Economic benefits of park and ride December 2014

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Executive summary

The project objectives were to assist decision-makers by providing guidance on:

- the rationale for investment in park and ride (P&R) as a cost-effective and efficient means of improving state highway and local arterial road performance and/or reducing public transport subsidies
- methods for the economic and financial appraisal of P&R investments
- the process and necessary conditions for optimal P&R investment decisions to be made.

The focus was on the assessment of individual P&R facilities using case studies rather than the development and assessment of an overall P&R programme for each region/corridor.

The project required development of a methodology for assessing the effects of investment in additional P&R spaces on demand and modal choice and hence determining scheme capital and operating costs, benefits to public transport (PT) system users, benefits and costs to PT operators, and 'decongestion' benefits to road system users.

Methodology

A review of current transport modelling practices indicated that internationally the preferred approach to modelling P&R options is to have P&R as an option at the strategic level of a transport model. However, the current Auckland and Wellington regional transport models have P&R as an option only at the sub-mode level and are thus inappropriate for estimating the modal effects of changes in P&R availability. The study therefore undertook primary market research with current P&R users at Waterloo and Petone stations (Wellington rail) and Albany (Auckland Northern Busway), to determine how the travel market would respond to the provision of additional P&R spaces and, in particular, the extent to which car drivers would switch from using car to travel to the CBD to using car to access P&R. There was a distinct difference between Wellington (where the PT service is well established and P&R appears primarily to be an alternative to other PT-based options) and Auckland where P&R on the relatively new Northern Busway appears to be attracting a higher proportion of former car drivers. Based on the surveys, 'diversion rates' were derived, as shown in the table below, and subsequently applied in the case studies analyses (refer below).

The number of potential new P&R users and the benefits to both existing and new P&R users were estimated from the extent of on-road parking at each site, the benefits they would enjoy and the proportion of potential users on-street parkers represent (as deduced from the table below). The number of new PT users was calculated and used to estimate the effect on PT operating costs, existing PT user costs and PT fare revenues.

Surveyed diversion rates (per 100 P&R users)

Previous/next best mode	Wellington*	Auckland
Car drivers	12	34
Direct bus service	3	16
Feeder bus service	9	6
On-street parkers	41	33
Parked at another station	16	6
Other	19	5
Total	100	100

* Average of Petone and Waterloo

A method for determining the effect of changes in the demand for road travel on corridor travel times was developed as a key input to the appraisal framework. This involved a simplified modelling approach which estimates the delays to other motorists caused by the marginal vehicle, based on the observed and free-flow travel times. Comparing this approach with results from capacity restrained traffic assignment models for Auckland and Wellington (using a SATURN model) gave a satisfactory correspondence. The simplified modelling approach was used for all case studies.

Economic and financial appraisal

A framework based on cost-benefit analysis (CBA) principles was developed for appraising the economic and financial impacts of the case study options. The framework was designed to separate the financial impacts (costs) to public authorities from the economic impacts (benefits) to transport system users. The financial impacts were divided between three public authorities – the road authority, the PT authority and the (notional) P&R authority; while the economic impacts were shown separately for three main transport user groups – road (car) users, PT users and P&R users/mode switchers.

The main economic input parameters relate to the value of travel time savings, in particular commuter walking and waiting time, and average travel time savings for general traffic. The method also took into account vehicle operating cost changes, GHG emission changes, and crash cost changes. Parameter values used were consistent with those in the NZ Transport Agency's *Economic evaluation manual* (EEM) where applicable.

The case study appraisals were undertaken on an annualised basis, avoiding the need for forecasting future demand changes. Key economic performance measures derived were: (i) the net annualised value (annual equivalent of the net present value); and (ii) the ratio of annual benefits to annualised public costs, (benefit-cost ratio (government)) (BCR(G)). The benefit items were disaggregated into the three main transport user groups, as noted above.

Funding allocation framework

A funding allocation framework was developed to provide guidance on the allocation of the costs for any P&R investment project between the various parties concerned, ie the road authority, the PT authority and (notionally) a P&R authority. The key concept underlying this framework was that the various parties should contribute funding (to worthwhile projects) in the proportions to which they, and their users, benefit. This framework was subsequently applied to the various case studies to illustrate its application and implications in practical cases.

Case studies

Case study purpose and selection

The project undertook five 'real world' case studies of investments in providing additional P&R capacity. The main purposes of these case studies were to provide a focus for the development, testing and fine-tuning of the appraisal methodology, to demonstrate the methodology and to provide estimates of economic/financial performance in each case.

The five case studies involved the provision of additional P&R spaces at existing sites on the rapid/express PT networks in Auckland and Wellington: two sites were on the Auckland Northern Busway (Albany and Constellation Drive), three were on the Wellington rail network (Petone, Waterloo and Porirua). The schemes also differed in terms of alternative PT means of travel to the CBD; length of time since establishment, the extent to which employment opportunities focus on the regional CBD, and the extent to which alternative P&R sites are readily available.

Case study economic/financial appraisal results

The case study economic/financial appraisal derived total costs and benefits for each case study scheme, based on the specified number of additional spaces to be provided, and then converted these to values per additional space, to facilitate comparative analyses. Key findings on economic/financial performance for the 'typical' case study are summarised as follows.

Costs. The largest cost item was the capital costs (land and construction) to provide the additional P&R spaces. In all cases these annualised capital costs were around $1,000 pa/space (corresponding to a total capital cost of around $15,000/space). The second largest cost item was the P&R site operating/ maintenance costs at $450 pa/space.

Benefits. Road decongestion accounted for the great majority (around 80%) of total benefits for the two Auckland case studies. In Wellington, the road decongestion benefits accounted for only 11% to 23% of the total benefits, with benefits to P&R users dominating (80% to 92%).

Overall economic performance. For each of the five case studies, the BCR(G) results were substantially greater than 1.0. The two Auckland schemes (with the high decongestion benefits) had BCR(G) estimates of about 3.8 (Albany) and 3.3 (Constellation). The three Wellington schemes, with much lower decongestion benefits, had BCR estimates between 2.1 and 3.0. These results were not very sensitive to plausible changes in input and methodology assumptions.

Impacts by transport agency. Allocating costs and benefits by agency, the majority of costs were incurred by the (notional) P&R authority; and the P&R users received economic benefits which in most cases exceed these costs. The net costs to the PT authority (for providing additional services are less additional fare revenues received) were relatively small, as were any benefits to existing PT users (through service frequency changes). Road users were the major recipient of economic benefits (relating to decongestion), while the road authority would not incur significant costs.

Conclusions

The appraisal methodology developed and tested in the case studies was designed to provide the best possible estimates of the economic/financial performance of potential P&R schemes. Its strength is that it provides a transparent and flexible spreadsheet-based tool, which is relatively easy to use by the analyst, is very flexible (for 'what if' testing) and can be readily refined by the analyst as appropriate. Its parameter values are consistent with EEM parameter specifications.

A 'diversion rate' approach was used to estimate modal shifts based on market surveys of the 'next best alternative' means of travel by current P&R users. This approach has limitations - we had to assume that diversion rates surveyed for one site can be applied to other, broadly similar, sites, and it is probably only valid for relatively small increases in the number of spaces. The methodology is also weak in terms of assessing likely diversion of P&R users between adjacent sites as a result of capacity changes, although the diversion rate surveys do provide some relevant evidence. This is one area where more work is required.

A method was developed for estimating 'decongestion' benefits which was corridor (and time-of-day) specific, was simple to calculate and does not require separate transport model runs.

The case studies show that increasing P&R provision gives high returns relative to most other types of investment schemes that encourage modal shift to PT in major urban areas, with best estimates of the BCR(G) being in the range 2.1 to 3.8 (the full range of sensitivity tests undertaken widen this range to 1.7 to 4.3). These relatively high returns are not unexpected, given that P&R schemes are targeted at car owners and encourage mode switching at times and in situations where PT offers an attractive alternative and decongestion benefits are likely to be maximised.

Recommendations

The following project recommendations are intended to provide an enhanced basis for the appraisal of P&R policies, programmes and initiatives for major New Zealand centres:

1 Incorporate in the Transport Agency's EEM and/or Planning & Investment Knowledge Base (PIKB), specific procedures for demand modelling and economic appraisal of P&R capacity expansion initiatives. These would be based on the methodology that was developed and applied in this research.

2 Develop further guidance for analysts on methods to assess (i) decongestion benefits and (ii) road crash benefits, associated with marginal changes in traffic volumes (arising from PT, travel demand management and related initiatives), and to incorporate this guidance in the EEM and/or PIKB.

3 Auckland Transport and Greater Wellington Regional Council (and other New Zealand regional/local authorities as appropriate) to use the P&R appraisal methodology developed in this research for (i) appraisal of the demand, economic and financial implications of providing additional P&R spaces at specific sites; and (ii) appraisal of the case for and implications of charging for P&R spaces, both in general and in the context of specific corridors/areas/sites.

4 Auckland Transport and Greater Wellington Regional Council to give further consideration to the case for and approach to enhanced modelling of P&R relative to alternative modes, as part of the next major update (re-formulation and re-calibration) of the Auckland) and Wellington strategic models and associated sub-models.

5 Where significant new/expanded P&R facilities are introduced, relevant authorities may consider post-implementation market research with new P&R users, in particular on their changes in travel patterns and mode choice. These results can then be applied to refine future P&R appraisals.

Abstract

This research report investigated the economic and financial benefits from providing expanded park and ride (P&R) facilities. The project objectives were to assist decision-makers by providing guidance on:

- the rationale for investment in P&R, as a cost-effective and efficient means of improving state highway and local arterial road performance and/or reducing public transport subsidies
- methods for the economic and financial appraisal of P&R investments
- the process and necessary conditions for optimal P&R investment decisions to be made.'

The research included a review of international literature and New Zealand practice on quantification, assessment and evaluation methodologies for P&R facilities. The outcome of the research was an economic and financial evaluation framework adopting a cost-benefit analysis methodology. This framework was tested by applying it to five case studies covering both Auckland and Wellington for potential expansion of existing rail and bus-based P&R sites. The case studies demonstrated that increasing P&R provision produced high returns relative to most other types of investment schemes that encourage modal shift to PT in major urban areas, with estimated benefit-cost ratios in the range of 2 to 4.

1 Introduction

The following sections present an overview of the project including objectives, the phased approach to the project and the structure of this report.

1.1 Project overview

The **purpose of this research** was 'to advise in what circumstances is investing in park and ride (P&R) an economic and efficient way of improving:

- state highway and local arterial road performance, and
- reducing public transport (PT) operating subsidies.'

The **objectives** were to assist decision-makers by providing guidance on:

- the rationale for investment in P&R (as a cost-effective and efficient means of improving state highway and local arterial road performance and/or reducing PT subsidies)
- methods for the economic and financial appraisal of P&R investments
- the process and necessary conditions for optimal P&R investment decisions to be made.

Key aspects of the scope of this research were as follows:

- The primary focus was P&R facilities for rail and bus rapid transport services (in Auckland and Wellington, New Zealand).
- The potential shift from informal to formal P&R was considered in determining benefits.
- Journey times/distances for car and PT legs were considered in determining benefits.
- Changes to CBD parking costs and user charges for P&R were not considered.
- The focus was on the justification of individual P&R facilities, rather than development/justification of the overall P&R programme (the latter was excluded from the scope of this research).

1.2 Project phases

The project had four main phases:

- Phase 1: Completed September 2013 with the delivery of Working Paper 1, which set out the project's scope and methodology, including changes in response to peer reviewer and Steering Group feedback.
- Phase 2: Completed December 2013 with the delivery of Working Paper 2, which set out the findings of the international literature and New Zealand practice review as well as initial scoping of case studies and findings of market research carried out in Auckland and Wellington.
- Phase 3: Completed February 2014 with the delivery of Working Paper 3, which documented the development of the demand modelling, appraisal and funding framework for consideration of P&R schemes that seek to improve road network performance and/or reduce PT subsidies. This phase also recommended five sites for the case studies, which were subsequently refined following Steering Group feedback.
- Phase 4: Commenced early March 2014. This was the final phase of the project, involving the case studies, and the application of demand modelling, appraisal and funding frameworks and

development of recommendations to optimise P&R investment decisions. This phase is documented, in conjunction with findings from phases 1 to 3 of the study, in this report.

1.3 Report structure

This report is structured as follows:

- Chapter 2: New Zealand practice review – this summarises current New Zealand practice in two key areas: the planning and practical aspects of P&R and demand modelling focusing on P&R.
- Chapter 3: Demand modelling framework – this covers the international literature review, options for estimating modal choice including New Zealand market surveys that were undertaken to quantify potential travel behaviour change, and estimating the change in road traffic congestion associated with increased park and ride provision.
- Chapter 4: Economic and financial methodology– this addresses both economic and financial evaluation of changes in P&R provision, including road, PT and P&R users.
- Chapter 5: Funding allocation –this explores a methodology for allocation of funding between the public authority groups.
- Chapter 6: Case studies – this presents the five preferred case studies to which the evaluation framework was applied.
- Chapter 7: Application considerations – this presents considerations for applying the framework.
- Chapter 8: Conclusions – this brings together the findings from preceding chapters and summarises the overall conclusions and recommendations from this research project.

Further detail is provided in a series of appendices, as set out in the table of contents.

The glossary documenting abbreviations is provided in appendix A.

2 New Zealand practice review

2.1 Introduction

This chapter provides an overview of current New Zealand practice in the planning and delivery of P&R facilities and the approach to demand modelling in New Zealand. The focus in both cases is on Auckland and Wellington as these are the two main P&R regions in New Zealand (with their metro rail networks and Auckland busway) although P&R is also being actively considered in other parts of New Zealand including in and around Christchurch, Hamilton and Dunedin.

2.2 Planning and practice

This section looks specifically at planning and practice in New Zealand, focusing on current Auckland and Wellington practice regarding the planning and delivery of P&R facilities. The international literature is covered in subsequent chapters.

There have been previous reviews looking at P&R practice in New Zealand. Eight years ago Vincent (2007) carried out a review of P&R policies and experience, which also drew from Woods (2006) who interviewed P&R practitioners in Auckland, Wellington and Christchurch. This earlier work '…found general support and enthusiasm for P&R'. (Vincent 2007, p18), with P&R policies contained in relevant strategy documents and funding provided through council rates and Land Transport NZ (now NZ Transport Agency) contributions.

There have been significant legislative and organisational changes since these earlier studies, as well as changes to funding requirements and a new generation of transport policies/strategies[1]. We sent a questionnaire on current practices to councils in Auckland and Wellington and the NZ Transport Agency (the Transport Agency), with responses set out in appendix B.

Our findings in regards to current New Zealand practice are set out below. Overall, we found that P&R practice has not changed significantly since 2007, despite important legislative and organisational changes.

2.2.1 Roles and responsibilities

In New Zealand, P&R is generally considered part of the PT network. In most of New Zealand, regional councils are responsible for PT services and therefore by extension the planning, delivery, management and funding of P&R facilities.

In Wellington, the Greater Wellington Regional Council (GWRC) is responsible for P&R. The GWRC focus is rail-based P&R as evidenced by their proposed 'Park and ride capacity strategy' including the recent revision of the *Wellington regional rail plan 2010–2035* (GWRC 2013) which is soon to be adopted. We note that changes in legislation enable GWRC to own land for P&R facilities, when previously it could not.

In Wellington, the city and district councils are separate from the regional council and are responsible for local roading, including parking. Many of these councils have transport strategies and/or parking plans to help manage transport and demand for parking within their jurisdictions. However, in respect to P&R almost all city and district councils see their role as being 'advocates' for P&R in their area. The key

[1] Changes included the creation of the NZ Transport Agency from the merger of Transit NZ (responsible for state highways) and Land Transport NZ (responsible for funding), local government amalgamation in Auckland leading to the creation of Auckland Transport and Auckland Council and changes to transport legislation. Detailed consideration of these changes is outside the scope of this project.

exception is Wellington City Council, which, due to the regional council's focus on rail-related P&R, has 'by default' assumed a role in respect to bus-related P&R, most of which is informal on-street parking.

In Auckland, local government amalgamation has resulted in a single Auckland Council, with both PT and local roading functions delegated to Auckland Transport (AT), a council-controlled organisation. Auckland Council is responsible for the overarching strategic direction for the region, with objectives set out in *The Auckland plan* (Auckland Council 2012b). AT's role is to ensure P&R development is aligned with these objectives. AT sees P&R as an integrated part of the PT network and is actively pursuing P&R opportunities across all PT modes.

The Transport Agency is responsible for state highways throughout New Zealand, and for administrating the National Land Transport Fund. As state highway provider, the Transport Agency might take a lead role in providing P&R facilities that provide benefits to the state highway network but to date has provided more of a supporting role to regional council proposals.

As funder, the Transport Agency provides a share of funding (generally around 50%) to regional and local councils for transport-related activities including P&R and PT. In Wellington, P&R facilities are funded by the regional council with a contribution from the Transport Agency. With the potential exception of Wellington City Council (in respect to bus P&R) city and district councils do not currently fund P&R facilities. The situation is similar in Auckland, although in this case all funding for AT comes from Auckland Council and the Transport Agency.

Transport operators are generally not involved in P&R processes, except as stakeholders, and do not provide any direct funding.

2.2.2 Policies and objectives

There is general support for P&R across all councils and the Transport Agency, with P&R seen as an important component of the PT network. Objectives for P&R in both Auckland and Wellington include extending coverage of the PT network and reducing road congestion. Both regions have guidelines for the location and prioritisation of P&R facilities and require the consideration of other access modes including walking and cycling and bus feeder services. Appendix C provides a summary of key policies and objectives in Auckland and Wellington.

In Auckland there is a hierarchy of planning documents, including the proposed Auckland Unitary Plan which sets out planning rules, the regional land transport strategy (RLTS) and regional PT plan. These documents set a clear direction for P&R as part of a multi-modal PT system, although the Unitary Plan appears rather complex (the rules chapter alone is over 2,000 pages long).

In Wellington, P&R is largely treated as an extension of the rail network. P&R policies and objectives are set out in some detail in the *Wellington regional public transport plan 2011–21* (GWRC 2011) and the recent 2013 update of the *Wellington regional rail plan 2010–2035* (GWRC 2013). There is, however, little consideration of P&R in higher-level planning documents, with virtually no consideration of P&R within the planning rules (ie regional policy statement and district plans) and a single policy in the RLTS providing for the ongoing development and maintenance of P&R. Some city and district councils have transport strategies and/or parking policies that provide for P&R facilities – refer practice review questionnaire in appendix B for further details.

In the case of the Transport Agency, its objectives are set out in a statement of intent which provides for P&R under the PT infrastructure category. The Transport Agency manages its National Land Transport Programme (NLTP) investment, which includes P&R projects to deliver on the *Government policy statement* (GPS12) (MoT 2011). The Transport Agency's Highways and Network Operations (HNO) group, in particular, seeks to reduce severe congestion, improve travel time reliability and safety, and support the efficient movement of freight.

P&R facilities are primarily funded through rates and a Transport Agency funding share (usually 50% in both Auckland and Wellington). Both regions also include policies that enable charging for the use of P&R facilities but at present there is no charge in place. We note that P&R facilities generally have superior levels of service such as CCTV cameras and security patrols compared with on-street and other parking sites.

2.2.3 Evaluation methodologies

We have considered the evaluation methodologies used in Auckland and Wellington to justify investment in P&R. We found that both regions have policies and guidelines for identifying and prioritising P&R investment as part of a broader programme – refer policies in appendix C[2].

AT indicated (refer appendix B) that it uses a 'strategic planning principles' approach derived from best-practice comparable cities, which aligns with the *Auckland regional public transport plan 2013* (Auckland Transport 2013). The process includes:

- assessment of suitable locations
- demand modelling (refer modelling practice review in section 2.3)
- benefit-cost analysis
- business cases by site (likely).[3]

In Wellington, GWRC has 'asset prioritisation framework processes' that are used to identify opportunities to purchase appropriate land, at or below market valuation, with guidelines contained in the regional rail plan (GWRC 2013). Wellington City Council also, in considering bus-based P&R, indicated that it works with GWRC to survey actual and potential demand along key bus routes. Previous studies are used as background/ justification, with scheme options and indicative costings then being developed. Proposals would be included in the council's long-term plan for community consultation (refer decision making below).

Ultimately, all P&R projects are justified using the NZ Transport Agency (2013) *Economic evaluation manual* (EEM) evaluation procedures, which is a requirement for Transport Agency funding. The project would also need to meet the Transport Agency's strategic fit, effectiveness and efficiency (benefit-cost ratio (BCR)) criteria to receive funding from the National Land Transport Fund administered by the Transport Agency. Further consideration of investment decisions is out of scope of this research project, although evaluation methodologies are discussed in chapter 4.

2.2.4 Decision-making processes

The decision-making processes for the planning and delivery of P&R facilities are largely set out in the policies and objectives section above and the policy documents summarised in appendix C. In summary, the decision-making process is as follows:

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[2] Programme evaluation is outside the scope of this research project. We note that the Auckland Transport assessment of suitable locations and GWRC's 'assessment prioritisation framework processes' may warrant further investigation in regards to identify potential sites for further investigation as part of a P&R investment programme. There may also be benefit in considering these tools as inputs into the development of programme business cases for P&R, as a precursor to site specific business cases, in accordance with the Transport Agency's business case requirements that have recently been introduced.

[3] As required to meet the Transport Agency's business case requirements.

- At the highest level, P&R is prioritised along with other transport projects in each region's regional land transport plan (RLTP) (formerly called regional land transport programme). Whether projects are individually identified or not will depend on scale and cost, but irrespective of this, all transport funding is required to be identified in the RLTP.
- Councils are also required to identify all funding and expenditure in their long-term and annual plans, with funding often grouped with related activities (eg for maintenance activities). Significant and high-cost P&R projects might be identified individually.
- A detailed assessment is then undertaken and a funding application submitted to the Transport Agency for approval[4].
- The proposal agency, in most cases either GWRC or AT will then make a final decision as to whether to proceed or not. This is often delegated to the officer level.

We note that P&R proposals may also need to go through other local planning processes, eg to obtain resource consent and other approvals. In Wellington there are bylaws that might be invoked and we note that some P&R facilities in Auckland have designations. There are also often a number of parties involved in any P&R development, including the PT authority, land owners, rail network operator, other PT operators, road controlling authorities, etc. This is particularly the case in Wellington where there are separate regional and city/district councils.

2.2.5 Conclusions

The practice review identified little recent change in P&R practice, despite significant legislative and organisational changes. New Zealand practice differs somewhat between Wellington and Auckland, largely due to different local government structures. In Wellington, the GWRC is the PT authority and the primary P&R authority (with a focus on rail-based P&R), while local councils and the Transport Agency are road authorities, responsible for local/arterial roads and state highways respectively. In Auckland, AT comprises all three authorities (with a focus on P&R across all the modes), along with the Transport Agency as the road authority for state highways.

2.3 Demand modelling in New Zealand

2.3.1 Overview

The focus of this section is on demand models that estimate modal choice and how they consider/evaluate P&R as a travel choice option. Auckland and Wellington are considered as these are the two main P&R regions in New Zealand (with their metro rail networks and Auckland Busway).

2.3.2 Wellington strategic models

In Wellington, there are two strategic level transportation planning models maintained and operated by the GWRC.

The Wellington Transport Strategy Model (WTSM) is a conventional four-stage (trip generation, distribution, mode split and assignment) model built by Beca/SKM using 2001 Census data and specifically collected New Zealand Household Travel Survey data. The model was updated in 2011 by Opus/Arup in conjunction

[4] We note that going forward P&R proposals will be developed using the business case approach recently adopted by the Transport Agency.

with GWRC staff, and at the time of this research study, was being updated to 2013 by TDG, also with the support of GWRC.

The main inputs to WTSM are land use, in the form of population, households and employment by type and geographical area and the transport network including roads and PT infrastructure and operating patterns. The primary model outputs are travel patterns in the form of origin and destination (O-D) matrices for each mode of travel (car, PT and 'slow modes') and a coarse representation of route choice and network operating conditions (vehicles on each road, PT patronage by service and congested road speeds/travel times).

The model is used to inform transport strategy and policy decisions in the Wellington region, and also provide demand matrices to more detailed, lower-tiered traffic assignment models for analyses where the level of detail in the WTSM is not sufficient.

The WTSM has 225 internal model zones plus three external loading points. This is considered relatively coarse by today's standards.

The form of the mode split estimation in WTSM is a logit equation.

In addition to the WTSM, the Wellington Public Transport Model (WPTM) is part of the transportation modelling toolbox maintained by GWRC. The WPTM was developed by Opus/Arup alongside their update of the WTSM in 2011. It is a route choice PT model (ie primarily assignment but with a logit model for access mode choice) with observed demands based on interview surveys and ticket data. Forecast demands are created by 'pivoting' the observed demand using synthesised demands from the WTSM.

The WPTM has 780 zones, the higher level of detail typical in PT models to reflect the difference between walk-in and ride-in catchments.

2.3.3 Modelling park and ride in Wellington

In the WTSM, P&R is considered in the PT assignment (ie determining route choice) rather than as a mode option in the modal split/destination choice equations. P&R access to rail stations is controlled by special links called 'p-connectors'. These connect origin zones to nodes representing pseudo rail stations so that only rail trips (paths) are possible using these special links and nodes. Origin zones can be connected to more than one station using p-connectors. Volumes allocated to these p-connectors in the assignment include walk access, bus access, and P&R access. The proportion of the volume on the p-connector associated with P&R trips is calculated based on a function of the p-connector length[5]. This methodology does not consider the capacity of the P&R facility nor can it distinguish between on- and off-street parking. Not all stations are coded with p-connectors, hence the introduction of P&R can be modelled at stations that previously did not have such a facility by adding a p-connector and nodes for the pseudo station.

For the alternative to PT trips, the WTSM calculates the number of car trips and their travel times from the start to end of each journey. These congested road travel speeds are based on standard speed-volume relationships that are input to the model with link-based coding to represent intersection delays. The software used for the WTSM cannot model the full interaction at intersections hence this proxy coding is used instead. This is not inappropriate for a strategic model with a coarse level of geographic zoning.

In terms of strengths of modelling P&R in the WTSM:

- The WTSM is capable of reallocating trips between car for the entire journey to P&R access to rail (ie it has a main modal split response).

[5] For p-connector >5km: P&R demand = p-connector volume * 0.6

For p-connector <5km: P&R demand = p-connector volume * (-0.0176*distance^2+0.2027*distance)

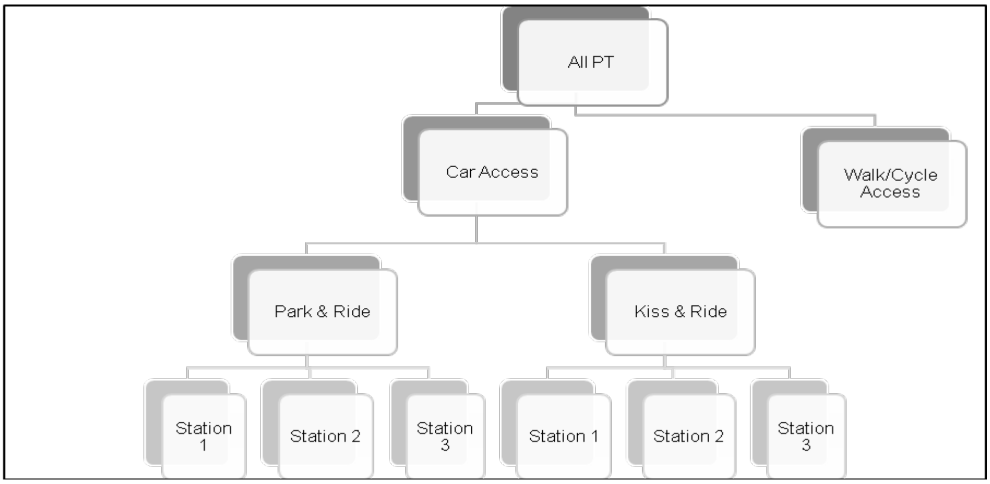
- The approach is a relatively straightforward mechanism for modelling complex travel behaviour.
- It is not complicated to incorporate P&R at other rail stations.

In terms of weaknesses:

- The set of zones connected to a P&R station (zones can connect to more than one station) via p-connectors is predetermined and specified in the input network coding. Hence the calculated P&R demand for a station can be affected by the predetermined inputs.
- There is also no feedback within the WTSM to modify network travel times resulting from station P&R choice or from increased travel times due to congestion on the network.
- The WTSM has a relatively coarse representation of travel times on the road network and hence a simplistic calculation of the road level of service.
- The model zoning is somewhat coarse and this will limit the features of P&R that can be evaluated. For example, multiple rail stations will lie within a single modelled zone, hence it would be difficult to reflect P&R capacities (for example) at two locations within a single zone.
- The forecasting ability of the model in terms of P&R utilisation is somewhat limited as the ability to use P&R is an input to the model (through the p-connectors and network coding).
- The equilibrium that might occur in reality in terms of choice of different P&R facilities based on capacity supply and demand will not be automatically reproduced in the model. Various model parameters could be adjusted to replicate this balance of supply and demand.

The WPTM has a more sophisticated mechanism for modelling P&R. WPTM uses a nested logit model to determine the access mode choice. The top level (see figure 2.1) of the choice hierarchy splits all PT trips based on the mode used to leave home (or origin), which is either walk or car. The second tier splits car trips into P&R and kiss and ride (K&R) trips. Lastly, the third level allocates P&R and K&R trips proportionally to the three best stations based on ‘utility’. The station utility function includes parameters such as parking cost and parking attractiveness, the latter a mechanism to ensure the model understands the relative capacity (ie small or large) of different P&R facilities.

Figure 2.1 WPTM choice structure



In terms of the strengths of modelling P&R in WPTM:

- The representation of P&R is more sophisticated in the WPTM than in the WTSM.

- Additional P&R capacity can be 'reflected' in the WPTM through the input parameters.

In terms of the weaknesses of modelling P&R in the WPTM:

- The WPTM cannot reallocate trips from using car for the entire trip to P&R followed by rail – there is no main modal split response.
- P&R capacity is not enforced in the WPTM (so more cars can P&R than the capacity of the station). While this may not be an issue where there is space for informal P&R on-street nearby, it does mean that the effect of a limited capacity cannot be reflected.

The WTSM and WPTM forecast travel patterns as a pair – with the WTSM using a crude mechanism to reflect P&R trips at the assignment stage of the four-stage model. While the WPTM adopts a more comprehensive approach to modelling P&R, it does not consider car journeys but reallocates PT trips, of which P&R is a subset.

2.3.4 Auckland strategic models

In Auckland, the strategic demand modelling tools are referred to as the AT Model (ATM2). The ATM2 is an integrated system of regional transport and land-use models developed for the Auckland Regional Council (ARC) by SKM Ltd in conjunction with Beca Infrastructure Ltd and David Simmonds Consultancy Ltd using 2006 Census data and specifically collected New Zealand Household Travel Survey data. The ATM2 consists of the Auckland Strategic Planning Model (ASP3) and the Auckland Regional Transport Model (ART3)

The ASP3 is a strategic land use model for medium- and long-term planning, scenario development and evaluation, and provides the necessary land-use inputs for transport modelling.

The ART3 is a conventional four-stage (trip generation, distribution, mode split and assignment) model with 512 zones covering the wider Auckland area and is used for medium-term project and policy planning and evaluation.

ART3 uses a logit equation to estimate modal choice.

Alongside the ATM2, the Auckland Passenger Transport Model (APT) is a separate, more detailed (905 zones) lower-tiered model, originally developed for ARC by Booz Allen and Hamilton (BAH) (2001 base year). The APT model is capable of evaluating a wide range of passenger transport projects in more detail than the ART3.

2.3.5 Modelling P&R in Auckland

In the ART3, P&R access to rail, bus and ferry is controlled by special links called 'p-connectors' in the PT assignment, similar to the approach in WTSM. These connect the P&R 'station' to the wider network, the catchment area of which has been predetermined from interview survey data. The catchment area in terms of model zones is hard-wired for each identified P&R station, and catchment zones can be linked to more than one P&R station. New P&R stations can be added but the catchment zones need to be predetermined and hence can affect the result. The p-connectors operate inbound only in the AM peak and outbound only in the PM peak. In the interpeak the p-connectors operate two-way but only p-connectors with a distance less than 1.2km are used. These conditions were based on findings from the Public Transport Interview Survey data. The access time on p-connectors is calculated using four different equations depending on whether rail or bus/ferry is being accessed and whether the distance is less than or greater than 3km. The four equations were derived from analysis of observed trip/mode/distance data. The access times are hard-wired and hence cannot dynamically reflect the change in network access time or the change in access mode split (on which the access time equations were based).

The APT is a PT generation, sub-mode split and assignment model. Base year demands have been derived from observed survey data and future estimates of travel are produced via growth factors, network changes and through a 'pivot point' calculation. The pivot point calculation combines observed base year PT (plus walk) demand with changes in road costs from ART3 to forecast the change in PT trips. The catchment zones for P&R stations are predetermined. Zones within 1km are excluded and zones can be connected to more than one station. The car travel cost from origin zone to P&R zone is extracted directly from the network with link times taken from the ART3. Initially only rail and ferry were considered as P&R locations, but this has been extended to cover the Northern Busway. New P&R sites require a new zone to be added and the catchment zones to be specified. Also, there is the issue of pivoting (factoring) zones with zero trips in the base matrix when changes in access connections and/or generalised cost occur. In such situations the number of trips needs to be manually estimated or similar/adjacent zone data can be replicated. A similar issue occurs where zones have low PT mode split and large changes in generalised cost as the true response may lie outside the calibrated range of the model.

The strategic transport models in Auckland are almost identical in form and function to those in Wellington (as they were developed by the same consultants). The strengths and weaknesses listed under Wellington therefore similarly apply to Auckland.

2.3.6 Summary of demand modelling in New Zealand

Forecasts of travel demand by mode are produced in Auckland and Wellington through the application of strategic travel models, the ART3 and WTSM respectively. Both of these consider P&R during the assignment of travel volumes to the networks and not as a main mode or sub-mode in the modal choice procedure. This is appropriate for a strategic level transport model, but does mean that the choice of P&R as a mode is assessed at a very high level of detail.

Based on the current structures of the Auckland and Wellington strategic travel models, it was concluded that for this project, the strategic travel models would not be sensitive enough to estimate usage of P&R for the case studies. Instead, diversion modelling would be applied to assess modal shift as it would be more responsive/robust and there is sufficient data available (from New Zealand market surveys described in section 3.3.2).

One of the project outputs is recommendations for enhanced P&R module(s) that can subsequently be incorporated in the relevant Auckland and/or Wellington regional models, for ongoing use for demand modelling and the assessment of P&R. This is addressed following the summary of the international literature review in section 3.2.2.

3 Demand modelling framework

3.1 Introduction

This chapter sets out the development of an 'approach to demand modelling, based on modelling tools/resources likely to be available to the relevant agency'.

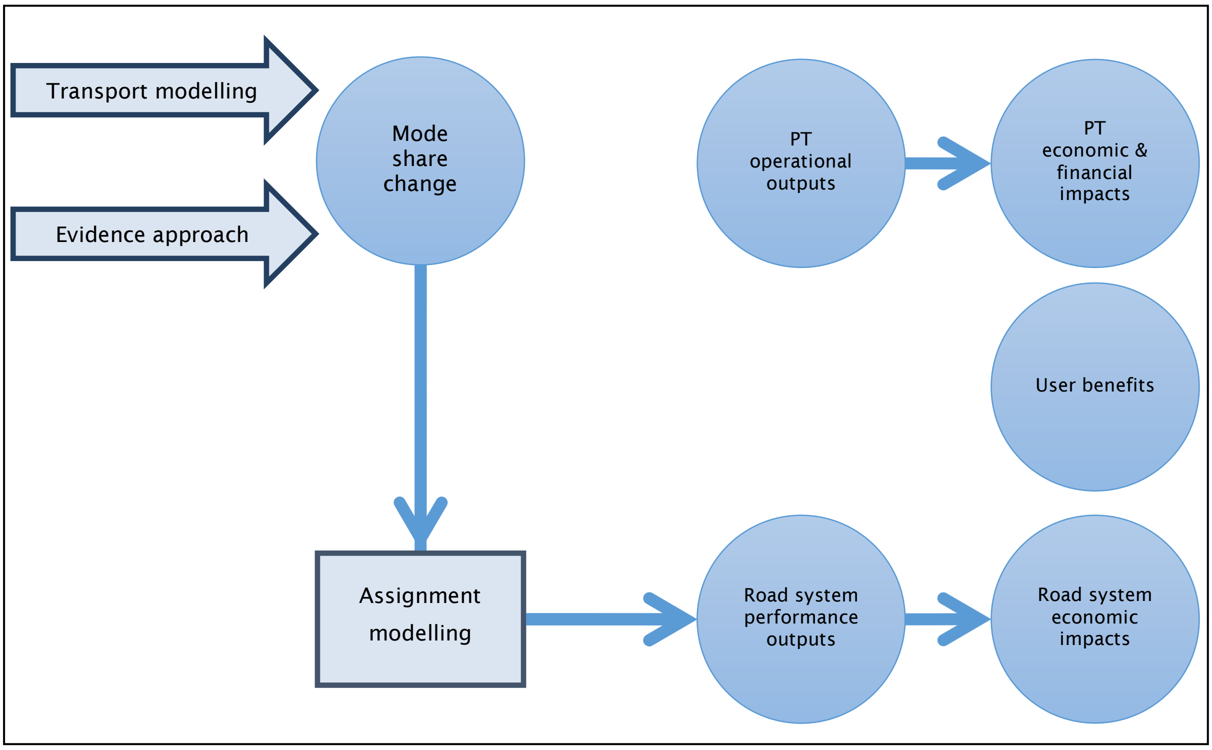
The demand modelling components are twofold and include:

1. Mode share assessment – to what extent does changing variables around P&R, such as location and journey time affect mode choice and resulting mode shares, reflecting the limited route choices generally available in Wellington and Auckland.
2. Road system performance outputs – what are the effects on the road network performance from changes in traffic levels associated with a change in P&R provision. This is quantified through the application of road traffic models that reflect queuing using capacity-restraint techniques.

For the mode share assessment, there are two possible approaches: formal/traditional demand models or an evidence-based approach based on diversion rates. Both were considered in this research project. The functionality and capability of the traditional demand models currently available in Auckland and Wellington and their application for the assessment of the impact of P&R is discussed in section 2.3 in terms of New Zealand practice. This is contrasted with the international approach to formal modelling.

A further consideration is that the demand modelling is interlinked with the economic and financial appraisal framework, and with the inputs to the appraisal output by the demand assessment. The illustration of the modelling framework and the economic and financial appraisal is shown in figure 3.1.

Figure 3.1 Demand, economic and financial framework



The other elements shown in figure 3.1 (PT operational outputs; PT economic and financial impacts, user benefits and road system economic impacts) are addressed in chapter 4 of this report.

This chapter on demand modelling includes:

- formal demand modelling – key findings from the review of international literature are presented followed by conclusions that focus on applicability to the New Zealand context (section 3.2)
- diversion rate approaches – a summary of findings from the review of international literature is provided, including outputs from New Zealand market surveys undertaken specifically for this study. This section concludes with a recommended approach for this project (section 3.3)
- road system performance outputs – discusses benefits derived from increased P&R provision quantified from existing traffic models in the form of reduced road congestion (travel time savings) (section 3.4)
- conclusions and recommendations (section 3.5).

3.2 Formal demand modelling – literature and practice review

The review of international practices identified a number of possible modelling processes that might deliver improvements to the current modelling of P&R facilities. A review of this literature is provided in appendix D.

Most detailed overseas regional models that include P&R use methods of analysis involving mode choice based on a logit equation formulation. Nested logit mode choice models are typically employed. However, there are instances where a combination of nested and multinomial logit models has been used to differentiate between mode choices for different trip purposes. The Brisbane Strategic Transport Model, in particular, highlights that for home-based work purposes a nested logit model is needed, whereas all other trip purposes are better represented with a multinomial logit model.

Most models reinforce the need to detail the residential catchment areas for each of the P&R locations, as well as the commercial destinations served by the PT services available from each P&R location. This is seen as necessary to avoid illogical trip paths in the model, although in reality some of these ‘illogical’ trips probably do occur. Catchments are already input into both the Wellington and Auckland models; however, they may not currently be specified robustly or consistently. Holguín-Veras et al (2012), in their paper on user rationality and optimal P&R location, detail a methodology to determine the P&R catchments, finding that these catchments are approximately parabolic in shape with their size determined by the quality of service provided at each P&R location. The P&R site is at the focus of the parabola and the long axis of the parabola extends upstream from the site. The size and shape of the parabola are dependent on the break-even boundary for motorists between their generalised costs for driving all the way to their destination and their equivalent costs for driving to the optimum P&R site and then continuing their journey by PT. Such analyses have resulted in a unique catchment for each P&R site based on the level of service provided by each facility. Illustrations of typical catchment areas are included in Holguín-Veras et al (2012) and Vincent (2007).

Several of the papers detail the process of using logit models to determine the choice between different station alternatives given the level of service associated with both the car access and the train legs represented. The level of service for each station is usually some utility function which includes parameters such as parking cost and parking attractiveness etc – the WPTM currently has a similar approach with utilities and logit formulation to determine mode of access to each station. In general, the research indicated the use of an iterative process to determine the best station alternatives. The number of alternative stations used in the analysis varied slightly but appeared to involve determining the number of stations that capture approximately 88% of all P&R and K&R trips. It was found that this capture rate could be achieved by including five stations in the analysis process.

Several papers also describe an iterative process for determining the choice between station alternatives that take into account the potential for creating overcapacity station parking lots. The systems proposed in some papers were based on the standard station choice process but included a check to ensure no station was overcapacity. If some facilities were found to be overcapacity, an additional impedance was imposed to redirect sufficient trips to other facilities. The iterative process continued until no overcapacity facilities existed or at very least to a position where the parking capacity constraints in the model were violated as little as possible. The Vancouver EMME/2 model uses a combination of the matrix convolutions module in EMME/2 and shadow pricing to achieve this. This process was found to improve the fit of modelled versus observed PT flows at locations where P&R facilities exist. In Wellington, where informal on-street parking is observed, this capacity could be included for the site, with a realistic cap on the distance from the station at which people would consider informal P&R a viable choice.

An analysis of the Sydney Household Travel Survey by Ho and Mulley (2012) indicated that the importance of joint household travel arrangements might be significantly underestimated in current PT models. These intra-household interactions in household activity and travel arrangements were found to account for more than 50% of weekday home-based tours in Sydney. The decision to undertake joint household travel was found to be driven by the unavailability of household cars for all household drivers and other social constraints (ie very young children who cannot stay home alone). An important distinction was made between car-sufficient households (where there are at least as many cars in the household as licence holders) and car-negotiating households (households with fewer cars than licence holders).

The paper has a number of significant findings that affect the use of PT services in general, and P&R facilities in particular. It found that car-negotiating households had a significant propensity for making PT tours involving drop-off/pick-up, indicating that limited car availability was a motivation for shared ride arrangements. It also found that for trip tours involving drop-offs, the drop-off provider from car-negotiating households was more likely to continue to use the car than to also use PT. Licence holders were highly unlikely to undertake both drop-off and pick-up in one car tour. Instead the licence holder was more likely to return home in between the rides and therefore form two separate tours. Members of high-income households were less likely to make fully joint tours by PT but were more likely to generate PT tours with shared rides to/from home.

Ho and Mulley (2012) proposed that policies aiming to increase PT use for commuting journeys through financial incentives would not significantly move workers out of their cars if they had to make a drop-off/pick-up of their children en route to/from work as part of their trip tour. Significantly, they found that for a scenario with lower fares for PT, a model incorporating joint household travel would show a lower modal shift from car to PT than a model without joint household travel. They proposed that this was because using a household car for joint household travel was still cheaper than using PT and so the effect of a lower fare policy on PT use would only apply to individual travel.

PT models in New Zealand do not usually involve trip tours and therefore the information provided by Ho and Mulley (2012) may not be easily incorporated into existing New Zealand models. However, it is clear from the Sydney analysis that the inclusion of joint household trips into the modelling process may make a major difference to the number of P&R trips included in PT analyses.

3.2.1 Key conclusions

One of the project outputs was a recommendation for enhanced P&R module(s) that could subsequently be incorporated in the relevant Auckland and/or Wellington regional models, for ongoing use for the demand modelling and assessment of P&R. The review of formal modelling at the strategic level in the international arena indicated that P&R is generally incorporated as an option in the modal choice model utilising a logit equation (nested or multinomial).

Both the Auckland and Wellington strategic travel models, ART3 and WTSM, utilise logit equations for modal choice and hence P&R could be included in the choice options. This would require observed travel data (which may have been collected through the household travel survey that was specifically commissioned for the model builds), the re-estimation (calibration) of the logit mode choice equations and revalidation of the full model. This is a significant task and should be considered during the rebuild of the models, which generally occurs every 10 to 15 years. The WTSM was constructed from travel behaviour data collected in 2001, and hence is likely to be rebuilt in 2018 (aligning with the national Census). The ART3 was built from 2006 travel behaviour data and therefore is unlikely to be rebuilt prior to the 2023 Census.

The ability to reflect road congestion and the choice of car for the complete journey compared with P&R and PT should also be considered. This may require a significantly refined level of model zoning, a greater sample of household travel survey data to support the more detailed zoning, and more sophisticated reflection of the road transport network including intersection delays. These issues would generally be considered and addressed during the ‘model specification’ stage of a strategic model rebuilt project.

Modal shifts from (relatively) small changes in P&R provision were evaluated (at least at a conceptual level) in this research project. Based on the strategic nature of the current Auckland and Wellington travel models, it was concluded that for this project diversion modelling would be applied to assess modal shift. Diversion modelling is more responsive and robust; and there is sufficient data available from New Zealand market surveys. This was applied in combination with standard road traffic assignment modelling tools to assess changes in road congestion levels.

3.3 Diversion rates – empirical evidence and project methodology

3.3.1 Diversion rates – empirical evidence

An alternative to the more formal approaches for modelling P&R is to apply a ‘diversion rate’ approach. In order to do this, empirical evidence is examined to gauge the likely diversion under different circumstances.

Two types of questions relating to alternative means of travel for users of P&R sites are commonly covered in market research work:

- What was your means of making this trip prior to the introduction/expansion of this P&R facility? (for new/expanded P&R sites)
- How would you make this trip if this facility were no longer available (temporarily or permanently)? (for established sites).

While, on initial consideration, it might be expected that the responses to both these questions would be very similar, this is often not the case in practice for valid reasons (eg people often modify their opinions after experiencing a new situation). This section summarises the evidence on questions of both these types.

3.3.1.1 Bus P&R – UK/EU

In terms of bus P&R, the UK has the most extensive evidence of all countries. Evidence on prior modes of transport of P&R users from 12 English surveys (nine cities) found that on average, prior modes were 61% car (driver), 21% PT, 18% other[6] (Hamer 2009). Details are provided in appendix E, section E3.

Results for prior mode trips from an analysis of 69 European (including UK) P&R sites showed broadly similar results: on average 70% were car (driver), 23% were PT (but including some active mode users and informal P&R users), 7% were 'unknown' and 'no trip' (Zijlstra et al 2013). Details are provided in appendix E.

In terms of evidence on the 'next best alternative' (NBA) if the P&R facility were no longer available, the UK mode proportions appear very similar to those for prior modes. Studies in three English cities (York, Oxford, Bristol) and in Scotland all gave results for NBA (main) modes for car between 54% and 63% (one study gave 70% for weekend travel) and for PT between 16% and 40%. In addition, figures for 'would not make trip' and 'would make an alternative trip' were significant, at between 6% and 13% (details in appendix E).

One UK study has compared results, for the same cities, for prior modes and NBA modes, focusing on PT mode shares only. The results are summarised in table 3.1. While this evidence is rather mixed, on balance it indicates that, following experience with P&R, its users are rather more favourably inclined to use PT than prior to this experience.

It should also be noted that, for people without an available car, alterative (prior/NBA) travel behaviour differs markedly according to trip purpose. For work/education trips, people are much more likely to travel by PT (or cycle); whereas for shopping trips they would be very likely to travel elsewhere or not make the trip (Parkhurst 1995).

Table 3.1 Change in perceived attractiveness of PT services following experience of P&R (Parkhurst 2001)

City	No. sites surveyed and opening date(s)	Previously used PT (%)	PT as stated alternative (%)
York	1 (1990)	19	35
York	1 (1990)	26/13	24/9
York	3 (1990–1995)	15	26
Oxford	4 (1973–1985)	36/35	31/20
Chester	1 (1992)	13	14
Brighton	1 (1991)	18	41
Cambridge	4 (1993–1997)	10	24
Coventry	1 (1991)	17	21
Norwich	3 (1991–1997)	24	29
Plymouth	2 (1992–1993)	14	32
Reading	1 (1997)	28	31
Shrewsbury	3 (1992–1995)	15	18

Note: Where two numbers are given, these relate to two different surveys.

3.3.1.2 Bus P&R – USA

Whereas most of the UK/EU bus P&R schemes listed in table 3.1 involve dedicated P&R buses operating on-street in mixed traffic (mostly in medium-size towns), most of the USA schemes involve dedicated buses

[6] The 'other' category includes people who did not previously make the same (or similar) trip. Excluding these, the stated car (driver) and PT percentage would increase.

operating on freeways or dedicated busways, mostly in the larger cities (ie more analogous to the Auckland Northern Busway P&R situation).

One study of prior modes for USA bus-based schemes found that, on average over nine cities, prior modes were driver alone 52%, car pool 13%, PT 21%, 'other' 2%, did not make equivalent trip 13% (quoted in Hamer 2009). A second USA study (probably with some overlap with the first) found prior modes were, on average: driver alone 49%, car pool 23%, PT 10%, no equivalent trip 15%.

3.3.1.3 Rail – UK/EU

While most of the bus-based schemes examined essentially comprise both a P&R facility plus dedicated P&R bus services, rail-based schemes essentially involve car parking facilities at (generally) existing rail stations, served by pre-existing train services.

The UK/EU data for rail P&R is rather limited and needs careful interpretation:

- A European study of 22 'satellite' (outside major cities) rail P&R facilities found that prior main modes were: car 35%, PT 56% (including 11% 'informal' P&R users), no similar trip or unknown 9% (refer appendix E).
- A survey of two Netherlands cities (Rotterdam, The Hague) found that NBAs for the main mode were: car 23%/19%, PT 31/37%, informal P&R –/20%, other access modes to rail –/17%, alternative or no similar trip 39%/2% (Mingardo 2013). Details are provided in appendix E.
- A Scottish study of prior modes for new users of the surveyed station indicated prior main modes as car 26%, other rail stations/routes 34%, bus 18%, other 22%. For continuing rail users of the station, the main change was from parking off-site to using the station car park; in addition, small proportions of these users changed their access modes from walk, bus or getting a lift to driving/parking (refer appendix E).

3.3.1.4 Rail – USA

USA evidence on prior behaviour relating to P&R for suburban rail systems is available for four cities – Philadelphia, Washington DC, San Francisco and Chicago. On average, this shows the following prior mode shares: driver alone 29%, car pool 13%, PT c.38%, other/did not make similar trip c.32%.

3.3.1.5 Summary

While there is considerable variation in the estimates, overall the evidence indicates that:

- For bus-based P&R, car would be the dominant prior mode, accounting for 60%–65% of prior travel by P&R users, in both UK/EU and USA. PT accounts for 20%–25% of prior travel. This indicates a relatively high level of 'success', if the objective is to attract people who would otherwise/ previously have made their full trip by car, and not to attract many people to P&R who were previously PT users for their full trip. There is no clear difference between these results for UK/EU and USA.
- For rail-based P&R, the proportion of P&R users attracted from car is lower at 20%–40%, P&R users attracted from PT is higher at around 30%–60%. It is unclear, given the limited data available, whether there are significant differences between these mode shares in UK/EU and USA.

We are not aware of any research studies that explored the factors influencing these different alternative/prior mode patterns for the two modes. We would hypothesise that:

- Bus P&R typically portrays a significantly different image and level of service than 'normal' bus services, particularly pitched at car users. It appears to be relatively successful at attracting this segment.

- Rail P&R is not seen as a separate product from 'normal' rail (unlike bus P&R relative to 'normal' bus), rather just a marginal variation, and therefore P&R provision does not have the same additional propensity to attract car users.

3.3.2 Overall impacts on vehicle kilometres travelled

The previous section summarised the international evidence on the impacts of P&R schemes (bus-based and rail-based) on mode shares, on both a 'prior' basis and a 'next best alternative' basis. Such information can provide a starting point for estimating the net effects of P&R schemes on overall vehicle kilometres travelled (VKT), which can then be used to estimate changes in vehicle operating costs (VOC), fuel consumption and greenhouse gas (CO2) emissions. However, the estimation of VKT impacts is not straightforward, and allowance needs to be made for the complex changes in travel behaviour with/without a P&R scheme. This requires data on the pattern of P&R user origins and destinations, and desirably (but often not in practice) should make allowances for (i) any differences in O-D patterns with/without the P&R scheme (eg changes in trip destinations); and (ii) any 'induced' trips associated with the P&R scheme.

Only a few attempts have been made internationally to make such assessments of VKT impacts: the main research contributions on this topic, for UK/EU situations, are outlined in appendix E.

The main findings are as follows.

3.3.2.1 Bus P&R schemes

UK research (Parkhurst 2000) on bus-based schemes in eight English towns/cities (including several historic towns) estimated net changes in car-equivalent VKT, taking account of the effects of: (i) changes in car VKT by former car drivers who switched to P&R; (ii) additional car VKT by former PT travellers who switched to P&R; and (iii) additional bus VKT associated with the P&R bus services. For all eight towns/cities net increases in VKT were estimated, in the range 0.9km to 20.7km per car parked (per round trip), with an unweighted average of 7.3km. Even if the contribution of the additional bus travel were ignored (as might be appropriate for a scheme making use of existing bus services), there would have been overall increases in five of the eight towns/cities and the unweighted average increase would have reduced to 3.1km.

EU research (Zijlstra et al 2013) into P&R schemes in Western Europe found, on average, an increase in car kilometres of 1.6km (per day per parking space). Broadly this average was made up of a 2.1km VKT reduction for people switching from direct car travel, more than offset by an average increase of 3.7km for people switching from direct PT travel. No allowance is included in these figures for any changes in bus VKT.[7]

There is insufficient definition available to fully reconcile Parkhurst's estimates with Zijlstra's estimates for VKT changes (per car parked). However, excluding the VKT contribution of P&R bus services, the differences are not large, with Zijlstra's unweighted average increase of 1.6km compared with Parkhurst's increase of 3.1km.

3.3.2.2 Rail P&R schemes

Zijlstra also examined the evidence on VKT impacts for a sample of western European rail-based ('satellite') P&R schemes, using data on prior mode shares.

In this case, he estimated an average reduction in VKT of 4.0km (per P&R space per day). This resulted from an average reduction of 7.3km for people attracted from car (much greater than in the bus case), partly offset by an average increase of 3.3km (similar to the bus case) for people attracted from PT.

[7] It is unclear from Zijlstra's paper to what extent the schemes examined involved increases in bus VKT, although this effect is undoubtedly significant (a proportion of the schemes were those also assessed by Parkhurst 2000).

The much higher figure for people attracted from car reflects the much longer trip lengths for use of rail 'satellite' P&R schemes and the high proportion of their trip distances switching to PT – relative to the bus users with shorter trip distances and the comparatively small part of that distance transferred to PT.

We expect this result would be typical of most rail-based P&R schemes – as long as they encourage travellers to transfer to P&R relatively close to their trip origin.

3.3.2.3 Summary

In summary, we conclude:

- It should not be assumed that all P&R schemes will result in net reductions in VKT, fuel consumption and hence GHG (CO2) emissions – even though such reductions may be the primary objective of many schemes.
- The impacts on these factors will depend principally on (i) the NBA mode shares (principally car vs PT); and (ii) the location of the P&R site relative to the total O-D trip of those using the site.
- For rail-based schemes, with P&R 'satellite' sites relatively close to trip origins, net reductions in VKT would normally be expected (the rail-based P&R schemes in the Wellington region are essentially of this type).
- For bus-based schemes, the conclusions tend to be much less favourable. Based on the UK and EU evidence, in the case of P&R sites relatively close to the main (CBD) destination area, increases in car VKT appear to have occurred in most cases. For such cases, any negative impact will be made worse to the extent that additional bus services are introduced to serve the P&R facility.
- However, most of the (relatively few) bus-based schemes in New Zealand are not of this type. The Albany scheme would appear to intercept a relatively large proportion of people who would otherwise drive all the way (appendix H, table H.3) at a relatively early stage in their journey – and in that sense is more typical of rail-based schemes.
- Detailed case-by-case analyses would be necessary to derive reasonably robust estimates of VKT impacts.

3.3.3 Project methodology

As concluded above, diversion rates were applied in this project to quantify modal shift associated with enhanced provision of P&R facilities (instead of formal modelling).

Table 3.2 provides a summary of the key groups of evidence on P&R 'diversion rates'. This brings together the international evidence for bus and rail P&R schemes (summarised in appendix E) with New Zealand evidence. Local behavioural sensitivities were determined by undertaking surveys with primary market research into the P&R market in Wellington (Waterloo and Petone stations) and Auckland (Albany station on the Northern Busway). The focus of these surveys was to explore the likely alternative behaviour of current P&R users (car drivers) if P&R at these sites was more restricted or not available:

- For the Wellington survey, people were asked about likely alternative means of travel (NBA), if they could not get a space in the P&R car parks.
- For the Auckland survey, people were asked about how they used to make their trip before the Albany P&R parking spaces were increased (in mid-2012).

Details of the surveys and the results are given in appendix F for Wellington and appendix G for Auckland, with the findings collated and summarised in appendix H.

We gratefully acknowledge the funding contributions made for these two surveys by AT and GWRC.

The summary in table 3.2 covers evidence on both prior modes of P&R users and NBA modes if the P&R option were not available on a semi-permanent basis.[8]

The table is intended to provide a basis for examining if any generalisations may be made on diversion rates for different P&R scheme types, in a range of situations, in order to define a set(s) of diversion rates for use in the various case studies. Key points from the table include:

- It focuses on diversion rates that would apply, where evidence is available, to the provision of additional P&R spaces (as was the focus of the study surveys); where this is not possible, it uses evidence on diversion rates for all (not just new/potential) P&R users, as this is what is available in most cases.
- It considers together diversion rate evidence on (i) prior modes (before the introduction of P&R spaces), and (ii) next best alternative modes (if P&R spaces were to be cut back, on a semi-permanent basis).
- It relates to main (line haul) modes only.
- It separates P&R schemes into two types:
  - A: The PT services exist independently of the P&R transfer facilities; the P&R initiative comprises provision of the station parking etc facilities (with augmentation of the existing PT services to provide sufficient capacity). Most/all rail-based P&R schemes are of this type (including in Auckland/Wellington), as is the Auckland Northern Busway scheme.
  - B: The P&R initiative comprises a dedicated PT service together with P&R transfer facilities, ie the service is an integral part of the P&R scheme and would not exist independently. The bus-based schemes in the UK, EU and USA are mostly of this type.
- There are substantial difficulties in comparing the market impacts of these two types of schemes: the comparisons involve for type A just P&R transfer facilities added to an existing service and for type B a (new) service together with P&R transfer facilities; For type A schemes, unsurprisingly the prior/NBA mode for most P&R users would be the same PT service; whereas for type B schemes, the service would not exist independently of the scheme, and hence prior/NBA PT mode shares are likely to be substantially lower.
- In an attempt to make comparisons between the diversion rate estimates for the two types of schemes, for the two New Zealand schemes (which are type A), we provide two sets of diversion rates: set (1) based on all incremental P&R users; and set (2) based on only the sub-set of these users that change their main (line haul) mode[9]. In comparison with other (type B in particular) schemes, set (1) estimates would be expected to give low proportions for car as the main mode; whereas set (2) estimates would give high proportions (and conversely for PT mode shares).

The most relevant features of the results in table 3.2 include the following:

[8] There is no reason why the prior mode responses and the NBA responses should be identical. In practice, they appear to be broadly similar, although with some tendency (from UK evidence) for the NBA responses to involve a greater PT mode share than the prior responses.

[9] Detailed figures for the New Zealand surveys taken from table H.3: the whole table relates to incremental P&R users; the sub-set that changed their main (line haul) mode are given in the top section of this table.

- For the type B schemes (which are all bus-based), there is a reasonable consistency in prior/NBA mode shares across the UK, EU and USA schemes. Car driver shares (including car passenger) where separately identified) are in the range of 60%–70%.[10]
- Correspondingly, the PT mode shares are generally in the range of 10%–30% (typically around 20%).
- Thus, in the case of type B schemes, involving dedicated PT services, the abstraction ratios for main modes are around 3:1 for car:PT. This appears to be a fairly consistent result across most type B schemes.
- For the type A schemes, the results are more difficult to interpret, particularly given that (i) it is unclear whether the EU and USA rail data are calculated on the set (1) or set (2) basis (we have assumed in the following that they adopt the set (1) basis); and (ii) the Auckland Northern Busway scheme is the only type A bus-based scheme in our dataset, so there are no close comparators.
- The set (1) car driver (with/without car passenger) proportions are in the range of 12%–35%, ie considerably lower than those for the type B schemes; while the set (2) proportions, at around 70%, are close to but on the high side of the type B estimates. This pattern of results is as expected.
- Conversely, the set (1) PT proportions are in the range of 40%–80%, much higher than for the type B schemes: while the set (2) proportions (where available) are in the range of 15%–30%, ie close to the proportions for the type B schemes.
- The set (2) data is of most relevance to the incremental main mode effects of increasing P&R supply. On this data, the abstraction ratio from car to that from other PT services is about 5:1 for the Hutt rail data, about 2:1 for the Northern Busway data. (The high rate for the Hutt rail services most likely reflects the limited bus services available, especially from the Waterloo area, as an alternative to the train services.)

Given the above findings and the difficulties in comparing the international data and situations with Wellington and Auckland, for the case studies we decided to adopt the following approach to diversion rates:

- for the Wellington rail cases, based on the Wellington data given in table 3.2 with possible adjustments according to the individual case study situation (eg taking account of alternative bus services)[11]
- for the Auckland Northern Busway cases, based on the Auckland (Albany P&R) data given in the table.

[10] The treatment of car passengers is unclear in many studies – they may or may not be included with car drivers or within the 'other' category.

[11] We note that the two Hutt line surveys (Waterloo and Petone) gave generally very similar NBA results, but with some differences relating to mode shares on alternative bus services.

Table 3.2 Summary of main mode alternatives evidence if no/reduced P&R (% of P&R users)

Mode/region	Car driver	Car passenger	RT	PT other	Other	Sources
TYPE B SCHEMES (DEDICATED PT SERVICES)						
RT – bus: USA prior	52%–49%	13%–23%	0%	21%–10%	15%–15%	Prior (i) Hamer 2009 etc – 9 cities; (ii) TCRP – 300 P&R sites
NBA	n/a	n/a	0%	n/a	n/a	
P&R – bus: EU prior	70%	?	0%	22%	8%	Prior: Zijlstra 2013 – 69 urban fringe sites
NBA	n/a	n/a	0%	n/a	n/a	
P&R – bus: UK prior	61%	?	0%	21%	18%	Prior: Hamer 2009 – 12 city surveys, average
NBA	46%–59%	?	0%	28%–19%	15%–14%	
TYPE (A) SCHEMES (EXISTING PT SERVICES)						
RT – rail: EU prior 1	35%	?	45%	?	20%	Prior: Zijlstra 2013 – 22 satellite sites
NBA 1	20%	?	70%	?	5%	NBA: Mingardo 2013 – Netherlands
RT – rail: USA prior 1	29%	13%	40%	?	c.20%	Prior: Hamer 2009 etc – 4 metro rail systems
NBA 1	n/a	n/a	n/a	?	n/a	
RT– rail: NZ (WGN) prior	n/a	n/a	n/a	n/a	n/a	NBA: Study surveys (Waterloo, Petone). Figures relate to 'new' P&R users
NBA 1	12%	3%	80%	3%	2%	
NBA 2	60%	15%	–	15%	10%	
RT – bus: NZ (AKL) prior 1	33%	1%	50%	16%	–	Prior: Study survey (Albany). Figures relate to 'new' P&R users
prior 2	66%	2%	–	32%	–	
NBA	n/a	n/a	n/a	n/a	n/a	

Note: RT = rapid transit; NBA = next best alternative

3.4 Road system performance outputs

3.4.1 Formal modelling

A component of the project was to estimate the effects of increased P&R provision on the performance of the road system(s), particularly in the affected corridors. This was a challenging task because increased P&R provision was likely to result in only relatively small changes in total road traffic in the corridor in question. Therefore traffic modelling methods utilising platforms that represent bottlenecks (by incorporating capacity restraint) were chosen for this task.

We used SATURN[12] models that were available for the Auckland Northern Corridor (SH1) and the Wellington Hutt Corridor (SH2), and applied these to produce a simple relationship which could then be applied to the case studies.

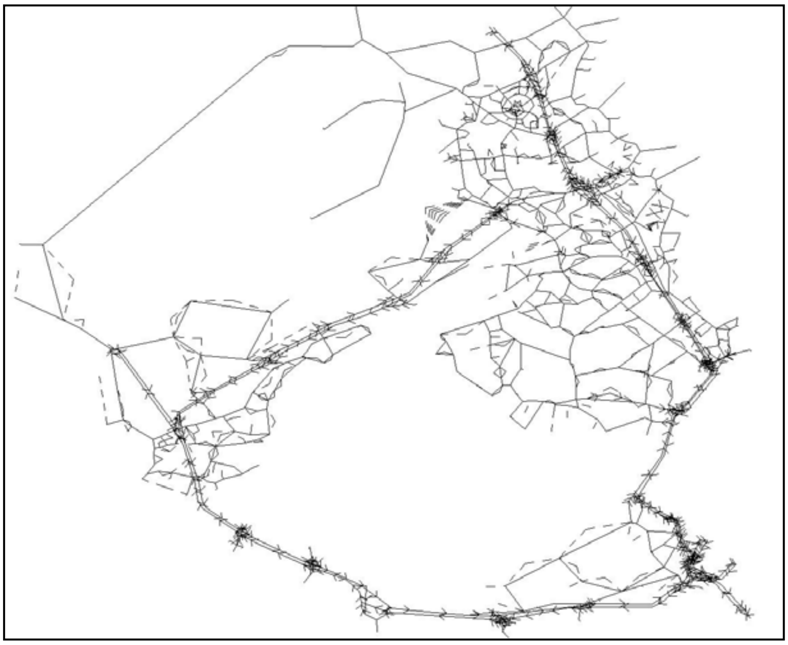
SATURN is a traffic assignment model. It represents traffic in units of vehicles (rather than people) and estimates route choice from a specified origin to a specified destination taking account of travel distances and travel times. Travel times can include delays from congestion at intersections and reduced speeds on roads from increased traffic volumes (through input speed-flow relationships). While we generically refer to 'vehicles', many SATURN models are developed with passenger car units (PCUs), which reflect the different road space taken up by a car (1 PCU) and a truck (2 PCUs, for example).

SATURN models are applicable for estimating vehicle travel times in congested road networks and take account of re-assignment (change in route choice) from changes in traffic volumes. SATURN models do not (in themselves) quantify the impacts on road system conditions from any modal shift, redistribution, or change of trip time. These effects on road travel can be quantified if they are externally estimated (ie through adjustment to the input vehicle matrix).

The SATURN model of Auckland used for this project is the Upper Harbour Corridor Model. The Upper Harbour Corridor (UHC) SATURN Model was developed in 2001, with updates to the model completed in 2012. The model reflects the average peak two-hour traffic flow for the AM peak period (7am to 9am), inter-peak period (12pm to 2pm) and the PM peak period (4pm to 6pm). A single average one-hour period is modelled for each of the three peaks, which is preceded by a one-hour preload enabling traffic conditions experienced prior to the average peak hour to be reflected (ie queue build-up before the peak one hour). The UHC SATURN model reflects the 2008 road network and its geographic coverage is shown in figure 3.2.

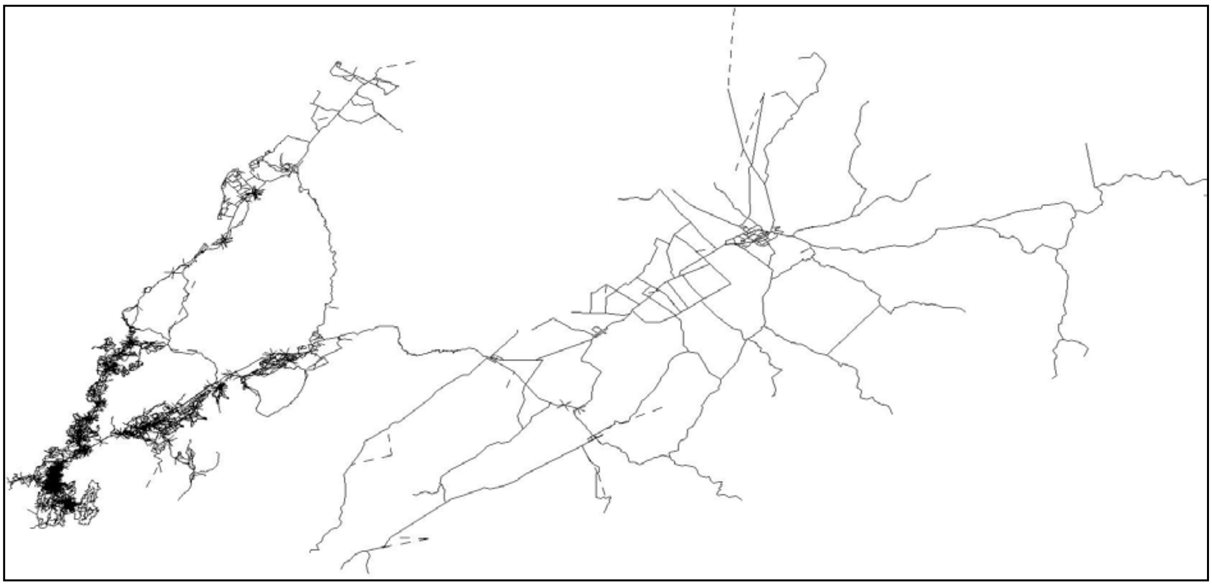
[12] SATURN (Simulation and Assignment of Traffic to Urban Road Networks) is a traffic network analysis program developed at the Institute for Transport Studies, University of Leeds and distributed by WS Atkins (United Kingdom) since 1981.

Figure 3.2 Extent of Upper Harbour Corridor Model, Auckland



The SATURN model of Wellington used for this project is the Northern Wellington SATURN Model (NWSM). The NWSM has been developed to represent a base year of 2011. The model considers the AM peak (7:30am to 8:30am), inter peak (one-hour average between 9am and 4pm) and the PM peak (4:30pm to 5:30pm) periods. Its geographic coverage is shown in figure 3.3 – while the model extent may appear significant, it is worth noting that the level of detail in the outer areas will be coarse.

Figure 3.3 Extent of the Northern Wellington SATURN Model



The Upper Harbour Corridor and Northern Wellington traffic models were run to produce a response for a range of reductions in the base-year traffic volumes between Albany and the Auckland CBD, and between Petone and the Wellington CBD. This involved subtracting up to 400 vehicles/peak hour for these O-D movements from the morning peak-hour base-year matrix. While this level of reduction is relatively large in terms of the specific O-D pairs, it is small (less than 1%) in terms of the total morning peak-hour matrix for the entire modelled area. More detail on the analysis undertaken and the model outputs is provided in appendix I.

Our testing showed:

- The behaviour of each model was reasonably stable when different levels of trips were removed from the specific O-D pairs, ie there was a reasonably consistent relationship between the percentage of traffic removed and the change in average speed (travel time) for the remaining traffic over the full network.
- These relationships were plausibly consistent with those found in other research into 'generalised' travel speed with respect to volume relationships.

On this latter point, our investigations expressed results in terms of the 'elasticity' of [average % speed change over the network] with respect to [average % VKT (or PCU-km) change in the network]. They resulted in elasticities of about 2.7 for the Petone–Wellington CBD case and about 2.5 for the Albany–Auckland CBD case. These elasticities relate to assignment-only modelling, ie no allowance was made for 'secondary' effects of reduced traffic volumes on trip re-timing, trip redistribution, mode shift or trip generation (allowance for such effects would tend to reduce the elasticity estimates obtained, but would increase the total benefit from the traffic reduction).

We compared these elasticity results with earlier investigations on this topic, undertaken by BAH (through Ian Wallis) for the Transport Agency (BAH 2003). These comparisons indicated that our results were within the range, but on the higher side, of the evidence examined in the early research, from London, Melbourne and various New Zealand sources (including runs of the Auckland and Wellington regional multi-modal models). One likely explanation for the relatively high figure from the SATURN tests is that these tests allow only for reassignment, not the other potential responses (as mentioned above) that are likely to occur, even if only to a small degree[13]. Another likely reason is that the SATURN models were run for specific, highly congested corridors, while the other studies were averages over wider networks.

3.4.2 A simplified modelling approach

3.4.2.1 Theory

The SATURN model predicts the effect on travel times of changes in the demand for travel. The relationship between the travel time and traffic density is often referred to as the 'fundamental law of traffic'. Basically what that law says is that as traffic on a road increases, speeds fall. Initially speeds only fall slowly and the flow (vehicles per hour) increases. But at some point, the road reaches capacity, where the flow is at a maximum. More vehicles attempting to use the road further reduce the speed until eventually speeds and flow are zero.

A useful result can be obtained from the description above: because the flow is increasing up to capacity and decreasing when demand exceeds capacity we can draw conclusions about the elasticity. If Q is demand and t is time, then flow increasing implies:

$$(Q + dQ)/(t+dt) > Q/t$$

$$\text{or} \quad Qdt < t\,dQ$$

$$\text{or} \quad \varepsilon = Qdt/tdQ < 1$$

That is, if demand is less than capacity, the elasticity is less than 1.0. Similarly if demand exceeds capacity the elasticity is greater than 1.0.

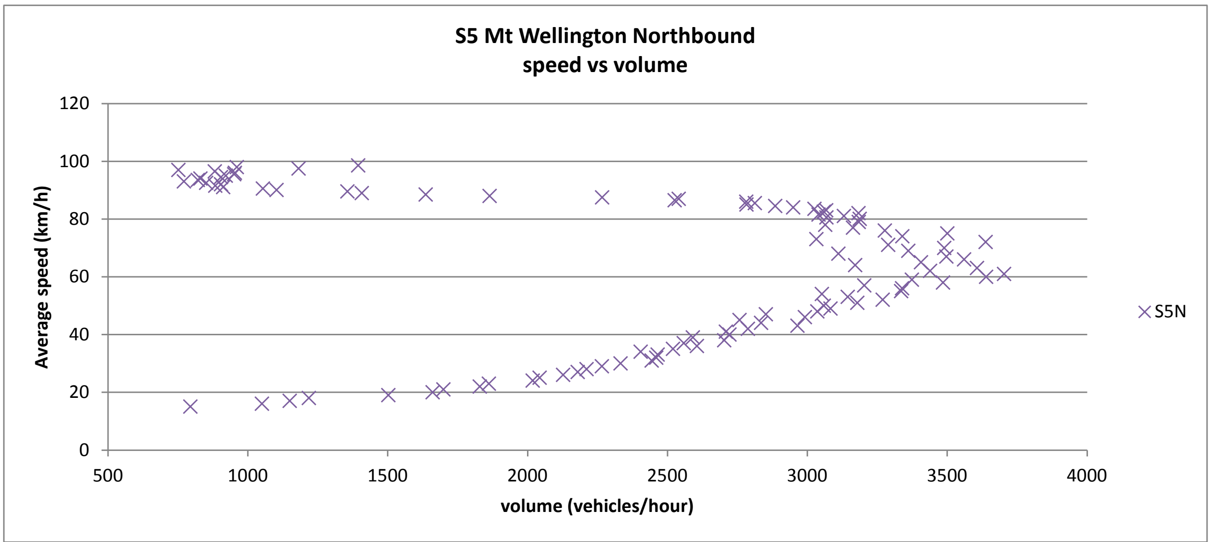
[13] Evidence from the BAH (2003) work indicates that allowing for these other potential responses may reduce the assignment-only elasticity estimates by as much as 50%.

This confirms that for the congested corridors, the elasticity can be expected to be greater than 1.0 and for uncongested corridors it will be less than 1.0.

Because the fundamental law of traffic is behavioural, and driver behaviour varies due to weather, traffic mix, traffic speed enforcement, distractions etc, plotting speeds against flows does not give a simple curve. The data displays a lot of randomness and day-to-day variation. Nevertheless it is possible to develop mathematical relationships that capture the essence of what appears to be occurring. Two such commonly used relationships are the Akçelik function and the Bureau of Public Roads (BPR) function. Transport assignment models such as the Auckland and Wellington strategic models use the Akçelik function because it has a linear response for volume to capacity ratios greater than 1.0, which makes these models converge much more quickly. The BPR function has a non-linear response and although it is much more tractable mathematically it creates problems with convergence when used in traffic models. The Akçelik function is based on queuing theory and is arguably superior theoretically where the nature of the congestion is a bottleneck, while the BPR function is based on traffic interaction and is theoretically superior where traffic is slowing due to high traffic densities rather than for a specific pinch point. Large networks will have some aspects of each situation.

Irrespective of their theoretical merits, the two models produce almost identical results in practice. This can be shown using data from the Transport Agency traffic monitoring sites. Figure 3.4 is based on the analysis of Auckland southern motorway traffic between October 2010 and December 2010. It clearly shows the fundamental law of traffic – but also shows a high degree of random scatter.

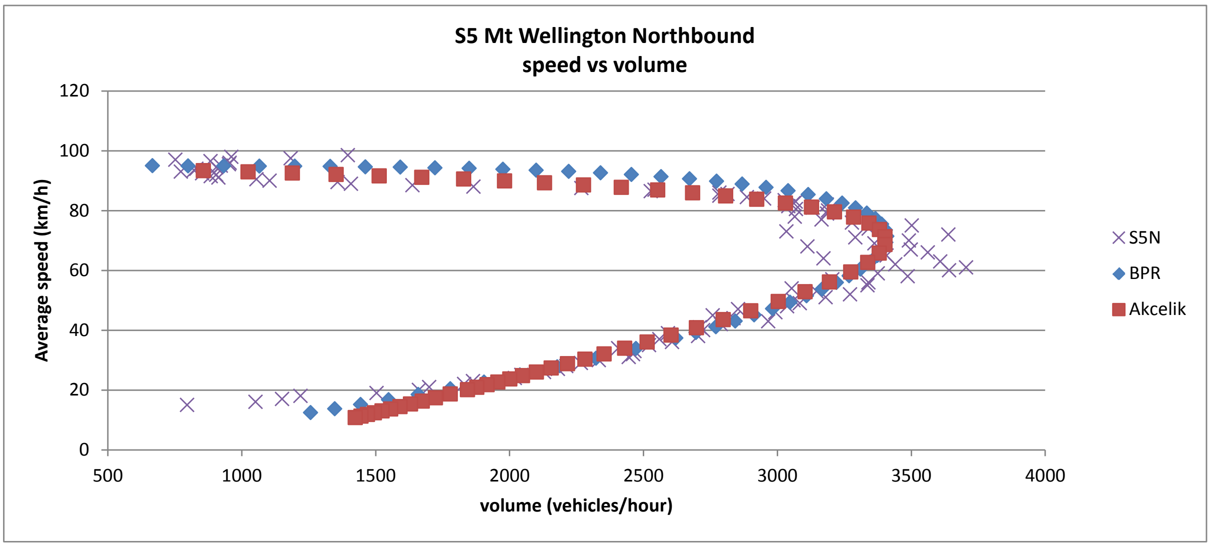
Figure 3.4 Average speed vs flow – southern motorway



Source: Consultant analysis/NZ Transport Agency

Figure 3.5 shows Akçelik and BPR functions fitted to the same data. While there are small differences between the two curves, the differences are less than the scatter in the data, and it is reasonable to conclude that either mathematical function could be used to represent the effect of traffic on vehicle speeds.

Figure 3.5 Comparison of observed data, BPR and Akçelik functions



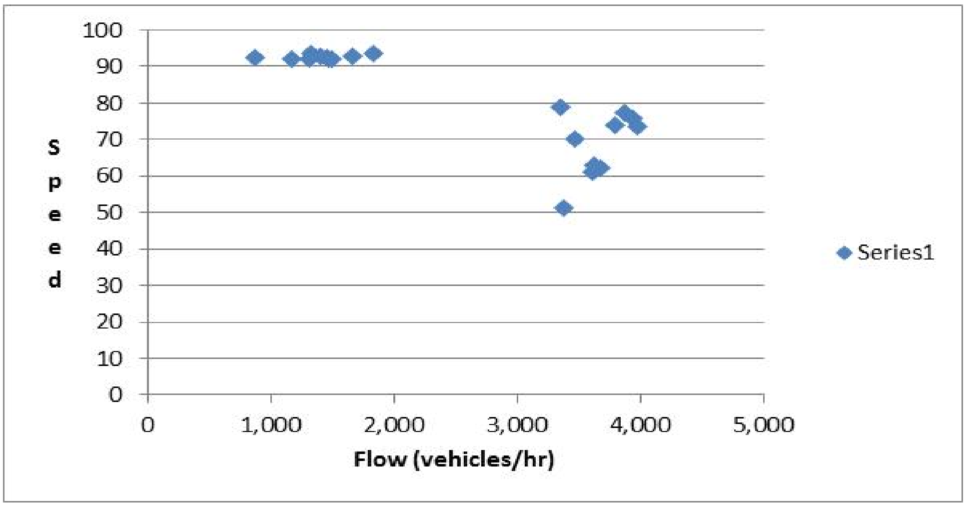
Source: Consultant calculations

Observed speed and traffic volume information was also extracted from the Transport Agency traffic monitoring system website for SH2 between Petone and Wellington north of the Ngauranga interchange (ID: 00210978). The period analysed was five weekdays from Thursday 28 November 2013.

Plotting north and southbound data for this site gives the plot shown as figure 3.6. The contra-peak direction flow traffic data is clustered in the top left corner with speeds of around 90–95km/h while the peak direction traffic flow is around the maximum (average) capacity of the road of just under 4,000 vehicles/hour[14].

While the scatter is too great to draw firm conclusions, the points are not inconsistent with a BPR curve as shown in figure 3.7.

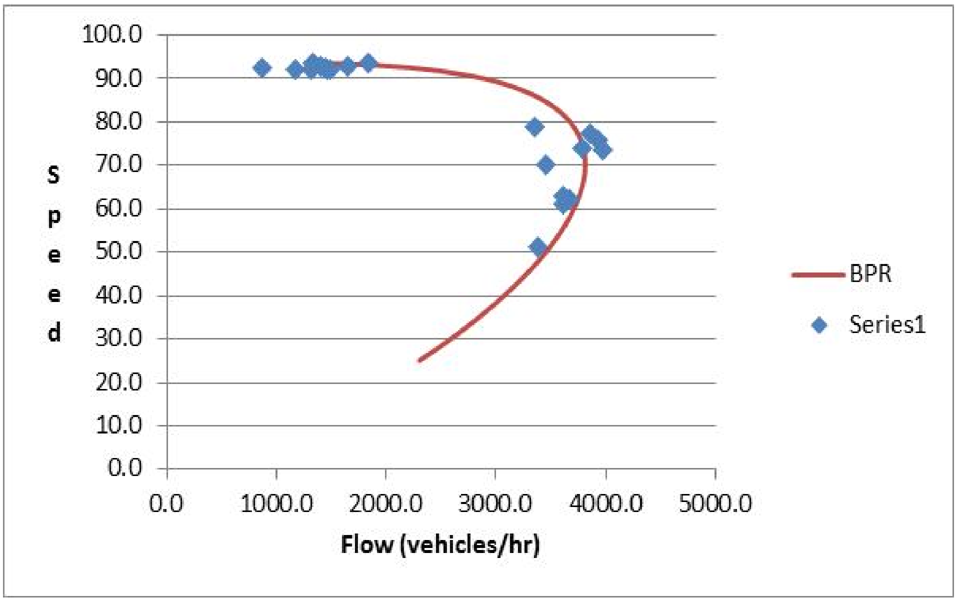
Figure 3.6 Traffic speeds and flows – Ngauranga



Source: Transport Agency traffic monitoring system site data

[14] Observed southbound traffic volume on SH2/SH1 of 4,000 vehicles/hour is an average from sections from Dowse Drive to south of Ngauranga – a section of state highway that increases from two to three lanes. Averaged traffic volumes were required to correspond with congested travel times through the equivalent section.

Figure 3.7 BPR curve fitted to Ngauranga data



Source: Transport Agency traffic monitoring system site data /consultant analysis

Being able to represent the fundamental law of traffic as a BPR function makes it possible to use the properties of the BPR function to derive some very useful relationships. The BPR function can be written as:

$$t = t_f * (1 + \alpha (Q/K)^{\beta})$$

Where t = travel time

t_f = free flow time

Q = demand

K = capacity

α, β coefficients

It follows that

$$dt /dQ = \beta \alpha (Q/K)^{\beta-1}$$

And hence

$$Q\, dt /dQ = \beta \alpha (Q/K)^{\beta}$$

$$= \beta (t - t_f)$$

Thus the congestion externality E is linearly proportional to the difference between the actual and the free-flow travel times.

Note also that the elasticity

$$\varepsilon = Q\, dt /t\, dQ = \beta (t - t_f)/t$$

and E = ε t

Although the Akçelik function is more complex and cannot be solved for ε analytically, it can be solved using numerical analysis, giving similar results.

We therefore have expressions for E and ε that can be derived simply from observed travel times. In the literature (Singh 1999) β is normally given the value 4.0, and that indeed appears to fit New Zealand data – it was the value used to plot the above graphs.

3.4.2.2 Application

The results derived above were used to estimate the elasticity and hence the congestion externality for each of the P&R case study sites. The calculation of the elasticity is shown in table 3.3.

Table 3.3 Elasticity calculation

	Albany	Constellation	Petone	Waterloo	Porirua
Congested time (minutes	50.9	46.1	21.6	25.2	20.9
Free flow time (minutes)	14.8	12.5	10.1	13.9	13.6
Elasticity	2.84	2.92	2.12	1.80	1.40

Source: Consultant estimates

The results for Albany (2.8) and Petone (2.1) compare well with the results from the SATURN model runs of 2.5 and 2.7 respectively. Furthermore the relative sizes of the elasticities seem reasonable considering the known traffic conditions in each corridor.

The simplified modelling approach was therefore adopted in the evaluation framework used for the case studies. The congested and free-flow travel times were obtained from the SATURN model but could be obtained by observation. This gave a very simple but theoretically sound means of estimating the specific elasticity for any location. The elasticity was multiplied by the congested travel time to obtain the marginal congestion externality (ie the externality resulting from an increase or decrease in demand by one vehicle).

The calculated elasticities were higher than those reported in the literature, but that was entirely to be expected. These calculations related to specific congested corridors. The estimates reported in appendix I are for networks that had a mixture of congested and uncongested links. This was the advantage of the proposed approach – the elasticities were specific to the site being studied.

3.5 Conclusions/recommendations

For formal demand modelling, the review of international literature indicated P&R is generally included in strategic travel models as a choice in the modal split. The Auckland and Wellington models (ART3 and WTSM) do not have P&R as a modal option at this level and are therefore not appropriate in their current form to estimate small changes in travel behaviour from increased P&R provision. P&R could ultimately be more formally included in these models as a modal option in the mode choice – although this is a significant task and should be considered during model rebuilds. As such, empirical evidence of travel behaviour responses was used for this project instead of formal modelling.

The international literature review of travel behaviour changes indicated that for bus-based P&R, the dominant prior mode was car. This was less so for rail-based P&R, where PT was the prior dominant mode. With significantly different environments, it was difficult to compare international experience with New Zealand.

Market research was undertaken in Auckland and Wellington to ascertain likely modal shifts from P&R changes. The results from these surveys were utilised for the case studies to ascertain prior modes and estimate the likely impacts of changes in travel patterns.

A way of determining the effect of changes in the demand for road travel on corridor travel times was required as a key input to the evaluation framework and for application to the five case studies.

This was approached by estimating the elasticity, which relates [average % travel time change in the corridor] to [average % volume change in the corridor]

Road network congestion changes were estimated with capacity-restrained traffic assignment models of Auckland and Wellington. An elasticity of [average % speed change over the network] with respect to [average % VKT change in the network] was calculated. For Petone to Wellington CBD, the elasticity was 2.7 while for Albany to Auckland CBD, the elasticity was 2.5.These results were comparable but higher than the international literature review suggested.

Consideration of the underlying fundamental law of traffic shows that the elasticity should be greater than 1.0 for congested ('hypercongested') routes and less than 1.0 for uncongested ('normal flow') routes. It is therefore likely that higher values were obtained in this study because they related to specific congested corridors, rather than to entire networks with both congested and uncongested routes.

While actual travel times vary from day to day in response to any number of influences, it is possible to replicate observed behaviour using mathematical models. Relationships deduced from the models can then be used to predict relationships in real life. Following this approach, a simplified modelling approach was developed which calculates the elasticity based on the observed travel times. Comparing this with results from SATURN modelling gave a satisfactory correspondence.

For the case studies, the elasticity was calculated from travel times. The proposed relationships were:

Elasticity $\varepsilon = 4*(\text{observed time} - \text{free flow time})/\text{observed time}.$

Externality $E = \varepsilon * \text{observed time}$

4 Economic and financial methodology

4.1 Introduction

This section sets out our framework and methodology (including parameter values) for the economic and financial appraisal of the case study options. This framework/methodology was developed in the light of our:

- initial investigations of potential approaches and methodologies, particularly those in use internationally, for the appraisal of P&R initiatives
- further investigations of alternative approaches and how they might best be applied in the context of this project.

From these investigations, we determined the following desirable characteristics for any appraisal framework/methodology used in case studies. The framework/methodology should:

- be based on cost-benefit analysis (CBA) principles. This emerged as our preferred approach early on in the project, and our preference for this was reinforced by our subsequent investigations
- be consistent with the *Economic evaluation manual* (EEM) (NZ Transport Agency 2013) for those aspects on which the EEM provides relevant information (eg parameter values)
- be sensitive to the different scales of impacts in the different case studies (a method using a 'generic' set of assumptions would not be suitable in this regard)
- provide, in particular, the best possible (unbiased) estimates of economic benefits (and costs) in the three principal impact areas, ie benefits to the road system, benefits to the PT system, and benefits to P&R users (mode switchers). To provide such estimates would require separate estimates of these benefit categories for each case study, depending on road traffic conditions, PT services and the P&R market.

Given these requirements, the decision was taken to develop a general framework and methodology specifically for the project, with the detailed inputs for each case study being tailored to the individual study conditions. Therefore we did not pursue the idea of making direct use of the SAF software developed by the UK Jacobs Consulting, although we did examine this methodology and software further.

In preference, our proposed methodology was developed 'from scratch' for the three major benefit categories (ie road traffic impacts, PT system impacts and P&R/mode switcher impacts). For each category, our major emphasis in methodology development was to devise robust and consistent (across case studies) methods to quantify the impacts in terms of demand, time savings, PT service changes etc, and then to apply unit benefit (and cost) values to these impacts, based on EEM or other sources as appropriate.

Chapter 4 contains the following topics:

- a summary of the literature review (section 4.2)
- an overview of our appraisal framework (section 4.3)
- a summary of the road system impacts (section 4.4)
- the PT system impacts (section 4.5
- the PT user benefits (section 4.6).

4.2 Literature review – benefits and evaluation methods

This section provides a summary of the findings from our review of international literature and practice on the types of benefits resulting from P&R policies and schemes, and on economic and financial appraisal approaches to assessing scheme benefits.

4.2.1 P&R policy goals/objectives and benefits

4.2.1.1 P&R goals and objectives

The benefits sought from P&R schemes depend on the objectives these schemes are intended to achieve, hence it is appropriate to first review the goals/objectives commonly associated with P&R policies. In this regard, we note that the P&R objectives specific to this research project focus on the role of P&R in improving road system performance (both state highway and local road) and/or reducing PT subsidies, in a cost-effective and efficient manner. In this section, we summarise PT goals/objectives from international literature and practice, which in many cases are rather broader than the objectives adopted in this project. We then outline potential benefit categories from P&R schemes.

Table 4.1 sets out typical statements of objectives for P&R policies, drawn from two previous New Zealand studies that reviewed the international literature. Numerous other international studies outline and comment on P&R system objectives (eg Meek et al 2009; Meek et al 2010; Duncan and Christensen 2013; Opus and Arup 2012; Litman 2010). The New Zealand practice review in section 2.2 also covers current P&R policies and objectives in Auckland and Wellington.

Table 4.1 P&R policy objectives – some examples

Citation	Objectives	Comments
Park and ride: characteristics and demand forecasting (Vincent 2007)	‘The main objective of P&R policies is to transfer parking demand from the central business district (CBD) to suburban/urban fringe locations, with a view to achieving the following benefits: • reducing traffic levels and congestion levels on urban radial routes and in the CBD itself • correspondingly reducing the need/pressure for increased road capacity as well as reducing emission levels, energy use and other environmental impacts • reducing the amount of parking required in the CBD . . . and replacing it with parking in other locations. P&R may also help to increase the level of service and cost-effectiveness of PT provision, by concentrating PT demand on the major line haul routes (between the P&R site and CBD) and reducing the need for PT services in low-density suburban areas, which are difficult to serve cost effectively.’	While P&R can be used to reduce the need for PT services in low-density suburban areas the needs of those who do not have access to a car is an important policy consideration.
The implications of park and ride for urban development strategies in major metropolitan areas in New Zealand (Woods 2006)	Objectives: Identified, from the literature, 11 ‘core’, most commonly identified objectives, as follows: Economic objectives: • Reducing the amount of parking required in the CBD and improving land use efficiency in the CBD. • More cost-effective provision of parking for central city. • More economically efficient transport system. Transport objectives: • Reducing congestion levels on urban radial routes. • Reducing congestion levels in the CBD itself. • Reducing the need/pressure for increased road capacity. • Increasing PT use. Environmental objectives: • Reducing local emissions/pollution levels.	These 11 objectives (or, indeed, the three most common objectives), appear to encompass the more focused objectives set for this project, but also have a wider coverage.

Citation	Objectives	Comments
	• Reducing transport-related GHG production. • Reducing other environmental impacts (eg noise). Social objectives: • Increasing social inclusion/community liveability. The author notes that these 11 objectives may be simplified further into three commonly mentioned objectives: (i) cheaper, more cost-effective provision of parking for the central city; (ii) reduced congestion on approach roads; and (iii) encouragement of PT use. The author also notes that these objectives will most readily be achieved if the P&R policy and programme forms part of a well-integrated strategy and is integrated with the wider PT system.	

4.2.1.2 P&R benefits

The international literature does not appear to set out explicitly the range of benefits (or costs) associated with P&R policies in general, although these can in large measure (although not entirely) be inferred from the range of P&R objectives. It is important that the economic evaluation considers a wide range of benefits and not just those linked to the P&R objective, so as to ensure that all relevant impacts are properly considered.

Table 4.2 provides a 'generic' listing of benefits and costs for PT-oriented schemes generally. While this is not specific to P&R schemes, most/all potential benefits and costs of such schemes are encompassed here. It will be seen that the costs (disbenefits) included here cover both economic and financial items.

Table 4.2 Public transport benefits and costs[(a)]

Category	Improved PT service	Increased PT travel	Reduced automobile travel	Transit-oriented development (TOD)
Indicators	Service quality (speed, reliability, comfort, safety, etc)	PT ridership (passenger-miles or mode share)	Mode shifts or automobile travel reductions	Portion of development with TOD -oriented design features
Benefits	• Improved convenience and comfort for existing users. • Equity benefits (since existing users tend to be disadvantaged). • Option value (the value of having an option for possible future use). • Improved operating efficiency (if service speed increases). • Improved security (reduced crime risk).	• Increased user security, as more users ride on PT and wait at stops and stations. • Mobility benefits to new users. • Increased fare revenue. • Increased public fitness and health (if PT travel stimulates more walking or cycling trips).	• Reduced traffic congestion. • Road and parking facility cost savings. • Consumer savings. • Reduced chauffeuring burdens. • Increased traffic safety. • Energy conservation. • Air and noise pollution reductions.	• Additional vehicle travel reductions ('leverage effects'). • Improved accessibility, particularly for non-drivers. • Reduced crime risk. • More efficient development (reduced infrastructure costs). • Farmland and habitat preservation.
Costs	• Increased capital and operating costs, and therefore subsidies. • Land and road space. • Traffic congestion and crash risk imposed by PT vehicles.	• PT vehicle crowding.	• Reduced automobile business activity.	• Various problems associated with more compact development.

Source: Litman (2013b)

Note: [(a)] Not all the benefits and cost items listed in this table are necessarily relevant to New Zealand P&R policies and programmes.

4.2.2 Appraisal approaches

This section provides a summary and commentary on the international literature on methods for appraising the economic and financial impacts of P&R schemes. Its focus is on ex-ante appraisal (sometimes described as 'evaluation', as in the EEM), rather than on ex-post evaluation and monitoring.

The relevant international literature specific to P&R scheme appraisal is not extensive. This is likely to be for two reasons:

1 Many P&R projects are relatively small (low cost) and may not be subject to formal economic/financial appraisal[15].

2 Appraisal procedures will (as in New Zealand) not generally be specific to P&R projects, but will be common to a much wider range of PT/travel demand management (TDM) types of projects.

While many P&R projects may be relatively small these can add up to a significant investment. It has to be argued that P&R should be assessed as a system (Parkhurst and Richardson 2002) and in practice P&R is an investment that is generally approached as part of a wider investment programme (eg refer Auckland and Wellington practice). System/programme considerations were outside the scope of our research, but are touched on in chapter 7.

Table 4.3 presents a summary of appraisal methods recommended or adopted for P&R projects specifically and, in most cases, also applicable to PT/TDM-type projects more generally. Of the four international reports/papers outlined here, the last of these (Jacobs Consulting 2011 *Value for money and appraisal of small scale public transport schemes*) was the only one that warranted serious consideration for use/adaptation for application in this project. It provides a methodology and associated computer software (SAF) designed to support CBA and value-for-money (VfM) appraisals for 'smaller' PT schemes (eg bus priority, bus stations/interchanges, P&R schemes, real-time information) in the UK context.

The strengths of the Jacobs Consulting methodology (and associated software) for use in the project were:

- It provides a methodology based on CBA methods, which could potentially be 'grafted' on to the existing EEM procedures.
- In particular, it incorporates a set of assumptions on the demand effects of P&R initiatives: these assumptions are derived from UK experience with P&R schemes. (EEM does not contain any guidance on demand forecasting for P&R schemes.)
- It includes a proven software package that incorporates both the demand and economic parameters appropriate to P&R scheme economic appraisal.

We considered two alternative approaches to the development of an economic appraisal methodology for P&R initiatives for use in this research project: one alternative was to use or adapt Jacobs Consulting's methodology and software; the other alternative was to develop our own methodology and software. The advantages of the 'home grown' approach were seen as:

- We could ensure that the product would be fully consistent with EEM requirements, particularly in terms of economic parameter values.
- It would enable us to develop methods, in particular for assessing demand effects, which would be tailored closely to the New Zealand situation and available New Zealand market research evidence.

[15] Although there are examples of larger schemes, there is a greater number of smaller projects.

- We/the Transport Agency would be able to have full control over the methodology and associated software, both within the research project and for any further development that might be seen as desirable subsequently.

Based on the above considerations, we decided the preferred alternative would be to develop our own methodology in the project, as described in subsequent sections of this chapter (and various appendices).

Table 4.3 P&R economic/financial appraisal – international approaches

Citation	Summary	Comments
The implications of park and ride for urban development strategies in major metropolitan areas in New Zealand (Woods 2006)	Provides an overview of appropriate appraisal approaches, divided into two main categories. **Economic (single criterion) analysis** These methods reduce all benefits and costs to monetary terms, to perform some sort of economic analysis and comparison. The methods focus on CBA, including BCRs, net present value (NPV), annualised cost methods and return on investment (internal rate of return). **Multi-criteria analysis (MCA)** MCA considers multiple criteria or 'measures of effectiveness', which may be quantitative or qualitative and should relate directly or indirectly to the objectives being sought. The basis of MCA is the identification of the objectives and associated criteria to be used in the decision-making process, and deriving measures and scales for each: each such measure/scale must be relevant to the criteria it represents, sensitive enough to indicate relevant differences between options and able to be understood by decision-makers. One example of MCA methods often used in assessments is the quadruple bottom line assessment: this incorporates four groups of objectives relevant to government sector decisions, ie social, economic, environmental and cultural. An extensive literature exists on the theory and practice of MCA methods generally.	The coverage of this source is very high level; it does not provide any information of direct use to this project.
The economic evaluation of bus and minibus taxi terminals and transfer facilities (Pienaar 1998)	Outlines more-or-less 'standard' economic appraisal procedures appropriate to the appraisal of PT terminals and transfer facilities (hence includes P&R facilities). Procedures based on social cost-benefit analysis, comparing 'with' and 'without' situations. Main cost and benefit items are: (i) infrastructure capital costs; (ii) facility operating costs; (iii) PT operating costs; (iv) travel costs of facility users; and (v) travel costs of road users on affected routes. In regard to item (iv), procedures are described to estimate the changes in generalised travel costs ('generalised time') for travellers on different transport modes and using the terminals/transfer facilities. A worked example is given of economic appraisal for a proposed passenger transport terminal, with results given for NPV, BCR and internal rate of return.	The economic appraisal techniques given are 'standard', and consistent with the principles for appraising PT/TDM schemes in the EEM. No information is provided on how to estimate the effects on PT and car travel demand associated with the new improved facility (in many cases, this would be the most challenging part of such appraisals). This source does not contain any enhanced methodology, parameter values, etc. (additional to EEM and the Wallis et al 2013) that would assist in this project.
How many parking spaces does it take to	Provides a 'rudimentary' social cost-benefit appraisal of the costs and benefits associated with providing additional (subsidised) parking at suburban rail stations in Chicago,	As noted by the author, the calculations should be regarded as indicative only. However, they

Citation	Summary	Comments
create one additional transit passenger? (Merriman 1998)	relative to a 'do nothing' base case. Appraisal takes into account (i) net (private) benefits of increases in the supply of station parking (based on broad estimates of consumer surplus per parker); (ii) reduction in social costs for road users resulting from transfer of some motorists to rail travel, comprising marginal congestion costs (the largest component), marginal (external) crash costs and marginal car pollution costs; and (iii) marginal increases in PT operating costs associated with the increased rail patronage.	provide a useful demonstration of methodology for such cases, in particular for estimating the demand effects of expanding P&R provision on both the highway (roading) and PT sub-systems. The author also comments on the likely distributional effects of increases in subsidies to provide additional P&R spaces for suburban rail users. The main beneficiaries of these additional subsidies are likely to be suburban residents commuting into the CBD by car, who would typically have above-average incomes.
Value for money and appraisal of small scale public transport schemes (Jacobs Consulting 2011)	Report of consultancy assignment for the GB Passenger Transport Executive Group (PTEG) on value for money and appraisal of small scale PT schemes. Scheme types covered are bus priority, bus stations/interchanges, real-time information, quality bus corridor, bus information/branding and P&R (bus and rail). Proposed an appraisal methodology with two high-level and complementary measures – BCR and VfM. BCR covers the 'conventional' economic benefits and would generally be estimated using WebTAG/new approach to appraisal methods. VfM covers 'public realm' benefits that cannot be readily monetarised, but are valued by users (and typically 'valued' through customer satisfaction etc surveys); such benefits tend to be particularly important for smaller schemes. The consultants developed/provided an Excel-based economic appraisal tool (SAF) for the appraisal of such schemes. This tool incorporates a number of simplified and averaged parameter values. It enables rapid and cost-effective appraisal of options for smaller-scale schemes with relatively local impacts. For P&R appraisal, SAF gives guidance (drawn from a substantial evidence base) on key inputs required: car-bus transfer, generated demand, abstraction from existing bus services and forecast car park occupancy.	As a potential adjunct to EEM methods for smaller (including P&R) schemes, this report and the SAF software appear to provide a promising basis for enhancing existing New Zealand methods. Adaptation of this report and associated software for this project was considered, as an alternative to the development of a 'home grown' methodology (see text).

4.3 Overview of appraisal framework

This section provides an overview of our proposed appraisal framework and methodology for the economic and financial appraisal of the case study options. Essentially, this methodology brought together all economic and financial impacts of each case study option (relative to a base case) within a CBA framework, and reported on both economic and financial performance of the options from the viewpoints of the key stakeholders, individually and in aggregate.

As shown in table 4.4, we developed an appraisal framework which focuses on the impacts on four stakeholder groups, ie:

- Three public authority groups, which we have called: (i) road authority (which could be split into two sub-groups if required); (ii) PT authority; and (iii) P&R authority (this may become part of the road authority or the PT authority in practice, but we have kept it separate for clarity at this stage).
- One user group (travellers), which (as shown) may be sub-divided into road (car) users, PT users and P&R users (including mode switchers).

The table 4.4 framework separates out (i) in the top part of the table, those cost and revenue items impacting on the public authorities' finances; and (ii) in the remainder of the table, the impacts on users, some of which are financial, others are 'soft' items (time savings, convenience etc). In essence, the top part of the table is concerned with the public sector (net) costs, which comprise the denominator of any BCR(G) appraisal; while the remainder comprises the user benefits, which form the numerator of any BCR(G) appraisal. The notes to the table set out, in brief, the content of each cell of the table, including the sections in this report where the basis for the estimates for each cell is described.

The following sections (and associated appendices) cover our methodology relating to each stakeholder group in turn, ie:

- section 4.4 (and appendix J) – impacts on the road system, covering road (car) users, including any associated externalities
- section 4.5 (and appendix K) – impacts on the PT system, covering the PT authority and PT users
- section 4.6 (and appendix L) – impacts on the P&R authority and on travellers directly affected (mode switchers) by the P&R options being assessed.

The framework/structure shown in table 4.4 was applied, with refinements, in each of the case studies, using a standard Excel-based pro forma.

Table 4.4 P&R economic/financial appraisal framework

Scheme definition:

Location:	[Petone station]
Definition – base case:	[Current P&R facilities, current rail services]
Definition – options:	[Increased P&R (100 spaces) – assumed no change in CBD parking. Rail service capacity increased (as appropriate)].

Assumptions:

Timing	[Fill in details for case study]
Pricing	[No P&R changes]

Item	Road authority	PT authority	P&R authority	Total	Notes
PUBLIC COSTS (FINANCIAL)					
Infrastructure (capital)					
P&R site – land			*A		
P&R site – construction			*B		
PT – vehicles		*E			
Operations and maintenance costs					
P&R site			*C		
PT – O&M		*F			
Revenues					
P&R charges			*D		
PT fare revenues		*G			
Overall public (financial)					
USER BENEFITS (ECONOMIC)	**Other road traffic etc**	**Other PT users**	**P&R users**	**Total**	**Notes**
P&R user benefits					
New users – gen time (benefits)			*H		
New users – fares/ charges			*I		
New users – VOC			*J		
Existing users – convenience			*K		
PT existing users					
Frequency benefits		*L			
Road system decongestion and externality					
Decongestion benefits (incl schedule delay)	*M				
VOC	*N				
Crash costs	*O				
Global envt costs	*P				
Local envt costs	*Q				
Overall user (economic)					
SUMMARY Overall NPV Overall BCR(G)					

Notes:

A Value (opportunity cost) of land used for new facility. May be included as a capital amount or as an annual (lease) charge.

B Estimation of construction costs for new/expanded facility, including all overheads (planning design, consents, etc). Estimate based on experience with similar facilities developed over recent years.

C Estimate of annual operating and maintenance (O&M) costs (incremental) associated with the new/expanded facility. Estimate to be based on experience with similar facilities (likely to be very small in the case of basic, sealed facilities).

D Estimated (incremental) revenues (if any) from P&R charges - only relevant under policy of charging for P&R.

E To the extent that the scheme results in increased peak period (peak direction) PT patronage, represents an allowance for the capital costs for additional peak vehicles required. Refer appendix K for details.

F As above, represents additional PT operating costs associated with accommodating any additional peak period passengers. Refer appendix K for details.

G Represents additional PT fare revenues (GST exclusive) associated with any additional PT passengers. [Allow for any changes in fare revenues on local services if significant.]

H Estimate of 'generalised journey time' benefits of new P&R users ('switchers').

I Estimate of any PT fares/P&R charges paid by switchers to P&R. [Strictly a transfer payment, with off-setting revenues under items D, G, rather than an economic cost or benefit.]

J Estimate of any vehicle operating cost (VOC) savings for switchers from car to P&R.

K Estimate of 'convenience' ('schedule delay') benefits to existing P&R users who can travel at their preferred time as a result of the increased P&R capacity.

L Benefits to existing PT users from increased service frequencies if more frequent services provided in response to increased demand with the new/expanded facility. Refer appendix K for details.

M Benefits to base/continuing road users resulting from reduced congestion (and reduced schedule delay) resulting from some car users switching to P&R. Refer appendix L for details.

N VOC reductions for base/continuing road users as a result of the reduced congestion etc. (as item M). Refer appendix L for details.

O Crash cost reductions (or increases) for base/continuing road users as a result of the reduced congestion etc (as item M). Refer appendix L for details. May also include a small component for bus users (and operators) who use the road system.

P Reductions in GHG emissions associated with any reductions in road traffic volumes and decongestion impacts (as item M). Refer appendix L for details.

Q Reductions in local environmental impacts associated with any reductions in road traffic volumes and decongestion impacts (as item M). Refer appendix L for details.

4.4 Road system impacts (users and externalities)

As is evident from table 4.4, for the case studies proposed for assessment, we did not anticipate any direct financial impacts on the road authority (separate from the P&R authority), ie there would not be any significant change in the road authority's capital or recurrent costs[16].

Impacts on road users were considered in two categories:

- *Mode switcher impacts.* This category covers the road traffic (VKT) impacts associated with people who use their cars either less or more when the P&R provision is expanded. Those who use their cars less typically switch from a 'car all the way' trip to a 'car to P&R site plus PT line haul' trip. Those who use their car more are people who change to accessing the P&R site as a car driver rather than by their previous mode (bus, walk, cycle, K&R, etc).

[16] Any potential changes in road authority revenues (eg resulting from a reduction in fuel consumption) have not been addressed here, but would be expected to be small relative to the items included in table 4.4.

- *Decongestion impacts.* This category relates to the changes in travel speeds and reliability for all traffic (including cars, trucks, buses) remaining on the road network, in response to the (generally) reduced traffic volumes.

The *mode switcher impacts* are not considered further here, but are addressed in section 4.6, as part of the user benefits assessment for all trips involving modal change (for line haul and/or access trip legs).

The *decongestion* (and related) impacts are the focus of this section. They comprise two sub-categories:

1 'Decongestion' and associated impacts on road users. These impacts arise from any switching of car (line haul) trips to use the P&R facilities, thus resulting in marginally lower levels of congestion and higher average speeds, resulting in time savings, for the remaining road users (refer section 3.4). Associated impacts of this 'decongestion' affecting road users may include reductions in schedule delays ('reversion to the peak') and changes in VOC (the outcome of changes in average travel speeds and maybe reductions in stop-start running)

2 'External' impacts arising from 'decongestion', which are largely borne by society as a whole rather than road users. These may include road crash costs[17], global environmental costs and local environmental impacts.

Appendix J sets out in detail our derivation of unit parameter values for use in the estimation of decongestion and related benefits.

Table 4.5 presents a summary of the unit values derived in appendix J. Particular points of note in relation to this summary include:

- All values are expressed in units of $/vehicle hour, for application to the changes in base traffic vehicle hours resulting from the 'decongestion'-related changes in average operating speeds.
- All values are consistent with the updated EEM values (in 2013 prices).
- The safety (crash) costs are shown as negative benefits, ie it is anticipated that faster average travel speeds result in higher crash costs for the network. However, the estimation of safety impacts is indicative only, given the lack of good information on how crash costs vary with average operating speeds for typical urban road networks.

Table 4.5 Summary of 'decongestion' unit benefit values[(a)]

Item	Unit benefit value (2013 prices)	Notes
Travel time savings	$27.98/veh hour	Includes congestion and reliability increments
Vehicle operating costs	$1.94/veh hour	
Environmental costs	$0.16veh hour	
Safety (crash) costs	-$2.27/veh hour	Indicative only
Total	**+ $27.81/veh hour**	

Note: [(a)] Full details in appendix J (table J.1)

[17] In practice, road crash costs are in part borne by road users individually or as a group, but in part are external to this group.

4.5 PT system impacts (operators and users)

Increases in P&R capacity are expected to result in increased patronage on peak-period rapid transit (line haul) services – with people switching in part from 'car all the way' travel, in part from other (non-rapid) PT services.

The authorities might respond to this increased patronage in various ways, including:

1 No response, ie the services would become more crowded (with crowding disbenefits)

2 Increase service capacity by increasing service frequencies (bus or train.

3 Provide services in higher capacity units (eg longer buses, trains with more carriages).

In each of these cases, there will be a different incidence of costs and benefits between PT users and PT operators – refer table 4.4, items F and L. In case 1, operator costs will not change, but user costs will increase as a result of the more crowded travel conditions. In case 2, all the additional costs will be borne by the PT operators in providing additional services; while users will gain benefits from the increased service frequency (greater convenience, less waiting time). In case 3, operator costs will tend to increase less than in 2, given operator economies of scale, while user costs will be unchanged.

While these (and perhaps other) options should be explored in a more comprehensive evaluation, for purposes of our case studies we assumed the following responses to PT demand increases at peak periods:

- For bus services, service capacity and frequency would increase in direct proportion to any increase in demand, ie case 2 above. All the additional costs would fall on the operator, while users would benefit from the increased frequencies.
- For rail services, service capacity would increase in direct proportion to demand, but the additional capacity would be provided through longer trains (more carriages per train), as case 3 above, rather than through more frequent services. Consequently there would be no benefits (or disbenefits) to PT users.

Appendix K sets out our methodology, including key parameter values, for estimating changes in PT operator costs and PT user costs in the various situations analysed. The key parameter values proposed for application in estimating PT marginal operator costs are set out in table K.1. This methodology etc is based on previous work undertaken by BAH (through Ian Wallis) for the MoT Surface Transport Costs and Charges Study (BAH 2005).

4.6 P&R user benefits

4.6.1 Context

This section of the report sets out our proposed methodology for application in the case studies, for assessing the economic benefits from providing additional P&R spaces to existing, new and potential P&R users, ie the people who would use the expanded P&R facility and/or whose travel behaviour would be directly affected by the expansion.

For the economic appraisal of multi-modal urban transport projects (including P&R initiatives), usually the demand modelling and economic appraisal would be integrated into a transport 'model'. This would incorporate a demand matrix and a network model, with user cost functions defined for each link in the model, and hence for each OD movement. The provision of additional P&R spaces would be reflected in changes in the user costs attributed to P&R links, and hence changes in behavioural 'generalised costs' would be derived for each movement. These changes would then be translated into economic benefits, by applying either behavioural unit cost values or, in this case, economic appraisal unit cost values (based on the EEM).

As discussed earlier, it was not feasible to use such an integrated modelling/economic appraisal approach in this case. Instead, the demand modelling had to adopt a 'diversion rate' approach, based on evidence from the project's market surveys, supported by wider international diversion rate evidence. The economic methodology then involved estimation of P&R demand curves (showing how P&R demand varies with the generalised costs of P&R trips) and the application of these together with the diversion rate evidence to derive a formula for economic benefits, as now outlined.

4.6.2 Assessment methodology

The benefit assessment methodology proposed is set out and explained in appendix L. Key features of this methodology are:

- It covers economic benefits to existing P&R users, new P&R users (using the additional P&R spaces to be provided) and other potential P&R users (in particular people who now park on-street around P&R sites, and will get benefits even if they do not use the additional P&R spaces).
- It involves the estimation of the demand curve for P&R spaces and the associated demand elasticity (with respect to the generalised costs of travel for the P&R market) for each case study location, based on data on the level of on-street parking and associated walking times to the station.
- The resultant benefit formula expresses total user benefits as a function of four variables for a given P&R site (details in appendix L):
  - current P&R site capacity (K)
  - number of additional P&R spaces proposed (ΔK)
  - current number of on-street parkers (potential P&R users) (N)
  - current maximum walking time to the station for on-street parkers (t)

4.6.3 Methodology application

The four variables 'driving' the benefit formula are as listed above. In terms of application of the methodology for each case study:

1. Current P&R site capacity was readily known for each site being considered.
2. Number of additional P&R spaces proposed was specified in each case study.[18]
3. Current number of on-street parkers. For most potential case study locations, we anticipated this figure would be already known (to a reasonable approximation). If not, it could be readily established by counts of the number of cars parked in the vicinity of each P&R location during the weekday inter-peak period (say between 1,000 and 1,200) during school/tertiary terms.

[18] For each site, the methodology made an estimate of the maximum number of additional P&R spaces that would be filled. For modelling/appraisal purposes, the maximum number of additional spaces proposed at any site should not exceed this estimate.

4 Current maximum walking times for on-street parkers. These could be estimated at the same time as any counts of the number of cars parked on-street: the walking time to the station for those people who park furthest from it would need to be estimated.

To derive annual benefits once these variables were established for each case study required two further inputs (common to all case studies):

1 Unit value of walking time for commuters. The model benefits were formulated in terms of minutes of walking time. Appendix L (section 4) sets out the basis for translating one minute of walking time into economic ($) values, based on EEM.[19]

2 Annualisation factor. The model as formulated relates to a single peak period. To derive annual benefits, a factor of 500 was applied (ie two peak periods, 250 weekdays per year).

4.7 Conclusions and implications

This chapter has developed an overall CBA-based framework for estimating the economic and financial impacts of the range of P&R options assessed in the case studies. The framework was designed to:

- separate the financial impacts (costs) to public authorities from the economic impacts (benefits) to transport system users
- show financial impacts separately for three public authorities – the road authority, the PT authority and the (notional) P&R authority
- show economic impacts separately for three main transport user groups – road (car) users, PT users and P&R users/mode switchers.

Detailed methodologies were developed, for application in the case studies, for the estimation of the transport user benefits accruing to these three groups. These methodologies were developed specifically for this project (but building on previous work) and were designed to adequately differentiate between the different case studies and the options to be assessed within each.

[19] In principle, any tine saving benefits to commuters from reduced walking times would be partly offset by health disbenefits resulting from reduced walking distances. However, this latter component would be relatively small and has therefore not been allowed for in our methodology.

5 Funding allocation framework and methodology

5.1 Introduction

This chapter sets out a proposed framework and methodology for allocation of funding for P&R projects, which has been developed following on from the economic and financial appraisal framework in chapter 4). Chapter 5 covers the following areas:

- literature review of funding approaches (section 5.2)
- objectives, roles and responsibilities (section 5.3)
- principles for funding allocation (section 5.4)
- proposed methodology and example application (section 5.5)
- conclusions/recommendations (section 5.6).

5.2 Literature review

We looked at current New Zealand practice (refer chapter 2) and sought out literature on the allocation of funding for P&R (and more generally). A summary of key references is provided in appendix M. Overall, there was little literature specific to the allocation of funding for P&R facilities, although we did review a number of references that dealt with the allocation of funding more generally. The experience in the UK and USA, and also in New Zealand, is that funding is largely driven by what is made available from the central/state government in terms of transport funding grants.

The literature primarily addressed central and local funding sources, with the allocation of funding in the UK and USA being largely driven by what is available from central/state governments (Duncan and Christensen 2013; Meek et al 2009). In the UK many practitioners have seen central government funding as an important driver of P&R development, which is complemented by local funding made up of local authority rates, developer contributions and central city parking charges (Meek et al 2009). Local authorities previously had to prepare 'local transport plans' every five years, which are multi-modal strategies that need to be prepared in order to receive central government funding (Curtis 1999; Meek et al 2009). Since 2010, the term of these plans and frequency of preparation has been relaxed with current plans covering the period 2011–26[20]. This approach is similar to New Zealand where local authorities generally develop P&R proposals for inclusion in three-yearly RLTPs, which are submitted to the Transport Agency for approval and generally seek a 50% funding share from the National Land Transport Fund (which is primarily made up of road user charges and fuel taxes).

In terms of funding allocation, for P&R this is generally based on the objectives of the relevant investment fund, for example the UK Department for Transport (DfT) Transport Investment Block funding for small PT projects, including P&R, is allocated using a 'needs based' assessment of six elements: deprivation, road safety, PT, air quality, congestion and accessibility (DfT 2012). These help justify investment from an individual organisation perspective but do not help when looking where funding 'should' fall, eg based on

[20] In the UK, rail P&R is most likely to be delivered through rail franchises, usually with very little local authority input (except for an advisory role) other than in major cities although integrated transport authorities have a significant coordinating role. P&R at the 19 largest railway stations is the domain of the network infrastructure company which owns, manages and develops them.

where benefits fall. As noted in Allison et al (2013) this is largely a political decision, although some guidelines can be provided and the concept 'that transport funding be equitable, that is, the distribution of costs and benefits should be considered fair and appropriate' (Litman 2013a) is an important one.

The Queensland Government in Australia has published *Developing a funding framework* (Queensland Government 2013) as part of its Project Assurance Framework used for preparing business cases. It is not specific to P&R nor transport more generally but provides guidelines on 'quantifying and attributing costs and benefits for a multi-agency project'. These are considered particularly relevant given the number of public authorities (with different policy goals/objects) involved in P&R investment in New Zealand. A key principle from this and other documents is that costs should be attributed across the various authorities on the basis of benefits accrued, which is the starting principle for our funding allocation framework below.

The Auckland Council (2012) alternative funding discussion document is not specific to P&R either but identifies five criteria for assessing alternative funding sources (fairness, administrative efficiency, transparency, neutrality, capacity) that could be relevant for P&R. Litman (2013a) also identified criteria for determining local funding sources for PT projects and services (potential revenue, predictability and stability, equity analysis, travel impacts, strategic development objectives, public acceptability, ease of implementation, legal status). We note that the consideration of funding allocation should be considered within the wider project appraisal approach, as Litman (2006) comments:

> *In general, an economic evaluation study should identify all impacts to society, but it can also define impacts from particular perspective, such as that of a particular agency, jurisdiction or social group.*

We believe that the principles set out in these references provide a sound basis for the development of a funding allocation framework, provided they are combined with a consideration of the various policy goals/objectives of the different agencies involved.

5.3 Objectives, roles and responsibilities

The objectives, roles and responsibilities of the public authorities involved in the planning and delivery of P&R facilities in New Zealand are set out in table 5.1.

Table 5.1 P&R roles/responsibilities and objectives of authorities in New Zealand

Authority	Role/responsibility	Objectives[a]	Comments
P&R authority	Lead authority for particular P&R investment	Increase P&R usage	The P&R authority is the authority responsible for delivering the P&R facility. The P&R authority is usually also the road and/or PT authority, with increase P&R usage usually a means of contributing to the objectives identified for those parties. We have assumed the P&R authority bears the direct financial costs of developing and maintaining the facility. This financial cost is offset by (economic) benefits for P&R users.
Road authority		Improved road network performance	The road authority is responsible for the road network, with separate authorities responsible for local/arterial roads and state highways. The road authority can be the P&R authority also. We have assumed the road authority does not bear any direct financial costs (separate from the P&R authority)[b] but there are (economic) benefits for road users, including decongestion and externality benefits. We have not at this stage attempted to allocate benefits between local/arterial and state highway road authorities[c].
• Local roading authority	Local/arterial roads		
• NZ Transport Agency	State highways		

Authority	Role/responsibility	Objectives[(a)]	Comments
PT authority	PT services and infrastructure	Reduced PT subsidies	The PT authority is responsible for PT services and infrastructure. Financial costs for the PT authority include capital costs for any additional vehicles and ongoing operating costs for the increase in service levels (required to provide additional capacity at peak). These costs may be partially offset by fares paid by P&R users. An (economic) benefit will accrue to existing PT users from increased services/frequencies provided for P&R capacity.

Notes:

[(a)] We have considered just two objectives: 1) improved road network performance, and 2) reduced PT subsidies (in line with research scope)

[(b)] Refer to discussion in chapter 4 for reasons why

[(c)] Where a suitable model was available, decongestion benefits (including VOC savings) could relatively easily be identified for the different road types but allocation of benefits could be more challenging for externality benefits

5.4 Principles for allocation of funding

An important concept underlying this funding allocation framework is that benefits should offset costs, and therefore parties should contribute funding in the proportion to which they benefit. This needs to be taken in the context of the objectives which are being sought; a party may benefit significantly but if those benefits do not align with their objectives they will be unwilling to contribute funding towards those benefits. It is therefore important that costs be attributed on the basis of benefits accrued towards achieving relevant policy goals/objectives for each organisation. We have considered two policy goals/objectives as part of this research project:

1 Improved road network performance

2 Reduced PT subsidies.

A number of other policy goals/objectives for P&R were also identified in section 4.2.1 but further consideration of these was outside the scope of this study. The consideration of CBD parking is one particular area where further investigation might be warranted, particularly where P&R might be provided to relieve pressure on CBD parking, and the relative pricing of CBD and P&R parking.

We have identified the following high-level principles to help guide decisions on the allocation of funding between the public authority groups (road, PT, P&R) involved in P&R investments in New Zealand, based on the respective roles and responsibilities discussed in chapter 2[21].

- Affordability – the project must be affordable, in total and for all the parties involved. Parties are only able to contribute funding within their means and will also generally have multiple competing policy goals/objectives.
- Equity – parties should contribute funding in proportion to the benefit they receive.
- Objectives – the benefits considered in allocating funding should contribute towards the objectives of the funding parties. This includes agreeing on the benefits that should be considered (and dis-benefits).

[21] The principles would also apply to other parties that might bear costs or benefit from the P&R investment but funding from other parties, including user charges and other funding sources (eg developer contributions) have not been investigated as part of this research project.

- Transparency – parties need to know how much they are paying and what they are paying for. This includes understanding how benefits and costs and identified and calculated.
- Neutrality – funding decisions should not cause 'undesirable' changes in behaviour. The definition of undesirable will depend on the context but could include consideration of distributional impacts where one party might benefit at the expense of another (eg between CBD parkers and P&R users).[22]

These principles are high level and their application will depend on the context. It would therefore be important to consider and discuss them early on with the relevant parties. These principles have been used as the basis of our funding allocation methodology set out below, noting that should it not be possible to meet these principles then this might be an indication that the P&R investment should not proceed (eg where benefits accrue to a party that is unable to pay or where the benefits do not contribute to their policy goal/objectives or these objectives are not high enough priority for that organisation).

5.5 Proposed methodology and example application

This section sets out a proposed methodology for allocating funding between P&R, PT and road authorities, before providing an example of its application using some of the case studies (see chapter 6).

5.5.1 Methodology

The methodology for the allocation of funding, assuming the authorities set out in table 5.1, is a simple four-step process:

1 Agree funding principles and objectives.

2 Apportion user benefits based on roles and responsibilities.

3 Apportion public costs based on roles and responsibilities.

4 Determine funding shares based on benefits and costs already apportioned.

These steps are described below.

5.5.1.1 Step 1: Agree funding principles and objectives

This involves consideration of the funding principles set out above and the objectives of potential funding parties. The funding principles above provide a good starting point for this discussion. It is also important that the funding parties are clear on their objectives and the benefits that will be considered and any other performance measures for ensuring those objectives are met. This covers more than just funding issues with the primary purpose to agree an approach acceptable to all parties, and should align with early consideration of the problem or opportunity defined as part of the 'strategic case' under the Transport Agency business case approach.

5.5.1.2 Step 2: Apportion user benefits based on roles and responsibilities

The second step involves apportioning user benefits (economic) based on role and responsibilities. User benefits are calculated based on the appraisal framework set out in section 4.3 and table 4.4 and apportioned between the P&R, PT and road authorities.

[22] Impacts could be financial or economic and could potentially be remedied if adversely affected parties were appropriately compensated. The key is that the funding does not cause 'undesirable' changes in behaviour, for example charging for P&R parking so that an authority could develop more CBD parking would be undesirable if the purpose of the P&R scheme was to reduce the number of car journeys into the CBD (noting charging is out of scope of this study).

The allocation of user benefits as part of the funding allocation framework is shown in table 5.2, with user benefits accruing to the road, PT and P&R authorities along the following lines:

- P&R user benefits accrue to the P&R authority (H+I2+J+K) and new ridership benefits to the PT authority (I1).
- PT existing user benefits accrues to the PT authority (L).
- Decongestion benefits (including O&M and deferral of capital expenditure) accrue to the road authority (M&N).
- Road system externalities accrue to the road authority (O+P+Q).

The benefits in each column are then summed to provide the total user benefits for each of the road, PT and P&R authorities, which are divided into the total benefits to generate the respective funding shares.

Table 5.2 Funding allocation framework – allocation of user benefits

	Cost/benefit items	Road authority	PT authority	P&R authority
User benefits (economic)	P&R user benefits	-	I1	H+I2+J+K
	PT existing user benefits	-	L	-
	Other road traffic (decongestion) benefits	M+N	-	-
	Road system externalities	O+P+Q	-	-
	Total user benefits	**$AA**	**$BB**	**$CC**

Notes: Letters reference to items in table 4.4: H=new P&R users (generalised time benefits), I1=new P&R users (PT fares), I2=new P&R users (P&R changes), J=new P&R users (VOC), K=existing P&R users (convenience), L=existing PT users (frequency), M=decongestion (including schedule delay), N=VOC, O=crash costs, P=global environmental costs, Q=local environmental costs

5.5.1.3 Step 3: Apportion public costs based on roles and responsibilities

This is similar to step 2 above but applied to the public costs (financial) part of the equation. The allocation of financial costs is shown in table 5.3, based on the following considerations:

- Infrastructure (capital) costs accrue to the P&R authority (A+B) and PT authority (E). We have assumed the road authority does not bear any direct/significant costs[23].
- Operations and maintenance accrue to the P&R authority (C) and PT authority (F).
- Revenues from additional PT users accrue to the PT authority (G) while any user charges for the P&R facilities accrue to the P&R authority (D), although this will depend on the revenue collection mechanism. These revenues offset the costs.

Depending on the region and authorities involved, the P&R authority may also be the PT and/or road authority in which case the distinction between the different parities is less important, but useful nonetheless to understand where the costs are falling.

[23] There may be situations, especially for larger projects, where the road authority will incur local roading costs to support development of P&R facilities, eg to facilitate local access. Should this be the case then these costs would need to be factored in as part of the methodology.

Table 5.3 Proposed framework for allocation of funding

	Cost/benefit items	Road authority	PT authority	P&R authority
Public costs (financial)	Infrastructure (annualised capital)	-	E	A+B
	Operations & maintenance	-	F	C
	Revenues	-	-G	-D
	Total financial costs	-	**$DD**	**$EE**

Notes: Letters reference to items in table 4.4: A=P&R site (land), B=P&R site (construction), C=P&R site O&M, D=P&R charges (which were outside the scope of this study), E=PT vehicles capital, F=PT O&M, G=PT fares (offset public costs)

PT vehicle capital costs will largely be included in the O&M costs

Charging for P&R was not considered as part of this study

5.5.1.4 Step 4: Determine funding shares based on benefits and costs already apportioned

The final step is to determine funding shares based on the benefits identified in step 2 while taking account of costs already incurred, as identified in step 3. The process is as follows:

1 Calculate share of benefits by dividing each authority's benefits (from step 2) into the total benefits.

2 Calculate the share of costs by multiplying each authority's share of benefits by total costs.

3 Identify funding payable to other parties by subtracting the costs already incurred by each party from their share of costs.

These steps ensure that the funding requirement is apportioned between the parties in proportion to the benefits they are receiving, with funding decisions made based on the funding principles and objectives set at the beginning of the process. For example, principles might be established around affordability to each party and if the funding required for the project was too high for a particular party this might be redistributed amongst the other parties, or the project might not proceed.

We have attempted to keep these considerations as simple as possible, with the allocation of funding based on annualised benefits and costs to identify where the benefits lie in relation to costs. A separate commercial exercise would be required in terms of specific funding requirements over time which would take account of the timing and nature of costs for different parties.

The next section provides some examples, based on the case studies, of how the funding allocation methodology can be applied.

5.5.2 Example application of methodology

The first step is to agree the funding principles and objectives/assessment criteria upfront, based on the objectives, roles and responsibilities set out in section 5.3. Our example application focuses on the subsequent steps required to calculate a funding allocation and then discuss what this means.

An example application of the methodology to the Albany case study is set out in table 5.4. Figures are in thousand dollars per annum ($000pa). This project had a BCR of 3.8 and based on the methodology 81% of the benefits accrued to the road authority and 21% to the P&R authority, while the PT authority incurred disbenefits of 2%. It is clear the road authority received the greatest benefits but as it was not incurring any direct costs from the P&R project, it therefore had to contribute funding to the P&R authority as, due to the investment required, the P&R authority had a funding deficit of -506 (refer last row in table). The road authority would contribute 505 and the PT authority 2. This is because while the PT authority received a disbenefit in terms of user benefits (-55) this was offset by a new financial benefit of 16, due to the increase in fare revenues (300) exceeding the additional O&M costs (284). No capital costs were identified for the PT authority as the cost of any additional vehicles (buses) was included in the O&M costs.

Table 5.4 Example application of methodology – based on Albany case study

	Cost/benefit items	Road authority	PT authority	P&R authority	Total
Public costs (financial)	Infrastructure (annualised capital)	-	-	439	
	Operations & maintenance	-	284	198	
	Revenues	-	300	-	
	Total financial costs	**0**	**-16**	**637**	**621**
User benefits (economic)	P&R user benefits	-	-	501	
	PT existing user benefits	-	-55	-	
	Road system decongestion and externality benefits	1,930	-	-	
	Total user benefits	**1,930**	**-55**	**501**	**2,375**
				BCR:	**3.8**
Calculate funding share	1 Calculate share of benefits	81%	-2%	21%	100%
	2 Calculate share of costs based on benefits	505	-14	131	621
	3a Calculate costs incurred by each party	0	-16	637	621
	3b Identify funding payable to other parties	505	2	-506	0

The following figure shows this methodology applied to each of the case studies. This shows that in all cases the direct cost to the P&R authority exceeded the direct P&R benefits, with additional funding required from the road and PT authorities. The benefits to the road authority could also be high compared with the PT and P&R benefits but in the case of PT the revenues from increased use generally exceeded the additional costs to PT and therefore the PT authority would contribute funding to the P&R authority.

Table 5.5 Funding allocation methodology – application to case studies

		Albany case study			
	Cost/benefit items	**Road authority**	**PT authority**	**P&R authority**	**Total**
Public costs (financial)	Infrastructure (annualised capital)	-	-	439	
	Operations & maintenance	-	284	198	
	Revenues	-	300	-	
	Total financial costs	**0**	**-16**	**637**	**621**
User benefits (economic)	P&R user benefits	-	-	501	
	PT existing user benefits	-	-55	-	
	Road system decongestion and externality benefits	1,930	-	-	
	Total user benefits	**1,930**	**-55**	**501**	**2,375**
				BCR:	**3.82**
Calculate funding share	1 Calculate share of benefits	81%	-2%	21%	100%
	2 Calculate share of costs based on benefits	505	-14	131	621
	3a Calculate costs incurred by each party	0	-16	637	621
	3b Identify funding payable to other parties	505	2	-506	0

		Constellation case study			
	Cost/benefit items	**Road authority**	**PT authority**	**P&R authority**	**Total**
Public costs (financial)	Infrastructure (annualised capital)	-	-	112	
	Operations & maintenance	-	65	45	
	Revenues	-	55	-	
	Total financial costs	**0**	**10**	**157**	**167**
User benefits (economic)	P&R user benefits	-	-	148	
	PT existing user benefits	-	-15	-	
	Road system decongestion and externality benefits	411	-	-	
	Total user benefits	**411**	**-15**	**148**	**543**
				BCR:	**3.26**
Calculate funding share	1 Calculate share of benefits	76%	-3%	27%	100%
	2 Calculate share of costs based on benefits	126	-5	45	167
	3a Calculate costs incurred by each party	0	10	157	167
	3b Identify funding payable to other parties	126	-14	-112	0

		Petone case study			
	Cost/benefit items	**Road authority**	**PT authority**	**P&R authority**	**Total**
Public costs (financial)	Infrastructure (annualised capital)	-	-	146	
	Operations & maintenance	-	-36	79	
	Revenues	-	26	-	
	Total financial costs	**0**	**-62**	**225**	**163**
User benefits (economic)	P&R user benefits	-	-	280	
	PT existing user benefits	-	-15	-	
	Road system decongestion and externality benefits	79	-	-	
	Total user benefits	**79**	**-15**	**280**	**343**
				BCR:	**2.11**
Calculate funding share	1 Calculate share of benefits	23%	-5%	82%	100%
	2 Calculate share of costs based on benefits	37	-7	133	163
	3a Calculate costs incurred by each party	0	-62	225	163
	3b Identify funding payable to other parties	37	55	-92	0

	Cost/benefit items	Waterloo case study: Road authority	PT authority	P&R authority	Total
Public costs (financial)	Infrastructure (annualised capital)	-	-	83	
	Operations & maintenance	-	-21	45	
	Revenues	-	15	-	
	Total financial costs	**0**	**-35**	**128**	**93**
User benefits (economic)	P&R user benefits	-	-	200	
	PT existing user benefits	-	-9	-	
	Road system decongestion and externality benefits	48	-	-	
	Total user benefits	**48**	**-9**	**200**	**239**
				BCR:	**2.57**
Calculate funding share	1 Calculate share of benefits	20%	-4%	84%	100%
	2 Calculate share of costs based on benefits	19	-4	78	93
	3a Calculate costs incurred by each party	0	-35	128	93
	3b Identify funding payable to other parties	19	32	-50	0

	Cost/benefit items	Porirua case study: Road authority	PT authority	P&R authority	Total
Public costs (financial)	Infrastructure (annualised capital)	-	-	154	
	Operations & maintenance	-	-38	83	
	Revenues	-	27	-	
	Total financial costs	**0**	**-65**	**237**	**172**
User benefits (economic)	P&R user benefits	-	-	481	
	PT existing user benefits	-	-23	-	
	Road system decongestion and externality benefits	58	-	-	
	Total user benefits	**58**	**-23**	**481**	**515**
				BCR:	**3.00**
Calculate funding share	1 Calculate share of benefits	11%	-4%	93%	100%
	2 Calculate share of costs based on benefits	19	-8	160	172
	3a Calculate costs incurred by each party	0	-65	237	172
	3b Identify funding payable to other parties	19	58	-77	0

5.6 Conclusions/recommendations

In this section we have defined roles/responsibilities for public authorities, set out funding allocation principles and proposed a framework for determining funding allocations for P&R-related investments based on a consideration of where net-benefits lie and the organisational objectives being achieved.

The resulting framework is intended to guide decisions on which public authorities should fund investments in P&R. It could also be used to help determine the proportion of costs that could subsequently be recovered through charges on users (or other beneficiaries, although that was not a consideration for this research and it is important to account for any reduction in demand that would likely accrue from user charges.

6 Case studies

The project involved five case studies, each examining the impacts of providing additional parking spaces at existing P&R sites on the Auckland and Wellington PT (rapid transit) networks.

The main purposes of these case studies were to:

- provide a focus for the development, testing and fine tuning of the appraisal methodology
- demonstrate to the project Steering Group and other potential users of the methodology how it would work in practice, and what were the key data issues and methodology considerations in its application
- provide estimates of economic/financial performance for the five cases examined (from which it might be possible to make some generalisations for other P&R cases).

This chapter sets out:

- the process of selecting the case studies (section 6.1)
- the final five case study sites and key features (section 6.2)
- the evaluation framework methodology, key inputs and their sources (section 6.3)
- the case study results and discussion of the findings (section 6.4)
- comments on the strengths and weaknesses of the research methodology (section 6.5).

6.1 Selection of case studies

The consideration of the case studies took place throughout the project as follows:

- scoping and evaluation of potential case studies (phase 2), development of the 'long list'
- detailed specification of case studies (phase 3), preparation of the 'short list'
- undertaking the case studies (phase 4).

This approach was intended to ensure that each phase of work focused on actual application considerations, and also for the Steering Group to make informed decisions as the project progressed on the most suitable case study considerations.

The initial scoping of potential case studies in phase 2 of the project built on the information obtained through the literature and practice review to identify potential case studies. This first step identified a number of potential case studies, including key information such as location, existing number of parking spaces (if any), potential additional parking spaces and a brief analysis of suitability for case study. This is referred to as the long list of case study sites and is provided in appendix N, section N1. The sites on the long list were evaluated (see appendix N, section N2) and from this, a short list of five potential case studies plus three reserve sites was recommended for Steering Group consideration at the end of phase 2 of the project.

The next step was the detailed specification of the case studies agreed to by the Steering Group. This took place within phase 3 of the project and involved producing a detailed specification of the case studies, for Steering Group sign-off prior to phase 4.

The short list of preferred sites from phase 2 of the study was:

- Albany Busway P&R

- Hibiscus Coast/Silverdale Bus P&R[24]
- Waterloo rail P&R
- Petone rail P&R
- Porirua rail P&R.

The sites on the reserve list were:

- Swanson rail P&R
- Westgate bus P&R
- Takapu Road rail P&R.

During phase 3 of the study, more research was undertaken into the preferred and reserve sites, particularly in terms of data and model availability, to determine the sites for the case studies. The modelling and analysis of these sites was then undertaken in the final phase 4 of the project.

The Hibiscus Coast/Silverdale P&R site was on the preferred list of case study sites at the end of phase 2. However, upon further review, it was found that this site was not included within any suitable existing traffic models. On this basis Hibiscus Coast/Silverdale was discarded as a preferred case study.

With the removal of Silverdale as a preferred case study, Swanson was initially considered as the replacement site from the reserve list. However, Swanson was also not covered by a suitable traffic model and did not enable interaction between P&R sites to be considered. On this basis, Swanson did not make a suitable replacement for Hibiscus Coast/Silverdale.

A key attribute of the Hibiscus Coast/Silverdale site was that it had strong interaction with the Albany site, in terms of users choosing between them. This was reflected in recent customer surveys carried out at Albany. There were no other combinations of sites on the long or short list that had the same amount of interaction between sites. As the consideration of the issue of interaction between P&R sites is part of the research brief, the only option remaining was to introduce another P&R site not previously considered in phase 2 of the study. Constellation Drive P&R was selected as a suitable replacement for Hibiscus Coast/Silverdale, as it was included in a suitable traffic model and was known to interact with Albany, again reflected by the recent customer survey at Albany.

Table 6.1 presents a summary of the preferred and reserve case studies developed during phase 3 of the study and how they were considered further. As noted above, Constellation Drive was introduced into the mix to enable the evaluation of site interaction. For the reasons outlined above, Hibiscus Coast/Silverdale and Swanson were no longer preferred case studies for future analysis, with Constellation Drive as the new preferred case study site alongside Albany, Petone, Waterloo and Porirua.

Table 6.1 Case study site status at the end of phase 3

Site	Base case	Option	Mode	Development plans	Suitable model	Outcome
Albany	Pre-2012 expansion (550)	Current site (1100)	Bus/busway	Yes	Yes	Proceed to phase 4 as preferred
Porirua	Current site (452)	Expansion (761)	Train	Yes	Yes	Proceed to phase 4 as preferred

[24] Subsequently rejected and replaced by Constellation bus P&R

Site	Base case	Option	Mode	Development plans	Suitable model	Outcome
Petone	Current site (266)	Expansion (566)	Train	Yes	Yes	Proceed to phase 4 as preferred
Hibiscus Coast	Stage 1 development (104)	Stage 2 development (500)	Bus/busway	Yes	No	Do not proceed
Waterloo	No recent upgrades	No proposed expansion	Train	No	Yes	Proceed to phase 4 as preferred
Swanson	Current site (42)	Expansion (138-500)	Train	Yes	No	Do not proceed
Takapu Road	Current site (80)	Expansion (250-300)	Train	Yes	Yes	Retain as reserve
Westgate	No park and ride	New facility (500)	Bus	Yes	Yes	Retain as Reserve
Constellation Drive (NEW)	Current facility (370)	No proposed expansion	Busway	No	Yes	Proceed to phase 4 as preferred

Details on the sites identified as reserve and those rejected due to lack of model coverage are provided in appendix N.3.

6.2 Case studies undertaken

Table 6.2 sets out the case studies considered in phase 4 of the study, including the base case and option.

Table 6.2 Case study sites (phase 4)

Site	Location	Base case	Option	Mode	Development plans	Suitable model
Albany	Auckland	Pre-2012 expansion (550)	Current site (1,100) Revised to 990 [+440]	Busway	Yes	Yes
Constellation Drive (NEW)	Auckland	Current site (370)	Notional upgraded facility (470) [+100]	Busway	No	Yes
Porirua	Wellington	Current site (452)	Expansion (761) Revised to 637 [+185]	Train	Yes	Yes
Petone	Wellington	Current site (266)	Expansion (566) revised to 441 [+175]	Train	Yes	Yes
Waterloo	Wellington	Current site (602)	Notional upgraded facility (702) [+100]	Train	No	Yes

During the application of the evaluation framework, an issue arose at some locations due to the size of the expansion to be assessed. In the absence of an appropriate model to calculate the modal shift, diversion rates from market surveys combined with the number of cars parked on-street in the vicinity of the sites in the base case were used. The methodology adopted is valid when the number of cars parked on-street is less than or equal to the likely shift from on-street parking to using the P&R facilities (ie the input diversion rate). In some cases (Albany, Porirua and Petone), the larger P&R facilities in the option provided more capacity for on-street parkers to relocate than the demand estimated from car 'diversion rate modelling' (supply greater than demand). This was addressed by reducing the additional P&R capacity and revising the option capacity as noted in table 6.2.

A full assessment of the case study sites, or any other site, can be undertaken if robust P&R modal shift models become available.

The application of the evaluation framework to these five case studies for the revised options is summarised in the next section.

6.3 Case study evaluation methods

Full results of the application of the economic and financial evaluation framework to the five case studies are provided in appendix O.

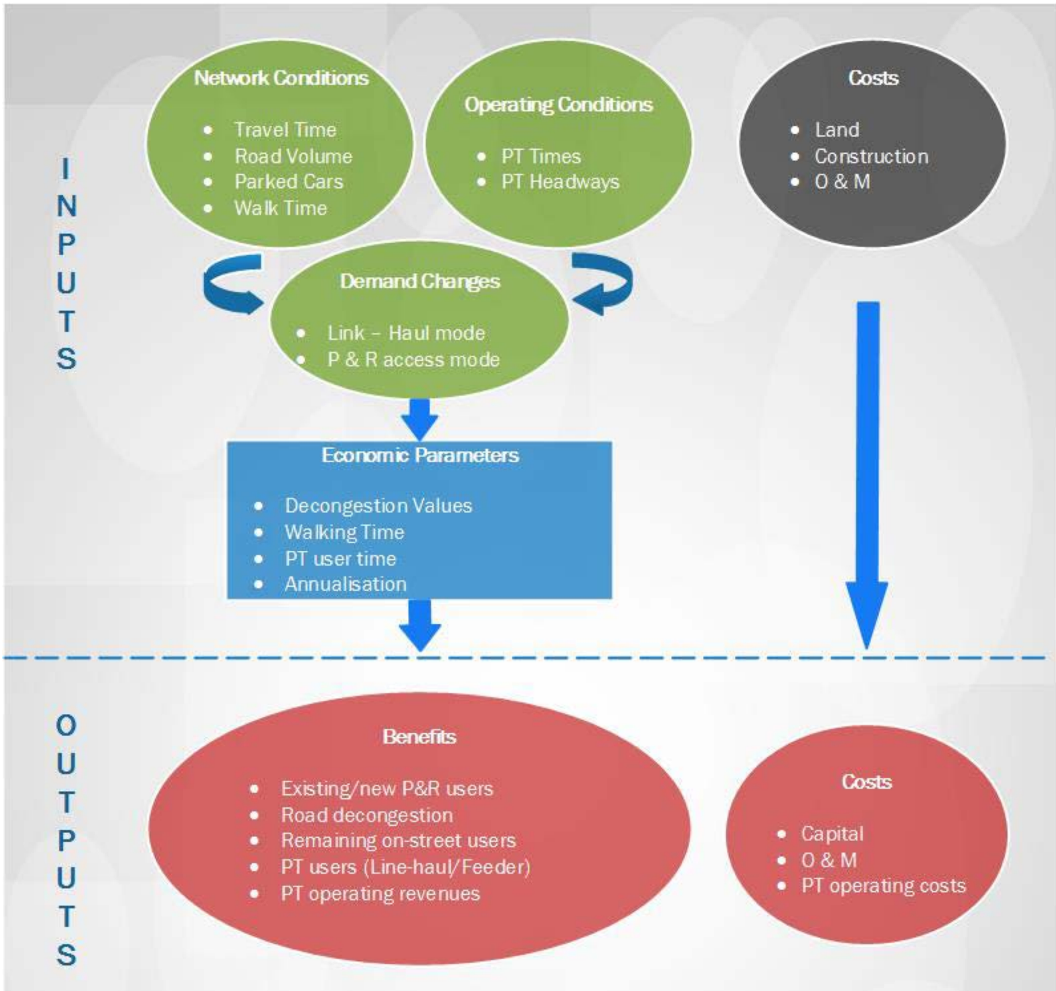
The following sections set out:

- an overview of our evaluation method
- the main inputs to the evaluation method
- results for the five case studies.

6.3.1 Overview of evaluation methodology

Our evaluation methodology is illustrated in figure 6.1. In short, (dis)benefits have been calculated for existing and new P&R users, existing PT users, road users who do not utilise P&R, and users of alternative PT or feeder bus services. Costs include land value, facility construction and ongoing O&M costs.

Figure 6.1 Schematic of evaluation methodology



The economic benefits included in the evaluation framework are:

- benefits to existing P&R users from greater availability of P&R spaces. Patrons who currently arrive early to be sure of a space may be able to travel later
- benefits to new P&R users who currently travel all the way by car or another PT service
- benefits to new P&R users who currently use the PT service but park on-street, use connecting bus services, or walk, but will now be able to park at the P&R site
- benefits to existing PT users from increased frequency (this applies to buses only as in the case of trains, extra passengers are assumed to result in longer trains)
- disbenefits to connecting or alternative PT service users who may face poorer service if patronage reduces
- benefits to road users who suffer less congestion as a result of some drivers switching, producing net VKT reduction and travel time savings.

Against this, some additional costs were included in the evaluation framework:

- the opportunity and development cost of the land and any ongoing maintenance costs
- the additional operating cost of the PT service.

To calculate the benefits and costs, the inputs to the evaluation framework are described in the next section.

6.3.2 Inputs to appraisal framework

In applying the appraisal framework for a specific site, a range of inputs must be provided. While for some of these inputs a default value has been provided, the majority cannot be generalised in this way. The site-specific inputs to the evaluation framework are:

- facility details – number of existing P&R spaces, proposed capacity increase and whether the P&R site is served by rail or bus
- costs – land costs, construction costs, planning costs and ongoing O&M costs – all for the proposed capacity increase
- network conditions – peak travel time by road, peak volume in the corridor (peak direction), number of cars parked on-street at the P&R site, and the maximum walking time from these on-street parked cars to the P&R facility
- operating conditions – PT fare and headways (line haul service, competing alternative services, feeder services)
- demand changes – changes in travel associated with the P&R site by mode and changes in the average distance travelled by mode.

The sources for the site-specific data input to the evaluation framework are summarised in table 6.3.

Table 6.3 Site-specific appraisal framework inputs – source

Category	Input	Default value	Source
Costs	Land area	30m^2/space $	Discussion with GWRC/AT. Auckland GIS system estimates. Value is a typical site average, including aisles and entrances/ exits.
	Land value	$300/$m^2$	Correspondence with GWRC and AT, information in press. Typical land value (opportunity cost basis).
	Construction	$2,800 space	Correspondence with GWRC and AT
	Planning/overheads	20% of construction	Estimate
	Annual P&R O&M	$450/space	Sourced from AT
Network conditions	Peak and off-peak travel times by road	n/a	SATURN models
	Peak volume in corridor		
	No. cars parked on-street		Estimated from Google Earth. This could be improved from local survey data on a case-by-case basis.
	Max walk time from on-street parking place	5 mins	Estimated from Google Earth (approximate only). Likely to replace by direct site observation for specific site studies.
Operating conditions	PT fare	$3-$5	AT (https://at.govt.nz/) and GWRC websites (www.metlink.org.nz/)
	PT headways	10–15 mins	Public timetable
Demand changes	Change by mode	From New Zealand market surveys (see appendix H)	
	Change in distance travelled	n/a	Other surveys from AT and GWRC; and consultant estimates

In addition to the site-specific inputs listed above, a range of economic values is used in the evaluation framework. Recommended values for these have been included; however, flexibility has been incorporated in the framework to allow sensitivity testing. The economic inputs include:

- unit value of walking time (appendix L4).
- unit values of 'decongestion' impacts (appendix J) covering:
  - value of car travel time savings, including allowances for congestion and reliability
  - value of vehicle operating cost changes
  - value of GHG emission changes
  - value of crash cost changes
- marginal PT operator costs per passenger, for AKL bus, AKL rail and WGN rail (figures cover marginal operating costs plus marginal annualised capital charges relating to additional PT vehicles) (appendix K1).
- parameters relating to PT user economies of scale (ie initial headway, wait time: headway factor, value of PT user time savings (appendix K2).
- annualisation factor, from single AM peak period to year (appendix L8).

Other general inputs (ie not site specific) used in the evaluation framework include:

- elasticity for % travel time savings with respect to % traffic volume change (line haul routes and local roads) (table 3.3)
- treatment of financial impacts on the PT system (ie changes in fare revenues and operating costs) as a benefit (to operators) or a cost (to government).

6.4 Case study economic/financial appraisal results and discussion

6.4.1 Economic/financial outputs and key performance indicators

The case study assessment involved applying the economic/financial appraisal methodology to the five specified case studies (table 6.2). The appraisals were undertaken on an annualised basis, with all benefit and recurrent cost items being assessed as annual amounts (avoiding the need for forecasting future demand changes) and all capital cost items being converted to an equivalent annual amount. Key economic performance measures derived were: (i) net annualised value (annual equivalent of NPV); and (ii) ratio of annual benefits to annualised public costs, BCR(G). The benefit items were disaggregated into three main areas:

1. Benefits to P&R (existing and new) users. The appraisal methodology estimates the benefits from increased P&R spaces at each site based on the present P&R capacity, the currently unmet demand and the estimated diversion rates for that site (established through the market surveys).
2. Benefits to road users. The methodology estimates the 'decongestion' and related benefits, based on the relationships developed between the change in demand and the travel time savings in the corridor (section 4.4).
3. Benefits to PT users (and operators). The methodology reflects how PT operating costs, PT user costs and PT fare revenues would be expected to vary in response to marginal changes in patronage.

Where appropriate, the methodologies developed made use of EEM evaluation parameters (values of time, etc).

6.4.2 Case study results

Table 6.4 provides a summary of the economic/financial appraisal results for the five case studies based on the specific number of additional spaces assessed. Table 6.5 shows the costs and benefits expressed per additional space; these results are more readily comparable across the five schemes and our commentary below focuses primarily on these. Full details of the results are given in appendix O.

Several points should be noted in interpreting these results:[25]

- All figures are provided on an annual basis (rather than a discounted cash flow basis over the scheme life). For this purpose, the capital costs involved in providing the additional spaces have been annualised (at 6% pa real over an assumed 20-year life, and allowing for residual value for the land at the end of this period).
- Our BCR estimates have been based on the EEM definition of BCR(G), ie with the BCR denominator representing the scheme costs to government, rather than the BCR(N) representing the costs from the national perspective. We consider this approach is more appropriate for schemes such as this, which generate significant revenues to partially offset ongoing O&M costs.
- The figures in tables 6.4 and 6.5 treat the net effects on PT operators (incremental cost less incremental fare revenues) as a cost (ie included in the BCR denominator), on the basis it will be funded by the public sector (through regional council contracts), rather than as an operator benefit (ie included in the BCR denominator). The alternative of treating this item as an operator benefit is examined through sensitivity tests, as below. This assumption affects the BCR results, but not the net annualised value for each scheme.

[25] The opportunity costs of the land required have been estimated in all cases, even if the land is already in AT/GWRC (or KiwiRail) ownership.

Table 6.3 Summary of case study results

Item	Component	Units	Albany	Constellation	Petone	Waterloo	Porirua
Additional P&R spaces assumed			440	100	185	175	100
PT user benefits	Direct benefits to P&R users	$000pa	500	110	280	185	480
	Benefits to remaining on-street	$000pa	1	37	0	15	1
	Line haul user benefits	$000pa	24	3	0	0	0
	Benefits to other PT	$000pa	-79	-18	-15	-9	-23
Road user benefits	Road decongestion benefits	$000pa	1,930	411	79	48	58
Producer benefits	Line haul provider benefits[(a)]	$000pa	0.0	0.0	0.0	0.0	0.0
	Cost to other PT providers[(a)]	$000pa	0.0	0.0	0.0	0.0	0.0
Total	**Total benefits**	**$000pa**	**2,375**	**543**	**343**	**239**	**515**
Summary of costs	P&R site capital costs	$000	6,364	1,649	2,163	1,236	2,287
	P&R site capital costs – annualised	$000pa	439.3	112.0	145.8	83.3	154.1
	P&R site O&M costs	$000pa	198.0	45.0	78.8	45.0	83.3
	PT op costs (net)[(a)]	$000pa	-16	10	-62	-35	-65
	Total annualised costs	**$000pa**	**621**	**167**	**163**	**93**	**172**
Benefits vs costs	**BCR (G)[(a)]**		**3.8**	**3.3**	**2.1**	**2.6**	**3.0**
	Net annualised value	**$000pa**	**1754**	**376**	**181**	**146**	**343**

Note: [(a)] These results take the perspective that any change in PT operator costs (net of farebox revenues) will be treated as a cost to government (in row 'PT op costs (net)'), rather than a benefit to PR service providers.

Table 6.4 Summary of case study results on a per additional space basis

	Dollars per annum/space				
	Albany	**Constellation**	**Petone**	**Waterloo**	**Porirua**
Benefits pa					
P&R users	1,138	1,477	1,601	2,005	2,597
PT users	-126	-153	-88	-92	-124
Road decongestion	4,386	4,108	451	478	313
PT operator benefits	0	0	0	0	0
Total user benefits	**5,398**	**5,432**	**1,963**	**2,391**	**2,786**
Costs pa					
P&R capital	998	1120	833	833	833
P&R O&M	450	450	450	450	450
PT operating (net)	-36	97	-353	-353	-353
Total costs (annualised)	**1,412**	**1,667**	**930**	**930**	**930**
Summary					
Net annualised value	**3,986**	**3,765**	**1,033**	**1,462**	**1,856**
BCR(G)	**3.8**	**3.3**	**2.1**	**2.6**	**3.0**

6.4.3 Commentary on main results

We summarise and comment on the main results from tables 6.3 and 6.4 (focusing primarily on table 6.5 results) as follows:

6.4.3.1 Overall costs:

- The largest cost item is the capital costs (land and construction) to provide the additional P&R spaces. In all cases these annualised capital costs are around $1,000pa/space (corresponding to a total capital cost of around $15,000/space).
- The second largest cost item is the P&R site operating/maintenance costs, at $450pa/space. (Given the relative size of this figure, it may be worth some further investigation of the robustness of the estimates.)
- The remaining cost item is the net PT operating costs, which comprise the differences between the incremental PT operating costs to carry the additional passengers less the incremental fare revenue from those passengers. In most cases the net cost is negative, indicating that the incremental revenues exceed the incremental costs (although the two are generally quite finely balanced).
- In total, the costs for the five schemes are in the range (rounded) $900–$1,700pa per space.

6.4.3.2 Overall benefits

- The benefits to P&R users across the five schemes are in the range $1,100–$2,600pa per space (ie on their own, very comparable with the total costs above). The differences between schemes largely reflect the extent of walking time savings by current on-street parkers (which similarly apply to other users of the additional P&R spaces).
- The road decongestion benefits vary within a wide range, between some $300pa/space (Porirua) and $4,400pa/space (Albany). The key drivers of these results are:

- the proportion of additional P&R users that would otherwise have driven to the CBD: this is considerably higher for the AKL sites (based on the Albany survey) than for the WGN sites (based on the Petone/Waterloo survey)
- the estimated elasticities for motorists' travel times with respect to traffic volumes; again, these are significantly higher for the AKL schemes than for the WGN schemes, reflecting greater levels of congestion in the AKL case.

- For the AKL schemes, the decongestion benefits account for the great majority (around 80%) of total benefits, for the WGN schemes in the range of 11%–23%.
- The remaining benefits component relates to PT users, being the 'Mohring effect' (user economies of scale, for existing PT users) resulting from service frequency changes in response to changes in PT patronage. The figures cover service frequency effects on the line-haul rapid PT services (benefits, through frequency increases) and on the local services and on any other line-haul (non-rapid PT) services (generally a disbenefit, through frequency reductions). Maybe somewhat surprisingly, the net results are negative in every case,[26] although they account for only a small proportion of total benefits/disbenefits.

6.4.3.3 Overall economic performance

- All the figures show BCR(G) results substantially greater than 1.0[27]. The two AKL schemes (with the high decongestion benefits) have BCR estimates of about 3.8 (Albany) and 3.3 (Constellation). The three WGN schemes, with much lower decongestion benefits, have BCR estimates between 2.1 and 3.0.
- Prima facie, these BCR(G) results might be considered on the high side, relative to most other schemes for encouraging mode switching and increasing PT usage. However, it should be borne in mind that P&R schemes such as these are very targeted at encouraging mode switching from car to PT at times and in situations where PT offers an attractive alternative mode and any decongestion benefits for the road system are likely to be maximised.

6.4.3.4 Impacts by transport 'authority'.

Table 6.6 provides a summarised breakdown of the case study costs and benefits between the three notional public authorities affected (refer table 4.4). It is evident that:

- The majority of total costs are incurred by the (notional) P&R authority and the P&R users receive economic benefits which in most cases exceed these costs.
- Road users are the major recipient of economic benefits (relating to decongestion), while the roading authority does not incur significant costs. (In principle, it might save or defer significant capital expenditures for providing additional roading capacity.)
- The net costs to the PT authority (for providing additional services less additional fare revenues received) are relatively small (positive or negative), as are any benefits to existing PT users (through service frequency changes).

Table 6.6 (or similar) can also provide the starting point for the allocation of the P&R scheme costs (capital and recurrent) between the authorities concerned, based on the funding allocation framework principles and methods (refer section 5.5).

[26] This negative result reflects that, as the initial service frequencies are much lower on the local/non-rapid PT services, the economic disbenefits of any reductions in service frequency levels exceed the benefits from any service frequency increases in the rapid PT services.

[27] The BCR estimate is the same, whether the figures are based on the total scheme or on a per space basis.

Table 6.6 Case study costs and benefits incidence –typical values (per additional P&R space pa)

Transport authority	Incidence of costs		Incidence of benefits	
	Item	Costs	Item	Benefits
Park and ride	P&R capital	$800 to $1,000	P&R users	$1,100 to $2,600
	P&R operating	$450		
Roading		–	Road users (decongestion)	$300 to $4,400
Public transport	Net operating costs	-$400 to + $100	PT users	-$100

6.4.4 Sensitivity tests and commentary

A range of sensitivity tests was undertaken to assess the effects of potential variations in key assumptions and variables. In each case, these were compared against the base case (for which the results were given earlier).

Table 6.7 gives the results of these sensitivity tests in terms of BCR(G) estimates. We comment as follows:

- Test 1 involves lowering our best estimates of decongestion benefits. This recognises that: (i) these benefits are a major component of the total benefits, particularly for the Auckland schemes; and (ii) there are significant uncertainties as to their best estimates. It is seen that this change considerably reduces the BCR estimates for the Auckland schemes by around 1.2 (Constellation) and 1.5 (Albany), but reduces them to a much lesser extent (around 0.2) for the Wellington schemes.
- Test 2 involves treating the net PT operator surplus as a benefit component instead of a component of operator costs. This has a relatively modest effect on the BCR results, with these changing (relative to the base) by between an increase of 0.14 and a reduction of 0.55.
- Tests 3 and 4 involve varying the base assumption that the bus service levels (on both line haul and feeder services) would vary in proportion to changes on patronage in the option. Test 3 assumes there is no change in service levels on alternative line haul and feeder bus services; while test 4 also assumes no change in service levels on the rapid transit services involved. The latter test in particular is extreme and most unlikely to be adopted in practice: it would lead to considerable crowding on the services concerned (to which we have not attributed any disbenefits, as crowding benefit factors are not covered in the EEM). The results of test 3 show modest reductions in BCR (relative to the base), while those for test 4 show significant increases for the Auckland schemes (as no additional bus service costs are involved and the disbenefits of this on users have not been estimated).

The sensitivity tests indicate that the base case economic performance results are not greatly affected by the assumptions in the different tests, with the exception of the decongestion benefits test. This is probably the most debatable aspect of the overall economic analyses (especially for the Auckland schemes). We have no reason to think that our base case decongestion estimates are either too high or too low.

Table 6.7 Sensitivity test results based on varied inputs

Test	BCR(G) estimates				
	Albany	Constellation	Petone	Waterloo	Porirua
Base	**3.82**	**3.26**	**2.11**	**2.57**	**3.00**
1 Decongestion benefit estimates halved	2.27	2.03	1.87	2.32	2.83
2 Financial impact on PT services included as benefit to PT operator (not cost to govt)	3.75	3.40	1.81	2.14	2.45
3 PT service variability – no variability in alternative line haul services or feeder services	3.53	3.19	1.71	2.05	2.38
4 PT service variability – no variability in all PT service costs with patronage	4.28	3.91	1.71	2.05	2.38

6.5 Strengths and weaknesses of the economic/financial appraisal methodology

The methodology has been designed, given existing data sources and tools, to provide the best possible estimates of the economic/financial performance of potential schemes to provide additional P&R spaces, in both an absolute sense (eg BCR performance) and in a relative sense (comparing between different locations).

The qualification about 'given existing data sources and tools' is important. Normally, for the appraisal of urban transport initiatives of a multi-modal nature, a suitable multi-modal (regional/sub-regional/corridor) model would be used. While both AKL and WGN have such models, they are not currently suitable for estimating the demand effects of P&R schemes. Reformulation and recalibration of the current models (ART, WTSM) would be required to provide upgraded models appropriate for P&R scheme assessment. This would not be a small task, and would be best implemented as part of the next model upgrade in both regions (refer section 3.2.3). In the absence of such model upgrades, we had to rely on the 'diversion rate' approach (calibrated by surveys undertaken as part of the project) to estimate the demand effects of increased P&R spaces at the various sites. This had several disadvantages relative to a formal multi-modal model:

- We had to assume the diversion rates surveyed for one site also applied at other broadly similar sites.
- Our approach was probably most reliable for small increments of P&R capacity and not suitable for large increments (where the number of additional spaces supplied exceeded the revealed demand from the diversion rate surveys).
- In particular, our approach was weak in assessing likely diversion of P&R users from one site to another as a result of capacity changes, although the diversion rate surveys did give some evidence relevant to this.

Another area of potential weakness (arguably) relates to the method used to estimate 'decongestion' benefits (which comprise the dominant component of total benefits for the AKL schemes). We derived the changes in road user travel times in the radial corridors affected based on estimates of elasticities of travel time with respect to traffic volumes – which were derived from a travel time vs volume/capacity function, calibrated to existing traffic data. This decongestion methodology was probably the most critical aspect of the overall methodology, given the size of decongestion benefits being estimated relative to other benefit components. However, it is a moot point whether our decongestion estimates were superior or inferior to those that might be derived from a typical regional/sub-regional transport model.

While the methodology does have several weaknesses, as just noted, we consider that it is the best possible (or close to it) methodology that could be developed within the project constraints (of time, money, data and tools). We consider that, applied with care and discrimination (including appropriate sensitivity testing), it can give reasonably good indications of the economic/financial performance of potential P&R investment schemes, in both an absolute sense (BCR performance) and a relative sense (for choosing between candidate P&R schemes). Particular strengths of the methodology, from the Transport Agency perspective, include:

- It makes the best possible use of available data and tools.
- It provides a flexible (spreadsheet-based) tool that is relatively easy to use by the analyst, is very flexible (for 'what if' testing) and can be readily refined by the analyst as appropriate.
- The methodology is transparent (not a 'black box').
- Numerous options can be tested relatively rapidly.
- Its parameter values are consistent with EEM parameter specifications.
- Its methodology is well documented in this report (see spreadsheets in appendix O).

6.6 Conclusions

The five case study sites evaluated through the application of the economic and financial appraisal methodology were:

- Albany bus P&R (Auckland)
- Constellation Drive bus P&R (Auckland)
- Petone rail P&R (Wellington)
- Porirua rail P&R (Wellington)
- Waterloo rail P&R (Wellington).

Our economic/financial appraisal methodology was developed to (i) make the best use of available data and modelling tools; (ii) highlight the effects of schemes on the various parties affected; (iii) be flexible and easy to use; and (iv) be compatible with EEM requirements.

Application of the methodology to the five case studies indicated that all the schemes performed relatively well in terms of BCR(G), reflecting that (i) the scheme capital costs were relatively modest, and (ii) the schemes were specifically targeted to reduce road traffic volumes and congestion at times and in locations where congestion was relatively high and good PT alternatives were available (at quite modest costs).

7 Application considerations

7.1 Overview

In this section we briefly set out how the demand modelling, appraisal and funding frameworks developed in this paper can be applied when considering investment in P&R facilities. The following application considerations are addressed:

- justification and decision-making requirements
- project identification process and requirements
- project appraisal process and requirements.

We briefly cover each of these aspects, nothing that the study terms of reference required us to focus on the last bullet point, ie the justification of individual facilities rather than the development/justification of an overall P&R programme.

7.2 Justification and decision-making requirements

In New Zealand there is general support for expanding and improving P&R facilities among the relevant public authorities. This support is provided through relevant plans and strategies, including long-term plans and regional PT plans. It is important to recognise that the justification for P&R and decision-making requirements may vary for each of the roading, PT and P&R authorities involved (refer further discussion in chapter 2).

One example of relevant considerations, for a combined PT and P&R authority, is the GWRC's (2013) *Wellington regional rail plan 2010–2035*, which sets out the requirements for its P&R programme. The rail plan P&R strategy draws on the earlier Vincent (2007) report on the characteristics and demand forecasting of P&R. The rail plan identifies the main role of P&R as being '…to transfer parking demand from the central city and other major commercial areas to suburban/urban fringe locations…' with the following benefits and success factors being identified[28]:

- Benefits[29]:
  - better utilisation of passenger transport capacity
  - reduced road congestion
  - increased parking capacity
  - improved environmental outcomes
- Success factors:
  - high-quality PT links
  - well designed and located facilities
  - high degree of safety and security
  - quality information and marketing.

[28] Our research project focused on the benefits of P&R in two areas: (i) improved highway and arterial level of service; and (ii) reduced PT subsidies. These are two potential outcomes/objectives and align with the 'benefits' identified in the GWRC approach. The GWRC 'success factors' are factors that must be in place for a P&R facility to be used, irrespective of the outcomes/benefits that the overall investment is intended to achieve.

[29] We note that a particular investment will not necessarily achieve all these benefits. The benefits considered would need to be aligned with the outcomes/objectives sought for any particular investment.

The implication is that these benefits and success factors are considered by the council when assessing and justifying investment in P&R facilities in the region. There appear to be no formal decision-making criteria but a set of guidelines is provided '…to guide park and ride decisions, including prioritising the development of park and ride facilities…'. They cover the following aspects:

- Ensure sustainability of existing facilities.
- Ensure safe and secure commuter parking facilities.
- Ensure appropriate capacity and locations.
- Ensure efficient and cost-effective developments.
- Ensure consideration and management of local effects.
- Ensure consideration of alternatives.
- Prioritise development of P&R facilities.
- Secure land and develop partnerships to promote the efficient and effective operation of the passenger transport network.

The alternative approaches criterion includes active mode improvements, PT service improvements, PT-oriented, developed and alternative P&R locations. The consideration of alternative options and P&R sites is an important component of any P&R programme. The consideration of P&R investments as part of a P&R programme is discussed further below.

7.3 Project identification process and requirements

Project identification processes and requirements in New Zealand are touched on in chapter 2, but were largely outside the scope of this study. In chapter 4 we also noted that while many P&R projects may be relatively small these can add up to a significant investment, and it is therefore important to consider P&R from the perspective of the overall system and by extension as part of a wider investment programme. In section 7.2, we started discussing the *Wellington regional rail plan 2010–2035* (GWRC 2013), which makes use of the earlier Vincent (2007) paper, and essentially takes this approach. The rail plan P&R strategy sets out the following approach to prioritisation of P&R investments:

- *Prioritise developments taking into account the need to provide sufficient capacity and maximise the catchment areas. Developments that maximise catchments and demand should be prioritised ahead of developments that do not.*
- *Prioritise developments taking into account efficiency and cost effectiveness. The most inexpensive, efficient and cost effective developments should be given priority within the following general framework:*
  - *Maintain and upgrade existing facilities*
  - *Expand existing on-street facilities*
  - *Develop new on-street facilities*
  - *Expand existing off-street facilities*
  - *Develop new off-street facilities*
- *Proposals should be prioritised within each category above based on potential to increase passenger transport patronage overall.*

The strategy also identifies the need to 'secure land and develop partnerships to promote the efficient and effective operation of the passenger transport network', the availability of land being a critical factor in terms of whether a P&R is feasible in any particular location. The rail plan identifies the following key factors to consider when prioritising P&R schemes:

- *Current and future demand*
- *Benefits and costs*
- *Location and catchment size*
- *Opportunities to develop alternative access modes (e.g. walking, feeder bus services) within the catchment.*

The approach is to collect data on current P&R usage and passenger counts at potential P&R stations which are compared across the region and potential future parking requirements identified. Potential sites are then prioritised based on the following considerations:

1. *Focus on developing on-street parking within catchments where demand exceeds supply*
2. *Focus on developing off-street parking within catchments where demand exceeds supply*
3. *Consider further land development opportunities.*

This approach provides for the identification and consideration of potential sites across the entire region enabling schemes to be developed in suitable locations. These can then be evaluated based on project appraisal methodologies set out in this research report.

7.4 Project appraisal process and requirements

Project appraisal process and requirements were the focus of this research project, and have been set out in chapters 3 (demand modelling framework), 4 (economic and financial framework) and 5 (funding allocation framework). The combined application of these frameworks was tested in the case studies set out in chapter 6. The general approach was as follows:

1. Agree performance measures and objectives (based on wider P&R programme).
2. Identify scheme options for sites identified in P&R programme.
3. Collect required data inputs/carry out surveys (as required).
4. Complete evaluation framework (excel pro forma provided).
5. Identify benefits and costs.
6. Identify potential funding allocation.[30]
7. Apply decision-making criteria.

The above steps provide a practical and pragmatic approach to the assessment of individual P&R schemes, which are ideally identified as part of a wider programme approach.

7.5 Summary/conclusion

The main conclusion to draw from this chapter is that it is important to consider investment in P&R as part of a wider investment programme.

[30] This covers the allocation of costs to agencies in proportion to where the benefits lie including identifying the road level of service enhancements and reduction to PT subsidies.

8 Conclusions and recommendations

8.1 New Zealand practice review

8.1.1 Planning and practice

In New Zealand, PT authorities (generally regional councils) are primarily responsible for P&R, with some local councils (in Wellington) involved in bus-based P&R, or otherwise as advocates. The Transport Agency is primarily a funding partner.

Overall, there has been little recent change in New Zealand P&R practice, despite significant legislative and organisational changes. This is unsurprising given that funding criteria have remained essentially the same over the period considered. Auckland appears to have a more comprehensive suite of policies and is considering P&R for all PT modes, whereas in Wellington P&R is focused largely on its urban rail network.

8.1.2 Demand modelling tools (Auckland and Wellington)

Forecasts of travel demand by mode are produced in Auckland and Wellington through the application of the strategic travel models, ART3and WTSM respectively. Both of these consider P&R during the assignment of travel volumes to the networks and not as a main mode or sub-mode in the modal choice procedure.

8.2 Demand modelling framework

8.2.1 Literature and practice review

For formal demand modelling, the international literature indicated P&R is generally included in strategic travel models as a choice in the modal split. P&R could ultimately be more formally included in the Auckland and Wellington strategic travel models as a modal option in the mode choice – although this is a significant task and should be considered during model rebuilds.

8.2.2 Road system performance outputs

Using capacity-restrained traffic assignment models of Auckland and Wellington, an elasticity of [average % speed change over the network] with respect to [average % VKT change in the network] was calculated for the AM peak period. For the Petone to Wellington CBD corridor, the elasticity was 2.7 while for the Albany to Auckland CBD corridor the elasticity was 2.5. These were compared with a simplified methodology based on mathematical relationships that reasonably replicate observed travel behaviour. The simplified methodology produced 2.1 and 2.8 for the elasticities in the Petone and Albany corridors respectively. This was considered a satisfactory correspondence. The simplified methodology requires only the observed congested and free-flow times and does not require any modelling. The simplified approach was therefore incorporated in the evaluation methodology to estimate road decongestion benefits.

8.3 Economic and financial framework

8.3.1 Literature and practice review

Our review of economic and financial ex-ante appraisal (evaluation) methods adopted internationally for P&R policies and facilities confirms that these are usually based on some form of CBA. New Zealand appraisal practices for P&R, as for other transport projects, are also based on CBA, within the guidelines set out in the updated EEM.

8.3.2 Appraisal framework

A CBA-based framework was developed for estimating the economic and financial impacts of P&R case study options. Our economic/financial appraisal methodology was developed to:(i) make the best use of available data and modelling tools; (ii) highlight the effects of schemes on the various parties affected; (iii) be flexible and easy to use; and (iv) be compatible with EEM requirements. The framework was designed to separate financial and economic impacts for four main 'stakeholder' groups: these comprised three public authorities – the road authority, the PT authority and (notionally) the P&R authority – and the transport system users (who may also be sub-divided between road users, PT users and P&R users).

The main economic benefit items incorporated in the evaluation framework were:

- benefits to existing P&R users
- benefits to new P&R users
- benefits to existing PT users
- (dis)benefits to connecting or alternative PT service users
- benefits to road users.

The (incremental) cost items included in the appraisal framework were:

- capital (land and construction) costs
- ongoing P&R facility O&M costs
- operating costs (net of revenues) for PT services.

8.4 Funding allocation

8.4.1 Literature and practice review

Very little literature was identified on the allocation of specific funding for P&R, although much more extensive information exists on urban transport funding more generally. The experience in the UK and USA, and also New Zealand, is that funding is largely dependent on what is made available from the central/state government.

The Auckland Council (2012) discussion document on alternative funding options and the Litman (2013a) paper on local funding sources for PT both set out criteria for assessing various transport funding options in general. We considered that these criteria, combined with a consideration of organisational objectives and evaluation of benefits that accrue to the various parties, would provide a sound basis for the development of the funding allocation framework.

8.4.2 Approach to allocation of funding

The funding allocation framework was designed to guide decisions on how the investments required for P&R should be funded between the relevant public authorities. The key concept underlying this framework was that the various parties should contribute funding (to worthwhile projects) in the proportions to which they, and their users, would benefit. We note that responsibilities and resources often do not match the potential benefits that might be derived by an organisation. This 'real world' tension was not a subject that our research delved into, but would need to be taken into account during the decision-making process.

The funding allocation methodology recommended involves economic and financial calculations, but the framework has to work within the context of various objectives and therefore the principles should be used to help decide what variations to the calculated allocation might be appropriate, depending on the circumstances. For example, this would be important for an organisation that might be identified as having to contribute funding but where the proposed investment might have outcomes that are contrary to that organisation's objectives: therefore funding on the basis of the funding allocation calculation may not be appropriate, in which case it would be important to revert to these higher-level principles.

8.5 Case study economic and financial appraisal

8.5.1 Sites selected

The five case studies were selected so as to include both bus-based and rail-based schemes, in both Auckland and Wellington regions. All five schemes were on the principal PT network, in the following locations:

- Albany (bus P&R, Auckland)
- Constellation Drive (bus P&R, Auckland)
- Petone (rail P&R, Wellington)
- Waterloo (rail P&R, Wellington)
- Porirua (rail P&R, Wellington).

Site-specific details were ascertained and included in the appraisal framework, with a range of economic parameters, to produce estimates of economic/financial performance. The case study appraisal results should be taken as providing indicative estimates of scheme performance at the initial stage; these could subsequently be refined as better input estimates become available for each scheme.

8.5.2 Conclusions on the appraisal methodology

The application of the appraisal framework to the case studies demonstrated that the framework itself was robust. Particular strengths of this methodology included:

- It makes the best possible use of available data and tools.
- It provides a transparent and flexible (spreadsheet-based) tool, which is relatively easy to use by the analyst, is very flexible (for 'what if' testing) and can be readily refined as appropriate.
- Numerous options (and sensitivity tests) can be assessed relatively rapidly.
- Its parameter values are consistent with EEM parameter specifications.
- Its methodology is well documented (in this report and the accompanying appraisal pro forma).

The main area of weakness in the appraisal methodology is associated with the mode choice estimates. The existing regional strategic transport models are too coarse to estimate relatively small changes in mode choice from increased P&R provision. We therefore adopted a diversion rate approach based on market surveys to estimate modal choice changes. This has the following weaknesses (relative to more sophisticated multi-modal modelling methods):

- Behavioural changes at one site are assumed to be applicable at other locations with the same transport mode from the P&R (ie bus-based or rail-based).
- The methodology is not well equipped to reliably estimate changes in demand and mode choice for large site expansions.
- The methodology cannot estimate demand for completely new sites.
- The approach is weak in assessing diversion between alternative P&R sites. .

8.5.3 Case study appraisal results

The application of the appraisal framework to the five case studies produced BCR(G) results substantially greater than 1.0. The two Auckland schemes (with relatively high decongestion benefits) had BCR estimates of about 3.8 (Albany) and 3.3 (Constellation). The three Wellington schemes, with much lower decongestion benefits, had BCR estimates between 2.1 and 3.0. Prima facie, these BCR(G) results might be considered on the high side, relative to most other schemes for encouraging mode switching and increasing PT usage. However, it should be borne in mind that P&R schemes such as these are very well targeted at encouraging mode switching from car to PT at times and in situations where PT offers an attractive alternative mode and any decongestion benefits for the road system are likely to be maximised.

The appraisal results for the five case study sites indicated that investment in P&R at these locations would be well worthwhile from an economic and financial perspective.

8.6 Application considerations

Three considerations in the application of the economic/financial and funding allocation evaluation framework were addressed:

1. Justification and decision-making requirements
2. Project identification process and requirements
3. Project appraisal process and requirements.

The methodology developed provides a pragmatic and effective approach to the assessment of individual P&R schemes, which ideally have been previously identified as part of a wider programme approach.

8.7 Recommendations

Based on the methodology developed in this research project and the experience with its application to selected case studies, we make the following recommendations intended to provide an enhanced basis for the appraisal of P&R policies, programmes and initiatives for major New Zealand centres:

1. Incorporate into the EEM and/or PIKB specific procedures for the demand modelling and economic appraisal of P&R capacity expansion initiatives, based on the methodology that was developed and applied in this research.
2. Develop further guidance for analysts on methods to assess (i) decongestion benefits, and (ii) road crash benefits, associated with marginal changes in traffic volumes (arising from PT, TDM and related initiatives), and to incorporate this guidance in the EEM and/or PIKB.
3. AT and GWRC (and other New Zealand regional/local authorities as appropriate) to use the P&R appraisal methodology developed in this research for (i) appraisal of the demand, economic and

financial implications of providing additional P&R spaces at specific sites; and (ii) appraisal of the case for and implications of charging for P&R spaces, both in general and in the context of specific corridors/areas/sites.

4 AT and GWRC to give further consideration to the case for and approach to enhanced modelling of P&R relative to alternative modes, as part of the next major update (re-formulation and re-calibration) of the Auckland (ART) and Wellington (WTSM) strategic models and associated sub-models.

5 Where significant new/expanded P&R facilities are introduced, relevant authorities may consider post-implementation market research with new P&R users, in particular on their changes in travel patterns and mode choice. These results can then be applied to refine future P&R appraisals.

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Appendix A: Glossary

AC	Auckland Council
AKL	Auckland
APT	Auckland Passenger Transport Model/Auckland Public Transport Model
ARC	Auckland Regional Council
ART3	Auckland Regional Transport Model
ASP3	Auckland Strategic Planning Model
AT	Auckland Transport
ATM2	Auckland Transport Model
BAH	Booz Allen Hamilton
BCR	benefit-cost ratio
BCR(G)	benefit-cost ratio (government)
BPR	Bureau of Public Roads (BPR) function
BRT	bus rapid transit
BSTM	Brisbane Strategic Transport Model
CAS	Crash Analysis System
CBA	cost-benefit analysis
CBD	central business district
DfT	Department for Transport (UK)
EEM	*Economic evaluation manual*
Envt	environmental
EU	European Union
GHG	greenhouse gas
GPS	*Government policy statement*
GST	goods and services tax
GWRC	Greater Wellington Regional Council
HNO	NZ Transport Agency’s Highways and Network Operations (HNO) Group
K&R	kiss and ride
KCDC	Kapiti Coast District Council
km	kilometres
LOS	level of service
LTMA	Land Transport Management Act 2003
MCA	multi-criteria analysis
MoT	Ministry of Transport
NBA	next best alternative
NLTP	National Land Transport Programme
NPV	net present value
NWSM	Northern Wellington SATURN Model

NX	Northern Express
O-D	origin-destination
O&M	operating and maintenance (costs)
P&I	NZ Transport Agency's Planning and Investment (P&I) Group
P&R	park and ride
pax	passenger
PCC	Porirua City Council
PCU	passenger car unit (equivalence factor between larger vehicles and cars)
PT	public transport
PTEG	Passenger Transport Executive Group (UK)
PTOM	Public Transport Operating Model
RLTP	regional land transport plan (or regional land transport programme prior to 2013)
RP	revealed preference
RPTP	regional public transport plan
RPTP 2013	*Auckland regional public transport plan 2013.*
RT	rapid transit
SAF	simplified appraisal framework
SH	state highway
SP	stated preference
STM	Sydney Strategic Travel Model
TDM	travel demand management
TOD	transit orientated design
Transport Agency	NZ Transport Agency
TT	travel time
UHC	Upper Harbour Corridor
UHCC	Upper Hutt City Council
veh	vehicle(s)
VfM	value for money
VKT	vehicle kilometres travelled
VMT	vehicle miles travelled
VOC	vehicle operating costs
WCC	Wellington City Council
WGN	Wellington
WP	working paper
WPTM	Wellington Public Transport Model
wrt	with respect to
WTSM	Wellington Transport Strategy Model

Appendix B: Practice review questionnaire

Responses to the practice review questionnaire are set out in table B.1. The purpose of the questionnaire was to identify current practice in the planning and delivery of P&R facilities (bus/rail/ferry) in Auckland and Wellington. The questionnaire was completed by the following organisations:

- Auckland Transport
- Greater Wellington RC
- Kapiti Coast District Council
- NZ Transport Agency
- Porirua City Council
- Upper Hutt City Council
- Wellington City Council

Table B.1 Responses to practice review questionnaire

Question	Responses
A. Roles, responsibilities and objectives	
A1. What roles and responsibilities (if any) does your organisation have in planning and delivering P&R facilities?	**NZ Transport Agency – Planning and Investment Group (P&I)** The Transport Agency – invests in PT infrastructure and services (50% funding assistance rate) as part of the NLTP. The Transport Agency is currently developing PT infrastructure guidelines with these sectors and also, where adjacent to the state highway network. It may plan and construct some facilities usually as a result of congestion or parking issues affecting the state highway. **NZ Transport Agency – HNO** HNO is responsible for spending monies that generate value for money outcomes on state highways, and would invest in P&R to the extent that it produces economic benefits for the state highway network that are economically efficient. **AT** Auckland Transport's role is to plan, deliver and manage P&R facilities in Auckland, as appropriate. **GWRC** Ownership of land and improvements, lease of land, funding and management of land purchase, maintenance, development, security, lighting, monitoring. **Wellington City Council (WCC)** WCC has a broad role to provide transport related facilities to its residents including provision of suburban (primarily commuter) parking sites to encourage transfer to buses for journeys into the CBD, eg Birdwood Street, Karori. **Upper Hutt City Council (UHCC)** GWRC has assumed responsibility for all aspects of the delivery and maintenance of P&R facilities within Upper Hutt. As an affected party UHCC has a role in providing comment on P&R and would therefore expect to be consulted and to provide feedback when any review or changes are carried out. **Kapiti Coast District Council (KCDC)** The KCDC's current position (extract from proposed district plan): 'Council's role with regard to rail transport is largely an advocacy role. The development of the railway network is the subject of existing designations for the land use and is determined by the railway

<table>
<tr><th>Question</th><th>Responses</th></tr>
<tr><td></td><td>operator - Kiwi Rail. The provision of passenger rail services is supported by GWRC funding. Council supports the maintenance and enhancement of the rail services for both passengers and industry. The District Plan addresses, where appropriate these services through facilitating associated facilities. However, smart land-use management decisions, particular in the location of residential activities and the management of urban densities, along with maximising access to rail stations can help support and increase the viability and returns on rail investment.'
Porirua City Council (PCC)
The PCC works with GWRC to ensure P&R facilities are provided to the satisfaction of Porirua residents, lobbying GWRC where necessary. Also works with the police to improve security at P&R facilities.</td></tr>
<tr><td>A2. Are any of the roles and responsibilities above additional to the minimum required under legislation, please describe and explain?</td><td>NZ Transport Agency – P&I
Planning and Investment role as per LTMA requirements. Approved organisations propose programmes, which may include P&R, which are then evaluated by the Transport Agency.
As part of the NLTP investment, PT network reviews which examine services and infrastructure are encouraged.
New Public Transport Operating Model (PTOM) provisions in the LTMA – principles – S115 (1)(a) – 'regional councils, and PT operators should work in partnership and collaborate with territorial authorities to deliver the regional PT services and infrastructure necessary to meet the needs of passengers'.
NZ Transport Agency – HNO
HNO is also driven by the LTMA. However, HNO would like to be innovative with respect to the LTMA and use its skills and experience to deliver highway outcomes using a broad range of approaches.
WCC
WCC is not required to provide parking facilities although it is empowered to do so under Clause 591 of the Local Government Act 1974.</td></tr>
<tr><td>A3. What objectives (if any) does your organisation expect to achieve from the provision of P&R facilities in your area, and where are these set out?</td><td>NZ Transport Agency – P&I
The Transport Agency's Statement of Intent is available at www.nzta.govt.nz/resources/statement-of-intent/index.html. NLTP investment is to deliver on the GPS.
NZ Transport Agency – HNO
HNO's objectives are those of the LTMA, GPS and Statement of Intent. In particular, it seeks to reduce severe congestion, improve travel time reliability and safety and support the efficient movement of freight.
AT
The parking strategy once approved by the AT Board sets out objectives for P&R as an integrated part of the PT network. Objectives include:
extending the catchment of the PT network by tapping into new markets providing opportunities for those car dependent for part of their journeys
reducing congestion on roads especially by removing commuter car-based trips
reducing pressure on commuter parking in city centre by relocating commuter parking to cheaper and more peripheral P&R sites.
GWRC
Reduction in peak road congestion and an increase in peak PT patronage. Wellington regional rail plan 2010–2035 (GWRC 2013, appendix G: GWRC Park and Ride Capacity Strategy).
WCC
A number of these are detailed at the high level in the WCC's (2006) Transport strategy 2006 – 2016.</td></tr>
</table>

Question	Responses
	KCDC *Long term plan (2012–2032)* • Trains, buses, cycling and walking: The Kapiti Coast community sees the establishment of a rail network which supports all communities, including Otaki, as essential to the future of the district. Ideally, there would be strong passenger rail links through to Otaki and Palmerston North. It will continue to advocate strongly for this service, including the Capital Connection rail commuter service between Palmerston North and Wellington, and for bus services which complement rail and provide improved services within each community. A great number of the relevant decisions will be made at regional and national levels; the council will continue to be a strong regional advocate for this vision. The council will continue to invest in cycling and walking, and to ensure road space is shared across modes. Transport Strategy - *Towards a sustainable transport system* (KCDC 2008) • Focus area 1: The transport system '...a transport network should: provide all communities with access to alternative travel modes (ie other than reliance on private vehicles), in particular for: access to work; … The transport network does not exist in isolation and two other areas of action are essential to achieving a sustainable network. These are: … ensuring strong links between the transport network (especially rail, bus, walkways and cycleways) and town centres. … Rail network … park and ride facilities at existing and proposed rail stations will continue to be supported, provided that there is a long-term focus on improved walking and cycling access, and direct bus feeder services to the stations. Priority in park and ride expenditure should be given to the relief of parking at Paraparaumu station until there is an extension of services at Raumati and to the north.' • Focus area 2: Achieving mode shift '… Parking … Kapiti Coast District Council will continue to manage the supply and use of on-street parking. It will regularly review the parking requirement for developments and the balance between on-street and off-street parking supply against the dual goals of support for the district's main centres and achieving mode shift. The council will continue to advocate for the supply of park and ride services for bus and rail users. The council will not provide off-street parking except where there is a need to facilitate use of transport services, or to ensure access to civic or essential services.' **PCC** As Porirua City does not finance P&R facilities these are not covered in the council's long-term plan or asset management plans.
A4. Do you have any comments on the P&R roles, responsibilities and objectives of other organisations in your region, eg are things working effectively/should they be done differently?	**NZ Transport Agency – P&I** RPTPs developed under the LTMA require regional councils, PT operators and local authorities to collaborate. P&I would expect to see closer planning of network and supporting infrastructure on a one network basis through the RPTPs and the new RLTPs. **NZ Transport Agency – HNO** HNO believes there is significant under investment in P&R leading to many car parks being over capacity resulting in poor parking behaviour and reduced numbers of passenger transport users. This also contributes to a reduction in the level of service of many of New Zealand's most important state highways. **AT** Auckland Council provides the overarching strategic direction over 30 years as outlined in the Auckland Plan's objectives. AT's role is to align its P&R development to deliver on these objectives, a major one being to increase PT patronage. **GWRC** Ideally any surplus land owned by public organisations in the vicinity of railway stations

Question	Responses
	should be made available at no or minimal cost for GWRC to develop and utilise for P&R purposes. **WCC** The regional council has been the primary investor in park and ride car parks at railway stations while the city council by default has assumed the role as provider of bus-related P&R, most of which comprises informal commuter parking on streets close to inbound bus stops on bus routes. **UHCC** No **KCDC** GWRC relationship working well, KCDC officers are on key working groups such as Travel Planning co-ordinators and PT Liaison Group. Also working with GWRC and Horizons on supporting the Capital Connection rail service.
B. Planning and funding policies	
B1. Does your organisation make use of the <u>regional transport strategy/programme</u> to justify involvement and/or investment in P&R facilities, please describe?	**NZ Transport Agency – P&I** P&I assesses what has been proposed by others and can have an influencing role at the regional level. **NZ Transport Agency – HNO** It is a supporting document but not the primary driver which is the level of service of the state highways. **AT** The *Auckland regional public transport plan 2013* (AT 2013) adopted in September 2013 after full regional consultation process, outlines certain policy directions and actions for P&R development in Auckland region. This plan was made compliant with the national LTMA 2013 amendment. The *Regional land transport programme 2012–15* (RLTP) (AT 2012a) contains certain P&R projects that have been prioritised together with all other transport related projects in region. **GWRC** *Wellington regional land transport strategy 2010–40* (GWRC 2010): Increased peak period passenger transport mode share. Improved land use and transport integration. *Wellington regional public transport plan 2011–21* (GWRC 2011): An integrated network of services that makes it easy and safe to change between and within modes. A high standard of PT infrastructure. **WCC** Not explicitly; however, the two councils' positions are compatible. **PCC** PCC comments on regional strategies and plans to encourage regional investment in P&R facilities in Porirua. **UHCC/KCDC** No
B2. Does your organisation have or make use of any provisions for P&R facilities in relevant <u>RMA plans</u> (ie district plan/regional plan), please describe?	**NZ Transport Agency** Not aware of any specifically. P&R facilities along Northern Busway were provided by territorial authority. **AT** The Auckland Council's Unitary Plan. now notified. will eventually replace legacy district plan. The Unitary Plan lays out rules that will affect P&R development in practice, especially if it needs to occur outside of the road corridor.

Question	Responses
	KCDC Current district plan, policy 13 To advocate for, and to encourage the use of improved rail passenger services to the district. **WCC/UHCC** No
B3. Does your organisation have or make use of any parking policies: if so do these include specific provision for P&R, please describe?	**NZ Transport Agency – P&I** P&I expects councils to support P&R facilities with appropriate parking policies to manage safety and congestion. **NZ Transport Agency – HNO** No specific policies. **AT** Yes, there are existing parking policies and current revision of policy which will be contained within the parking strategy, which covers both parking and P&R. **GWRC** See *Wellington regional rail plan 2010–2035* (GWRC 2013, appendix G: GWRC Park and Ride Capacity Strategy). **WCC** Yes, the WCC (2007) *Parking policy* makes specific reference to the role of parking in supporting sustainable transport solutions including PT. **UHCC** UHCC does not have any parking policies with specific provision for P&R. **KCDC** No [other than as set out in the 2008 transport strategy]. **PCC** PCC Is currently producing a parking strategy for the CBD. This will include the P&R at Porirua station.
B4. Does your organisation have or make use of any council bylaws relevant to P&R facilities?	**NZ Transport Agency – HNO** HNO parking restriction bylaws at Waikanae along SH1 around the train station added since Tranz Metro train services were extended north. **WCC** Yes indirectly. The WCC's (2008) traffic bylaw provides for the council to pass resolutions relating to management of parking places/spaces. **PCC** PCC parking enforcement officer occasionally patrol the Porirua P&R. There are no bylaws specific to this P&R. **UHCC/KCDC** No
B5. Does your organisation have any policies or activities in its long term plan making provision for P&R facilities, please describe?	**NZ Transport Agency – P&I** No – dependent on approved organisations proposing such facilities. **NZ Transport Agency – HNO** Not at this stage but a key outcome of this research project is to develop a framework for a business case that will do exactly this. **AT** Yes, there are P&R projects in the LTP/RLTP. **GWRC** Maintain and improve rail rolling stock, stations, over-bridges subways, and car parks in accordance with the rail asset management plan. Average condition ratings for car parks.

Question	Responses
	Performance targets: Baseline: 2.9 | 2012/13: 2.7 | 2013/14: 2.6. **WCC** Yes, see WCC (2007) *Parking policy*. In terms of the LTP, the council has allowed funding from 2016/17 for roadside parking improvements which could include P&R arrangements. **UHCC** No **KCDC** Yes refer to answer in A3.
B6. Does your organisation provide for any P&R funding (in its long term plan revenue and financing policy or elsewhere), please describe?	**NZ Transport Agency – P&I** Yes – via the NLTP. **NZ Transport Agency – HNO** NLTP is used for business cases. **AT** Yes **GWRC** Yes, see above – land purchase, development, maintenance, security. **WCC** See above. **UHCC/KCDC** No
C. Decision-making requirements and processes	
C1. What decision-making procedures does your organisation have for investing in and/or approving P&R facilities, and at what level are decisions taken?	**NZ Transport Agency – P&I** NLTP evaluation process. Would expect all new proposals from the 2015–18 NLTP to be developed through a business case approach. **NZ Transport Agency – HNO** HNO would need to submit to the NLTP evaluation process aided by a business case framework as discussed above. **AT** The programme for P&R development developed by AT planners would be subject to prioritisation with other transport projects as part of AT's (2012b) *2012–2041 Integrated transport programme*. Final approval by the AT Board. **GWRC** LTP and Annual Plan budget rounds, *Wellington regional rail plan 2010–2035* (GWRC 2013). Any decision to purchase land requires full council approval and where appropriate Transport Agency approval. Maintenance budgets and upgrades are driven by the Asset Management Plan and Asset Prioritisation Framework processes at Rail Manager level. **WCC** It can be expected that any proposal for P&R investment would be approved by the council committee at the LTP stage at the high level, and subsequently as and when bylaw procedures are invoked. RMA procedures would be involved for any off-street proposals. **PCC** Council meetings, but currently no PCC investment in P&R.
C2. Do you have any comments on P&R decision-making requirements and processes in the region overall, eg	**NZ Transport Agency – P&I** Regional councils are funded for PT services and necessary supporting infrastructure – which does not always mean a P&R facility would be a priority. Legislation has changed so regional councils can own infrastructure now. No one really sees it as their role to provide PT parking – big cost on top of PT operations.

Question	Responses
are things working effectively/should they be done differently?	In Brisbane their policy is not to provide P&R at stations within 10km of city. Experience here shows that any P&R facility provided always quickly fills to capacity – suppressed demand. Issue of additional charging for this service has not been explored much in New Zealand. **GWRC** The Transport Agency and GWRC are now working closely on land development/transaction opportunities (eg Porirua, Raumati, Petone) which is creating mutual benefit for both organisations. Long-term arrangements are also in place with KiwiRail and local iwi (in Waikanae). Some progress is also being made with territorial authorities, eg PCC. **WCC** Cannot comment other than to note that regional council investment has not kept pace with demand.
D. Methodologies to justify investment in P&R	
D1. What methodologies (if any) does your organisation apply to justify involvement or investment in P&R?	**NZ Transport Agency – P&I** See earlier comment – refer HNO. **NZ Transport Agency – HNO** Seeking an economic based or even financially based process for decision making centred on the outcomes for the state highway network. **AT** Strategic planning principles based on best practice comparable cities; alignment with the RPTP especially: • assessment of suitable locations • demand modelling • BCA • business cases by site (likely). **GWRC** NZ Transport Agency EEM, strategic fit, effectiveness, efficiency. As part of Asset Prioritisation Framework processes GWRC also considers opportunities to purchase appropriate land at or below market valuation. **WCC** WCC would survey the actual and potential demand for P&R parking along key bus routes in collaboration with the regional council. Then look at ways of providing for some or all of the demand and develop scheme options including indicative costings. Any subsequent recommendation to proceed would be input to the LTP. Previously commissioned reports on P&R potential would be referenced as input to the process. **KCDC** Policies to encourage the increased use of rail to get commuters to work and to make this as efficient and easy as possible. **PCC** No PCC investment in P&R.
D2. Are you aware of any other methodologies that you consider appropriate to justified investment in P&R (please provide references if available)?	**NZ Transport Agency – HNO** GWRC approach used to be on a demand-based process. If a given P&R was full and people were parking on street and other places then the parking numbers needed to be increased. **WCC** No. P&R parking has not been seen as a high priority for direct provision by the council in among its other transport priorities. **UHCC** No.

Question	Responses
E. Opportunities for P&R facilities and potential case studies	
E1. Do you see any opportunities for provision of further P&R facilities within your region, please specify?	**NZ Transport Agency** Yes, nationally where congestion priorities would deem this. **AT** Yes, Auckland has been shown to be undersupplied when compared with comparable cities. **GWRC** Petone (Transport Agency land), Tawa (private land), Waikanae (KCDC, private, Transport Agency), Paekakariki (KiwiRail), Takapu Rd (private), Taita (private), Paraparaumu (Transport Agency, private). **WCC** Future rail-related P&R can be seen as a regional council role. Previous studies have shown limited scope for economic creation of bus-related P&R due to the high cost or difficulty of finding suitable off-road sites together with the cost of construction and ongoing operation and maintenance. **UHCC** Yes. All-day parking associated with P&R activities exceeds the existing supply at Trentham railway station and at Silverstream railway station, and is having a negative impact on other land uses in the area. All-day parking associated with P&R activities at Upper Hutt railway station extends beyond the extent of the area designated for the purpose. **KCDC** Not any further facilities; however, there are opportunities to better manage what is provided at present in the form of parking controls – parking permits, formalisation of informal parking on private property (at Paraparaumu), improved cycle facilities – more cycle lockers etc.
E2. Please recommend any potential case studies to be undertaken as part of this research project. We are seeking to identify a selection of case studies for potential new or expanded facilities, and covering the following aspects: Range of PT facilities located within the same catchment area, and Varying distances from CBD If possible, please provide a brief description of the potential facility, including existing and proposed number of parking spaces and why you	**NZ Transport Agency** • Waikanae railway and bus station • Porirua station car park is being upgraded. A survey was conducted of users prior to this by PCC? • GWRC may have other train stations along network which have been identified • Petone bus and rail station and the Waikanae bus and rail station as above. **AT** Potential case studies (to be discussed): • Albany busway - existing • Westgate bus – new facility with access to state highway • Swanson rail – end of western line future electric train services **GWRC** • Petone, Waterloo **WCC** A preliminary draft report on P&R opportunities in Wellington city was prepared in 2011. It included the following sites: • Chaytor Street – 33 spaces • Crawford Green – 95 spaces • Dover Street – 16 spaces • Devonshire Road – 20 spaces **UHCC** • Wallaceville railway station P&R car park sealed, then seal extended in stages • Upper Hutt railway station bus depot converted to P&R spaces

Question	Responses
think it would make a good case study.	**KCDC** • Waikanae – difficult location for park and ride, limited pedestrian access, severed from main settlement by SH1, existing local bus service diverted to the platform. End of the line for Wellington-Kapiti so draws in commuters from a wider catchment, eg Otaki and Levin. **PCC** There is a high demand for P&R in Porirua, but little land available for this development, except at Porirua station.
E3. Are you aware of any P&R projects in your region undertaken in recent years that could be suitable candidates for a post-evaluation case study of benefits of P&R? Is so, please provide brief details.	**NZ Transport Agency** Petone - after SH2 upgrades. There used to be many all over the Wellington region but not much seems to be happening now. **AT** Albany, Auckland biggest P&R was expanded by a couple of hundred bays 15 months ago – subject to pilot survey already. **GWRC** Waikanae P&R development associated with upgraded station and extension of metro services. Porirua P&R development of existing undeveloped land. **WCC** The car park on Birdwood Street, Karori provided by Zealandia which is also used for bus P&R. **KCDC** As above. **PCC** Porirua P&R is to be extended and developed soon, now that GW owns the land under a previously 'informal' P&R.

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Appendix C: P&R policies and objectives in Auckland and Wellington

C1 Auckland

Auckland has a comprehensive suite of strategies and plans that provide for P&R. The Proposed Auckland Unitary Plan (notified in September 2013), *Auckland regional land transport strategy 2010–2040* (Auckland Regional Council 2010), *Auckland regional land transport programme 2012–2015* (AT 2012), *Auckland regional public transport plan* (AT 2013) provide for P&R and are discussed below.

AT is also currently developing a parking strategy that will seek to:

- extend PT network catchment by intercepting car users
- reduce congestion on roads by removing commuter car-based trips
- reduce pressure on city centre parking by relocating commuter parking to cheaper more peripheral P&R sites.

C1.1 Proposed Auckland Unitary Plan 2013 – Auckland Council

The Unitary Plan is a 'rulebook' that will shape the way Auckland grows; it replaces the regional plan and district plan prepared under the Resource Management Act 1991. The Unitary Plan has been notified and is currently open to submissions.

Part 1 sets out the strategic direction and includes transport objectives and policies in section 3.3. Within this section, policy 1 makes provision for P&R as follows:

> *1 Enable the effective, efficient and safe development, operation and maintenance of an integrated intraregional and interregional transport system including: …*
>
> *e. the public transport network, including the development and operation of bus and train stations and stops, bus way, park and rides, ferry wharves and terminals …*

Part 2 provides for P&R to be included in concept plans, eg s2.22 provides for P&R at Glenn Innes and Panmure stations as part of the Tāmaki sub precinct plan, and s7.10 provides for P&R as part of the Westgate Precinct Plan.

Part 3 covers rules, it is 2,248 pages long and includes rules specific to P&R facilities. A comprehensive review of rules is outside the scope of this study, although it is worth noting the rules for restricted-discretionary activities that cover: location and design, compatibility with surrounding activities, access to/from the facility, safe and efficient operation of the roading network. The assessment criteria for restricted-discretionary activities include avoiding adverse effects on the local roading network and public transport services and related infrastructure.

Part 4 sets out definitions, with park-and-ride defined as follows:

> *Park-and-ride*
>
> *Parking which is purpose designed and provided specifically for users of a public transport network who:*
>
> - *travel by private vehicle to the park and ride parking area, then*
> - *transfer to the Rapid and Frequent Services Network to continue their journey*

- *and includes pedestrian and cyclist facilities*

The facility is located and designed to support the Rapid and Frequent Services network.

Part 7 covers designations, and includes designations for a number of P&R facilities, including:

> *Albany Bus Station – the construction, operation and maintenance of a busway station, park and ride facility, public car-parking as a secondary purpose as long as it does not negatively affect the primary park and ride facility, and associated works. …*
>
> *Constellation Drive Station – for the construction, operation and maintenance of roads, buildings, facilities and amenities and park and ride facilities (including a Busway control room and any ancillary structures, works and activities) for the purpose of providing a rapid transit facility for buses and high occupancy vehicles. …*

C1.2 Auckland Regional Land Transport Strategy 2010

The *Auckland regional land transport strategy 2010–2040* (RLTS 2010) (Auckland Regional Council 2010) was prepared prior to local government amalgamation. It remains in force until adoption of a new RLTP; which will replace the RLTS under amended legislation adopted in 2013. The RPTP 2013 is required to give effect to the PT components of the RLTS, and also under its replacement RLTP.

The RLTS 2010 addresses P&R in the following policy:

> *Policy 4.2.3 'Provide park-and-ride facilities at appropriate locations based on the criteria in Appendix G (city and district councils).'*

Appendix G sets out the 'Regional park-and-ride criteria' as follows:

> *At the time of writing, the Park and Ride Strategy (Auckland Regional Transport Authority (ARTA) is still in a draft form (27/10/09). Therefore this appendix should be considered an early description of the main criteria for which Park and Rides will be identified in the Auckland region.*
>
> *Short term versus long term*

- *Short term generally means one to three years. The short term assessment criteria looks at how well each site fits with existing demand, services and facilities.*
- *Long term means five years or more and the time frame may differ from one project to another.*
- *Long term assessment criteria look at how well each site fits with long term land use plans such as the Auckland Regional Growth Strategy (RGS) and long term assumptions about infrastructure services.*

> *Short term criteria*

- *Land availability – Land appears to be available that could potentially be acquired and developed as a Park and Ride in the short term.*
- *Park and ride market – There is an extensive area of medium to low-density residential development for which this is a logical place to park for travel to the Auckland central business district (CBD).*

- *Appropriate road network – The road network makes it easy to get from the catchment area to the Park and Ride without encountering severe morning peak congestion. The road network naturally funnels a large market to the Park and Ride.*
- *Passenger transport network – Availability of frequent, fast and direct passenger transport service should either exist or be easy to develop in response to the new Park and Ride facility.*

Long term criteria

- *Low land value and development potential – A Park and Ride is a relatively inefficient use of land, and therefore presumes a low land value. A Park and Ride is therefore viable in the long term only if there is not a compelling higher-value use for the land. This is not just a matter of development economics, but also of transport system efficiency. While Park and Ride facilities are helpful in attracting patronage to passenger transport, dense development is far more effective to this end. For this reason, a long-term Park and Ride should be on land that is not planned to be a town centre or some other high land value use.*
- *Park and ride market – The RGS indicates that there will be an extensive area of medium to low-density residential development for which this is a logical place to park for travel to the Auckland CBD.*
- *Appropriate road network – The long-term road network, including any planned improvements, makes it easy to get from the market area to the Park and Ride without encountering severe morning peak congestion. The road network naturally funnels a large market area to the Park and Ride.*
- *Passenger transport network – Must be on the quality transit network (QTN).*

Assessment categories

- *Discarded – Sites that score poorly against both short-term and long-term criteria should be discarded from further consideration.*
- *Permanent (i.e. both short-term and long-term) – Sites that score well on both criteria should be developed soon and with the expectation of permanence. Relatively expensive fixed infrastructure can be considered in these cases.*
- *Interim – Sites that score well in the short term but not the long term are considered interim. A classic example would be a location that is envisioned as a town centre in the RGS, but where there is currently no development or development pressure. Interim facilities can be appropriate for relatively inexpensive Park and Ride infrastructure.*

C1.3 Auckland Regional Public Transport Plan 2013

The Auckland RPTP 2013 includes the following policies and actions set out below. In addition, table 8-2 of the RPTP sets out the 'proposed infrastructure programme for new network (prioritised)' which includes a number of P&R facilities within the priority list.

Policy 1.5 Integrate public transport services with parking policies

a. *Promote the complementary design of public transport services and parking regulations and policies, including pricing.*

b. Design parking and Park-and-Ride pricing policies in a manner that is supportive of public transport services, given prevailing fare strategies.

c. Review area parking strategies and pricing policies to effectively manage parking around transport interchanges and to encourage usage of feeder bus services.

Policy 3.5 Provide Park-and-Ride facilities at appropriate sites

a. Complete a Park-and-Ride strategy that clarified the role of Park and Ride within the public transport network, and sets clear priorities for future investment, funding and pricing.

b. Take steps to develop and operate Park-and-Ride facilities at selected peripheral locations to extend the catchment area of the public transport network and encourage patronage growth.

c. Investigate and, where appropriate, develop Park-and-Ride facilities, using the following criteria to determine investment priorities:

- *Park-and-Ride is planned as an integral part of the public transport network, extents the public transport customer base and encourages public transport patronage.*
- *Potential sites are located to intercept commuter trips from catchment area that have high Park-and-Ride potential, based on assessed demand.*
- *Park-and-Ride facilities are located to relieve congestion by intercepting commuter traffic, and to ensure that vehicles accessing the facilities do not worsen local traffic congestion.*
- *New Park-and-Ride facilities are focused on outer areas where public transport services are limited, or to serve areas that are beyond the walk-up catchment of the rapid and frequent service network.*
- *Park-and-Ride provision is avoided in metropolitan and town centres, except as part of a staged transition to other uses.*
- *Park-and-ride locations take fare zone boundaries into account.*

d. Where appropriate, introduce charges for Park-and-Ride facilities to manage demand and ensure that facilities complement the wider public transport system and integrate charges with public transport fares, using the AT HOP card where practical.

C2 Wellington

C2.1 Wellington Regional Land Transport Strategy 2010–40

The *Wellington regional land transport strategy 2010–40* (RLTS) (GWRC 2010) includes policy j) which is to 'Support the ongoing development of new and existing park and ride facilities' (p37) and includes a strategic target of 'Continued improvement in walking, cycle and park 'n ride facilities at and around public transport interchanges' (p36).

The long term vision for the Hutt Corridor and Western Corridor also includes 'Comprehensive bus services and adequate park and ride facilities will provide additional access for the community' (pp89,90).

The 'role of modes' section identifies opportunities to improvement integration between private car and PT modes. For rail it is to 'maintain and develop park & ride facilities' and for bus and ferry to 'investigate park & ride facilities where appropriate'.

C2.2 Wellington Regional Public Transport Plan 2011–21

The *Wellington regional public transport plan 2011–21* (RPTP) (GWRC 2011) identified 'Rail network development and reliability' as a specific PT issue, with the explanation including (p5):

> *Currently, 30% of rail commuters use park and ride facilities provided by Greater Wellington. These parking facilities are operated free of charge. With future patronage growth it will not be possible to sustain this level of access because nearby land is in short supply. In addition, the cost of providing and maintaining park and ride facilities is increasing.*

The RPTP include the following policy for P&R:

> *Policy 2.4: Maintain existing park and ride and passenger drop-off facilities and identify opportunities for additional facilities.*
>
> *This policy applies to all park and ride facilities that provide access to bus and/or rail services.*
>
> *Park and ride and passenger drop-off facilities are mainly used by peak commuters and help concentrate passenger trips along key high capacity corridors, in particular, along the rapid transit network. They enable people who live in areas with insufficient demand to support a public transport service to use public transport for at least part of their journey.*
>
> *Park and ride and passenger drop-off facilities are mainly used by peak commuters and help concentrate passenger trips along key high capacity corridors, in particular, along the rapid transit network. They enable people who live in areas with insufficient demand to support a public transport service to use public transport for at least part of their journey.*
>
> *Greater Wellington will consider opportunities to enhance existing facilities or develop additional facilities in accordance with relevant guidelines (refer Methods below).*
>
> *The importance of a high standard of public transport infrastructure is also addressed by Objective 6.*
>
> *Methods:*
>
> 1. *Maintain park and ride and passenger drop-off facilities in accordance with the Public Transport Asset Management Plan.*
> 2. *Update Greater Wellington's Public Transport Infrastructure Guidelines to include current guidelines for the location and design of park and ride facilities.*
> 3. *Provide cycle parking (e.g., cycle stands) at selected interchanges and railway stations.*
> 4. *Work with local authorities to regularly monitor the number, placement and quality of park and ride facilities.*

The characteristics of the rail and bus rapid transit network are identified as including, under infrastructure and right of way, 'park and ride facilities at suburban stations outside town centres' (p80). P&R is also cross-referenced throughout the plan, including in respect to quality and maintenance of PT infrastructure. The government rail package is outlined in s6.4.2, which includes provision for 'KiwiRail to transfer (or equivalent) all rail park and ride facilities to Greater Wellington'. We note that the infrastructure guidelines and rail package information is superseded with the 2013 revision of the Wellington Regional Rail Plan (refer below).

C2.3 Wellington Regional Rail Plan 2010–2035

The *Wellington regional rail plan 2010–2035* (GWRC 2013 revised) was adopted by the council in February 2014. It includes a new 'Park and Ride Capacity Strategy' in appendix G, based on the PT infrastructure guidelines and guidelines for the location and design of park and ride facilities referred to in the RPTP (refer above).

P&R is identified as having the following benefits, in addition to enabling access to the PT network where direct access by walking may not be feasible:

- better utilisation of passenger transport capacity
- reduced road congestion
- increased parking capacity
- improved environmental outcomes.

Key success factors are identified as follows:

> *A strong park and ride market will generally only develop in regions with relatively high parking charges in their central city and/or other major commercial areas and limited road capacity into these areas. The strong park and ride market in Wellington is a factor of these and also of the high quality passenger transport network.*
>
> *Provided the above conditions are met key success factors for individual park and ride facilities include:*
>
> 1. *High quality public transport links – Public transport links must ensure a high level of service (e.g. fast, frequent, and reliable) that is competitive with the private car to provide an incentive for people not to drive all the way.*
> 2. *Well designed and located facilities – Facilities should also be easy to access and be well maintained.*
> 3. *High degree of safety and security – Personal safety and car security are important considerations with perceptions just as important as actual crime statistics.*
> 4. *Quality information and marketing – Facilities must also provide sufficient capacity to meet demand such that people using the facility on a regular basis have a reasonable chance of finding a parking space at that facility.*

Guidelines include:

> *5.1.3 Ensure appropriate capacity and locations*
>
> *Facilities should be located to provide sufficient capacity taking into account current and future demand and to maximise benefits and overall passenger transport patronage.*
>
> *The following guidelines should also be considered when deciding the most appropriate location for developing existing or new park and ride facilities:*
>
> - *The facility should be located to maximise the overall passenger transport catchment for all access modes.*

- *The facility should be located so as not to reduce the number of people using active modes or feeder bus services to access the passenger transport network.*
- *Current and future demand should be considered, including potential repressed demand for the facility, and alternative locations.*

The following information is intended to assist in determining the most appropriate location for park and ride facilities:

1. *Locate facilities in congested travel corridors.*
2. *Locate facilities upstream of areas experiencing major traffic congestion.*
3. *Locate facilities on key demand corridors.*
4. *Locate facilities in areas with less dense populations including where passenger transport services are less feasible.*
5. *Locate facilities so commuters do not have to backtrack to reach the facilities.*
6. *Locate facilities to minimise any overlap between the primary service areas (50% demand catchments) of facilities (refer diagram below) unless required to provide sufficient capacity.*

5.1.6 Ensure consideration of alternatives

The following alternatives should be considered in the assessment:

- *Active mode improvements (e.g. walking and cycling) – Such improvements could include improvements to pedestrian routes within five minutes' walk of the passenger transport service or improved cycle facilities/routes.*
- *Passenger transport service improvements (e.g. feeder bus services) – Such improvements could include enhancement to connecting passenger transport services or provision of new feeder services. Improved interchange facilities and the provision of integrated ticketing are also possible alternatives that could be considered.*
- *Transit oriented developments – Such developments could generate more passenger transport trips than alternative park and ride facilities on the same land (subject to land tenure issues).*
- *Park and ride alternatives (e.g. different locations or number of spaces provided) – Consideration should also be given to the proximity of the facility to the station as close proximity could deter access by active modes with people driving short distances.*

5.1.7 Prioritise development of park and ride facilities

An assessment should be undertaken of any park and ride proposal to enable the prioritisation of developments.

Priorities should be set in accordance with the following guidelines.

- *Prioritise developments taking into account the need to provide sufficient capacity and maximise the catchment areas. Developments that maximise catchments and demand should be prioritised ahead of developments that do not.*

- *Prioritise developments taking into account efficiency and cost effectiveness. The most inexpensive, efficient and cost effective developments should be given priority within the following general framework:*
    1. *Maintain and upgrade existing facilities*
    2. *Expand existing on-street facilities*
    3. *Develop new on-street facilities*
    4. *Expand existing off-street facilities*
    5. *Develop new off-street facilities*
- *Proposals should be prioritised within each category above based on potential to increase passenger transport patronage overall.*

5.2 Priority order

Key factors to consider when prioritising the development and expansion of park and ride facilities are:

- *Current and future demand*
- *Benefits and costs*
- *Location and catchment size*
- *Opportunities to develop alternative access modes (e.g. walking, feeder bus services) within the catchment*

In applying these key factors, the priority order for the development and expansion of park and ride infrastructure should be as follows:

1. *Focus on developing on-street parking within catchments where demand exceeds supply*
2. *Focus on developing off-street parking within catchments where demand exceeds supply*
3. *Consider further land development opportunities*

These priorities are designed to best reflect the guidelines by ensuring the sustainability and a safe and secure environment for park and ride facilities across the region, while also allowing consideration of opportunities for further development and expansion as required. There also needs to be sufficient flexibility to secure land as it becomes available where such land is consistent with the key factors.

There is further detail within the guidelines, including a summary of existing facilities and proposals. Key projects in the Wellington Regional Rail Plan include facility upgrades on Kapiti and Hutt Valley lines, with particular stations identified as being of greater priority.

C2.4 Long-term Plan 2012–22

The PT activity in GWRC's (2012) *Long-term plan 2012–22* includes provision and maintenance of P&R facilities, including requisite funding. The plan also sets out the following policy for charging, also there are at present no user charges:

Charging for Park & Ride car parks

Currently, 30% of rail commuters use Park & Ride car parks provided by Greater Wellington. A charge could be considered in the future to:

- *Provide funding to cover the cost of providing and maintaining the car parks, including associated security services (patrols and CCTV).*
- *Discourage those living in close proximity to the car parks from driving to the station (a 2002 survey showed that 50% of users travelled from within 1.85 km of a station).*
- *Encourage users to consider other modes of travel to the station where these are available and practicable (e.g., using a connecting bus service, walking and cycling).*
- *Manage demand. The ability of Greater Wellington to provide additional parking spaces in line with growing rail patronage and demand is limited by the availability of land in close proximity to stations.*

Parking charges would be levied directly on the users of the car parks and become part of the user charge for public transport services. Charges would be set at a level that remained substantially cheaper than parking in the Wellington CBD, and would take into account the total cost of the trip so that public transport remained a competitive travel mode. Charges could be introduced on a trial basis and may be targeted at certain car parks where demand exceeds supply.

C3 References

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Appendix D: Review of modelling approaches

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road perfor-mance		
Modelling park-and-ride in the West Midlands region (Fox 2005)	UK	High	Yes	Yes	**Description** As there was insufficient data to analyse and model P&R from the Household Interview survey, methods were created that allowed P&R models to be developed from existing PT survey data. Procedures were also developed to jointly estimate models of access mode and station choice (representing P&R) and mode-destination choice. P&R was modelled in PRISM by representing two linked choices. The first choice was of access mode to PT, distinguishing car driver (P&R), car passenger (K&R) and other access modes (walk, cycle and other PT modes). The second was the choice of access station for car access modes. By summing the predictions of the P&R models across journey purposes, it was possible to obtain forecasts of demand for each P&R site. The model could therefore be used to assess the feasibility of proposed P&R developments as well as growth in demand at existing sites. **Comments** While the P&R survey data provided information about the characteristics of existing P&R users, it was not suitable for the development of access mode choice models because non-P&R users were not surveyed. The West Midlands did, however, have a very large survey of 8,500 train users at 93 stations within the PRISM area that enabled them to analyse trips by purpose and access mode thereby determining P&R and K&R model parameters. The nested logit model structure for access to train and metro was used. The structural parameters θAccMdStaCh, θAccMd_MDCh and θAS_Scale allowed for the calculation of the relative elasticity of main mode and access mode choice. It was necessary to calculate these parameters to implement the models using a single integrated structure. The current model did not allow for preventing the number of P&R parkers exceeding the number of spaces available at stations. The analysis did suggest that as the model involves an iterative process, a negative constant could be applied to over-saturation stations.	The paper presented a method using a nested logit model to determine P&R usage by considering up to three possible station locations for each trip. The process did not include a capacity constraint on individual stations. This system of analysis was the basis for the current Sydney Strategic Travel Model (STM).

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road perfor-mance		
					The analysis found that the sensitivity of access mode choice was approximately 40% of the sensitivity of station choice which indicated that users were more likely to switch station than access mode. It also found that for PT journeys, car access time was valued at 2.9–4.3 times the PT in-vehicle time indicating that travellers endeavoured to minimise car access time (similar to the STM results). The question of how many possible station alternatives should be analysed for access purposes for any given O-D pair was discussed. The model used 10 stations but indicated that three stations accounted for 88% of all demand. The model produced the following P&R related outputs: • Files detailing the number of cars predicted to park at each zone with a train station, and at each zone with a metro station (by purpose). • Files detailing the total number of tours by main and access mode (by purpose). • Matrices of train trips for assignment in VISUM – the train legs of car access trips were summed together with other train trips into a single train trip matrix (split by time period). • Matrices of metro trips for assignment in VISUM – the metro legs of car access trips were summed together with other metro trips into a single metro trip matrix (split by time period). • Matrices of car driver trips for assignment in VISUM – the car access legs of PT trips were summed together with trips where car driver is the main mode to form a single car driver matrix (split by purpose and time period). The inclusion of car access legs to PT tours in the car driver matrix ensured that the impact of P&R choice on congestion was properly represented. P&R trips might cause localised congestion in the vicinity of the station, which could impact upon car driver main mode travellers.	
Extending the Sydney strategic model to represent toll road and	AUS	High	Y	Y	**Description** The paper reports on how P&R was modelled by explicitly representing different access mode options to train (P&R, K&R, other), and for car access choice of station. It reports on adjustments that were made to the model to replicate the observed variation in access mode shares with distance to stations. A nested logit model was developed for main travel mode, PT mode, train transport access	The paper presents a method using a nested logit model to determine P&R usage by considering up to five possible station locations for each trip. The process did not include a capacity constraint on individual

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road perfor-mance		
park-and-ride choices (Fox et al 2011)					mode, station choice and destination. **Comments** The approach used in the STM followed the approach used in the West Midlands PRISM model and represented two linked choices: • access mode to train: P&R, K&R and other • for car access (P&R and K&R), choice of access station. To represent the choice between different station alternatives, the level of service associated with both the car access and the train legs was represented. The five stations selected were the 'best' options, given the level of service for both the car access and train legs. An iterative process was used to determine the five best station alternatives. The model then predicted the choice between the five station alternatives given the different levels of service associated with each station option. Level of service for the walk and bus access option was taken directly from EMME model used in the analysis. By modelling the choice of access station, it was possible to represent the impact of the calculated car access legs of the trip tours on congestion on the network. Representing P&R and K&R separately also enabled predictions to be made of the number of cars parking at each station. The analysis found that: • Using five stations in the analysis captured approximately 88% of all P&R and K&R cases. • Car access time was valued three times more highly than rail in-vehicle time, and around two times more highly than bus time. This meant individuals would tend to minimise their car access legs relative to their train and bus legs. • In order to improve predictions, P&R and K&R were made unavailable for tours under 10km, origin-specific factors were included to allow for areas with higher than expected car access and factors were included to reflect that 'other' access mode was unlikely for the longest train tours.	stations. A number of local adjustments were required to improve local validation.

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road performance		
Incorporating intra-household interactions into a tour-based model of public transport use in car-negotiating households (Ho and Mulley 2012)	AUS	High	Y	-	**Description** The paper explores ways in which household members cooperated in the scheduling of joint activities and shared rides for their home-based trip tours. A nested logit model was developed to integrate intra-household interactions with tour-based mode choices, using three years pooled data of the Sydney Household Travel Survey. The use of inter-household interactions can impact on the overall level of PT use and in particular the level of P&R and K&R activity predicted by a four step model. **Comments** Joint household travel was found to be driven by the unavailability of household cars for all household drivers and social constraints (ie very young children who cannot stay home alone). An important distinction was made between car-sufficient households (where there are at least as many cars in the household as licence holders) and car-negotiating households (households with fewer cars than licence holders). The results showed that joint household travel accounted for more than half of weekday home-based tours in Sydney, and that the mode choice associated with different joint tour patterns was influenced by household and individual characteristics, tour attributes and transport-related fringe benefits. The paper presents a number of findings: • Car-negotiating households had a significant propensity for making PT tours involving drop-off/pick-up, indicating that limited car availability was a motivation for shared ride arrangements. • For drop-off tours, the negative utility variable for car-negotiating households suggested that drop-off providers were more likely to use car and walking than PT also. • Members of high-income households were less likely to make fully joint tours by PT but were more likely to generate PT tours with shared rides to/from home. • Licence holders were significantly less likely to undertake both drop-off and pick-up in one car tour than to return home in between the rides and therefore	This paper presents valuable details of how joint household trips have a significant impact on the number of trips that may use P&R facilities. The paper indicates that the use of P&R facilities by households varies depending on whether the household is car-sufficient or car-negotiating. The methodology was for trip tours, which is not largely used in New Zealand.

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road perfor-mance		
					form two separate tours. • Policies aiming to increase PT use for commuting journeys through financial incentives would not significantly move workers out of their cars if they had to drop-off/pick-up their children en route to/from work. • For a scenario with lower fares for PT, a model incorporating joint household travel would show a lower modal shift from car to PT than a model without joint household travel. This was because using a household car for joint household travel was still cheaper than using PT and so the effect of a lower fare policy on PT use would only apply to individual travel.	
Application of a park-and-ride forecasting procedure in the Greater Vancouver Trans-portation Model (Hull 1998)	Canada	High	Yes	Yes	**Description** The paper reviews the development of P&R modelling in Greater Vancouver using EMME/2 and described the creation of a model with a generic logit function-based procedure using matrix convolutions. The methodology calculated the combined car and PT costs via a P&R site and included the addition of a modal bias and a shadow price for when demand exceeded capacity. Demand was distributed between feasible P&R sites by using an iterative multinomial logit process, with the resulting car access and PT egress matrices being added onto the car and PT total trip matrices for assignment. It was found that shadow pricing was an effective way to model competition for parking spaces at overloaded P&R locations and the use of the matrix convolutions module provided a practical way to implement P&R modelling within EMME/2 with an efficient use of matrices. **Comments** Procedures for modelling P&R were based on the following assumptions: • PT users to destinations with abundant free parking would not use P&R. • Trip makers would not use P&R if the PT generalised cost from their origin zone to their destination was lower than the P&R cost via a parking lot. • Where P&R was a reasonable option, the decision on PT access mode could be modelled using a logit function based on the comparison of generalised costs by each access mode.	The paper introduces the use of shadow pricing to model competition for parking spaces at overloaded P&R locations. The paper also introduces detailing the catchments of each P&R location as well as the commercial destinations served by each of the PT services so as to avoid illogical trip paths accessing the P&R station.

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road perfor-mance		
					• P&R generalised costs included appropriate parking charges and uncertainty of finding a park when demand exceeded capacity. • Trip makers would be reluctant to use P&R unless travel time saved justified the use of car ie someone living 200m from a PT station was more likely to walk to the station than use P&R. This used a modal penalty to avoid over prediction of short car trips (four minutes for rail and six minutes for bus served). • The primary mode of P&R users was PT, so the car leg trip would generally be shorter than the PT leg – to match the observed distribution it was necessary to weight the car leg of trip (by 1.25 for rail served and 1.35 for bus served). • Where P&R was a reasonable option, the effective PT cost considered in making decisions about trip distribution and mode split would be lower than for people with no P&R option. It was necessary to detail the residential catchment areas for each of the P&R locations as well as the commercial destinations served by each of the PT services available from each P&R location. This was necessary to avoid modelling illogical trip paths. Based on the observed origins of P&R trips in the Vancouver region, it was necessary to include a car time or impedance weight to ensure that trips from distant origins were not over predicted. Both the car time/impedance weight and the sub-modal bias appeared to vary according to the PT mode served by the P&R site. Lower values appeared to apply to services operating within an exclusive right-of-way and/or offering higher travel speeds and services that were more reliable. The modelling process used the following steps: • Compute car and PT impedances for all zone pairs (including dummy zones representing P&R sites). • Compute MIN PRI(ij), P&R impedance using minimum path. • Calculate 'enhanced transit impedance' ETR(ij) for O-Ds with access to P&R. • Run the distribution and car/PT mode split using ETR(ij) as the PT impedance. • Split forecast choice PT trips into walk and P&R access modes using a logit	

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road perfor-mance		
					function with the calibrated exponent (b) and the respective impedances – TI(ij) and MIN PRI(ij). • Compute P&R impedance for each logical path based on PRI(ikj) = AI(ik) * Wkm + TI(kj) + Pkm + SPk. • Distribute forecast P&R trips among competing P&R lots based on a multinomial logit function of the form: PRT(ikj) = PRT(ij) * exp (- b * PRI(ikj))/S(k) (exp (- b * PRI(ikj))). • Compare T(ikj) with the estimated peak hour capacity of the parking lot 'k' and adjust SPk for overloaded parking lots. • Recalculate MIN PRI(ij) and PRI(ikj) for all 'k' and repeat steps 5 through 8 until constrained demand at overloaded lots has converged to a value approximately equal to capacity. • Separate forecast P&R trips (PRT(ikj)) into their car (AT(ik)) and PT (TT(kj)) components. • Subtract forecast P&R trips (PRT(ij)) from the PT trip matrix, add the car leg of P&R trips (AT(ik)) to the car trip matrix and add the PT leg of P&R trips (TT(kj)) to the PT trip matrix. • Assign car and PT trip matrices to the network. The results of applying the proposed P&R methodology improved the fit of modelled versus observed PT flows where P&R was prevalent and was generally within 10% of observed during the peak hour.	
Park-and-ride: Good for the city, good for the region? (Karamychev and van Reeven 2011)	Nether-lands	High	Yes	Yes	**Description** A discrete choice model was used to analyse the effect of opening a theoretical P&R facility at the edge of an urban region on the modal choice of individuals who already travelled into the 'city' without P&R. Individuals were assumed to be heterogeneous in their location as well as in the costs of using private car and PT. The analysis allowed for choosing between three modes of transportation: the car, PT, or both with a transfer at a P&R facility. The P&R facility was assumed to be located along the existing PT network at the edge of the city. The model accounted for the generalised costs for each of these three modes and the differences in these	A theoretical mathematical model of P&R in a homogeneous system. Some of the findings may be of use.

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road perfor-mance		
					costs characterised the preference for one mode over another. The model was extended to accommodate for congestion effects. Individuals were expected to experience instantaneous disutility from traffic at any point on their route. This converted the discrete choice model into a rational expectations model, where initial belief about traffic intensities along the route induced a modal split that caused traffic intensities to equal the expected ones. This allowed for a situation where the reduced congestion in the inner area, due to former car users moving to P&R, could result in some inner city PT users switching back to car use. **Comments** The model is a theoretical mathematical model of a circular 'city' with the CBD in the centre and homogeneous distribution of households throughout the surrounding area. The paper proposes that general P&R facilities might serve two different but not mutually exclusive purposes. First, P&R allowed individuals to avoid driving their car into the city and to save on costs caused by congestion and parking. This made P&R only attractive to individuals with a preference for using a private car. Second, P&R allowed individuals to avoid slow and low-frequency local PT services on the periphery and use P&R to access directly the mainline PT network. This made P&R only attractive for individuals with a preference for PT. P&R may also serve both purposes at the same time. In the absence of congestion, the analysis found that in all instances, opening a P&R facility reduced total car traffic if the distribution of individuals' net costs was increasing weakly. This traffic-reducing effect was increased if P&R provided a cheaper alternative to city driving AND also provided cheaper access to the PT network. Therefore opening a P&R facility decreased car traffic under any increasing density function, but providing cheaper access to the PT network also resulted in a traffic decrease if the corresponding density function 'slightly' decreased. In the presence of congestion, P&R had another effect on modal split. By shifting traffic away from the city into the periphery, it reduced congestion, and made the	

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road perfor-mance		
					private car more attractive than PT for individuals who resided next to the city border. As a result, some individuals would switch from PT to the car for their trip into the city centre. This effect vanished if the cost of using P&R was low. The paper proposes that P&R should therefore be made as cheap and as efficient as possible.	
Developing passenger mode choice models for Brisbane to reflect observed travel behaviour from the South East Queensland Travel Survey (Khan et al 2007)	AUS	High	Y		**Description** The paper details the development of a mode choice module for the Brisbane Strategic Transport Model (BSTM); capable of estimating mode shares in a multi-modal travel environment. The mode choice module consisted of both multinomial and nested logit models for eight trip purpose categories – home-based work(white collar), home-based work (blue collar), home-based education (primary and secondary), home-based education (tertiary), home-based shopping, home-based other, work-based work and other non-home based trips. The mode choice module consisted of car driver, car passenger, walk to PT, P&R, K&R and two active modes of walking and cycling. **Comments** The analysis used data from the South East Queensland Travel Survey of 4,000 households undertaken in 2004. The calibration process involved randomly selecting two-thirds of the 25,000 trip records for use in calibration, leaving the remaining one-third of the trip records for validation purposes. Various levels of service modal attributes and household parameters were tested with the utility functions associated with each travelling mode, and assessed on the basis of the t-ratio values and magnitude of standard error obtained from the estimation runs. The mode choice structures used in the BSTM involved nested logit models of both home-based work purposes and multinomial logit models for all other trip purposes. The analysis found that: • Blue collar home-based work trips were less likely to be undertaken by both P&R and K&R than white collar home-based work trips. • High negative mode split parameter values for P&R and K&R indicated that qualitative attributes, such as comfort and convenience, might substantially	The paper presents a mode choice model of both multinomial; and nested logit models. Indicates differences in blue and white collar P&R use and significant P&R use differences for other purposes, especially education.

Citation	Country	Quality	Aspects covered: Mode share	Aspects covered: Road performance	Description/comments	Relevance (ie to determine improved modelling methods)
					influence the mode choice for non-car modes for home-based shopping and home-based other trips. • No respondent was found to use P&R mode for a primary or secondary education trip from home. It was hard to tell if this was purely a Brisbane feature of P&R or more general. • No respondent undertook work-based work trips using P&R and K&R. • High negative mode split parameter values for P&R and K&R indicated an insignificant percentage mode split for these modes for non-home based trips.	
Modeling an elastic-demand bimodal transport network with park-and-ride trips (Lam et al 2007)	China	High	Yes		**Description** The analysis simultaneously considered the commuter's choice of the pure mode versus the P&R mode, the choice of parking location for the pure mode, the choice of transfer point for the P&R mode, as well as the route choice for each mode. The demand elasticity of transport system, the capacity constraints of transport facilities, and the congestion interaction throughout the super-network were also explicitly incorporated into the proposed model. **Comments** The analysis was purely theoretical in nature and only considered two modes in detail. It created a logit-based formula which endeavoured to ensure the network congestion and capacity of available P&R car parks were taken into account. It was of limited use as it only formulated a solution for a bi-modal system and did not take into account different behaviour for different trip purposes.	Theoretical model using a logit model in mode choice element of a bimodal super-network analysis.
Modelling park and ride (O'Cinneide and Casserly 1999)	Ireland	Low	Yes		**Description** Two models were developed for Cork using a generalised cost model for the feasibility of P&R and a demand prediction model for estimating the use of the P&R services. The analysis identified variables for use in both types of P&R analyses, the assumptions made for calculating the value of each variable and outlined the methodology for selecting P&R services based on the outputs of each method. **Comments** The paper is not particularly detailed in the use of models for the prediction of P&R services. It concentrates on detailing the generalised costs for direct car	Low relevance. Simplified methods for both demand and generalised cost analyses for P&R in Cork using very site-specific values.

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road perfor-mance		
					travel and by P&R for Cork. The results were entirely empirical for Cork and unlikely to be transferable to other areas. The analysis determined that the generalised costs of travel in the Cork P&R generalised cost model were as follows: GCij = (0.25*Cost of motoring*Distij)/Value of time+ (Cost of Parking)/Value of time + Travel timeij. GCikj = (0.25*Cost of motoring*Distik)/Value of time+ (P&R fare)/Value of time + Travel timeik + 3*(Wait time) + Timekj + Modal Penalty. Where GCikj = generalised cost from origin(i) to P&R(k) to destination(j) The analysis found that for Cork the car trip was always cheaper than the P&R trip. The Cork P&R demand prediction model estimated the potential demand for each P&R location with the use of an empirical formula created for the study. The formula was as follows: Potential Demand = (Population)*(% car ownership)*(% constrained users)*(mean of % with Leaving Certificate education and % in socio-economic groups C/D)*(% working in destination area)*(% PT users).	
Park and ride: charac-teristics and demand forecasting (Vincent 2007)	NZ	High	Yes		**Description** This report examines the modelling of P&R PT usage in a New Zealand context. It provides an overview of the concept of P&R, as well as local and international evidence on the usage and support of P&R schemes. International modelling methodologies are summarised and approaches applied to the development of the P&R in the Wellington model. **Comments** The paper examines two different approaches (regional and site-specific) to modelling car access/P&R demand to rail stations in Wellington. Both approaches required the definition of car access catchments to each site. The analysis found that in a Wellington context, station catchments depended on the level of service offered, the number of express and total services serving the station, the time and distance to the central business district (CBD), whether the parking site was lit and whether it was at the end of a line.	Details current New Zealand practices and summarises overseas practices. Applies methods to Wellington to create catchment, regional and site specific model results for P&R.

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road perfor-mance		
					For the regional method, cost skims from the WTSM were used in the development of a regional-based model. While there are cost skims for car and PT, there are no cost skims for P&R. Splitting a P&R trip into two legs, namely the car and then the PT (and assuming no car at the egress end), the total cost was the car cost from the trip origin to the rail station of choice, plus the PT cost from the station to the final destination. This was similar to the process used elsewhere in the UK and in the Vancouver model. The combined cost would be minimised as follows: $PRCost_{i,j} = MIN_k [CarCost_{i,k} + PTCost_{k,j}]$ where: $PRCost_{i,j}$ = P&R cost between origin i and destination j. $CarCost_{i,k}$ = Car cost between origin i and intermediate site k. $PTCost_{k,j}$ = PT cost between intermediate site k and destination j. EMME/2 matrix convolution function was used to undertake the complex cost matrix calculations. The project used a dummy EMME/2 network containing the zone numbers from the WTSM model. The car and PT generalised cost matrices were then input into the network, and combined minimised P&R costs between each zone pair were developed. The paper comments that a better process would have been to code P&R sites with their own individual zones, so that more accurate costs to and from the intermediate (P&R) sites could be calculated and represented, as done in other international models. After trying to calibrate various model types, it was decided to use a nested logit formulation, with separate models for competition (where the number of household adults exceeded the number of cars) and choice (where the number of adults were equal to or less than the number of cars), and scaling the modal costs by the square-root of distance. An iterative procedure was developed in EMME/2 whereby modal proportions by model zone were calculated by competition/choice, modelled site usage was determined, and site-specific penalties were calculated where demand exceeded supply. This was repeated until a convergence criteria was reached. The sum of squares of the difference between subsequent site usages was calculated and convergence was reached when this value was less than 1. The site-specific method used regression analysis to determine what attributes	

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road perfor-mance		
					could predict P&R facility usage. These were categorised as 'transport related', 'facility related', and 'landuse related'. Transport-related variables included the characteristics of the PT that served an individual site, as well as other competing modes. Facility-related variables included the impact of signage, safety, paving, shelter etc at the site. Land-use variables relied on the definition of a site's catchment and used corresponding population and employment data. The analysis resulted in a set of parameters based on: • a balancing constant • number of peak express services to CBD • Hutt line location attribute constant • Johnsonville line location attribute constant • if the station car park was patrolled • if station was advertised as having P&R • total population within 50% catchment area • competing population within 50% catchment area from other stations • adult fare to CBD.	
Using Truro's activity based parking model to investigate optimum pricing for workplace parking charging (Clarke et al 2008)	UK	Low			**Description** The paper describes the updating of the Truro Activity Based Parking Model so that it could forecast optimum parking charges. **Comments** The overall Truro model contains a nested logit model which concentrates on the production of trips that can be reassigned to parking available parking spaces rather than the destination zone. P&R is not specifically dealt with in the paper and is only mentioned as an initial element of the mode choice consideration along with car and PT.	None

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road perfor-mance		
An analysis of park-and-ride provision at light rail stations across the US (Duncan and Christensen 2013)	USA	Low			**Description** This paper details an analysis of predicting the likelihood of a rail station throughout the USA having a P&R facility. **Comments** The analysis tried to understand the reasons behind P&R provision by estimating a logit model that predicted the presence of parking at a set of new light rail stations across the USA. The analysis found that parking facilities occurred more frequently in lower density environments where land was cheap and available. After controlling for station attributes, certain PT operators exhibited a greater propensity to provide P&R facilities (eg those that served multiple jurisdictions, had large service areas, and relied heavily on local funding). P&R provision also varied based on the characteristics of the municipality in which the station was located.	None, the paper reports if a P&R facility was provided rather than the need for one.
Siting park-and-ride facilities using a multi-objective spatial optimization model (Farhan & Murray 2008)	USA	Average			**Description** The research concentrated on three major siting/modelling concerns that it believed needed to be addressed when siting P&R facilities: covering as much potential demand as possible, locating P&R facilities as close as possible to major roadways, and siting such facilities in the context of an existing system. This paper presents a multi-objective spatial optimisation model for integrating these considerations. **Comments** The analysis primarily dealt with site-specific modelling of a P&R facility. The paper presents a multi-objective model for locating P&R facilities in order to maximise coverage of demand, account for demand decline as service distance increased (using a negative exponential gravity type formula), consider existing services and account for the accessibility to major roadways. The analysis created three objectives of maximising demand coverage, minimising travel time between facility and major roadways and maximising the number of existing P&R facilities included in the analysis. A weighting method for each of the three objectives was used to reduce the number of possible solutions and maximise the chances of finding non-inferior solutions. The method used was:	The paper presents a simply GIS based process that could be used to determine the location of a new P&R facility when other competing facilities existed.

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road perfor-mance		
					Maximise w1a1 − w2a2 + w3a3. Where a1, a2 and a3 were the three model objectives with w1, w2 and w3 being the corresponding importance weights. Varying the values of w1, w2, and w3 and solving the model again would produce another non-inferior solution, if one existed and appropriate weights had been used. The paper suggests that a range of weights needed to be tested in order to obtain the entire set non-inferior solutions. The reason for this was that any non-inferior solution might be of interest in a planning or policy context and all were valid.	
Assessing the impact of integrated trans modal urban transport pricing on modal split (Ghali et al. 2000)	UK	Low	Yes		**Description** The paper presents the results of travel behaviour research and modelling of alternative trans-modal pricing scenarios based on results of stated preference surveys undertaken in eight European cities. **Comments** The paper presents the results of the stated preference surveys and estimates the TransPrice value of time in UK pounds for each of the survey cities. These values were used in existing logit mode choice models to determine the impact of various parking price scenarios on mode choice.	None, the paper only presents model results of mode split changes as a result of pricing changes.
Network flow-based strategies for identifying rail park-and-ride facility locations (Horner and Groves 2007)	USA	Average	Yes	Yes	**Description** The paper develops an optimisation process for finding the most advantageous rail P&R locations based upon network traffic flows. The models also place facilities in an effort to intercept a maximum number of vehicles as early as possible in their journeys. Operationally, the models are provided with a complete picture of the vehicle miles travelled (VMT) on a road network. The models place facilities assuming that any flow intercepted by a sited P&R results in the vehicle departing the network, leading to reduced automobile VMT. The model sites P&R facilities so that large vehicle flows have an opportunity to change travel modes as soon as possible. **Comments** The paper focuses on traffic flows, optimally located P&R should be positioned to ‘remove’ the maximum number of VMT possible from the road network. It	Limited, only presents a strategy for identifying potential P&R sites based entirely on intercepting the maximum number of vehicles as possible as early as possible in their trip. Does not consider infrastructure constraints, travel demand, cost, trip purpose, time of day, PT services etc. It also assumes any intercepted vehicle will use the P&R facility and be removed from the road network.

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road performance		
					assumed that vehicles would be more likely to utilise a P&R facility early in their journey. Choosing a more upstream location should pull more VMT from the road network than another location downstream might do. The function maximised the number of VMT removed from the network by placing p P&R facilities. In the formulation, the number of facilities to be sited, p, is user-specified. It incorporated three constraints. Constraint 1 ensured that, at most, 100% of the VMT along a path was used or 'removed.' Constraint 2 required that a path could not have VMT removed from it without a facility. Finally, Constraint 3 ensured that p facilities would be sited. The analysis was identified by the writers as being of a theoretical nature and focused exclusively on the use of network flows to identify optimal facility locations. Therefore, if used in practice, the approach might be best suited for augmenting existing means of siting rail P&R. It did not weigh travel demand, trip generation characteristics or political concerns.	
User rationality and optimal park-and-ride location under potential demand maxi-misation (Holguín-Veras et al 2012)	USA	High	Yes		**Description** The study was intended to develop the understanding of the factors that determine the optimal location of P&R facilities to maximise potential market attracted to the P&R. It also analysed the relationship between catchment, driver rationality and services. The analysis produced formulas that utilised factors to maximise P&R usefulness, identify the catchment area for a given location and consider the conditions under which a user would benefit from P&R. **Comments** The formulations were based on the assumption that a traveller would use a P&R facility if and only if the corresponding generalised cost was lower than the drive only alternative. The analysis also assumed a car-only alternative. This implied that the P&R system must provide a service that was fast, inexpensive and frequent enough to overcome the difference in costs as a result of travel and transfers. The analysis considered two 'city' scenarios: linear and two dimensional. The linear scenario was only representative of a corridor type study of P&R use. The two dimensional analysis proved that, for a given trip from *i* to *j*, the set of feasible P&R locations followed an ellipse-like shape with the trip origin as a	The analysis provided detailed modelling for defining catchment areas for potential P&R sites.

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road perfor-mance		
					focus. These shapes depended on variables such as trip distance, PT level of service (LOS), etc. The analyses indicated that the area enclosed by the ellipse increased with the PT LOS and trip distance, as did the corresponding catchment areas. The analysis revealed that while the actual shape of the catchment area was not a parabola; a parabola provided a reasonable approximation. A procedure was developed to estimate a P&R catchment for a given LOS provided by competing modes. The method was based on the assumption that the area was parabolic and could be estimated using trip origin break-even distance and the distances that defined the chord of the parabola sited at the P&R site. The analysis indicated that the method produced a conservative estimate of a P&R catchment but performed better than other alternative procedures such as conical approximations.	
Park and ride modelling: lessons learnt from the UK (Jarvis 2011)	New Zealand	Average	Yes	Yes	**Description** This PowerPoint presentation discusses P&R modelling in the UK which used diversion rates and four-stage models that included P&R in the mode split. **Comments** The presentation shows results from a number of studies in Stoke-on-Trent and Medway towns. It concludes that diversion models provided simple initial estimates of P&R use, multi-modal models could help identify site location as they allowed for all modal costs, and could optimise P&R ride bus fares and parking. Charges and demand prediction models might provide more accurate forecasts in order to ascertain the number of parking spaces required for a site.	Low. Indicates methodologies and results of two studies.
Optimizing pricing policies in park-and-ride facilities: a model and decision support	Greece	Average			**Description** The study proposed a model for obtaining optimal pricing schemes in terms of financial performance, while taking into account of constraints associated with policies such as preferential treatment of specific categories of users. The model was straightforward and could adequately handle additional policy and operating constraints to those presented in this study. **Comments** P&R pricing policy analysis only.	None

Citation	Country	Quality	Aspects covered: Mode share	Aspects covered: Road perfor-mance	Description/comments	Relevance (ie to determine improved modelling methods)
system with application (Kepaptso-glou et al 2010)						
Continuum modelling of park-and-ride services in a linear monocentric city with deter-ministic mode choice (Liu et al 2009)	China	High	Yes		**Description** The paper presents a deterministic continuum equilibrium model to characterise commuters' modal choice and P&R transfer behaviours in a linear monocentric city with infinite P&R facilities. Some equilibrium properties were examined in detail by looking into the relationship of mode choices of commuters from different locations. **Comments** The paper assumed that parking charges gradually decreased from the city centre to the corridor boundary and commuters were continuously distributed along the corridor. Commuters chose either the railway or highway for travelling from their home to the centre in the morning. If choosing the highway, the commuters also considered the use of P&R facilities available anywhere throughout the corridor. At equilibrium, the variable travel cost per unit distance on the highway was no higher than that on the railway along the corridor. As a result, the railway was used only between the city centre (the destinations of morning commuters) and some location in the linear city, beyond which all commuters chose the highway. A discrete approximation version of the continuum model was developed and then solved using the Frank–Wolfe algorithm. Numerical results showed that the proposed model could capture the travel behaviour well. It found that only a few P&R facilities were actually used by commuters and raising parking charges for the P&R mode would cut down the P&R traffic greatly although some direct demand for the railway mode would be induced.	Limited
Modelling passenger demand for parkway rail	UK	High	Yes		**Description** The paper reports the development and application of a parkway forecasting model, where 'parkway' is defined as a convenient out-of-town station for inter-urban rail journeys and does not necessarily serve a local population as a P&R site	Little, limited ability to transfer the simplified procedure and empirical coefficients to New Zealand. May be doubtful that inter-city operation

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road perfor-mance		
stations (Lythgoe and Wardman 2004)					would. The objective of the study was to develop a model that was more straightforward to apply than existing procedures specified in the *Passenger demand forecasting handbook* (Association of Train Operating Companies 2002). The focus of the report was entirely on inter-urban journeys over 80km. **Comments** The model created concentrates on inter-city train movements. It used ticket sales data to indicate rail demand and gravity models to estimate the total demand between areas surrounding the O-D stations. The model used a hierarchical logit model approach with the choice of making a rail journey in the upper nest and the choice of station in the lower nest. The choice of station was a multinomial logit model. The results provided reasonable elasticities and forecasts and showed that parkway users have different preferences from other rail users. The authors concluded that the inclusion of a competition parameter improved the explanatory power of existing elasticity forecasting techniques and resulted in a more plausible generalised cost elasticity. The study found that for parkway facilities, the elasticity of rail demand given a change in generalised cost was high, potentially as a result of inter-urban travellers having a higher preference for car travel and a high aversion to access time.	can be transferred to intra-city P&R facility operation.
Analysis of park-and-ride decision behaviour based on decision field theory (Qin et al 2013)	China	Good	Yes		**Description** The paper states that research on P&R choice behaviour is mainly based on economic theories. It is not suitable to analyse the changes of choice behaviour in a situation where new options are available. The economic theories are unable to explain the effects of the factors of cognitive capability, deliberation time, and attention on the decision behaviour. The research used decision field theory (DFT), which is a dynamic, cognitive approach to modelling human decision making based on psychological principles to create a decision model of P&R. The effects of factors, eg deliberation time, deliberation threshold and initial preference, for mode choice were also examined. **Comments** DFT is a combination of two prior and independent lines of psychological theory:	Little, it provided a framework in which a similar study could be undertaken in New Zealand but there is doubt that the empirical coefficients and weighting could be used here.

Citation	Country	Quality	Aspects covered: Mode share	Aspects covered: Road performance	Description/comments	Relevance (ie to determine improved modelling methods)
					approach–avoidance theories of motivation and information-processing theories of choice response time. The study conducted a survey to obtain values for various parameters used in the model. It surveyed information about daily travel information and influencing factors such as driving time, transfer, walking and waiting time, riding time, fuel cost, bus or subway ticket cost, parking fee, comfort, traffic congestion and the number of transfers. All these factors were evaluated in five levels: (1) very unimportant, (2) unimportant, (3) important, (4) relatively important, and (5) very important. The results of the survey provided parameter estimates for the weighting of each of the influencing factors. It also provided coefficients for memory retention capability and initial preference toward travel mode. The analysis modelled the change in mode choice with deliberation time of the trip maker. It was found that the traffic intervention measures such as providing the additional P&R information regarding facility locations, parking fee, available parking spots might be able to improve the carefully deliberative process in the decision process and then increase the utility of P&R facilities. It also suggested that travellers' dependence on cars should be reduced during a decision process to increase the relative choice probability of P&R. For example, providing free PT transfer tickets would be an incentive to reduce the traveller's dependence on cars. Furthermore, increasing the comfort level of PT and providing free parking for the P&R facility would push travellers to choose P&R.	
Modelling park and ride and road pricing with MVMODL in Leicester (Tolofari 1997)	UK	Good	Yes		**Description** The implementation of a model for testing policies, P&R and toll road in Leicester. The model consisted of a nested logit model, where the P&R was a sub-mode of the car and comprised two parts: an incremental choice model for car/PT (changing modal shares were deducted from cost trends) and a lower absolute model for car and P&R. The model was based on the generalised costs for car, PT, P&R. The process was iterative in order to ensure convergence in the result. **Comments** The model was created in 1997 to model P&R and pricing policies using MVMODL	Little. Older analysis; later analyses have provided more detailed nested logit models.

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road performance		
					as part of LERTS. Costs for P&R were provided by a separate Greater Leicester Transport Model for car and PT. The main result of the model was that the measure with the greatest impact on the use of P&R was the increased cost of parking downtown.	
Driving to suburban rail stations (Vijayakumar et al 2010)	Canada	Good			**Description** The study examined the effects of station and individual characteristics on passenger demand and driving distances for commuter rail services in Montreal, Quebec, Canada. The analysis presented in the paper used methods developed in evaluating pedestrian access to PT to reach the P&R. In so doing, the factors influencing how far people were willing to drive to commuter rail stations were evaluated. Service catchment areas based on driving distances were also developed to understand service and facility characteristics that attract users. **Comments** The analysis included two statistical models. The first model estimated driving distance to rail, whereas the second model estimated passenger demand at the station. The objective of the first model was to understand the distances driven to commuter rail stations on the basis of individual, trip and station characteristics. The second model tried to capture the effects of parking facilities and other factors on PT demand at stations to identify policies that could enhance this demand in the future. Both models used regression analysis of O-D survey and boarding data from the Montreal region to produce coefficients for the regression analysis. Analysis of the driving distance to rail stations showed that people drove farther to commuter rail stations with an increase of overall trip length, thus suggesting that competitive train service could reduce the number of cars entering the CBD. Higher train frequencies also attracted people to drive longer distances. Parking capacity had a small but significant effect on driving distance. Station boarding was affected by station and train line characteristics. Every additional parking spot attracted 1.12 passengers, and increased street connectivity around the station influenced demand at rail stations as well.	Low, paper provides regression analysis methods for determining driving distances to a P&R site and the demand for a P&R site. Methodology may be useful but results are Montreal specific.
Integrating parking cost	USA	Good			**Description** The Chicago Area Transportation Study (CATS) existing mode choice model's PT	Good. The simplified methodology for including parking cost into the

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road perfor-mance		
into transit generalized cost - an application of using matrix convolution (Xie & Wies 2001)					utility function included many components including the congested time of auto access and the cost of base fares and zonal fares in addition to the in-vehicle time, out-vehicle time, waiting time and boarding time, but did not consider parking cost. The traveller's decision to drive to a P&R lot to board PT, or take a bus to get to a rail facility depended on the generalised PT cost. The cost of driving to a P&R lot should therefore include both the driving cost and parking cost. Parking cost has effects not only on mode choices to destinations, like auto trips to the CBD, but also on mode choices to PT facilities, primarily commuter rail. A methodology was developed to calculate generalised parking cost (in terms of minutes) as an input to mode choice model, taking into consideration general parking conditions in the Chicago CBD, in the P&R lots, and in all other urbanised, less urbanised and suburban areas. **Comments** The whole planning region is categorised as 11 area types from insider CBD to external area. The generalised parking cost consisted of three components: the average daily parking fee, the parking capacity and the area type. The parking fee was converted into minutes by using a dollar-to-minute conversion factor. The size of the parking capacity in each zone was considered as a utility in the generalised parking cost function. The utility of the parking capacity was assumed to rise with the capacity at a diminishing rate, and a maximum capacity value was assumed as a ceiling so there would be very little or no extra utilities above the maximum capacity value. The function created was: Generalised parking cost = area type value + 0.7*parking fee –0.3*Ln(parking capacity)$^{1.2}$ The three input variables were entered into the EMME/2 calculations as three extra attributes. The calculation was added to a P&R application in a matrix convolution in which highway assignment was used to estimate the driving cost, and the station access links were used to identify station zones. The station zones were the zones with commuter rail station(s), heavy rail station(s) and/or bus station(s).	PT generalised cost for a regional model.

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road perfor-mance		
					The generalised parking costs were calculated for all station zones. If a station zone was used as an intermediate zone where P&R would occur for any interchange zone pair, the generalised parking cost associated with that particular station zone would be added to the total generalised PT cost for the interchange zone pair. The methodology used in this study had several advantages. First, by using the highway links as P&R drive links and the highway congested time as the auto access time, it was unnecessary to code the detailed P&R drive links. Second, by using the station access links to identify station zones, it was unnecessary to build extra matrices for stations or parking lots. Third, by using the area type variable, the parking conditions of the whole region could be accessed to some extent, especially when the comprehensive parking inventory was not available. The model had some limitations: the parking demand was not constrained by parking capacity; the parking cost did not increase with the parking demand; subsidised or reimbursed parking fees were not considered; and finally the sensitivity of the model needed to be further tested. It should be noted that the model was not intended to accurately estimate the parking costs for individual parking lots nor reproduce the station choices, but to represent the generalised PT cost for mode split, and so would be more appropriate for a regional model.	
A logit parking choice model with explicit capacities (Spiess 1996)	USA	High	Yes		**Description** The purpose of the paper was to consider in detail the intermediate destination choice for P&R trips, in particular on modelling the logit type choice of parking location by taking into account capacity for each possible P&R location. **Comments** The paper introduces P&R site capacity into the P&R choice function for selecting which site will be used by P&R trips. It introduces an iterative process, which uses values from a previous model run to calculate parking location choice. The process checks that no location is overcapacity and if it is found that some facilities are overcapacity, an additional impedance is imposed at the facility to redirect sufficient trips to other facilities. The iterative process continues until no	The paper shows a simply implemented process for including P&R parking costs and parking capacity into a logit model choice model.

Citation	Country	Quality	Aspects covered		Description/comments	Relevance (ie to determine improved modelling methods)
			Mode share	Road perfor-mance		
					overcapacity facilities exist. The paper notes that in reality the process proposed seeks a solution by converging to a position where the parking capacity constraints in the mode are violated as little as possible. The paper was primarily aimed at EEME/2 models with the use of matrix convolutions and macros specific to EMME/2.	
The attitude and preference of traveller to the park & ride facilities: a case study in Nanjing, China (He et al 2012)	China	Low			**Description** The paper presents an investigation to understand drivers' willingness to use P&R facilities and the factors which influence drivers' decision. The paper is based on the results of an onsite face-to-face survey in Nanjing, China. **Comments** Used binary logit regression analysis of Chinese survey data to determine influence of range of factors. Unlikely to be applicable to New Zealand.	None.

Appendix E: Review of travel behaviour evidence

E1 Travel behaviour impacts – New Zealand research evidence

E1.1 Overview

Rather limited prior market research has been undertaken in New Zealand into the travel behaviour or attributes of P&R users and into user response to changes in P&R provision. The great majority of such research over the last 20 years has been in the Wellington region, with some research in Auckland. The Wellington/Auckland research relevant to this project is summarised in this appendix[31].

E1.2 Waterloo Telephone Survey (1994)

A random telephone survey of people travelling from the 'wider Waterloo area' to the Wellington central city area was carried out to assist in evaluating P&R alternatives for Waterloo and to provide data for analysis of other Hutt Valley corridor P&R issues (Travers Morgan (NZ) Ltd 1994).

Respondents were asked to indicate what they would have done for their trip to Wellington under several different scenarios. The main conclusions relating to **station car parking availability** were:

- New P&R users at Waterloo attracted by the availability of extra car parks would primarily be current train users. Around half of those parking at stations other than Waterloo would switch to Waterloo if parking was assured and around 15% of train users with a car available (half of all train passengers) would also become P&R users at Waterloo.
- Very few motor vehicle users (less than 1%) would switch to using the train if extra parks were available at Waterloo or improvements were made to all station car parks.

These results are consistent with the understanding that most motor vehicle users do not use the train for convenience-related reasons and significant improvements to the total PT system are required to attract these people. Providing a P&R facility, even one of a high quality, will on its own attract few motor vehicle users to switch from car to PT.

Another aspect of this survey involved asking existing train users to rank different car park features in terms of importance. Good security and good lighting received the highest rankings, followed by a short walk to the platform.

E1.3 Waterloo 'After' Survey (2000)

Following the extension of the Waterloo P&R facility, users of the new facility were surveyed as to their **prior travel behaviour**. The findings were:

- 10% previously drove all the way into Wellington CBD
- 75% previously parked their car elsewhere in the vicinity of Waterloo
- the remainder either parked at another station or accessed the station by non-car mode.

[31] Some of this material is drawn from Vincent (2007), other material is new/additional.

E1.4 Wellington City Bus P&R Survey

Travers Morgan (NZ) Ltd (1995) carried out a random survey of people travelling from three selected areas to work in the Wellington central city area before 9am weekdays. Respondents were asked a number of questions regarding their attitude towards P&R facilities associated with bus services. They were also asked to indicate the likelihood of using a specific P&R car park in their area. The responses covered both motor vehicle users and bus users who would normally have a car available for their trip to work. The results are summarised below.

E1.4.1 Existing bus users

- Nearly all bus users walked to the bus stop, with only a very small number taking their car to the bus stop and parking there (7%).
- The majority of bus users surveyed had a motor vehicle available for their most recent trip to work (65% of bus users) and nearly all of these had it available to them as a driver (90% of this group).
- The most common reasons for those people who had a motor vehicle available and chose to travel by bus were no parking at their destination (34% of this group) and convenience (33%).
- Only a very small proportion of those with a vehicle available indicated they would be ‘almost certain’ to use the proposed P&R facility in their area (4%), with the great majority (84%) stating they would be ‘not likely’ to use it.

E1.4.2 Non-bus users (ie all respondents who did not travel by bus on their most recent trip)

- Over half (55%) of the respondents who made their most recent trip to work by motor vehicle indicated they did not use the bus at all for their travel to work. However, 9% used the bus at least once a week and a further 10% used the bus at least once a month.
- The main reason for not using the bus was convenience which related primarily to the need for the car during the day, the greater flexibility of the car and the relative ease of travel (eg don’t have to walk to bus, better in bad weather, less waiting time). The next highest reason was travel time, which related to the shorter journey time of car versus bus.
- A significant proportion (43%) of motor vehicle users parked in employer-provided parking. This group would be very unlikely to switch to bus unless there was a change in their personal circumstances (eg if the car park was not available). In this case 64% of motor vehicle users indicated they would switch to bus for their trip to work.
- Non-bus users were asked to indicate how likely was it they would use the bus under six different bus service scenarios:
  - existing fares halved
  - more frequent bus service (every five minutes)
  - bus stop very close to your house
  - bus stop very close to your work
  - express services to city centre
  - P&R facility available (no other change)
  - P&R facility available, bus frequency every five minutes, express service available

- The most attractive single improvement for non-bus users appeared to be instituting express services. This reflected the importance of journey time for commuters. Simply providing a P&R facility on its own was the least attractive improvement.
- Motor vehicle users were asked how likely was it they would use a specific proposed new P&R facility. Only 3% indicated they would be almost certain to use the proposed new car park. The majority (66%) stated they would not be likely to use it at all.

E1.5 Birdwood Street Bus P&R Survey (1999)

A survey of users of the Birdwood Street (Karori) car park was undertaken by Booz Allen Hamilton for WCC in May 1999. Thirty-one cars used the car park: 16 survey forms were handed out and 13 returned (post-paid).

Relevant results include the following:

- Reasons for use of bus: most common reasons for use of the bus rather than driving all the way were: cheaper (33%), lack of parking at destination (31%).
- Reasons for use of facility: main reasons given for use of the P&R facility rather than parking elsewhere on the Karori bus route were the greater service frequency and the lack of car parks elsewhere. Twelve of the 13 respondents had e a closer bus service to their home; but preferred to catch the bus from the P&R facility because of higher frequency, faster trip, more convenient times etc.
- Reasons for driving to site: people drove to the P&R site because it was too far or too long to walk and no one was available to drop them off.
- Prior travel mode: prior to the opening of the facility, about 30% of respondents drove all the way and 30% walked to their nearest bus stop. Of the 17 respondents, eight made additional bus trips, with five making shorter bus trips; while five long car trips (to CBD) were replaced by 13 short (local) car trips.
- Alternative travel mode: if the P&R facility were no longer available, 19% said they would drive all the way, 31% would walk to their nearest bus stop and 50% would drive to another location and take the bus.

E1.6 GWRC P&R Survey (2002)

A survey of P&R users was carried out by the GWRC (Wellington Regional Council at the time) one morning in April 2002, covering 1,362 P&R users and all rail P&R car parks throughout the region (Vincent 2007). Of the respondents, 95.4% were travelling from home to work, 1.3% going to education and 0.8% to recreation. Thus, nearly all P&R users were commuters.

Also, 97.4% of respondents were travelling to Wellington station, with 77.5% using the P&R car park five times a week and 14.1% three or four times a week. The P&R users came from high car-owning households with 51.8% having two cars in their household and 15.6% with three or more cars.

Respondents were also asked what they would do if the P&R car park they were using on that day was not available to them. Of those who replied, 62.1% indicated they would park on the street nearby, 11.4% would park at another rail station and 8% would drive all the way to their destination (18.5% did not answer this question).

E1.7 Summary of Wellington market research studies

The main findings from the P&R studies summarised above were:

- Nearly all rail P&R users were commuters travelling to Wellington CBD.
- Most rail P&R users made use of the P&R car park three to five days a week.
- The level of rail service at a station affected the number of P&R users at that station.
- Only a very small proportion of motor vehicle users would be likely to switch to P&R if additional P&R car parks were available, or improvements were made to the car parks (less than 1% of motor vehicle users in the 1994 Waterloo telephone survey and 2.7% of motor vehicle users in the 1995 bus P&R survey.
- There was some informal bus P&R in Wellington City (1995 survey found 6.7% of bus users were P&R; this proportion may have increased with the advent of coupon parking).
- 34% of bus users who had a car at home took the bus because of no parking at their destination.
- 43% of motor vehicle users in the 1995 survey parked in employer-provided parking, and
- 64% of these users indicated they would switch to bus if a car park was not available.
- The WRC 2002 P&R survey found that 8% of current P&R users would drive all the way to their destination if their current P&R car park was not available (rather than park on the street or park at another station).

E1.8 Auckland Northern Busway Survey (2007)

Auckland Regional Transport Authority (ARTA) undertook a survey of users of the express bus services operating between the Albany and Constellation stations into the Auckland CBD, in March 2007 (Percy et al 2007). The survey covered the Northern Express services and the other express services using the Busway (87X, 881X, 76X, 85X, 86X, 956). The total sample size was 1,387.

Table E.1 gives the breakdown of modes used for access to the busway station. The major roles of P&R and K&R, especially for the NX users, are notable.

Table E.2 gives the breakdown of the prior main modes of transport for the same trip, prior to the introduction of the busway/express services. It shows this breakdown for (i) all respondents; (ii) all those using the NX services; and (iii) P&R users of the NX services. The survey included a substantial 'other' category of responses to this question: this mainly reflected people who did not make their trip prior to the opening of the busway. Table E.2 shows results both including and (in brackets) excluding these respondents.

Table E.1 Northern Busway – access modes 2007

Access mode	All respondents	NX service respondents
P&R – driver alone	43%	55%
– driver with passenger	6%	6%
K&R (dropped off at station)	20%	25%
Bus – same bus service	21%	5%
– other bus service	3%	5%
Walk	6%	7%
Cycle	<1%	<1%
Other	1%	1%
Total	**100%**	**100%**

Table E.2 Northern Busway – prior modes 2007

Prior mode	All respondents	NX service	
		All	P&R users
Bus	45% (55%)	36% (44%)	34% (42%)
Car – driver	26% (32%)	33% (41%)	42% (52%)
Car – passenger	9% (11%)	10% (12%)	4% (5%)
Motor bike	<1% (<1%)	<1% (<1%)	<1% (<1%)
Cycle	<1% (<1%)	<1% (<1%)	<1% (<1%)
Other	18% (–)	19% (–)	19% (–)
Total	100% (100%)	100% (100%)	100% (100%)

Key points of these results, excluding the 'other' category, include:

- Overall (all respondents), 55% previously made their trip by bus, 43% by car (32%) as driver).
- For the NX service users, 44% previously made their trip by bus, 53% by car (41% as driver).
- For the NX P&R users, 42% previously made their trip by bus, 57% by car (52% as driver).

In relation to this latter group, it should be noted that the results reflect a combination of the P&R provision and the enhanced bus services.

ARTA (Percy et al 2007) also made use of the 2007 survey data to estimate the change in VKT and hence in CO_2 emissions associated with the NX users (comparing their weekday travel in 2007 with their travel prior to November 2005). Key findings include:

- The NX users reduced their car travel by 3.9 million km pa.
- On average, this represents a reduction of some 10 car km per weekday per NX user. This reduction is attributed primarily to the 26% of the NX users who formerly made the full trip by car, and most of whom now make a much shorter car trip (as driver or passenger) to the busway station.
- The resulting saving in CO_2 emissions was estimated at 1,162 tonnes pa. The majority of this (1,022 tonnes) is the direct effect of the reduced car travel, with the remainder relating to the use of more fuel-efficient buses than previously.
- No allowance has been made for any changes in traffic congestion levels (on the basis that these would be minimal, given that the road operates at well over capacity at peak periods).

E2 Travel behaviour impacts – international evidence

Table E.3 Evidence on prior travel behaviour – rail P&R

Country/city	Reference	Prior mode (% P&R users)									Notes
		Main modes					Access modes				
		Car (driver)	Car (pool)	PT	No trip	Other	Car (driver)	Car (pax)	Bus	Walk	
USA:	Hamer (2009), based on Barton Aschman (1981), Bowler et al (1986) and Foote (2000)										
a) Philadelphia		44%	6%	50%	0%	0%					Philadelphia results do not include ‘no trip’ or other responses. Therefore these results are not included in averages.
b) Washington DC		25%	18%	38%	19%						
c) San Francisco		37%	18%	n/a	n/a	n/a					
d) Chicago		24%	**4%**	26%	18%	28%					
Average		**29%**	**13%**	**n/a**	**n/a**	**n/a**					
Europe – data for 22 rail ‘satellite’ P&R sites	Zijlstra 2013	35%		45%		20%					PT includes some active mode users and informal P&R users (11%).
Scotland	Arup et al 2012	26%		52%		22%					Figures are % of new P&R users when site extended: PT comprises 34% rail (other stations), 18% bus.
	Arup et al 2012						74%	9%	9%	9%	Figures are prior access modes of new P&R users (when more spaces), who had previously accessed the station by other means.

Table E.4 Evidence on prior travel behaviour – bus P&R

Country/city	Reference	Prior mode (% P&R users)					Notes
		Main modes					
		Car (driver)	Car (pool)	PT	No trip	Other/ DK	
England:	Hamer (2009), based on WS Atkins (1998) and other sources						Data relate to weekday travel only. 'Other' category includes different modes and no previous similar trip. 'Car' is said to be driver only (not clear re car passengers).
a) Oxford		57%		8%		35%	
b) Oxford		66%		24%		10%	
c) Oxford		55%		36%		9%	
d) York		63%		19%		18%	
e) York		66%		26%		8%	
f) Brighton		50%		18%		32%	
g) Cambridge		58%		10%		32%	
h) Coventry		52%		17%		31%	
i) Norwich		56%		24%		20%	
j) Plymouth		70%		14%		16%	
k) Reading		66%		28%		6%	
l) Shrewsbury		71%		15%		14%	
Weighted average		**61%**		**21%**		**18%**	
USA:	Hamer (2009), largely based on Barton Aschman (1981), Bowler et al (1986)						'Car (driver)' category stated as 'driver alone'. Car (pool) believed to include all cars with 2+ occupants.
a) Hartford		57%	15%	23%	5%	0%	
b) Miami		54%	10%	22%	14%	0%	
c) Milwaukee		42%	12%	44%	2%	0%	
d) Seattle		59%	11%	29%	1%	0%	
e) Dallas		50%	11%	11%	25%	3%	
f) El Paso		62%	20%	7%	8%	3%	

Country/city	Reference	Prior mode (% P&R users) – Main modes: Car (driver)	Car (pool)	PT	No trip	Other/ DK	Notes
g) Fort Worth		63%	15%	8%	9%	5%	
h) San Antonio		57%	10%	10%	20%	3%	
i) San Francisco/LA		22%	9%	38%	29%	2%	
Weighted average		**52%**	**13%**	**21%**	**13%**	**2%**	
Europe – data for 69 urban fringe P&R sites	Zijlstra (2013)	70%		22%		8%	PT includes some active mode users. DK includes informal P&R users (1%).
USA – summary data for c. 300 P&R facilities	*TCRP 95*	49%	23%	10%	15%		From TCRP report 95, chapter 3 (table 3.15). Derived from Bowler et al (1986) and presented in Weant and Levinson (1990).

Table E.5 Evidence on next best alternative modes – bus P&R

Country/ city	Reference	NBA modes (% of P&R users) – Main modes NBA modes: Car O-D	Car to inner	PT O-D	Walk/ cycle O-D	No alt trip	Other/ DK	Access modes (to bus): Informal P&R	Alternative access location	Changed timing	Alternative access mode	Notes, comments
UK:	Parkhurst (1995)											For Oxford, 'car to inner' comprises 16% who would drive to the Inner suburbs and then walk, 8% who will then catch a bus.
a) York		63	n/a	16		13	9					
b) Oxford		33	24	26		7	10					
UK - Bristol	Hewett et al (1996)	(a) 54 (b) 70		50 18		12	6					(a) = weekdays, (b) = weekends.
Scotland	Arup et al 2012	63		37				8	9		3	Total for two sites ('remote' sites, outside Aberdeen, Edinburgh). PT O-D (37%) comprises 17% bus O-D, 20% rail O-D with change in access modes

		NBA modes (% of P&R users)										
		Main modes NBA modes						Access modes (to bus)				
Country/ city	**Reference**	**Car O-D**	**Car to inner**	**PT O-D**	**Walk/ cycle O-D**	**No alt trip**	**Other/ DK**	**Informal P&R**	**Alternative access location**	**Changed timing**	**Alternative access mode**	**Notes, comments**
England:												
a) Brighton	WS Atkins in Meek et al (2011)	26		41	-	28						
b) Cambridge		39		24		12						
c) Coventry		50		21		21						
d) Norwich		53		29		12						
e) Plymouth		47		32		11						
f) Reading		43		31		18						
g) Shrews-bury		53		18		14						
h) York		57		26		7						
Average (unweighted)		46		28		15						
England:	Various in Meek et al (2011)											
i) Chester		60		14		12	15					Other = other P&R site
j) Maidstone		66		15		10						
k) Norwich		78		12		5						
l) Notting-ham		59		25		10						
m) Oxford		33		31		7	8					Other = other P&R site
Average (unweighted)		59		19		9	5					

Table E.6 Evidence on next best alternative modes – rail P&R

Country/ city	Reference	NBA modes (% of P&R users)										
		Main modes						Access modes to rail				Notes, comments
		Car O-D	Car to inner	PT – O-D	Walk/ cycle O-D	No/alt trip	Other/ DK	Inform-al P&R	Alternative access location	Changed timing	Alternative access mode	
Nether-lands	Mingardo (2013)											Alternative access modes are principally cycle.
a) Rotterdam		23		70	4	-					39	
b) Hague		19		74	5	2		20			17	
Australia – Perth	Olaru et al (2013)	24		10		5	22		25			Question appears to be based on short-term unavailability of P&R spaces at normal station. 'Alternative location' = drive to alternative station. 'Other' includes trip retiming, informal (on-street) parking, K&R.
Scotland	Arup et al (2012)	8		84		5	3	31	15		38	Average of results for six different stations – proportions vary considerably between stations.

E3 Impacts of P&R schemes on VKT

E3.1 UK bus P&R schemes

Parkhurst (2000) further analysed the data for bus-based P&R in eight English cities assembled by WS Atkins Consultancy (1998), to estimate the effective changes in VKT resulting from each scheme. Based on the number of parking spaces at each site, the trip O-D details for the site users, and their stated alternative modes, he estimated changes in car-equivalent (PCU) VKT both within and outside each urban area.

E3.1.1 Traffic within the urban area

Estimates were made of the:

- number of cars 'intercepted' (ie parkers at the P&R site who would otherwise have driven to the city centre)
- maximum reductions in car travel associated with these intercepted cars (based on their trip origins)
- distance travelled by P&R scheme buses (with a factor of 2.5 applied to convert bus km to equivalent car km).

The resultant net changes in equivalent car km within the urban area for each of the eight P&R schemes are summarised in the third column of table E.7. It is seen that, with one exception (Coventry – a very poorly utilised scheme), traffic within the urban area reduced in every case, by between 1.1km and 6.0km per car parked.

E3.1.2 Traffic outside the urban area

Estimates were made of the:

- additional travel by intercepted motorists in travelling to/from the P&R site (recognising that many P&R users would deviate from their shortest route between their trip origin and the city centre in order to access the P&R site)
- abstraction from PT (all the way) travel
- extent of trip generation as a result of the P&R facility and associated PT services.

The net change (increase) in VKT associated with the intercepted motorists and PR users together is shown in the fourth column of table E.7, expressed per car using the P&R site (the trip generation effect has not been included here, due to particular uncertainties in its quantification). For all schemes, there were substantial net increases in VKT, in the range of 6.7km to 25.0km per car parked.

The RH column in table E.7 shows the estimated net change in car equivalent VKT for each P&R scheme, as the sum of the intra-urban and extra-urban traffic components. In all cases, there were significant overall increases in car-equivalent VKT, as the additional VKT outside the urban area exceeded the reductions within the area. The net increases varied widely, between 0.9km and 20.7km per car parked; but in six of the eight cases the increases were between 2.7km and 9.3km.

Table E.7 UK bus P&R schemes – estimates of VKT impacts (Parkhurst 2000)

City	Distance of P&R site from CBD (km)	PCU km changes per day per car parked[(a)]		
		Change in traffic within urban area	Change in traffic outside urban areas	Net change
Brighton	4	-1.1	+7.9	+6.7
Cambridge	3 to 5	-5.0	+13.8	+8.8
Coventry	2.5	+2.6	+6.7	+9.3
Norwich	3 to 6	-4.3	+25.0	+20.7
Plymouth	1.5 to 5	-4.3	+9.1	+4.8
Reading	5	-3.0	+7.5	+4.4
Shrewsbury	3 to 4	-6.0	+6.9	+0.9
York	3 to 5	-5.8	+8.5	+2.7

Note: [(a)] + figures denote an increase in km, - figures a reduction.

E3.2 Appraisal of European P&R schemes

Zijlstra (2013) has undertaken analyses of almost 100 bus-based ('urban fringe') and rail-based ('satellite') P&R facilities in western Europe, to examine prior mode shares (in particular for former car users) and VKT impacts of new/expanded P&R facilities. His results are summarised in table E.8.

We comment as follows:

- For the rail-based schemes, the average reduction in VKT per P&R user is about 4.0km (range 3.4km to 5.8km)[32]. This 4.0km average is the net impact of a 7.3km reduction (on an average trip of 28.1km) for the target group (former car users), partly offset by a 3.3km increase for the non-target group (principally former PT users).
- For the bus-based schemes, there is a net average **increase** of 1.6km (range 1.35 to 2.77km). This is made up of a 2.1km reduction (on an average trip of about 20km) for the target group, which is more than offset by an average increase of 3.7km for the non-target group.
- No allowance has been made in these estimates for any changes in PT service km. (Parkhurst's analyses showed that increases in bus km were a significant factor for the UK bus schemes, but this may not be so for many European bus-based schemes.)
- No allowance has been made for induced travel behaviour: there is some evidence that this is quite significant for some surveyed schemes.
- The average net **increase** in VKT per P&R user for the bus-based schemes (1.6km) may be contrasted with Parkhurst's estimates for **reductions** in VKT (cars only) in the range 1.5 to 8.5km (table 3).

The reason for these disparate results is not clear, without more detailed investigations; it could well be related to the differing estimates of trip lengths and prior mode shares for the two datasets.

[32] The range of values given reflects a range of assumptions adopted for those P&R users for whom prior travel behaviour is unknown.

Table E.8 Changes in VKT for the average bus-based urban fringe P&R facility, and the average rail-based satellite P&R facility

Item	Bus-based urban fringe lots		Rail-based satellite facilities	
	N	Ave	N	Ave
Average distances (km)				
Distance to P&R	42	16.7	7	7.4
Distance from P&R	45	3.6	13	21.7
Distance otherwise travelled by car		19.8		28.1
Share of users of P&R facility (%)				
Former car users	50	70%	49	35%
Former PT and active mode users	50	22%	49	45%
Former (informal) P&R users	3	1%	40	11%
Unknown prior travel behaviour	35	7%	48	9%
Effects (per P&R user)				
Reduction in km by target group	2.14		7.30	
Extra km by non-target group	3.71		3.30	
Change in VKT (per P&R user)	**+1.57**		**-4.01**	
VKT range (min-max)	-1.35	+2.77	-3.35	-5.83

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Appendix F: Wellington survey – Petone and Waterloo P&R

Petone and Waterloo P&R survey, carried out in November 2013.

F1 Overview

F1.1 Methodology

- The methodology for this survey was a combination of intercept and paper self-completion.
- Interviewers intercepted passengers heading to the Waterloo and Petone stations and asked them to complete a paper survey.
- Whenever possible interviewers filtered respondents and asked only those who had driven to the station and were disembarking at Wellington railway station to complete the questionnaires.
- Respondents completed their questionnaires and handed them to interviewers collating the surveys at the Wellington Railway Station.
- The questionnaire is in the next worksheet.

F1.2 Data processing notes

- Responses from non-drivers were removed from the data analysis.
- Respondents who did not answer question 1 on getting to the station were removed from the analysis.
- An assumed NA was calculated for non-responses to line items in Q9 and Q10.

F1.3 Summary

- A total of 282 people who had driven to one of the stations and went on to catch a train completed the questionnaire. 116 of the respondents caught a train from Petone station and 166 from Waterloo station.
- Just under two-thirds of the respondents were female and the remainder male. The majority of respondents were aged between 35 and 64 years (77%).
- The primary destination for respondents was central Wellington (98%). All but one of the respondents was travelling to work.
- Most respondents travelled alone to the station (85% of drivers had no passengers). Most of the drivers had short journeys (77% drove for 10 minutes or less to get to the station).
- The majority of respondents made this journey (using any mode) four to five days a week (95%). The majority also used the same mode as on the morning of the study, all or most of the time (87%). The majority of respondents parked at the station P&R all or most of the time (82%).
- The most popular alternative means of making the journey were (combined most times and occasionally): driving all the way (63%), driving to a different station and catching the train (30%) and catching a ride all the way (24%).
- The most popular alternative means of making the journey if no park was available were (combined quite likely and unlikely): parking on the street and catching the train (79%), and travelling earlier to get a park (68%).
- The circumstances in which people were most likely to drive all the way to their destination were: because of train delays or cancellation, needing a car to get an appointment during, before or after work and when the passenger was running late.

F2 Questionnaire

Thank you for helping us with our Park & Ride research

The purpose of this survey is to help us[1] understand why you use Park & Ride (car and then train) for the journey you are now on, and what alternative means of travel you might consider. **Every** completed survey will be entered into a draw for a **$500** Visa Prezzy Card.

Once completed, please hand your survey to the researchers (wearing bright green shirts) located outside New World Metro and at the City Buses exit, at Wellington Station.

If you are getting off this train at a different station, you do not need to complete this survey.

Q1 How did you get to this Station this morning? PLEASE TICK ONE BOX

As a **driver** (including motorbikes and scooters)		**GO TO Q2**
As a **passenger** (including motorbikes and scooters)		**NOTE:**
By **public transport** (including bus and taxi)		**GO TO Q12**
Active travel (including bicycle and walk)		(Turn Over)

Q2 How many people came in your vehicle to this Station this morning (please include yourself)?
PLEASE TICK ONE BOX

1 (just me as the driver)	
2	
3	
4	
5 or more	

Q3 How long did your vehicle journey to this Station take this morning?
PLEASE TICK ONE BOX

Up to 5 minutes	
6-10 minutes	
11-15 minutes	
16 minutes or more	

[1] This is independent research funded by the NZ Transport Agency.

Q4 This morning, did you park in this Station Park and Ride car park?
PLEASE TICK ONE BOX

Yes - in the Station Park and Ride car park	
No - somewhere else near the Station	

Q5 What is your destination this morning?
PLEASE TICK ONE BOX

Central Wellington (including CBD, Thorndon and Te Aro)	
Wellington City (but outside the central area)	
Other - please specify suburb: ______	

Q6 How often do you make the journey between where you started from today and your destination today (by whatever route and means of transport), during the weekday morning peak period?
PLEASE TICK ONE BOX

4 or 5 days/week	
2 or 3 days /week	
About 1 day /week	
Less often than 1 day/week	
Not applicable	

Q7 Again thinking about the journey you are making today, how often do you drive to this Station and then catch a train to your destination during the weekday morning peak period?
PLEASE TICK ONE BOX

4 or 5 days/week	
2 or 3 days/ week	
About 1 day/week	
Less often than 1 day/week	
Not applicable	

Q8 When you make this journey by driving to this Station and catching the train, how often do you park in the Station Park and Ride car park?
PLEASE TICK ONE BOX

All or most times	
Sometimes	
Seldom or never	

PLEASE TURN OVER

Q9 How often do you use these **other** methods of travel, to get to the same destination as you are going to this morning (please just think about weekday peak period travel).

PLEASE TICK ONE BOX FOR EACH METHOD	Most times	Occasionally	Never
Drive all the way			
Catch a bus all the way			
Cycle all the way			
Get a ride in someone else's car all the way			
Drive to another Station and then catch the train			
Catch a bus to this Station and then catch the train			
Walk or cycle to this Station and then catch the train			
Get a ride with someone else to this Station and then catch the train			
Get a ride with someone else to another Station, and then catch the train			
Other (please specify):			

Q10 If you could **NOT** normally get a space in this Station Park & Ride car park at your usual time of travel, how likely would you be to use each of the following other methods to get to your destination?

PLEASE TICK ONE BOX FOR EACH METHOD	Very likely	Quite likely	Unlikely
Travel earlier, to get a parking place in the Station Park and Ride car park			
Park on the street near this Station and then catch the train			
Drive all the way			
Catch a bus all the way			
Cycle all the way			
Get a ride in someone else's car all the way			
Catch a bus to this Station and then catch the train			
Walk or cycle to this Station and then catch the train			
Get a ride with someone else to this Station and then catch the train			
Get a ride with someone else to another Station, and then catch the train			
Drive to another Station (where I could park) and catch the train from there			
Not make the journey			
Other (please specify): ______			

Q11 During the weekday morning peak period, in what circumstances would you **drive all the way** to your destination?

Q12 What is the main purpose of your trip to your destination this morning?
PLEASE TICK ONE BOX

To/from work	
To/from education	
Other	

Q13 What is your gender?

Male	
Female	

Q14 What age group are you in?
PLEASE TICK ONE BOX

Less than 18 years	
18-24 years	
25-34 years	
35-44 years	
45-54 years	
55-64 years	
65 years plus	

THANK YOU – please hand your survey in at Wellington Station
Every completed survey will be entered into a draw for a **$500** Visa Prezzy Card. Please write your contact details below so we can get in touch if you win the prize. We will ONLY use this contact information to administer the prize and will destroy all contact details once the prize has been issued.

Name:	
Telephone Number:	
Email address:	

F3 Main tables

Q1. How did you get to this Station this morning?									
	Driver		Passenger		PT		AT		TOTAL RESPONSES
	N	%	N	%	N	%	N	%	
Petone	116	77%	17	11%	3	2%	15	10%	151
Waterloo	166	66%	20	8%	3	1%	64	25%	253
TOTAL	282	70%	37	9%	6	1%	79	20%	404

Q2. How many people came in your vehicle to the station this morning?											
	Just me		2		3		4		5		TOTAL RESPONSES
	N	%	N	%	N	%	N	%	N	%	
Petone	98	84%	14	12%	4	3%	0	0%	0	0%	116
Waterloo	141	85%	22	13%	3	2%	0	0%	0	0%	166
TOTAL	239	85%	36	13%	7	2%	0	0%	0	0%	282

Q3. How long did it take you to get to the station this morning?									
	Up to 5 min		6-10 min		11-15 min		16 min plus		TOTAL RESPONSES
	N	%	N	%	N	%	N	%	
Petone	47	41%	51	44%	11	9%	7	6%	116
Waterloo	50	30%	68	41%	43	26%	4	2%	165
TOTAL	97	35%	119	42%	54	19%	11	4%	281

Q4. This morning, did you park at the Station Park and Ride?					
	Yes		No		TOTAL RESPONSES
	N	%	N	%	
Petone	92	79%	24	21%	116
Waterloo	129	78%	37	22%	166
TOTAL	221	78%	61	22%	282

Q5. What is your destination this morning?							
	Central WLG		WLG, outside CBD		Other		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	115	99%	1	1%	0	0%	116
Waterloo	160	96%	4	2%	2	1%	166
TOTAL	275	98%	5	2%	2	1%	282

Q6. How often to you make this journey - any mode, weekday morning peak?											
	4-5 days/wk		2-3 days/wk		1 day/wk		Less often		NA		TOTAL RESPONSES
	N	%	N	%	N	%	N	%	N	%	
Petone	112	97%	4	3%	0	0%	0	0%	0	0%	116
Waterloo	155	93%	8	5%	0	0%	3	2%	0	0%	166
TOTAL	267	95%	12	4%	0	0%	3	1%	0	0%	282

Q7. How often to you drive to this Station and then catch a train to your destination?											
	4-5 days/wk		2-3 days/wk		1 day/wk		Less often		NA		TOTAL RESPONSES
	N	%	N	%	N	%	N	%	N	%	
Petone	103	89%	8	7%	1	1%	4	3%	0	0%	116
Waterloo	141	87%	13	8%	2	1%	7	4%	0	0%	163
TOTAL	244	87%	21	8%	3	1%	11	4%	0	0%	279

Q8. When you make this journey by driving to this Station and catching the train, how often do you park in the Station Park and Ride car park?							
	All or most times		Sometimes		Seldom or never		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	96	83%	8	7%	12	10%	116
Waterloo	136	82%	10	6%	20	12%	166
TOTAL	232	82%	18	6%	32	11%	282

Q9A. How often do you make this journey by: driving all the way															
	Most times		Occasionally		Never		NA								TOTAL RESPONSES
	N	%	N	%	N	%	N	%							
Petone	8	7%	70	60%	26	22%	12	10%							116
Waterloo	28	17%	71	43%	47	28%	20	12%							166
TOTAL	36	13%	141	50%	73	26%	32	11%							282

Q9B. How often do you make this journey by: catching a bus all the way															
	Most times		Occasionally		Never		NA								TOTAL RESPONSES
	N	%	N	%	N	%	N	%							
Petone	0	0%	19	16%	62	53%	35	30%							116
Waterloo	1	1%	17	10%	94	57%	54	33%							166
TOTAL	1	0%	36	13%	156	55%	89	32%							282

Q9C. How often do you make this journey by: cycle all the way															
	Most times		Occasionally		Never		NA								TOTAL RESPONSES
	N	%	N	%	N	%	N	%							
Petone	0	0%	7	6%	74	64%	35	30%							116
Waterloo	0	0%	5	3%	98	59%	63	38%							166
TOTAL	0	0%	12	4%	172	61%	98	35%							282

Q9D. How often do you make this journey by: getting a ride in someone else's car all the way															
	Most times		Occasionally		Never		NA								TOTAL RESPONSES
	N	%	N	%	N	%	N	%							
Petone	0	0%	28	24%	53	46%	35	30%							116
Waterloo	0	0%	39	23%	75	45%	52	31%							166
TOTAL	0	0%	67	24%	128	45%	87	31%							282

Q9E. How often do you make this journey by: driving to another station and then catching the train															
	Most times		Occasionally		Never		NA								TOTAL RESPONSES
	N	%	N	%	N	%	N	%							
Petone	5	4%	25	22%	50	43%	36	31%							116
Waterloo	6	4%	50	30%	57	34%	53	32%							166
TOTAL	11	4%	75	27%	107	38%	89	32%							282

Q9F. How often do you make this journey by: catching a bus to this station and then catching the train															
	Most times		Occasionally		Never		NA								TOTAL RESPONSES
	N	%	N	%	N	%	N	%							
Petone	1	1%	12	10%	64	55%	39	34%							116
Waterloo	5	3%	16	10%	86	52%	59	36%							166
TOTAL	6	2%	28	10%	150	53%	98	35%							282

Q9G. How often do you make this journey by: walk or cycle to this station and then catch the train															
	Most times		Occasionally		Never		NA								TOTAL RESPONSES
	N	%	N	%	N	%	N	%							
Petone	2	2%	16	14%	63	54%	35	30%							116
Waterloo	3	2%	28	17%	81	49%	54	33%							166
TOTAL	5	2%	44	16%	144	51%	89	32%							282

Q9H. How often do you make this journey by: getting a ride with someone else to this station and then catching the train															
	Most times		Occasionally		Never		NA								TOTAL RESPONSES
	N	%	N	%	N	%	N	%							
Petone	0	0%	17	15%	63	54%	36	31%							116
Waterloo	2	1%	31	19%	76	46%	57	34%							166
TOTAL	2	1%	48	17%	139	49%	93	33%							282

Q9I. How often do you make this journey by: getting a ride with someone else to another station and then catching the train															
	Most times		Occasionally		Never		NA								TOTAL RESPONSES
	N	%	N	%	N	%	N	%							
Petone	0	0%	9	8%	66	57%	41	35%							116
Waterloo	1	1%	8	5%	96	58%	61	37%							166
TOTAL	1	0%	17	6%	162	57%	102	36%							282

Q9. How often do you make this journey by: SUMMARY															
	Most times		Occasionally		Never		NA		Combined most and occasionally		Combined Never and NA				TOTAL RESPONSES
	N	%	N	%	N	%	N	%	N	%	N	%			
Drive all the way	36	13%	141	50%	73	26%	32	11%	177	63%	105	37%			282
Drive to another station + train	11	4%	75	27%	107	38%	89	32%	86	30%	196	70%			282
Catch a ride all the way	0	0%	67	24%	128	45%	87	31%	67	24%	215	76%			282
Catch a ride to this station + train	2	1%	48	17%	139	49%	93	33%	50	18%	232	82%			282
Walk or cycle + train	5	2%	44	16%	144	51%	89	32%	49	17%	233	83%			282
Catch a bus all the way	1	0%	36	13%	156	55%	89	32%	37	13%	245	87%			282
Bus + train	6	2%	28	10%	150	53%	98	35%	34	12%	248	88%			282
Catch a ride to another station + train	1	0%	17	6%	162	57%	102	36%	18	6%	264	94%			282
Cycle all the way	0	0%	12	4%	172	61%	98	35%	12	4%	270	96%			282

Q9 other. What other methods do you use to make this journey?

Petone

Catch bus home, leave car for son.
Live up Korokoro Rd, no footpath or public transport, so need to drive.
Only replacement buses sometimes.
Walk to another station then catch the train occasionally.
Walk to another station.
Walk to Melling when not dropping kids off.

Waterloo

Drive to another station and cycle the rest of the way - most times.
Run all the way.
Walk to another station.
Walk to station from home.

Q10A. If you could not get a space in the Station Park and Ride how likely would you be to: travel earlier to get a P and R space

	Very likely		Quite likely		Unlikely		NA		TOTAL RESPONSES
	N	%	N	%	N	%	N	%	
Petone	46	40%	32	28%	22	19%	16	14%	116
Waterloo	82	49%	32	19%	29	17%	23	14%	166
TOTAL	128	45%	64	23%	51	18%	39	14%	282

Q10B. If you could not get a space in the Station Park and Ride how likely would you be to: park on the street near the station and then catch the train

	Very likely		Quite likely		Unlikely		NA		TOTAL RESPONSES
	N	%	N	%	N	%	N	%	
Petone	53	46%	37	32%	13	11%	13	11%	116
Waterloo	91	55%	41	25%	12	7%	22	13%	166
TOTAL	144	51%	78	28%	25	9%	35	12%	282

Q10C. If you could not get a space in the Station Park and Ride how likely would you be to: drive all the way

	Very likely		Quite likely		Unlikely		NA		TOTAL RESPONSES
	N	%	N	%	N	%	N	%	
Petone	13	11%	33	28%	49	42%	21	18%	116
Waterloo	14	8%	19	11%	89	54%	44	27%	166
TOTAL	27	10%	52	18%	138	49%	65	23%	282

Q10D. If you could not get a space in the Station Park and Ride how likely would you be to: catch a bus all the way

	Very likely		Quite likely		Unlikely		NA		TOTAL RESPONSES
	N	%	N	%	N	%	N	%	
Petone	1	1%	13	11%	72	62%	30	26%	116
Waterloo	3	2%	6	4%	107	64%	50	30%	166
TOTAL	4	1%	19	7%	179	63%	80	28%	282

Q10E. If you could not get a space in the Station Park and Ride how likely would you be to: cycle all the way

	Very likely		Quite likely		Unlikely		NA		TOTAL RESPONSES
	N	%	N	%	N	%	N	%	
Petone	2	2%	8	7%	78	67%	28	24%	116
Waterloo	2	1%	4	2%	109	66%	51	31%	166
TOTAL	4	1%	12	4%	187	66%	79	28%	282

Q10F. If you could not get a space in the Station Park and Ride how likely would you be to: get a ride in someone else's car all the way

	Very likely		Quite likely		Unlikely		NA		TOTAL RESPONSES
	N	%	N	%	N	%	N	%	
Petone	1	1%	10	9%	75	65%	30	26%	116
Waterloo	0	0%	19	11%	95	57%	52	31%	166
TOTAL	1	0%	29	10%	170	60%	82	29%	282

Q10G. If you could not get a space in the Station Park and Ride how likely would you be to: catch a bus to this station and then catch the train

	Very likely		Quite likely		Unlikely		NA		TOTAL RESPONSES
	N	%	N	%	N	%	N	%	
Petone	7	6%	15	13%	67	58%	27	23%	116
Waterloo	3	2%	15	9%	96	58%	52	31%	166
TOTAL	10	4%	30	11%	163	58%	79	28%	282

Q10H. If you could not get a space in the Station Park and Ride how likely would you be to: walk or cycle to this station and then catch the train

	Very likely		Quite likely		Unlikely		NA		TOTAL RESPONSES
	N	%	N	%	N	%	N	%	
Petone	6	5%	17	15%	65	56%	28	24%	116
Waterloo	16	10%	17	10%	88	53%	45	27%	166
TOTAL	22	8%	34	12%	153	54%	73	26%	282

Q10I. If you could not get a space in the Station Park and Ride how likely would you be to: get a ride with someone else to this station and then catch the train

	Very likely		Quite likely		Unlikely		NA		TOTAL RESPONSES
	N	%	N	%	N	%	N	%	
Petone	3	3%	13	11%	70	60%	30	26%	116
Waterloo	3	2%	19	11%	95	57%	49	30%	166
TOTAL	6	2%	32	11%	165	59%	79	28%	282

Q10J. If you could not get a space in the Station Park and Ride how likely would you be to: get a ride with someone else to another station and then catch the train

	Very likely		Quite likely		Unlikely		NA		TOTAL RESPONSES
	N	%	N	%	N	%	N	%	
Petone	1	1%	9	8%	76	66%	30	26%	116
Waterloo	1	1%	7	4%	106	64%	52	31%	166
TOTAL	2	1%	16	6%	182	65%	82	29%	282

Q10K. If you could not get a space in the Station Park and Ride how likely would you be to: drive to another station (where I could park and then catch the train)															
	Very likely		Quite likely		Unlikely		NA								TOTAL RESPONSES
	N	%	N	%	N	%	N	%							
Petone	14	12%	27	23%	48	41%	27	23%							116
Waterloo	24	14%	42	25%	57	34%	43	26%							166
TOTAL	38	13%	69	24%	105	37%	70	25%							282

Q10L. If you could not get a space in the Station Park and Ride how likely would you be to: not make the journey															
	Very likely		Quite likely		Unlikely		NA								TOTAL RESPONSES
	N	%	N	%	N	%	N	%							
Petone	1	1%	2	2%	77	66%	36	31%							116
Waterloo	1	1%	0	0%	104	63%	61	37%							166
TOTAL	2	1%	2	1%	181	64%	97	34%							282

Q10. If you could not get a parking space what would you do: SUMMARY															
	Very likely		Quite likely		Unlikely		NA		Combined likely and very likely		Combined unlikely and NA				TOTAL RESPONSES
	N	%	N	%	N	%	N	%	N	%	N	%			
Park on the street + train	144	51%	78	28%	25	9%	35	12%	222	79%	60	21%			282
Travel earlier to get a park	128	45%	64	23%	51	18%	39	14%	192	68%	90	32%			282
Drive to another station + train	38	13%	69	24%	105	37%	70	25%	107	38%	175	62%			282
Drive all the way	27	10%	52	18%	138	49%	65	23%	79	28%	203	72%			282
Walk or cycle + train	22	8%	34	12%	153	54%	73	26%	56	20%	226	80%			282
Bus + train	10	4%	30	11%	163	58%	79	28%	40	14%	242	86%			282
Catch a ride to this station + train	6	2%	32	11%	165	59%	79	28%	38	13%	244	87%			282
Catch a ride all the way	1	0%	29	10%	170	60%	82	29%	30	11%	252	89%			282
Catch a bus all the way	4	1%	19	7%	179	63%	80	28%	23	8%	259	92%			282
Catch a ride to another station + train	2	1%	16	6%	182	65%	82	29%	18	6%	264	94%			282
Cycle all the way	4	1%	12	4%	187	66%	79	28%	16	6%	266	94%			282
Not make the journey	2	1%	2	1%	181	64%	97	34%	4	1%	278	99%			282

Q9. and Q10. Using other options: summary															
	Q9 Currently mostly or occasionally do		Q10 If no parking was available very likely or likely to do												TOTAL RESPONSES
	N	%	N	%											
Drive to another station + train	86	30%	107	38%											282
Drive all the way	177	63%	79	28%											282
Walk or cycle + train	49	17%	56	20%											282
Bus + train	34	12%	40	14%											282
Catch a ride to this station + train	50	18%	38	13%											282
Catch a ride all the way	67	24%	30	11%											282
Catch a bus all the way	37	13%	23	8%											282
Catch a ride to another station + train	18	6%	18	6%											282
Cycle all the way	12	4%	16	6%											282

Q10, other. If you could not get a space in the Station Park and Ride what other methods would you use to get to your destination?
Petone
Can't - have to arrive at 8:30am after school drop-off, can't leave earlier.
I drop children off on way to train which limits my options of alternatives.
The Petone car park is now full by 8am. My recall is that a year ago it was probably around 8:15am, about 15 minutes later!
Walk to another station.
We park on the grass verge by Pito-one Rd when late e.g. after a dentist appointment or Korokoro hill car park at bottom on Korokoro Road.
Waterloo
Go to next railway station.
I already park on street as station park is full by 7:40am. I might walk to Naenae and take train there but it is more expensive to "train" from there.
I always get space.
I do get park at usual time of travel.
I live in Wainuiomata, cycle in out of the station.
There is hardly ever a park and ride space at the time I get my train (8:22) on the Waterloo side of the station. I don't bother even driving to see any more.
Walk to a closer station then catch the train.
Walk to nearest station and put up with fewer train options.

Q11. During the weekday morning period, in what circumstances would you drive all the way to your destination?			
Petone (from most mentioned to least, only notes points mentioned by 5 respondents or more)			
	N	%	Total
Need car to get to an appointment during, before or after work	38	32%	117
Train delay/cancellation	24	21%	117
When I am running late	8	7%	117
When I have an early or late start for work	7	6%	117
When I am going to the airport	5	4%	117
When I have luggage	5	4%	117
When there is no parking at the Station	5	4%	117
During the weekday morning period, in what circumstances would you drive all the way to your destination?			
Waterloo (from most mentioned to least, only notes points mentioned by 5 respondents or more)			
	N	%	Total
Train delay/cancellation	60	36%	166
Need car to get to an appointment during, before or after work	38	23%	166
When I am running late	16	10%	166
When I have an early or late start for work	6	4%	166
When I have use of a car park in town	5	3%	166
Inclement weather	5	3%	166

Q12. What was the main purpose of your trip this morning

	Work		Education		Other		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	115	100%	0	0%	0	0%	115
Waterloo	165	99%	1	1%	0	0%	166
TOTAL	280	100%	1	0%	0	0%	281

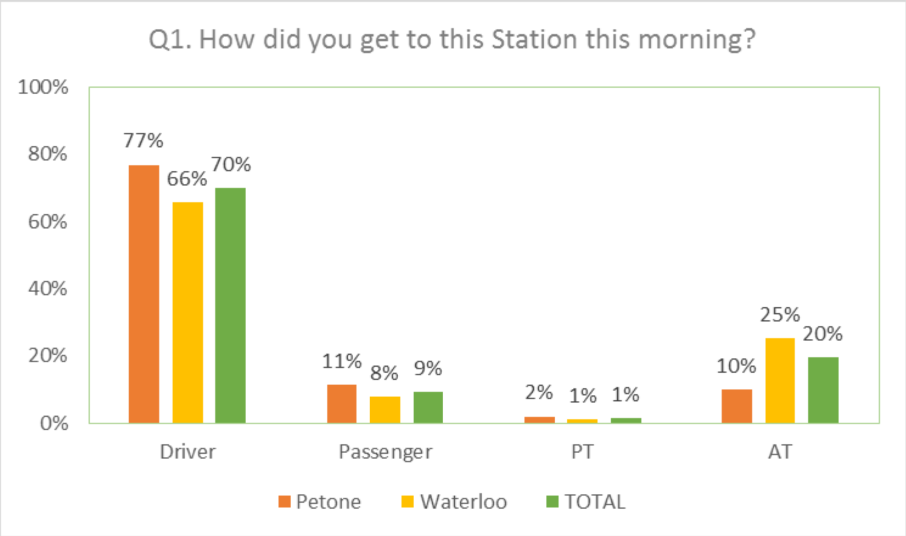
Q13. Gender

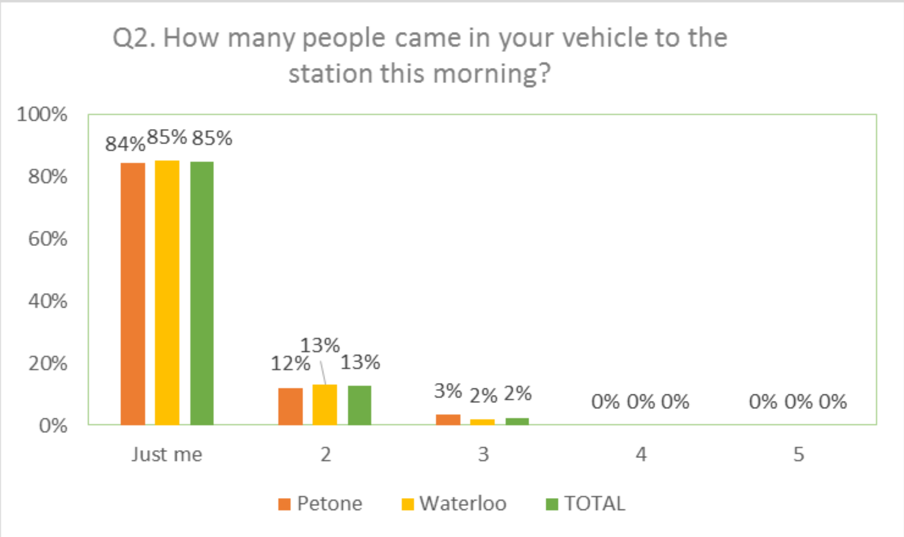
	Male		Female		TOTAL RESPONSES
	N	%	N	%	
Petone	48	42%	67	58%	115
Waterloo	56	34%	108	66%	164
TOTAL	104	37%	175	63%	279

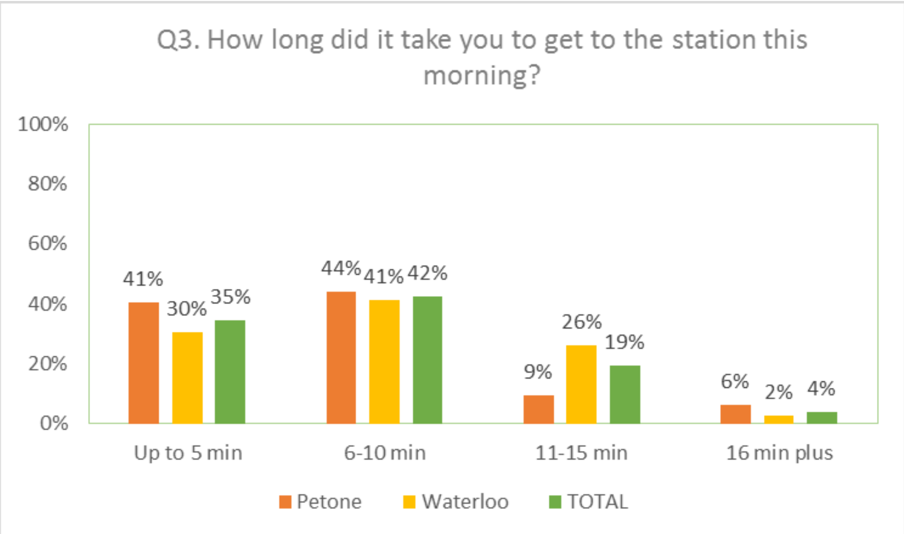
Q14. Age group

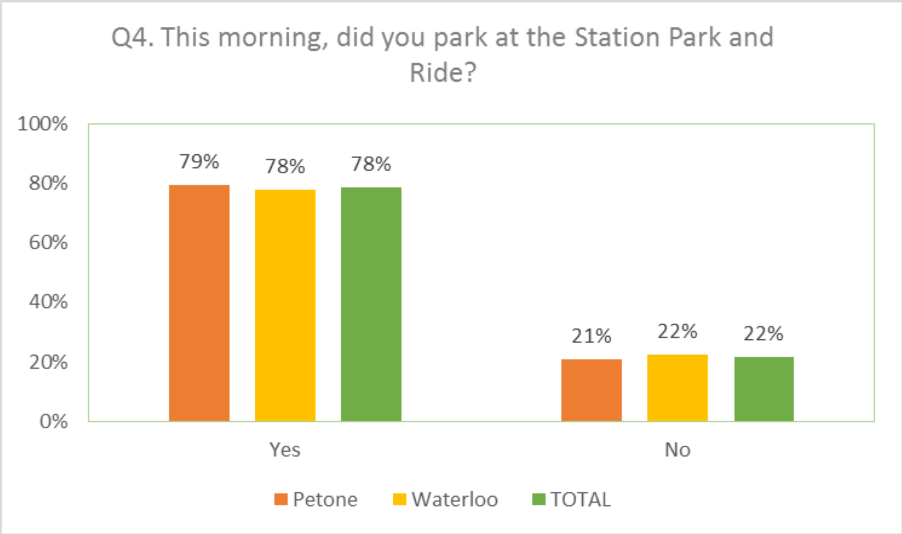
	Less than 18		18-24		25-34		35-44		45-54		55-64		65 plus		TOTAL RESPONSES
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	
Petone	0	0%	5	4%	18	16%	36	32%	34	30%	20	18%	1	1%	114
Waterloo	0	0%	9	5%	27	16%	47	28%	44	27%	34	21%	4	2%	165
TOTAL	0	0%	14	5%	45	16%	83	30%	78	28%	54	19%	5	2%	279

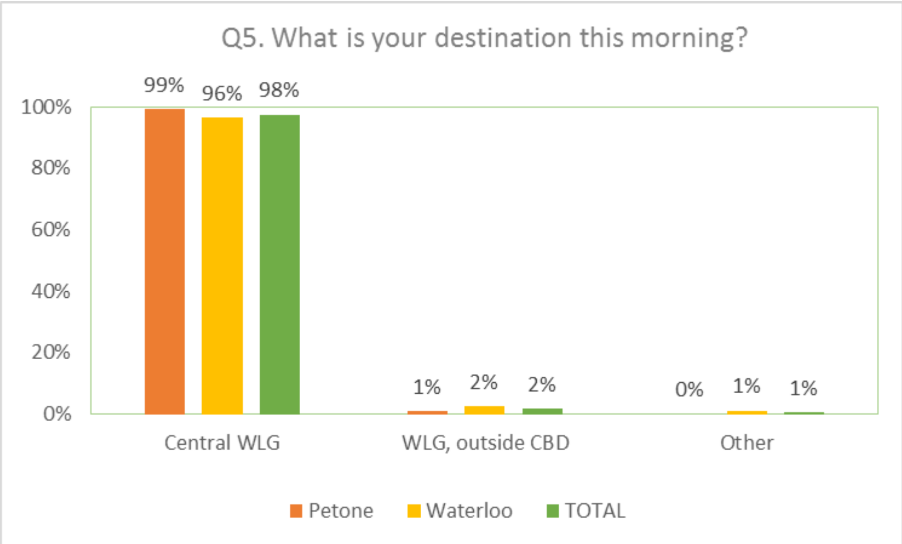
F4 Graphs

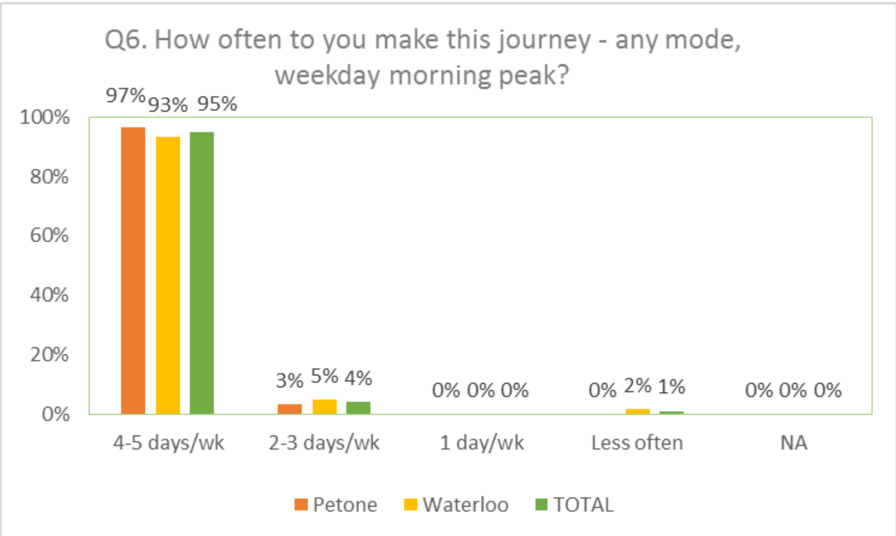

Q1. How did you get to this Station this morning?
100%
80%
60%
40%
20%
0%
77%
66%
70%
11%
8%
9%
2%
1%
1%
10%
25%
20%
Driver
Passenger
PT
AT
Petone
Waterloo
TOTAL

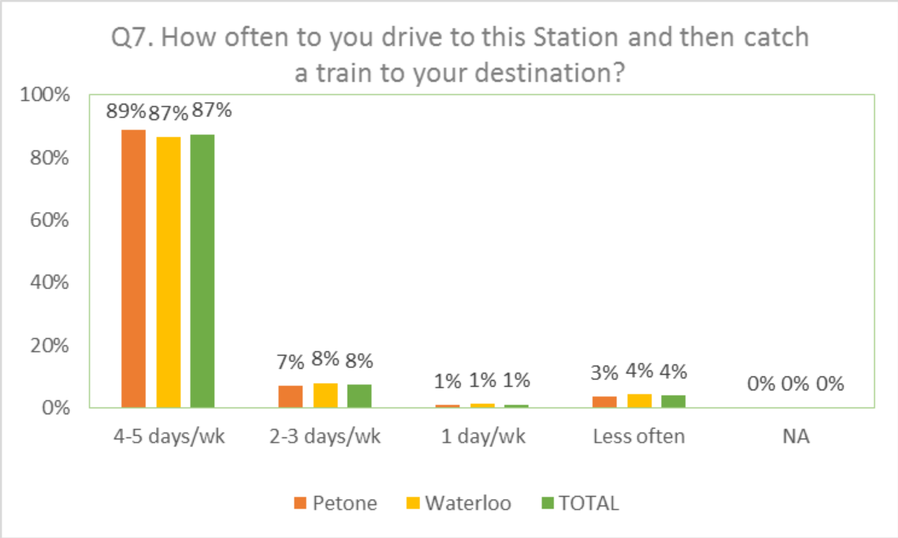

Q2. How many people came in your vehicle to the station this morning?
100%
80%
60%
40%
20%
0%
84%
85%
85%
12%
13%
13%
3%
2%
2%
0% 0% 0%
0% 0% 0%
Just me
2
3
4
5
Petone
Waterloo
TOTAL

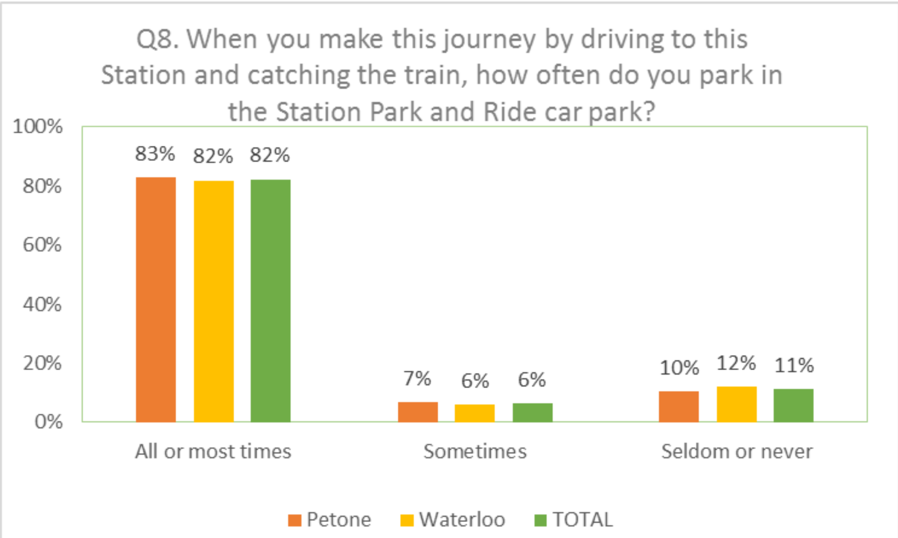

Q3. How long did it take you to get to the station this morning?
100%
80%
60%
40%
20%
0%
41%
30%
35%
44%
41%
42%
9%
26%
19%
6%
2%
4%
Up to 5 min
6-10 min
11-15 min
16 min plus
Petone
Waterloo
TOTAL

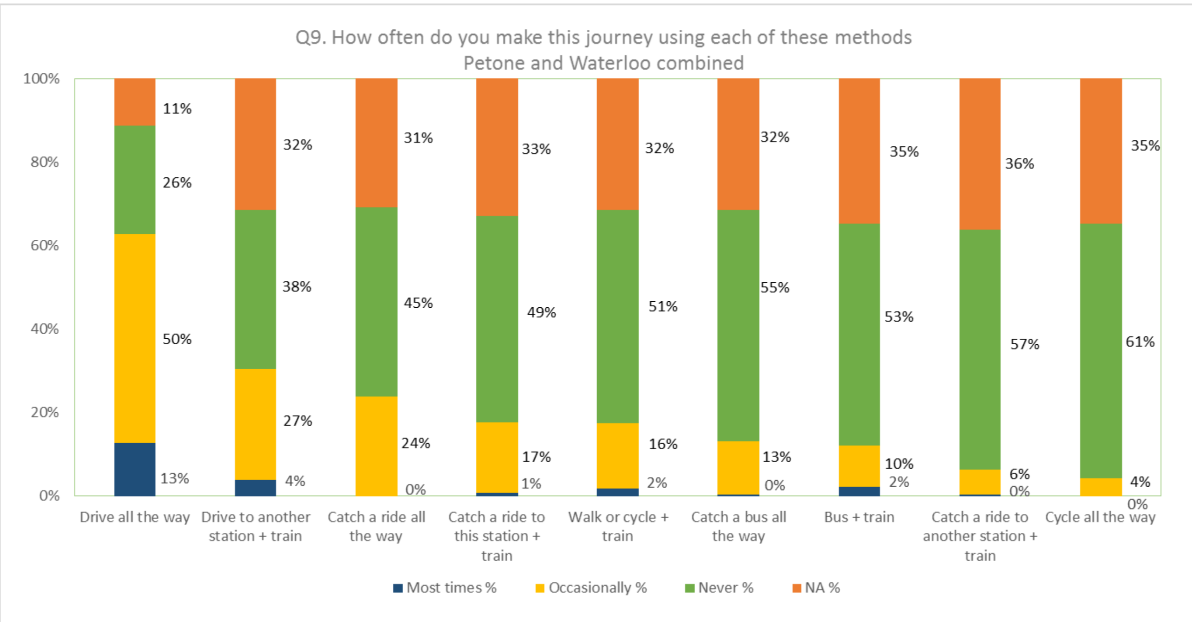

Q4. This morning, did you park at the Station Park and Ride?
100%
80%
60%
40%
20%
0%
79%
78%
78%
21%
22%
22%
Yes
No
Petone
Waterloo
TOTAL

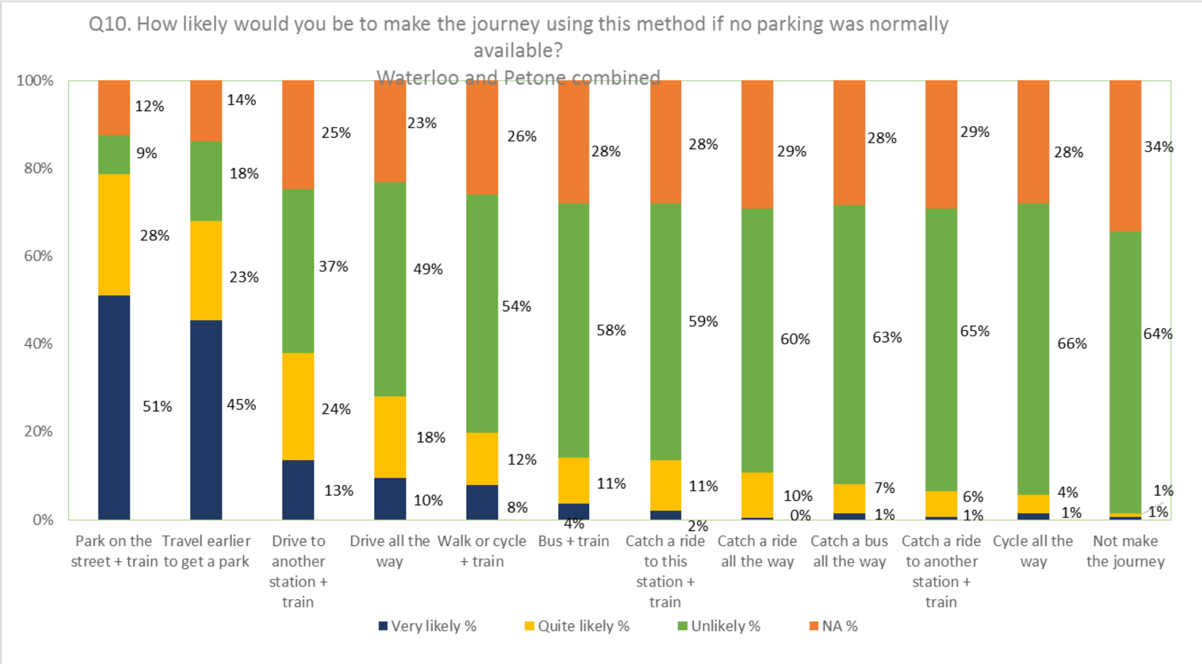

Q5. What is your destination this morning?
100%
80%
60%
40%
20%
0%
99%
96%
98%
1%
2%
2%
0%
1%
1%
Central WLG
WLG, outside CBD
Other
Petone
Waterloo
TOTAL


Q6. How often to you make this journey - any mode, weekday morning peak?
100%
80%
60%
40%
20%
0%
97%
93%
95%
3%
5%
4%
0% 0% 0%
0%
2%
1%
0% 0% 0%
4-5 days/wk
2-3 days/wk
1 day/wk
Less often
NA
Petone
Waterloo
TOTAL


Q7. How often to you drive to this Station and then catch a train to your destination?
100%
80%
60%
40%
20%
0%
89% 87% 87%
7% 8% 8%
1% 1% 1%
3% 4% 4%
0% 0% 0%
4-5 days/wk
2-3 days/wk
1 day/wk
Less often
NA
Petone
Waterloo
TOTAL


Q8. When you make this journey by driving to this Station and catching the train, how often do you park in the Station Park and Ride car park?
100%
80%
60%
40%
20%
0%
83% 82% 82%
7% 6% 6%
10% 12% 11%
All or most times
Sometimes
Seldom or never
Petone
Waterloo
TOTAL


Q9. How often do you make this journey using each of these methods
Petone and Waterloo combined
100%
80%
60%
40%
20%
0%
11% 26% 50% 13%
32% 38% 27% 4%
31% 45% 24% 0%
33% 49% 17% 1%
32% 51% 16% 2%
32% 55% 13% 0%
35% 53% 10% 2%
36% 57% 6% 0%
35% 61% 4% 0%
Drive all the way
Drive to another station + train
Catch a ride all the way
Catch a ride to this station + train
Walk or cycle + train
Catch a bus all the way
Bus + train
Catch a ride to another station + train
Cycle all the way
Most times %
Occasionally %
Never %
NA %



F5 Q9&10 with no assumed NA

How often do you make this journey by: driving all the way							
	Most times		Occasionally		Never		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	8	8%	70	67%	26	25%	104
Waterloo	28	19%	71	49%	47	32%	146
TOTAL	36	14%	141	56%	73	29%	250

How often do you make this journey by: catching a bus all the way							
	Most times		Occasionally		Never		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	0	0%	19	23%	62	77%	81
Waterloo	1	1%	17	15%	94	84%	112
TOTAL	1	1%	36	19%	156	81%	193

How often do you make this journey by: cycle all the way							
	Most times		Occasionally		Never		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	0	0%	7	9%	74	91%	81
Waterloo	0	0%	5	5%	98	95%	103
TOTAL	0	0%	12	7%	172	93%	184

How often do you make this journey by: getting a ride in someone else's car all the way							
	Most times		Occasionally		Never		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	0	0%	28	35%	53	65%	81
Waterloo	0	0%	39	34%	75	66%	114
TOTAL	0	0%	67	34%	128	66%	195

How often do you make this journey by: driving to another station and then catching the train							
	Most times		Occasionally		Never		TOTAL RESPONSES
	N	%	N	%	N	%	

Petone	5	6%	25	31%	50	63%	80
Waterloo	6	5%	50	44%	57	50%	113
TOTAL	11	6%	75	39%	107	55%	193

How often do you make this journey by: catching a bus to this station and then catching the train							
	Most times		Occasionally		Never		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	1	1%	12	16%	64	83%	77
Waterloo	5	5%	16	15%	86	80%	107
TOTAL	6	3%	28	15%	150	82%	184

How often do you make this journey by: walk or cycle to this station and then catch the train							
	Most times		Occasionally		Never		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	2	2%	16	20%	63	78%	81
Waterloo	3	3%	28	25%	81	72%	112
TOTAL	5	3%	44	23%	144	75%	193

How often do you make this journey by: getting a ride with someone else to this station and then catching the train							
	Most times		Occasionally		Never		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	0	0%	17	21%	63	79%	80
Waterloo	2	2%	31	28%	76	70%	109
TOTAL	2	1%	48	25%	139	74%	189

How often do you make this journey by: getting a ride with someone else to another station and then catching the train							
	Most times		Occasionally		Never		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	0	0%	9	12%	66	88%	75
Waterloo	2	2%	31	28%	76	70%	109
TOTAL	2	1%	40	22%	142	77%	184

If you could not get a space in the Station Park and Ride how likely would you be to: travel earlier to get a P and R space							
	Very likely		Quite likely		Unlikely		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	46	46%	32	32%	22	22%	100
Waterloo	82	57%	32	22%	29	20%	143
TOTAL	128	53%	64	26%	51	21%	243

If you could not get a space in the station park and ride how likely would you be to: park on the street near the station and then catch the train							
	Very likely		Quite likely		Unlikely		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	53	51%	37	36%	13	13%	103
Waterloo	91	63%	41	28%	12	8%	144
TOTAL	144	58%	78	32%	25	10%	247

If you could not get a space in the station park and ride how likely would you be to: drive all the way							
	Very likely		Quite likely		Unlikely		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	13	14%	33	35%	49	52%	95
Waterloo	14	11%	19	16%	89	73%	122
TOTAL	27	12%	52	24%	138	64%	217

If you could not get a space in the station park and ride how likely would you be to: catch a bus all the way							
	Very likely		Quite likely		Unlikely		TOTAL RESPONSES
	N	%	N	%	N	%	

Petone	1	1%	13	15%	72	84%	86
Waterloo	3	3%	6	5%	107	92%	116
TOTAL	4	2%	19	9%	179	89%	202

If you could not get a space in the station park and ride how likely would you be to: cycle all the way							
	Very likely		Quite likely		Unlikely		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	2	2%	8	9%	78	89%	88
Waterloo	2	2%	4	3%	109	95%	115
TOTAL	4	2%	12	6%	187	92%	203

If you could not get a space in the station park and ride how likely would you be to: get a ride in someone else's car all the way							
	Very likely		Quite likely		Unlikely		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	1	1%	10	12%	75	87%	86
Waterloo	0	0%	19	17%	95	83%	114
TOTAL	1	1%	29	15%	170	85%	200

If you could not get a space in the station park and ride how likely would you be to: catch a bus to this station and then catch the train							
	Very likely		Quite likely		Unlikely		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	7	8%	15	17%	67	75%	89
Waterloo	3	3%	15	13%	96	84%	114
TOTAL	10	5%	30	15%	163	80%	203

If you could not get a space in the station park and ride how likely would you be to: walk or cycle to this station and then catch the train							
	Very likely		Quite likely		Unlikely		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	6	7%	17	19%	65	74%	88
Waterloo	16	13%	17	14%	88	73%	121
TOTAL	22	11%	34	16%	153	73%	209

If you could not get a space in the station park and ride how likely would you be to: get a ride with someone else to this station and then catch the train							
	Very likely		Quite likely		Unlikely		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	3	3%	13	15%	70	81%	86
Waterloo	3	3%	19	16%	95	81%	117
TOTAL	6	3%	32	16%	165	81%	203

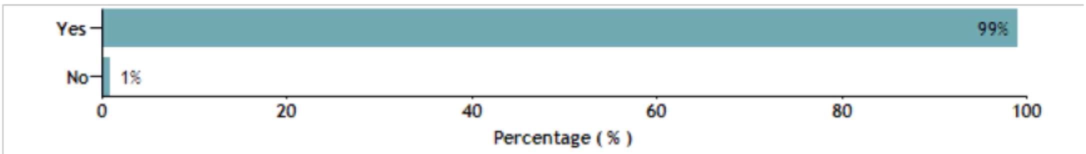
If you could not get a space in the station park and ride how likely would you be to: get a ride with someone else to another station and then catch the train							
	Very likely		Quite likely		Unlikely		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	1	1%	9	10%	76	88%	86
Waterloo	1	1%	7	6%	106	93%	114
TOTAL	2	1%	16	8%	182	91%	200

If you could not get a space in the station park and ride how likely would you be to: drive to another station (where I could park and then catch the train)							
	Very likely		Quite likely		Unlikely		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	14	16%	27	30%	48	54%	89
Waterloo	24	20%	42	34%	57	46%	123
TOTAL	38	18%	69	33%	105	50%	212

If you could not get a space in the station park and ride how likely would you be to: not make the journey							
	Very likely		Quite likely		Unlikely		TOTAL RESPONSES
	N	%	N	%	N	%	
Petone	1	1%	2	3%	77	96%	80
Waterloo	1	1%	0	0%	104	99%	105
TOTAL	2	1%	2	1%	181	98%	185

Appendix G: Auckland survey – Albany P&R

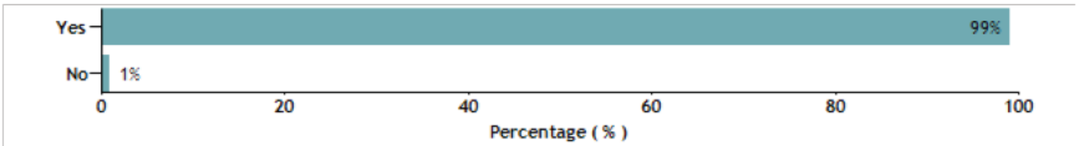
Question 1A Did you *drive* to the Albany Park and Ride this morning?



Number of responses to this question 235 (100%)
Total number of responses for this survey 236

Answer	Count	%
Yes	233	99
No	2	1

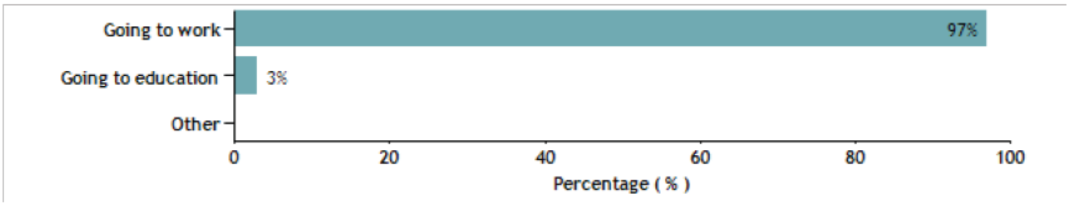
Question 2A Did you/will you catch a *bus* from the Albany Park and Ride this morning?



Number of responses to this question 233 (99%)
Total number of responses for this survey 236

Answer	Count	%
Yes	231	99
No	2	1

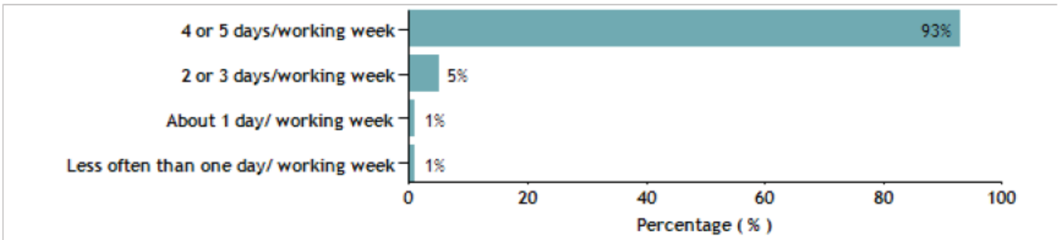
Question 3A What is the *main purpose* of your trip this morning?



Number of responses to this question 232 (98%)
Total number of responses for this survey 236

Answer	Count	%
Going to work	225	97
Going to education	7	3

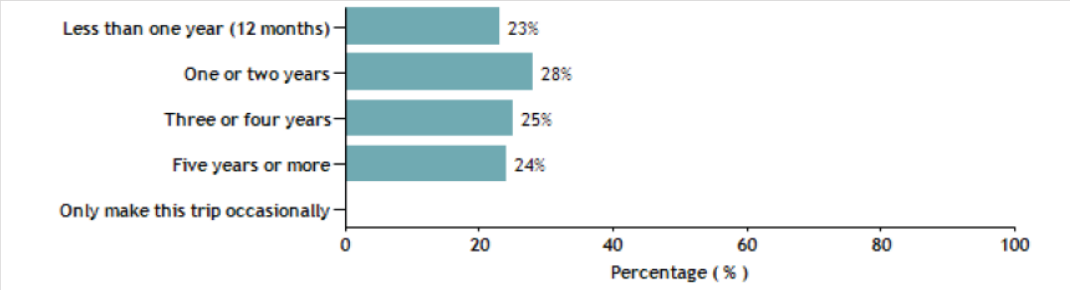
Question 3B Thinking about the trip you are making this morning, *how often* do you make this trip (using any transport mode or route)?



Number of responses to this question 232 (98%)
Total number of responses for this survey 236

Answer	Count	%
4 or 5 days/working week	216	93
2 or 3 days/working week	12	5
About 1 day/ working week	2	1
Less often than one day/ working week	2	1

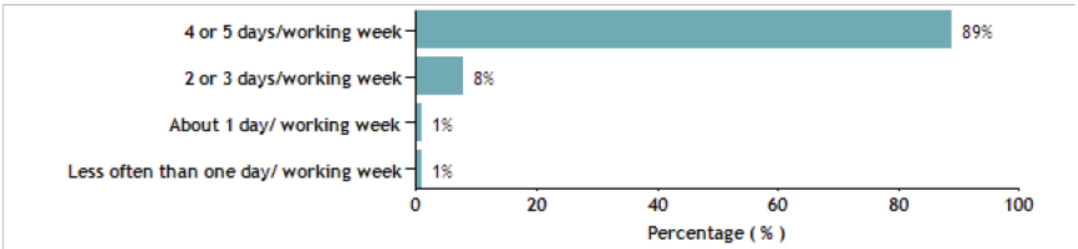
Question 3C Thinking about the trip you are making this morning, *how many years* have you been regularly making this trip for (using any transport mode or route)?



Number of responses to this question 232 (98%)
Total number of responses for this survey 236

Answer	Count	%
Less than one year (12 months)	53	23
One or two years	65	28
Three or four years	59	25
Five years or more	55	24

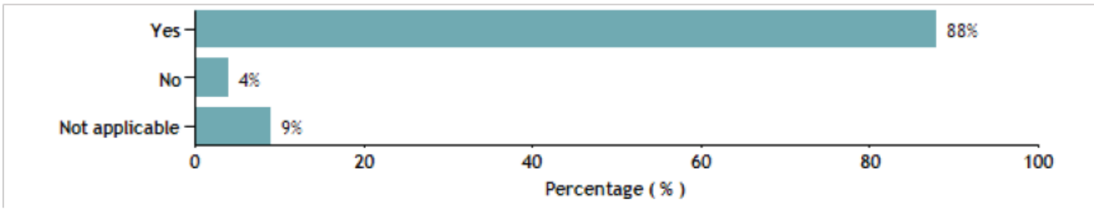
Question 3D When you make this trip, how often do you make it in the *same way* as today, i.e. drive to the Albany Park and Ride then catch a bus?



Number of responses to this question 232 (98%)
Total number of responses for this survey 236

Answer	Count	%
4 or 5 days/working week	207	89
2 or 3 days/working week	19	8
About 1 day/ working week	3	1
Less often than one day/ working week	3	1

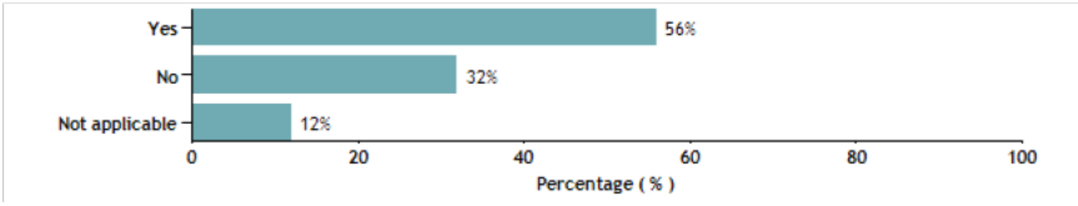
Question 3E Do you recall that a lot *more parking spaces* were added to the Albany Park and Ride car park in the middle of last year (about 15 months ago)?



Number of responses to this question 232 (98%)
Total number of responses for this survey 236

Answer	Count	%
Yes	203	88
No	9	4
Not applicable	20	9

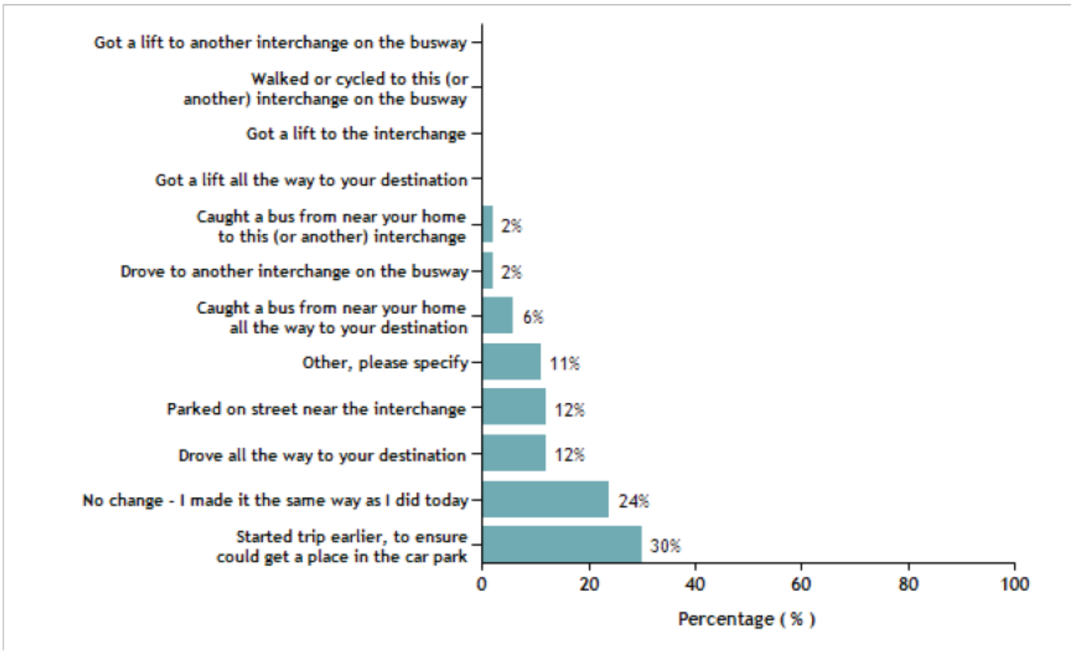
Question 3F Has the greater availability of parking spaces since last year (when the car park was extended) made any *difference* to how or at what time you usually make this trip?



Number of responses to this question 232 (98%)
Total number of responses for this survey 236

Answer	Count	%
Yes	129	56
No	74	32
Not applicable	29	13

Question 3G How did you *usually* make this trip *before* the additional parking spaces were available?
PLEASE CHOOSE ONE RESPONSE ONLY



Number of responses to this question 232 (98%)
Total number of responses for this survey 236

Answer	Count	%
No change - I made it the same way as I did today	56	24
Started trip earlier, to ensure could get a place in the car park	70	30
Parked on street near the interchange	28	12
Got a lift to the interchange	1	0
Drove to another interchange on the busway	5	2
Caught a bus from near your home to this (or another) interchange	4	2
Caught a bus from near your home all the way to your destination	14	6
Drove all the way to your destination	28	12
Got a lift all the way to your destination	1	0
Other, please specify	25	11

Appendix H: New Zealand market surveys

H1 Introduction

Primary market research into the P&R market was undertaken in both Wellington (Waterloo and Petone stations) and Auckland (Albany station, on the Northern Busway), with a focus on exploring the likely alternative behaviour of current P&R users (car drivers) if P&R at these sites was more restricted or not available:

- For the Wellington survey, people were asked about their next best alternative (NBA) likely means of travel, if they could not get a space in the P&R car parks.
- For the Auckland survey, people were asked about how they used to make their trip before the Albany P&R parking spaces were increased (in mid-2012).

Details of the survey results are given in appendix G (Wellington) and appendix G (Auckland). Summary comments on each survey follow below.

We gratefully acknowledge the funding contributions made for these two surveys by AT and GWRC.

H2 Wellington (Petone/Waterloo) survey

This survey was carried out in the AM peak period at Waterloo (20 November 2013) and Petone (19 November 2013) stations on the Hutt Valley line. Survey forms were handed out to people walking between the P&R car parks and the station platforms. The completed forms were collected at Wellington railway station.

404 completed surveys were received, of which 282 (166 Waterloo and 116 Petone) were from car drivers. The remaining completed surveys (by walkers/cyclists, car passengers and PT users) were not used in the analyses.

The overall response rate, in terms of completed forms as a proportion of those handed out, was 62%.

The patterns of response for the Waterloo and Petone stations were very similar. Given this, the following summary results relate to the two stations combined.

Some key survey statistics from the survey are:

- 100% of the sample had their main trip purpose as work[33].
- 98% of the sample had their trip destination as central Wellington.
- 62% were female.
- 93% were in the age brackets 25–64.
- 95% made the trip (irrespective of mode or route) on four or five weekdays per week.
- The great majority (more than 90%) made their trip by the same mode and route on most or all occasions.
- When making their trip by driving to the station and catching the train, 82% parked in the P&R car park all or most times, 6% sometimes, 11% seldom or never.

[33] Only one person recorded their purpose as education. This will reflect that people under age 18 were not surveyed.

When **not** making their trip by driving to their regular (Waterloo/Petone) station and catching the train, other means used were:

- **Main mode alternatives:**
  - car driver all the way (13% most times, 63% most times/occasionally)
  - car passenger all the way (0%/24%)
  - bus all the way (0%/13%)
  - cycle all the way (0%/4%).
- **Access (to train) alternatives:**
  - car driver to another station (4%/31%)
  - car passenger to same/other station (1%/24%)
  - walk/cycle to station (2%/18%)
  - bus to station (2%/12%).

The responses to the question 'If you could **not** normally get a space in this station P&R car park at your usual time of travel, how likely would you be to use each of the following other methods to get to your destination?' are summarised in table H.1, on two bases:

- 'Survey – unadjusted'. This gives the number of all responses in the 'very likely' category plus half those in the 'quite likely' category[34], as a measure of the relative probability of choosing each travel method.
- 'Suppressed P&R site users'. Drawing from the previous column, this provides our estimates of the proportions of cars (car drivers) who would no longer use the Waterloo/Petone P&R parks together with their alternative means of travel (main mode and access mode), ie the proportions represent the next best alternative mode of those additional users of the Waterloo/Petone car parks if the parking capacities were increased.

[34] For all options offered, between 12% and 34% (typically around 25%) of respondents did not tick any box. We have assumed these non-responses are equivalent to an 'unlikely' response, and so have grouped them in this way in presenting our results.

Table H.1 If you could NOT normally get a space in the station P&R car park at your usual time of travel, how likely would you be to use each of the following methods to get to your destination? (Waterloo/Petone)

Travel method	Responses (very likely +0.5*quite likely)	Suppressed P&R site user proportions – estimated[(a)]
Main mode change		
Car driver – all the way	19	12
Car passenger – all the way	5	3
Bus - all the way	5	3
Cycle – all the way	3	2
Access (to train) change	**32**	**20**
Car driver – park on street	65	41
Car driver – travel earlier to get P&R space	57	-
Drive to another station	25	16
Walk or cycle to station	14	9
Bus to station	10	6
Car passenger to station	8	5
Car passenger to other station	4	2
Suppressed trip	**183**	**79**
Would not make this journey	2	1
Total	**217**	**100%**

Note:

(a) Takes all responses from previous column, except 'car driver – travel earlier to get P&R space', sums these and then factors so that they total 100(%).

In terms of these 'new' P&R users, the most significant categories by alternative means of travel are:

- **Change in train access mode (only):** (79% total)
  - Car driver – park on the street 41%
  - Car driver - park at other station 16%
  - Car passenger – same/other station 7%
  - Walk/cycle to station 9%
  - Bus to station 6%
- **Main mode change:** (20% total)
  - Car driver 12%
  - Car passenger 3%
  - Bus 3%
  - Cycle 2%.

H3 Auckland (Albany) survey

A survey was carried out over the AM peak period on 28 November 2013. Car drivers transferring from the P&R car park to the bus stops at the Albany station were given a flyer asking them to complete a web-based survey relating to the trip they were making: 235 responses were received over the following five days. These responses represented some 21% of the car capacity of the P&R car park. (While the response rate is relatively low, we have no reason to think that the resultant sample is biased.)

Some key survey statistics from the survey are:

- 97% of the sample were going to work.
- 93% made this trip (irrespective of mode or route) on four or five weekdays per week.
- The great majority (more than 90%) made their trip by the same mode and route on most or all occasions.
- 88% recalled that parking capacity at the Albany P&R site was increased (approximately doubled) in mid-2012.
- Of the people who had been making their trip since before the car park was extended, about 60% said that this had made a difference to how or at what time they made their trip.

The responses to the question 'How did you usually make this trip before the additional parking spaces were available?' are summarised in table H.2, on two bases:

- 'Survey unadjusted'. This gives the percentage breakdown of all responses to the question.
- 'Albany new P&R users – estimated'. This provides our estimates of the prior means of travel for those people who did not use the P&R site prior to its enlargement, but now do so. (While these estimates have involved a number of assumptions, our judgement is that they are fairly robust and unlikely to be much in error.)

Table H.2 'How did you usually make this trip before the additional parking spaces were available?' (Albany)

Travel method	**% responses**	
	Survey – unadjusted	**New Albany P&R users – estimated[(a)]**
Started trip earlier to ensure could get place in car park	33	--
No change –same way as today	26	--
Parked on street near station	13	32
Drove all way to destination (car, m/cycle)	13	13
Caught a direct bus from near home all way to destination	7	16
Drove to another interchange on busway (then caught the bus)	2	6
Caught a bus from near home to this (or other) interchange	2	6
Car passenger – all way to destination	1	1
Car passenger – to interchange	1	1
Other	2	5
Total[(b)]	**100**	**100**

Notes:

[(a)] Estimate of new P&R users over all categories except the first two in the unadjusted results. Estimates of new users also make a proportion of the 'other' category, based on further inspection of the 'other' explanations given.

[(b)] Totals may not balance due to rounding.

In terms of the **new P&R** users, the significant categories, by prior means of travel, are:

- Drove all the way to the destination 33%
- Parked on street near the station, then caught the bus 32%
- Travelled by direct bus from near home all the way to their destination 16%
- Drove to another busway station, then caught the bus 6%
- Travelled by feeder bus from near home to Albany (or other) station 6%
- 'Other' 5%
- Total 100%

H4 Conclusions and recommendations

Both the Wellington and Auckland surveys were designed to provide primary market research in the New Zealand context as to the market response that would be expected (in terms of modes of travel) to the provision of additional P&R spaces at 'rapid transit' stations (rail for Wellington, bus/BRT for Auckland).

In the light of the practical possibilities available, the two surveys tackled this requirement through somewhat different approaches:

- The Wellington surveys used a stated preference (SP)/intentions approach, asking existing P&R users how they would respond to **fewer** P&R spaces; and then 'inverting' their responses to estimate likely responses to an **increase** in spaces.
- The Auckland survey used a RP revealed preference (RP) or prior behaviour) approach, asking existing P&R users how they **did** change their travel behaviour in response to a recent **actual** increase in P&R spaces.

Table H.3 compares the evidence from the two surveys as directly as is possible. Notable results include:

- In the Waterloo/Petone cases, new P&R users would be mainly those who already used the rail services but would change their access mode to rail (79%) – most of these would switch from parking on-street (41%) or from parking at another station (16%). Those who would change their main mode of transport to the CBD were a minority (20%) of the new P&R users: the largest category here were those who switched from driving all the way (12%); the small proportion who would change from bus all the way (3%) reflected the relative lack of bus services to Wellington city from the Waterloo (in particular) and Petone areas.
- In the Albany case, the new P&R users were evenly split between those who already used bus services but would change their access mode and those changing their main mode. Those changing access mode, were (as in the Waterloo/Petone cases) those who would switch from parking on-street (32%) or from parking at another busway station (6%). The 50% who would change their main mode were split between those switching from driving all the way (33%) and those who would catch a 'local' bus from near their home direct to the CBD (16%).

It is perhaps surprising that the differences in the results for the Waterloo/Petone cases and the Albany case are so pronounced – particularly for the proportions changing their main mode. Possible factors contributing to these differences include the following:

- The relative availability of direct bus services from suburban areas into the CBD – in the Albany case, these provide a competitive alternative for many people; while for the Waterloo area in particular no direct bus services are available.
- In the Waterloo/Petone cases, travellers will have long been familiar with using the train for trips to Wellington city and therefore will tend to discount/ignore other (main mode) options, and focus more on access mode options; whereas in the Albany case, the 'rapid transit' system is relatively new and people will be more familiar with other (main mode) options.
- The potential differences in responses between surveys based closely on actual behaviour (RP) compared with those based on stated intentions (SP). In our view, greater weight should be given to the Auckland survey results over the Wellington results, primarily on the basis that actual (revealed) behaviour evidence would generally be superior to hypothetical (stated) evidence.

Table H.3 Summary of prior/NBA travel behaviour of 'new' P&R users (in response to additional P&R provision)

Prior travel behaviour	% of 'new' P&R users	
	Waterloo/Petone (NBA)	Albany (prior)
Prior/NBA main mode		
Car driver – all the way	12	33
Car passenger – all the way	3	1
Bus - all the way	3[a]	16[b]
Cycle – all the way	2	-
Sub-total	**20**	**50**
Prior/NBA access mode (to line haul PT service)		
Car driver – park on street	41	32
Car driver – park other station	16	6
Car passenger	7	1
Local bus	6	6
Walk/cycle	9	--
'Other'	1	5
Sub-total	**80**	**50**
Total	**100**	**100**

Notes:

[a] Low figure reflects limited bus services between Waterloo (especially) and Petone areas to CBD.

[b] Represents users of direct bus services from near home to CBD.

For the next phase of work and for the case studies, the evidence on alternative modes from these New ealand surveys will need to be brought together with that from our international review, so as to derive some best estimates and sensitivity ranges for the proportions of users of additional P&R spaces who would switch their main mode (in particular), principally from driving all the way and from using (local) bus all the way.

Appendix I: Demand modelling – road system

I1 Upper Harbour Corridor SATURN Model

The AM period was used to evaluate the impact of increased P&R usage on road network congestion as it represents a peak commuter period. The PM period, which could also have been selected for this evaluation, was expected to produce similar levels of congestion but in the opposite direction of travel.

For the AM peak, the UHC SATURN model has two average on-hour assignments (7am to 8am and 8am to 9am). The first hour loads traffic onto an ‘empty’ network, while the second hour loads traffic onto the road network including queues and delays estimated from the first hour assignment. The P&R tests were evaluated using the primed (preloaded) network or second one-hour assignment to provide on-street queues and delays during the analysis hour.

Select link analysis of the SH1 northern corridor between Albany and Auckland CBD was undertaken to isolate the origin and destination (O-D) pairs for vehicles using the motorway and potentially shifting to P&R. The car trips associated with the O-D pairs were then factored down to test demand reductions associated with increased use of P&R. The total demand between the selected O-D pairs was reduced by decreasing the number of car trips by: 23 (-5%), 35 (-7.5%), 46 (-10%), 83 (-18%), 102 (-22%) and -203 (-44%). The preliminary testing of these scenarios only evaluated demand reductions reflecting increased use of P&R. The demand changes assessed at this stage did not allow for the increase in car trips from people’s homes to the P&R site.

Figures I.1 to I.3 show the changes in travel distance (pcu-km), travel time (pcu-hrs) and speed for each demand reduction test for the total road network (ie the changes are not just in the corridor). Some variation exists for the smaller changes in demand. This is likely to be a result of ‘model noise’ which disappears as the reduction in demand increases, producing a more stable linear relationship.

The R squared values displayed in the following graphs are equal to or greater than 0.85, indicating a robust trend.

Figure I.1 Auckland network results – travel distance

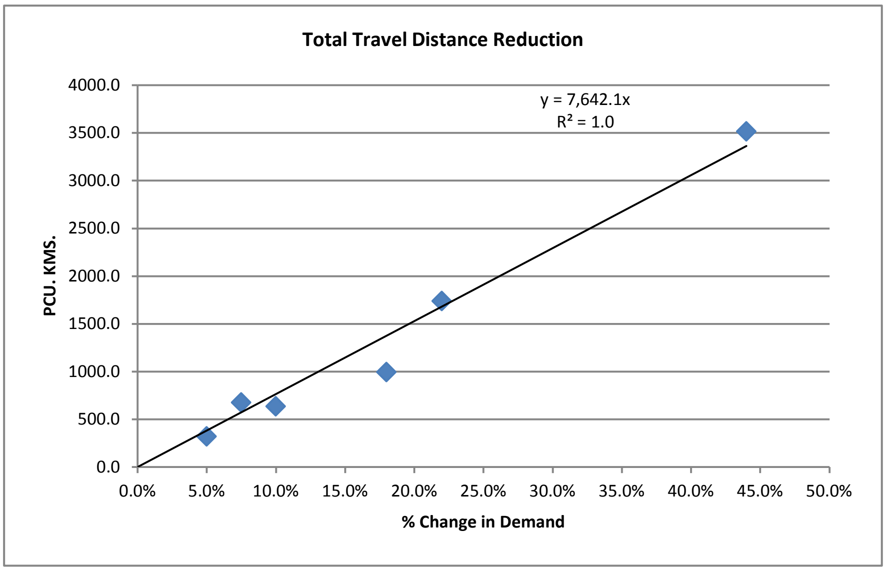


Figure I.1 Auckland network results – travel time

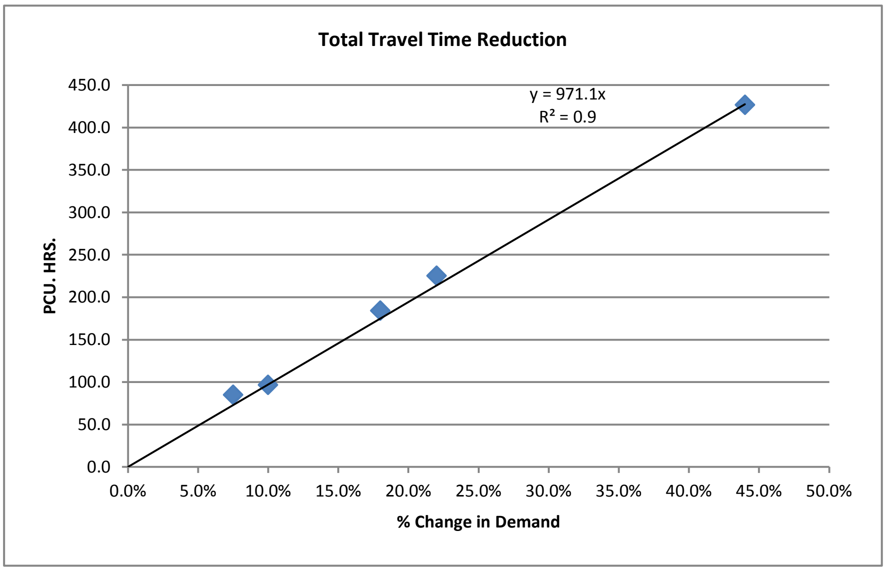


Figure I.2 Auckland network results – travel speed

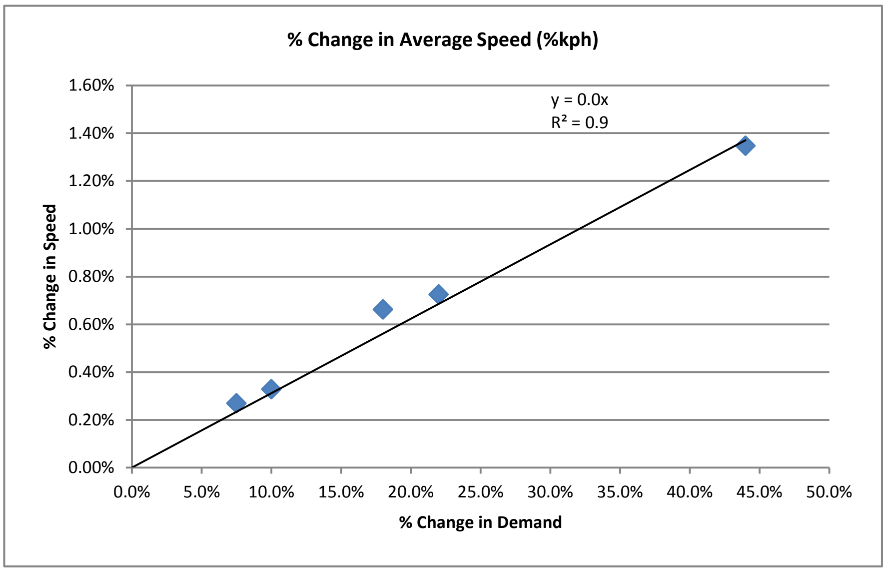
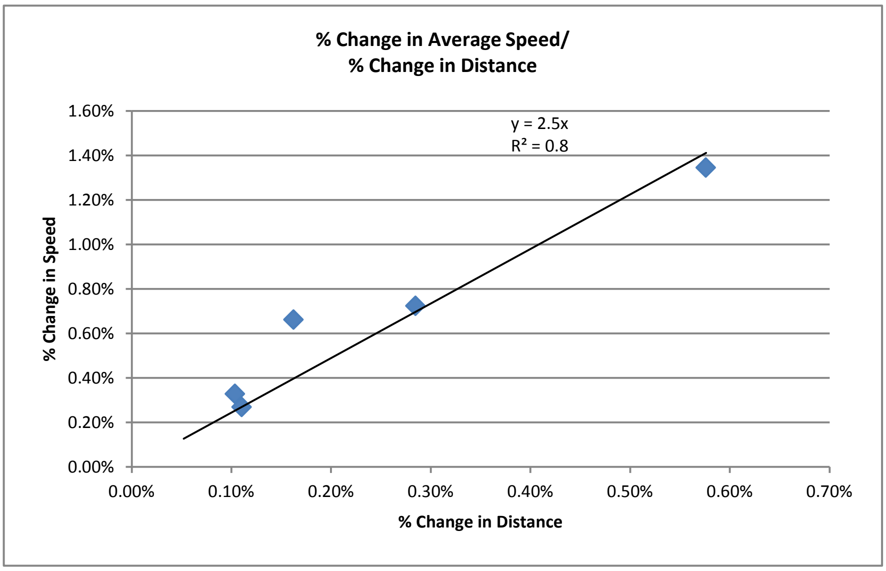


Figure I.4 shows the percentage change in speed verses the percentage change in distance across the full network. For each test, particularly at the larger demand changes, the elasticities indicated are within the expected range.

Figure I.4 Auckland network results – speed vs distance



So over the network, the percentage change in speed verses the percentage change in vehicle distance (VKT) was regressed to produce an elasticity of 2.5.

While the above analysis considered changes over the entire modelled network, the impact in the corridor was also calculated. The percentage change in speed verses the percentage change in distance (VKT) for the northern corridor ranged from 2.94 to 1.7.

All calculations (network-wide and corridor) were based on PCUs and not vehicles.

I2 Northern Wellington SATURN Model

Similar demand reduction tests were then carried out using the Northern Wellington SATURN Model (NWSM). The AM model was selected as the test period, although the PM peak could equally have been used as it would have possibly produced similar levels of congestion but for the opposite direction of travel. The NWSM uses demand time slicing to represent the pre- and post-peak periods on the road network. The AM test was carried out on the third time slice of the AM period which represented the peak hour.

The same methodology of using select link analysis in the corridor of interest (SH1/SH2 corridor from Petone to Wellington CBD) was undertaken to identify O-D pairs to reduce and reflect the increased use of P&R. The isolated O-D pairs travelling to the CBD were reduced by the following number of car trips: 70 (-7.5%), 168 (-18%) and 411 (-44%). The demand changes did not allow for increases in car trips from people's homes to the P&R site.

Figures I.5 to I.7 show the changes in travel distance (pcu-km), travel time (pcu-hrs) and speed for each demand reduction test across the total road network (ie results are for the network as a whole and not just the response in the corridor). The trend lines/R squared value indicates a strong linear relationship between all three tests.

Figure I.5 Wellington network results – travel distance

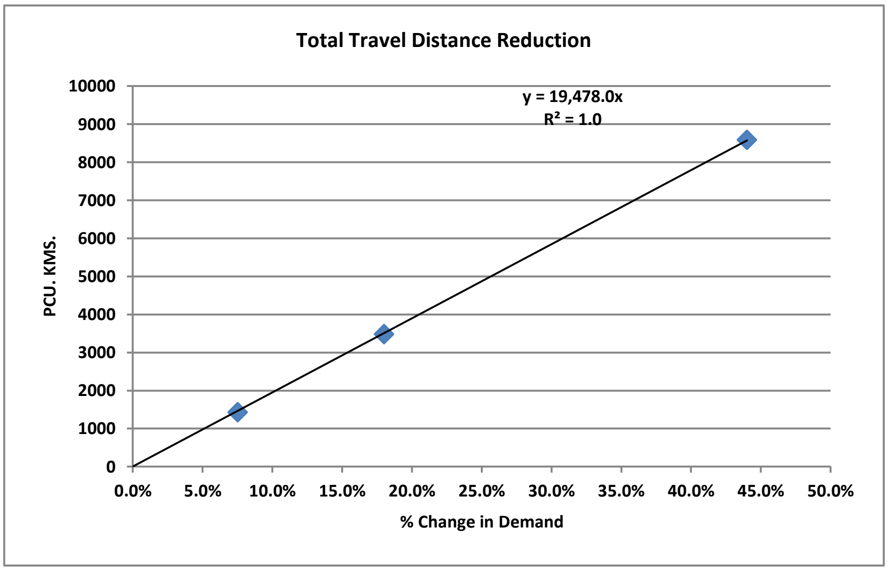


Figure I.6 Wellington network results – travel time

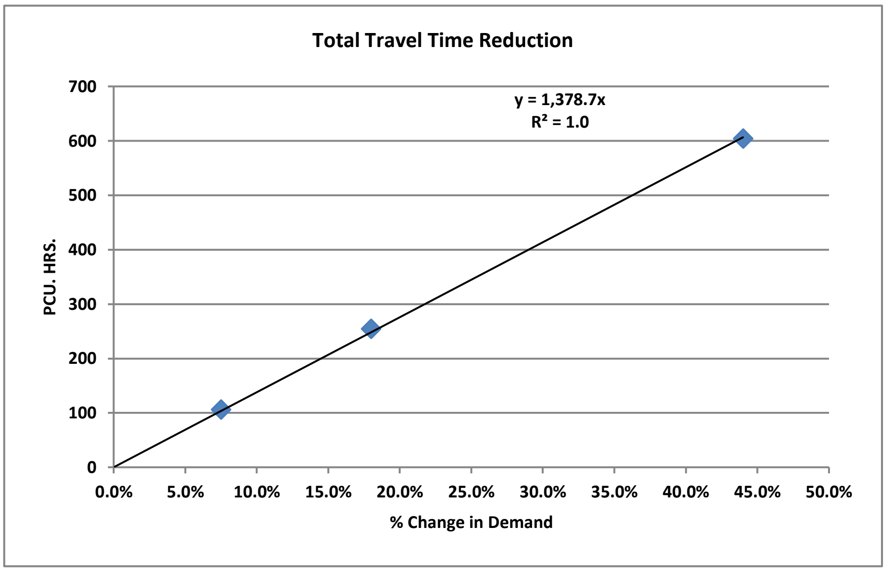


Figure I.7 Wellington network results – travel speed

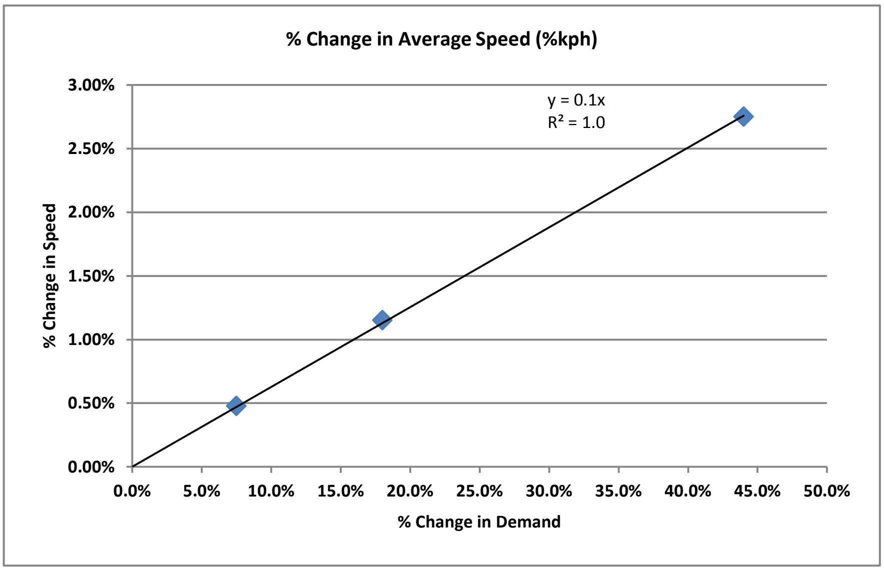
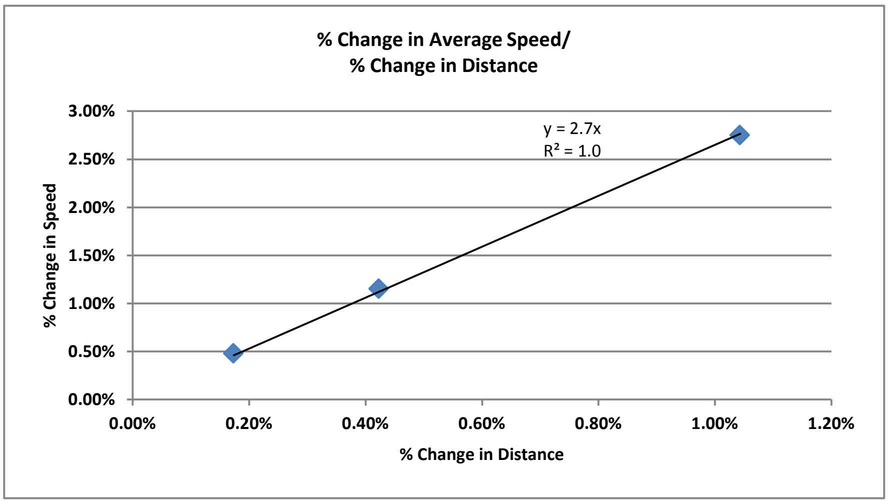


Figure I.8 shows the percentage change in speed verses the percentage change in distance for the entire modelled network. The elasticity relationship holds in this model as per the Upper Harbour Corridor Model.

Figure I.8 Wellington network results – speed vs distance



Over the network, the percentage change in speed verses the percentage change in vehicle distance (VKT) was regressed to produce an elasticity of 2.7.

Again, the results above are for the entire modelled network and not just the corridor where the demands were changed. The percentage change in speed and percentage change in distance (VKT) was calculated for the SH1/SH2 corridor only between Petone and Wellington CBD (CBD inbound trips only). Elasticities of around 0.23 were calculated, which may indicate a high level of suppressed demand in the corridor, or more likely, spurious model results.

I3 Summary

Both network-wide and corridor elasticities were calculated for the percentage change in speed (PCU-KPH) versus the percentage change in distance (VKT using PCUs) for Auckland and Wellington.

The corridor results were stable for Auckland, with elasticities between 1.7 and 2.94. For Wellington, the corridor elasticity was 0.23, which was outside expected ranges. Corridor results were therefore not used for this project.

The network-wide results, however, were relatively stable, comparable and were in the expected range for both Auckland and Wellington. These results (2.5 for Auckland and 2.7 for Wellington) could be used for this project.

Appendix J: Road user unit benefit estimates

J1 Overview

In general, the various P&R expansion/enhancement options assessed in the case studies affect road system performance, and consequently economic benefits, in two ways:

1. Changes in traffic volumes on the road network, resulting from (i) some trips that were previously made all the way by car switch to using car to the P&R site, then train for the remainder of the trip; and (ii) some trips that were previously made by bus, walk or cycle to a P&R site are replaced by car access to the site. It seems likely (and this was tested in the case studies) that in most cases there is a net reduction in car VKT.
2. Changes in traffic speeds ('decongestion') for the traffic remaining on the road network, in response to the (generally) reduced traffic volumes.

The mode switching effects (item 1) comprise items (time, VOC, accidents) that are largely internal to the user; these were taken into account in the estimation of mode switcher benefits. The external component of these costs comprised environmental costs: in practice, these would be small (to the extent they could be quantified), and were ignored in our analyses. Hence some of the item 1 cost and benefit items are not covered in this appendix, but are addressed in appendix L.

This appendix therefore focuses on item 2 costs. It derives unit economic benefit parameter values to estimate the 'decongestion' (and associated) impacts of the various P&R options assessed in the case studies:

- The traffic modelling and road system performance aspects of the project (eg refer section 3.4) provide estimates of the average changes in road traffic (peak period) speeds in each of the corridors in question, from which the changes in total vehicle hours are derived.
- This appendix derives factors to be applied to this change in vehicle hours to estimate the annual economic benefits in $ terms, for inclusion in the economic appraisal (table 4.4, items M–Q).

Our derivation of unit benefit parameter values draws on the following sources:

- *NZ Transport Agency research report 489* (Wallis and Lupton 2012) 'The costs of congestion reappraised'. The analyses in this report drew heavily on and were designed to be consistent with the then current EEM (2010 version).
- Earlier work undertaken for the Transport Agency and its predecessors, in particular analyses undertaken for the New Zealand Patronage Funding project (BAH 2003).
- NZ Transport Agency (2013) *Economic evaluation manual* (used to update earlier work).

The following sections of this appendix address:

- values of time savings, including allowance for reduced traffic congestion and improved trip reliability
- vehicle operating cost savings
- environmental costs/benefits
- safety (crash) costs/benefits.

J2 Unit values of time savings

The EEM methodology estimates travel time benefits (from an infrastructure, pricing, etc scheme) as the sum of three components:

- base travel time benefits
- travel time benefits from reduced traffic congestion
- travel time benefits from improved trip reliability.

We cover each of these in turn.

J2.1 Base travel time values

EEM (2013) table A4.1b gives base values of time for commuter travel (all modes/person types). The appropriate 'base' value from that source is $7.80/person hour (2002 prices).

J2.2 Incremental travel time values for reduced congestion

EEM (A4.4) states: 'For all bottleneck delay, the maximum increment for congestion from table A4.1 or table A4.3 should be added to the base value of travel time'.

We assumed the maximum congestion incremental value should be that given in table A4.1b (as this table is to be used for calculation of travel time benefits, rather than table A4.1a).[35]

As most of the congestion reduction between our base case and optimised case was likely to relate to bottleneck delays, we assumed the maximum increment was appropriate.

Therefore, we used the maximum value from table A4.1b, ie $3.15/person hour (2002 prices), applied for both drivers and passengers.

J2.3 Incremental travel time values for improved trip time reliability

EEM (A4.5) provides a set of procedures for estimating the benefits from improvements in trip time reliability: these procedures relate reliability in large measure to the volume-to-capacity ratios on the links and intersections traversed.

The procedures are relatively complex to apply, and would require the running of a detailed traffic model. Instead, we proposed to take a short-cut approach, based on experience from more detailed studies where the incremental value of reliability benefits had been derived as a proportion of the base travel time benefits. We were advised that, typically, the incremental reliability unit value was in the range 5%–8% of the base travel time unit value[36]. We therefore applied a proportion of 6.5% in this case.

J2.4 Adjustments for car passengers and cost escalation

The above figures are in 2002$ per person hour. For application, we applied two factors:

- **Car occupancy.** For peak period travel, we took average vehicle occupancy as 1.3, and factored the above values by this figure to derive the total vehicle travel time savings per vehicle hour.

[35] Table A4.1a gives a lower maximum congestion increment for passengers than for drivers, but we assume this is not appropriate for calculating travel time benefits.

[36] Advice (personal communication) from Andrew Murray (Beca) 15 April 2011.

- **Cost escalation.** To adjust values to July 2013$, we applied an escalation factor of 1.40 (EEM table 12.2).

The result of the above is that the value of time savings for cars in peak periods is $20.86/vehicle hour (2013 prices), as shown in table J.1.

J3 Impact on vehicle operating costs

Previous work examined the relationship between changes in travel time costs and changes in vehicle operating costs (VOC) (both on a ¢/km basis) at different average speeds, based on EEM travel time and VOC unit values (BAH 2003, appendix F).

Over the range of speeds examined in that work, it was found that the change in VOC was 5.5%–6.0% of the change in travel time costs (for the driver). On this basis, we assumed that the VOC component of any decongestion benefits was 6% additional to the driver travel time (TT) component[37].

This 6% estimate applies to the base value plus incremental congestion value of time, at 2002 prices, consistent with the method used for the original BAH (2003) estimate.

J4 Impact on environmental costs

J4.1 Greenhouse gas emissions (GHG)

Reductions in congestion tend to result in reductions in fuel consumption and hence in GHG emissions. We provided an order-of-magnitude assessment of this effect, as follows:

- Carbon emissions were valued at approximately 4.5% of total VOC, at 2008 prices (EEM, A9.6/A9.7).
- The fuel cost component accounted for c. 50% of total VOC (EEM A9.7).
- At the margin (for changes in travel speed), we would expect that most of any VOC change related to changes in fuel consumption. Hence, at the margin, changes in carbon emissions were likely to be valued at around 9% of any changes in VOC.

We therefore applied this 9% proportion to estimate the unit value of changes in carbon emissions from the unit changes in VOC estimated earlier (section J.3).

J4.2 Local environmental impacts

No attempt was made to value the changes in any local environmental impacts associated with the changes in traffic speeds between the base situation and the option situation.

Such local impacts might include noise, air quality and water quality. Previous research (eg BAH 2003) suggests that any marginal changes in these costs through changes in average traffic speeds of the extent under consideration in this study would be very small (relative to the other cost items that were valued).

J5 Impact on safety (crash) costs

Reductions in congestion are likely to result in some marginal increase in crash costs, for a given traffic volume (VKT) on the network. UK research indicates that this effect is likely to be quite significant: in

[37] A figure of 7% was used in the STCC study.

urban conditions, crash rates appear to rise quite sharply with reduced levels of congestion, and the proportion of crashes that are fatal or serious also rises. (BAH 2003, appendix C).

At this stage a detailed methodology had not been developed to estimate the magnitude of the crash disbenefits (or benefits) associated with P&R options (relative to the base case). However, a 'back of the envelope' assessment was as follows:

- Average social costs of road crashes in the Auckland urban area over the five-year (calendar) period 2006–10 were $768 million pa (2010$) – based on Crash Analysis System (CAS) data analyses.
- The proportion of this total related to the peak periods (defined as 7am–9am and 4pm–6pm, seven days/week) was 27.3%, ie $209.7 million pa – based on further CAS analyses.
- Deducting the Saturday/Sunday peak periods (assuming the crash costs at these periods are two-thirds of the peak figure per weekday) gives a factor of 0.79, leaving a cost of $166 million pa for the weekday peak periods.
- We assume this cost would increase in direct proportion to average speed if congestion were reduced. Hence, a 1% increase in average speed over the whole AKL road network would increase crash costs by 1%, ie by $1.7 million pa on the AKL peak figure of $166 million pa.
- The total AM peak (2006) travel time on the AKL road network is estimated at 150,000 hours per peak period (Wallis and Lupton 2013, table 4.1), which equates (* 500) to 75 million vehicle hours per year (peak periods only).
- Thus a 1% increase in average speed, or 1% reduction in vehicle hours (c. 75 million hours pa) is estimated to result in an increase in crash costs of $1.7 million pa. Hence the average increased crash costs per vehicle hour saved is 1.7/0.75 = $2.27 per vehicle hour.[38]

This estimated figure represents disbenefits from higher operating speeds. While these are significant, they are less than 10% of the benefit items (table C.1).

J6 Summary

Based on the analyses in this appendix, table J.1 provides our estimates of unit benefit values for those cost items on which values have been placed. It is seen that (in $/veh hour at July 2013 prices):

- The overall unit benefit value is $30.08/veh hour.
- The travel time component, including its congestion and reliability components, totals $27.98/veh hour, about 93% of the total.
- These unit benefits are partially offset by a disbenefit relating to increases in crash costs, estimated at $2.27/veh hour, and resulting in an overall net benefit estimate of $27.81/veh hour. However, note that this unit crash cost figure should be regarded as indicative only.
- The net figure of $27.81/veh hour is to be applied to the estimated total change in vehicle hours (excluding mode switchers) between the base situation and the P&R option to derive our estimate of the 'decongestion' benefits to 'base' road users.

[38] This estimate relates to 2006–10 crash statistics in 2010$. We assume that it applies unchanged to more recent statistics in 2013$ on the assumption that the effects of reducing crash rates will offset the increases in unit costs per crash.

Table J.1 Summary of road user unit ('decongestion') benefit values

Item	Base date	Unit value @ base date ($/veh hr)	Factor to July 2013[(a)]	Unit value @ July 2010 ($/veh hr)
Travel time savings				
Base value	July 2002	15.13	1.40	21.18
Congestion increment	July 2002	3.88	1.40	5.43
Reliability increment	July 2002	0.98[(b)]	1.40	1.37
Sub total	July 2002	19.99	1.40	27.98
Vehicle operating costs	July 2002	1.14[(c)]	1.70	1.94
Environmental costs				0.16[(d)]
Total[(d)]				30.08
Disbenefits: Crash costs				-2.27
Net 'decongestion' benefits				**27.81**

Notes:

[(a)] Taken from EEM vol 1, appendix A12.3.

[(b)] Taken as 6.5% of base TT value (refer section B2.3).

[(c)] Taken as 6% of TT savings (base + congestion increment) value.

[(d)] Taken as 8% of the VOC change (refer section B5.1).

[(e)] Excluding crash costs (refer section B4).

J7 References

Booz Allen Hamilton (BAH) (2003) Patronage funding report. Internal report to Transfund NZ.

NZ Transport Agency (20130 *Economic evaluation manual*. Accessed 21 October 2014. http://nzta.govt.nz/resources/economic-evaluation-manual/economic-evaluation-manual/index.html

Wallis, IP and DR Lupton (2013) Costs of congestion reappraised. *NZ Transport Agency research report 489*.

Appendix K: PT system impacts

K1 Marginal operator costs

Previous work, undertaken by Ian Wallis (BAH 2004) investigated marginal PT operating costs (on an economic basis) for AKL bus and AKL/WGN rail in some detail. That work is highly appropriate for the present requirements, as it includes estimates of marginal costs per (incremental) passenger on bus and rail services at peak periods. Rather than attempt to replicate the previous work in detail, we have updated the previous estimates to current (2013/14) prices, and summarise the approach and the results in this section.

The previous work, undertaken in consultation with AT (previously ARC) and GWRC staff, adopted assumptions that in the event of sustained increases in peak period demand:

1. Peak services would be increased pro rata to existing services (eg a 10% increase in peak demand in the peak direction would require a 10% increase in peak period capacity)
2. For bus services, such an increase in capacity would be provided through a pro rata increase in peak service frequencies (ie a 10% frequency increase in this case); whereas for train services, the increased capacity would be provided through more carriages (10% in this case) on the existing services, ie involving longer trains.

We have continued to adopt these assumptions for this project.

Table K.1 shows our updated peak period marginal costs on these bases. For example, on a per passenger basis, peak period marginal (gross) costs ($13/14) would be $4.60 per passenger on AKL bus, $5.04 on AKL rail and $3.65 on WGN rail. Alternative figures are provided on a per passenger km basis: on this basis the rail figures are considerably lower than the bus figures (in part the result of the assumption about operating longer trains). The table also gives average fare revenues (per passenger etc) on services, for comparison with the marginal costs.

It should be noted that the above estimates include an annualised capital charge for the additional buses/rail carriages required to provide the additional peak period capacity. In all three cases, these capital charges are around half of the total marginal costs.

It is also notable that, in all cases, the incremental (marginal) fare revenues associated with additional peak period passengers are less than the incremental costs involved. This is unsurprising, given the relatively high incremental costs associated with incremental peak period services.

Table K.1 PT marginal operator costs – AKL bus, AKL rail and WGN rail (2001/02 and 2013/14)

Item	2001/02[(a)]			2013/14[(b)]		
	AKL bus	AKL rail	WGN rail	AKL bus	AKL rail	WGN rail
Marginal operating costs – peak[(c)] ($)						
Per passenger	3.15	3.45	2.50	4.60	5.04	3.65
Per pax km	0.45	0.23	0.10	0.66	0.34	0.15
Average fare revenues[(d)] ($)						
Per passenger	1.41	2.00	2.14	2.06	2.92	3.12
Per pax km	0,20	0.13	0.09	0.29	0.19	0.13

Notes:

(a) 2001/02 estimates taken from BAH (2004). All figures GST exclusive.

(b) 2013/14 figures estimated as 1.46 * 2001/02 figures. Factor 1.46 represents approximate movement in current Transport Agency bus cost index over period 2001/02 to Sept 2013 Q.

(c) Operating cost figures relate to peak periods only. It is assumed that in all cases an X% increase in peak period demand would result in an X% increase in peak period capacity; in the case of trains this would be provided through more carriages per train; in the case of buses by pro rata increases in frequencies. Figures per passenger and pax km are alternatives (not additive).

(d) In the case of rail, the fare revenues given relate to total operations (but will be close to peak period averages); for buses the figures are best peak period estimates. Figures per passenger and pax km are alternatives (not additive).

K2 User economies of scale

Increases in PT patronage are likely to result in some combination of operator economies of scale (marginal operator cost is less than average cost) and user economies of scale (where marginal user cost is less than average user cost). The previous section addressed operator economies; this section addresses user economies.

To the extent that increases in patronage result in increases in service levels and frequencies (as in the bus case above), existing passengers benefit from reductions in bus waiting times. This is a ‘user economy of scale’, also known as the ‘Mohring effect’. (It is the inverse of what occurs on the road system, where increases in demand for travel result in increases in waiting time (congestion) for existing users.)

The BAH (2004) report also addressed user economies of scale. It showed that, subject to specified assumptions, the benefit to existing passengers of increased service levels (resulting in reduced waiting times) is equal to that part of the waiting time function variable with the headway times the unit value of the waiting time savings. It also showed that a wide range of unit benefit values may result from this benefit formulation, with values varying in direct proportion to:

- initial headway
- service: patronage ‘gearing ratio’
- wait time: headway factor
- value of time savings

For typical peak bus services (with service: patronage gearing = 1.0, as assumed in the operating cost function above), values are in the range $0.32 (10 minute headway, wait time: headway factor 0.2) to $1.28 (20 minute headway, wait time: headway factor 0.4) per incremental passenger.

The above figures, drawn from the BAH report, are expressed in July 2002 prices. For the present work, they were increased to July 2013 prices, using the EEM factor of 1.40 (EEM 2013, table A12.2).

For peak rail services, on the assumption (above) that the response to increases in patronage would be to run longer, rather more frequent, trains, the user economies of scale effect are zero.

K3 References

Booz Allen Hamilton (BAH) (2004) Surface transport costs and charges study: costing of urban public operations (working paper, draft 6).

Appendix L: P&R user benefit assessment methodology

L1 Overview

This appendix sets out our methodology for assessing the economic benefits of providing additional P&R spaces. Economic benefits addressed below include:

- benefits to existing P&R users who benefit from greater availability of P&R spaces. Users who currently arrive early to be sure of a space may be able to travel later
- benefits to new users who currently travel all the way by car or another PT service
- benefits to new users who currently use the PT service but park their car on-street or use connecting bus services or walk, and will now be able to take their car to the P&R park
- benefits to existing PT users from increased frequency (applies to buses only – in the case of trains, extra passengers are assumed to result in longer trains)
- disbenefits to connecting or alternative PT service users who may face poorer service if patronage reduces
- benefits to road users who suffer less congestion as a result of some drivers switching.

Against these benefits there are additional costs, including the:

- opportunity and development cost of the land and any ongoing maintenance costs.
- additional operating cost of the PT service.

Finally, when we calculate the perceived user benefit, the user perceives the fare as a cost. Adding this back (since it is a transfer payment not an economic cost) and setting it against the additional operating cost, the last bullet point above becomes a net revenue. This can be treated either as a producer surplus if it accrues to the operator, or as a reduction in subsidy if it accrues to the funding agency.

These effects are considered in the following sections.

L2 Existing and new P&R users

This section of the methodology addresses the benefits to existing P&R users and additional users, ie people who would use the official P&R car park, resulting from an expansion of P&R capacity. It is based on the idea that if the number of P&R spaces is constrained, that constraint imposes a cost on travellers. Easing the constraint reduces the cost. The reduction in cost is the ‘consumer surplus’ from the increased number of spaces.

We establish the demand for additional P&R spaces at the particular location from the presence of on-street parkers. Official P&R usage is constrained by the capacity of the site; and this constraint results in on-street parking on adjacent streets. There will be other potential P&R users who currently use other modes or walk to the transit station. Based on the surveys of existing P&R users who were asked how they would travel if the P&R site was not available (or before it was available), we can estimate the total potential demand.

The number of potential customers who are unable to use the P&R facility because of the limited capacity is:

$E = N/d$

where N = the current number of on-street parkers
d = proportion of diverted passengers who park on street.

We know that, at the margin, on-street parkers face a cost of t minutes. We do not have information about other users. However, we can assume that in equilibrium, all diverted users face the same cost on average. Thus the cost for potential P&R users who cannot get a space will equal 't', the time involved in walking from the furthest on-street parking location to the station.

What is perhaps less obvious is that existing P&R users also face a cost of 't'. To get a space, users have to be at the park early. Assuming a Wardrop-type equilibrium in which all used travel options end up costing the same, the cost of getting up early to get a space must equal the cost of getting up late and walking further. In both cases at the margin it equals 't'.

If we increase the number of spaces by E, everyone can use the park, and thus everyone saves the equivalent of 't' minutes. The benefit would be (Q +E) *t,

where Q is the current number of spaces.

If only ΔK P&R spaces are added ($\Delta K < E$), the change in the perceived price (generalised cost) will be proportionately less:

$$\Delta P = (\Delta K/E) \,.\, t \qquad \text{(Equation L.1)}$$

Hence the total benefits to existing P&R users of expanding P&R capacity by ΔK spaces are:

$$Q.\, \Delta P = K \,.\, \Delta P = K.\, (\Delta K/E) \,.\, t \qquad \text{(Equation L.2)}$$

This represents (the current number of P&R spaces) * (the proportion of the potential demand met by the additional spaces)* (the maximum user cost of walking from the on-street parking places).

And the benefits to the new P&R users are:

$$\Delta K.\, \Delta P = \Delta K.\, (\Delta K/E) \,.\, t \qquad \text{(Equation L.3)}$$

These benefits are calculated as minutes of walking time. They are monetised by multiplying by the value of walking time for PT users. Users are assumed to be all commuters.

L3 Remaining on-street parkers

This section of the methodology addresses the benefits to current on-street parkers who do not get use of one of the additional P&R spaces, but whose walking distances will be reduced as a result of other current on-street parkers taking up the new P&R spaces.

The number of on -street parkers in this category will be (E- ΔK)*d. The proportionate reduction in the number of on-street parkers (resulting from the additional P&R spaces) will be (ΔK/E).

The current maximum walking time to the station for on -street parkers was t. Hence to a first approximation (assuming walking times are proportional to the number of on-street parkers), the reduction in maximum walking time will be:

$$\Delta t = (\Delta K/E) \,.\, t \qquad \text{(Equation L.4)}$$

This reduction will apply to (E- ΔK)*d on-street parkers, with the resultant benefit given by:

$$(E- \Delta K).\, d.(\, \Delta K/E) \,.\, t \qquad \text{(Equation L.5)}$$

Again the benefits are monetised by multiplying by the value of walking time.

L4 Unit value of walking time

In translating this benefit formula into $ benefit values, the unit value of walking (access/egress) time for P&R users for evaluation purposes needs to be established. Based on EEM (2013), table L1 below derives a unit value of 25.5¢/person minute or $15.29/person hour (2013 prices). Subject to any comment from the Transport Agency, we propose to use this value.

Table L.1 Derivation of unit (evaluation) value of walking time

Item	Price basis	Factor	Unit value		Notes[(a)]
			$/hr	¢/min	
Base value - commuting	2002	1.00	7.80	13.0	Table A4.1
Update factor	2013	1.40	10.92	18.2	Table A12.2
Walking time factor	2013	1.40	15.29	25.5	Table A4.1[(a)] gives pedestrian value of 1.4*seated PT value, so we assume this also applies to evaluation values (for pedestrians relative to 'standard' in-vehicle time).

Notes:

[(a)] References given here all relate to EEM (2013 update).

L5 PT (rapid transit) impacts

Those new P&R users who formerly drove or used another mode all the way represent new PT (line haul) customers. There are two potential impacts from increased patronage: existing user benefits from increased frequencies (the Mohring effect), which apply for bus services but not for trains as it is assumed that for train services the capacity of the train is increased; and a producer benefit which is the difference between the additional revenue and the increased operating cost.

The Mohring effect can be shown to be equal to the average waiting time multiplied by the number of additional passengers – and monetised by multiplying by the value of waiting time.

The effect on the PT line subsidy is calculated by estimating the revenue and cost per person. Revenue is simply the fare from the station taking account of common discounts. The cost is calculated as the average cost per additional inbound seat resulting from an increase in capacity. This uses industry-based train and bus operating costs. Even if the cost is likely to be higher than the revenue we still call this a producer surplus to keep the terminology consistent with economic convention.

If the operator's contract is net and there is no adjustment to subsidies (the operator takes responsibility for both the incremental revenues and the incremental costs), the producer surplus accrues to the operator. From an economics perspective, the surplus should then be included in the benefits. If the financial impact of the changes accrues to the funding agency, then the producer surplus should be deducted from the agency cost. The spreadsheet (see appendix O) allows for these two options. If the contract effect is not either of these (eg a gross contract where the revenue accrues to the agency but the costs to the operator), the spreadsheet should be adjusted explicitly. In no case should the funding arrangement affect the net present value (although it will affect the BCR).

L6 Competing PT service and feeder service impacts

The impacts on any competing and feeder public transport services are just the converse of the PT line impacts discussed in the above section. It is assumed that the numbers who transfer are small and we therefore base the calculation on averages rather than a detailed analysis. If it is likely that these services will be significantly affected this section of the spreadsheet could be expanded to cover each service explicitly.

L7 Road congestion impacts

A vehicle travelling in congested conditions imposes a cost (externality) on all other vehicles – additional demand causes all vehicles to slow. As more vehicles join, the flow increases up to a point where traffic flow is maximised – referred to as 'capacity'. If further vehicles attempt to join, the effect of all vehicles slowing down is to reduce the traffic flow until at some point the road comes to a standstill. It can be shown mathematically that if the road is operating at capacity, the cost (in vehicle minutes) of an extra vehicle is just equal to its travel time. More generally, it can be shown that the externality is proportional to the difference between the actual travel time and the free-flow travel time. The constant of proportionality will depend on the characteristics of the network. It can be shown (Wallis and Lupton 2013) that both an Akçelik function (used in the SATURN model) and a BPR function with the power term coefficient equal to 4.0 provide a good fit to Auckland motorway data, including for periods of severe congestion. This indicates that the constant of proportionality should be about 4.0. (see section 3.4.2)

Ex-car commuters using P&R thus 'save' congestion costs equal to 4 x the difference between the peak and the free-flow travel time for their former trips. Note only P&R patrons who divert from road all the way provide this benefit. It is calculated in vehicle minutes, so we have multiplied by a value of time for average motorists during the morning and afternoon peaks to give a monetary value to the 'decongestion' (refer appendix J).

While not strictly necessary, we have made the calculation in two steps: first we calculate the elasticity – the change in travel time resulting from a change in demand – and then the externality. We do it this way so the elasticity (which reflects the degree of congestion) can be compared with the values obtained with the SATURN model and internationally reported values. The elasticities calculated for Albany and Petone are 2.8 and 2.1 respectively, which compare with modelled results of 2.5 and 2.7. Given the general variability in travel times, this is a remarkably good fit.

When using the spreadsheet, the user can accept the estimate of the elasticity from the travel times or overwrite it with an estimate from model runs or international comparisons.

As well as impacting congestion on the line haul, the switch to P&R will affect congestion on the roads around the P&R station. The default analysis is very simplistic and is the converse of the line haul effect. It can be made more sophisticated if this is an issue.

All road congestion costs are estimated in congested vehicle minutes and multiplied by the typical value of time for vehicles in the morning and evening peaks, including an allowance for vehicle occupancy. The basis for the unit 'decongestion' benefits is set out in appendix J.

L8 Annualisation and present value

The public transport subsidy and congestion benefits occur every commuter peak. We have multiplied them by 500 to give an annualised figure and taken the resulting sum – less an allowance per space for car park maintenance – at 6% for 20 years to obtain the present value.

Appendix M: Funding allocation literature

The following table provides a summary of the literature reviewed on P&R funding sources and allocation approaches.

Citation	Summary	Comments
An analysis of park-and-ride provision at light rail stations across the US (Duncan and Christensen 2013)	This paper seeks to explain factors influencing the provision of P&R at new light rail stations in the US. In terms of funding, it finds that the *…source of a transit agency's funding also appears to have a strong relationship with propensity to provide parking … Agencies that have received a high percentage of their funding from local sources (e.g., sales taxes or property taxes) have a greater probability of providing parking and those that receive a high percentage from state sources have a lower probability of parking provision.* (p154). The author notes that state funding sources are only available for selected capital investments and cannot be relied on for day-to-day funding needs.	Not particularly relevant, does not provide any justification for allocation of funding.
Stakeholder perspectives on the current and future roles of UK bus-based Park and Ride (Meek et al 2009)	*While P&R schemes require significant investment to meet both capital and operating costs, the overall view of participants was that the funding of schemes can actually be a motivation to their introduction rather than a barrier. It was suggested for instance, that P&R is a valuable component to attract funds within the package of measures presented in the Local Transport Plan (LTP), a five yearly document submitted to the national government in which authorities present their transport provision plans related to government goals and bid for their funding. Indeed, the main role of the government in P&R planning was considered by most participants to be one of funding.* P&R is also funded through developer contributions levied under UK planning legislation, where *…planning permission granted by the local authority includes an obligation for the developer to contribute towards the cost of providing parking spaces at the P&R site to offset the traffic impact of their development.* Also'*…hypothecated revenue from highly profitable on-street parking provision in city centres was also considered to be a significant source for the operation and maintenance of P&R sites.*	This paper provides some useful insights into potential alternative funding sources/tools for P&R in New Zealand, in particular developer contributions and hypothecated city centre parking revenues. We note that such methods would be more easily introduced where the agency collecting the funds is also responsible for development and maintenance of P&R facilities.
Development of a public transport investment model (Allison et al 2013)	The primary purpose of this paper was to develop an economic modelling tool to assist in public transport investment decisions. It sought to estimate the optimum public transport price based on a number of input factors to guide decision on appropriate levels of subsidies. The paper discusses the concept of investing for outcomes: *In theory, 'outcome-based' funding relates subsidy payments to the policy objectives the funding is intended to achieve, and would support a smart investor approach.* On the matter of who should fund the public transport subsidy: *The issue of who should pay arises in the development of funding methodology. The investment model indicates whether fares are optimal and hence what*	The model is not directly applicable to P&R but the discussion around linking investment to outcomes is useful, and would imply that funding for P&R should be based, in our case, on road performance benefits and reduced public transport service subsidy outcomes. This still leaves at issue the allocation of funding as various agencies will have different objectives, with it ultimately being a political

Citation	Summary	Comments
	commuters should pay and what subsidies are required to achieve efficient resource allocation. *The model is, however, silent on the matter of how local and national government should share in the cost of funding the subsidy. Taken from a pure national cost–benefit lense, central government should be indifferent regarding what kind of economic benefit it funds – whether congestion savings or reduced waiting times. However, in practice there are issues of budget affordability, ensuring aligned incentives, and particular agency policy objectives to consider. The question of who should fund the cost of subsidies is then a political economy and agency issue as much as it concerns the need to develop a simple and enduring funding methodology.'* (p51)	decision. The central government also has an interest in where investment occurs, with the GPS identifying specific funding 'buckets' for transport investment, eg state highways, local roads, public transport.
Getting Auckland moving: alternative funding for transport discussion document (Auckland Council 2012)	This discussion document identified the following five criteria for assessing alternative funding tools: ***Fairness*** *- The amount paid by individuals or groups should reflect their ability to pay, balanced with the benefit received for the service funded by the tax or charge.* ***Administrative efficiency*** *- The costs of raising the revenue should be a small percentage of the amount to be raised. That is, it should not cost 50 cents to collect a dollar.* ***Transparency*** *- Those paying should know how much they are paying and what it is that they are paying for.* ***Neutrality*** *- Paying the tax or charge should not cause undesirable changes in behaviour, e.g. congesting suburban streets because charges are payable on motorways.* ***Capacity*** *- The source of funds should be large enough to provide the revenue needed without causing unacceptable hardship to those paying.* The document applies these criteria to a number of funding options, including potential for additional car parking charges.	The document does not specifically address P&R but provides a good set of criteria for considering the allocation of funding to various parties for P&R facilities. Some of these (eg fairness) are rather subjective and would require appropriate (measurable) performance measures and justification.
Value for money and appraisal of small scale public transport schemes (Jacobs Consulting 2011)	In the UK *…here is now, more than ever, a requirement to demonstrate the VfM case for small public transport schemes.* A key source of funding for small-scale public transport schemes, including P&R, is the DfT's Integrated Transport Block fund which is allocated using a 'needs-based' formula. The DfT also has a '*Local Sustainable Transport Fund which will provide funding for local authorities and PTEs for transport interventions which will support economic growth and reduce carbon emissions as well as providing cleaner environments, improved air quality, enhanced safety and reduced congestion.*' (p9)	Does not provide detail on funding allocation, but highlights the link between funding and specified objectives. The Local Sustainable Transport Fund is intended to focus on achieving more radical behaviour change through revenue-led, rather than capital-led, schemes, but we are not aware of this being applied to P&R.
Consultation on integrated transport block funding (Department for Transport 2012)	Discussion document on the DfT's integrated transport block funding. Funding is allocated using a 'needs-based' assessment based on six elements: deprivation, road safety, public transport, air quality, congestion and accessibility. The existing formula and weights and a number of alternative weighting options are presented in the discussion document,	Shows link between funding and specified objectives, also illustrates the impact of different weightings on objectives.

Citation	Summary	Comments
	including the various funding allocations resulting from different weightings	
Local funding options for public transportation (Litman 2013a)	The following criteria are identified for evaluation of funding options for public transport projects and services: potential revenue, predictability and stability, equity analysis, travel impacts, strategic development objectives, public acceptability, ease of implementation, legal status. A range of funding options is also identified and advantages/disadvantages listed, although many are not relevant to P&R.	Paper covers public transport projects and benefits, it does not discuss P&R but the criteria are still applicable. The concept *that transport funding be equitable, that is, the distribution of costs and benefits should be considered fair and appropriate* should not be lost.

Appendix N: Case studies

The project scope provided for five case studies to be undertaken. The consideration of case studies took place throughout the project as follows:

- Scoping of potential case studies (phase 2) – preparation and evaluation of a 'long list' of potential studies.
- Detailed specification of case studies (phase 3) – recommend five case studies and reserve options in case insufficient data was available.
- Undertake case studies (phase 4).

The 'long list' of potential case studies; the evaluation of the long list; and case studies that were rejected are discussed in the following sections.

N1 Long list of potential case studies

The first step was to identify a number of potential case studies, including key information such as location, existing number of parking spaces (if any), potential additional parking spaces and a brief analysis of suitability for case study. This long list of potential case studies provided to the Steering Group for consideration is presented below.

We asked practitioners in Auckland and Wellington to help identify potential case studies, for new or expanded facilities, covering the following aspects:

- range of PT modes (bus/rail/ ferry[39])
- different facilities located within the same catchment area
- varying distances from the CBD.

The resulting long list of potential case studies is set out in the following table.

[39] Although no ferry sites have been identified for a case study.

Table N.1 Long list of potential case studies

#	Facility	Brief description of site and location	City	Mode	Type	Spaces before	Spaces after	Status/ pre-post evaluation (year)
1	Albany busway station	Extension of parking to the existing P&R bus station, which is part of the Northern Busway.	AKL	Bus	Expand	550	1100	Complete (2012)
2	Hibiscus Coast busway station (Silverdale)	Transformation from the interim car park, which has a significant uncovered walk to the bus stops, to a busway station similar to those at Albany and Constellation Drive.	AKL	Bus	Expand	104	500	Proposed
3	Westgate P&R	New P&R in the Westgate and Triangle Road area. The P&R strategy paper identifies the need for 200 spaces by 2020 and an additional 300 spaces by 2035.	AKL	Bus	New	0	500	Proposed
4	Swanson station	End of electric rail services in the west with large hinterland catchment where bus feeders limited. Adopted RPTP 2013 ends rail services to Waitakere (the next station out) which reinforces the need to expand P&R for those wishing to drive to Swanson which will have high-quality frequent all-day rail services.	AKL	Rail	Expand	42	138 to 500	Proposed (2015–16)
5	Petone station	185 parks adjacent to station, 96 parks (leased from the Transport Agency) off Petone Road, access via pedestrian bridge over SH2. Large area between SH2 and Petone Road owned by the Transport Agency could enable expansion.	WGN	Rail	Expand	266	566	Proposed
6	Waterloo station	The current P&R facility is at capacity and there are currently no options for future development that would be economically viable.	WGN	Rail	Expand	601	601	Proposed
7	Wallaceville station	Car park surfacing and seal extension leading to increased capacity.	WGN	Rail	Upgrade	125	147	Complete 2013
8	Upper Hutt station	Current P&R facilities are leased from UHCC. However if they redevelop the station then these facilities would likely be lost. There is, however, land held by KiwiRail that could be developed on the eastern side of the track with space for 50–60 car parks.	WGN	Rail	Expand	6	50-60	Complete
9	Takapu Road station (2009)	Developer presented opportunity to provide up to 300 additional P&R spaces. GWRC evaluation identified potential demand of up to 250 P&R spaces but did not proceed further as no funding available. Land is steep and would prove costly to develop.	WGN	Rail	Expand	80	250	Evaluated (2009)

#	Facility	Brief description of site and location	City	Mode	Type	Spaces before	Spaces after	Status/ pre-post evaluation (year)
10	Porirua station	Substantial expansion underway to existing car park area.	WGN	Rail	Expand	452	761	Complete 2014
11	Waikanae station	Development associated with upgraded station and extension of metro services. Difficult location for P&R, limited pedestrian access, severed from main settlement by SH1, existing local bus service diverted to the platform. End of the line for Wellington-Kapiti so draws in commuters from a wider catchment eg Otaki and Levin.	WGN	Rail	Upgrade	77	150	Complete (2011)
12	Chaytor Street P&R in Northland	Proposed new P&R facility close to existing bus stops.	WGN	Bus	New	0	33	Investigation only
13	Crawford Green P&R in Miramar	Proposed new P&R facility and relocation of existing bus stops.	WGN	Bus	New	0	95	Investigation only
14	Dover Street car parking in Berhampore	Proposed series of 16 angle car parks to fit within a road reserve that is close to a high-frequency PT service.	WGN	Bus	New	0	16	Investigation only
15	Devonshire Road car park in Miramar	Proposed new car park on existing green space on a local road close to existing bus stops.	WGN	Bus	New	0	20	Investigation only
16	Birdwood Street P&R in Karori	Proposed expansion of existing park and ride facility due to on-street parking becoming unavailable.	WGN	Bus	New	28	Not yet decided	Investigation only

N2 Long list evaluation

We requested that the Steering Group confirm five case studies for consideration (as provided for in the scope) and up to two reserve case studies. The reserve case studies would only be investigated further should there be issues with information on and suitability of the preferred sites.

To assist the Steering Group in making a decision we completed a long list evaluation of potential case studies against the following criteria:

1 Is the site served by a high-frequency PT service (eg rail and bus rapid transit network) (RTN).

2 Is the site located upstream of significant AM peak weekday congestion points on the SH network ('Upstream?').

3 Is the site accessed from a local road (LR), arterial road (AR), or does the access come directly from a state highway (SH) ('Access?').

4 Rank the sites according to the size of facility to consider modelling ('Size?').

The long list evaluation is reported in the following table.

Table N.1 Long list evaluation of potential case studies

#	Facility	1 *RTN?*	2 *Funnel?*	3 *Access?*	4 *Size?*	Brief discussion of suitability as case study
1	Albany busway station	RTN Bus	Yes SH1	AR&SH	[1] (1100)	Good existing site. Lots of survey info.
2	Hibiscus Coast busway station (Silverdale)	RTN Bus	Yes SH1	AR	[5] (500)	Good proposed site. Info likely to be available.
3	Westgate P&R	RTN Bus	Yes SH16	AR&SH	[5] (500)	Good proposed site. Info likely to be available.
4	Swanson station	RTN Rail	No AR	AR	[5] (500)	Good proposed site. Info likely to be available.
5	Petone station	RTN Rail	Yes SH2	SH&AR	[4] (566)	Good existing site. Lots of survey info.
6	Waterloo station	RTN Rail	Yes SH2	AR	[3] (601)	Good existing site. Lots of survey info.
7	Wallaceville station	RTN Rail	Yes SH2	LR	[7] (147)	Site considered perhaps too small to be significant.
8	Upper Hutt station	RTN Rail	Yes SH2	AR	[Small] (50-60)	Data available but this is a small site.
9	Takapu Road station	RTN Rail	Yes SH1	SH&AR	[6] (250)	Potential reserve site?
10	Porirua station	RTN Rail	Yes SH1	SH&LR	[2] (761)	Potential case study; but info has been scarce to date. Reserve site?
11	Waikanae station	RTN Rail	Yes SH1	SH	[7] (150)	Site considered perhaps too small to be significant, but is at end of a rail line.
12	Chaytor Street car	RTN	No	AR	[Small]	Site considered too small to be

#	Facility	1 *RTN?*	2 *Funnel?*	3 *Access?*	4 *Size?*	**Brief discussion of suitability as case study**
	park in Northland	Bus			(33)	significant.
13	Crawford Green car park in Miramar	RTN Bus	Yes SH1	LR	[Small] (95)	Site considered perhaps too small to be significant.
14	Dover Street car park in Berhampore	Bus	No	LR	[Small] (16)	Site considered too small to be significant.
15	Devonshire Road car park in Miramar	RTN Bus	No	LR	[Small] (20)	Site considered too small to be significant.
16	Birdwood Street car park in Karori	Bus	No	LR	[Small] (28)	Site considered too small to be significant.

On the basis of our evaluation as set out in table N.2, we recommended the following case studies as the most suitable for further investigation:

1 Preferred case studies:
   a Albany busway P&R
   b Constellation bus P&R
   c Waterloo rail P&R
   d Petone rail P&R
   e Porirua rail P&R
2 Reserve case studies:
   a Swanson rail P&R
   b Westgate bus P&R
   c Takapu Road rail P&R

The reasoning for selecting the above recommended case study sites is summarised as follows:

- Albany P&R had been recently extended and based on the survey results there was already pressure for further expansion and/or new facilities at other P&R stations on the Northern Express service. The existing travel behavioural data for this site made it ideal as a case study to test the evaluation framework.
- Constellation P&R site was included latterly replacing the initial recommendation of the planned Silverdale P&R site. While Silverdale presented a predictive case study opportunity, as in what might happen with new/additional trips on SH1, it was not covered by a congested traffic assignment model and hence data availability became an issue that led to the rejection of Silverdale as a case study.
- Waterloo P&R and Petone P&R were selected not only due to the recent surveys carried out at these sites, but also because they act in the same catchment so enable discussion on catchment overlap effects, especially as there is no easy answer for expansion at Waterloo.
- Porirua made the recommended list due to the scale of the facility and its location in relation to the SH network.
- The reserve sites were all considered worthy of being recommended, as they added further variety to the recommended list, should they be moved up. Swanson and Westgate both reflected

hinterland/end-of-line issues and Takapu Road could make for an interesting case study with respect to shared parking resource with other land uses.

N3 Case studies not undertaken

The status of sites for which case studies were not delivered can be categorised as either:

- Reserve case studies – case study sites that were only to be considered if, after the further investigation carried out as part of phase 3 of this study, any of the preferred case study sites were not suitable for detailed analysis.
- Case study sites not covered by appropriate traffic models – traffic models producing congested travel times from the site to the CBD were not available and hence the information to apply the evaluation framework to the case study site could not be completed.

Key aspects of the sites that were either a reserve case study or rejected due to not being covered by an appropriate traffic model are provided in the table below for completeness.

Table N.1 Features of case studies not undertaken

Status	Facility	Discussion
Reserve case study	Takapu Road train station P&R (Wellington)	Takapu Road is a site that is integrated into Boscobel Lane which runs through the parking areas and allows for on-street parking. Boscobel Lane also provides access to four residential houses and a function centre. Not accounting for informal on-street parking, there are 80 spaces currently provided. Takapu Road is part of the Northern Wellington SATURN model. A developer had previously proposed to expand the parking area to 300 spaces but GWRC identified there was only demand for 250. Takapu Road was a reserve case study due to the shared space use.
Reserve case study	Westgate P&R (Auckland)	Currently the Westgate P&R site does not exist. In the future there is a proposal to include a P&R facility at Westgate as part of the RTN. The P&R will support the bus network and the Massey North development will add to its usage. The Westgate retail complex is included as part of the Upper Harbour Corridor SATURN Model. Westgate was selected as a reserve site to investigate the difference between having no facility and having a facility. The proposed development includes 500 spaces.
Case studies not covered by appropriate traffic models	Hibiscus Coast bus station P&R (Auckland)	The Hibiscus Coast site is a new development with 104 spaces with proposals to extend this to 500. This site was originally considered as a preferred case study. However, it is not covered by a suitable traffic model to enable consideration of interaction with Albany as originally intended. On this basis this site was removed as either a preferred or reserve case study.
Case studies not covered by appropriate traffic models	Swanson train station P&R (Auckland)	Swanson Station is not near the SH network and is located in a semi-rural environment. There are currently 42 spaces provided and there is some shared use with the Swanson Station Café. Swanson is not included within any suitable traffic models to enable consideration of 'end-of-line' type issues as originally intended. On this basis the site was removed as either a preferred or reserve case study.

Status	Facility	Discussion
		In addition, the recent double tracking of the Western line and the current electrification project has resulted in several changes to the site. More changes are expected after the electrification project is complete, as Waitakere may no longer be served by rail services. These changes are still unconfirmed and proposals to extend the Swanson P&R remain variable.

Appendix O: Case study results

			Albany	Constellation	Petone	Waterloo	Porirua
P&R site	Mode (1- rail; 2 = road)		2	2	1	1	1
	Current P&R spaces	#	550	370	266	602	452
	Specific site details (if available)						
	Proposed capacity (increment)	**# spaces**	440	100	175	100	185
	Peak travel time by road	**min**	50.9	46.1	21.6	25.2	20.9
	PT mode fare (excl GST)	**$**	4.87	3.91	2.66	2.66	2.66
Current on-street parking	P&R cars parked on-street in vicinity	#	142	191	72	99	77
	Max walk time to station for on-street parkers	**mins**	4	11	5	5	6
P&R capital costs	Land area required for increment (approx)	**m2**	14080	2900	5250	3000	5550
	Current land ownership (if available)						
	Land value per m2	$	302	403	300	300	300
	Construction costs/space	**$/space**	4,000	4,000	2,800	2,800	2,800
	Land value (opportunity cost)	**$000**	4,252	1,169	1,575	900	1,665
	Construction costs	**$000**	1,760	400	490	280	518
	Planning/overheads/contingencies etc	**$000**	352	80	98	56	104
	Total capital costs	$000	6,364	1,649	2,163	1,236	2,287
	Total capital cost per additional space	**$000/space**	14	16	12	12	12
P&R operating costs	Annual O&M costs (approx) for Increment	**$000pa**	198	45	79	45	83
Demand impacts:							
Prior mode shares			N Busway	N Busway	HV rail	HV rail	HV rail
Main mode changers:	* Car driver (all the way)	**%**	33%	33%	12%	12%	12%
	* Car passenger (all the way)	**%**	1%	1%	3%	3%	3%
	* Local bus (all the way)	**%**	16%	16%	3%	3%	3%
	* Other (walk, cycle, taxi etc)	**%**	0%	0%	2%	2%	2%
Access mode changers:	*Car driver-- park on street	**%**	32%	32%	41%	41%	41%
	*Car driver-- park at other station	**%**	6%	6%	16%	16%	16%
	*Car passenger	**%**	1%	1%	7%	7%	7%
	*Local bus	**%**	6%	6%	6%	6%	6%
	*Walk/cycle/other	**%**	5%	5%	10%	10%	10%
	* Total	100%	100%	100%	100%	100%	100%

			Albany	Constellation	Petone	Waterloo	Porirua
Direct benefit to P&R users	Reduction in generalised cost	**min**	4.0	1.8	5.0	2.1	5.9
	Benefit to existing users	$/peak	555.8	173.7	337.7	317.6	680.7
	Benefit to new park users	$/peak	444.7	47.0	222.2	52.8	278.6
		$000pa	**500.2**	**110.4**	**279.9**	**185.2**	**479.7**
Benefits to remaining external parks	Reduction in time for external parkers	**min**	3.97	1.84	4.98	2.07	5.91
	Remaining on-street parkers	#	1	159	0	58	1
	Annual benefit	$000pa	**0.6**	**37.3**	**0.2**	**15.3**	**0.9**
Line haul PT system & user impacts:	Additional line haul passengers	#	220	50	35	20	37
	Variability of line haul service cost with patronage (0=none; 1 =fully variable)		1	1	0	0	0
	Average headway for line haul service	**min**	2	1	7	9	9
Line haul operator effects	Unit marginal op cost/passenger	**$**	4.61	4.61	0	0	0
	Increase in PT costs	$000pa	506.6	115.1	0.0	0.0	0.0
	Increase in PT fares revenue	$000pa	535.7	97.8	46.6	26.6	49.2
	Increase in net PT operator revenue (producer surplus)	$000pa	**29.1**	**-17.3**	**46.6**	**26.6**	**49.2**
Mohring effect	PT user benefits/passenger (economies of scale)	**$**	0.22	0.11	0.00	0.00	0.00
	PT user benefits	$000pa	**24.0**	**2.7**	**0.0**	**0.0**	**0.0**
Competing PT service impact	Reduction in alternative PT service passengers	#	70.4	16.0	5.3	3.0	5.6
	Variability of alternate service frequency with patronage (0=none; 1 =fully variable)		1	1	1	1	1
	Current headway of alternate service	**min**	15	15	10	18	30
	Unit marginal op cost/passenger	**$**	4.60	4.60	4.60	4.60	4.60
PT operator effects	Increase in PT costs	$000pa	-161.9	-36.8	-12.1	-6.9	-12.8
	Average revenue per passenger	**$**	4.87	3.91	2.66	2.66	2.66
	Increase in PT fares revenue	$000pa	-171.4	-31.3	-7.0	-4.0	-7.4
	Increase in net PT operator revenue (producer surplus)	$000pa	**-9.5**	**5.5**	5.1	2.9	5.4
Mohring effect	PT user benefits/passenger (economies of scale)	**$**	1.64	1.64	1.09	1.97	3.28
	PT user benefits	$000pa	**-57.7**	**-13.1**	**-2.9**	**-2.9**	**-9.1**
Feeder bus service impact	Reduction in feeder bus service passengers	#	26.4	6	10.5	6	11.1
	Variability of feeder service frequency with patronage (0=none; 1 =fully variable)		1	1	1	1	1
PT operator effects	Current headway of feeder service	**min**	15	15	22	19	23
	Unit marginal op cost/passenger	**$**	4.60	4.60	4.60	4.60	4.60

			Albany	Constellation	Petone	Waterloo	Porirua
	Increase in PT costs	$000pa	-60.7	-13.8	-24.2	-13.8	-25.5
	Average revenue per passenger	$	4.87	3.91	2.66	2.66	2.66
	Increase in PT fares revenue	$000pa	-64.3	-11.7	-14.0	-8.0	-14.8
	Increase in net PT operator revenue (producer surplus)	$000pa	-3.6	2.1	10.2	5.8	10.8
Mohring effect	PT user benefits/passenger (economies of scale)	$	1.64	1.64	2.40	2.07	2.51
	PT user benefits	$000pa	**-21.6**	**-4.9**	**-12.6**	**-6.2**	**-13.9**
Road system & user impacts:							
Line haul impacts (peak periods)	Reduction in car driver trips	#	145	33	21	12	22
	Peak hour factor		0.8	0.8	0.8	0.8	0.8
	Peak travel time by road		*50.9*	*46.1*	21.6	25.2	20.9
	"Free flow" time by road	#	14.8	12.5	10.1	13.9	13.6
	Estimated elasticity (% speed v % volume)	#	2.84	2.92	2.12	1.80	1.40
	Reduction in total time per marginal vehicle	#	144.23	134.48	45.77	45.21	29.39
	Reduction in total corridor TT-- per peak vehicle	*hr*	*1.92*	*1.79*	*0.61*	*0.60*	*0.39*
	Reduction in total road system costs	$000pa	**3935.2**	**833.9**	**180.6**	**102.0**	**122.6**
	Ashley factor		*0.5*	*0.5*	*0.5*	*0.5*	*0.5*
	Reduction in total road system costs	$000pa	1967.6	417.0	90.3	51.0	61.3
Car access impacts (peak periods)	Additional/ modified car trips to station:						
	* parked at other station	#	26.4	6	28	16	29.6
	* car passenger	#	4.4	1	12.25	7	12.95
	* local bus		26.4	6	10.5	6	11.1
	* walk/ cycle/other	#	22	5	17.5	10	18.5
Car ave trip distance (increase):	* drive all the way	**km**	-18.3	-15.1	-13.6	-19.6	-22.4
	* parked at other station	**km**	-2	-2	-2	-2	-2
	* car passenger	**km**	3.1	2.8	4.4	4.1	3.9
	* local bus	**km**	3.2	2.8	3.6	3.7	2.8
	* walk/ cycle/other	**km**	2.7	1.5	2.0	1.0	1.8
Total VKT increase/peak period:	* parked at other station	km	-52.8	-12	-56	-32	-59.2
	* car passenger	km	13.5	2.8	54.5	28.7	50.0
	* local bus	km	83.2	16.6	38.3	21.9	30.9
	* walk/ cycle/other	km	58.5	7.4	35.7	10.4	33.1
	* Total (per peak period)	km	102	15	72	29	55
	* Total (per year)	**000 km**	51.2	7.4	36.2	14.5	27.4
	Access:LH (de)congestion rate per VKT	#	0.5	0.5	0.5	0.5	0.5
	Decrease in total (local) road system costs	$000pa	-37.9	-6.2	-11.5	-3.1	-3.4

			Albany	Constellation	Petone	Waterloo	Porirua
Total road decongestion benefits		**$000pa**	**1929.7**	**410.8**	**78.9**	**47.8**	**57.9**
Summary of benefits							
PT user benefits	**Direct benefits to P&R users**	$000pa	500	110	280	185	480
	Benefits to remaining on-street parkers	$000pa	1	37	0	15	1
	Ex line-haul PT user benefits	$000pa	24	3	0	0	0
	Benefits to other pt users	$000pa	-79	-18	-15	-9	-23
Road user benefits	**Road decongestion benefits**	$000pa	1930	411	79	48	58
Producer benefits	Include financial impact as PT operator benefit??	Yes=1	0	0	0	0	0
	PT line-haul operator benefits	$000pa	0.0	0.0	0.0	0.0	0.0
	Benefit to other PT operators	$000pa	0.0	0.0	0.0	0.0	0.0
Total	**Total benefits (pa)**	**$000pa**	**2375**	**543**	**343**	**239**	**515**
Summary of costs	P&R site capital costs	$000	6364	1649	2163	1236	2287
	P&R site capital costs--annualised	$000pa	439.3	112.0	145.8	83.3	154.1
	P&R site O&M costs	$000pa	198.0	45.0	78.8	45.0	83.3
	PT Op costs (net)	$000pa	-16	10	-62	-35	-65
	Total annualised costs (pa)	**$000pa**	**621**	**167**	**163**	**93**	**172**
	BCR (G)--annualised		**3.82**	**3.26**	**2.11**	**2.57**	**3.00**
	Net annualised value		**1754**	**376**	**181**	**146**	**343**
	Target BCR		**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
	Conclusion		**pass**	**pass**	**pass**	**pass**	**Pass**
Summary per additional P&R place	***All units $pa/space***						
Benefits pa	**P&R users**		1138	1477	1601	2005	2597
	PT users		-126	-153	-88	-92	-124
	Road decongestion		4386	4108	451	478	313
	Total user benefits		**5398**	**5432**	**1963**	**2391**	**2786**
Costs pa	**P&R capital**		998	1120	833	833	833
	P&R O&M		450	450	450	450	450
	PT operating (net)		-36	97	-353	-353	-353
	Total costs (annualised)		**1412**	**1667**	**930**	**930**	**930**
Summary	**Net annual value**		**3986**	**3765**	**1033**	**1462**	**1856**
	BCR (G)		**3.82**	**3.26**	**2.11**	**2.57**	**3.00**