PUBLIC TRANSPORT VIABILITY-WESTERN BAY OF PLENTY SUB-REGION

Tauranga-WBOP SmartGrowth

November 2002

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[redacted]

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EXECUTIVE SUMMARY

Study Purpose

Booz Allen Hamilton was engaged by SmartGrowth to investigate the potential public transport demand for the Tauranga-WBOP sub-region. This study sought to examine the likely demand for a 'best-case' public transport scenario for the sub-region. The purpose behind this demand estimation was to be able to identify the potential impact of public transport provision on future road infrastructure requirements. The study did not therefore assess benefits and/or costs of the public transport services modelled.

Factors Affecting Public Transport Demand

The study assessed the main factors which affect public transport demand. Key findings were :

- the international experience has been that public transport systems operating on separated corridors perform much better than road-based public transport systems. 120Providing priority to public transport over other traffic (eg bus lanes) can improve the performance of road-based public transport. However, the likely Tauranga bus volumes would not be likely to warrant the introduction of bus lanes.
- A review of international evidence found that rail systems generally achieve around 30% higher usage levels than comparative road-based bus systems (separated busways such as the Adelaide OBahn can achieve similar demand levels to rail). It could be expected therefore that a rail based system would be the 'best-case' public transport scenario for the Tauranga-WBOP sub-region.
- However, international experience has shown that relatively high passenger demand is required for a rail service to be 'viable' in economic or financial terms. A light rail service, for example, requires loadings of 5000-10,000 passengers per hour in the peak direction to be viable, which is much higher than the expected loadings for a Tauranga public transport service.
- Key demographic factors supporting high public transport usage are low car ownership rates, a high proportion of young people, and high population densities. Tauranga does not currently have these characteristics.
- Imposing parking restraint has been shown to decrease the use of single-occupant-vehicles and increase public transport usage. The impact of parking restraint on travel mode will depend on the type of parking policies introduced, the level of public transport service available, and a number of 'environmental factors' eg degree of control the local authority has over parking.

Public Transport Demand Estimation

Demand modelling was undertaken for two public transport options: a high frequency bus based network; and, a high frequency rail based network involving a combination of light rail and suburban rail services. Each public transport option involved a comprehensive route network for Tauranga and link services to Te Puke and Omokoroa. The bus and rail options were modelled for each of the 3 growth scenarios developed by the SmartGrowth project (Low, Current, and High). In addition, the expected impact of a Public Transport Corridor growth strategy whereby all growth occurred within 800m of the public transport service was modelled.

It should be noted that the bus and rail demand estimates derived assume that complementary measures such as bus priority measures and parking restraint in the Tauranga City CBD will be in place. The estimates produced in this study should be seen as the upper bound of likely public transport demand.

As expected, the bus service demand estimate was below the rail demand estimate, with the rail estimate around 30% higher than the bus estimate. A rail-based system was therefore confirmed as the 'best-case' public transport option for this exercise (ie in terms of total usage; bus would most likely be a more 'cost-effective option than rail for the sub-region).

The estimated total annual boardings for a rail based public transport system in the Tauranga-WBOP sub-region in 2026 are around 5.2 million a year. This equates to around 24 trips per person (compared to around 0.35 million passenger boardings for the current bus service and less than 3 trips per person).

Impact on Road Traffic

New Zealand and international evidence show that if a new rail-based public transport service was introduced in New Zealand ex-car drivers would constitute around 50% of new public transport trips. An estimate has therefore been made of the number of car trips per day that would be 'taken off' the road by a rail system. Table 1 shows the expected impact, in this regard, of the modelled rail system.

TABLE 1 CAR TRIPS REMOVED BY RAIL SYSTEM

	Number of Car Trips Removed per Day						
Rail Line	**2001**	**2026**			**2050**		
		Low	**Current**	**High**	**Low**	**Current**	**High**
Mt Maunganui	604	865	882	900	872	910	956
Welcome Bay	468	723	727	743	751	761	792
Greerton	986	1,409	1,439	1,470	1,460	1,525	1,616
Bethlehem	644	917	921	934	921	944	969
Otumoetai	699	992	998	1,012	999	1,024	1,052
Papamoa	801	1,230	1,251	1,267	1,260	1,301	1,348
Te Puke	520	865	872	879	1,012	1,002	942
Omokoroa	449	840	750	754	967	937	780
Total	5,171	7,840	7,840	7,959	8,242	8,403	8,454

Conclusions

Providing a high level of public transport service in the Tauranga-WBOP sub-region will only have a relatively modest impact on road traffic levels, and therefore will not be likely to have a major effect on the amount of road infrastructure required.

However, substantial increases in public transport usage above current levels are possible, and significant economic and mobility benefits are likely to be generated from improving public transport services in the sub-region (and providing complementary measures such as public transport priority measures and parking restraint).

1 INTRODUCTION

1.1 Introduction

Booz Allen Hamilton was engaged by SmartGrowth, to investigate the potential public transport demand for the Tauranga-WBOP sub-region. This Public Transport (PT) viability study sought to examine the likely demand for a 'best-case' public transport scenario for the Tauranga-Western Bay of Plenty (WBOP) sub-region. The purpose behind this demand estimation was to be able to identify the potential impact of public transport provision on future road infrastructure requirements. The study did not therefore assess benefits and/or costs of the PT services modelled.

1.2 Tasks Undertaken

The following tasks were undertaken as part of this study :

- Review of experience with PT demand in similar areas elsewhere.
- Identification of the key factors affecting public transport demand, including the conditions necessary for a 'high-level' PT service (eg light rail) to be viable.
- Review of the evidence relating to the impact of urban form on PT demand.
- Estimation of likely demand for a 'high-level' PT service in the WBOP sub-region.

1.3 Report Structure

The remainder of this report is set out as follows :

Chapter 2	-	Sets out the study findings regarding PT usage in other cities, and the relative impacts of different factors on PT demand.
Chapter 3	-	Provides the results of the PT demand estimation for the WBOP sub-region.
Appendix A	-	Rail Demand Model details.

2 PUBLIC TRANSPORT DEMAND

2.1 Public Transport Usage – Other Cities

In assessing the potential for public transport (PT) in the Tauranga-WBOP sub-region it is instructive to examine the demand for PT in similar sized areas which have more developed PT systems. Table 2.1 shows the 1999 PT demand for a range of small to medium New Zealand and Australian cities[1].

TABLE 2.1 PUBLIC TRANSPORT USAGE IN NEW ZEALAND & AUSTRALIAN CITIES (1999)

	Population (000)	PT Modes	PT Bdgs (000)s	Bdgs/ Person	PT Share – all trips[1]	Veh km/ Person	Bdgs/ Veh Km
New Zealand							
Auckland	1029.0	Bus/Rail	40953.0	39.8	4.1%	27.1	1.5
Wellington	432.0	Rail/Bus	25725.0	59.5	6.2%		
Christchurch	342.1	Bus	9579.0	28.0	2.9%	18.9	1.5
Hamilton	117.2	Bus	1261.4	10.8	1.1%	8.7	1.2
Napier/Hastings	115.8	Bus	400.0	5.7	0.4%	5.0	1.1
Dunedin	111.8	Bus	2342.0	20.9	2.2%	20.6	1.0
Palmerston North	75.6	Bus	460.0	6.1	0.6%	6.9	0.9
Invercargill	49.3	Bus	282.0	5.7	0.6%	7.0	0.8
Wanganui	41.4	Bus	113.3	2.7	0.3%	5.8	0.5
Nelson	40.0	Bus	39.5	1.0	0.1%	2.9	0.3
Australia							
Perth	1368.5	Rail/Bus	71892.0	52.5	5.5%	57.8	0.9
Adelaide	990.7	Rail/Bus	56400.0	56.9	5.9%	51.4	1.1
Brisbane(BT)	864.0	Rail/Bus	40784.0	47.2	4.9%	41.3	1.1
Canberra	307.8	Bus	16155.0	52.5	5.5%	73.3	0.7
Gold Coast	303.6	Bus	11196.2	36.9	3.8%	33.1	1.1
Newcastle	228.6	Bus	12570.0	55.0	5.7%	42.3	1.3
Hobart	184.5	Bus	7055.0	38.2	4.0%	44.0	0.9
Geelong	154.8	Bus	2926.0	18.9	2.0%	17.5	1.1
Logan	148.1	Bus	1642.9	11.1	1.2%	19.8	0.6
Sunshine Coast	146.6	Bus	2666.5	18.2	1.9%	26.0	0.7
Cairns	108.9	Bus	2043.7	18.8	2.0%	34.9	0.5
Townsville	105.6	Bus	965.0	9.1	1.0%	13.4	0.7
Darwin	88.5	Bus	3143.5	35.5	3.7%	37.8	0.9
Ipswich	86.3	Bus	650.6	7.5	0.8%	14.4	0.5
Ballarat	80.8	Bus	1951.0	24.1	2.5%	16.8	1.4
Bendigo	76.4	Bus	1316.0	17.2	1.8%	12.1	1.4
Launceston	60.0	Bus	1739.3	29.0	3.0%	28.3	1.0
Maryborough/H Bay	50.1	Bus	277.0	5.5	0.6%	10.4	0.5
Wodonga	30.9	Bus	191.4	6.2	0.6%	6.5	1.0
Burnie	17.5	Bus	489.9	28.0	2.9%	32.3	0.9

Note: (1) total trips based on average 3 trips per person and 320 average days/year

[1] Note: Australasian cities have been used for comparative purposes for potential PT demand given their similarity to Tauranga. Other overseas cities are not as useful for this purpose given their much different city characteristics, particularly in terms of density and car ownership (eg European and Asian cities have much higher densities and levels of PT service, with much higher PT trip rates).

Several observations can be made regarding Table 2.1 :

- Generally, PT patronage (PT Trips/person) increases with the size of the city.
- This is in part related to the higher level of service provided in larger cities (Vehicle kms/person). Service level does explain a certain amount of the difference between cities. For example, Hamilton and Dunedin are of a similar size but Dunedin PT usage is nearly twice that of Hamilton. This corresponds to the difference in PT level of service, with Dunedin's vehicle kms per person over twice that of Hamilton.
- However, as seen by the trips/vehicle kms ratio, level of service does not explain all of the difference in PT demand between cities, and can not be treated as a causatory factor. Other city characteristics (eg population density, size of CBD, car ownership levels, geography, demographic makeup) also have an impact on PT demand.
- Cities with PT running on separated corridor (rail services and busway services) generally have significantly higher PT usage than cities with on-road services (eg bus).
- No Australasian cities under 400,000 population have a rail service (the only city under 800,000 with a rail service is Wellington which has a very linear geography).
- New Zealand cities generally have lower PT trip rates than Australian cities of comparable size. An comparison of total PT boardings for the New Zealand cities with the total PT boardings for the Australian cities covered shows that, after allowing for the difference in level of PT service provided, New Zealand cities have around 17% fewer PT boardings.

Table 2.1 also shows that only a small proportion of all trips are made by PT (only 6% in the cities with the highest PT usage levels). However, PT can carry a significant proportion of trips for certain trip purposes, destinations and time periods. Generally, PT achieves its highest modal shares for work trips to the Central Business District (CBD) at peak times. This is illustrated by Table 2.2. which shows modal share for PT in Wellington[2].

TABLE 2.2 PT MODAL SHARE – WELLINGTON

Trip Purpose	Am Peak To CBD	Non-CBD	Interpeak To CBD	Non-CBD
Home Based Work	37.5%	9.9%	22.6%	8.2%
Other	14.2%	13.3%	7.9%	5.9%
Total	29.2%	12.2%	9.0%	6.0%

Wellington currently has the highest PT modal share of any cities in New Zealand (Auckland, by comparison, has only 9.8% of total am peak trips made by PT compared to 15.2% of Wellington am peak trips), with close to a third of all peak trips to the CBD made by PT. However, even in Wellington, PT's modal share is substantially lower for trips to non-CBD destinations, with interpeak usage of PT being much lower than peak usage.

Wellington is, of course, much larger than Tauranga-WBOP with a much different geography and city pattern (eg distinct corridors leading to a large CBD), and is therefore not a suitable applicable comparison for the purpose of estimating likely PT demand in Tauranga-WBOP. The New Zealand cities of similar size to Tauranga-WBOP, Dunedin

[2] Analysis from 2000 Wellington Transport Model

and Hamilton do not have well developed PT systems and cannot provide a benchmark for potential PT growth.

The most useful city for comparative purposes in our Australasian database (Table 1) is Hobart in Tasmania[3]. Hobart has a population of around 185,000 people, which is close to the expected population of Tauranga-WBOP over the next 20 years, and is also spread geographically around a waterway. Hobart's CBD has an employment of around 13,000 jobs which is similar to what might reasonably be expected for the Tauranga CBD in 20 years or so (currently around 7,000 jobs). Hobart also has a relatively high car ownership rate (0.56 cars per person in 1996, which was higher than Tauranga) and a slightly higher proportion of young people than Tauranga (44% under 30 compared to 40% for Tauranga).The similarity to Tauranga also extends to parking. In Hobart parking is not a substantial constraint to car usage given that most parking is free, with most parking for workers/students being provided by employers or educational institutions,

As seen in Table 2.1, Hobart has an extensive bus service with over 7 million passenger trips a year, or, 38 trips a year per person. This is a PT trip rate nearly equal to that of Auckland, and only lower than Wellington of the New Zealand cities. For its size a high level of PT service is provided in Hobart (44 vehicle kms per person, which is higher than both Auckland and Christchurch, as well as Brisbane). Given a similar level of PT service the Tauranga-WBOP area may be able to achieve a similar level of PT usage.

In respect to mode share, PT accounted for 7.3% of all journey to work trips in Hobart in 1996, 15.2% of work trips to the CBD, and 5.0% of work trips to other destinations. This is lower than for Wellington (as would be expected), but higher than Christchurch (where around 9% of work trips to the CBD are by bus).

The only caveat on using Hobart as a comparison for Tauranga is that, as indicated above, Australian cities generally have a higher PT trip rate than New Zealand cities (around 17% higher on average after adjusting for level of PT service).

2.2 Factors Affecting PT Usage

A review[4] of key international (including NZ) econometric studies[5] into factors 'driving' trends in PT usage found that a number of factors have a 'significant' impact on PT demand. These factors can be divided into PT System features (primarily fare levels, service level, and PT speed) and factors external to the PT System. These factors are summarised below, along with discussion regarding the implications for Tauranga.

[3] Note: the other Australian cities of a comparable size to Tauranga-WBOP all have significantly different characteristics.
[4] Booz Allen Hamilton, 'Factors Affecting Public Transport Usage', 2001
[5] These studies generally involved regression analysis of PT usage against a range of dependent variables. The results are generally expressed as 'elasticities' ie a measure of the expected change in PT usage as a result of a change in the variable. For example, an elasticity of 0.5 for level of PT service would mean that a 100% increase in PT service would result in a 50% increase in PT usage.

PT System Features

- Fare Level

As fares increase demand for PT services decreases. Fares elasticities generally in –0.2 to –0.5 range (0.3 commonly used for New Zealand analyses). Historically bus fares have been relatively high in Tauranga (due to commercial service provision). Substantial fare reductions would increase usage.

- Service Level

As service levels increase (higher frequencies and/or increased coverage) PT usage increases. Elasticities generally in 0.2 to 0.6 range, 0.4 commonly used in New Zealand analyses). Service levels are currently very low in Tauranga meaning there is substantial scope for increasing PT usage by increasing service levels.

- PT Speed

The relative speed of PT services to on-road motor vehicle travel speed has an impact on the relative attractiveness of PT travel and thereby on PT usage. Where PT has its own separate corridor (eg busway, rail) it is able to operate at much higher speeds than on-road PT (eg bus) and is often able to bypass congested roadways thereby giving it an advantage over motor vehicles. One analysis found an elasticity of 0.46 wrt the ratio of average PT speed to average roadway speed. Given Tauranga's geographic pattern which compresses traffic onto key corridors providing separate corridors for PT (or at least priority measures) could significantly increase PT usage.

External Factors

- Car Ownership

As car ownership increases PT usage has been found to decrease (elasticity ranges of –0.3 to –0.8 for cars/person). Tauranga currently has a relatively high car ownership level (eg in 1996 Tauranga had a car ownership rate of 0.52 cars/person compared to 0.46 for Hamilton, and 0.50 for Christchurch) which will tend to act as a constraint on PT demand if it continues at this level.

- Car Operating Costs

PT usage has been found to increase as car operating costs increase. A recent Wellington study found a petrol price elasticity of 0.18. Parking supply and pricing also has an impact on PT usage, with PT usage increasing as parking supply tightens and parking charges increase. Compared to other New Zealand centres parking in the Tauranga CBD is relatively well supplied and inexpensive. Tightening parking supply and increasing parking charges would increase PT usage (assuming the an adequate level of PT service was provided).

- Economic Variables

Car ownership appears to reflect economic factors to a large extent. However, income has been found to also have a small effect on PT demand additional to car ownership (elasticity of 0.1 to 0.2), with increasing income resulting in increasing PT usage.

- Demographics

Numerous surveys of PT users have found that 'youth' (say age 12-25) have much higher PT trip rates than other sections of the population, with the 15-25 age group having a PT trip rate 2.4 times that of the general population. Elderly people also make relatively high use of PT; however, they make a lower number of trips than the general population and therefore have less impact on total PT usage. Tauranga has a substantially older population than the New Zealand average and a lower proportion of young people (40% under 30 in 1999 compared to 49.9% in Dunedin and 45.6% in Hamilton). This will have a constraining effect on PT usage.

- Population Density

Substantial evidence is available to show a positive relationship between population density and PT usage ie as density increases PT usage increases. An elasticity of 0.4 has been found[6]. Tauranga has a relatively low population density with a density of 6.1 persons per hectare in 1996 compared to 18.9, 22.0 and 17.0 for Auckland, Wellington and Christchurch metropolitan areas respectively. Increasing Tauranga's population density would increase PT usage. However, large increases will be required to get near the New Zealand major metropolitan cities.

Overall Tauranga can not be considered to currently have characteristics which would suggest a high demand for PT services. Tauranga's high car ownership rate, relatively low proportion of young people, low population (and employment) density, and lack of separated PT corridors will dampen PT demand. However, some of these factors could be redressed to a certain extent by Territorial Authority policies (eg introduction of bus lanes).

2.3 PT Priority

PT priority measures are aimed at giving in-traffic priority to PT vehicles over other travel modes. PT priority measures are implemented to enable priority vehicles to bypass congested locations, or travel through them quicker than other traffic. In this way they aim to :

- reduce travel time for PT (mainly buses and light rail)
- increase travel reliability for users of these modes
- produce mode shifts to PT.

PT priority measures can be grouped into three categories:

- PT Lanes - this involves the provision of a dedicated road lane (of varying lengths) accessible only to PT (these are generally Bus Lanes). This may be within the existing road space, or may involve providing extra road space.
- Traffic Signal measures - these measures give PT priority in-traffic over other modes at traffic signals;
- Other Traffic Control measures - these involve imposing traffic restrictions on other modes to give PT priority.

[6] Analysis of Newman & Kenworthy International Database

As indicated above, PT priority measures have been found to increase PT patronage, although generally only by a small amount. One of the most common forms of PT priority is to introduce with-flow bus lanes. An examination of international evidence shows that the effects of with-flow bus lanes depend on the local situation, the length of the lane, degree of congestion, bus passenger flow etc. A saving of 2-3 minutes in bus travel time over the length of the lane seems a typical achievement[7]. On-time running has also improved as a result of bus lanes, and bus patronage has often increased (in one case a direct patronage effect of 6 to 7% was estimated). Accident rates have fallen in several case (for example, in London the introduction of 29 with-flow bus lanes resulted in the number of accidents involving buses falling by 12%[8].

Bus lanes were introduced in Auckland in the late 1990s on key bus corridors (eg Dominion Road, Mt Eden Road). Surveys found significant reductions in peak travel times for bus travel, and an increase in bus patronage. For example, Dominion Road bus services morning peak patronage increased by 10% in the first year of the bus lane's operation. However, service frequencies were also increased in conjunction with introduction of the bus lane, and additional marketing of the services was undertaken. The patronage effect directly attributable to the bus lane would thus have been significantly less than 10%.[9]

Bus lanes have also experienced implementation difficulties. For example, studies conducted on a 1 km portion of a London motorway bus lane showed that bus speeds were no higher than other traffic.[10] The reasons for the failure of these bus lanes were attributed to intentional infringement of the lanes by other vehicles, unintentional blocking of the start of the lanes by vehicles trying to merge into the single, all-vehicle lane, and failure of the set-back at the main traffic signals to clear due to downstream congestion. There is also little evidence of changes in modal split arising from these measures because of the minimal time savings achieved for most schemes.

In assessing whether PT priority schemes should be considered transport planners have generally used a system of ‘Warrants’. The most readily applicable warrants for assessing the need for PT priority in Tauranga-WBOP are known as 'Broad Warrants'. These attempt to give a rough indication of the feasibility of the priority measure by reference to likely bus traffic only. These Warrants are normally in terms of bus volumes per hour. An example of typical values for arterial roads (as distinct from Freeways), postulated by Levinson[11] are set out in Table 2.3.

[7] Transport and Road Research Laboratory (1976) Bus Priority Systems.
[8] Transport Research Centre 1990.
[9] Auckland City Report to Transport and Roading Committee, 'Buses First Progress Report', 31 March 1999
[10] Cracknell and Case 1992
[11] Levinson,H.S. et al. “Bus Use of Highways Planning and Design Guidelines” N.C.H.R.P. Report 155, Highway Research Board, 1975 quoted in Richardson and McKenzie 1976.

TABLE 2.3 EXAMPLE OF BUS PRIORITY WARRANTS		
Type of Measure	**Range in One-Way Peak Hour Bus Volumes**	**Range in One Way Peak Hour Bus Passenger Volumes**
Bus streets	20-30	800-1,200
CBD curb bus lanes, main st	20-30	800-1,200
CBD bus lanes	30-40	1,200-1,600
Median bus lanes	60-90	2,400-3,600
Contra-flow bus lanes, short	20-30	800-1,200
Contra-flow bus lanes, longer	40-60	1,000-2,400
Bus pre-emption of traffic signals	10-15	400-600

As can be seen from Table 2.3, reasonably high bus volumes are required to warrant a bus lane. At lower volumes than shown in the table (ie a bus every 2-3 minutes) other traffic will be very tempted to use the lane and enforcement will become very difficult, making the lane unworkable. It is noted that Dominion Road (Auckland) has 20-30 buses per hour operating during the time in which the bus lanes are in operation.

It is very unlikely that bus volumes would approach the levels required to justify a bus lane in Tauranga. The only exception to this may be on the main approaches into the Tauranga CBD when a number of bus routes have joined together for the last section of the journey; and, on the Harbour Bridge (if several routes are operating at high frequencies across the Bridge).

2.4 Rail Systems

2.4.1 Attractiveness of Rail

Rail services are generally considered to be the highest level of PT service. There is a wealth of evidence internationally that light rail (and other rail-based modes) are regarded by users and potential users as more attractive than on-street bus systems. This attractiveness may in part reflect greater service reliability, if buses are held up by traffic congestion while light rail services are segregated from this. It may also reflect perceived differences in ride quality. However it is also likely to be due to factors such as the visibility and perceived permanency of the light rail installation. summarises the international evidence on the effects on public transport usage of introducing a light rail service to replace typical on-street bus services. International evidence shows that, if all other factors are equal, an on-street light rail service is likely to generate patronage 20% - 30% higher than for the bus services it replaces.

Urban railways are often divided into four groups (Simpson 1989):

- Suburban (or regional) railways, also known as ‘heavy rail’, eg electric multiple unit systems in Wellington, Sydney and Melbourne.
- ‘Medium’ systems, including some metros, eg London Underground, most German U-Bahnen.
- Light Rail systems, eg. German Stadbahnen, London Docklands Light Railway.
- Tramways, eg Melbourne, Adelaide.

Light Rail has become popular in recent times and is often considered to be the best possible PT option for an urban area. In essence, the case is that Light Rail is an attractive public transport mode for users, more attractive and more cost-effective than the bus and hence helps to attract people from their cars; it can support desired land use patterns (concentration rather than sprawl); and is less costly and more cost-effective than heavy rail.

2.4.2 Light Rail Characteristics and Typology

Light rail is a highly versatile public transport mode capable of providing solutions of a range of transport problems in a variety of different situations. For any given transport task, light rail's place tends to lie between buses and heavy rail systems, providing greater capacity and comfort than the former but implying generally lower capital and operating costs than the latter.

Light rail can thus fill a gap between buses and heavy rail. Where bus capacity is insufficient for the task (even with dedicated bus lanes) or where a cleaner, more pedestrian-friendly mode is required, and where the enormous capital cost of a new heavy rail line (especially underground) cannot be justified on the basis of expected patronage levels, then light rail can be a good choice.

Table 2.3 offers one possible hierarchy of different design levels for light rail systems from a basic system to a metro-style operation. Such a hierarchy is, of course, indicative at best, with local infrastructure needs governed by a range of factors that varies from city to city. One useful message of such a hierarchy, however, is that there is the potential for a city's investment in light rail to begin with a basic system and for operations to be expanded as patronage develops (Public Transport Advisory Council, NSW, 1997).

2.4.3 Conditions for Rail Viability

In any corridor, the higher the passenger volumes, the better is the economic case for providing systems with larger vehicles and a greater (if not complete) degree of segregation from other traffic. Such systems generally involve higher capital costs (for both infrastructure and vehicles) than on-street bus services, but lower operating costs per passenger carried at high passenger volumes. They are also likely to provide higher speed performance (eg through use of reserved rail track). At sufficiently high volumes, the benefits of the lower operating costs and the higher performance are likely to out-weigh the higher capital costs, in both financial and social cost terms.

The 'standard' view is that buses (on-street) are most economic up to something between 2000 and 5000 passengers/hour (peak direction) in a given corridor. As shown in Table 2.3, light rail requires much higher passenger loadings to be 'viable' and would not be considered where low volumes were expected (as illustrated by Table 3, relatively high population densities are required to generate the demand levels required for light rail services. When considering metro or suburban rail services, passenger loadings in the range of 15,000 - 20,000 passengers/hour are required.

The Tauranga/WBOP region is not likely to have the patronage densities or demand for PT services discussed above, and is unlikely to be able to sustain a rail service.

TABLE 2.3: LIGHT RAIL SYSTEM TYPOLOGY		Level I	Level II	Level III	Level IV
AREA CHARACTERISTICS					
Population and travel demand classification	Area size	Small city	Medium city	Large city/ conurbation	Metropolis/ conurbation
	Population of service area (million)	0.2-0.5	0.5-1.0	1.0-2.0	2.0-5.0
	Population density in traffic corridor (persons per km ^{2})[1]	2,000	3,000	5,000	8,000
	Public transport demand of a 15km-long corridor (passenger trips per weekday)	30,000	60,000	100,000	160,000+
	Additional demand from feeder traffic (passenger trips per weekday)	5,000	15,000	25,000	40,000+
Criterion for choice of system level	Minimum specific transport performance per weekday (passenger km per route km)	2,000	5,000	10,000	15,000+
DESIGN FEATURES					
Route	Alignment/right-of-way	All at grade 20% shared 80% separate	5% tunnel/ elevated 10% shared 85% separate	20% tunnel/ elevated 80% separate	50%+ tunnel/ elevated 50% separate
Stops/stations	Typical stop spacing (m)	400 - 500	600	750	1000
Vehicles	Control cabs per car	Single/double-ended	Double-ended	Double-ended	Double-ended
	Passenger capacity per car (6 standing passengers per m^2)	160	200 - 230	260	300
Operation	Maximum cars per train	2	2	3	4
	Minimum headway (seconds)	90	90	90	90
	Maximum capacity passengers per hour in each direction)	13,000	18,000	31,000	48,000
	Train protection system	None; manual	Some sections with train protection system	Mostly with train protection system	Train protection throughout
	Average operating speed (km/h)	20	25	30	40

2.5 Impacts of Urban Form

Numerous studies have examined the impacts of land use characteristics (urban form) on demand for PT. Summaries of the main research undertaken into the relationship between urban form and PT demand are provided in three US Transit Cooperative Research

Program (TCRP) publications: 'An Evaluation of the Relationships between Transit and Urban Form' (Research Results Digest June 1995-Number 7), Transit and Urban Form (TCRP Report 16, 1996), and 'Transit Focused Development' (TCRP Synthesis 20, 1997). A summary of the main points made in these publications is provided below.

The evidence on the likely impacts of different urban form aspects on PT demand are outlined below.

- Compact Employment Centres

  Central business districts (CBDs) in which large numbers of employees are located in a densely built area afford strong support for PT usage. These centres offer a large number of commuter destinations within walking distance of PT stations, and PT is often cheaper and quicker than driving and parking a car for commuters. Several regressions studies have found that PT usage increases with increasing density and size of CBD employment areas[12]. Studies have also found that higher density suburban employment centres have higher PT usage than lower density suburban employment centres[13].

- Compact Residential Areas

  Several studies have shown that PT usage increases with the density of residential development. As indicated earlier, doubling residential densities could be expected to increase PT usage by up to 40% for light rail services. The effects of density are related to the distance of potential riders from PT stations. Parson Brinkerhoff et al (TCRP Report 16) found that each doubling of distance from a light rail station reduced ridership by 1/3rd.

- Connectivity between Employment & Residence

  The linkage between concentrations of jobs and concentrations of residents has also been found to affect PT usage. JHK and Associates[14] found that the patterns of origins and destinations were critical to the use of PT, and concluded that poor PT accessibility at either end of the trip results in poor PT usage.

- Mixes of Uses

  Several studies have found that suburban centres with mixed uses generate greater use of PT. Cervero[15] found that more PT, walking and cycling trips were generated by suburban activity centres that incorporated some housing than by centres that had no housing. He also concluded that the presence of a significant amount of retail uses increased PT use. However, others have noted that the interdependency of density and land use mix makes the separation of their influences on PT difficult.

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[12] Eg Parsons Brinckerhoff et al in TCRP Report 16, 1996

[13] eg Douglas, B, 'Comparison of Commuting Trends between downtown, suburban centres, and suburban campuses in the Washington Metropolis area, 1992.

[14] JHK & Associates, 'Development-Related Ridership Survey I', Washington Metropolitan Area Transit Authority, Washington DC, 1987

[15] Cervero, R, 'America's Suburban Activity Centers: The Land Use-Transportation Link', 1989

- **Development Design** — Design attributes, combined with density and other characteristics of "traditional" neighbourhoods, have been shown to influence mode choice. For example, one study[16] found that street connectivity, sidewalk connectivity, street crossings on arterials, and absence of topographic constraints on pedestrian activity increased the likelihood of PT usage. However, as stated by Parsons Brinckerhoff et al 1996, "it is difficult to untangle the effects of land use mix and urban design from the effects of density" since most compact neighbourhoods display designs and mixes intrinsic to the densities involved.

TCRP Synthesis 20 summarises the available evidence on the impacts of land use on PT demand by identifying urban form characteristics that support higher levels of PT usage :

- Compact urban form having a discrete number of significant employment centres in the region that generate bi-directional flows on the PT system;
- Employment and residences concentrated in PT corridors, with particular attention giving to locating residents near stations linked to employment centres;
- Higher densities of development that discourage use of cars and increase personal accessibility to PT;
- A rich mix of land uses that allows workers and residents to walk or use PT to replace separate car trips;
- An enhanced environment around stations and in corridors for pedestrians and cyclists.

In summarising the evidence on the impact of urban form on PT demand, we would conclude that the main 'measurable' urban form factor which affects PT demand is density, both population density and employment density. The impact of other urban form characteristics on PT demand are difficult to distinguish from density given the correlation that exists (ie denser areas tend to incorporate the other urban form characteristics that support PT usage).

2.6 Parking Impacts

The availability and price of parking has been found to have an impact on choice of travel mode. One US study[17] into the relationship between parking provision and PT usage found that :

"Cities with restrictive parking practices, including higher parking prices, tend to have better transit (PT) service and higher transit ridership rates. Changes in factors related to parking price have a stronger effect on mode choice than do factors related to transit service; however, the most effective means of increasing transit share is by increasing parking price and improving transit service. Effects are greatest in the urban core of larger metropolitan areas."

Booz Allen has reviewed international experience with parking policies and their impact on travel behaviour for a number of parking studies[18]. This review has found that the

[16] Friends of Oregon, LUTRAQ: The Pedestrian Environment Model Modifications. Vol 4A, 1993

[17] TCRP Report 40, 'Strategies to Attract Auto Users to Public Transportation', 1988

availability of free or low-cost parking increases the likelihood of single-occupant-vehicle (SOV) use and decreases PT usage. Policies to restrict the availability of parking and to charge for parking (or increase the cost of parking) have been found to reduce SOV use and to increase PT usage.

There are essentially two main parking policy approaches: parking pricing, which involves charging for parking, or increasing parking charges for certain types of parking (eg long-stay parking); and, parking supply, which involves restricting the availability of parking. These two approaches can be applied to either on-street parking or off-street parking. Table 2.4 provides an overview of the main types of parking policy instruments available.

TABLE 2.4 PARKING POLICY INSTRUMENTS

Type of Parking	Dimension of Control	Policy Instrument
On-Street	Price	Charge for parking previously free Increase parking tariffs Introduce parking permits with a fee
	Supply	Ban parking (totally or at specific times) Ban parking with exceptions for special groups Adjust permitted duration of stay
Off-Street	Price	Increase parking tariffs Adjust tariffs -discourage long-term use -encourage HOV vehicles Introduce a parking tax
	Supply	Prohibit/slow new parking development Reduce existing parking stock Adjust operating regimes Relocate parking

Table 2.5 presents the results of a number of documented cases (sample of cases examined) where parking restraint policies were implemented. As these examples show, the impact of parking policies on PT usage varies depending on the type of parking policy implemented and the characteristics of the location involved. Generally parking policies have a direct impact on the amount of SOV car use; however, the degree to which this translates into increased PT usage varies markedly with a key factor being the price and suitability of the PT service. There are also several constraints on the impact of parking policies. The main constraints are :

- Through-traffic – parking policies do not have any impact on through-traffic. In areas with a high proportion of through-traffic parking policies will have a much reduced impact on modal share.
- Control of Parking – the impact of local authority driven parking restraint can be very limited if it only controls a small proportion of total parking in the area.
- Private Non-Residential (PNR) parking – the issue of control is particularly relevant in regard to PNR parking. Under current legislation it is very difficult to influence the way in which PNR parking is used.

[18] Parking studies carried out by Booz Allen recently include: Wellington Regional Parking Strategy for Wellington Regional Council, Auckland Regional Parking Study for Auckland Regional Council.

TABLE 2.5 EXAMPLES OF PARKING POLICY IMPACTS		
Location	**Description**	**Results**
Parking Pricing Policies		
Washington, DC	Imposition of parking charges for US Federal Government workers	1-10% reduction in car driver mode share at central area sites 2-4% reduction in car driver mode share at suburban sites. The price changes had the greatest effects at central area locations with good PT accessibility.
City of Madison	Peak hour surcharge of $1.00 @ 4 parking facilities combined with new shuttle service.	5-8% of commuters switched to public transport; 22% switched parking location & 6% parked after the peak
City of San Francisco	Parking charges at all parking facilities increased by a 25% tax.	Variation in impact- number of cars parked declined at 7 facilities and increased at 6 others. Demand elasticity for all trip purposes of about -0.3. Resulted in c.2% reduction in CBD traffic levels
City of Eugene, Oregon	Parking charges at two city parking buildings and charges at 2 surface lots raised (by 2-3 times). No change to meter charges but fines increased for short term shopper parking.	Monthly parking permit sales declined from 560 to 360 parkers (36%)- half of these became carpoolers or rode a free shuttle, while the other half appear to have changed parking locations.
Ottawa, Canada	37500 Federal Government employees had substantial parking charges imposed in 1975	Proportion using car for journey to work reduced from 35% to 27%. However the significance of the result is somewhat obscured by other simultaneous measures.
Oxford, UK	Severe parking restraint on public spaces in CBD was largely matched over 10 year period by increases in free private parking.	There was some shift (c.10%) from car use to bus use for CBD trips
Parking Supply Policies		
The Hague, Netherlands	Closure of a carpark in town centre	81% of previous car drivers continued as car drivers. Of the suppressed car drivers, 78% changed to PT, 20% became car passengers
Utrecht, Netherlands	• Parking enforcement increased: no of patrols doubled. • Residents only parking created; bollards & flower boxes used to protect against illegal parking • Fixed penalty tickets replaced by increased parking fees dependent on location and overstay duration.	• Substantial reductions in illegal parking • Small modal shift to cycling & public transport • Willingness to pay increased
Cambridge	• 10% or 20% reduction in residential parking for different levels of PT • city centre-maximum 5% of business space for parking • Long stay off-street public parking virtually eliminated within 1 mile radius of town centre – P+R provided • On-street parking either dedicated to residents, short term (2 hrs max), or 1 hr prohibition of waiting in middle of day (1989)	• The limited parking controls did not produce any detectable impact on traffic flows either at city radial level or in town centre. Apparently little impact on peak commuter journeys • Only a few commuted payment agreements entered into • P& R ridership low in peak commuting times, more popular with shoppers.

In conclusion, if significant parking restraint was imposed in the Tauranga City CBD in conjunction with improvements to the PT service this would have an impact on modal share for trips to the CBD. The actual impact would be dependent on the actual parking policies implemented, the level of PT service introduced, and the amount of CBD parking outside of the control of the local authority.

2.7 Impact on Road Traffic

Where PT services are improved, or new services are instituted, with resulting increased PT usage, the total number of trips on the new/improved public transport service is (B+N), where:

B = all trips which were previously made by public transport, either on the unimproved service (B_1) or on alternative services (B_2)

N = the total new trips to the public transport system.

N may be broken down according to the previous mode of these new public transport trips:

D = previously car drivers

P = previously car passengers

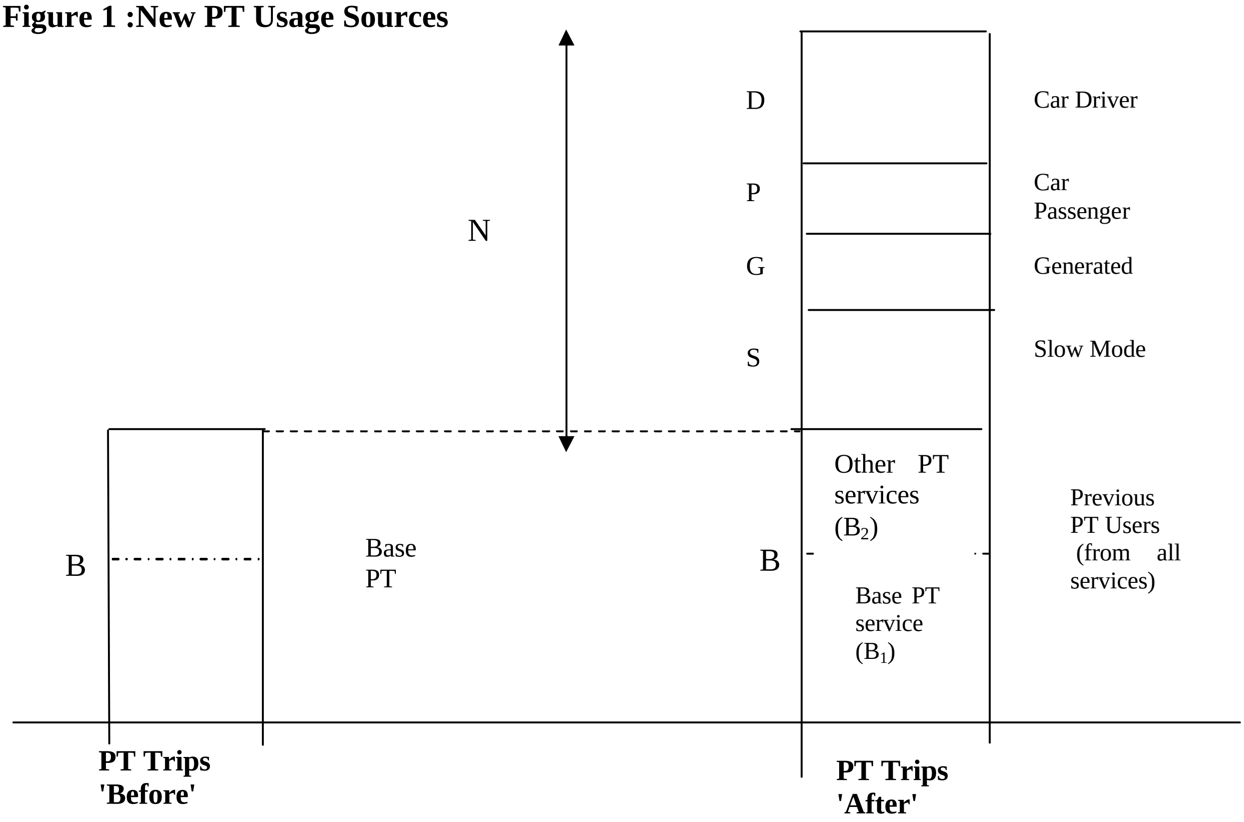
S = previously slow mode (walk or cycle)j

G = previously no equivalent trip (ie generated).

This formulation is represented graphically in Figure 1.

To assess the impact of improved PT services (and increased PT usage) on road traffic levels, it is necessary to know the proportion of additional public transport person trips (on the improved services) that would previously have been car driver trips (D in the formulation above).

Figure 1 :New PT Usage Sources



Booz Allen reviewed the international experience on the source of new PT usage arising from PT improvements[19]. The evidence on car drivers/passengers together as **a proportion of all new public transport trips** may be summarised as:

- Europe - typically 35-40% (range 30-42%)
- UK - typically 45-50% (range 30-52%)
- Australia - typically 50-60% (range 49-69%)
- USA - 68% (one example only).

These results show significant differences in diversion rates between the different countries. It is hypothesised that these differences are primarily the result of differences in:

- car ownership and availability (eg higher in USA than Europe)
- 'base' mode shares of public transport (substantially higher in Europe than in USA/Australia)
- urban densities and trip lengths, which influence the scope for walking/cycling as an alternative (eg higher densities/shorter trip lengths in Europe/UK than USA/Australia).

The above new trip proportions relate to car drivers and passengers together. As indicated above, to identify the impact on road traffic it is necessary to separate out the car driver component. The best evidence on this for the Adelaide O-Bahn which found a driver:passenger split of approximately 2:1, which appears intuitively plausible, and is sensibly consistent with the split for other types of PT improvement projects.

This 2:1 ratio implies that car drivers as a **proportion of all new public transport trips** are two-thirds of the results quoted above. This would give the following results:

- Europe c.25%
- UK c.30%
- Australia 35-40%
- USA 45-50%.

Given that Australia is the closest to New Zealand of the above areas in terms of key city and PT characteristics (eg car ownership, urban densities), the Australian proportion is most applicable for New Zealand situations. This would mean that where a new PT service was introduced, or an existing PT service was improved, car drivers could be expected to constitute 35-40% of new PT trips **on average** (this proportion is known as the car driver diversion rate).

Following on from our May 2000 review we carried out further analysis of car driver diversion rates for Transfund as part of the Patronage Funding investigation[20]. This analysis found higher car driver diversion rates for rail services than the PT average. Based on this work we would expect car driver diversion rates for a Tauranga rail-based system to be around 50%.

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[19] Booz Allen Hamilton, 'Effects of Public Transport System Changes on Mode Switching and Road Traffic Levels', May 2000

[20] Booz Allen Hamilton, 'Passenger Transport Evaluation and Funding Procedures', September 2000

3 DEMAND ESTIMATES

3.1 Overview of Analysis

This chapter summarises the PT demand estimation analyses undertaken. to investigate the potential PT demand for the sub-region. These analyses aimed to determine the likely demand for a 'best-case' public transport scenario for the Tauranga-Western Bay of Plenty (WBOP) sub-region. As indicated earlier, the international experience has been that PT systems operating on separated corridors, or with high in-traffic priority, perform much better than road-based PT systems. A review of international evidence by Booz Allen found that rail systems generally achieve around 30% higher usage levels than comparative road-based bus systems (separated busways such as the Adelaide OBahn can achieve similar demand levels to rail). Our expectation therefore was that a rail based PT system would be the 'best-case' public transport scenario for the sub-region.

Demand modelling was therefore undertaken for two PT options: a high frequency bus based network; and, a high frequency rail based network involving a combination of light rail and suburban rail services. Each PT option was modelled for each of the 3 growth scenarios developed by the SmartGrowth project (Low, Current, and High). In addition, the expected impact of a PT Corridor growth strategy whereby all growth occurred within 800m of the PT service was modelled. The expected impacts on traffic levels were also assessed. This chapter presents the results of these analyses.

It should be noted that the bus and rail demand estimates derived assume that complementary measures such as bus priority measures and parking restraint in the Tauranga City CBD will be in place. The estimates provided here should be seen as the upper bound of likely PT demand.

3.2 Overall PT Usage

As indicated in Section 2.1, Hobart is a useful comparative city for Tauranga-WBOP in terms of providing a guide to the likely potential for PT services and PT demand. Hobart, with a population of 185,000 people, has an extensive bus service with over 7 million passenger trips a year, or 38 passenger trips a year per person. Allowing for the higher PT trip rates of Australian cities this would equate to around 31 trips per person. This PT trip rate is nearly 3 times Hamilton's trip rate and 50% above Dunedin's.

If Tauranga District was able to achieve this PT trip rate it would currently have around 2.8 million PT trips made a year (compared to around 0.35 million currently). In assessing the potential demand for PT in Tauranga-WBOP the Hobart average PT trip rate (adjusted down for the Australian –New Zealand difference) can be used as a guide as to an upper bound as to what is achievable for the region. It is most unlikely that PT trip rates much above the Hobart level could be achieved for Tauranga-WBOP.

3.3 Bus Demand Estimation

3.3.1 Bus Demand Modelling

In 1999/2000 Booz Allen carried out a study for Environment BOP to analyse the need for a PT service in Tauranga, and to identify and evaluate the PT service options available to meet that need[21]. As part of the analysis undertaken for the 1999/2000 study a PT Transport Demand model was developed which estimated total PT demand for Tauranga. In addition, a more detailed bus service demand model was developed to estimate the likely demand for particular bus service options. The bus demand model was based on the PT Transport Demand Model, and related bus service patronage to the total population of the area served, and adjusted demand for socio-demographic characteristics and level of service.

The 1999/2000 bus demand model has been updated for the current study by :

- Adding bus services for Western Bay of Plenty.
- Applying SmartGrowth scenario population estimates.
- Running the model for a high frequency service.

The bus route network was assumed to be that specified in the 1999/2000 Tauranga Public Transport Study, with the addition of link services to Tauranga from Omokoroa and Te Puke. Thus, the services included were :

Tauranga services

- Tauranga to Mt Maunganui
- Tauranga to Bayfair
- Mt Maunganui to Palm Beach
- Papamoa Beach Feeder
- Matua
- Otumoetai
- Bethlehem Heights
- Cambridge Heights Feeder
- Greerton
- Gate Pa Feeder
- Parkvale
- Welcome Bay
- Bayfair to Polytechnic

WBOP Link Services

- Te Puke to Tauranga
- Omokoroa to Tauranga

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[21] Booz Allen Hamilton, 'Tauranga Public Transport Study' –Stage 1 and 2 reports, for Environment Bay of Plenty, 1999/2000

The frequencies assumed for the Tauranga services were: 10 minutes at peak times, 15 minutes in the interpeak, and 20 minutes at other times. The Te Puke and Omokoroa link services would run every 15 minutes at peak times, every 30 minutes in the interpeak, and every 20 minutes on Saturdays.

3.3.2 Bus Demand Estimates

The estimated bus demand for each of the SmartGrowth scenarios in 2026 and 2050 is shown in Table 3.1

3.4 Rail Demand Estimation

As indicated earlier, rail services are generally considered to provide a better level and quality of PT service than on-road bus services, with generally higher usage levels (although busways can achieve similar usage levels to rail). The approach taken to estimate the upper bound of potential demand for PT in Tauranga-WBOP was therefore to assume a rail service could be instituted in the sub-region. It should be noted, however, that this does not mean that we consider a rail service would be economically viable for the sub-region. As indicated earlier relatively high PT usage volumes are required for rail services to be viable in economic terms[22].

3.4.1 Rail Demand Estimation Model

The demand estimation approach was based on the rail demand estimation models developed as part of an investigation into 'Commuter and Light Rail Transit Corridors: The Land Use Connection', carried out by Parsons Brinckerhoff Quade & Douglas (PBQD), Inc in 1996 for the United States (US) Transportation Research Board[23]. As part of this study PBQD carried out multi-regression analysis on patronage and demand variables for 19 US Light Rail lines and 47 US Commuter Rail lines. This process enabled PBQD to determine the statistical significance of the different demand variables in terms of their impact on rail patronage (by station), and the coefficients of demand (effectively demand elasticities). Separate demand equations for Light Rail and Commuter Rail were developed based on the results of this analysis (the variables included were: population densities, existence of feeder bus service, park-and-ride availability, distance to nearest station and to CBD, employment density, terminal station dummy variable, and, for Commuter Rail, household income).

The TCRP Light Rail model has been further improved upon by Professor Robert Cervero of Berkeley University, an internationally recognised expert in transport analysis. He noted that the TCRP Light Rail model neglected to include a variable measuring public transport service intensity[24]. Professor Cervero added three additional variables to the TCRP Light Rail model: CBD vs Non-CBD location, Peak Service Intensity, and, a unique city effect dummy variable. With these improvements, we consider the Cervero Light Rail model to be the preferred light rail demand estimation model. However, in determining the appropriate rail demand model for New Zealand rail services it needs to be borne in mind

[22] The brief for this project did not include assessing the economic viability of possible PT systems but rather identifying the most likely maximum PT demand levels achievable.
[23] Parsons Brinckerhof Quade & Douglas, Inc, TCRP Report 16 'Transit and Urban Form', 1996
[24] LDR International, Inc., "Technical Appendix C: Ridership Modeling (by Professor Robert Cervero)," 2025 Integrated Transit/Land-Use Plan for Charlotte-Mecklenburg, October 1998

that New Zealand rail services are neither Light Rail or Commuter Rail services in the US mould, but somewhere between the two. The TCRP Commuter Rail model will therefore also be required for the analysis. Extracts from TCRP Report 16, and a paper from Professor Cervero explaining his model modifications, are attached as Appendix A.

Booz Allen has previously assessed the applicability of the Cervero and TCRP rail demand estimation models to New Zealand conditions[25]. The approach adopted was to apply the TCRP and Cervero models to the Wellington situation and to compare the modelled demand with actual rail usage. This found that, although there was scatter in the individual station model patronage estimates, the total rail line patronage followed a clear pattern: the Cervero Light Rail model patronage estimates were consistently above the actual patronage, by around 80%; and the TCRP Commuter Rail model estimate was generally lower than the actual patronage, by around 75%. This result was expected given that the Wellington rail system is somewhere between a US Light Rail and Commuter Rail system.

Given the rail system classification described above, it was determined that the most appropriate model estimate for the Wellington rail line would be halfway between the Cervero Light Rail estimate and the TCRP Commuter Rail estimate. This halfway point estimate (Cervero Light Rail/TCRP Commuter Rail Model) was found to be a good representation of the actual patronage. It was therefore concluded that the Cervero Light Rail/TCRP Commuter Rail model is a valid approach to estimating suburban rail patronage in New Zealand conditions.

3.4.2 Tauranga-WBOP Rail Service Demand Estimation

The Cervero Light Rail/TCRP Commuter Rail model has been used for estimating the demand for a hypothetical Tauranga-WBOP rail system. Given that this model is a good representation of the Wellington rail system it may over-estimate potential patronage for the Tauranga-WBOP situation. However, this model will provide an upper bound to potential PT patronage for Tauranga.

The hypothetical rail system for Tauranga-WBOP modelled involved 8 rail lines with 2 of these running on the current rail lines. The rail lines modelled were:

- Mt Maunganui to Tauranga CBD
- Papamoa to Tauranga CBD
- Otumoetai to Tauranga CBD
- Bethlehem to Tauranga CBD
- Greerton/Pyes Pa to Tauranga CBD
- Welcome Bay to Tauranga CBD
- Te Puke to Tauranga CBD
- Omokoroa to Tauranga CBD.

Rail stations have been assumed to be every 500m to 800m in Tauranga (light rail type distances), and located at population centres on the Te Puke and Omokoroa rail lines.

[25] Analysis for Pegasus Bay Study for Southern Capital Ltd, 2001

Demand has been modelled for each of the SmartGrowth scenarios for 2026 and 2050 (and in 2001). A relatively high frequency service has been assumed :10 minute peak frequency for Tauranga City services, and 15 minute peak frequency for rural service. These frequencies are higher than the current Wellington rail service frequencies. Feeder buses to the outer rail stations were assumed, along with Park + Ride at outer stations.

Key inputs were:

- Population estimates for Tauranga by area unit provided by Tauranga District Council (TDC) for 2001 and 2021.
- Population figures for WBOP for 2001 and 2021 (medium projection) from NZ Statistics website.
- SmartGrowth population estimates for each of the three growth scenarios: Low, Current, and High.
- 2001 Tauranga CBD employment figures provided by TDC.
- 2026 Tauranga CBD employment : calculated by applying the ratio of growth between Tauranga's population and CBD employment numbers in 1995-1999 period in conjunction with forecasts of Tauranga's population predictions during the period of 2001 and 2026 (same procedure for 2050).
- 2001 Household Income was provided by WBOP, but only (2001) Personal Income was available for Tauranga. A factor if 1.5 was applied to Tauranga Personal Income to derive estimated Household Income.
- Household Income was assumed to remain constant in real terms from 2001 to 2050.

3.4.3 Rail Demand Estimates

The estimated rail demand by line for 2001, 2026 and 2051 is detailed in Table 3.2. This table shows that the expected demand in the individual corridors (lines) is much lower than that which is generally considered to be required for a light rail service to be viable (5,000 – 10,000 passengers/hour peak direction compared to maximum of 3,500 per day on any one line in 2050).

3.4.4 Total PT Boardings

Total PT boardings for the Tauranga-WBOP region with a rail system would also include feeder bus boardings, which would be equal to around 10% of total rail boardings. Thus, total annual PT boardings with the modelled rail-feeder bus network would be around 5.2 million in 2026 and 5.5 million in 2050. This would equate to a PT trip rate of 24 trips per person in 2026, and 20 trips per person in 2050.

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TABLE 3.1 ESTIMATED BUS DEMAND														
	Daily Boardings							**Annual Boardings**						
Service Name	**2001**	**2026**			**2050**			**2001**	**2026**			**2050**		
		Low	**Current**	**High**	**Low**	**Current**	**High**		**Low**	**Current**	**High**	**Low**	**Current**	**High**
Tauranga to Mt Mang	696	1,153	1,239	1,310	1,097	1,230	1,358	187,052	309,922	332,976	352,036	301,477	338,230	373,515
Tauranga to Bayfair	506	838	900	952	797	894	988	135,953	225,258	242,014	255,868	219,121	245,833	271,480
Mt Mang to Palm Beach	1,099	1,820	1,956	2,067	1,731	1,941	2,145	295,301	489,277	525,672	555,763	475,945	533,968	589,674
Papamoa Beach Feeder	698	1,847	1,969	1,999	1,919	2,049	2,140	187,545	496,510	529,432	537,336	527,758	563,561	588,492
Matua	182	239	241	254	213	226	235	48,880	64,146	64,917	68,237	58,531	62,197	64,442
Otumoetai	334	439	444	467	391	416	431	89,855	117,917	119,334	125,437	107,597	114,336	118,461
Bethlehem Heights	696	937	968	1,028	870	954	1,042	187,169	251,844	260,123	276,433	239,388	262,186	286,479
Cambridge Heights	240	319	319	335	281	298	309	64,487	85,632	85,632	90,001	77,214	82,038	85,024
Greerton	244	383	407	444	399	441	519	65,657	102,946	109,431	119,329	109,518	121,324	142,721
Gate Pa Feeder	153	239	254	277	249	275	324	40,999	64,284	68,333	74,514	68,388	75,760	89,121
Parkvale	307	481	511	557	500	554	651	82,406	129,207	137,346	149,769	137,457	152,273	179,129
Welcome Bay	294	462	491	535	480	532	625	79,147	124,097	131,914	143,846	132,021	146,251	172,045
Bayfair to Polytechnic	712	1,317	1,317	1,427	1,369	1,338	1,440	191,529	354,117	354,117	383,533	376,319	367,952	396,065
Te Puke	775	1,010	1,008	1,028	1,049	1,032	1,042	208,456	271,389	271,095	276,309	288,554	283,755	286,423
Omokoroa	609	1,362	912	921	2,414	1,825	835	163,779	366,008	245,176	247,661	663,876	501,792	229,676
Total	7,545	12,844	12,936	13,601	13,758	14,005	14,083	2,028,214	3,452,555	3,477,511	3,656,070	3,783,166	3,851,457	3,872,747

[redacted]

TABLE 3.2 ESTIMATED RAIL DEMAND														
	Daily Boardings							**Annual Boardings**						
Rail Line	**2001**	**2026**			**2050**			**2001**	**2026**			**2050**		
		Low	**Current**	**High**	**Low**	**Current**	**High**		**Low**	**Current**	**High**	**Low**	**Current**	**High**
Mt Maunganui	1,428	1,950	1,984	2,021	1,963	2,041	2,132	392,821	536,294	545,525	555,750	539957	561,274	586,209
Welcome Bay	1,157	1,666	1,675	1,706	1,722	1,743	1,804	318,062	458,064	460,508	469,055	473642	479,191	496,107
Greerton	2,191	3,037	3,098	3,160	3,141	3,270	3,451	602,610	835,281	851,864	868,913	863703	899,302	949,050
Bethlehem	1,509	2,053	2,062	2,088	2,063	2,107	2,157	414,933	564,585	567,184	574,276	567212	579,468	593,207
Otumoetai	1,618	2,204	2,216	2,244	2,218	2,268	2,325	445,008	606,060	609,376	617,164	609889	623,613	639,347
Papamoa	1,821	2,680	2,723	2,754	2,740	2,822	2,916	500,894	737,041	748,705	757,224	753421	775,955	801,794
Te Puke	1,100	1,791	1,804	1,819	2,084	2,063	1,943	302,601	492,473	496,209	500,222	573178	567,425	534,462
Omokoroa	917	1,700	1,519	1,528	1,953	1,893	1,580	252,278	467,424	417,784	420,092	537112	520,666	434,397
Total	11,741	17,081	17,081	17,319	17,884	18,207	18,308	3,229,207	4,697,221	4,697,154	4,762,697	4,918,114	5,006,894	5,034,571

3.5 Comparison of Rail and Bus Demand Estimates

As was expected, the bus demand estimates were lower than the rail demand estimates. The 2026 rail estimates were 30-36% higher than the 2026 bus estimates which reflects the international evidence on the comparative usage levels generated by rail and bus systems. This analysis therefore confirms our initial assumption that the best case PT system for the Tauranga-WBOP sub-region would be a rail-based system (with bus feeder services).

3.6 Traffic Model Estimation Method

As a cross-check on the rail model demand estimates an estimate of total PT demand was derived from the Tauranga-WBOP traffic model. The approach adopted was to apply 'adjusted' Wellington PT modal share proportions[26] (Table 2.2) for peak/interpeak and CBD/Non-CBD trips to the traffic model output of total trips by origin-destination to give total PT trips for one weekday.

The total PT trips for 2001using this approach was estimated as 13,689 trips per weekday, which compares well (+16%) with the modelled 2001 rail demand of 11,741 trips per weekday. The traffic model estimation approach therefore appears to confirm that the estimated rail demand is of the right 'order of magnitude', and that the rail demand model provides a reasonable basis for estimating future PT demand for Tauranga/WBOP.

3.7 Impacts of Urban Form Changes

As indicated in Section 2.5, the main 'measurable' urban form factor which affects PT demand is density, both population density and employment density. The rail demand model used in this analysis includes population density as a model factor. This means that the higher density assumptions incorporated in the SmartGrowth 'High' scenario are included in the rail demand estimates.

In addition, the impact of an even higher population density scenario was modelled to test the likely impact on PT demand . This scenario was a PT Corridor growth strategy ie it assumed that all of the population growth occurring in the area covered by the rail model (98% of Tauranga District population and 71% of WBOP population) occurred within 800m of the rail line.

The impact of this PT corridor growth strategy was similar for all three SmartGrowth scenarios, increasing total rail usage by 6-9%. The 2026 and 2050 rail demand estimates for the rail corridor growth strategy for the 'Current' SmartGrowth scenario are shown in Table 3.3, along with the base estimates[27] for comparison purposes. The increases within Tauranga District are significantly lower than this average (apart from Papamoa), while the WBOP increases are substantially higher.

[26] The Wellington PT modal share proportions were adjusted down using figures available for Hobart to provide comparative modal share proportions for the Tauranga situation.

[27] Base estimates assume that population growth within an area unit will occur evenly throughout that area unit.

TABLE 3.3 RAIL CORRIDOR GROWTH SCENARIO (CURRENT GROWTH DEMAND ESTIMATES)						
Rail Line	**2026**			**2050**		
	Base	**Rail Corridor Growth Scenario**	**% Difference**	**Base**	**Rail Corridor Growth Scenario**	**% Difference**
Mt Maunganui	1,984	2,002	1%	2,041	2,064	1%
Welcome Bay	1,675	1,749	4%	1,743	1,831	5%
Greerton	3,098	3,159	2%	3,270	3,357	3%
Bethlehem	2,062	2,091	1%	2,107	2,142	2%
Otumoetai	2,216	2,256	2%	2,268	2,316	2%
Papamoa	2,723	2,897	6%	2,822	3,017	6%
Te Puke	1,804	2,049	12%	2,063	2,622	21%
Omokoroa	1,519	1,874	19%	1,893	2,360	20%
Total	17,081	18,077	6%	18,207	19,709	8%

3.8 Likely Impact on Road Traffic Levels

As indicated in Section 2.7, it can be expected that where a new rail-based PT service is introduced in New Zealand ex-car drivers would constitute around 50% of new PT trips. Table 3.4 provides an indication of the number of car trips per day that would be 'taken off the road' by the modelled rail system.

TABLE 3.4 CAR TRIPS REMOVED BY RAIL SYSTEM							
	Number of Car Trips Removed per Day						
Rail Line	**2001**	**2026**			**2050**		
		Low	**Current**	**High**	**Low**	**Current**	**High**
Mt Maunganui	604	865	882	900	872	910	956
Welcome Bay	468	723	727	743	751	761	792
Greerton	986	1,409	1,439	1,470	1,460	1,525	1,616
Bethlehem	644	917	921	934	921	944	969
Otumoetai	699	992	998	1,012	999	1,024	1,052
Papamoa	801	1,230	1,251	1,267	1,260	1,301	1,348
Te Puke	520	865	872	879	1,012	1,002	942
Omokoroa	449	840	750	754	967	937	780
Total	5,171	7,840	7,840	7,959	8,242	8,403	8,454

APPENDIX A - RAIL DEMAND MODEL DETAILS

- TCRP Model – TCRP Report 16 Extract
- Cervero Modification – report extract