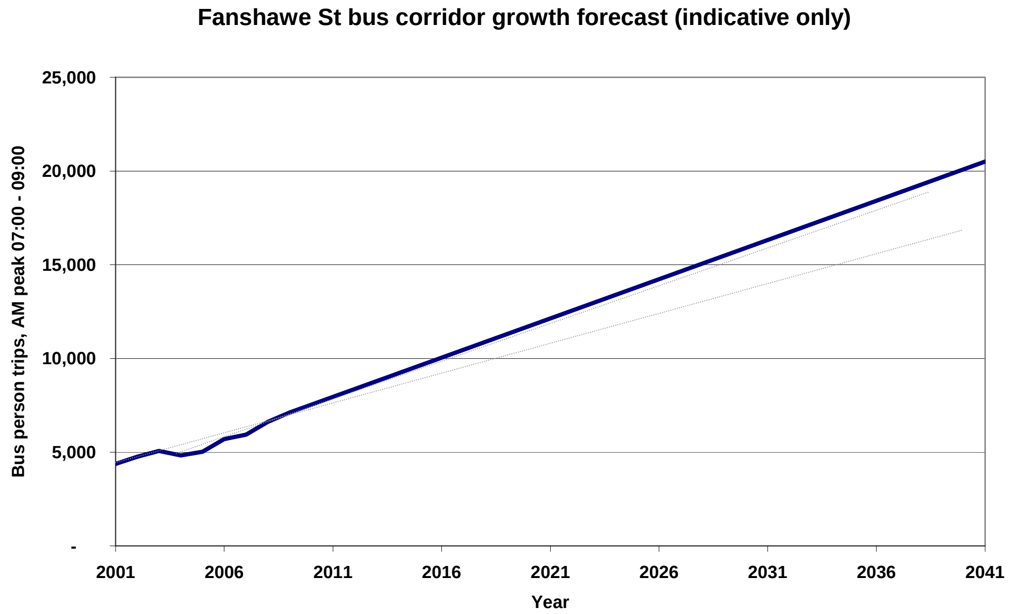


Figure 3-1 Fanshawe St corridor – estimated growth to 2041

3.2 Comparison with Model Forecasts

Results were provided from runs of Auckland Regional Council's APT public transport model. For a 2041 scenario without a CBD rail loop or a Parnell rail station, the following demand on bus services from the North Shore were reported:[4]

- 17,400 trips on Fanshawe Street; and

[4] *"PT trips and landuse 21 May 2010" spreadsheet from Peter Clark, ARTA, May 2010.*

- 2,200 trips on Shelly Beach Road.

The total trips at these two points are about 19,600 similar to the strategic estimate of about 20,000. The APT model assigns a larger number of trips to Shelly Beach Road than would arise from the limited number of services using this route.

Results were provided from runs of the ART3 regional model conducted as part of the AWHC project.[5] The model forecasts growth in bus passenger demand across the harbour (southbound in the AM peak 2 hours) from 5,100 in 2006 to 16,600 in 2041 under the RLTS set of assumptions. This translates to a growth of about 225% similar to the strategic estimate of 245% growth in the same period.

The review of the APT and ART3 model results suggest that the strategic estimate of 20,000 passengers is a reasonable upper limit estimate of future demand. A separate run of the ART3 model with different assumptions from the RLTS with respect to, for example, fuel prices, produced much more modest growth in bus trips of only 132%. Achieving the level of 20,000 passengers in a 2 hour period is dependent on achieving the strong forecast growth in CBD employment and limited growth in car travel.

Growth in Bus Volumes – 2041 One Hour Peak

The capacity of the Northern Busway system is assessed in terms of peak buses per hour. The following steps were taken to translate the estimate of 2041 two hour passenger demand to 2041 one hour bus volumes:

- As demand for travel to the CBD increases, it is assumed that demand will spread itself more evenly over the 2 hour period; in 2007 the peak 1 hour to 2 hour factor for bus passengers on Fanshawe Street was 1.54; in 2041 it is assumed this factor will increase to 1.7 representing a spreading of peak demand;

- Applying the above peak spread factor in 2041 gives an estimate of peak 1 hour bus passenger demand of about 12,100;

- As discussed earlier in this report, introducing higher capacity buses is an appropriate response to increasing demand; it is assumed that in 2041 at least 20 % of the buses using the Northern Busway in the peak period will be higher capacity, articulated buses;

- In 2007, the average bus occupancy in the peak hour was about 43 passengers per bus; assuming the same occupancy for 80% of the fleet, but a higher average occupancy of 75 for the remaining 20% gives an average occupancy across the full fleet of about 49; and

- Applying the average peak hour occupancy of 49 to the estimated peak 1 hour demand of 12,100 gives a peak hour bus volume of about 250 buses – this is an increase of about 180 % over 2007/08 peak volumes of about 90 buses per hour.

[5] *"WHC – Cross Harbour Demands for Network Plan (PB 20072010)" spreadsheet from David Young, 20 July 2010.*

3.3 Suitability of Demand Forecasts

The preceding sections of this report have presented an argument that the strategic corridor demand growth forecasts developed in this study represent a reasonable "maximum growth" scenario.

Section 1.3 earlier discussed a range of alternative land use scenarios that have been considered by Auckland Regional Council. Auckland City Council has also developed, in the past, alternative assumptions regarding CBD growth.

Without critically reviewing the details of the alternative land use forecasts it is argued here that it is very unlikely that Northern Busway corridor demand would sustain growth rates higher than those developed in this report. While it is common for busway systems to experience strong per annum growth in the years immediately following opening, as has been experienced on the Northern Busway, there are many factors that might limit sustaining this growth, or higher, over 30 years and more, and such outcomes would not normally be considered appropriate for strategic transport planning purposes.

3.4 Summary of Busway Capacity

The Northern Busway has experienced strong growth in demand over the last 5 years with a corresponding strong increase in bus services during the peak hours. The 2009 Central Area cordon counts recorded a total of 185 buses citybound along Fanshawe Street in the 7:00 to 9:00 period – this corresponds to a peak hour flow of about 105 buses.

A strategic analysis of future demand, validated against recent model results, suggests that the AM peak hour bus flows into the CBD would increase to no more than 250 buses per hour in 2041.

It is recommended that for the purposes of this study a target capacity for the Northern Busway system of 250 buses per hour be adopted. This level is similar to that achieved on other major busway systems around the world including Brisbane's South East Busway and Sydney's Harbour Bridge bus lane.

While the current peak hour bus flows are placing considerable pressure on the Fanshawe Street bus stops, they are well below the recommended Busway target capacity of 250 buses per hour. This report has identified a range of measures to reach the target capacity over time including:

- Introduction of express services that skip some stops – e.g. Fanshawe Street;
- Introduction of higher capacity, articulated buses;
- Improvement of dwell times through the introduction of cashless services and/or smart card ticketing;
- Provision of additional bus stops on Fanshawe Street;
- Extension of bus lanes east of Nelson Street after opening of Victoria Park Tunnel; and
- Development of increased bus capacity into the CBD via Fanshawe Street or other point (for example Cook Street).

Further investigations would be required to establish the best option to increase capacity into the CBD from the North Shore Busway. The main recommendation from this stage of the 2010 Capacity Study is that consideration should be given to the provision of increased bus infrastructure capacity as integral to the options being developed for the AWHC.

Implementing the measures listed above, and traffic reductions arising from the completion of the Victoria Park Tunnel, should ensure that Fanshawe Street will have capacity to carry about 180 buses per hour in the peak flow direction unless activity in the Wynyard Quarter unduly impacts on bus operations. On this basis it is recommended that planning for increased bus access capacity to the CBD be targeted for a 2020 commencement. Such capacity increase should be consistent with and integrated into the outcomes from the Auckland CBD PTIS study, and is required independently of the AWHC project.

In the remainder of this report there is a discussion around the impact of buses in the Auckland CBD and the circumstances under which rail might be developed along a North Shore corridor. It is argued that provision of North Shore rail would be part of a longer term rail network development program to support regional job growth in centres such as Albany and Takapuna.

However, options to further extend the capacity (and therefore life) of the Northern Busway beyond the 2040 time horizon could be considered to have more value for money than construction of a rail corridor between the CBD and Albany. Under the circumstances where the Northern Busway corridor is split between two CBD access routes, there would be opportunities to further increase busway capacity beyond the target level of 250 buses per hour adopted in this study for 2040 by way of a higher priority to bus movements over general traffic including the possibility of establishing bus only streets.

4.0 Buses in Urban Centres

4.1 Section Objective

Whilst 250 buses per hour may be accommodated by the North Shore Busway, what impact will they have on Auckland's CBD? This following may provide better understanding of what the impact on the city streetscape, pedestrians, other bus routes and other traffic this number of buses would have.

This section looks at the projections, planning and practise currently undertaken around traffic management and street environment in:

- Auckland;
- Other cities in New Zealand;
- Australia; and
- Other parts of the world.

Specifically this section of the report identifies similar examples of dealing with high volumes of buses and the impacts and mitigations other cities plan for and what the outcome is in practice.

Areas of comparison to be made include:

- Quantity of services (volumes);
- Quality of services (vehicle type); and
- Environment they run in (retail, residential, street width, pedestrian numbers, other factors).

Finally, an assessment of the above factors will give an indication of the environmental capacity of the various approaches.

4.2 Environmental Capacity

The concept of environmental capacity (essentially the ability of an environment to accommodate activities without unacceptable impact) is a key measure in sustainability and has been adopted in transport and traffic terms to account for capacity beyond the usually engineering-based measures in highway capacity manuals, such as lane carrying capacity, delays and queue lengths.

The application of environmental capacity to transport and traffic is in its early stages, but it is a way to consider some of the wider impacts and benefits of transport networks in:

- Noise;

- Air pollution;
- Pedestrian impacts;
- Other amenity aspects;
- Crash risks;
- Severance; and
- Planning blight

While many of these impacts can be determined quantitatively via direct measurements and the use of proxies such as vehicle kilometres travelled (VKT), the concept of transport and traffic environmental sustainability recognises that each has a powerful subjective element.

The acceptability or otherwise of impacts is therefore highly subjective, though they are often linked with economic productivity.

In New Zealand and elsewhere, bus flows in cities are the subject of concern over impacts on environmental capacity, particularly where bus flows increase to levels where bus priority measures are provided or contemplated, with impacts on other vehicles and pedestrian and bicycle movements.

The essential issue is a problem of conflicting functions for city streets; as destinations, particularly for pedestrian movements, and transport links. One of the difficulties in resolving the perceived conflict is that the transport function is, at least partly, servicing and reinforcing the destination function – city streets that attract activity (such as Main Streets and shopping streets) are at least partly successful because of their transport function. “Solving” the problem by reducing the transport function (say by relocating buses to other corridors) may have unintended consequences, such as reducing the accessibility of the destination or encouraging more private traffic.

As well, buses have an important role in reducing congestion in city centres – they are part of the solution to the congestion problems that often prompt proposals to reduce bus flows. A city street carrying 250 buses per hour (a capacity of 12,500 passengers per hour) is potentially replacing almost 10,500 car trips per hour – a flow that would require more than four times the road space to accommodate in addition to extensive areas for parking.

In many cities, environmental capacity impacts of buses (as well as private traffic) are triggers for introduction of alternative travel modes such as underground rail or light rail; and private vehicle access disincentives, such as restrictive parking policies, congestion and access charges and the like.

However, many cities find that, despite introduction of new mass transit modes, the need to manage some buses on the surface remains.

Bus flows of greater than 100 buses per hour on city centre corridors may not have significant impacts on the economic productivity of the city, depending on the circumstances and management of buses. In Wellington CBD for instance, bus flows of more than 115 per hour (2008 data) on Lambton Quay are apparently compatible with a corridor that has the highest rents and the lowest vacancy rates in New Zealand.

Both the problem of bus flows in city centres and the solutions available to manage them, or to overcome the environmental capacity impacts of city bus flows, are complex. In PB's view, the broader implications of solutions (particularly where these involve reducing bus flows through relocation of bus routes, or forced passenger transfer at the CBD edge) should be considered in addition to issues such as flows of buses, pedestrians and other vehicles, crash rates, air quality problems etc.

Subsequent sections of the report describe current practices in managing bus flows in Australia and New Zealand.

4.3 CBD Roadway Capacity Assessment

To understand what kind of environmental impacts future bus numbers may have in Auckland this assessment has considered the bus numbers forecasted for the CBD in the year 2041.

Bus movements at peak times are expected to grow significantly over the next 31 years. Our forecast and impact assessment is made based on the following assumptions,

Assumptions

1. Total people trips (all modes) in the AM peak (7am to 9am) to the CBD would rise from 75,000 in 2006/2007 to just over 120,000 in 2041 (source: RLTS).
2. Assuming the CBD Rail Loop is in place, train journeys would increase from 4,300in 2006/2007 to almost 30,000 (in the AM peak) by 2041. Bus journeys would increase from 21,000 to 35,000.
3. Travel over the peak 60 minutes (of the two hour peak) represents 60% of the total AM two hour peak.
4. Average bus load 39.
5. 246 buses from the North Shore would arrive in the CBD in the peak hour (PB study).
6. 298 buses from the East, West, South and Isthmus in the peak hour (remainder).
7. The assessment considered bus routes may change within the CBD (for example as per Auckland City Council PTIS study) but for this assessment main corridors were considered to remain consistent.
8. All CBD bus corridors have single bus lanes.
9. Growth in use of services has been 'straight lined' between 2010 and 2041 for this assessment (no yearly fluctuations).
10. The "Transit Capacity and Quality of Service Manual" 2003, Transportation Research Board, is accepted as an authoritive text on bus lane capacity (as below)
11. Based on good bus operation over single bus lanes on bus corridors in the CBD, acceptable operation would range between 'CBD' flow rates (as below) and 'Arterial' flow rates. Bus flows therefore of less than 100 per hour are considered acceptable, bus flows between 100 and 130 are considered marginal and flows of greater than130 would be considered unacceptable (would lead to poor performance). See Table 4-1 below.

Table 4-1 Suggested Bus Flow Service Volumes for Planning Purposes

(Flow Rates for Exclusive or Near - Exclusive Lane)			
ARTERIAL STREETS			
Free Flow -	25 or less	15	
Stable Flow - Unconstrained	26 to 45	35	
Stable Flow - Interference	46 to 75	60	
Stable Flow - Some Platooning	76 to 105	90	
Unstable Flow - Queuing	106 to 135	120	
Forced Flow - Poor Operation	Over 135*	150*	
CBD STREETS			
Free Flow 20 or less	20 or less	15	
Stable Flow - Unconstrained	21 to 40	30	
Stable Flow - Interference	41 to 60	50	
Stable Flow - Some Platooning	61 to 80	70	
Unstable Flow - Queuing	81 to 100	90	
Forced Flow - Poor Operation	Over 100*	100*	
*Results in more than one-lane operation.			

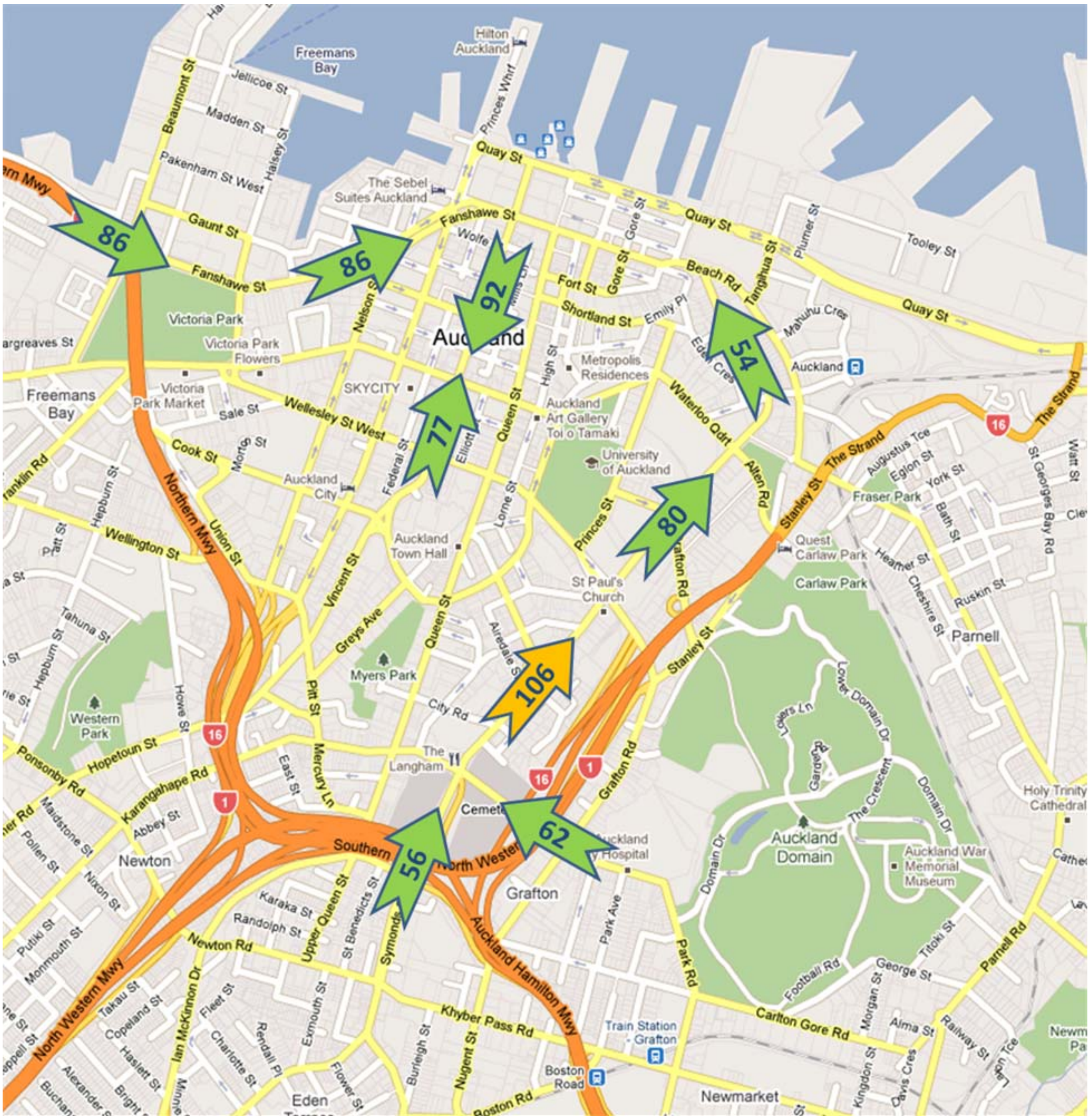
Source: "Transit Capacity and Quality of Service Manual" 2003, Transportation Research Board.

Assessment of Impact

The figures on the following pages show the current and projected impact of buses on main CBD corridors as per the assumptions in **Section 4.3.**

- Peak hour (AM) bus flows 2010;
- Peak hour (AM) bus flows 2041;
- Year of CBD corridor over capacity – with CBD Rail Loop; and
- Year of CBD corridor over capacity – without CBD Rail Loop.

Current (2010) ‘scheduled’ peak bus levels within peak 60 minute period on main CBD bus corridors.



Key to Bus Lane Performance:

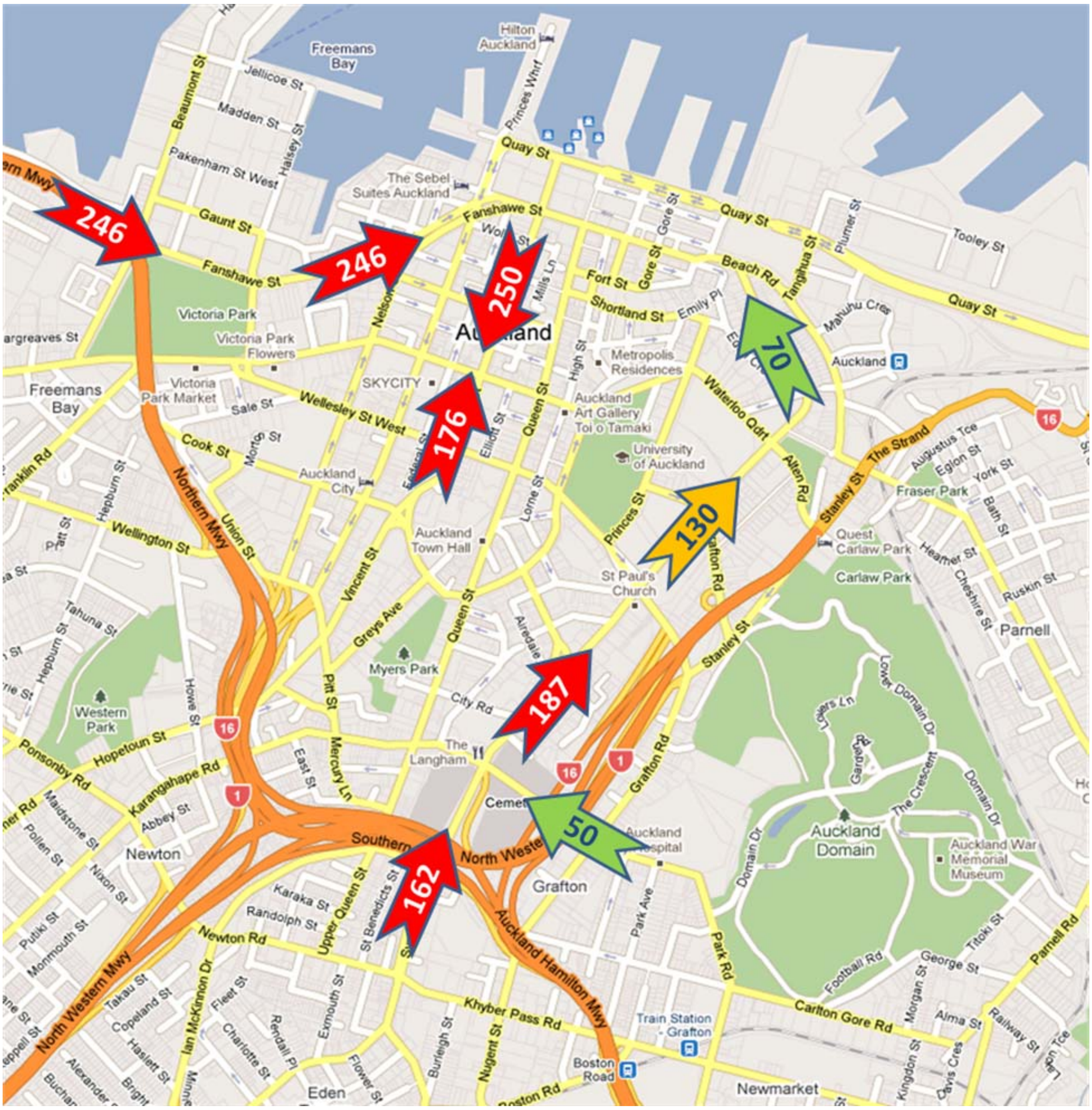
Acceptable/Good

Marginal

Unacceptable/Poor

Figure 4-1 AM Peak hour bus numbers current – CBD main corridors

Future (2041) peak bus levels within peak 60 minutes on main CBD bus corridors, with CBD Rail Loop.



Key to Bus Lane Performance:

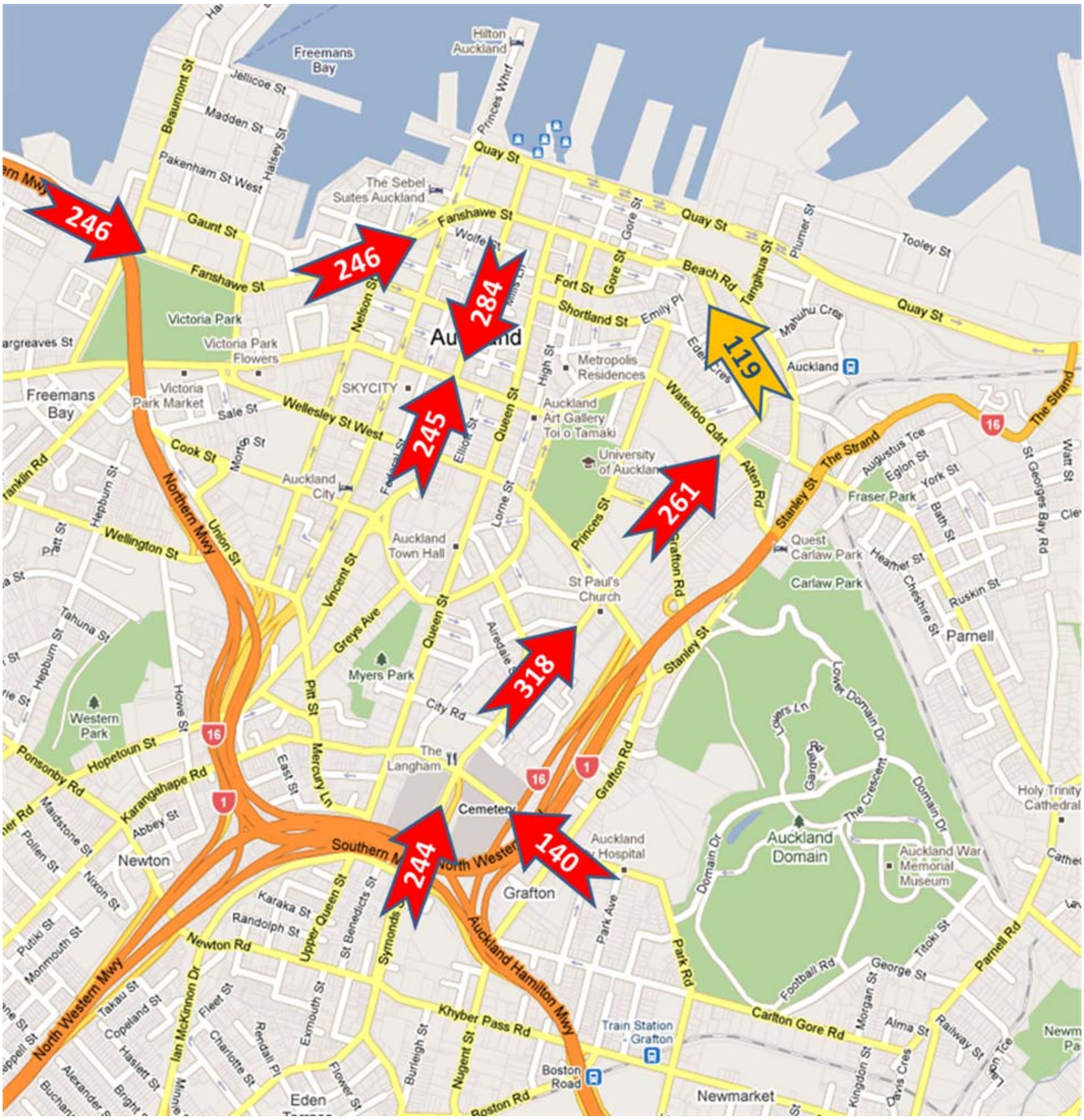
Acceptable/Good

Marginal

Unacceptable/Poor

Figure 4-2 AM Peak hour bus numbers 2041 – CBD main corridors with CBD rail loop

Future (2041) peak bus levels within peak 60 minutes on main CBD bus corridors, **without** CBD Rail Loop.



Key to Bus Lane Performance:

Acceptable/Good

Marginal

Unacceptable/Poor

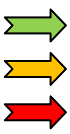
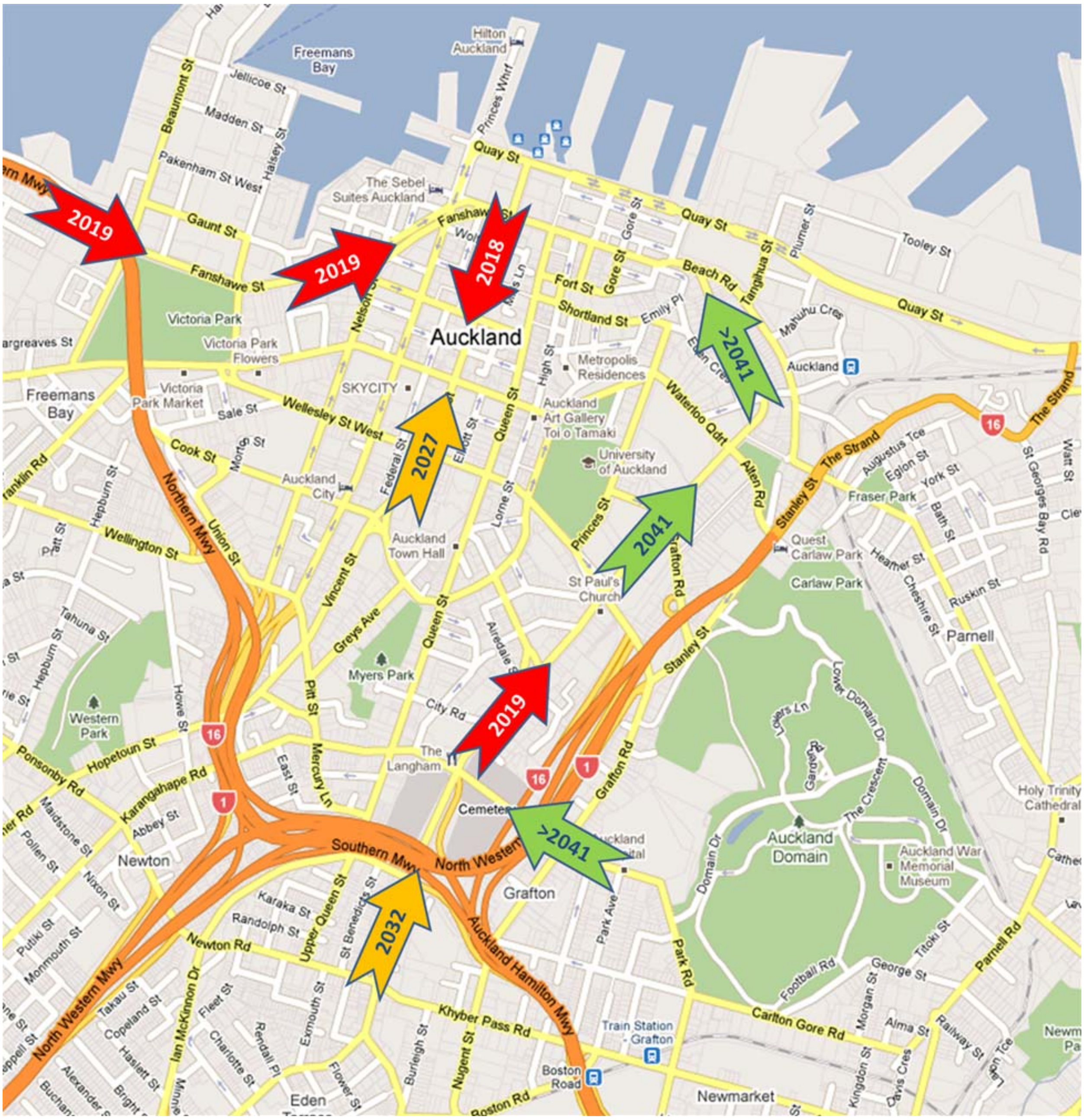


Figure 4-3 AM Peak hour bus numbers 2041 – CBD main corridors without CBD rail loop

Year of bus lane desired maximum capacity (130 buses per hour) with CBD Rail Loop.



Key to year of bus lane capacity constraint:

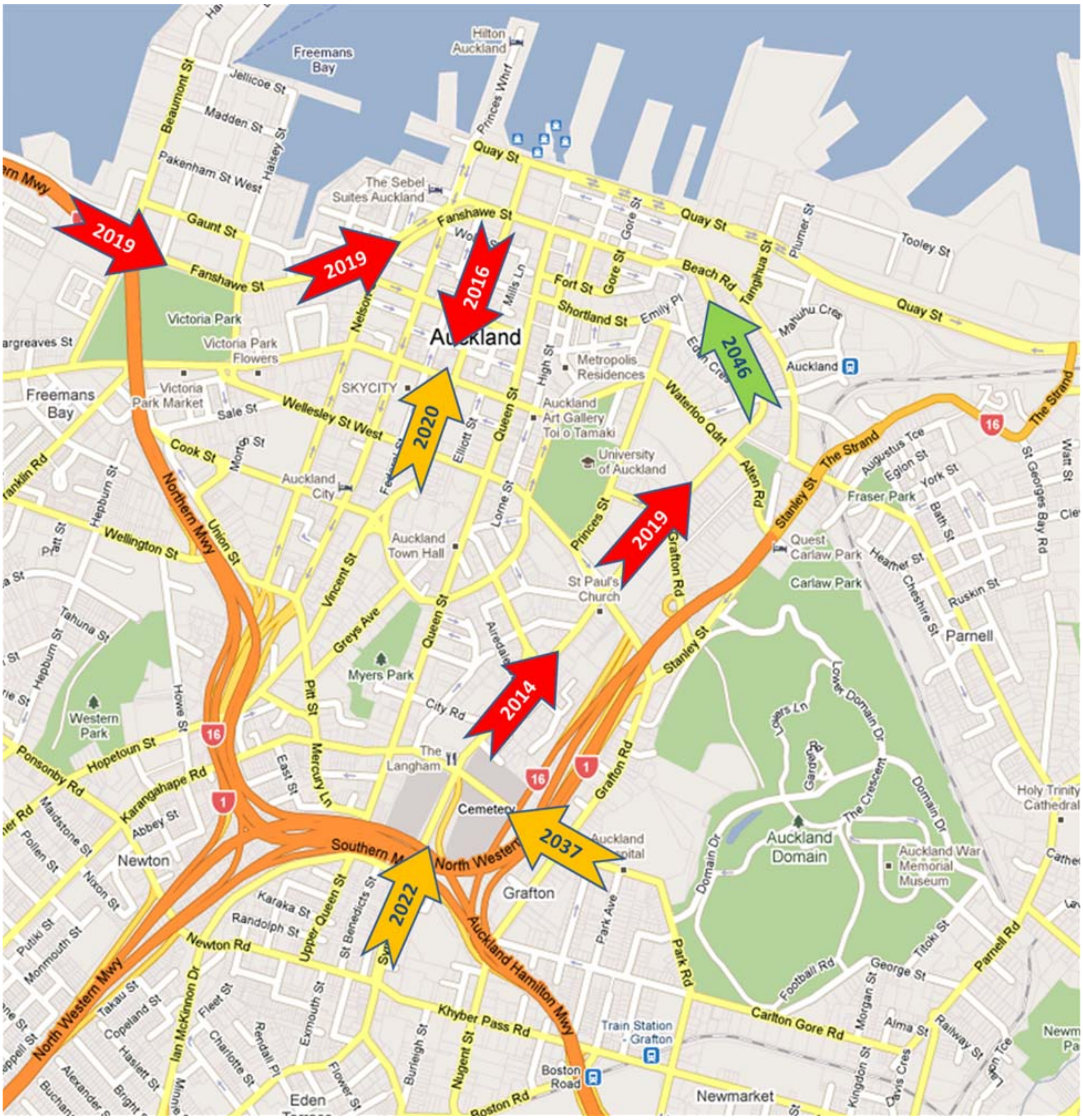
Acceptable/Good

Marginal

Unacceptable/Poor

Figure 4-4 Year of Bus Lane max. capacity with CBD Rail Loop

Year of bus lane desired maximum capacity (130 buses per hour) **without** CBD Rail Loop.



Key to year of bus lane capacity constraint:

Acceptable/Good

Marginal

Unacceptable/Poor

Figure 4-5 Year of Bus Lane max. capacity without CBD Rail

Key Observation without CBD Rail Loop

Observations are made assuming high operational efficiencies leading to levels of service similar to guidelines for arterial bus lanes (max 130 buses per hour). In reality service levels for CBD locations (100 buses per hour) may only be possible in some locations;

- Without the CBD Rail Loop Auckland CBD would require twin or triple bus lanes (both sides of road), on most corridors;
- Fanshawe Street between Beaumont and Hobson Street would be at capacity in 2019;
- Symonds Street between Karangahape Road and Wellesley Street will be at capacity by 2014;
- Symonds Street between Khyber Pass Road and Karangahape Road will be at capacity by 2019;
- Albert Street southbound, between Customs and Wellesley Streets would be at capacity by 2016; and
- Albert Street northbound, between Customs and Wellesley Streets would be at capacity by 2020.

Key Observation with CBD Rail Loop

Observations are made assuming high operational efficiencies leading to levels of service similar to guidelines for arterial bus lanes (max 130 buses per hour). In reality service levels for CBD locations (100 buses per hour) may only be possible in some locations;

- Fanshawe Street between Beaumont and Hobson Street would be at capacity in 2019;
- Symonds Street between Karangahape Road and Wellesley Street will be at capacity by 2019;
- Symonds Street between Khyber Pass Road and Karangahape Road will be at capacity by 2032;
- Albert Street southbound, between Customs and Wellesley Streets would be at capacity by 2018; and
- Albert Street northbound, between Customs and Wellesley Streets would be at capacity by 2027.

4.4 Practice

Introduction

The following summarises measures that may be implemented by planning authorities to facilitate high bus flows in central business districts. The summary outlines general techniques and provides supporting examples. The information is focused on accommodating high bus flows in mixed traffic. The potential techniques are organised as bus preferential treatments, transit operating measures and special running ways. Examples illustrate the application of each.

Bus Preferential Treatments

Bus preferential treatments seek to improve operational efficiency in areas, such as CBDs, with limited street capacity and relatively high daily parking costs. The treatments include physical improvements, operating changes, and regulatory changes. Among these are:

- Traffic signal priority;
- Boarding islands;
- Kerb Extensions;
- Yield to bus laws; and
- Parking restrictions.

The treatments impact general vehicular traffic, parking, cycling and pedestrians. They have been made more acceptable to roadway users and decision-makers when the improvements to transit operations do not create extreme disruptions. In addition, support has been generated by focusing on the benefit of maximising the person-carrying capacity of streets.

The following information has been adapted from the Transit Cooperative Research Program (TCRP) Report 90: Bus Rapid Transit, Volume 2 Implementation Guidelines, 2003.

Traffic Signal Priority

Signal priority measures include passive, active, and real-time priority, in addition to pre-emption.

Passive strategies attempt to accommodate transit operations through the use of pre-timed modifications to the signal system that occur whether or not a bus is present to take advantage of the modifications. Reducing the traffic signal cycle length on a CBD street system is an example of a passive priority measure. These adjustments are completed manually to determine the best transit benefit while minimising the impact to other vehicles. Passive priority can range from simple changes in intersection signal timing to system-wide retiming to address bus operations.

Active strategies adjust the signal timing after a bus is detected approaching the intersection. Depending on the application and capabilities of the signal control equipment, active priority may be either conditional or unconditional. Unconditional strategies provide priority whenever a bus arrives. Conditional strategies incorporate information from on-board automatic vehicle location (AVL) equipment (e.g., whether or not the bus is behind schedule, and by how much), and/or automatic passenger counting (APC) equipment (e.g., how many people are on-board), along with signal controller data on how recently priority was given to another bus at the intersection, to decide whether or not to provide priority for a given bus.

Real-time strategies consider both automobile and bus arrivals at a single intersection or a network of intersections. Applications of real-time control have been limited to date and require specialised equipment that is capable of optimising signal timings in the field to respond to current traffic conditions and bus locations.

Pre-emption can be classified separately because it results in changes to the normal signal phasing and sequencing of the traffic signal to provide a clear path for the pre-empting vehicle through the intersection. Pre-emption is most commonly associated with emergency vehicles (e.g., ambulances, fire trucks, and police cars), and with trains, when grade crossings are located adjacent to a signalised intersection (to clear vehicles off the grade crossing, and then prevent access to the crossing until the train has cleared the crossing). Because pedestrian crossing phases are also pre-empted, pedestrians can find themselves unexpectedly facing a solid DON'T WALK indication while crossing the street. Because buses do not announce their arrival by sirens and lights, as do emergency vehicles, pre-emption can lead to potentially serious pedestrian safety issues. From a vehicle operations standpoint, pre-emption can disrupt the coordination existing between traffic signals, which may result in significant congestion that also affects subsequent buses.

Table 4-2 Bus Signal Priority Systems

Treatment	Description
Passive Priority	
Adjust cycle length	Reduce cycle lengths at isolated intersections to benefit buses
Split phases	Introduce special phases at the intersection for the bus movement while maintaining the original cycle length
Area-wide timing plans	Preferential progression for buses through signal offsets
Bypass metered signals	Buses use special reserved lanes, special signal phases, or are rerouted to non-metered signals
Adjust phase length	Increased green time for approaches with buses
Active Priority	
Green extension	Increase phase time for current bus phase
Early start (red truncation)	Reduce other phase times to return to green for buses earlier
Special phase	Addition of a bus phase
Phase suppression	Skipped non-priority phases
Real-Time Priority	
Delay-optimising control	Signal timing changes to reduce overall person delay
Network control	Signal timing changes considering the overall system performance
Pre-emption	
Pre-emption	Current phase terminated and signal returns to bus phase

Boarding Islands

Where significant parking activity, stopped delivery vehicles, heavy turning traffic volumes, and other factors slow traffic in the kerb lane of a multiple-lane street, buses may be able to travel faster in the lane to the median. Boarding islands allow bus stops to be located between travel lanes so that buses can use a faster lane without having to merge into the kerb lane before every stop. Pedestrian safety issues must be addressed when considering the use of boarding islands.

Kerb Extensions

Kerb extensions at transit stops (also known as bus bulbs) are similar to boarding islands in that they allow transit vehicles to pick-up passengers without moving into the kerb lane. Kerb extensions may be used where streets have kerbside parking and high traffic volumes. In these cases, it may not be desirable for a bus to pull to the kerb to stop because of the delays involved in waiting for a sufficiently large gap in traffic that will allow the bus to pull back into the travel lane.

Kerb extensions are typically developed by extending the kerb into the parking lane to allow buses to stop in the travel lane to pick up and discharge passengers. Kerb extensions can actually create more on-street parking than would exist with a stop flush with the regular kerb line, as the area before or after the bus stop used by buses to pull in or out of the stop can now be used for additional parking. If bicycle lanes exist, they may need to be routed around the kerb extension, creating potential pedestrian/bicycle or auto/bicycle conflicts.

As noted by Levinson, the extensions can benefit bus operation by:

- Creating additional space for amenities at bus stops;
- Reducing street crossing distances for pedestrians;
- Eliminating lateral movements of buses into and out of stops;
- Eliminating delays associated with buses re-entering a traffic stream or; and
- Segregating waiting bus passengers from pedestrian flow along a sidewalk.

Extensions may result in queuing traffic behind stopped buses causing auto drivers to change lanes to avoid a stopped bus, precluding adding capacity for moving traffic, and costing more than conventional bus stops. Supporting conditions include:

- Frequent bus service;
- High levels of boarding and alighting;
- Kerb parking;
- Low auto operating speeds;

- Two travel lanes each way; and
- Difficult bus re-entering problems.

The extensions may be located near side, far-side, or mid-block. When far-side us stops are used, right turn lanes can be provided on intersection approaches by removing several parking spaces.

Yield-to-Bus Laws

Some jurisdictions, including the states of Florida, Oregon, and Washington, and the provinces of British Columbia and Québec, have passed laws requiring motorists to yield to buses signalling to re-enter the street from a bus stop. Depending on motorist compliance with the law, the re-entry delay associated with merging back into traffic from an off-line stop can be almost eliminated. Some state jurisdictions (e.g., Québec and Washington) remind motorists of the law through the use of stickers mounted to the back of the bus. Some agencies in areas without yield-to-bus laws also use similar stickers appealing to motorist courtesy to let the bus back in. Oregon has developed a flashing electronic YIELD sign that has traffic control device status (i.e., motorists must obey it like they would a traffic signal or regulatory sign).

Parking Restrictions

Parking restrictions are typically required in the vicinity of a kerbside stop to allow buses to pull out of the street and up to the kerb to load and unload passengers. In areas where high parking turnover interferes with the flow of traffic on a street, parking restrictions may allow restriping to provide a right-turn-only lane (note traffic travels in right hand side of streets in North America) that can also be used by buses as a queue jump lane. Part-time or full time parking restrictions can be used to provide part-time exclusive bus lanes. In some instances, parking restrictions have been mitigated through stop consolidation (see below), which can increase the overall number of parking spaces in an area. As a general guide, restricting kerb parking can be supported when traffic volumes exceed 500 to 600 vehicles per lane per hour, the streets operate at auto speeds below 20-25 mph and the lanes are needed for bus or BRT use (Levinson).

Transit Operating Measures

There are a number of options available to in the way that transit service is designed and operated that can also provide significant capacity. Techniques documented in TCRP Report 90 include:

- Bus stop relocation;
- Bus stop consolidation;
- Skip stop operation; and
- Platooning.

Bus Stop Relocation

The traffic signal systems used on streets are often designed to progress the flow of general traffic: the signals at a series of intersections are timed to turn green as a platoon of vehicles approaches each intersection from the preceding intersection. When bus stops are consistently placed on one side of an intersection (the near side, for example), buses will often arrive at the intersection while the signal is green. By the time passengers have finished loading and unloading, the signal will have turned red and buses must wait for the other traffic movements to be served. Alternating near-side and far-side stops can allow buses to take advantage of existing signal progression designed to facilitate vehicle flow.

When signals are spaced relatively close together, buses can take advantage of the existing signal progression when bus stop locations alternate from near side to far side from one intersection to the next. For example, a bus leaves a near-side stop with a platoon of other vehicles when the traffic signal at that stop turns green. The bus proceeds through the next signal with the other vehicles, and arrives at a far-side stop. By the time passenger movements are completed, the signal behind the bus may have turned red and the bus will have an easier time merging back into the street. It can then proceed to a near-side stop at the next signal, arriving and starting its dwell during the red interval, and can continue during the next green interval.

Bus Stop Consolidation

In general, minimising the number of stops that buses must make will improve overall bus speeds. However, care must be taken that dwell times at critical stops (those stops with the highest dwell time) are not lengthened when a stop is removed and passengers are required to use a nearby stop that is already well-used.

Consolidating bus stops involves trade-offs between the convenience of the passengers using a particular stop, and those passengers already aboard a bus who are delayed each time the bus stops. Requiring passengers to walk a long distance to another stop may discourage people living or working in the vicinity of a removed stop from using transit. In addition, the pedestrian environment along the street with bus service may not support pedestrian activity (for example, due to a lack of sidewalks). Eliminating a stop can be politically difficult at times when local residents object to having “their” stop removed. However, when stops are located close together (e.g., every block), and a consistent, objective process is used to determine which stops are eliminated, consolidating bus stops can provide benefits to all transit users.

Skip-Stop Operation

When all buses stop at every bus stop, the available capacity is used up more quickly than if buses are spread out among several groups of stops. This technique of spreading out stops among two to four alternating patterns, known as skip-stops, offers the ability to substantially improve overall facility bus capacity.

An example of the technique in an urban core is the Portland, Oregon Fifth Avenue bus mall. Buses using the mall are divided into four groups with similar regional destinations. Each group is identified by a particular directional symbol, such as the “W” for “west”. All buses belonging to that group make all stops designated for that group, and bypass the other groups’ stops. Two sets of stops are located in each block, and each group of buses stops every other block. Other signing systems are possible; for instance, Denver uses an “X-Y-Z” lettering system to designate skip-stops located along the downtown portions of 15th and 17th Streets.

These block-skipping patterns allow the bus facility capacity to nearly equal the sums of the capacities of the individual stops, thereby providing a nearly three- or four-fold increase in facility capacity, as well as a substantial improvement in average travel speeds. Due to traffic control delays, the irregularity of bus arrivals, and other factors, the actual capacity increase will be somewhat less than the ideal amount. Also, to maximise the capacity and speed benefits, buses must be able to use the adjacent lane to pass other buses. When that lane operates at or close to capacity, buses may not be able to pass other buses easily.

Platooning

Platooning occurs when a set of buses moves along a street as a group, much like individual cars in a train. Passing activity is minimised, resulting in higher overall travel speeds. Platoons can be deliberately formed, through careful scheduling and field supervision, or can be developed by traffic signals, much as platoons of vehicles form and move down the street together after having been stopped at a traffic signal.

In downtown Ottawa, the city's busway systems feed into arterial street bus lanes. These lanes are able to accommodate the scheduled volumes of buses, in part because the traffic signal progression on those streets is designed to favour buses (i.e., both bus travel time between stops and dwell times at stops are taken into consideration). The combination of the exclusive lanes and the signal progression naturally forms bus platoons, even though buses may not arrive downtown exactly at their scheduled time. Platooning has also been raised as a potential tool to manage high volumes of buses entering and exiting the CBD in the Perth, WA. At this time, it has not been formally adopted.

Table 4-3 General Planning Guidelines for Bus Preferential Treatments: Operations

Treatment	Primary	Secondary	Related Land Use and Transportatin Factors
Bus-activated signal phases	Low-volume movement	High bus delay on approach	At access points to bus lane and interchanges; or where bus turning movements experience significant delays.
Bus signal priority	Intersections with high bus delay, coordinated signal system	Preferable at intersections with far-side stops	Traffic signal controller software may need to be upgraded.
Bus signal pre-emption	Intersections with high bus delay, uncoordinated signal system	Preferable at intersections without pedestrians	Pedestrian clearance or signal network constraints.
Queue Jump	Intersections with large amounts of control delay (HCM LOS D or	Right turn lane existence, bus routes with sub-15 minute headways	Merge on opposite side of intersection should consider bus operations.

Treatment	Primary	Secondary	Related Land Use and Transportatin Factors
	worse)		
Kerb Extensions	Areas with high pedestrian traffic	Insufficient sidewalk space for shelter	Impacts to other road users and drainage issues.
Boarding Islands	Streets with four or more lanes	Locations where geometric conditions allow	Impacts to other road users, pedestrian access to islands may be a concern.
Parking Restrictions	Need for additional bus capacity	On-street parking exists	Local business and residence parking impacts.
Stop Consolidation	Long routes with high ratio of dwell time to travel time	Pedestrian environment	May reduce access to transit routes if stops are too far apart.

Special Running Ways

Special running ways (busways, bus lanes, and queue bypasses) should be provided where there is:

- Extensive street congestion;
- A sufficient number of buses;
- Suitable street geometry; and
- Community willingness to support public transport, reallocate road space as needed, provide necessary funding, and enforce regulations.

Running ways are intended to maximise the person-flow along a roadway with a net savings in the travel time per person. Where road space is allocated to special running ways, the aims to ensure that the person-minutes saved on buses exceed the person-minutes lost by people in cars. The following information is provided in TCRP Report 90 referenced above.

The factors that influence whether bus lanes may be appropriate include:

- Congestion;
- Travel time savings;
- Person throughput;
- Vehicle throughput;
- Local agency support;

- Enforceability; and
- Physical roadway characteristics.

Generally, bus vehicle capacity sets the upper limit for bus volumes on bus lanes. A study of bus operations in Manhattan recommended the following desirable maximum a.m. peak hour bus volumes for arterial street bus lanes:

- Two lanes exclusively for buses: 180 buses/hour;
- One lane exclusively for buses, partial use of adjacent lane: 100 buses/hour;
- One lane exclusively for buses, no use of adjacent lane: 70 buses/hour; and
- Buses in kerb lane in mixed traffic: 60 buses/hour.

Table 4-4 below presents general planning guidelines for bus priority treatments on arterial streets. A comparison of person volumes on buses operating in mixed traffic with person volumes in other vehicles operating on the street can also be used to help decide when to dedicate one or more lanes to exclusive bus use. Of note is the minimum thresholds for bus streets/malls, CBD kerb bus lanes and median bus lanes. Additional information regarding these three types of bus facilities is provided below.

Table 4-4 General Planning Guidelines for Bus Preferential Treatments : Urban Streets

Treatment	Minimum One-Way Peak Hour Bus Volumes	Minimum One-Way Peak Hour Passenger Volumes	Related Land Use and Transportatin Factors
Bus streets or malls	80-100	3,200-4,000	Commercially oriented frontage.
CBD kerb bus lanes, main street	50-80	2,000-3,200	Commercially oriented frontage.
Kerb bus lanes, normal flow	30-40	1,200-1,600	At least 2 lanes available for other traffic in same direction.
Median bus lanes	60-90	2,400-3,600	At least 2 lanes available for other traffic in same direction; ability to separate vehicular turn conflicts from buses.
Contraflow bus lanes, short segments	20-30	800-1,200	Allow buses to proceed on normal route, turnaround, or bypass congestion on bridge approach.

Treatment	Minimum One-Way Peak Hour Bus Volumes	Minimum One-Way Peak Hour Passenger Volumes	Related Land Use and Transportatin Factors
Contraflow bus lanes, extended	40-60	1,600-2,400	At least 2 lanes available for other traffic in opposite direction. Signal spacing greater than 500-ft (150-m) intervals.

The following discussion of special running ways has been adapted from Levinson, Herbert, 'Bus Rapid Transit on City Streets - How Does It Work' (Prepared for Second Urban Street Symposium, Anaheim, CA July 28-30, 2003.)

Concurrent Flow Kerb Bus Lanes

Concurrent flow kerb bus lanes are the most common type of bus priority treatment, but have not been extensively used for BRT. Traditionally, they have been used to facilitate bus movements in central business districts by segregating buses from other traffic. They may be single lanes as those for Boston's Silver Line BRT or dual lanes as found along Madison Avenue, New York City.

Kerb bus lanes are the easiest priority treatment to implement and have the lowest installation costs since they normally involve only pavement markings and street signs. They occupy less street space than most other types of bus lanes. The lanes are usually least effective in terms of image afforded and travel time saved. They are difficult to enforce and may impact kerb access. Right turns, when permitted, conflict with bus flow.

On one and two-way streets, an 11 to 13-foot (3.4 to 4 metre) bus lane should be provided along the kerb. However, where street width permits and there are high demands for kerb access, a 20-foot (6 metre) wide kerb bus lane can enable buses to pass loading and unloading cars and trucks. (This arrangement is used in downtown San Francisco).

Where street width and circulation patterns permit and peak bus volumes exceed 90 to 100 buses per hour, "dual" bus lanes are recommended. This arrangement enables buses to pass each other safely, make skip-stops feasible, and reduces the magnitude and variance of bus travel times. However, dual lanes preclude right turns by general traffic in North America.

Concurrent Flow – Interior Bus Lanes

These lanes can be provided adjacent to the parking lanes on both one-way and two-way streets. Examples of such lanes are found in downtown in Ottawa and along Washington Street in Boston where they serve the Silver Line BRT. The lanes remove buses from most kerbside conflicts with illegally parked vehicles, and they do not affect left turn access. Right turns can be permitted from the bus lane, or provided in the kerb lane by prohibiting kerb parking on intersection approaches.

Kerb extensions can be provided on the far side of intersections. Parking can be retained at all times during off-peak periods. Where parking is retained, and parking and un-parking manoeuvres may conflict with buses. The lanes normally require wide streets, typically 60 and 70 feet (18.3 and 21.3 metres) with and without left turn lanes (in North America).

Contra-flow Bus Lanes

Single and dual contra-flow lanes enable buses to operate opposite to the normal traffic flow on one-way streets. However, they may be used for a single block on two-way streets to enable buses to reverse direction. They normally operate at all times. They are used for distribution of busway vehicles in downtown Los Angeles (Spring Street) and downtown Pittsburgh.

Contra-flow lanes allow new bus service on existing one-way streets, utilise available street capacity in the off-peak direction of flow, and permit passenger loading on both sides of one-way streets, thereby increasing kerbside bus loading capacity. Buses are removed from other traffic flows and are not affected by peak hour queues at signalised intersections. The lanes provide a high degree of bus service reliability, and identity, and they are “self enforcing” since the presence of violators is easily detected.

Contra-flow lanes may be provided in the next lane from the kerb, allowing delivery and service vehicles to use the kerb lane. This improves their ability to provide access to adjacent properties and improves pedestrian safety, but it requires an extra lane of road space. Such a treatment was installed on Sansome Street in downtown San Francisco in 1997.

Bus Streets

Bus streets can provide cost-effective downtown distribution for both buses by fully separating bus and car traffic. They may be warranted where high bus volumes traverse narrow streets or as part of downtown revitalisation proposals. They may include the last block of an arterial street, a dead-end street at the end of several bus routes; a “bus loop” necessary to change directions at major bus terminals; downtown US malls; and bus circulation through auto-free bus zones. Existing bus streets in North America include 16th Street Bus Mall in Denver (see case study below), 5th and 6th Street Bus Malls in Portland, Nicollet Mall in Minneapolis, and Fulton Street Brooklyn.

Bus streets clearly identify transit routes, are easy to enforce; they increase walking space for pedestrians and waiting space at stops. But as their use by buses increases, they may become less attractive for pedestrians. Thus, they are a compromise between giving buses unhindered passage, and providing freedom of pedestrian movement.

It is recommended that bus streets incorporate kerb loading zones for off-peak service vehicles where the necessary service cannot be provided from intersecting streets or off-street. Where other options are not feasible, pickups and deliveries can be permitted on the bus streets when the bus traffic is low (i.e., night hours).

Access to parking garages may require car use for short discontinuous sections of street. Such an arrangement is incorporated in Portland Oregon’s dual-lanes one-way 5th and 6th Avenue bus streets; cars must turn off at the first cross street after leaving the parking garage.

When there are more than 50 buses per hour, it is desirable to provide passing opportunities at stops. In cases of very heavy bus volumes, (e.g. over 90 buses per hour), dual lanes may be desirable in each direction. Specific designs can include bus pull-outs, central medians at key points, widened foot paths, connections to other transit services and passenger amenities.

Median Arterial Busways

Median arterial busways are physically separated roadways that are located in the centre of wide two-way streets. Median arterial busways operate in New Orleans, Cleveland, Eugene, and Minneapolis in the US and in Richmond, British Columbia in Canada. Their development is the result of successful use in South American cities (e.g., Curitiba and Sao Paulo, Brazil; Bogota, Columbia and Quito, Equador).

The busways are completely segregated from general traffic, thereby eliminating the passenger loading, kerb access, and right turn problems associated with kerb lanes. They can provide a strong sense of permanency and obvious attractive stations.

In urban settings, most rights-of-way will require space-frugal designs. Where right turns are prohibited, the busway plus station envelope can be reduced from four to three lanes. This, however, requires offsetting the busway about 6 to 8 feet at stations.

4.5 Auckland Planning Framework and Practice

This section provides a short summary of relevant recent Auckland City planning relating to ‘urban environment and their relationship to public transport.

Passenger Transport Integration Study

The following represents direct extracts from Phase 3 of the study or summarises key points.

Background

Significant growth is forecast for the Auckland CBD with an expectation that there will be 105,000 more jobs and 29,000 more residents in 2041 than there were in 2006.

With only limited capacity to provide for the increased number of daily journeys into the city via car or ferry, trains and buses will need to carry most of the additional journeys to and from the CBD.

The Passenger Transport Integration Study (PTIS) 2010 for Auckland City Council is a plan to accommodate bus services in the CBD as an integral part of the high quality multi-modal passenger transport system. The PTIS assumes a CBD Rail Loop will be built.

The study was deemed necessary to provide future direction for supporting Auckland’s development and growth as a world class city. Specifically, the study looks as the options to integrate multi-modal passenger transport improvements with the public realm to enhance the quality of the urban environment.

The study identifies bus volumes to 2041 and identifies routes and infrastructure to support these volumes. Street function has been identified through other planning documents such as “CBD Streetscape Guidelines” and “Central Area Access Strategy”.

Debate

The PTIS recognises the impact of buses on the environment, safety and amenity. Issues on urban impact include:

- Bus layovers dominating footpaths;
- Exhaust and noise emissions from moving and stationary buses;
- Topography of CBD – its impact on bus emissions accelerating up hill;
- High volume of buses across CBD;
- Crowding at bus stops and bus stop location hindering pedestrian access; and
- Quality of bus stops in relation to urban streetscape.

Photo 4.1 Link buses - Auckland

Source: transportblog.co.nz

Approach

The PTIS recommends that the objectives for passenger transport improvements are to:

- Provide a high quality environment;
- Provide capacity and coverage to accommodate economic growth and provide greater transport choice;

- Simplify the system (infrastructure, routing, information);
- Use urban space efficiently;
- Ensure efficient operation of the passenger transport system (through improvements to journey time reliability);
- Better use existing transport capacity, networks and infrastructure; and
- Provide an integrated and convenient passenger transport service and system.

Method

Nominated Streets

Specific streets are nominated for designation for high quality passenger transport priority based on Council's CBD Streetscape Guidelines. These guidelines provide for a hierarchy or classification of streets depending on intended usage, i.e. from being pedestrian focused or being vehicle focused with gradients in-between

Consolidated stop use.

High dwell times reduce the optimum use of stops and contribute to kerb space being overly dominated by buses and affecting general street amenity. Using stops more efficiently can reduce this.

Stops are widely distributed across streets in the CBD. Consolidated stops are required to provide greater capacity, improve operation and stop legibility. Concentrating stop infrastructure in fewer locations can limit the widespread impacts on the pedestrian environment, improve safety and security, and provides the opportunity for improved physical and visual integration with the public realm.

Reduce reliance on on-street layovers within the CBD

Improve pedestrian amenity whilst providing conveniently located layover facilities necessary to provide efficient bus operations.

The streets in the CBD are used by buses for layover. To assist with Council's objective to provide a high quality street environment, there is a need to reduce the reliance on on-street layovers within the CBD especially on sensitive frontages (such as high pedestrian activity areas). This will help to reduce the negative amenity impacts of buses at the kerb and in high pedestrian activity areas.

High quality higher capacity passenger transport vehicles.

Improving the quality of the fleet, and in particular buses, can improve both the on-board comfort of passengers and minimise the impact of bus emissions (noise and air) on pedestrians.

Passenger transport infrastructure design

A passenger transport system with infrastructure and facilities that are safe, convenient and attractive, can encourage greater use of passenger transport and contribute to enhancing the quality of the urban streetscape environment.

Example – Wellesley Street

- Provide two priority lanes for passenger transport in both directions (therefore four in total) between the two Mayoral Drive junctions;
- Reduce/remove general car traffic;
- Consolidate stops at key activity nodes integrated with stops in the centre of the street and wider footpaths; and
- Incorporate design around the shared space on Elliot Street.

Public Life Survey

The following represents direct extracts from, or summarises parts of, the Public Life Survey, July 2010, produced by Gehl Architects for Auckland City Council.

Background

In 2008, Jan Gehl, the world's leading expert in urban design, was commissioned by the Urban Design group at Auckland City Council to undertake the first ever Public Life Survey to assess the condition of public life in the Auckland City centre.

The survey was based on pedestrian surveys and observational research on how people interact and behave in public spaces.

Observations

The report notes that Auckland enjoys a well-developed network of bus routes covering most of the city centre and provides a much needed alternative to the use of private cars.

New buses and more frequent bus services have increased the number of bus commuters but not enough to outweigh the vast percentage who commute by car. Also, this extensive service means that many streets are used for bus transport producing a negative impact on the street environment with noise and pollution.

The survey notes that bus stops create a feeling of congestion on the footpath in many locations, for example Victoria Street. They also express concern that the current situation regarding bus layovers in the city centre severely downgrades the streetscapes and creates unsafe situations for pedestrians.

Gehl observes that the present dominance of buses in the city centre causes a need for more options and a more environmentally sustainable surface system to accommodate the demands of a 21st century public transport system.

Conclusion and Recommendations

Gehl concluded that Auckland City Council's focus on urban design had produced streetscape upgrades of international standard where the needs of people had been given priority over cars.

The report recommends Auckland looks to its CBD to become a traffic calmed city centre with a new set of street typologies identifying a hierarchy of pedestrian and vehicular priorities to underline legibility and orientation by different identities, characters and use of the streets.

They recommend practices to reduce car dominance and create a better traffic balance step by step by means of new street layout and street use aiming to invite people to walk, bike and use public transport.

- Think in terms of 'people' instead of 'vehicular capacity' and put people first in the planning process;
- Ensure that streets are not only for transport, but also for a wide range of more recreational activities as well as forming social meeting places; and
- Pedestrian priority should be introduced in various ways thus emphasised and made visible.

Specifically for bus transport:

- Provide dedicated bus lanes to improve efficiency and reliability of public transit service;
- Park and ride facilities should be established at strategic locations outside the city centre to relieve the current traffic pressure from private cars, and to motivate more people to use public transport to get to the city centre; and
- Investigate placement of new layover terminus outside the city centre to avoid bus layovers in the centre.

4.6 Other NZ Cities

Auckland is not the only city in New Zealand giving thought to the perceived impact of buses on their urban environment.

Manners Mall - Wellington City

Background

Wellington City Council is opening Manners Mall to buses and creating a new shared space in lower Cuba Street.

The changes are designed to:

- Improve bus services (by removing a bus diversion imposed by Manners Mall being pedestrian-only);
- Create new public spaces; and
- Provide clearer pedestrian links with Civic Square and the waterfront.

The new two-way bus-only roadway will enable buses to travel in both directions from the railway station to Courtenay Place through Lambton Quay and Willis and Manners streets.

Photo 4.2 Manners Mall to bus lane conversion

Debate

The arguments against the Council's plan centred on 3 main fronts: the loss of public space, a loss of public transport efficiency, and the cost to the ratepayer.

The main credible concern was with the apparent reduction in public space. However, the reduction in traffic on other streets provided an opportunity to improve pedestrian connections and as such was viewed as neutral change.

Manners Mall was considered tired, a 'hang out' for groups who often caused trouble and somewhat of a 'problem area.'

Photo 4.3 Buses on Lambton Quay

In addition to debate on Manners Mall the presence of buses, and other vehicles, on Lambton Quay has been debated within the framework of local body elections. Property Developer Sir Bob Jones (who in August withdrew from the mayoral race) suggested earlier that Lambton Quay should be pedestrianised and all traffic (largely) should be redirected to other streets. Sir Bob went further to suggest that buses needn't access the CBD at all and should terminate at either end and people walk from there.

Colombo Street Christchurch

Colombo Street is Christchurch's main street and an important bus corridor, carrying some 200 buses per hour in its busiest section. The bus function of Colombo Street has been controversial for more than 10 years and the establishment of the Bus Exchange in Lichfield Street (which in conjunction with one-way streets in the CBD increased bus flows in Colombo Street) created concerns from businesses over the loss of kerbside parking and complaints about the impacts on amenity of bus flows. These issues were highlighted in a Ministry for the Environment *Urban Design Case Study* -

(http://www.mfe.govt.nz/publications/urban/urban-design-case-studies-mar05/html/page10.html).

Christchurch City Council has also implemented measures to restrict private vehicle access to Colombo Street (including a "bus gate" in Cathedral Square) to deter private through traffic and so-called "boy racers" while supporting its use as a bus corridor. Bus priority measures on approach corridors (including Colombo Street south) have been implemented under a citywide bus priority scheme with the catchphrase “everybody wins when the bus comes first” – however, bus lanes have not been implemented within the CBD core.

The Bus Exchange which includes on-street bus stops in Colombo Street, is considered a success by Council, with substantial growth in bus patronage contributing to sustainable transport outcomes of the City.

While Council’s plans for a new Transport Interchange should reduce bus flows in Colombo Street; and longer-term plans include potential light rail replacing buses on major corridors, there is expected to be ongoing friction regarding buses in the city for some time to come. The problem is essentially the conflict between the main street as a destination and a transit corridor. With a bus-based public transport network, Christchurch has few alternative CBD bus streets which would provide comparable servicing of the CBD core. One of the successes identified in Christchurch’s transport system has been better servicing of passenger destinations in the CBD by through-running of buses – relocating buses to other streets would be likely to erode these improvements.

Recent establishment of a shopfront bus passenger lounge at a major Colombo Street bus stop has relieved footpath congestion caused by waiting passengers and approaches such as this may help to address perceived environmental capacity problems.

Photo 4.4 Buses on Colombo Street outside Bus Xchange

4.7 Australian Planning and Practice

A review of Australian practice and strategy has identified similar issues to that being considered in Auckland.

Adelaide – Currie Grenfell Streets Corridor

Adelaide operates a mechanically guided busway (O-Bahn) on an elevated transit structure. The 7.4 mile busway carries more than 20,000 daily riders on a high speed, express service to and from the urban core. Within the core, the Currie Greenfell Streets corridor receives and generates much of the bus traffic associated with the O-Bahn (fixed guideway) as well as other regional bus routes.

The South Australia Department of Transport Energy and Infrastructure (DTEI) and the City of Adelaide are currently investigating improvements to the Currie Grenfell Street Corridor in the CBD. In 2006, the corridor experienced a 2 hour peak of 232 buses per hour in the AM with a peak hour of 190 buses. The 2 hour peak is expected to grow to 308 buses in 2021.

The corridor is currently comprised of three general traffic lanes in each direction with kerbside bus stops. The proposed improvements include 1 kerbside bus lane, 1 inside through bus lane and 1 median general bus lane in each direction. In a limited number of locations, general traffic will be allowed to travel in the kerbside lane to access and egress car parks. Signals are optimised along the corridor to accommodate the balanced bus flows in both directions as well as tram crossing at the King William Street intersection.

Sydney CBD Streets

While Sydney has an extensive underground rail network serving the CBD, it still has some 192 bus routes terminating in, or operating through the CBD, making use of three main bus corridors:

- George Street;
- Elizabeth Street; and
- Castlereagh Street

Sydney's heavy rail network services most of the surrounding greater Sydney metropolitan area, with the exception of the northern peninsula and parts of the south-eastern suburbs; and this is reflected in the distribution of bus routes to the CBD, with some 93 routes serving the northern suburbs (and carrying some 17,300 bus passengers into the CBD in the peak 2 hours in 370 buses) and 47 routes from the east, carrying some 17,000 people in the peak 2 hours.

Sydney's main street – George Street - carries more than 300 buses in one direction in the peak 2-hour period and other CBD streets carry between 197 and 300 buses in the peak 2 hour periods.

See bus flows at peak time in Sydney CBD in **Appendix C.**

One of the most significant problems for Sydney buses is the management of bus flows approaching the CBD from the north, across the Sydney Harbour Bridge. A lack of capacity in bus terminals and interchanges in the north of the CBD results in long queues (more than 1,000m) during the morning peak period.

Photo 4.5 Buses on Sydney Harbour Bridge

At present, bus flows in Sydney CBD streets are managed by no more than on-street bus lanes, some of which operate 18 hours or 24-hours, but many of which operate only during peak hours.

Bus flows on north-south and east-west streets, as well as high pedestrian crossing demands (even with extensive below-ground pedestrian networks) rule out bus signal priority at intersections. A number of key CBD intersections also operate “scramble/barns dance” pedestrian phases. Bus flows of the scale currently operating in Sydney CBD result in periods with long bus queues and slow bus travel times.

With the widespread introduction of bus lanes in the CBD, kerbside parking is generally not available on the main bus streets and past footpath widening has improved footpath capacity (particularly in George Street) to the practical limit possible without further restrictions on traffic lanes.

Bus streets in the CBD do not have indented bus bays, so stopping buses can impede bus flows. There may be further scope for rationalisation of bus stops within the CBD, but it is unlikely that further reduction in the number of bus stops on key bus streets would substantially improve either bus flows or conditions for other CBD users.

The NSW Government has begun to introduce measures to speed bus passenger loading, including pre-pay only routes, where tickets are not sold on board – passengers must be in possession of one of the many pre-pay ticket products to board some bus routes; and areas of the CBD are designated as pre-pay only areas (with bus stops in the CBD core operating as pre-pay only for all routes).

Figure 4-6 Sydney CBD prepay zone

In the longer term, Sydney City Council and the NSW Government are examining the potential for reintroduction of surface light rail within the CBD, partly replacing some bus routes. However, since the cancelling of the NSW Government's Metro rail program, there are only limited plans for more underground rapid transit routes. While light rail in the CBD may offer some perceived amenity benefits, it has some practical constraints, including:

- A lack of capacity enhancement when compared with bus services – a surface light rail system (tramway) operating on CBD streets has little to differentiate it (in terms of operating speed and passenger capacity) from buses on the surface;

- Passenger resistance to transfer – if the CBD light rail does not replace buses across a wider route network, its introduction may result in a reduction of patronage. Public transport users are resistant to intermodal transfer, particularly close to their destination, so a scheme involving peripheral interchanges and termination of bus routes at the edges of the CBD may result in less public transport use overall; and

- Higher priority requirement – introduction of a fixed track mode on surface streets generally has a greater requirement for priority, with the effective loss of traffic lanes and parking. Safe passenger access to stops can also create design and management challenges; and light rail systems will often require greater constraints on private and service vehicle movements and parking.

Brisbane

Brisbane City Council has implemented an extensive busway system which includes bus tunnels with underground busway stations in the city centre, at King George Square and Queen Street. The bus tunnels were introduced to overcome surface capacity problems in the city centre and the South East Busway alone caters for some 200 buses per hour (see Figures below).

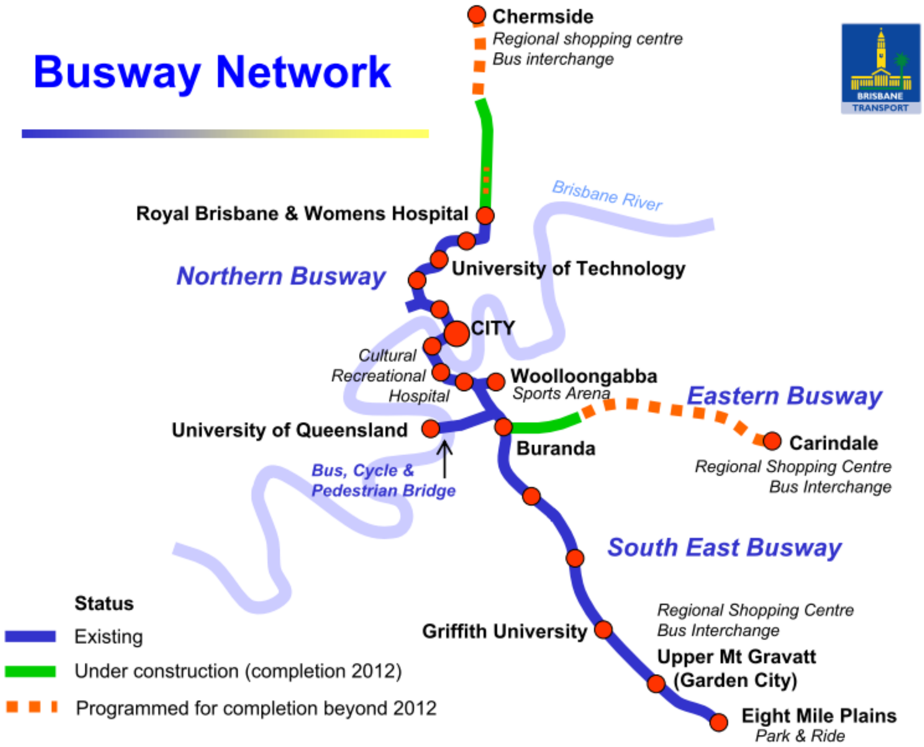


Figure 4-7 Brisbane Busway Plan

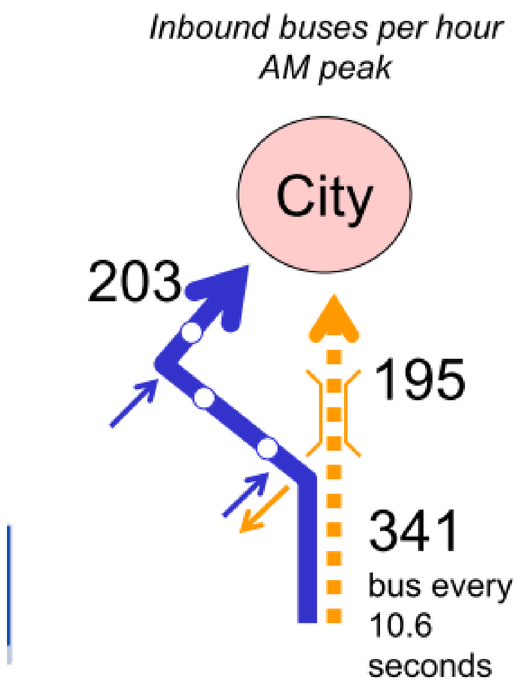


Figure 4-8 Brisbane Busway Peak Hourly Flows

Source: Brisbane City.

Photo 4.6 Brisbane South East Busway Tunnel

The below-ground busway system has not eliminated surface bus movements - there are still extensive bus marshalling and passenger facilities on the surface such as Adelaide street.

However, reliability on major bus services heading north, east and south has significantly improved and good public space has been created such as the Queen Street Mall (under part of which lies the Queen Street bus station).

Photo 4.7 Queen Street Mall, Brisbane *(source: Wikimedia)*

4.8 Other World City Planning and Practise

A desk top search of similar world cities was undertaken to undercover any similar issues, research, planning and best practise.

Oxford Street – London, UK

"The wall of slow-moving metal running along Oxford Street tarnishes what should be a world-class shopping experience." Victoria Borwick, London Assembly, on BBC News.

City of Westminster Council in London has been examining the perceived detrimental effects of 300 buses per hour on Oxford Street.

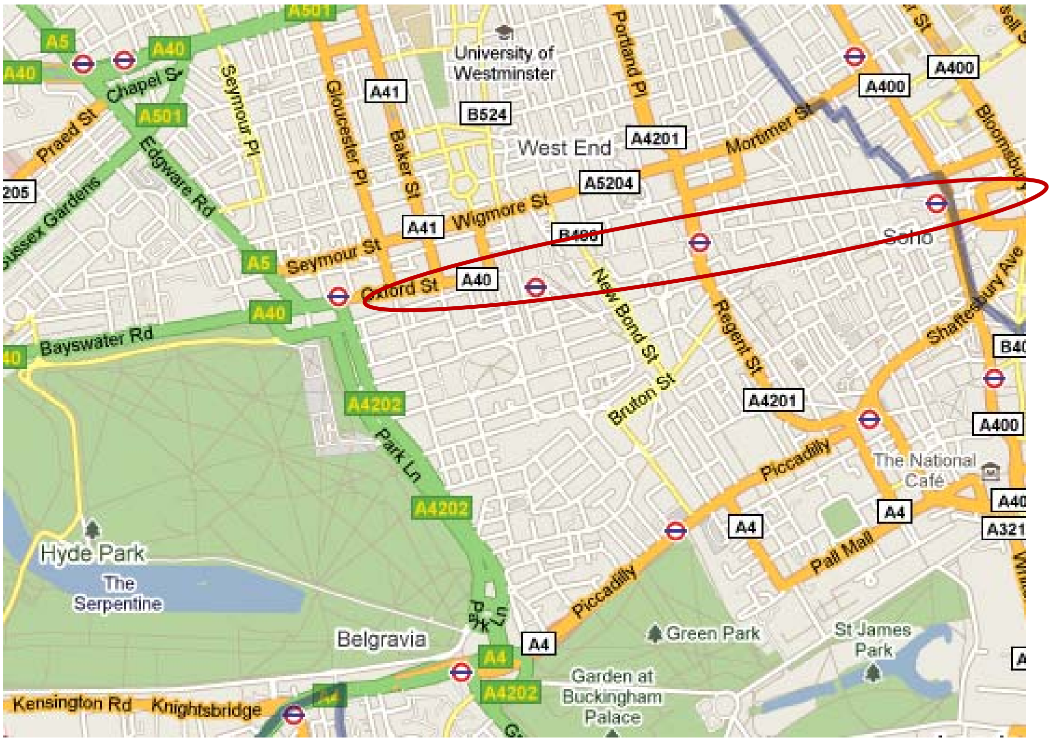


Figure 4-9 Oxford Street Bus Zone

Oxford Street, in London, UK is a large east/west corridor serving as an alternative to the A40/A501 or Piccadilly / Pall Mall and serves as a major bus corridor, including some locations where private vehicles are banned (except for access) and the road operates as a bus only street.

"Oxford Street suffers from its own success and feels crowded and at times uncomfortable. We are working with Transport for London and Westminster City Council to try to reduce the number of buses on the street, widen the pavements and improve the look of the street, especially at the eastern end. The extensive investment in the Crossrail station at Tottenham Court

Road should act as a catalyst to make this area more fitting as the eastern gateway to the West End".

Building a Living City, City of Westminster.

Photo 4.8 Buses on Oxford Street

Source: thelondondailynews.com.

However to put the above into context Oxford Street, Regent Street and Bond Street accommodate 1,200 bus movements per hour with 170,000 passengers getting on or off Buses on Oxford Street alone and 1.2 million passing through on a daily basis. Oxford Street is closed to private vehicles except for access and essentially "buses only" however Regent Street and Bond Street remain high volume roads, with associated bus lanes.

The volume of buses on Oxford Street has contributed to:

- A bus related accident every 3.4 days;
- A rise in serious injuries and deaths involving buses;
- Making Oxford Street one of London's most polluted corridors; and
- Forcing traffic to move at an average speed of 4mph.

Extract of Story from BBC NEWS:

http://news.bbc.co.uk/go/pr/fr/-/2/hi/uk_news/england/london/8497509.stm

Photo 4.9 New Oxford Street

Source: Wikimedia.

Baroness Valentine, chief executive of London First, said: "The West End should be a welcoming environment for visitors, not an open-air bus depot. By reducing the number on Oxford Street we can free up subsidy for less well-served areas at the same time as improving the pedestrian experience."

This study also notes commercial interests in reducing buses on Oxford Street. New West End Company, a retail group, want the mile and a half long shopping area pedestrianised.

Approach to solving problem

Transport for London (TFL) is look at rerouting buses, introducing shuttle buses and pedestrianising the street as possible long-term solutions with an aim to cut 20% of the bus traffic by 2011.

TFL will also look to reposition bus stops and bus stands, divert buses along roads adjacent to Oxford Street and introduce more "bendybuses" to reduce the number of buses (as bendy buses carry more passengers.)

Special Running Ways – Case Studies

Examples of special running ways in the US and Australia are provided below.

Denver – 16th Street Mall Shuttle

Currently, the shuttle operates with about 600 round trip loops per day. At peak operating times, it stops every 75 seconds with 48 buses per hour. During peak operating time, the operating plan can accommodate 4,300 passengers per hour. Current ridership estimates suggest typical daily patronage of approximately 50,000 passengers per day.

The RTD FasTracks program and associated construction of the Denver Union Station Multi-modal Transit Hub will require increases in capacity to the shuttle system. Based on the 2030 forecasts, it is anticipated that the DUS will accommodate approximately 103,000 passengers per day. Of this, 14,000 passengers are expected in each of the peak AM and PM hours. This will exceed the capacity of the current shuttle system.

The proposed changes to the Mall Shuttle operating plan include double-heading buses on every other 75 second cycle, which translates to an increase of the number of buses from 48 to 72 per hour. Given the fixed traffic signal timing plan of the downtown street grid, RTD does not believe increasing Mall Shuttle service beyond this proposed plan is feasible. The proposed plan will have a capacity of between 6,600 and 8,000 passengers in a peak hour.

Additionally, a downtown circulator has been proposed to parallel the Mall on 18th and 19th Streets to mitigate the heavy demand on the Mall Shuttle. The details have not been fully developed, however preliminary concepts include buses running every 150 seconds (or 24 buses per hour). If additional capacity is needed, the 15th and 17th street corridors have been identified as potential routes for modified or increased bus service to accommodate longer trips within the downtown.

Photo 4.10 Denver – 16th Street Mall

Source: Patsoll.com

Seattle Washington Metro Bus Tunnel

The 2.1 mile downtown bus tunnel opened in 1990 and could support 300 buses per hour. The average time savings for buses using the tunnel exceed 5 minutes per trip (2.5 minutes per mile) and removing buses from city streets has expedited general traffic flows.

Prior to the tunnel, bus routes mainly access the long narrow CBD on a relatively few number of north-south streets. The heavy bus volumes and frequent conflicts with general traffic led the city to build the tunnel and a 4 acre bus staging area in the CBD. It also required the introduction of a dual-powered (electric and diesel) buses to reduce noise and diesel fumes in the tunnel.

Initially, up to 70 buses per hour per direction operated. It had the potential to accommodate 165 buses per hour per direction, but the King County METRO believed that 125 buses per hour per direction provided optimal service. The tunnel was subsequently adapted to accommodate the joint operation of a light rail system as well.

Among the cited benefits of the tunnel include reduced passenger and vehicular accidents, decreased surface noise, odour and particulate pollution, enhanced aesthetics in the CBD and improved rider security. The tunnel concept has potential application in downtown areas where congestion is frequent, bus volumes are high and street space is limited and heavy rail service already exists.

Photo 4.11 Seattle Bus Tunnel

Source: orenstransitpage.com

Boston Silver Line

The Silver Line includes a combination of facilities to create a CBD-based BRT. The facilities include kerb bus lanes, inside bus lanes, a contra flow lane and a bus subway (as well as mixed flow). Using dual-mode buses (electric and diesel) articulated, multi-door vehicles, it links the CBD to the MBTA's Orange Subway Line to the south along Washington Street. The Dudley Square Station at the Orange Line is a major bus transfer point. The Silver Line is the only bus service that links Dudley Station to the CBD. The Silver Line also provides a BRT express service between the CBD and the Logan International Airport in the opposite direction. The estimated peak hour peak direction bus flow is approximately 75 buses per hour.

Established in 2002, the line functions as the City's 'fifth rapid transit' route. It involves extensive use of Intelligent Technology Systems to facilitate operations (e.g., traffic signal priority and computer aided dispatching) and provide passengers with real time information. It includes stylish shelters. The line is also noteworthy for the staged transformation of an existing bus line over a four year period.

The line was not created to relieve bus congestion in the CBD. Rather, it was a response to community concern when the elevated Orange Line (heavy rail) was removed from the Washington Street corridor. It is presented to highlight the integration of multiple techniques based on localized conditions along the corridor. By seeking to emulate the characteristics of a light rail system (to address community concerns), it has also catalysed real estate investment at or near station areas helping to revitalize neighbourhoods along the line.

LRT Conversions

In addition to the modification of the Seattle Bus Tunnel to accommodate LRT, transit systems are also considering LRT as an alternative to high volume bus corridors in CBDs. Two examples are provided below.

Ottawa Bus Way

Ottawa, Canada has one of North America's largest BRT networks. A series of transitways converge in the CBD, where buses operate in dedicated lanes along city centre streets. Built in the 1980s, the BRT is considered very successful in terms of patronage. In a city of 800,000, it serves 240,000 daily riders. Buses entering and exiting the city centre travel on single lanes along the same one-way pair of street. The lanes are also shared with turning general traffic. Approximately 100 buses per hour during peak periods are required to share the same stops along the corridor. Consequently, lengthy queuing of buses occurs creating a virtual wall of buses along city streets.

In 2008, the city released its long-term transit plan which recommended replacement of the bus system with rail transit lines extending through the CBD, including a LRT tunnel in a portion of the CBD. Other factors contributing to the decision to replace the BRT with LRT include long-term business enhancement, improved emissions, energy efficiency and more efficient use of labour. In 2009, the city announced its preferred alignment for the CBD bus tunnel and the first phase of the new LRT system. The system will be designed to accommodate 6 train car sets in anticipation of the networks current high ridership.

Perth - Alexander Drive/Fitzgerald Street

The Public Transport Authority (PTA) in Western Australia had investigated the feasibility of developing a BRT corridor as a radial spoke to the north of the CBD. The line is intended to relieve patronage pressure on the existing Northern Railway and to fill a coverage void in the central north portion of greater Perth. Demand forecasting indicated that up to approximately 90 buses would enter the CBD during the peak hour.

Due to geometric constraints along the four lane section of Fitzgerald Street, the PTA is now considering the feasibility of LRT. Fitzgerald Street is typical of a former 'electric trolley street' and lacks a verge to allow street widening. It is fronted by many vibrant small businesses and the footpath along these businesses extends to the kerb edge.

The agency estimates that 80-90 buses per hour is beyond the capacity of such streets to operate effectively. Of particular concern to the PTA is the bunching of buses in the core area due to lack of space for buses to pass stopped buses without having to enter the general traffic lane.

4.9 Buses in Urban Centres - Summary

Many cities struggle with managing buses on surface streets and environmental capacity problems, with severance, noise, air quality and pedestrian safety problems.

A range of solutions being considered include – replacement of buses in CBDs by underground rail and surface light rail; speeding passenger boarding such as through Prepay, reducing stops etc; bus tunnels to reduce surface bus flows.

Not all cities however want to reduce buses on their CBD streets – Christchurch and Wellington for example are increasing bus facilities and reducing access for other traffic.

Getting effective bus priority in the CBD is problematic – greater bus priority can increase perceived problems of access and amenity for other modes, and effective bus priority difficult to achieve anyway – crossing bus routes, high pedestrian demands at intersections and on footpaths (ruling out indented bus bays).

Buses are not just a problem – they are part of the solution and it is important not to reduce PT servicing of the CBD (which is a success factor for CBDs) in trying to solve a conflict between functions (destination and transport route).

Solutions should focus on identifying the actual problems (safety, air quality, noise) and trying to solve them – for example the Oxford Street "reduce buses by 20%" objective doesn't appear to be a valid solution - it's a number that just says "buses are a problem, if we reduce the number of buses we'll have less problem" – by keeping other vehicles out, widening footpaths to reduce conflicts, prepay to reduce boarding times and re-routing where it makes more sense. Bus servicing of the CBD is important, "don't throw the baby out with the bathwater!"

5.0 Comparison of Busway and Rail Systems

5.1 Introduction

The preceding sections of this report concluded that the North Shore busway would have sufficient capacity to cater for likely growth through to at least 2040 provided certain measures were implemented and improvements made to access routes into the City from the Northern Motorway.

In this section of the report, a comparison is made between busway and rail systems with respect to service attributes, corridor capacity, system attractiveness and transit mode share response. Consideration is also given to differences between the two types of systems with respect to CBD impacts and their role in shaping cities.

Comments in this section regarding rail are made on assumptions of a suburban or metro rail system (otherwise referred to as commuter or heavy rail systems). A comprehensive review of different rail types is not provided here, but it is assumed that rail in the North Shore would be either an electric suburban system, similar to that to be operating on the electrified lines in Auckland, or a metro rail system. Constructing a light rail system along the Northern Busway corridor would not deliver any benefits over the existing busway system and is not considered here.

Within this section of the report, reference is made to an indicative rail alignment for the North Shore shown below in Figure 5-1 – this is discussed in more detail in section 7.2 but it is important to note that this has been adopted for the purposes of this report only and does not reflect any detailed consideration of alternative alignments.

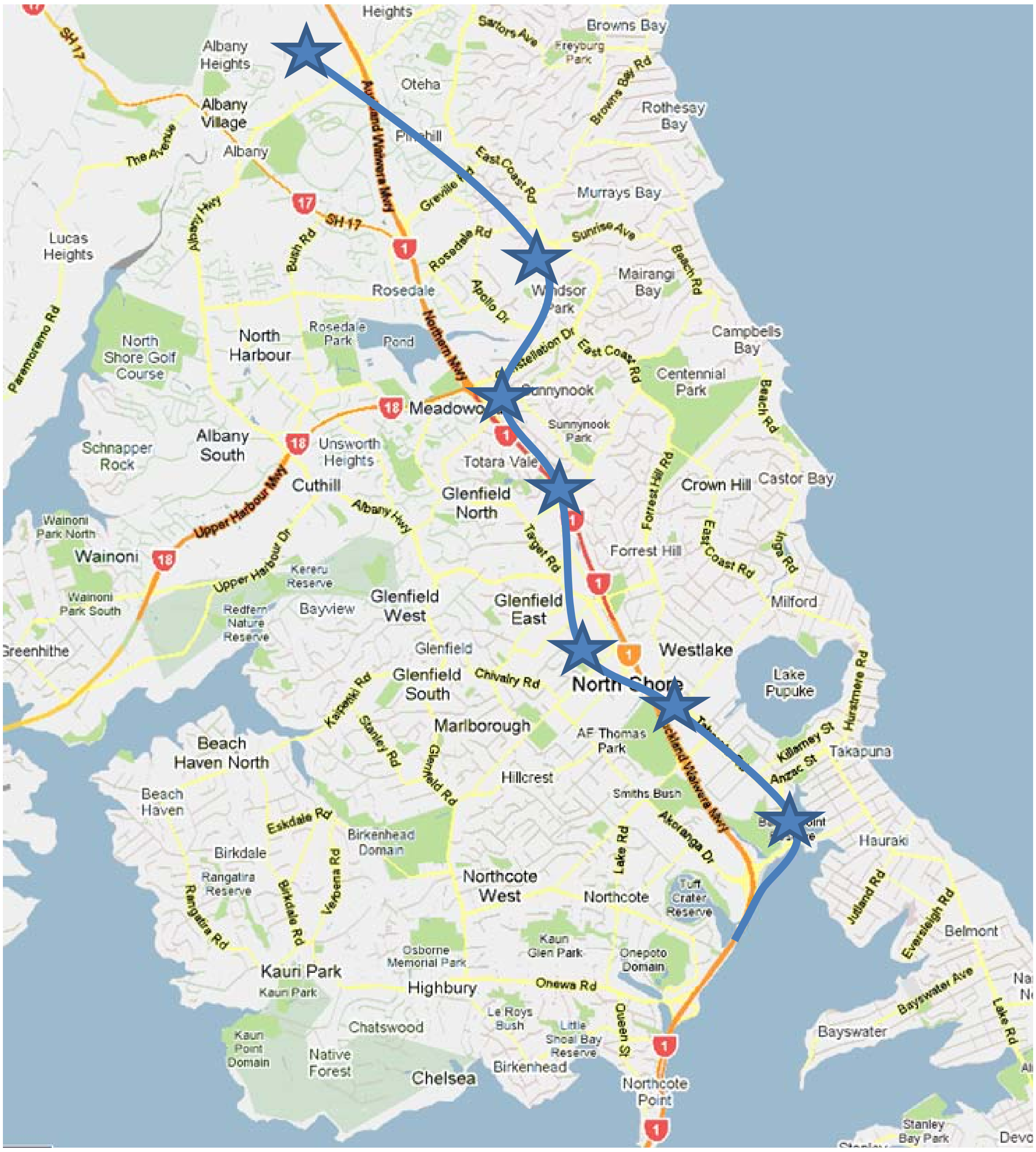


Figure 5-1 Indicative North Shore Rail Alignment

5.2 *Service Attributes and Corridor Capacity*

In comparing bus and rail based transport systems, the following service attributes are considered:

- Service speed;
- Service frequency;
- Service coverage; and
- Vehicle attributes – ride comfort, seating availability, others.

Service speed

Depending on horizontal and vertical alignment, trains are generally able to develop faster speeds that bus-based systems even on dedicated roadway. The Northern Busway has a speed limit of 80 km/h on the dedicated busway sections but attains slower speeds on shared lanes, surface street bus lanes and through bus stations.

Urban rail systems are able to achieve speeds up to 100 km/h depending on track curvature and gradients. The topography of the North Shore appears to have the potential for relatively unrestricted alignments and high speeds should be attainable. Metro systems, which use lighter rolling stock, are able to achieve high acceleration and deceleration rates – these are usually limited by rider comfort more than technological limits.

Average speeds for rail of at least 45 km/h, including stops, should be achievable on the alignment shown in Figure 5-1 above which would have few steep gradients and relatively long station spacing. The approximate length of this alignment is 15 kilometres giving a possible travel time from Albany to the CBD of about 20 minutes or even less. This compares a travel time on the Northern Express bus service from Albany to Britomart of 35 to 40 minutes.

Service Structure and Frequency

A major difference between busway and rail systems relates to service structure.

Busway Systems

The underlying principle of a busway corridor is that the busway itself forms a backbone for a network of bus services. The Northern Busway is a good example of how such a CBD-based system operates with a combination of trunk, feeder and cross-regional services. This is illustrated conceptually in Figure 5-2 below. Trunk and feeder services provide fast, direct access to the CBD. As the system develops there are opportunities to split services at the CBD end to provide more direct access to other destinations in the area. High underlying service frequencies ensure that interchange between services is quick and convenient.

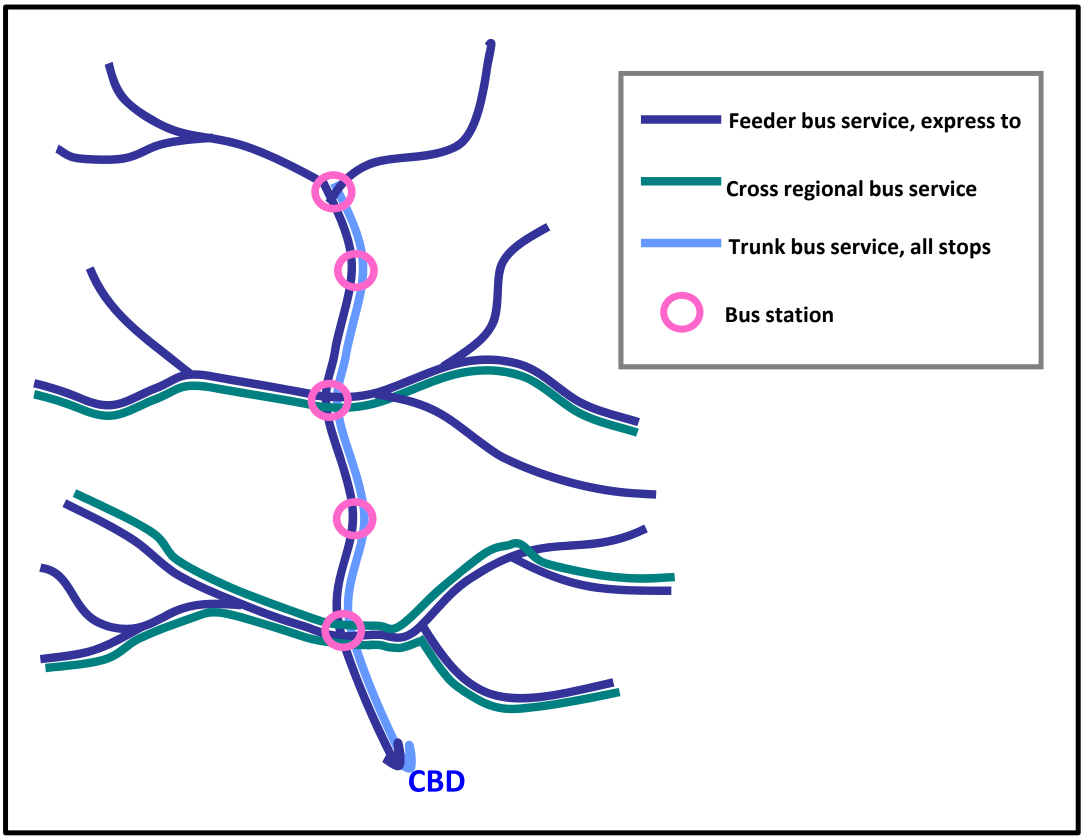


Figure 5-2 Busway Service Concept

Bus systems in general are able to support higher service frequencies than rail simply though smaller vehicles. Combining different trunk and feeder services generates increased frequencies along the corridor towards the CBD. There is a high degree of flexibility in combining services with different stopping patterns as buses are able to overtake each other through stations.

Rail Systems

In contrast to busway systems, rail systems have less flexible service structures and limited network coverage. A rail corridor can support a network of bus services, as shown in below, but people travelling from locations away from the rail corridor are required to transfer between bus and rail. That is, the integrated network is a combination of cross-regional and feeder bus services and trunk rail services.

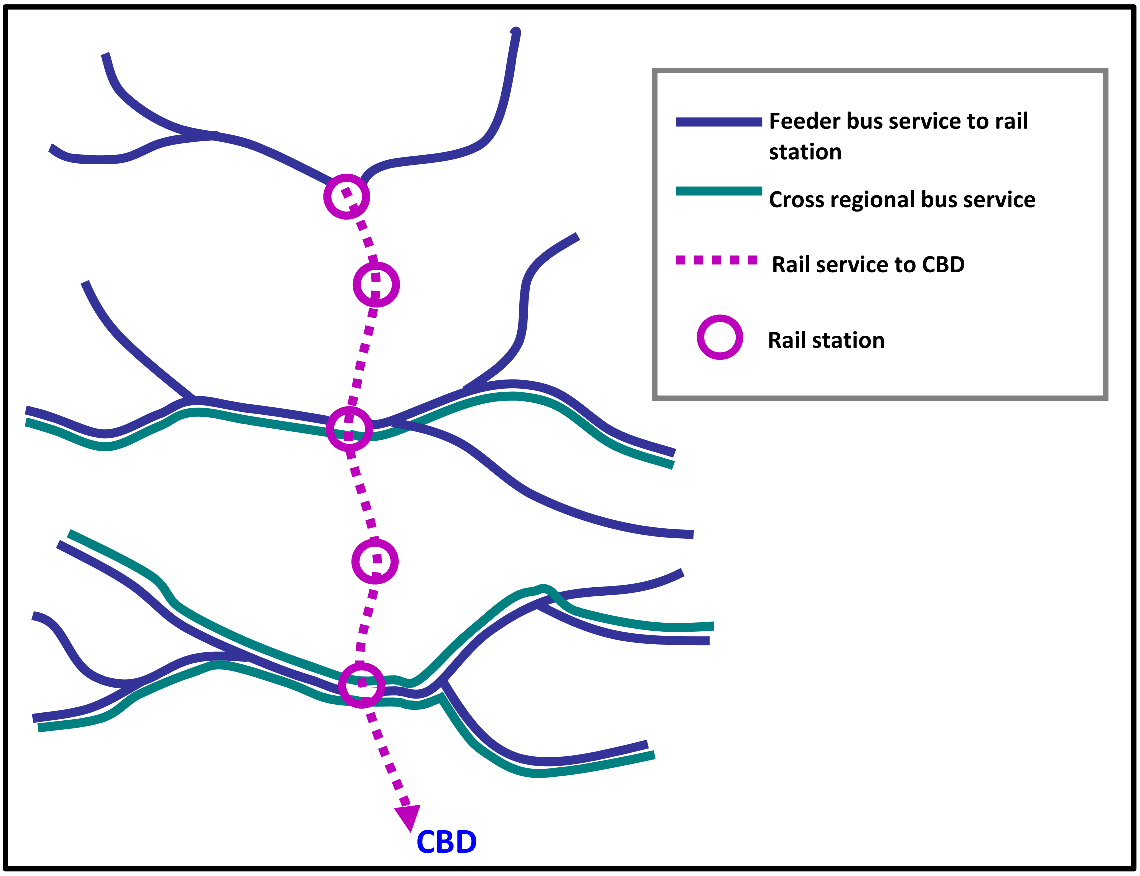


Figure 5-3 Rail Service Concept

There is less flexibility in combining services with different stopping patterns on a rail system depending on the number of tracks provided and service frequency. The Main West Line in Sydney has up to six rail tracks and has a complicated pattern of services combining express with all stops. More common are rail corridors with just two tracks. Under these circumstances, there is some opportunity to run express and all-stop services if the frequencies are no more than about 10 trains per hour.

Given the length of the indicative rail alignment shown earlier and the limited number of proposed stations, it would be expected that all services would run all stops between Albany and the CBD.

Vehicle Attributes

In terms of ride comfort, buses are more suited to shorter trips. Surveys of transit users consistently indicates an inherent preference for rail travel over bus, all other service attributes equal, particularly for longer distances. This relates to less tangible aspects of travel such as ride comfort and reliability.

There is some flexibility within rail systems in providing different types of trains. Suburban trains typically have more seating than metro trains which have a stronger focus on standing room and quick loading and unloading. As a suburban or regional rail line, the North Shore line would be relatively short at about 15 km to Albany. The maximum travel time of 20 minutes does lend itself to provision of metro-style trains with less seating than what might be provided for longer journeys. Train passengers would be prepared to stand for at least 10 minutes on a fast, high frequency rail service.

Capacity

There is considerable overlap between busway and rail systems with respect to passenger carrying capacity.

Busway System

Earlier work in this report recommended an ultimate design capacity of the Northern Busway corridor about 250 buses per hour able to carry about 12,500 passengers per hour based on average bus loading of 50 (allowing for some higher capacity, articulated buses). An uninterrupted section of busway has a capacity of at least 500 buses per hour based on an equivalent car carrying capacity of 1,800 vehicles per hour and a bus being equal to 3 passenger cars. As discussed earlier, busway systems will typically have their capacity determined by bus station operations and CBD circulation.

Rail System

The current program for electrification of the Auckland rail network includes acquisition of new electric rolling stock with a reported capacity of about 700 passengers per train, and a target of running 6 trains per hour on each of the Western, Eastern and Southern Lines. Under this scenario, the rail lines will be able to carry about 4,200 passengers per hour, much less than the capacity of the Northern Busway. Even at its ultimate capacity of about 20 trains per hour, the current rolling stock would deliver no more than about 14,000 passengers per hour. Suburban rail systems with longer trains could achieve capacities of over 20,000 passengers per hour. The CityRail network in Sydney currently operates up to 18 trains per hour using 8-car double deck rolling stock with about 900 seats per train and a nominal crush capacity of about 140 % of seated capacity. This gives a maximum capacity of about 22,700 passengers per hour.

Suburban rail system capacity is usually limited by seating configuration and boarding and alighting times at stations. Trains with a higher number of seats have less door width per train length and resulting higher boarding and alighting times. This limits the number of trains per hour that can be operated on a line before reliability is impacted. A maximum of 20 trains per hour is commonly used for such train types.

Metro rail systems are capable of higher capacity than suburban systems through two aspects - less seating and hence higher number of passengers per square metre; and more doors and hence shorter dwell times. Metro systems operating under Automatic Train Operation (ATO) are capable of operating up to 30 trains per hour.

TCRP Transit Capacity Manual

Figure 5-4 below is an excerpt from the *Transit Capacity and Quality of Service Manual - 2nd Edition, TCRP Report 100, 2003*. This shows modal capacity ranges based on US systems. There is a distinction drawn between “commuter rail” and “heavy rail” with definitions of the two modes provided below the figure. In this report commuter rail is referred to as suburban rail, while heavy rail is referred to as metro systems.

The figure shows that there is considerable overlap between busway and commuter rail, whereas heavy rail has capacities beyond the range of busway systems. The target passenger capacity adopted in this study, of about 12,500 passengers per hour, is at the high end of the range indicated in this figure. However, as described earlier in this report, there are examples in Australia of bus corridors achieving this capacity.

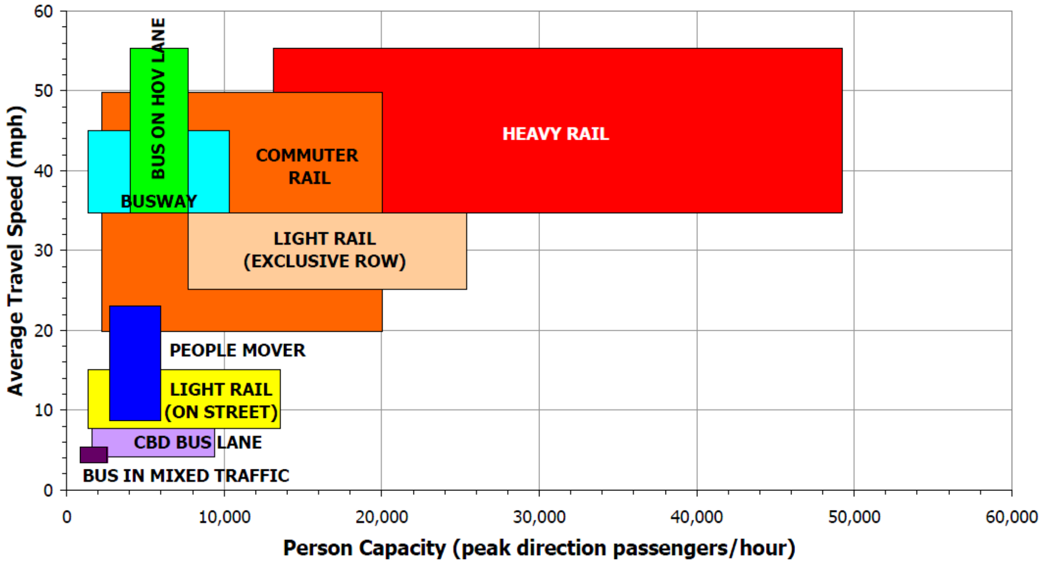


Figure 5-4 Comparison of modal capacities and average travel speed

Source: TCRP Transit Capacity Manual.

Commuter Rail - the portion of passenger railroad operations that carries passengers within urban areas, or between urban areas and their suburbs, but differs from rail rapid transit in that the passenger cars generally are heavier, the average trip lengths are usually longer, there are few standing passengers, and the operations are carried out over tracks that are part of the railroad system in the area. In some areas it is called regional rail.

Heavy Rail - a transit system using trains of high-performance, electrically powered rail cars operating in exclusive rights-of-way, usually without grade crossings, with high platform stations. The tracks may be in underground tunnels, on elevated structures, in open cuts, at surface level, or any combination thereof. Some local terms used are elevated, the el, the “L,” the rapid, the subway, metro, (for metropolitan railway), or underground (British).

5.3 System Attractiveness and Transit Mode Share

Overview

Rail systems are most attractive to people that are within walking distance at the start and end of their trip – typically within 1 km of a station. For people living outside a rail station walk catchment, busway systems may provide a better level of service by way of a door-to-door service of reasonable frequency compared with a journey that requires an access, rail and possibly an egress component.

For regular commuters travelling to a CBD, for example, rail systems will generally provide a better level of service to a busway over longer distances – say more than 5 – 10 km from the CBD. For shorter distances, any travel time saving offered by rail is offset by a forced bus-rail transfer - which is usually valued at about 10 minute of equivalent in-vehicle time – as well as additional walk and waiting time.

The comparative attractiveness of busway and rail systems can be seen by examining current levels of transit usage in some existing cities as is done in the following sections that examine transit mode share in Sydney, Brisbane and Wellington.

Each of the figures in the following sections shows locations in each city where transit share for work trips originating in that area are above a certain level. Transit in this case refers to motorised transit – rail, bus and ferry. The following notes apply to the figures:

- The size of the circle is in proportion to the number of work trips originating in that location;
- The colour of the circle is blue if rail is the dominant transit mode; green for bus and pink for ferry; this applies to the primary mode of transit so that bus / rail trips are treated as rail trips; and
- Darker colours are used in locations with higher transit share.

All results are based on 2006 Census data.

Sydney

Figure 5-5 below shows locations in the Sydney region where transit share for work travel is above 50 %. High rail usage is concentrated around areas within 2 km of rail stations, particularly those where high frequency, direct services are available to the CBD. By contrast, bus-based areas with high transit levels are spread out over a wider area about corridors with high service frequency and express services to the City. Sydney's only busway systems are focussed on Parramatta CBD with lower overall transit usage and these corridors do not appear on the map.

Figure 5-6 below shows the relationship between rail mode share for work trips originating in a particular location and straight line distance to the nearest rail station. Locations with very high transit mode share are all within 1 km of the nearest rail station.

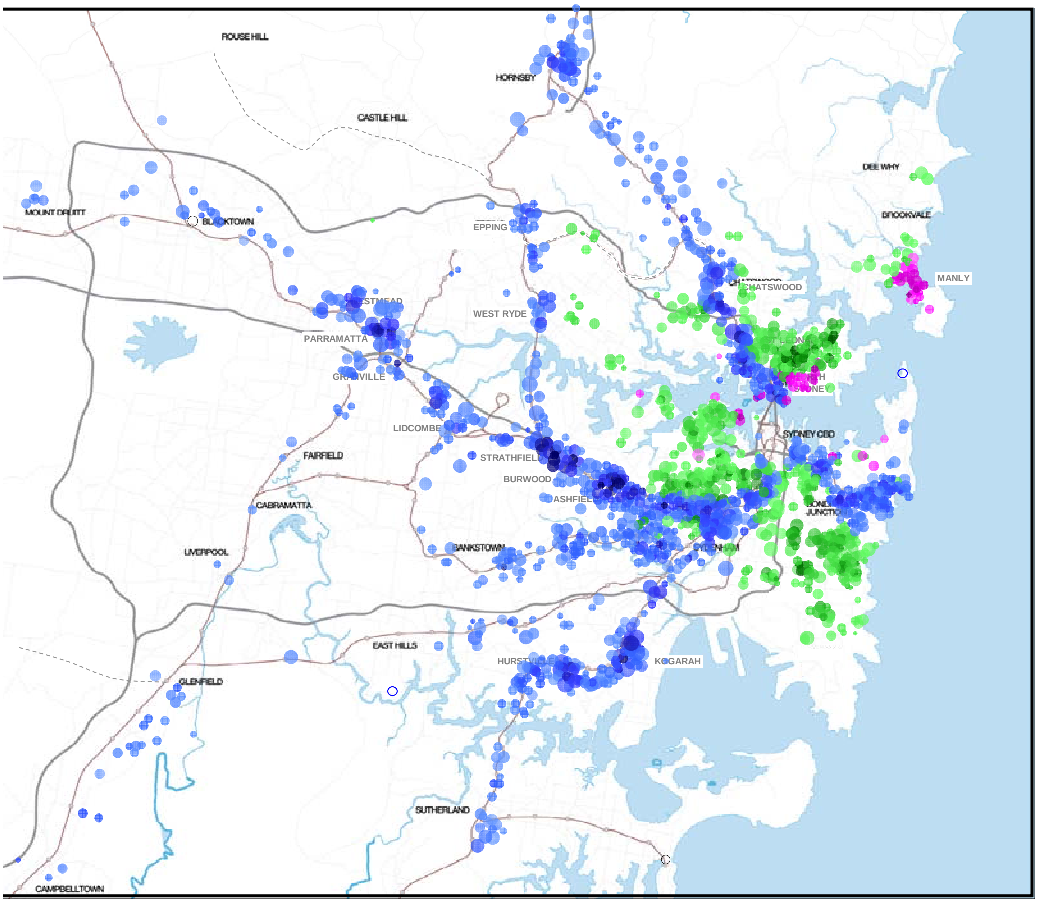


Figure 5-5 Sydney Public Transport Mode Share Map – Locations with 2006 Public Transport Share for Work Trips >50%

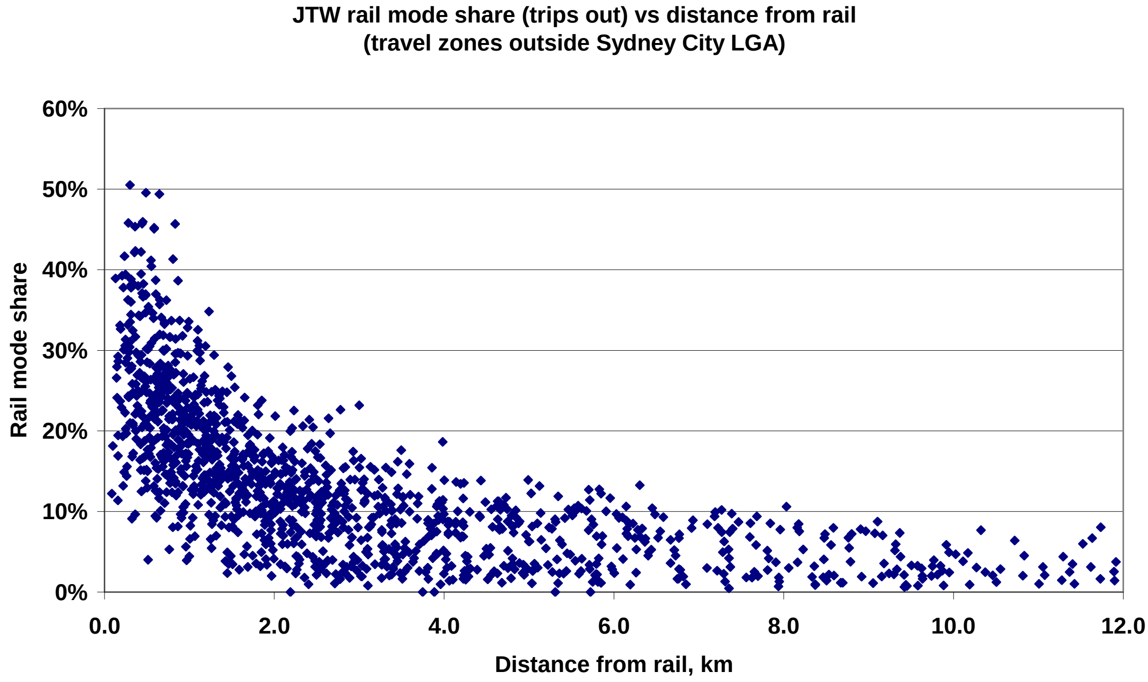


Figure 5-6 Relationship between rail mode share and distance to rail, Sydney 2006

Brisbane

In many respects Brisbane with its highly developed busway systems provides the best comparison of the relative attractiveness of busway and rail systems and their influence on transit mode share.

Figure 5-7 shows locations in Brisbane where transit share for work travel is above 20 %. The locations in Brisbane with high public transport share are an interesting combination of inner city, bus and ferry areas and outer city rail areas. The vast majority of locations with very high public transport share – over 40 % - are located close to rail stations on the Ipswich and North rail lines.

The South East Busway corridor, shown as the dotted red line, has no concentration of high transit share next to the busway itself but rather an even spread of moderate transit share across its catchment area.

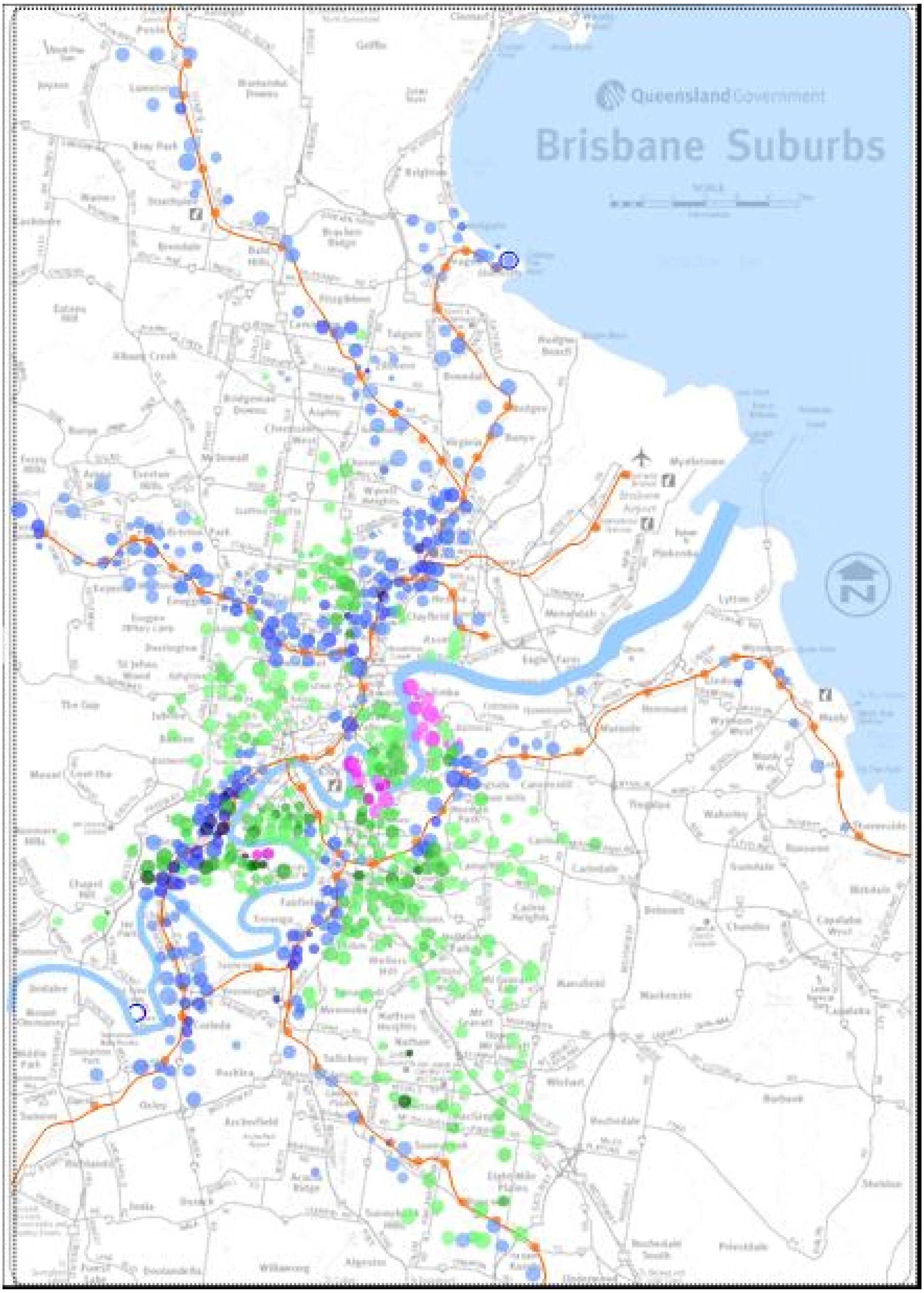


Figure 5-7 Brisbane public transport mode share map – locations with 2006 public transport share for work trips >20%

Wellington

Figure 5-8 to Figure 5-10 below show locations in Wellington where transit share for work travel is above 20 %. While Wellington does not have a busway system, it does have a network of express bus services operating to the CBD that provide reasonable travel times.

High rail usage is concentrated around the rail lines further than about 5 km from the CBD, while high bus-based transit usage is spread more evenly over a wider area, particularly close to the CBD. The concentration of high rail usage around Waterloo station on the Hutt Valley rail line provides a good example of the circumstances where rail competes most effectively against bus.

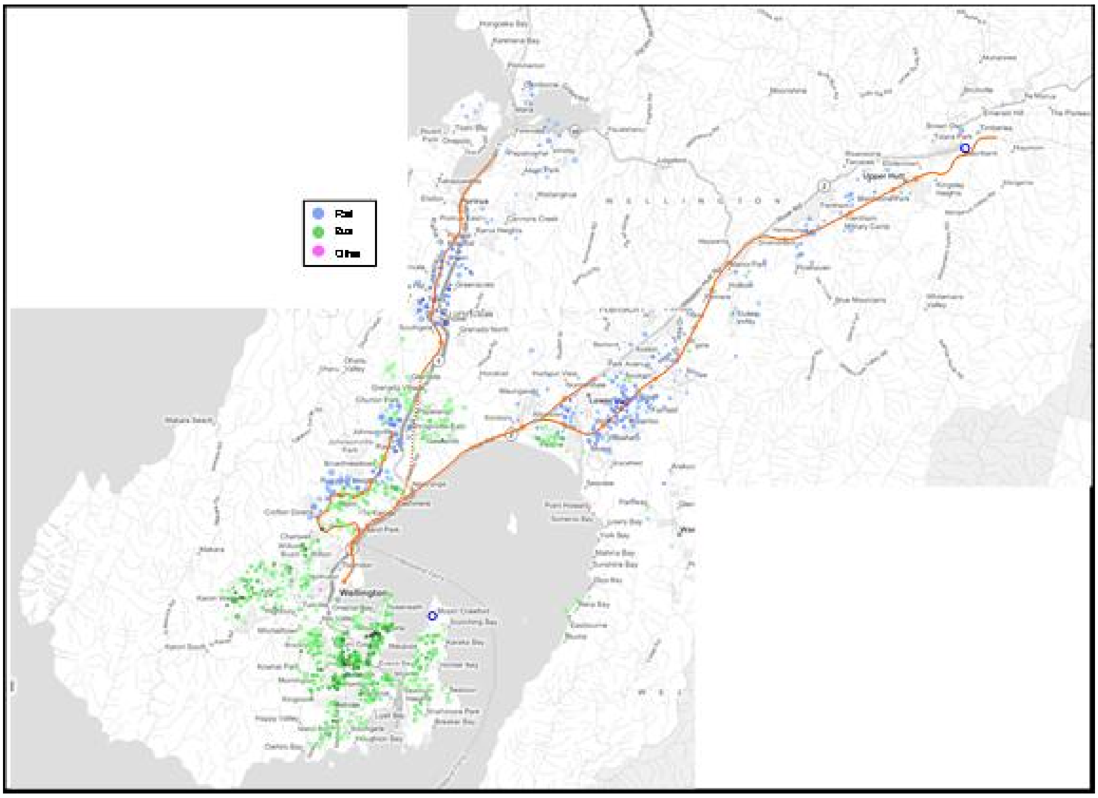


Figure 5-8 Wellington public transport mode share map – locations with 2006 public transport share >20%

Figure 5-9 Wellington public transport mode share map – Johnsonville rail line inset

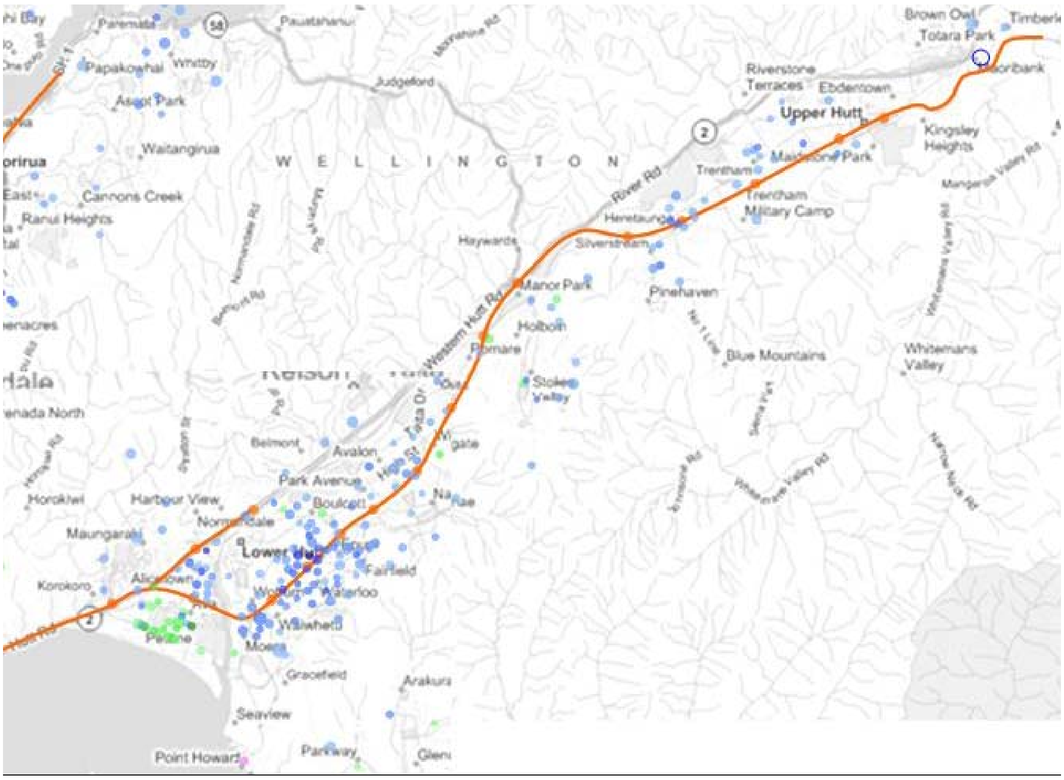


Figure 5-10 Wellington public transport mode share map – Hutt Valley inset

Summary

The preceding examples of transit mode share around bus and rail based systems demonstrates the following key aspects of the two systems:

- Surface street bus systems perform well in inner-city areas providing high frequency, short trips into a CBD;
- Rail systems perform well for locations further from the CBD – the highest concentration of rail users in cities with well developed rail networks are around stations about 10 km from the CBD from which high frequency express trains are available into the City; and
- Rail usage declines quite steeply outside the walk catchment of a rail station reflecting the additional cost of an access trip – bus or car.

For the above reasons, rail systems perform best in connecting areas of concentrated activity at a reasonable distance apart where a high proportion of rail users are within walking distance of rail stations.

5.4 CBD Issues

Bus-based systems have the advantage of being able to provide better coverage of a CBD through targeted circulation or through routes. For example, many of the existing services operating on the Northern Busway service both the Britomart and mid-City areas.

As CBD bus volumes increase, the circulation of buses through confined CBD streets can become a limiting factor as congestion increases and travel times decrease. Auckland is facing the same challenges as other cities such as Sydney and Brisbane in being able to accommodate strong growth in bus demand on increasingly congested surface streets.

The earlier sections of this report addressed this specific issue in relation to the Northern Busway and developed the idea of providing additional access to the CBD to take pressure away from the existing Fanshawe Street bus lanes.

The more significant solution to surface street problems is to build underground transit infrastructure. This can be done for either bus or rail based systems. Costs of providing underground bus tunnels and stations may be similar to, or higher, than that for rail systems. Bus tunnels may be larger in diameter and bus stations may be longer and wider than train stations.

5.5 Shaping Cities

There is a general consensus that rail systems have a stronger city shaping function than bus-based systems. In many cities in the region, higher density areas are located in close proximity to rail stations.

Figure 5-11 below shows the distribution of high density residential areas in the Sydney region – locations with greater than 70 persons per hectare (gross). Outside the inner city area, densities are high around parts of the rail network as well as around the old tram network in the Eastern Suburbs.

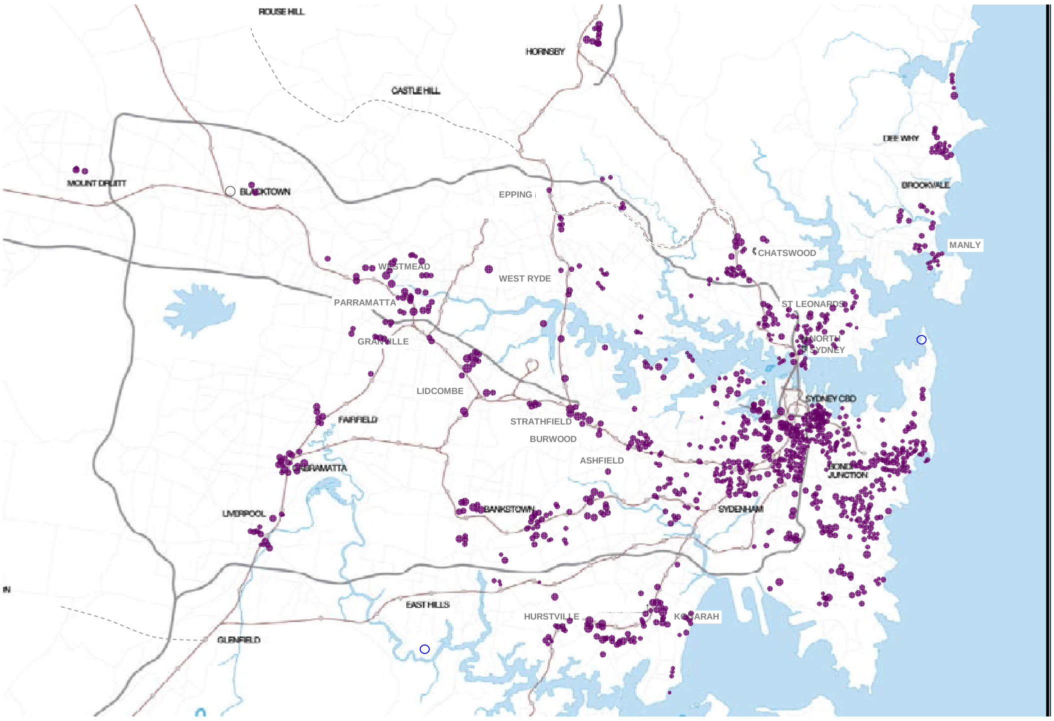


Figure 5-11 Locations in Sydney with population density greater than 70 persons/ha

Source: 2006 Census.

While Sydney shows a strong relationship between density and proximity to rail, particularly outside the inner city area, there are fewer examples in other cities. Figure 5-12 below shows locations in Brisbane where population density is greater than 35 persons per hectare – a lower level than that used in Figure 5-11 for Sydney. There are fewer examples in Brisbane of high density centres around rail stations particularly in the suburban areas.

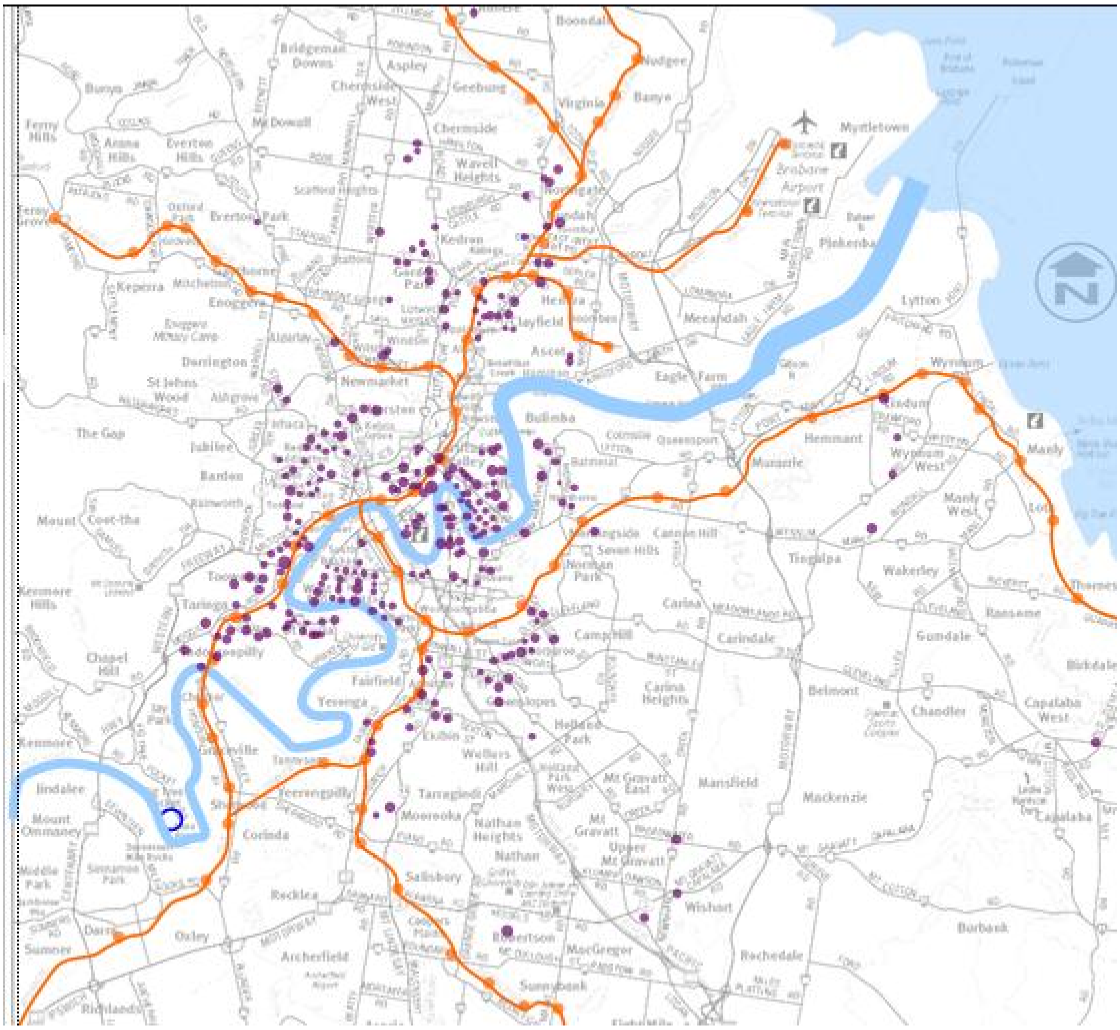


Figure 5-12 Locations in Brisbane with population density greater than 70 persons/ha

Source: 2006 Census.

Decisions regarding provision of rail in rapidly developing cities such as Auckland require a clear view of the long term benefits that rail delivers. Rail projects are difficult to justify based on conventional Australian and New Zealand economic evaluation methods that use short evaluation periods and high discount rates. Other countries, such as the UK, have recognised this limitation and adopt substantially longer evaluation periods and lower discount rates. These were adopted as an acknowledgement of the need to consider longer term benefits for projects with high initial capital expenditure.

6.0 Role of Rail in Auckland and the North Shore

6.1 Introduction

This section of the report discusses the concept of North Shore rail within the context of Auckland regional growth and rail network development applying principles established in the preceding section of this report.

The growth strategy for the Auckland region is used as a starting point as land use growth will be a key driver in transport system development.

A staged development of the Auckland regional transit network is then presented as the framework for understanding the role of North Shore rail.

6.2 Auckland growth

Regional Growth Strategy

The *Auckland Regional Growth Strategy: 2050 (1999)* outlines a vision for managing growth in the Auckland region through to 2050.

The Growth Concept within the RGS, shown in Figure 6-1 below, promotes "quality, compact urban environments". One of the central features of the Growth Concept is that" "most urban growth [will be] focused around town centres and major transport routes to create higher density communities, with a variety of housing, jobs, services, recreational and other activities (mixed use)"

Within the Growth Concept figure below, intensive centres and corridors are shown in yellow, existing business areas are shown in blue, and future urban areas (greenfield) are shown in pink.

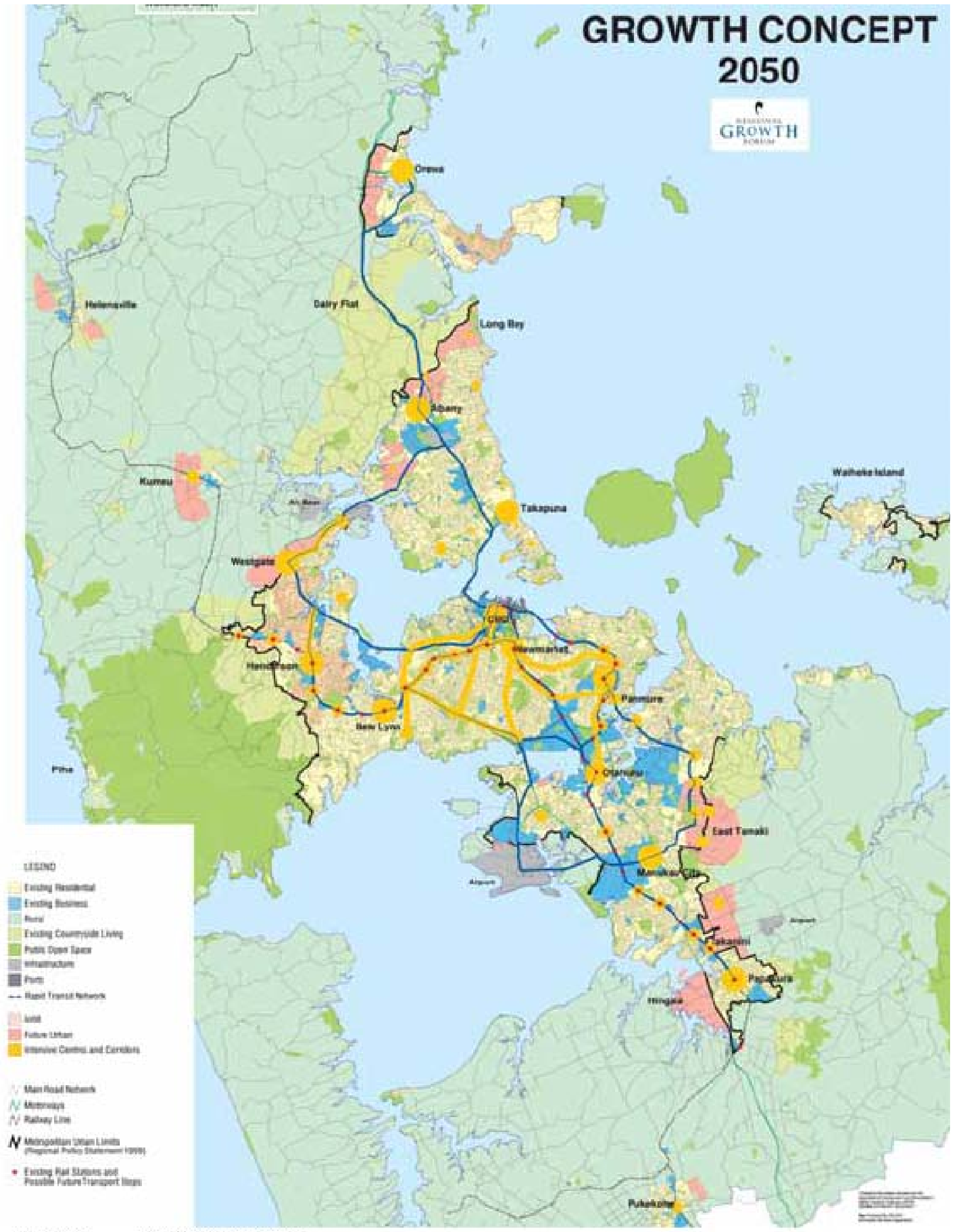
On the North Shore, Albany and Takapuna are shown as the subregional centres. Future urban areas are shown on the northern fringe of existing development, and existing business areas south of Albany and alongside the Northern Motorway are shown in blue.

The RGS outlines the following principles for growth in the North Sector (which includes the North Shore):

Population growth will be in four areas:

- Orewa (Hibiscus Coast);
- Albany greenfields including Greenhithe, Albany and Long Bay – accommodating up to 30,000 people;
- General infill;
- Rural towns;

- Concentrated growth in three sub-regional centres – Orewa, Albany and Takapuna; and
- Planned population growth from 233,000 (1996) to 440,000 (2050).



Map B.1: Growth Concept 2050

Figure 6-1 Auckland Regional Growth Concept

Source: Regional Growth Strategy, 1999

Density Supporting Transit

Section 5.5 earlier in this report discussed the role of density in supporting high transit use – it was particularly noted that rail systems are best suited to connecting centres with high activity density (population and employment).

Figure 6-2 provides a benchmarking of existing and future gross urban density in the Auckland region against international standards for sustainable transport *(Millennium Cities Database for Sustainable Transport compiled by Kenworthy and Laube, 2001, for the UITP in Brussels).* Auckland appears to have an underlying land use pattern of low density both existing and in the future.

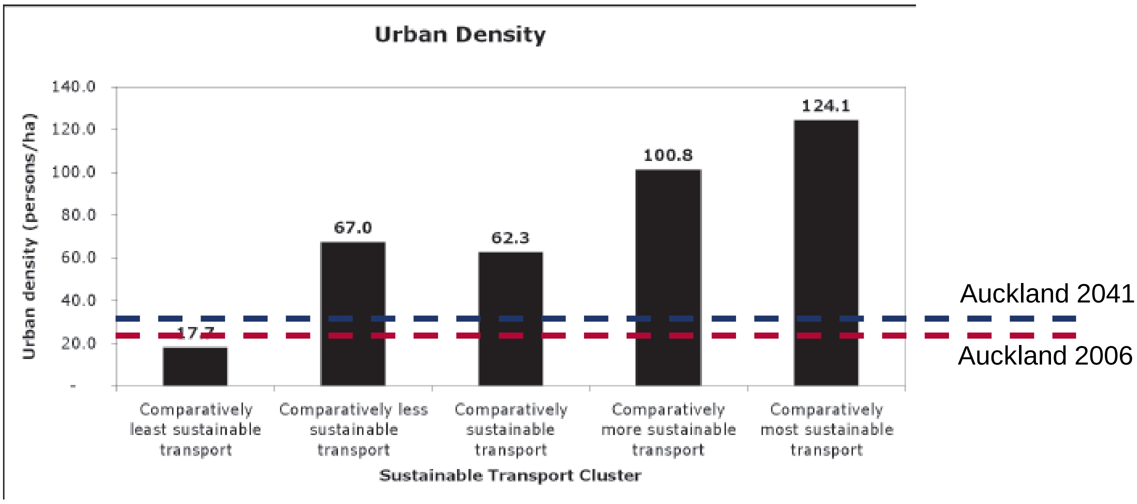


Figure 6-2 Benchmarking of Auckland gross urban density

Source: Auckland – a public transport intensive scenario for 2041, Strategic Network Option 3, PB 2009.

However, using gross urban density as a measure of transport sustainability can be misleading. Figure 6-3 below shows areas of Auckland (Census mesh blocks) with moderate density – typically 10 to 15 dwellings per hectare (measured against the gross mesh block area). This shows that there are many areas of Auckland, particularly on the Isthmus, that achieve densities sufficient to support quality transit. Within the North Shore, there are areas with good density away from the Northern Motorway corridor.

Figure 6-4 provides a comparison of the distribution of Auckland region population by density against other cities in Australia and New Zealand. The figure shows the percentage of regional population living in locations (Census mesh blocks) with a particular gross density. In general, Auckland has a good concentration of population living in areas between 35 and 40 persons per hectare – a density sufficient to support a quality transit network.

What is lacking in all of the benchmark cities in Figure 6-4, except Sydney, are a set of strong mixed-use centres with high densities of population and employment. Figure 6-4 shows that over 10 % of Sydney's population lives in areas with greater than 80 persons per hectare (Figure 5-5 earlier in this report shows the distribution of high population density areas in Sydney). In Auckland this figure is about 2 % most of which would be in the CBD.

The conclusion from this brief analysis is that the established areas of Auckland have population densities that support quality transit. However, the absence of large, higher density centres means that bus networks are likely to perform as well as rail in servicing the needs of these areas.

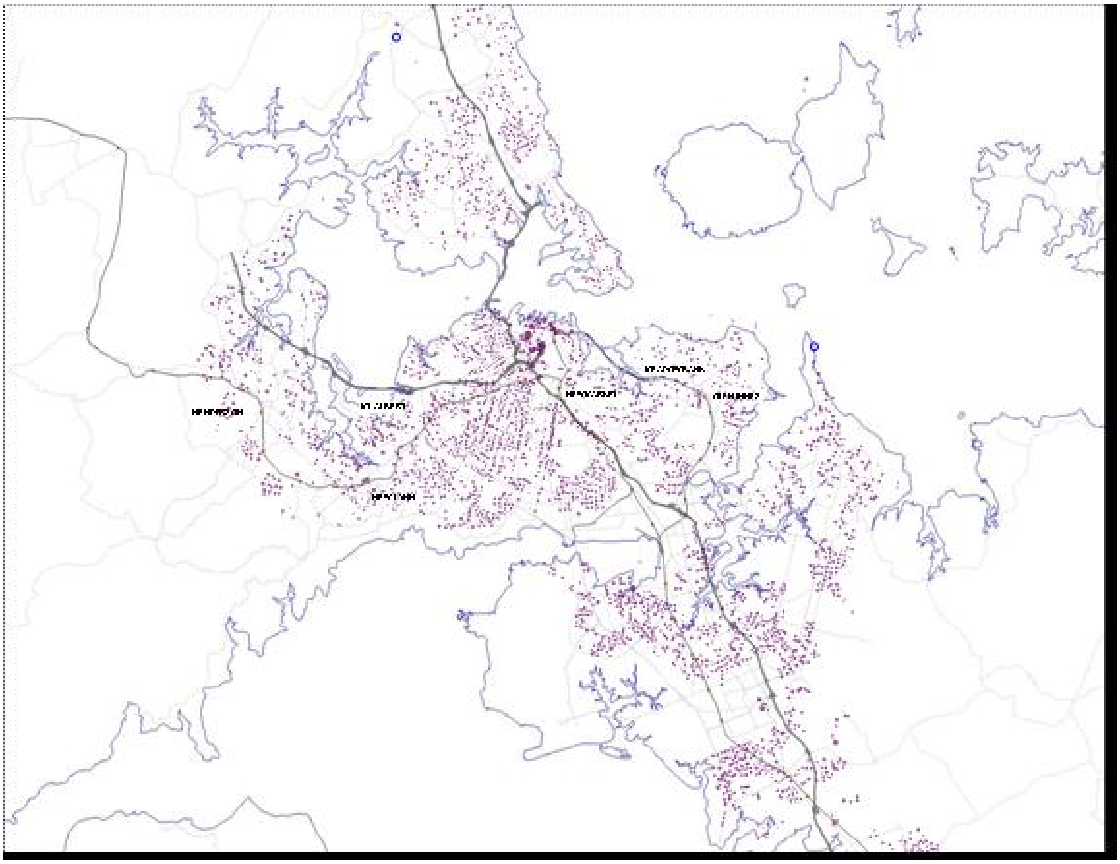


Figure 6-3 Locations in Auckland with density greater than 35 persons per hectare

Source: 2006 Census – Mesh block level gross density.

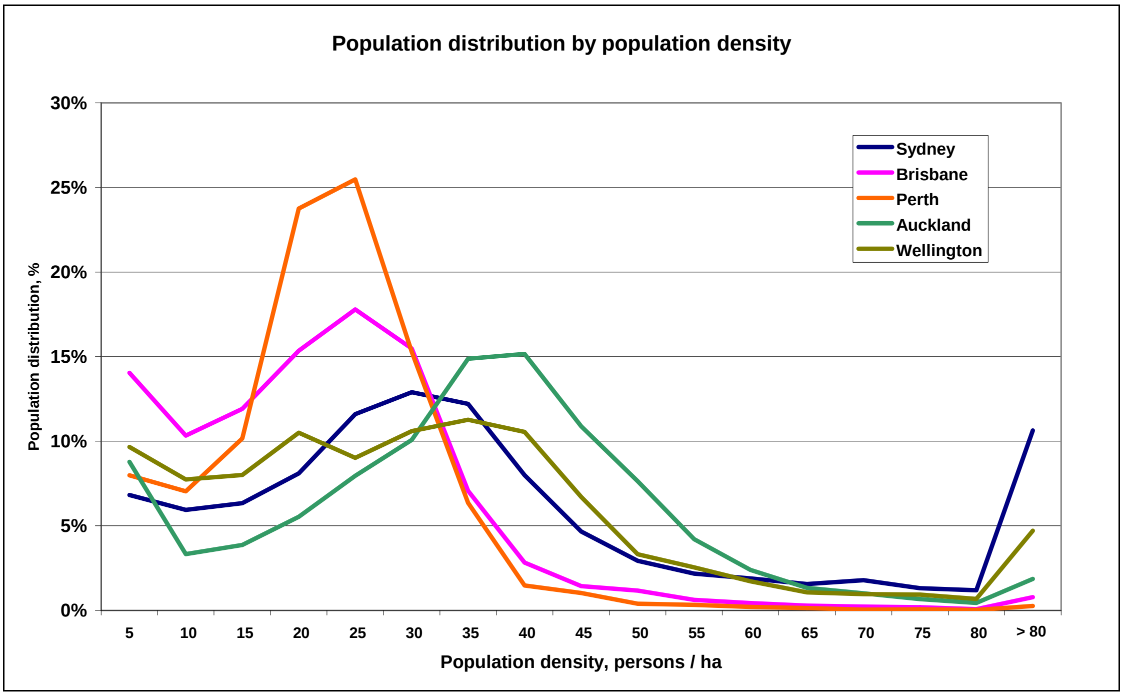


Figure 6-4 Distribution of population by density – comparison of ciites

Source: 2006 Australian and NZ Censuses.

The expected impact of the RGS on population and employment densities are shown in Figure 6-5 and Figure 6-6 below which compare densities between 2006 and 2041.

These figures indicate some strengthening in densities outside the CBD, particularly in locations on the North Shore such as Takapuna and Albany.

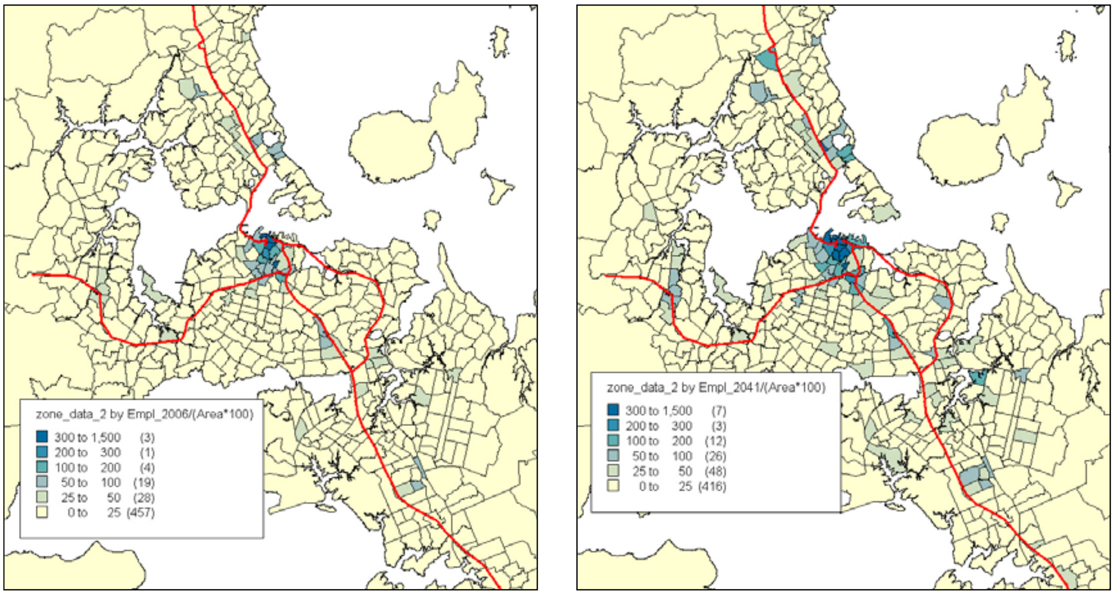


Figure 6-5 Forecast change in employment density 2006 to 2041

Source: Auckland – A public transport intensive scenario for 2041, Strategic Network Option 3, PB 2009.

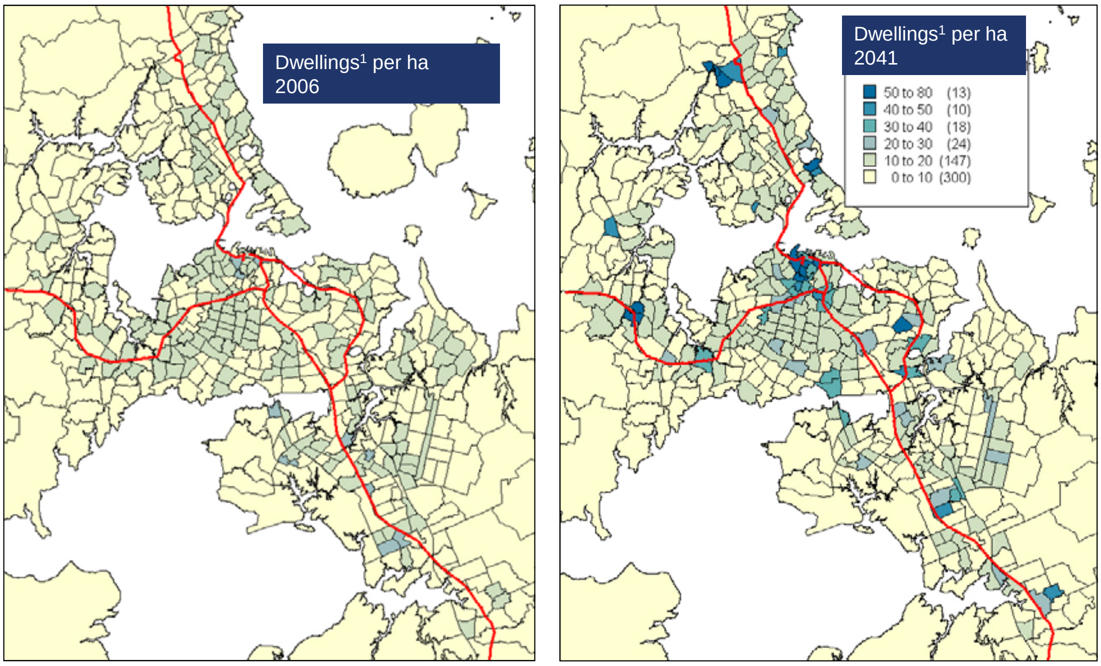


Figure 6-6 Forecast change in population density 2006 to 2041

Source: Auckland – A public transport intensive scenario for 2041, Strategic Network Option 3, PB 2009.

Table 6-1 below is an excerpt from the Auckland Regional Policy Statement *(Change 6 - Appeals Version - March 2010, Appendix H)* that outlines residential and employment densities within different types of centres and corridors that are deemed to support different levels of public transport provision.

A review of these densities *(Auckland Urban Density Study, Draft Report, August 2006)* noted that there are as least as many instances of reasonably high densities (above 40 dwellings per hectare) in suburban areas such as Albany as there are instances of high densities around rail stations. Only centres such as the CBD and Newmarket currently achieve residential densities approaching, or above, the 60 dwellings per hectare proposed for sub-regional centres.

By contrast, Auckland does appear to have subregional centres, such as Takapuna and Newmarket, with employment densities at the target level of 300 employees per hectare or higher.

Figure 6-5 and Figure 6-6 above indicate that both Takapuna and Albany are expected to have future densities at a level that supports rapid transit both with respect to population and employment.

Table 6-1 Proposed level of public transport provision

	PROPOSED LEVEL OF PUBLIC TRANSPORT PROVISION		
CENTRE TYPE	RAPID TRANSIT	QUALITY TRANSIT NETWORK	LOCAL CONNECTOR NETWORK
SUB REGIONAL CENTRE	*Residential Density (Gross)* 60 Dwellings Per Ha. *Employment Density (Gross)* 300 Employees Per Ha.	*Residential Density (Gross)* 40 Dwellings Per Ha. *Employment Density (Gross)* 200 Employees Per Ha.	NA NA
CORRIDOR	*Residential Density (Gross)* 40 Dwellings Per Ha. *Employment Density (Gross)* 200 Employees Per Ha.	*Residential Density (Gross)* 30 Dwellings Per Ha. *Employment Density (Gross)* 150 Employees Per Ha	NA NA
TOWN CENTRE	*Residential Density (Gross)* 40 Dwellings Per Ha. *Employment Density (Gross)* 200 Employees Per Ha	*Residential Density (Gross)* 30 Dwellings Per Ha. *Employment Density (Gross)* 150 Employees Per Ha	*Residential Density (Gross)* 20 Dwellings Per Ha. *Employment Density (Gross)* 50-100 Employees Per Ha

Source: RPS, 2010

Concentrated CBD employment

Another key driver of transit system growth is the concentration of employment in centres, particularly a strong CBD.

Figure 6.7 below provides a benchmark of the existing and forecast future percentage of Auckland regional employment based in the CBD against international standards (Millennium Cities Database for Sustainable Transport compiled by Kenworthy and Laube, 2001, for the UITP in Brussels). Auckland's forecast future concentration of CBD employment of around 20 % rates well against levels that support sustainable transport.

As for the comparison of gross population density earlier, the use of just CBD employment as a measure of supporting sustainability can be too simplistic. For example, Sydney achieves a very high level of transit usage for travel to work and yet only has about 12 % of employment in the CBD. Sydney's strength is that about 30 % of employment is located in centres served by the rail network across the entire region. The role of CBD and other centres-based employment in supporting transit system growth is discussed further in section on in this report.

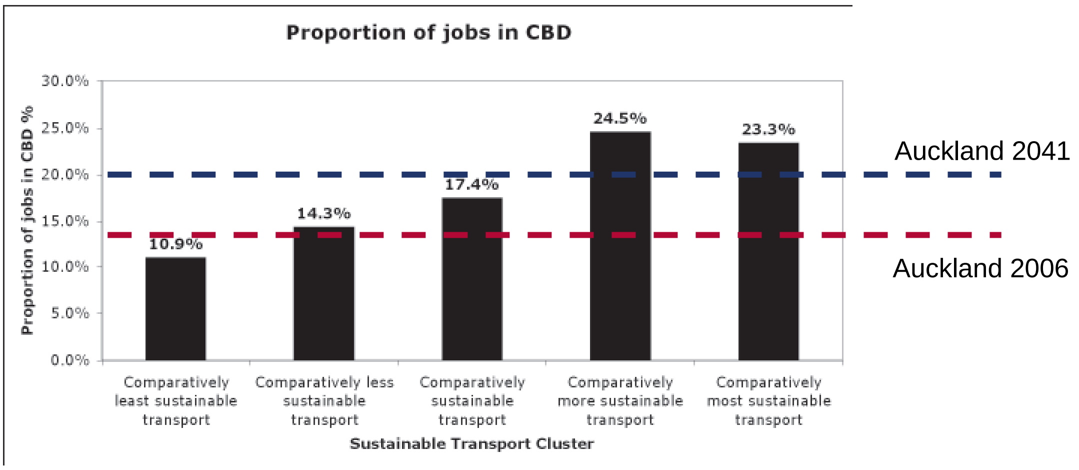


Figure 6-7 Benchmarking of Auckland CBD jobs proportion

Source: Auckland – A public transport intensive scenario for 2041, Strategic Network Option 3, PB, 2009.

Improving Transit Share

The *NZ Transport Strategy, 2008*, outlines targets for future public transport use including 7 % PT use nationally, with Auckland attaining same per capita usage as Wellington.

The development of a PT intensive transport scenario as part of the RLTS review (*Auckland - a public transport intensive scenario for 2041, Strategic Network Option 3, PB, 2009)* made the following important conclusions regarding achieving the NZTS targets in Auckland:

- Public transport use will need to increase from the current 40 boardings per capita per year to 117 boardings;
- The journey-to-work public transport mode share would need to increase from the current 7% to between 15% and 20% in 2041, based on population and employment forecasts;
- Mode share for non-work purposes would also need to increase by similar proportions;
- This level of change will require a substantial behavioural shift among the existing population as well as high public transport mode share for any new population. Based on experience from other cities, a range of interventions will be required including:
- Improved transit level of service to challenge the car;
- Demand management to provide a level playing field of transport choices; and
- Land-use plan to increase densities and reduce the need to travel by car.

Section 5.3 earlier demonstrated that rail corridors can deliver very high transit share to areas within walking distance of stations. Concentration of future growth around such corridors would be a key measure in attaining ambitious overall mode share targets.

6.3 Auckland Transit Network Development

Regional Land Transport Strategy

The Auckland Regional Land Transport Strategy 2010-2040 (Consultation draft, 2009) describes a number of strategic options to meet transport objectives:

Strategic Option 1 - Demand Management – heavy use of factors which push people away from motor vehicle use (including road pricing) towards use of public transport (PT), walking and cycling. This would need to be supported by improvements to PT and walking and cycling to accommodate the diverted demand.

Strategic Option 2 - Mixed Investment – continuation of the current strategy of improvement in all modes, with some shift away from road investment.

Strategic Option 3 - Change led by Public Transport (PT) Improvements – heavy investment in PT infrastructure and services in order to "pull" people from cars to PT, but some investment in roading.

Strategic Option 4 – Quantum Shift – a combination of the "push" factors from Strategic Option 1 (congestion pricing and parking measures) with the "pull" factors of Strategic Option 3 together with a "what if" land use designed to maximise the opportunities for public transport, walking and cycling.

Some of the context behind Strategic Option 3 was provided in the preceding section of this report. Testing of this option through the development of the RLTS showed a modest five per cent increase in public transport trips and it was concluded that *"these results are somewhat disappointing considering the high cost that is likely to be associated with the development of this option".*

Using transport models to estimate change in mode share arising from major investment in public transport can underestimate existing, let alone future, mode share within walking distances of rail stations. **Section 5.3** earlier in this report demonstrated high transit share around key rail stations in existing cities. Such high concentrations cannot be explained simply by comparing overall travel costs by different modes as is done in transport models – there are more complex issues related to how people choose where to live and work. Additionally, transport models are unlikely to capture the city-shaping function of rail. For these reasons, scenarios with high levels of public transport investment should not be dismissed based on preliminary estimates of modest direct benefits.

The preferred strategic option from the RLTS, shown in Figure 6-8 below, includes expansion of the Rapid Transit Network by construction of the CBD Rail link, provision of passenger rail to the airport; extending the Northern Busway to Orewa; and higher frequencies on the Quality Transit Network. It is argued that "the preferred strategic option supports the planned intensification of development in growth centres which will be well served by public transport".

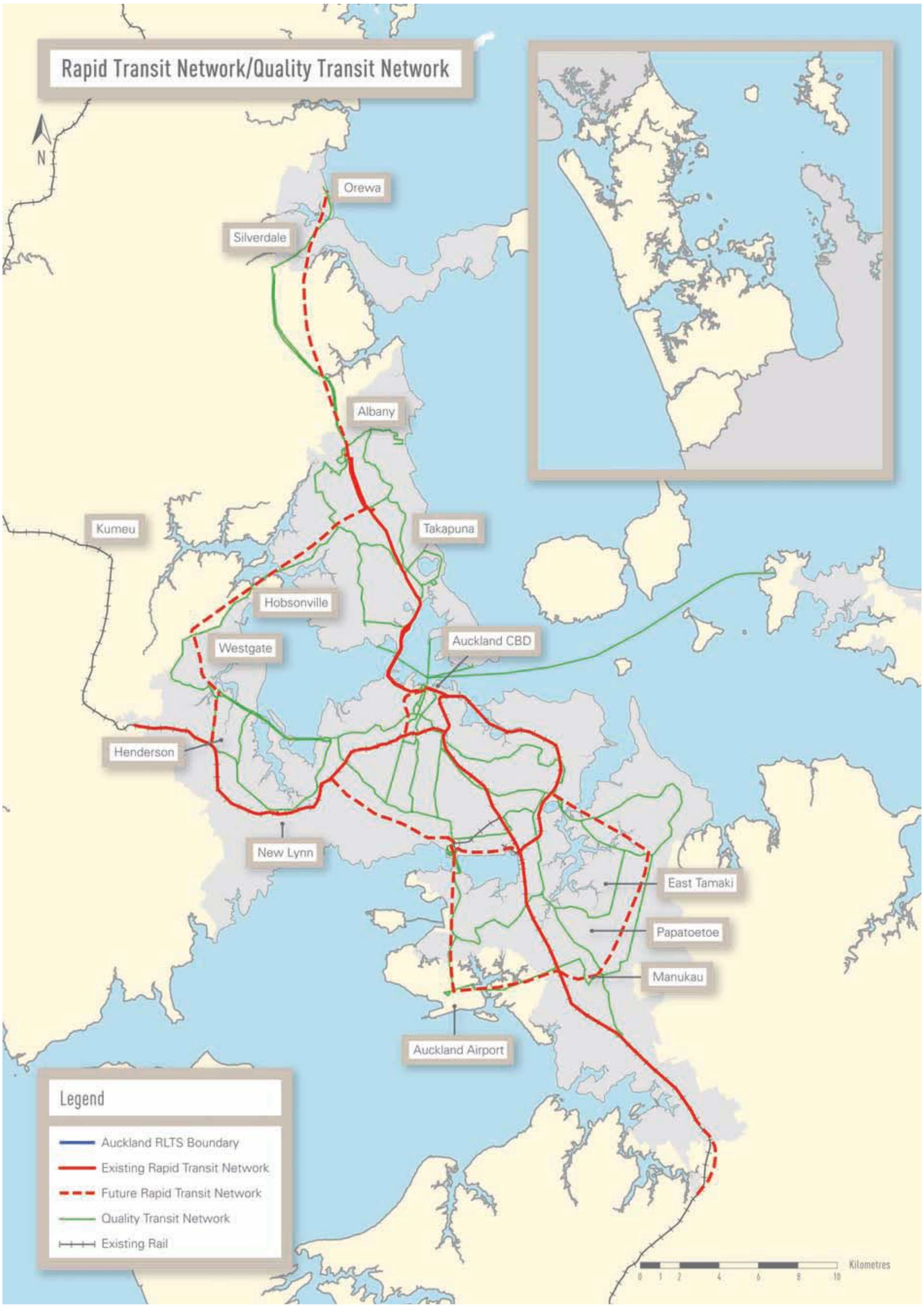


Figure 6-8 Future development of rapid and quality transit network

Source: RLTS 2009.

The RLTS assesses North Shore Rail in the following way:

It is expected that the Northern Busway will operate effectively during the period of this strategy. It will provide an attractive public transport connection between the North Shore, the CBD and the rest of the RTN and QTN system, and will provide a strong public transport core for movement around the North Shore. Towards the end of the period of this strategy however the Busway is likely to approach its operational capacity and this may constrain further growth of public transport patronage. It is therefore necessary to continue investigation of rail and to protect the ability for the future introduction of a North Shore rail. The route to be protected across the Harbour is the route identified in study undertaken in 2008, which involved tunnelling from the CBD to a station under Gaunt Street in the Wynyard Quarter, then continuing in tunnel under the Harbour to emerge in the vicinity of the Esmonde Road interchange. This particular option is known as Option 2C (which also includes the road component described in Policy .6.2.2 below). On the North Shore there may be advantages in following a different route from the Northern Busway, in order to access centres not on the Busway and to maximise the benefits of rail in supporting the development of more concentrated mixed use centres in accordance with the Regional Growth Strategy.

In general, this is a reasonable assessment of the long term potential for North Shore Rail. The following section of this report attempts to provide a stronger exploration of the conditions under which expansion of the rail network is warranted.

Stages of Rail Network Development

The potential role of rail in shaping cities in general was discussed in **Section 5.5** of this report.

Auckland's existing rail network is undergoing a substantial upgrade that includes track and station improvements, electrification and acquisition of new rolling stock. At the end of this current stage of rail network development, it is planned to operate six trains per hour on each of the Western, Eastern and Southern lines during peak periods. This will represent a transformation of the rail network from its limited operation about 10 years ago and will support continued strong growth in rail patronage – Figure 6-9.

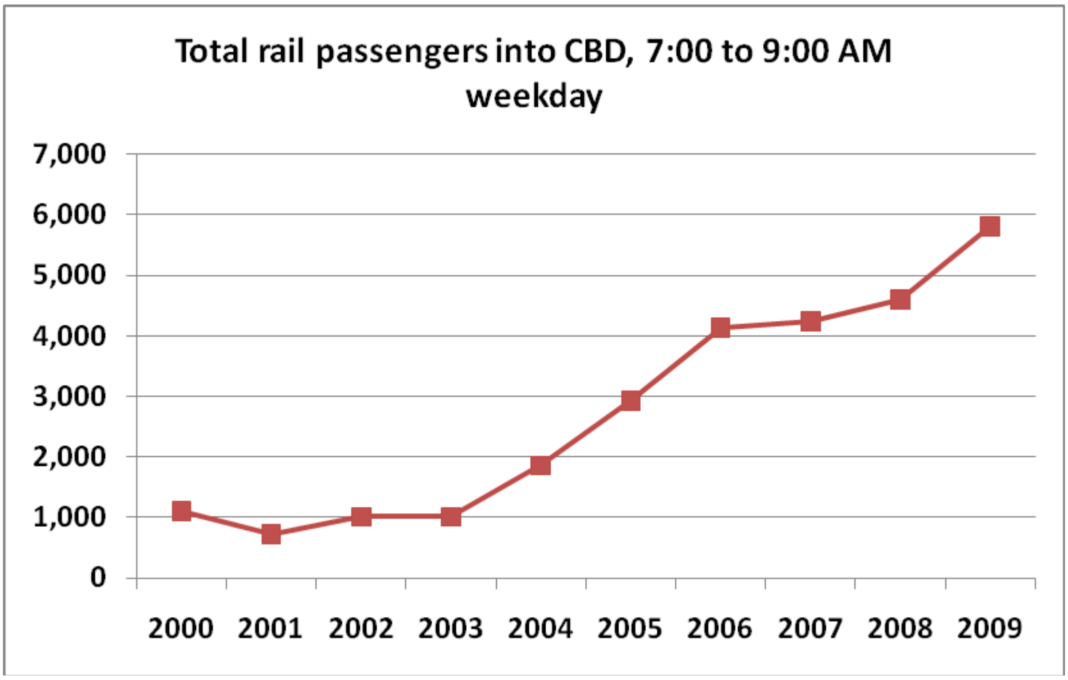


Figure 6-9 CBC rail patronage, 2000 to 2009

Source: Auckland City Council Cordon Counts.

The second stage in developing Auckland's rail network will be the planned construction of the CBD Rail Link as outlined in the RLTS. This project will deliver rail services to the heart of the CBD, unlock capacity constraints at Britomart, and support strong planned employment growth in the CBD. This project is a key element of the RLTS and will deliver, in combination with the Northern Busway, an integrated, largely radial Rapid Transit Network with a strong focus on the CBD.

Under this stage of regional development strong growth is expected in key subregional centres outside the CBD such as Albany and Takapuna on the North Shore. Employment in these centres is likely to have a subregional rather than regional focus. Regional, centres-based employment is best concentrated in the CBD for a range of economic and transport reasons.

The third stage of Auckland regional development will begin when the CBD is considered to be approaching capacity and there will be a strong desire to provide alternative locations for regional, centres-based employment. During this stage, many of the subregional centres will experience further employment growth and specialised centres and higher density business parks may emerge. The role of the transport system in this stage is to strengthen cross-regional connections between the centres and transition towards a genuine network of corridors rather than CBD radial corridors. More emphasis is placed on connections through the CBD and direct cross regional links that do not focus on the CBD.

The type of rapid transit network that eventuates during this third stage was put forward as part of the development of Scenario 3 of the RLTS study as shown in Figure 6-10 below. The existing rail network is expanded to include two new lines including one from the North Shore through the CBD, down the Dominion Road corridor towards the airport. A second new line would run from Manukau through Flatbush and Panmure to Newmarket.

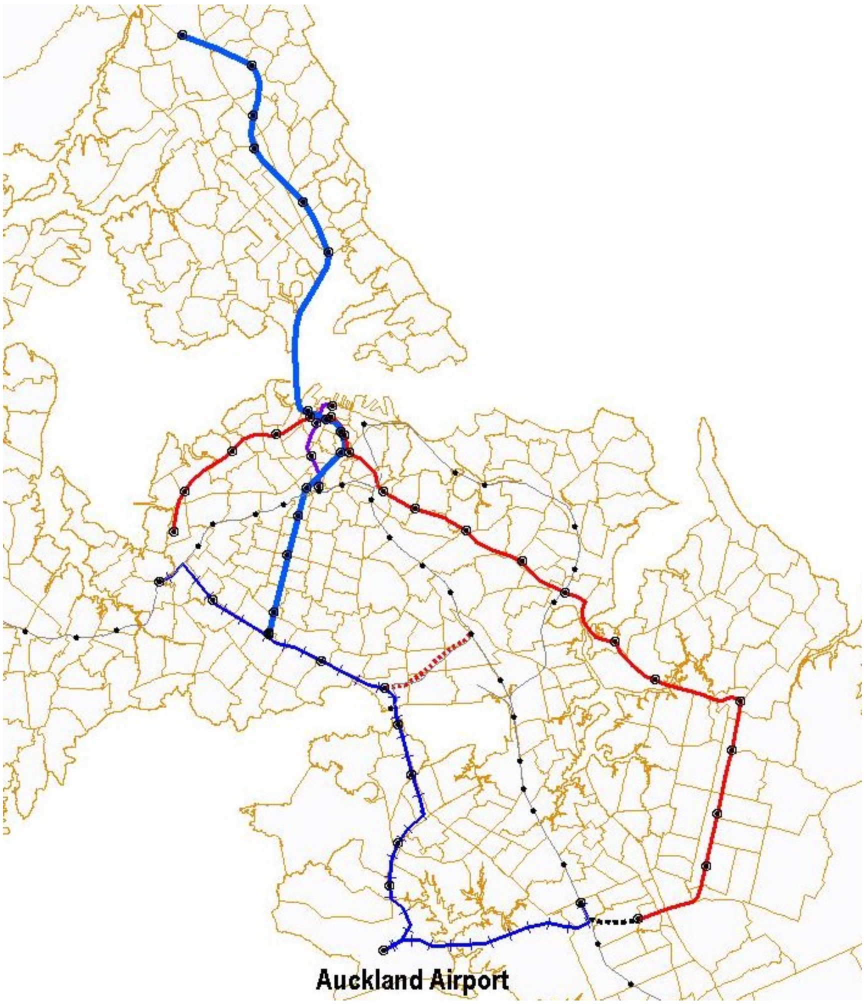


Figure 6-10 Rapid Transit Network – Strategic Network Option 3

Source: PB, 2009.

For a city of Auckland's size it is important that the transit network is developed in these stages with clear objectives in each stage. For example, it is difficult to present a strong case for the CBD Rail Link while also presenting the case for supporting higher employment in centres outside the CBD.

The transition from a CBD, radial rapid transit network to a more regional one is an important step in a city's growth. Most large European and Asian cities have had high densities and dense transport network for many years. Newer cities have lower underlying densities that necessitate careful integration of land use and transport through different stages of development to achieve overall objectives.

The main implications of this approach is that any decisions regarding provision of rail to the North Shore need to be made within the wider context of regional growth and network development.

6.4 Developing North Shore Rail - Role of the Subregional Centres Albany and Takapuna

The Regional Growth Strategy Section of this report showed that the Regional Growth Strategy for Auckland envisages strong population and employment growth in the North Shore with intensification in the key subregional centres of Albany and Takapuna.

As described in the preceding section, in the time period of the RLTS – to 2040 – it is expected that Auckland CBD will be the focus of regional, centres-based employment growth supported by major improvements to the RTN. In this respect, Albany and Takapuna are likely to provide a concentration of jobs and services largely for North Shore residents and the key transport task will be connecting these centres to the established and future residential areas.

While continuing to support demand for travel between the North Shore and the CBD, the Northern Busway provides the opportunity to strengthen links between Albany, Takapuna and the wider North Shore area. Direct, high frequency bus services could operate between Albany and Takapuna providing opportunities for interchange from other services and park and ride facilities at Albany. Cross regional services could be concentrated more on the two centres. The underlying flexibility of the busway system provides an inherent advantage over rail during this stage of development of the two centres.

Under this stage of busway development, bus priority measures would need to be considered between the Northern Busway and Takapuna centre to deliver reasonable travel times and reliability.

The Stages of Rail Network Development Section earlier outlined the potential that beyond the time period of the RLTS subregional centres such as Albany and Takapuna could grow in status to become true regional centres attracting trips from across the Auckland region. Under this scenario, North Shore rail would become part of an expansion of the regional rail network including new lines such as Avondale – Southdown and the airport loop. Connecting a North Shore rail line to an expanded network will substantially strengthen its benefits over the busway.

7.0 North Shore Rail Concept

7.1 Introduction

Key issues to be considered in developing the concept for North Shore rail are:

- Rail alignment in the North Shore and CBD including station spacing and location;
- System type – suburban vs. metro rail; and
- Integration with bus services and park and ride.

7.2 North Shore Rail Alignment

Two main options exist for the North Shore rail alignment – using the existing busway corridor or developing a new alignment.

A brief, qualitative assessment of establishing a rail line within the existing and extended busway corridor was conducted by Connell Wagner *(Northern Busway Extension: Light Rail and Heavy Qualitative Comparison, 2008)*. With respect to a heavy rail alignment, the following points were made:

- Constructing a double track rail line within the existing busway corridor will requiring widening by about 3 metres and completion of new retaining walls;
- The existing vertical alignment is not compatible with heavy rail requirements requiring new cut and fill structures which would present significant construction costs and challenges;
- New stations would be required that would be longer than existing bus stations; and
- A new rail alignment would be required from Constellation Drive.

Additionally, Figure 6-3 earlier shows that population densities within about 1 kilometres of the busway corridor are low with a predominance of business and industrial land use.

Based on this assessment, it is clear that opportunities to establish a rail line to Albany within the existing motorway and busway corridors, without significant costs and possible property acquisition, are limited. Opportunities for a surface corridor away from the motorway / busway may exist but are likely to also involve substantial costs and property acquisition.

For these reasons, it is likely that the preferred rail corridor for the North Shore would be an underground one that provides the best connections to centres without trying to use limited opportunities within the existing corridor.

Figure 7-1 shows an indicative rail corridor alignment that attempts to serve key locations on the North Shore including Takapuna, Smales Farm, Wairau Valley, Sunnynook, Constellation Drive, Windsor Park and Albany. This alignment only follows the Motorway corridor for a short section and may be fully underground.

A key requirement for a rail corridor in the North Shore will be to service Takapuna and Albany.

Choosing an appropriate location for a station in Takapuna may be difficult depending on the alignment between the CBD and Takapuna. The alignment shown below attempts to use the east side of the Motorway corridor at surface with a station in the Takapuna industrial area. A more direct alignment to the CBD may support a station closer to Takapuna centre itself although a rail station could serve as a transformation of an industrial area into a higher density employment centre.

Similarly, choosing an appropriate location for a station in Albany requires consideration of the University, North Harbour Stadium, park and ride facilities, employment centre and residential areas.

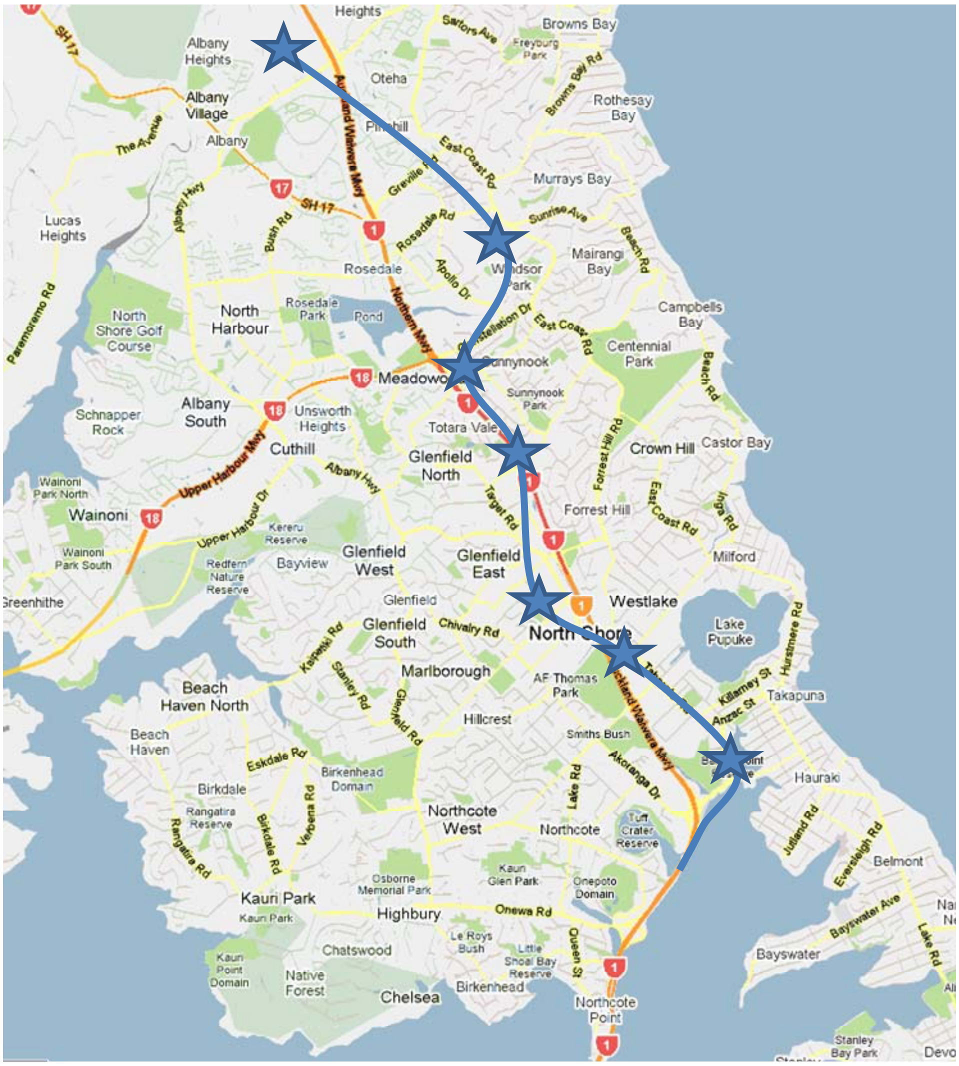


Figure 7-1 Indicative North Shore rail alignment

7.3 Rail System

Section 6.0 of this report provided an overview of the characteristics of suburban and metro rail systems. Given expected future land use patterns on the North Shore it is unlikely that densities in the rail corridor would support short station spacing and high passenger volumes that warrants provision of a metro rail system. It is more likely that a suburban rail system, with a higher emphasis on seating would be appropriate, although metro rail systems do have considerable flexibility in seating provision – for example, the BART system in San Francisco has many characteristics of a suburban rail system.

The selection of the appropriate rail system is often dependent upon conditions in the CBD and surrounding areas. Constraints within the CBD may dictate use of rolling stock that can handle steep gradients and/or tight curves. Train dwell times at busy CBD stations may also be critical in determining train configuration.

Overall, decisions regarding the type of rail system for a North Shore rail line would be most appropriately made on the basis of wider rail network development and integrating the North Shore line with other lines.

7.4 Integration with Bus Services and Park and Ride

Establishing a rail link between the CBD and Albany would provide the opportunity to restructure bus services in the area. Many existing direct CBD bus services would be replaced by feeder services into rail stations and the centres of Albany and Takapuna. Buses currently using the Onewa Road connection to the Motorway would continue this operation although direct services from areas such as Birkdale and Highbury to Takapuna would increase to provide access to the centre as well as interchange opportunities with rail for travel to the north.

A conceptual representation of how bus services might integrate with a rail corridor was provided in Figure 5-3 earlier.

Park and ride facilities can play an important role in supporting transit patronage particularly in low density areas on the fringe of a CBD. Experience in Auckland with the Northern Busway and other cities such as Perth with its Northern rail line demonstrate strong demand for park and ride for long distance rail travel.

Park and ride facilities are best targeted at rail stations that do not have a strong emphasis on centre development – parking areas can sterilise areas around stations and limit transit oriented development opportunities. Challenges will arise at stations like Albany where there will be a strong demand for park and ride as well as opportunities for TOD around a station. There may be strong justification for a dedicated park and ride station at the point where the rail corridor crosses the Northern Motorway. Such facilities provide a strong incentive for drivers on the Motorway to avoid congestion and can even provide opportunities for pricing of parking with an integrated parking / rail ticket.

7.5 Busway Future with Rail

The North Shore rail corridor would serve as the primary Rapid Transit Network corridor through the North Shore and would be the focus of intensified land use within the subregional centres of Albany and Takapuna, as well within the business areas between.

As described in the preceding section, it is likely that direct bus services to the CBD along the existing Northern Busway corridor would continue from areas south of Takapuna, particularly services that currently use the Onewa Road access point. However, the rail line would effectively replace all existing bus stations from Akoranga to Albany.

Under provision of a rail line, opportunities would exist to convert the busway to HOV lanes – tolled or untolled – or remove the busway for motorway widening.

7.6 CBD Rail Alignment and Connections

Some preliminary work has been done by ARTA to examine how a North Shore rail line might pass through the CBD and connect with the planned CBD rail link. The high cost of constructing underground rail lines and stations warrants the future extension of the North Shore line to either connect with an existing line, such as the Southern Line, or to continue as a new corridor towards the airport, for example.

Careful consideration needs to be given to these network issues to try and achieve balanced demand and common system requirements. The requirements of North Shore rail, for example, are probably most consistent with the existing Southern Line operations. In the long term future, a North Shore rail line connecting through to the existing Southern Line would provide a new CBD corridor further increasing rail capacity into the CBD but, just as importantly, providing direct transit connections between northern and southern parts of the Auckland region.

Figure 7-2 and Figure 7-3 below show preliminary concepts on how a North Shore rail line would run through the CBD and connect with the CBD rail link. The first option shows a new CBD alignment running through the proposed Aotea station and connecting with the Southern line at Newmarket. The second option shows an alignment via Britomart. In each case, there is the potential for new stations at Gaunt Street (Wynyard Quarter), Auckland University and Auckland Hospital.

The establishment of a rail station within Wynyard Quarter is a key benefit of a North Shore rail line. It would support the strong residential growth planned for the area and provide key connections to the North Shore, the CBD and surrounding areas such as Newmarket.

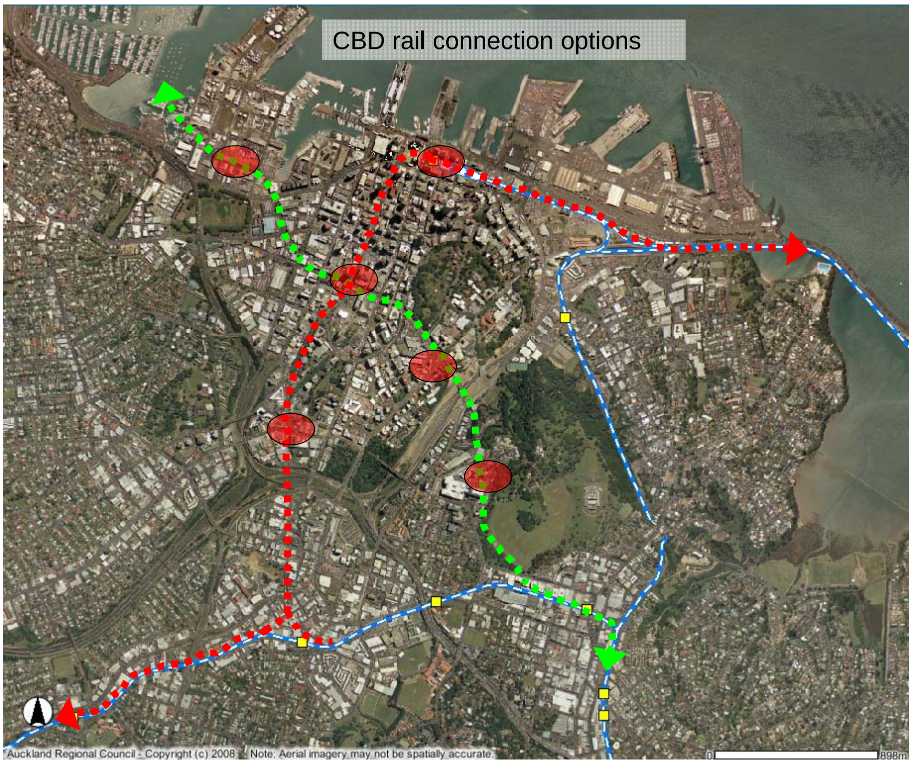


Figure 7-2 CBD Rail and North Shore rail connection – Option 1

Source: ARTA.

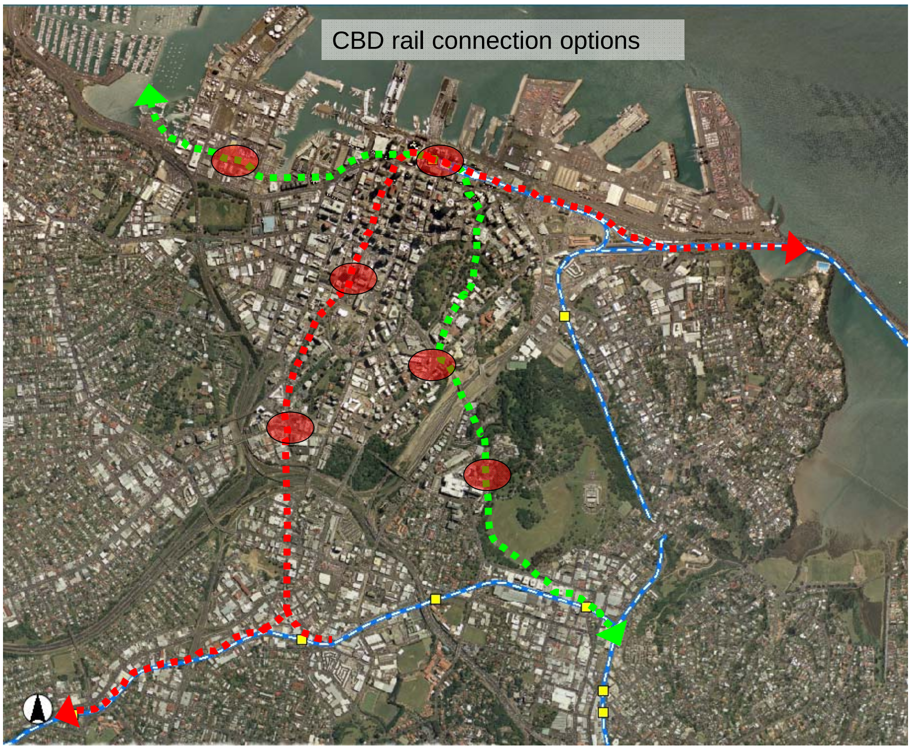


Figure 7-3 CBD Rail and North Shore rail connection – Option 2

Source: ARTA.

7.7 Construction Costs

Broad costs of rail infrastructure would be as follows:

Table 7-1 Broad costs (in millions) of rail infrastructure to and through the North Shore

			Stations								
			Hospital	Symonds Street	Aotea	Gaunt			**Stations**	**Total length**	**Cost**
North Shore Rail Tunnel	Khyber Pass	Gaunt St	$ 307	$ 307	$ 307	$ 307			4	3,000	$1,499
	Gaunt St	Takapuna								6,000	$3,001
	Takapuna	Albany	Takapuna	Smales Farm	Wairau	Constellation	Rosedale	Albany			
			$ 307	$ 307	$ 307	$ 307	$ 307	$ 307	6	14,000	$6,998
	Total Rail Tunnel Option										**$11,498**

Rail tunnel @ $500,000 per metre

Stations @ $307,000,000 each

Notes:

Station costs have been based on provisional station costs for the Auckland CBD Loop, which may therefore overstate the cost of stations on the North Shore where sites may be comparatively shallower and less complex to build.

Tunnel costs assume mainly bored tunnel, also based on Auckland CBD loop provisional costs per meter. Cut and cover could be possible in some areas.

Commentary

The cost of rail to the North Shore is dominated by the need to provide most of the route below ground level via tunnel. Opportunities for an at grade solution are limited and could involve significant property purchase.

Rail Staging

Rail Staging

While there may be options for staging of the North Shore rail line, the main purpose of constructing the rail line would be to provide rail services to Albany in order to maximise the benefits from completing a rail crossing of the Waitemata Harbour. Staged construction to, for example, Takapuna or midway between Takapuna and Albany, would limit benefits to the North Shore, reduce land use opportunities and rely on some continued busway operations.

Should a rail line be staged, interaction with the Northern Busway service would need to be considered. Would you terminate them at a big interchange (Smales Farm, Constellation Drive?) or continue to run them into the city? A staged option could be used to provide some relief to the busway without dramatically changing it.