Western Corridor transportation study

Rail issues and options

18 April 2005

Transit New Zealand
Ararau Aotearoa

Greater Wellington Regional Council

Rail Issues and Options

Prepared for

Greater Wellington Regional Council

and Transit New Zealand

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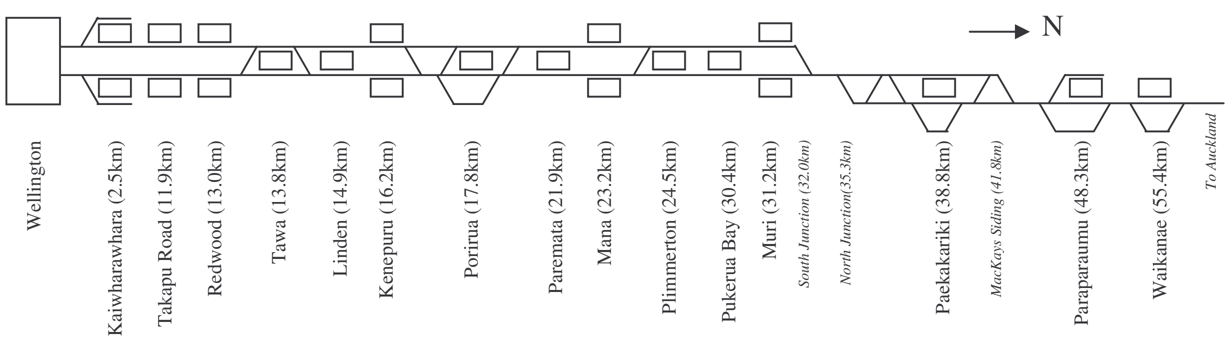
Executive Summary

Background

The purpose of this report is to examine rail operations and infrastructure options for the development of the Western Corridor rail network that will compliment road development in the Western Corridor to deliver the best possible outcomes for transport service provision.

Infrastructure

The railway track between Wellington and Muri is double track. Just beyond Muri at South Junction there is a single track section of about 2km, returning to double track at North Junction prior to Paekakariki. At Mackay's Siding, about 3km beyond Paekakariki, the double track reverts to a single track mainline and continues as such to the northern boundary of the study area. At Paraparaumu there is a crossing loop and a dead ended 'dock' providing a second platform face for suburban train turnbacks. At Waikanae there is a single platform face and crossing loop. The following schematic diagram provides an overview of the track layout.



The rail track is narrow gauge 3'6" (1067mm) which is in common with Queensland and Tasmania in Australia. This affects the availability of second hand rollingstock and also places limitations on the power capacity of traction motors under locomotives as a result of the limited space available for the equipment between the bogie frames.

The hill at Pukerua Bay, with a 1:57 compensated grade, is the ruling grade for the line between Wellington and Palmerston North.

There are seven tunnels between Wellington and Paraparaumu, five of which are on the single track section between Muri and Paekakariki, as described in the following table:

Tunnel ID	Section	Length
No.1 Tawa	Wellington – Takapu Road	1,238m
No.2 Tawa	Wellington – Takapu Road	4,325m
No.3 Pukerua	Muri – Paekakariki (Single track section)	153m
No.4 St.Kilda	Muri – Paekakariki (Single track section)	290m
No.5 Sea View	Muri – Paekakariki (Single track section)	278m
No.6 Brighton	Muri – Paekakariki (Single track section)	244m
No.7 Neptune	Muri – Paekakariki (Single track section)	59m

The only significant bridge is located North of Paremata, across the entrance to Porirua Harbour.

The line is installed with an automatic signalling system that provides typical headways of around 2 to 3 minutes. This level of throughput capacity is consistent with most mixed purpose, high traffic density railways in the world. On the single track sections a form of Centralised Traffic Control (CTC) is installed.

The track from Wellington to Paekakariki was electrified in 1940 with a 1500vDC system, and then extended to Paraparaumu in 1983. The design of the system is consistent with many of the older style electrified systems in the world with the capacity of the system to feed trains related to the number and spacing of electrical substations along the track. As there is no electrification between Paraparaumu and Palmerston North any trains travelling into this section are required to be hauled by diesel locomotives.

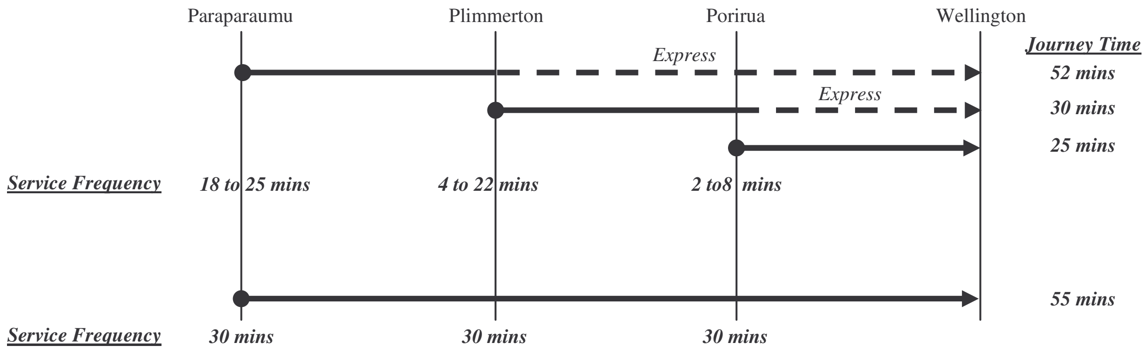
It is also noted that the section of track between Kaiwharawara and Wellington, including Wellington Junction, is shared with the Wairarapa line. This could become a constraint to timetabling for additional Paraparaumu line services. Issues in this area are complex and would require a level of detailed analysis that is beyond the scope of this study.

Train operations

Wellington suburban passenger services
Suburban services utilise electric multiple units (EMU's predominately operated as 2 car sets during off peak times and are built up to 4 car, 6 car and 8 cars sets during peak periods. 4 car sets are common and 8 car sets are rare. Each car has 74 seats and has a theoretical standing capacity of 74 people, although in practice the system is generally managed such that the number of standing passengers is held at about 25 before there is a trigger for service changes.

Timetabling conforms to a type of layered pattern with trains originating/terminating at Porirua and Plimmerton during the peak periods, and Paraparaumu all day from around 5am to midnight. Trains from Paraparaumu run express from Porirua to Wellington during the peak periods.

During the peak periods timetabling is generally based on optimising operational constraints rather than any type of symmetrical timetable. A 30 minute memory timetable is applied during the off peak periods. The service pattern is represented in the following schematic:



There is currently sufficient capacity in the infrastructure to meet demand but there is a shortage of rollingstock to match the expected demand growth.

Regional and long distance passenger services

Tranz Scenic operates two long distance passenger trains each day out of Wellington on the North Island Main Trunk Railway:

- The "Overlander" – a day time train to/from Auckland in each direction
- The "Capital Connection" – offers a daily return journey from Palmerston North to Wellington. This train is popular with commuters from the Paraparaumu area due to its express schedule and higher levels of comfort.

Trains consist of Toll NZ locomotives provided under a 'hook and pull' contract arrangement, and passenger saloon type sitting carriages.

Freight services

A private company called Toll Rail, which is a subsidiary of Toll NZ and in turn is part of the Toll group of companies, undertakes freight rail operations. New Zealand Railway Corporation owns and maintains the track infrastructure and provides train control functions. The only infrastructure owned by Toll Rail are freight handling centres and maintenance depots.

Toll Rail operates up to 10 trains per day in each direction between Wellington and Palmerston North, most of which are operated as fixed consist unit trains. There is a preference in the marketplace for overnight service delivery, which has trains departing in the early evening and arriving early morning. This sometimes creates conflicts with suburban peak services.

Diesel locomotives are used between Wellington and Palmerston North, electric locomotives between Palmerston North and Hamilton and then once again diesel locomotives from Hamilton to Auckland. Banker locomotives are used between Wellington and Paekakariki to assist trains over the hill near Pukerua Bay.

Freight train lengths are limited as follows:

- Crossing loop lengths – most crossing loops on the Northern Trunk line are around 700m
- Wellington yard tracks – currently the longest arrival tracks are about 800m, but options are available to improve the layout to increase lengths to around 900m
- Hook and pin couplers – these are not as strong as the automatic knuckle style couples used on most other rail networks (eg Australia) and limit the trailing weight of trains to 900t at ruling grade loads. Banker locomotives are attached to the rear of trains in order reduce coupler strain and haul heavier loads over the Pukerua Bay hill.

Despite these limitations, trains of up to 950m in length are operated on the line.

Tunnel clearances on the line have recently been improved and it is now possible to carry 9’6” high shipping containers on standard deck height container wagons. However, minimum clearances remain and it is necessary to apply heavy speed restrictions (25kph) to trains carrying this type of load.

At Wellington trains arrive into the Freight Yard and then pulled back to then be placed into the ferry sidings at Waterloo Quay. Toll Rail would prefer to arrive trains directly into the ferry sidings but the infrastructure costs required to achieve this have been identified as being prohibitive.

At this time, freight train operations are accommodated during peak periods, provided that the train presents at a time when a planned pathway is available. In many other cities where track capacity is scarce, freight trains face an access curfew during suburban peak periods. The implication from this is that there is still some track capacity available during peak periods.

The main benefit of excluding freight trains from the peak period mainly stems from issues of service reliability resulting from poor on-time presentation of the freight train at the suburban boundary, and delays it incurs after entering the suburban area (slow running, vehicle defects etc).

Public transport connections

A number of the rail stations on the track are serviced by bus connections as summarised in the following table.

Station	No. of Bus Routes	Areas Serviced
Wellington	Multiple	Most inner suburbs
Kaiwharawhara	Nil	
Takapu Road	Nil	
Redwood	Nil	
Tawa	Nil	

Station	No. of Bus Routes	Areas Serviced
Linden	Nil	
Kenepuru	Nil	
Porirua	11	City Link North – Whitby, Ascot Park South – Johnsonville East – Sievers Grove, Waitangirua, Ranui Heights West – Titahi Bay
Paremata	1	East – Whitby
Mana	Nil	
Plimmerton	Nil	
Pukerua Bay	Nil	
Muri	Nil	
Paekakariki	1	Local Town Service
Paraparaumu	11	North – Otaki, Waikanae, Waikanae Beach South – Paekakariki, Raumati South West – Paraparaumu Beach

Although there is already a high degree of timetable co-ordination between bus and train in this corridor not all trains have a connecting bus service, which effectively reduces travel time choice for people in affected areas. Increasing bus frequency in these areas could have a similar affect to increasing train frequencies for these people but not have the potentially high infrastructure costs sometimes associated with rail infrastructure options related to increasing train frequencies.

Options for increasing train capacity

The EMU's providing suburban services predominately operated as 2 car sets during off peak times and are built up to 4 car, 6 car and 8 cars sets during peak periods. During the peak, 4 car sets are common and 8 car sets are rare. Each car has 74 seats and a theoretical standing capacity of 74 people, although in practice, the system is managed such that the number of standing passengers is held at about 25 before there is a trigger for service changes. Making an assumption that the average EMU train has 5 cars (an average for 4, 6 & 8 car sets), and are all full with 100 passengers per car, then the total number of people delivered on the 11 morning trains during the peak period is 5,500.

With minor upgrade the network between Wellington and Paraparaumu could cater for 8 car train sets. By building all train sets up to 8 cars it would be possible to increase the carrying capacity of the network by 3,300 passengers to a total of 8,800.

The capital requirements to achieve this would be:

- Purchase of the additional carriages. A review of train working reveals that 3 train sets are reused during the peak period (ie make a second inbound trip) therefore, a total of 8 sets are required for the morning peak. This drives the need to purchase 24 new cars to build these to 8 car sets
- Lengthening of a small number of platforms, and
- Construction of additional stabling capacity.

Options for double deck rollingstock have been dismissed on the basis of clearance constraints associated with the tunnels and numerous road over rail bridges.

However it is unlikely that this strategy of building train capacity will be successful on its own. Its delivery assumes that the existing network will be able to draw 3,300 additional passengers as a result of providing additional train capacity alone, based on existing timetabling. In reality it will be necessary to improve access to, and the attractiveness of, the network in order to realise the generation of this demand.

Options for increasing track capacity

Operations in the Western Corridor are currently constrained by a number of issues related to infrastructure design.

The greatest determinants of track infrastructure capacity are the single track sections from North Junction to South Junction, and from MacKays Crossing to Paraparaumu. These sections interact with each other to restrict the working of trains between Paraparaumu and Muri. Existing operational patterns are designed so that they deliver the required volume of services with consideration of these constraints, but there are frequent affects on service reliability when out of course operations occur. The delay of one service can flow to others as they await a pathway over the single track sections and this results in a network that is perceived as unreliable. The other thing that the single track sections determine is the shape of the timetable. It is not currently possible to install a symmetrical clock face timetable (ie one where the trains leave at regular intervals) on this line due to the intensity of use of the single track sections, introduction of the regional passenger and freight trains through the peak, and the use of short starter suburban trains from intermediate stations along the line (Plimmerton and Porirua).

The conclusion is that a service frequency to Paraparaumu of less than 20 minutes requires one or more of the following supporting features:

- Provision of train stabling at Paraparaumu so that fresh train sets can be introduced as the peak progresses and it becomes increasingly hard to return train sets from previous runs, especially when regional passenger or freight trains are introduced
- Standing trains over at Paraparaumu for longer than the minimum 10 minute turnback period. Estimated to require an additional train set due to reduced turnarounds and therefore efficiency of the fleet
- Flighting of trains from Paraparaumu in order to reduce the number of conflicts on the single track sections. May also need more temporary train storage space at Paraparaumu
- The section of single track between North and South Junctions

- The section of single track from Paraparaumu and MacKays Crossing.

The degree of express running installed in a timetable affects the capacity of the track. Optimum track capacity is gained when all trains work over the line at the same relative speed. When an express train is scheduled between stopping services then a large gap must be left between the stopping services thus reducing throughput. As the need for express train running increases, there will be added pressure for additional track capacity. Providing a third bi-directional track that changes operating direction to suit the direction of the peak flow usually satisfies this circumstance. The third track allows express trains to overtake stopping trains and therefore reduces the headways between the trains. It should be noted that a length of third track of about 10km is required in order to achieve this overtaking move. The reason for this is that the fast train will initially be controlled some distance behind the slow train by the signalling system. Upon entering the overtaking track it must first catch the slow train, overhaul it, and then establish a sufficient clear lead so that the slow train can slot in behind it whilst maintaining signal control distances. The availability of a suitable corridor with adequate width over 10km, to provide the third track to allow this overtaking move, is unlikely for the Western Corridor without exceptional infrastructure costs.

The signalling systems used between Wellington and Paraparaumu are sufficient to handle the volumes of traffic expected on this line. Typically the system can handle up to about 30 trains per hour but this is reduced by station dwell time to about 24 trains per hour with an acceptable degree of service reliability. This capacity is reduced when a mixture of train speeds and types is introduced. It is not expected that signal upgrades will be required other than where track alterations are made.

Options for growing patronage

The opportunity for growth in patronage resulting from diversion of trips from cars will largely be price and journey time sensitive.

Journey time reductions for suburban rail systems are usually difficult and expensive to achieve. Issues such as grade and curve easing generally are not viable options because they return benefits in the magnitude of seconds rather than minutes of journey time. The introduction of higher speed rollingstock is also of little benefit as the short distances between station means that the higher speed range is not utilised. It is true that modern EMU designs utilise a higher acceleration rate and braking effect and this sometimes provides marginal advantage, but the effects are so small that most this advantage is usually absorbed into the ‘make up’ time built into timetables to improve service reliability. The use of express trains is often pursued as the cheapest means of delivering journey time benefits where there is spare track capacity. Eventually however, as train volumes increase, the strategy of using express trains leads to a premature need for track amplification (ie third track) and at this stage turn into a very expensive solution.

Service reliability is often cited by commuters as one of their main concerns about public transport. The level of service reliability is usually inversely related to the how closely the network is operating to its capacity. Because trains follow each other along a single track, with limited overtaking opportunities, then delay to one train will affect the following train(s), depending on how close they are behind. This situation is exasperated when sections of single track are encountered where late trains in opposing directions have the opportunity to affect each other. The single track sections between North and South Junctions, and MacKays Crossing to Paraparaumu are classic examples of this problem.

Another cause of service reliability issues is the complexity of train timetabling. It is noted that train timetabling for the Western Corridor is extremely complex with a mixture of express and stopping services, three different train turnback points, regional passenger services and freight trains all mixed on the corridor.

Finally, most suburban rail systems have identified that the operation of freight train services through peak periods is a major cause of service unreliability. The fact that these trains are generally slow moving, more so with the gradients and tunnel speed restrictions experienced on the Western Corridor, and are notoriously poor timekeepers in their own right. Significant volumes of freight business are required in order to justify a dedicated route through the metropolitan area, and this is unlikely to be justified in the Wellington situation. The option of a curfew on freight train operations during the peak periods is the solution adopted by most metropolitan rail networks.

Improving accessibility is a key issue affecting the delivery of future patronage growth of the rail corridor. All the discussion to date has related to constraints on the network and the potential solutions in order to carry more passengers. However, no additional passengers will be carried unless commuters perceive that the service offers a viable alternative to road. Possible improvements to the rail network to attract people out of their cars and onto trains include:

- Increasing train frequencies
- Electrification extension from Paraparaumu to Waikanae
- Additional stations
- Additional parking at stations
- Additional public transport services to, and from, stations
- Travel information
- Improved model interchange facilities
- Encouraging higher density housing around stations.

Train frequency in the corridor is constrained by the:

- The section of single track between North and South Junctions
- The section of single track from Paraparaumu and MacKays Crossing
- The double track section between Kaiwharawhara shared with the Wairarapa Line
- The junction on the approach to Wellington Station.

The cost of improving the infrastructure at these points in order to allow greater train frequency is expected to be expensive and is only likely to be considered after the capacity of the existing network has been fully exploited.

Determining future rail capacity requirements

The calculation of travel demand for this study is being undertaken using the GWRC Transport Model. The model uses a wide range of inputs such as population forecasts, demographics, origin/destination matrices, and travel time information to allocate trips between modes. Outputs from the model are responsive to the assumptions adopted in regard to the extent of upgrade to both the road and rail network. In order to establish the upgrade requirements for rail it is necessary to understand the magnitude of change in demand so that an appropriate scale of solution is identified. Hence, this presents a situation whereby the definition of the infrastructure issues is influenced by the magnitude of demand, and the magnitude of demand is responsive to the nature of the infrastructure solution applied.

In order to quantify the expected range of infrastructure options required, the model has been used to generate a best and worse scenario for rail patronage as described below.

Rail best case
This is based on significant rail expenditure on upgrades whilst the road corridor is retained as at present. Assumptions included:

- Enhancement of park and ride facilities at Paraparaumu, Paremata and Porirua to ensure that rail usage is not constrained by this feature
- Electrification extension to Waikanae to capture an expanded market
- Closure of Muri and Redwood stations to reduce journey times
- New stations at Lindale, Raumati, Aotea, Glenside and MacKays (note this actually reduced patronage due to the additional travel time inserted into the majority of trips. This will be explored further later in this report)
- Improved modal interchange at Porirua to make transfers more attractive
- Improved rollingstock quality to make the journey more attractive
- Station facility upgrades to make waiting for trains more acceptable.

Rail worst case
This is based on major upgrade to the road corridor to remove any impediments to journey time whilst leaving the rail corridor as it is today.

Results from modelling
Results from modelling show:

- Maximum corridor patronage in 2016 is approximately 4,500 for the low case, 5,000 for the base case and 5,500 for the high case
- Patronage growth between 2004 and 2016 is expected to be 8% for the low case, 20% for the base case, and 33% for the high case
- Patronage growth is strongest on the section of line beyond Porirua but it is coming off a lower base than stations to the south of Porirua.

Train capacity requirements
In order to assess the train service level requirements for the Western Corridor, the patronage forecasts developed above have been converted into equivalent carloads by assuming a peak loading factor of 70 passengers per car. This is low compared to the actual capacity of the cars used on the line (seating capacity of 74 and crush capacity of 100) but reflects current loading, and hence passenger comfort, levels currently being experienced.

Conclusions
Conclusions that can be drawn from this analysis include:

- The current and forecast passenger volumes from Waikanae do not fill one EMU train. Note that Waikanae is currently serviced by one diesel hauled service. Also note that the additional patronage from Waikanae is likely to be a diversion of existing patronage from Paraparaumu
- Although it has been identified that patronage growth is strongest beyond Porirua, there is generally sufficient capacity in the existing trains to cater for this. The exception is that under the high patronage case, one additional train would be required
- Under the low patronage case, the only requirement is for one additional train originating from Porirua
- Under the base patronage case, the requirement is for three additional trains originating from Porirua
- Under the high patronage case, the requirement is for one additional train to originate from Paraparaumu and 5 additional trains to originate from Porirua, assuming that the additional Paraparaumu service runs express.

Additional infrastructure cases

Further to the patronage cases identified above three additional infrastructure cases were also assessed. The three additional infrastructure cases are:

- Case A – Extension of electrification to Lindale Station (15 minute service)
- Case B – Extension of electrification to Lindale Station (10 minute service)
- Case C – Extension of electrification to Waikanae Station (15 minute service)

The following table summarises each of the infrastructure cases identified as providing solutions to a range of patronage cases:

Scenario	Description	Scope of Works
Scenarios produced in response to patronage modelling		
Low Patronage Case	No rail upgrade but full road upgrade	• Add one additional 4 car train from Porirua • Provide additional train stabling
Base Patronage Case	Maintenance of existing rail market share	• Add one additional 6 car train from Porirua • Increase the size of three trains from 6 to 8 cars • Provide additional train stabling
High Patronage Case	Unrestricted rail upgrade but no road upgrade	• Add two additional 8 car trains from Porirua • Increase the size of two trains from 6 to 8 cars • Reinforce traction power supply • Provide additional train stabling
Scenarios produced based on perceived infrastructure needs		

Infrastructure Case A	15 minute train frequency out of Lindale and 7.5 minute train frequency out of Porirua	• Extend electrification on single track to Lindale • Duplicate from Raumati South to Paraparaumu • Install additional platform and train turnback siding at Porirua • One additional train set
Infrastructure Case B	10 minute train frequency out of Lindale and 5 minute train frequency out of Porirua	• Extend electrification on single track to Lindale • Duplicate from MacKays Crossing to Raumati South • Install additional platform and train turnback siding at Porirua • Three additional train sets
Infrastructure Case C	15 minute train frequency out of Waikanae and 7.5 minute train frequency out of Porirua	• Extend electrification on single track to Waikanae • New crossing loop between MacKays Crossing and Paraparaumu • Install additional platform and train turnback siding at Porirua • Three additional train sets

Paraparaumu service frequency limitations

Analysis of the capacity to operate trains out of Paraparaumu has been undertaken by examining scheduling options with 5 minute service frequency increments. The following table summarises the findings.

Service Frequency	*Capacity Delivered (4 car/8 car)*	*Service Frequency Impact*			*Infrastructure Improvements Required to Support Service Frequency*	*Scope for Regional Passenger Train Pathway*	*Scope for Freight Train Pathway*
		Waikanae	*Paraparaumu - Plimmerton*	*Plimmerton - Wellington*			
5 mins	4800/9600	Current	Improvement	Improvement	Full track duplication	If slowed down	Not available
10 mins	2400/4800	Current	Improvement	Current	Full track duplication	If slowed down	Not available
15 mins	1600/3200	Current	Improvement	Reduction	**Min:** Track duplication MacKays to Paraparaumu **Preferred:** Full duplication in order to provide service reliability	If slowed down, but still may need duplication of North/South Junctions for reliability	Not available without duplication of North/South Junctions
20 mins	1200/2400	Current	Current	Reduction	**Min:** Nil, but service reliability will be poor **Preferred:** Short track duplication north of MacKays (nominally 1km)	Available	Only available if there is a suitable holding track at Paekakariki
25 mins	800/1600 plus	Current	Reduction	Reduction	Nil	Available	Only available if there is a suitable holding track at Paekakariki
30 mins	800/1600	Current	Reduction	Reduction	Nil	Available	Available
35 mins	less than 800/1600	Current	Reduction	Reduction	Nil	Available	Available
40 mins	~600/1200	Current	Reduction	Reduction	Nil	Available	Available

The conclusion drawn from this work is that a schedule frequency of better than 20 minutes is not sustainable with the existing infrastructure and where trains from Paraparaumu are formed by services worked out of Wellington. In order to sustain 20 minutes it is preferable to undertake a short extension of the double track north of MacKays Crossing.

Marginal improvements to service frequency can be achieved when trains, which have been stabled at Paraparaumu, are brought into operation to run one or more of the peak hour services nested between the base 20 minute pattern. In order for this to occur, it would be necessary to provide suitable train stabling sidings at Paraparaumu.

Waikanae service delivery options

Analysis of the capacity to operate trains out of Waikanae has been undertaken by examining scheduling options with 5 minute service frequency increments. Note that the following analysis applies with electrification extended from Paraparaumu to Waikanae. The following table summarises the findings.

Service Frequency	Capacity Delivered (4 car/8 car)	Service Frequency Impact			Infrastructure Improvements Required to Support Service Frequency	Scope for Regional Passenger Train Pathway	Scope for Freight Train Pathway
		Waikanae	Paraparaumu - Plimmerton	Plimmerton - Wellington			
5 mins	4800/9600	Improvement	Improvement	Improvement	Full track duplication	If slowed down	Not available
10 mins	2400/4800	Improvement	Improvement	Current	**Min:** Crossing facility at Paraparaumu Preferred: Full track duplication	Only with track duplication MacKays to Paraparaumu	Not available
15 mins	1600/3200	Improvement	Improvement	Reduction	Track duplication MacKays to Paraparaumu	Not available without duplication Paraparaumu to Waikanae	Not available without duplication of North/South Junctions
20 mins	1200/2400	Improvement	Current	Reduction	**Min:** Crossing facility at Paraparaumu Preferred: Track duplication MacKays to Paraparaumu	Not available without duplication MacKays to Paraparaumu	Only available if there is a suitable holding track at Paekakariki
25 mins	800/1600 plus	Improvement	Reduction	Reduction	**Min:** Crossing facility between MacKays and Paraparaumu Preferred: Track duplication MacKays to Paraparaumu	Not available without duplication MacKays to Paraparaumu	Only available if there is a suitable holding track at Paekakariki
30 mins	800/1600	Improvement	Reduction	Reduction	**Min:** No change Preferred: Short track duplication north of MacKays (nominally 1km)	Available	Available with track duplication, still some reliability risk at South Junction
35 mins	less than 800/1600	Improvement	Reduction	Reduction	Nil	Available	Available
40 mins	~600/1200	Improvement	Reduction	Reduction	Nil	Available	Available

The conclusion drawn from this work is that a schedule frequency of better than 35 minutes may not sustainable with the existing infrastructure and where trains from Waikanae are formed by services worked out of Wellington. In order to sustain more frequent service levels then some degree of track duplication will be required.

Marginal improvements to service frequency can be achieved when trains, which have been stabled at Waikanae, are brought into operation to run one or more of the peak hour services nested between the base 35 minute pattern. In order for this to occur, it would be necessary to provide suitable train stabling sidings at Waikanae.

1. Introduction

1.1 Background

The purpose of this report is to examine rail operations and infrastructure options for the development of the Western Corridor rail network that will compliment road development in the Western Corridor to deliver the best possible outcomes for transport service provision.

1.2 Content qualifications

All scheduling solutions explored in this report are focused towards the examination of specific track capacity issues and do not represent a total timetabling solution for the corridor. Further work may be required with the preferred solutions/outcomes to ensure that a balanced timetable can be implemented across the full length of the corridor to match demand requirements.

2. Description of the railway infrastructure

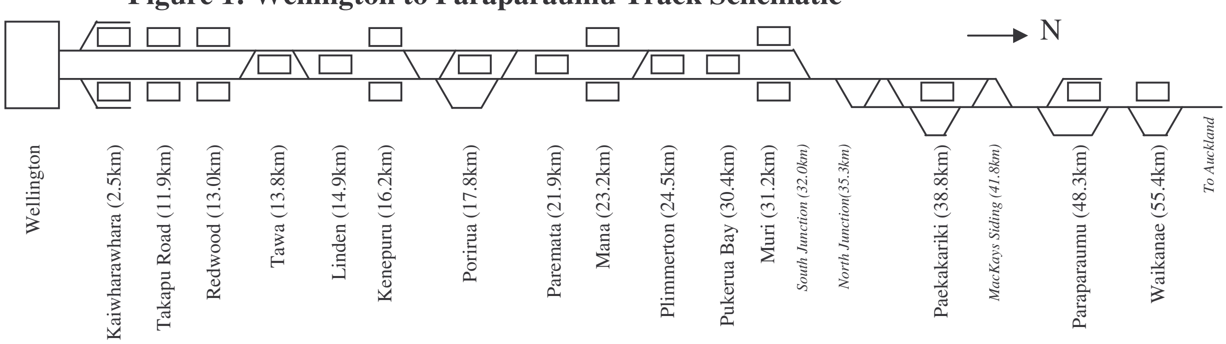
2.1 Background

For the purposes of this report on railway infrastructure and operations it has been assumed that the study area extends from Wellington to Waikanae.

2.2 Track and structures

The railway track between Wellington and Muri is double track. Just beyond Muri at South Junction there is a single track section of about 2km, returning to double track at North Junction prior to Paekakariki. At Mackay's Siding, about 3km beyond Paekakariki, the double track reverts to a single track mainline and continues as such to the northern boundary of the study area. At Paraparaumu there is a crossing loop and a dead ended 'dock' providing a second platform face for suburban train turnbacks. At Waikanae there is a single platform face and crossing loop. The following schematic diagram provides an overview of the track layout.

Figure 1: Wellington to Paraparaumu Track Schematic

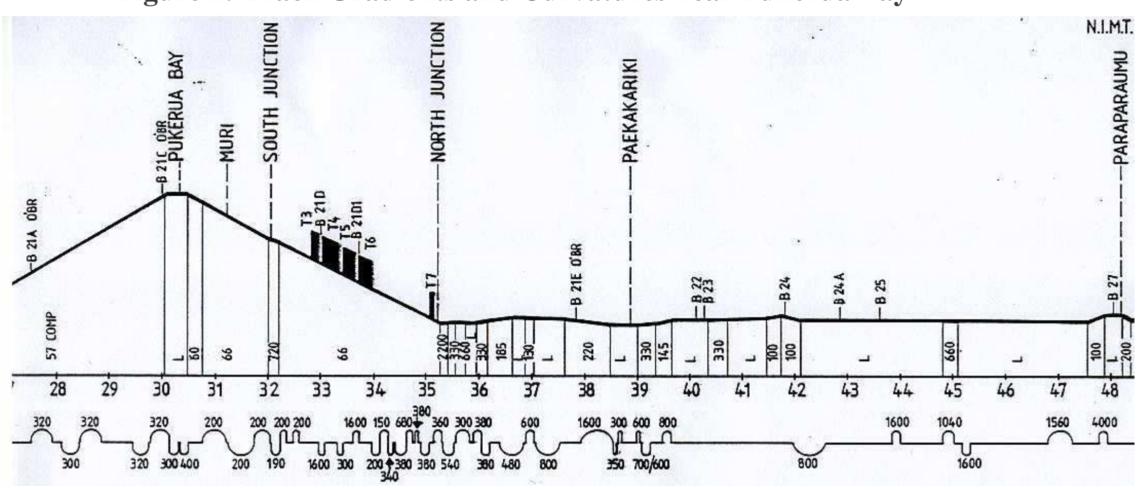


The rail track is narrow gauge 3'6" (1067mm) which is in common with Queensland and Tasmania in Australia. This affects the availability of second hand rollingstock and also places limitations on the power capacity of traction motors under locomotives as a result of the limited space available for the equipment between the bogie frames.

Wellington Station consists of 9 dead end platforms and provides terminal capacity that far exceeds the capacity of the tracks that feed it. Wellington is the main passenger terminus for railway lines converging from Hutt Valley, Auckland and Johnsonville. The Picton Ferry Terminal near the station is the focal point for the inter island rail ferries but does not have direct rail access and many of the freight trains arriving at Wellington need to be shunted to this location.

To the north of Wellington the terrain is steep. The original main line used to follow the alignment of the Johnsonville Line but a new mainline was constructed through tunnels to the east. This has removed the torturous climb out of Wellington. Once through the two tunnels, one of which is in excess of 4km long, the railway follows the gently undulating terrain beside the Porirua Stream. North of Porirua, the railway line closely follows the coast and its double track is sandwiched between the sea and the main road. On approaching Pukerua Bay the railway line climbs sharply on a 1:57 compensated grade. Curve radii as little as 200m are encountered around the Pukerua Bay area. The route north of Pukerua Bay becomes torturous as both the railway and the main road fight for alignment between the sea and a parallel range of hills that fall sharply into the sea. At this location the road is positioned against the coastline and the railway is cut into the side of the hills on a falling gradient of 1:66 until it reaches roadway level. The hill at Pukerua Bay is the ruling grade for the line between Wellington and Palmerston North.

Figure 2: Track Gradients and Curvatures near Pukerua Bay



Along the narrow coastal corridor, the railway is reduced to a single bi-directional track and five tunnels have been provided in order to negotiate some to the ridges. South of Paekakariki the terrain becomes more accommodating and the line is returned to double track as it heads towards Paraparaumu, the terminating point of the suburban rail system and the electrified network. At MacKays Siding, just short of Paraparaumu, the line returns to single track and continues like this past the northern boundary of the study area. There are crossing/passing loops located at Paraparaumu and Waikanae to allow opposing trains to pass each other on the single line section.

There are seven tunnels between Wellington and Paraparaumu, five of which are on the single track section between Muri and Paekakariki, as described in the following table.

Table 1: Details of Tunnels

Tunnel ID	Section	Length
No.1 Tawa	Wellington – Takapu Road	1,238m
No.2 Tawa	Wellington – Takapu Road	4,325m
No.3 Pukerua	Muri – Paekakariki (Single track section)	153m
No.4 St.Kilda	Muri – Paekakariki (Single track section)	290m
No.5 Sea View	Muri – Paekakariki (Single track section)	278m
No.6 Brighton	Muri – Paekakariki (Single track section)	244m
No.7 Neptune	Muri – Paekakariki (Single track section)	59m

The only significant bridge is located North of Paremata, across the entrance to Porirua Harbour.

2.3 Signalling

The line is installed with an automatic signalling system that provides typical headways of around 2 to 3 minutes. This level of throughput capacity is consistent with most mixed purpose, high traffic density railways in the world. On the single track sections a form of Centralised Traffic Control (CTC) is installed.

2.4 Electrification

The track from Wellington to Paekakariki was electrified in 1940 with a 1500vDC system, and then extended to Paraparaumu in 1983. The design of the system is consistent with many of the older style electrified systems in the world with the capacity of the system to feed trains related to the number and spacing of electrical substations along the track.

There is no electrification between Paraparaumu and Palmerston North hence any trains travelling into this section are required to be hauled by diesel locomotives.

The section of track further to the north between Palmerston and Hamilton was electrified in 1986, utilising an AC supply, in order to improve the haulage efficiency for heavy freight trains through the often tortuous terrain of the central north island.

Once again there is no electrification between Hamilton and Auckland hence any trains travelling into this section are required to be hauled by diesel locomotives.

3. Description of train operations

3.1 Rail market segments

3.1.1 Wellington suburban passenger services (Tranz Rail)

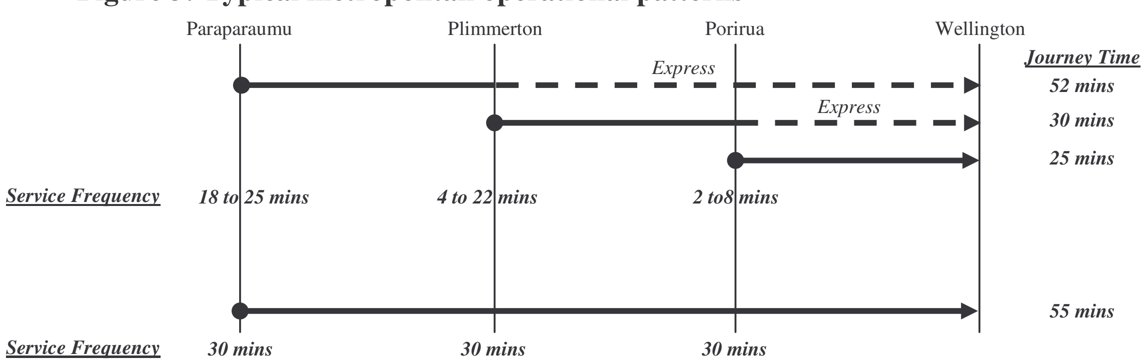
Suburban services utilise electric multiple units (EMU's predominately operated as 2 car sets during off peak times and are built up to 4 car, 6 car and 8 cars sets during peak periods. 4 car sets are common and 8 car sets are rare. Each car has 74 seats and has a theoretical standing capacity of 74 people, although in practice the system is generally managed such that the number of standing passengers is held at about 25 before there is a trigger for service changes.

Timetabling conforms to a type of layered pattern with trains originating/terminating at Porirua and Plimmerton during the peak periods, and Paraparaumu all day from around 5am to midnight. Trains from Paraparaumu run express from Porirua to Wellington during the peak periods.

During the peak periods timetabling is generally based on optimising operational constraints rather than any type of symmetrical timetable. A 30 minute memory timetable is applied during the off peak periods.

The service pattern is represented in Figure 3:

Figure 3: Typical metropolitan operational patterns



Most of the growth in patronage is occurring towards the end on the line in the outer suburbs. This is resulting in pressure to increase train numbers to Paraparaumu, which in turn is closing the window on the ability to turn trains around at intermediate locations such as Porirua and Plimmerton (signalling and headway issues being the main reasons). The options to be considered include running these trains through to Paraparaumu or building new infrastructure at Plimmerton to better accommodate the turnbacks. The demand growth in the Waikanae area is driving the investigation of the extension of the electrified system.

There is currently sufficient capacity in the infrastructure to meet demand but there is a shortage of rollingstock to match the expected demand growth.

3.1.2 Regional and long distance passenger services (Tranz Scenic)

Tranz Scenic operates two long distance passenger trains each day out of Wellington on the North Island Main Trunk Railway:

- The "Overlander" – a day time train to/from Auckland in each direction
- The "Capital Connection" – offers a daily return journey from Palmerston North To Wellington. This train is popular with commuters from the Paraparaumu area due to its express schedule and higher levels of comfort.

Trains consist of Toll NZ locomotives provided under a 'hook and pull' contract arrangement, and passenger saloon type sitting carriages.

3.1.3 Freight services (Toll NZ)

A private company called Toll Rail, which is a subsidiary of Toll NZ and in turn is part of the Toll group of companies, undertakes freight rail operations. New Zealand Railway Corporation owns and maintains the track infrastructure and provides train control functions. The only infrastructure owned by Toll Rail are freight handling centres and maintenance depots.

Toll Rail operates up to 10 trains per day in each direction between Wellington and Palmerston North, most of which are operated as fixed consist unit trains. There is a preference in the marketplace for overnight service delivery, which has trains departing in the early evening and arriving early morning. This sometimes creates conflicts with suburban peak services.

Diesel locomotives are used between Wellington and Palmerston North, electric locomotives between Palmerston North and Hamilton and then once again diesel locomotives from Hamilton to Auckland. Banker locomotives are used between Wellington and Paekakariki to assist trains over the hill near Pukerua Bay.

Freight train lengths are limited as follows:

- Crossing loop lengths – most crossing loops on the Northern Trunk line are around 700m
- Wellington yard tracks – currently the longest arrival tracks are about 800m, but options are available to improve the layout to increase lengths to around 900m
- Hook and pin couplers – these are not as strong as the automatic knuckle style couples used on most other rail networks (eg Australia) and limit the trailing weight of trains to 900t at ruling grade loads. Banker locomotives

are attached to the rear of trains in order reduce coupler strain and haul heavier loads over the Pukerua Bay hill.

Despite these limitations, trains of up to 950m in length are operated on the line.

Tunnel clearances on the line have recently been improved and it is now possible to carry 9’6” high shipping containers on standard deck height container wagons. However, minimum clearances remain and it is necessary to apply heavy speed restrictions (25kph) to trains carrying this type of load.

At Wellington trains arrive into the Freight Yard and then pulled back to then be placed into the ferry sidings at Waterloo Quay. Toll Rail would prefer to arrive trains directly into the ferry sidings but the infrastructure costs required to achieve this have been identified as being prohibitive.

3.2 Train operation management

Recent changes have seen the role of train control in the corridor pass from Toll Rail to the New Zealand Railway Corporation. This is consistent with a rail administration model that places the ownership of the track and train control into a single organisation, separate to the train operators. It is similar to arrangements in place in Australia with the Australian Rail Track Corporation (ARTC).

At this time, freight train operations are accommodated during peak periods, provided that the train presents at a time when a planned pathway is available. In many other cities where track capacity is scarce, freight trains face an access curfew during suburban peak periods. The implication from this is that there is still some track capacity available during peak periods.

3.3 Multimodal public transport

A number of the rail stations on the track are serviced by bus connections. Insufficient research is available to examine the effectiveness of connections but the following table indicates stations with multimodal connections.

Table 2: Multimodal Connections at Stations

Station	No. of Bus Routes	Areas Serviced
Wellington	Multiple	Most inner suburbs
Kaiwharawhara	Nil	
Takapu Road	Nil	
Redwood	Nil	
Tawa	Nil	
Linden	Nil	
Kenepuru	Nil	
Porirua	11	City Link North – Whitby, Ascot Park South – Johnsonville East – Sievers Grove, Waitanggirua, Ranui Heights

Station	No. of Bus Routes	Areas Serviced
		West – Titahi Bay
Paremata	1	East – Whitby
Mana	Nil	
Plimmerton	Nil	
Pukerua Bay	Nil	
Muri	Nil	
Paekakariki	1	Local Town Service
Paraparaumu	11	North – Otaki, Waikanae, Waikanae Beach South – Paekakariki, Raumati South West – Paraparaumu Beach

4. Options for increasing train capacity

The EMU's providing suburban services predominately operated as 2 car sets during off peak times and are built up to 4 car, 6 car and 8 cars sets during peak periods. During the peak, 4 car sets are common and 8 car sets are rare. Each car has 74 seats and has a theoretical standing capacity of 74 people, although in practice, the system is managed such that the number of standing passengers is held at about 25 before there is a trigger for service changes. Making an assumption that the average EMU train has 5 cars (an average for 4, 6 & 8 car sets), and are all full with 100 passengers per car, then the total number of people delivered on the 11 morning trains during the peak period is 5,500.

With minor upgrade (refer to Section 7.5.1), the network between Wellington and Paraparaumu could cater for 8 car train sets. By building all train sets up to 8 cars it would be possible to increase the carrying capacity of the network by 3,300 passengers to a total of 8,800.

The capital requirement to achieve this would entail:

- The purchase of the additional carriages. A review of train working reveals that 3 train sets are reused during the peak period (ie make a second inbound trip) therefore, a total of 8 sets are required for the morning peak. This drives the need to purchase 24 new cars to build these to 8 car sets
- Lengthening of a small number of platforms, and
- Construction of additional stabling capacity.

Options for double deck rollingstock have been dismissed on the basis of clearance constraints associated with the tunnels and numerous road over rail bridges.

However it is unlikely that this strategy of building train capacity will be successful on its own. Its delivery assumes that the existing network will be able to draw 3,300 additional passengers as a result of providing additional train capacity alone, based on existing timetabling. In reality it will be necessary to improve access to, and the attractiveness of, the network in order to realise the generation of this demand.

5. Options for increasing track capacity

5.1 Existing track capacity

Operations in the Western Corridor are currently constrained by a number of issues related to infrastructure design.

The greatest determinants of track infrastructure capacity are the single track sections from North Junction to South Junction, and from MacKays Crossing to Paraparaumu. These sections interact with each other to restrict the working of trains between Paraparaumu and Muri. Existing operational patterns are designed so that they deliver the required volume of services with consideration of these constraints, but there are frequent affects on service reliability when out of course operations occur. The delay of one service can flow to others as they await a pathway over the single track sections and this results in a network that is perceived as unreliable. The other thing that the single track sections determine is the shape of the timetable. It is not currently possible to install a symmetrical clock face timetable (ie one where the trains leave at regular intervals) on this line due to the intensity of use of the single track sections, introduction of the regional passenger and freight trains through the peak, and the use of short starter suburban trains from intermediate stations along the line (Plimmerton and Porirua).

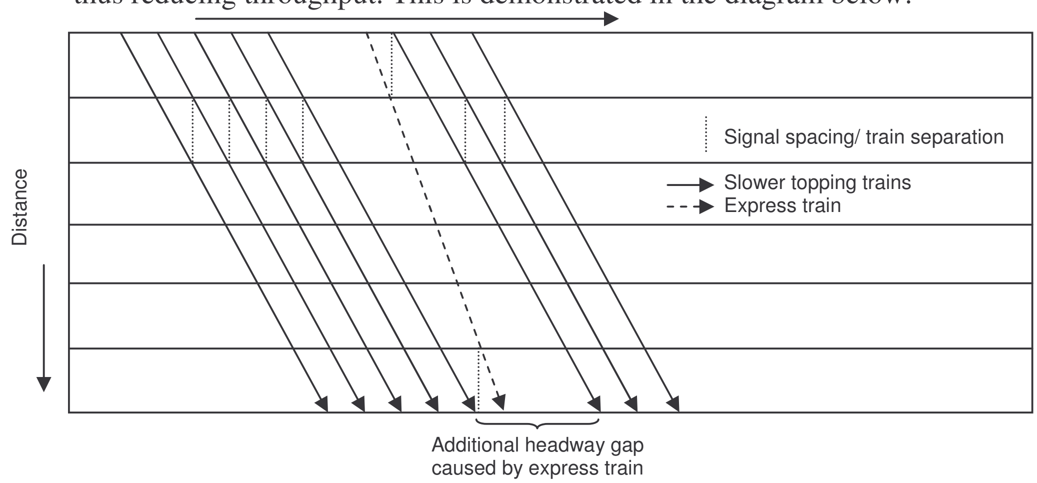
Exploration of the capacity to operate suburban trains from Paraparaumu over the single track sections between Paraparaumu and Muri has been undertaken in Appendix A.

The conclusion is that a service frequency to Paraparaumu of less than 20 minutes requires one or more of the following supporting features:

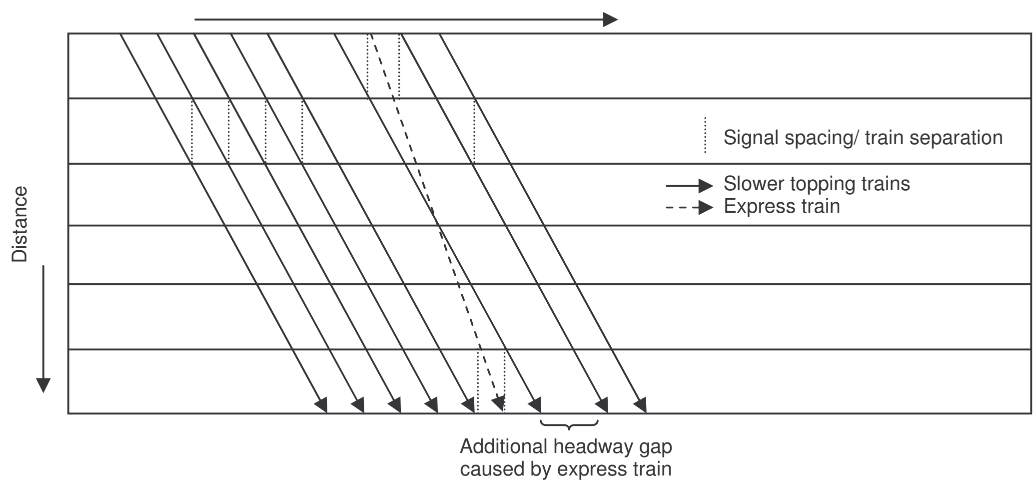
- Provision of train stabling at Paraparaumu so that fresh train sets can be introduced as the peak progresses and it becomes increasingly hard to return train sets from previous runs, especially when regional passenger or freight trains are introduced
- Standing trains over at Paraparaumu for longer than the minimum 10 minute turnback period. Estimated to require an additional train set due to reduced turnarounds and therefore efficiency of the fleet
- Flighting of trains from Paraparaumu in order to reduce the number of conflicts on the single track sections. May also need more temporary train storage space at Paraparaumu
- The section of single track between North and South Junctions
- The section of single track from Paraparaumu and MacKays Crossing.

5.2 Scheduling decisions

The degree of express running installed in a timetable affects the capacity of the track. Optimum track capacity is gained when all trains work over the line at the same relative speed. When an express train is scheduled between stopping services then a large gap must be left between the stopping services thus reducing throughput. This is demonstrated in the diagram below:



As the need for express train running increases, there will be added pressure for additional track capacity. Providing a third bi-directional track that changes operating direction to suit the direction of the peak flow usually satisfies this circumstance. The third track allows express trains to overtake stopping trains and therefore reduces the headways between the trains. It should be noted that a length of third track of about 10km is required in order to achieve this overtaking move. The reason for this is that the fast train will initially be controlled some distance behind the slow train by the signalling system. Upon entering the overtaking track it must first catch the slow train, overhaul it, and then establish a sufficient clear lead so that the slow train can slot in behind it whilst maintaining signal control distances. The following diagram indicates how this works:



The availability of a suitable corridor with adequate width over 10km, to provide the third track to allow this overtaking move, is unlikely for the Western Corridor without exceptional infrastructure costs.

5.3 Signalling system

The signalling systems used between Wellington and Paraparaumu are sufficient to handle the volumes of traffic expected on this line. Typically the system can handle up to about 30 trains per hour but this is reduced by station dwell time to about 24 trains per hour with an acceptable degree of service reliability. This capacity is reduced when a mixture of train speeds and types is introduced. It is not expected that signal upgrades will be required other than where track alterations are made.

6. Options for growing patronage

6.1 Improving total journey time

The opportunity for growth in patronage resulting from diversion of trips from cars will largely be price and journey time sensitive. Speeding up rail services, or the slowing down of road journeys as a result of congestion, are two possible drivers for mode shift. If the road is to be improved thus reducing congestion and improving journey time then, rail is likely to have to match this in order to retain market share and improve it in order to grow patronage at a rate faster than road.

Journey time reductions for suburban rail systems are usually difficult and expensive to achieve. Issues such as grade and curve easing generally are not viable options because they return benefits in the magnitude of seconds rather than minutes of journey time. The introduction of higher speed rollingstock is also of little benefit as the short distances between station means that the higher speed range is not utilised. It is true that modern EMU designs utilise a higher acceleration rate and braking effect and this sometimes provides marginal advantage, but the effects are so small that most this advantage is usually absorbed into the ‘make up’ time built into timetables to improve service reliability.

The use of express trains is often pursued as the cheapest means of delivering journey time benefits where there is spare track capacity. Eventually however, as train volumes increase, the strategy of using express trains leads to a premature need for track amplification (ie third track) and at this stage will turn into a very expensive solution (Refer to Section 5.2).

The solution is to undertake an audit of passengers’ total journey time from door to door and to explore how the total journey may be made shorter. This opens up consideration of the following issues:

- Use of express train services where track capacity will allow
- Removing some stations where demand is low or they are close to other stations. Fewer stops on a route translates to shorter journey time
- Improving the frequency of connecting public transport services (usually buses). The general rule to ensure the best possible bus service is that buses connecting to rail services should operate the same service frequency as

rail and should coordinate with the rail timetable in order to minimise interchange time and make journey time more predictable. Modal interchange connection time at stations, both origin and destination, is a significant portion of the journey and can sometimes represent 30% or more of the total journey time depending on the trip duration

- The location of stations relative to population centres and destinations (discussed further in Section 6.3 below).

6.2 Improving service reliability

Service reliability is often cited by commuters as one of their main concerns about public transport. The level of service reliability is usually inversely related to the how closely the network is operating to its capacity. Because trains follow each other along a single track, with limited overtaking opportunities, then delay to one train will affect the following train(s), depending on how close they are behind. This situation is exasperated when sections of single track are encountered where late trains in opposing directions have the opportunity to affect each other. The single track sections between North and South Junctions, and MacKays Crossing to Paraparaumu are classic examples of this problem.

Another cause of service reliability issues is the complexity of train timetabling. It is noted that train timetabling for the Western Corridor is extremely complex with a mixture of express and stopping services, three different train turnback points, regional passenger services and freight trains all mixed in the same corridor.

Finally, most suburban rail systems have identified that the operation of freight train services through peak periods is a major cause of service unreliability. The fact that these trains are generally slow moving, more so with the gradients and tunnel speed restrictions experienced on the Western Corridor, and are notoriously poor timekeepers in their own right. While it is acknowledged that both Tranz Rail and Toll Rail have customer commitments that require it to meet ferry sailing times, which in turn, require a train arriving during the morning peak. It does not make sense to jeopardise the delivery of suburban rail services in order to accommodate this requirement. Other solutions need to be found. Significant volumes of freight business are required in order to justify a dedicated route through the metropolitan area, and this is unlikely to be justified in the Wellington situation. The option of a curfew on freight train operations during the peak periods is the solution adopted by most metropolitan rail networks.

6.3 Improving accessibility

Improving accessibility is a key issue affecting the delivery of future patronage growth of the rail corridor. All the discussion to date has related to constraints on the network and the potential solutions in order to carry more passengers. However, no additional passengers will be carried unless commuters perceive that the service offers a viable alternative to road. Possible improvements to the rail network to attract people out of their cars and onto trains include:

Increasing train frequencies – Increasing train frequency improves the travel choices available for travellers and ensures a better probability that a train will operate at a time close to the preferred time of travel. As service frequencies increase to around 10 minutes or better, passengers begin to disregard timetables and arrive randomly at stations with an expectation of not having to wait long for the next train. Increasing train services requires infrastructure upgrades to improve capacity and the acquisition of additional rollingstock.

Electrification extension from Paraparaumu to Waikanae – previous studies have established that electrification of the existing track from Paraparaumu to Waikanae, including station modifications at Waikanae to facilitate suburban train terminations, can be undertaken without the need for additional rollingstock or track duplication. This project would place rail services within easy reach of people living at the northern end of the Kapiti Coast and thus lead to potential additional rail demand. There would also be a degree of demand transfer with people who currently drive to Paraparaumu to use the suburban train service now catching it from closer to home.

Additional stations – By adding stations close to residential and other travel nodes there will be an increase in the number of people within walking distance (about 400m to 800m) of a station. These new stations may generate some transfer of demand from other stations where these passengers already travel an extended distance to use a park and ride facility. Additional stations have been proposed at Cruickshank Road, Raumati, Lindale, Timberlea, Glenside, Newlands, MacKays, and Aotea. It should be noted that the greater the number of stops that are incorporated into train timetables then the longer the journey time which works against the objectives discussed in Section 6.1 above.

Additional parking at existing stations – The provision of parking translates directly into passenger journeys. However the ratio of passenger generation to car parking spaces provided is low, close to one passenger per space. Therefore car parking becomes a necessary evil and is generally provided where the cost of doing so is low and the land has a low opportunity cost related to other potential uses.

Additional public transport services to, and from, stations – the use of public transport to get people to stations is generally preferred to the option of providing huge car parks. The trick here is to make the transport as attractive as possible with frequent services and short and predictable interchanges with rail. There is a low capital cost associated with establishing bus services but the frequency of service has a marked impact on ongoing operating costs. Light rail is often considered as an alternative but this is both expensive to install and costly to operate and can generally only be justified where usage will be fairly intense. It is not well suited as a feeder service to rail stations.

Travel Information – people express a desire to access timetables and other travel choice information prior to their journey, and to receive basic real time information during their journey, such as when the next train or bus (in the case of modal interchange) will arrive and whether it has been delayed and by how long. This information is available via the internet and with handout timetables but the need is simplified if a memory or clock face type timetable can be installed. The real time information requires the installation of specific technology and display screens at railway stations and feeder bus stops.

Improved modal interchange facilities – the exchange between modes at railway stations is an important part of the travel experience. The needs of people at modal interchanges relates to minimum dwell time (previously discussed), shelter and information (previously discussed). The issue of shelter relates to providing some protection from the elements and somewhere comfortable and safe to wait. Treatments include bus terminals but should also consider the walk from one mode to the other.

Encouraging higher density housing around stations – this is about creating demand by increasing the number of people living within close proximity to station. These transit orientated cities feature high density housing, easy access to public transport and de-emphasise car usage (reduced garage space, traffic control measures in roads etc).

7. Assessment of improvement strategies

The Western Corridor Transportation Study (WCTS) has developed a comprehensive suite of strategies that could be employed to assist growth in rail patronage and deliver the necessary capacity to support this (refer to Table 3 below). The following sections of this report examine each of these and conclude as to which strategies are likely to be effective in achieving the goals. Those found to be ineffective or of low relevance, will be eliminated from further consideration when formulating future rail scenarios in latter sections.

Table 3: Improvement Strategy Elements

Reference	Element Description
Track Improvements	
RT1	Double Track between North and South Junctions
RT2	Double Track between MacKays Crossing and Raumati
RT3	Double Track between Raumati and Paraparaumu
RT4	Double Track between Paraparaumu and Waikanae
RT5	Double Track between Waikanae and Otaki
RT6	Double Track between Otaki and Auckland
RT7	Passing Loops at Various Locations
RT8	3rd Dedicated Freight Track
RT9	4th Track
RT10	Grade Easing
RT11	Curve Easing
RT12	Heat Restrictions
RT13	Weight Restrictions
RT14	Improve Structure Gauge for Freight Tunnels/Veranda
RT15	Improve Signalling
RT16	New Stabling North of Waikanae
RT17	Rail Corridor Along Transmission Gully Route
RT18	Porirua – Hutt Valley Route
RT19	Connect Johnsonville Line to Northern Trunk Route at Tawa

RT20	Kapiti Coast Loop (Raumati-Waikanae section)
RT21	Akatarawa Rail Route
Electrification Extension	
RE1	Extension of Electrification to Waikanae
RE2	Electrification Extension to Otaki
Stations & Modal Interchanges	
RS1	New Rail Station at Lindale
RS2	New Rail Station at Raumati
RS3	New Rail Station at Aotea
RS4	New Rail Station at Glenside
RS5	New rail Station at Newlands
RS6	New Rail Station at MacKays Crossing
RS7	Removal of Muri/Pukerua Bay Station
RS8	Removal of Redwood/Takapu Station
RS9	Park and Ride Capacity Improvements
RS10	Bus Interchange at Lindale
RS11	Bus interchange at Porirua
RS12	Improved Cycle Storage at Stations
Train Upgrades	
RU1	Upgrade of Train Units
Railway Management	
RM1	Improved Rail Frequency on Existing Infrastructure
RM2	Management of Rail Priorities – Freight Secondary to Commuter Trains
RM3	Fare Levels and Structures – Integrated Ticketing
RM4	Freight Rail Diversion Through Wairarapa
RM5	Integrated Scheduling
RM6	Free Carriage of Bicycles
RM7	Passenger Real Time Information
Light Rail	
LT1	Light Rail Beyond Plimmerton on Existing Track
LT2	Whitby Light Rail
LT3	Paraparaumu Beach Light Rail
LT4	Sky Rail
LT5	Paekakariki-Lindale Tram

7.1 Track improvements

7.1.1 RT1 - Double track between north and south junctions

Double tracking between North and South Junctions is not an enabler for improving service frequency for trains operating to Paraparaumu until service frequency moves towards 10 minute spacing. This is extremely optimistic in view of the population forecasts provided for use by this study.

However, North/South junction has a significant affect on the achievement of service reliability.

A number of reports have been undertaken on the costs of duplicating the track section with all reports identifying significant costs and risks which reflects a lack of detailed engineering assessment undertaken to date, issues related to expected difficulties with ground stabilisation, dealing with large quantities of cut, and environmental issues.

Any railway operator would like to see the elimination of sections of single track located in the middle of double track corridors. Unfortunately, the costs associated with the works in this case are likely to be extremely difficult to justify purely on the basis of service reliability. The single track sections only become a serious constraint on capacity if service frequencies, to either Paraparaumu (or Waikanae if electrification is extended), are improved to about 10 minutes.

7.1.2 RT2 - Double track between MacKays Crossing and Raumati RT3 - Double track between Raumati and Paraparaumu

Analysis of train operation has disclosed that the extension of the double track beyond MacKays crossing is not required to support existing levels of rail service. However, during peak periods, such an extension could have marginal benefits in terms of recovery from out of course running, particularly in relation to the passage of freight trains and regional passenger trains. The benefits in this regard are minor and are not sufficient to justify the expenditure involved.

Should train frequency to Paraparaumu be increased beyond the existing 5 per peak period then it may be necessary to undertake some track duplication.

Before making a decision to undertake the duplication, the full range of operational options should be explored first.

Train operation analysis detailed in Appendix A identifies that it is not possible to increase EMU service frequency to Paraparaumu to 3 trains per hour (ie 20 minute service frequency) without either:

- Accepting a low level of service reliability as a result of a tight cross at MacKays Crossing and compressed turnaround times at Paraparaumu, or
- Duplicating at least some of the track between Paraparaumu and MacKays Crossing, with the preference being to extending the double track at the MacKays crossing end by at least 1km, or
- Flighting trains schedules, by bringing trains into service during the peak from a new storage sidings at Paraparaumu, thus reducing the number of counter peak moves on the single track section, or
- Combining two outbound trains to be split at Paraparaumu to form two separate departures, thus reducing the number of counter peak moves on the single track section, or
- Installing stabling sidings at Paraparaumu to reduce the counter peak flows and tack pressure off the single track section.

Accepting a lower level of service reliability is unlikely to be supported as a solution by train operators, or greeted warmly by passengers and therefore is not considered further.

Combining outbound trains reduces pressure on the single track section by reducing counter peak flows but is limited by storage space at Paraparaumu platforms. In order to support this solution, and with consideration of the fact that the provision of an additional service will require an additional train set that must be stored somewhere, then the lowest cost location to provide the additional storage is likely to be at the existing stabling sidings at Paekakariki.

The alternative would be to provide a stabling siding at Paraparaumu and avoid the need to combine any outbound train services. The provision of this siding is expected to be more expensive than an option of extending the existing sidings at Paekakariki because of the need to install it off the mainline and hence this will involve signalling modifications. If this option is advanced it is suggested that the siding be placed to the north of Paraparaumu rather than adjacent to the station in order to avoid compromising park and ride facilities. This will require a short length of electrification of the mainline.

Analysis contained in Appendix B indicates that the extension of rail service to Waikanae may place new demands on this section of single track. This issue will be considered as part of the element RE1 Extension of Electrification to Waikanae in Section 7.2.1 below.

The conclusion to be drawn is that there are cheaper alternatives available to provide incremental increases in train frequencies to Paraparaumu than to duplicate the track for the full distance between MacKays Crossing and the future site of the proposed Raumati South Station and/or the full distance between MacKays Crossing and Paraparaumu.

7.1.3 RT4 - Double track between Paraparaumu and Waikanae

This option provides minimal benefits for the operation of regional train services. It would only be considered should the suburban rail services be extended to Waikanae.

Duplication of the track is considered as part of the element RE1 Extension of Electrification to Waikanae in Section 7.2.1 below.

7.1.4 RT5 - Double track between Waikanae and Otaki

This assumes that suburban rail operations are extended to Otaki and a better than 20 minute service frequency is to be provided. The first step may be to provide a crossing loop midsection as a lower cost preliminary stage.

The issue of providing suburban style rail services to Otaki will be dependent on demand. Project population analysis suggests that the population base at Otaki is insufficient to justify such capital investment. (Section 7.2.2 addresses this issues further).

7.1.5 RT6 - Double track between Otaki and Auckland

This section of track is outside the study area. Duplication of this track only assists regional passenger trains and freight trains. The affect of the duplication would be to increase track capacity and improve service reliability.

The primary impact on the study area would likely be an improvement in the presentation of regional services on-time at the suburban boundary which would in turn improve the service reliability for suburban services as a result of a more predictable interaction between services.

Duplication of the track would be extremely expensive and would deliver only minor improvements in service performance of the suburban network. It may be better to focus on providing infrastructure within the suburban area that provides this function of giving operational flexibility and allowing better recovery from out of course running.

7.1.6 Passing loops (RT7, RT8, RT9 & RT20)

RT7 - Various locations

Passing loops are generally installed on single-track railways to allow two trains to either pass in opposing directions (crossing loop), or overtake in the same direction (overtaking track).

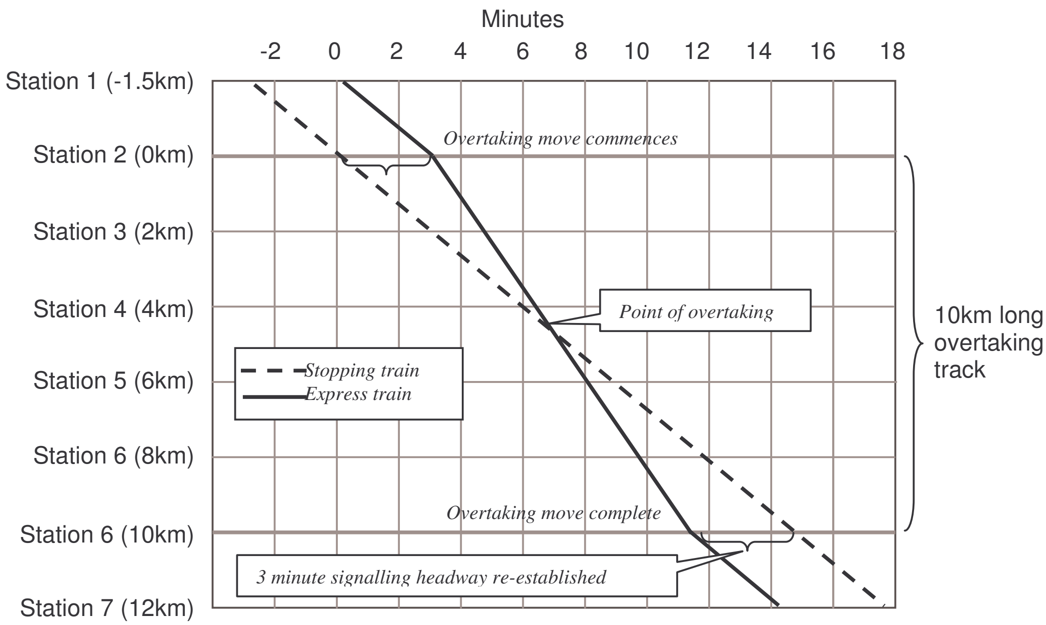
Crossing loop length is determined by the length and speed of the trains that they are intended to service. In freight applications the loops need to be not much longer than the length limit for the trains because it is normal for the train placed into the loop to be brought to a stand whilst the opposing train runs past. This arrangement of bringing one train to a standstill is less attractive on suburban train systems because of the additional time it places into timetables. In order to schedule a running cross with any reliability the crossing loop would need to be in excess of 1km in length. One way of overcoming this is to locate the crossing loops at stations where one or both trains may be stationary but this is more expensive because a second station platform face is required.

In addition, it is not as simple as this because the placement of crossing loops is critical to the design of the timetables in respect to service frequency. The major disadvantage of crossing loops over double tracking is that they are inflexible. In other words they cannot usually accommodate changes to service density (changes to timetables move the desired crossing location along the track to a new location), and they usually feature as the cause of service reliability issues (delays to trains in one direction can transfer to trains in the other direction and continue to compound).

The single line sections in the Western Corridor are between North and South Junctions, and MacKays Crossing to Paraparaumu and beyond. Placing a crossing loop between North and South Junction would increase operational flexibility but given that this section is only 3km long and that the loop may need to be at least 1km long in order to allow running crosses then this does not seem to represent an effective solution. The single line section between MacKays Crossing and Paraparaumu is 6.5km long and to Waikanae 14km long and this presents a better opportunity for the use of crossing loops. Whilst the placement of crossing loops will be considered as part of the operational analysis, it is expected that they will not provide a suitable solution for a suburban rail system such as that on the Western Corridor.

The use of an overtaking track is completely different proposition to crossing loops. Overtaking tracks are used to allow one train (usually an express service operating in the peak flow direction) to overtake a slower (stopping) service. The track would be signalled for bi-directional operations and be operated in the peak flow direction (ie inbound in the morning peak and outbound in the evening).

Previous research into the use of overtaking tracks has consistently identified the need for the track to be around 10km long. This may seem an extraordinary length so further explanation is provided below using a time distance graph and assuming station spacings of about 2kms:



Assumptions:

1) Stopping train average speed assumed to be 40kph (including station dwell times). Note: Current timetables in the corridor provide for 42kph average speed for stopping trains.

2) Express train average speed of 70kph. Note: Current timetables provide for 70kph. Note: Current timetable provide for 56kph between Plimmerton and Wellington although this appears to be conservative. A slower express train speed will require a longer overtaking track.

3) Signalling headway of 3 minutes (including provision for service reliability). If more time is required to ensure service reliability then the overtaking track will need to be longer.

Put into context, this represents the distance between say Plimmerton and Tawa and is a substantial proportion of the corridor length over which express trains operate. Furthermore, the overtaking track could be expensive to construct due to the nature of the terrain in the corridor and would need to be physically located north of Takapu Road to avoid the tunnels and south of Plimmerton where the first express services are scheduled. There are a number of corridor constraints in this section including the bridge over Pauatahanui Arm (Porirua Harbour) and the narrow reservation available for road and rail along the edge of Porirua Harbour, north of Porirua. In addition, every station will need to be modified to provide for the additional fast track given that its ideal alignment is between the two slower tracks. Assuming an order of magnitude construction cost of $20M per kilometre, this represents an investment of $200m in order to provide a time gain of 6 minutes for express train passengers (ie only those passengers that live north of Plimmerton and only during the peak periods).

Review of current timetables show that express trains between Plimmerton and Wellington are only scheduled 3 minutes faster than stopping trains. At this speed they will not complete the overtaking move within 10km and it will be necessary to also undertake speed enhancements in addition to provision of the third track (refer to RT10 to RT13 below).

It should be noted however that if an overtaking track is not provided and the practice of operating some trains as express services continues, then this will reduce the throughput capacity of the corridor compared to a situation where all trains are scheduled to stop at all stations. A solution is to ensure that all trains operate at comparable average speeds in the corridor by running them all as stopping all stations or introducing a skip stop pattern where alternate trains service every second alternate station.

Given the high cost of providing an overtaking track, and the limited benefits it will provide it is not intended to pursue this option further unless it becomes essential in order to deliver travel time savings, or if track capacity issues between Plimmerton and Wellington demand it.

RT8 - 3rd dedicated freight track

The purpose of a dedicated freight track is to separate freight trains from suburban trains in order to:

- Release track capacity for suburban operations as slow moving freight trains require a large gap between the suburban services
- remove the potential for service reliability impacts as a result of the poor time keeping and performance of freight trains.

Such a solution is normally applied where the demand for freight trains services to operate during suburban peak times is high. An example of this would be the southern approaches to Sydney where freight train services are currently excluded from entering Sydney via this route during peak periods (refer to Section 7.5.2 for further discussion on Train Management issues).

The cost of providing an independent freight track can be extremely high and in the case of Wellington, the issues associated with terrain (eg tunnels) and corridor width are expected to make this prohibitive for the foreseeable future, and definitely beyond the capacity of Toll NZ to fund from its freight business. At present this problem extends to only one freight train that is scheduled to arrive during the early part of the morning peak.

RT9 - 4th track

It is not proposed to consider this element further. Four track solutions are only applied in high demand corridor (with number of trains per hour exceeding about 30 whereas the Western Corridor has about 9 trains per hour). Solutions such as full double track would be applied in the first instance followed by a third track.

RT20 - Kapiti Coast Loop (Raumati-Waikanae section)

This section of the rail corridor is single track and all trains will be operating as stopping all stations services. Consequently this project element refers to the need for a crossing loop. This issue will be considered as an option when assessing capacity issues associated with increasing service frequencies and/or extension of electrification to Waikanae.

7.1.7 Rail track improvements to increase speed (RT11, RT12 & RT13)

RT10 - Grade easing

It is noted that the maximum gradient in the corridor is 1:57 near Pukerua Bay. This is not particularly steep for suburban trains and much steeper gradients are experienced on the Johnsonville line. The acceleration characteristics of electric traction motors is such that performance is not greatly compromised up hills of this magnitude and they will gain a little coming down the other side. Even if the hill were to be removed completely, the gains in running time will be measured in seconds rather than minutes.

There are significant benefits to freight trains because gradients limit the size of the load that can be hauled for a given motive power allocation. As this represents a direct benefit to the freight business then Toll NZ should finance any such project from the benefits gained. A secondary impact is that the gradient (and usually associated curves) slow the freight trains down. As a freight train operating between faster EMU suburban trains slows, track throughput capacity is reduced. This can be accommodated by either leaving a sufficient headway between suburban trains or by excluding the freight train from operating at critical suburban operating times. Further, there is a greater probability that freight trains will break down when straining up hill and this can have significant repercussions on suburban operations, which ads to the argument to remove freight trains from peak period operations.

The removal or easing of gradients is a very expensive exercise to do because of the amount of earthworks required over a significant distance. Furthermore, it is difficult to undertake such projects whilst keeping the line open and where such works have been undertaken, it usually accompanies a new alignment.

It is not considered that gradient easing be considered further unless it is associated with an option for a new alignment (eg a new route to avoid the North/South Junction area).

RT11 - Curve easing

The speed of trains around curves is restricted because the forces can lead to passenger discomfort and possible derailment. The tighter the curve, the lower the speed limit. There are numerous tight curves on the Northern Trunk, some with radii as tight as 190m, which is getting close to the tightest curves normally found on standard rail systems. Nonetheless most curve speed restrictions do not fall below 60km per hour.

The area where the greatest potential to increase speed lies between Muri and North Junction (5km) where track speed restriction as low as 40kph apply.

Simulation has been used to estimate the impact of upgrading this section of track to a 60kph restriction and it was found that the total saving in running time would be 1.5 minutes. It is noted that the practicality of easing these speed restrictions is low given the nature of the terrain, and would require significant infrastructure works are undertaken at high cost.

The conclusion is that easing of curves to enable higher running speeds is very expensive to achieve but provides potential savings in train running time. However, unless a significant number of curves are eased with major (and expensive) deviations then it is considered that any small saving will be absorbed into the timetable and used to offset service reliability rather than providing an advertised reduction in journey time.

RT12 - Heat restrictions

Heat restrictions are generally temporary in nature, applying on days of high temperature when heat expansion of the rails can lead to buckles that can derail trains. The need for heat restrictions is usually as a result of poor track maintenance practices and is not normally necessary for track that complies with internationally accepted engineering construction and maintenance standards.

It is understood that the Wellington system has had some issues with heat related incidents in recent years but it is believed that these issues have now been rectified and that this is no longer a major issue.

7.1.8 RT13 - Weight restrictions

The issue of improving track condition works in one of two ways:

- The improved track would be able to accommodate higher axle loads, but this only really aids freight trains as it allows a marginally greater payload per wagon and will have little affect on the capacity of the corridor
- The improved track would allow higher maximum speeds for light axle load vehicles such as the suburban EMU trains. To test the sensitivity of running times to this issue, a computer simulation has been set up to replicate existing operating conditions. The parameters were then changed to allow an increase in maximum line speed by 10kph. The result was that total transit time between Paraparaumu and Wellington improved by only 35 seconds. The reason for the small change is that suburban trains only have the potential to reach maximum line speed at three locations along the track due to other restrictions relating to curves, junctions and station stops. These locations are between Paraparaumu and Paekakariki for 8km, between Paremata and Porirua for 1km and in Tunnel No.2 for 2.5km. It is important to note that in order to take advantage of the higher speeds it would also be necessary to confirm the impact this would have on traction motors and ride quality of the suburban trains.

It is concluded that improvements in track quality to allow higher maximum operating speeds will not deliver significantly faster transit times, but the benefits may still be worth pursuing where this allows a better recovery margin for late train running.

7.1.9 RT14 - Improve structure gauge for freight tunnels/veranda

Current freight train operations are affected by a loading gauge restriction relating to the ability to carry containers higher than 2.9m (9’6”), and also placing speed limitations on freight trains carrying containers higher than 2.6m (8’6”) on most wagon types through the tunnels in the section between North and South Junctions as follows:

Container Height	Wagon Types	Speed limit through tunnels
2.6m	Some wagons	15 kph
2.6m	Most wagons	25 kph
2.9m	Limited wagons	25kph

In addition there are speed limits of between 15kph and 55kph for some wagonloads past the verandas at Plimmerton and Linden stations.

The above information affects the capacity of the rail corridor in two ways.

- The speed limit means that freight trains need to slow down relative to suburban services resulting in reduced track capacity. However, the speed of freight trains over the track section will remain low even if these restrictions are removed due to an absolute speed restriction of 50kph applying between North and South Junctions, and the fact that freight trains working towards Wellington are negotiating a steep gradient that constrains practical operating speeds. The issue of freight trains operating during peak periods is addressed further in element RM2 below although it is undesirable for freight train movements such as these to be mixed amongst peak period suburban train operations
- Restrictions on the carrying ability of wagons means that freight must be packaged in smaller containers thus potentially increasing the number of loads to be carried and perhaps leading to an additional train. The effects here are extremely minor and will not be pursued further.

In essence, easing of rollingstock clearance constraints will financially benefit the freight train operator but will have little impact on track capacity, or journey times, for suburban peak operations. Therefore this issue is not pursued further.

The only other perceived reason for increasing clearances is for the purpose of purchasing large rollingstock, particularly double deck carriages. This cannot be supported on the basis that existing trains are operating with 4 cars (and a couple of 6 cars) during the peak period, whereas the system could accommodate 8 car trains at relatively little cost (platform lengthening and electrical substation upgrades). It is noted that Sydney is currently considering moving back to single deck rollingstock due largely to station dwell time issues associated with peak loadings.

7.1.10 RT15 - Improve signalling

The Western Corridor utilises three primary signalling systems:

- Automatic signals on the double track sections where the signal aspects are automatically controlled by the passage of trains through electrical track circuits
- Centralised Traffic Control (CTC) on the single track sections where all signals and points are controlled remotely by a train controller in Wellington
- Specific junctions that are controlled by signal persons in local signal boxes such as Wellington Junction.

Generally speaking, the signalling design in the corridor is efficient in the handling of trains. Signal design, in particular the spacing between signals, determines the minimum achievable headway between trains. The minimum spacing between signals is determined by the speed of trains operating over the track section, and more specifically the stopping distances required from that maximum speed. Typical minimum train headways at EMU mainline operating speeds is around 2.5 to 3 minutes and this standard is achieved over much of the Western Corridor.

One solution to achieve closer headways is to slow trains down such that stopping distances are reduced and signals can be placed closer together. Although trains are travelling slower, they are closer together and therefore a higher service frequency is delivered. This approach is normally reserved for circumstances where intense rail operations occur and not to a whole corridor. This approach is not recommended for the Western Corridor due to the large distances involved and due to the focus on transit time in this Study in order to maintain rail market share against a road that may reduce in transit time as a result of upgrade works.

Another solution is to move to an entirely different signalling philosophy such as Moving Block. These types of systems are relatively new and have not been widely applied to long rail lines such as the Western Corridor. Such systems rely on maintaining a minimum safe stopping distance between trains by constantly interrogating the distance between the trains relative to their speed, and calculated stopping distance requirements, in real time. They are expensive to install and require in-cab signalling rather than line side signals.

One area where signalling systems cause delays to trains or slow them down is at junctions where the probability of interaction between trains is the greatest and trains must be slowed down to negotiate turnouts. Having sections of single track in the Western Corridor increases the number of junctions in the corridor compared to a situation where there is double track throughout. Therefore double tracking returns a much greater improvement to train throughput than tweaking the signalling system.

The opportunity exists to revisit the design efficiency of the signalling system as part of track amplification projects, when new or modified signalling equipment will need to be installed. As such, it is believed that there is little to be gained from redesigning the signalling system without doing this in conjunction with track infrastructure changes.

7.1.11 RT16 - New stabling north of Waikanae

If there is an increase in service frequency from outer areas or electrification is extended beyond Paraparaumu, then there is a strong probability that additional train sets will be required. This conclusion is based on the fact that a round trip to Paraparaumu takes in excess of 2 hours and the morning peak spans only about one hour making it impossible to reuse a train set for a second (additional) run. The situation is slightly different with trains originating at Plimmerton and Porirua where there is a possibility of a second peak period trip.

Existing train stabling for the Western Corridor is located at Wellington and Paekakariki.

There are a number of views as to the most appropriate location for train stabling. Historically train stabling has been located near the heart of networks (such as at Wellington). The alternative is to locate the train stabling towards the outer end of the line. This choice will be based on the following attributes:

Table 4: Advantages & disadvantages of centralised vs. decentralised train stabling

Location of Train Stabling	Advantages	Disadvantages
Centralised (eg Wellington)	• After the peak trains can be placed directly into storage as they finish their inbound revenue service • Trains can be placed directly into outbound revenue service for the evening peak • All trains from all lines stored together giving better flexibility in allocation of the fleet and allowing transposals to cover set failures.	• Morning peak hour trains may need to be worked empty to the end of the lines in order to run their first inbound revenue service • Evening peak hour trains may need to be worked back empty from the end of the lines in order to be stabled • Land has high value and opportunity cost leading to pressures for alternative development • Creates congestion at the central station junction by working sets to/from stabling during peak operating periods • Where there are capacity constraints such as single line sections working empty sets against the peak reduces corridor capacity
Decentralised (eg Paekakariki/Waikanae)	• Trains can be placed directly into outbound revenue service for the evening peak • After the peak trains can be placed directly into storage as they finish their inbound revenue service • Land is cheap and has a low opportunity cost • Corridor capacity is not affected by working empty sets to the end of the line against peak operations.	• After completing morning peak hour duties, the trains must be returned empty to the stabling facilities • Trains must be worked empty to the central area to run evening peak hour services • Fleet is stored at a number of locations reducing transposal options to cover set failures • A different approach is required to train maintenance

Placing sufficient stabling at the end of single line track sections (such as Paraparaumu) reduces capacity pressures on the corridor by reducing the volume of counter peak moves and could defer the need for crossing loops or duplication.

The establishment of a new stabling facility north of Waikanae is conditional on electrification extension to Waikanae. This element will therefore be considered as part of the element RE1 Extension of Electrification to Waikanae in Section 7.2.1 below.

7.1.12 RT17 - Rail corridor along Transmission Gully route

One option being considered for road is to use transmission gully as an alternative route for road traffic to take pressure off the existing congested sections of the road.

The rail route would depart from the Northern Trunk line near MacKays Crossing and rejoin it again around near Tawa. This option has a number of significant issues as listed below:

- Road gradients for this route are as steep as 8.5% (1:12) whereas the maximum rail gradient needs to be around 2% (1:50) for freight train operation
- The diversion would carry suburban trains for stations beyond MacKays Crossing only (currently only Paraparaumu). These areas do not have a sufficiently large enough population base to justify a 20 minute peak period train services (30 minute off peak) similar to what this area currently enjoys as a result of the trains being also used to service stations to the south of MacKays Crossing
- A similar density suburban rail operation would still be required on the Northern Trunk south of MacKays due to the existing population densities
- This route would allow freight trains to be largely removed from the suburban operations but at an extremely high cost.

It is proposed that this element receive no further consideration.

7.1.13 RT18 - Porirua to Hutt Valley route

The concept of a new railway line from Porirua to Hutt Valley would facilitate the movement of people between these two growth corridors. However a 2004 trail bus operation was unsuccessful at unlocking a suitable demand base and was discontinued.

This would not be effective at providing an alternative route for people in the Western Corridor to commute to Wellington due to the additional route distance. Nor does the route provide an alternative to resolve the existing capacity issues of the Western Corridor as these predominantly occur north of Porirua.

There are a number of engineering issues associated with the construction of such a railway due to access issues and steep gradients. Construction costs are expected to be extremely high given the anticipated need for numerous tunnels and bridges.

This issue should not be pursued further as part of the Western Corridor Transport Study.

7.1.14 RT19 - Connect Johnsonville line to northern trunk route at Tawa

The Johnsonville Line used to form part of the Northern Trunk route until the tunnels under Newlands (Tawa Tunnels) were completed in 1935 and the Johnsonville to Tawa section closed in 1937. At this time the line was truncated at Johnsonville and became dedicated to suburban rail operations. The Wellington to Johnsonville line is single track with crossing loops, has gradients in excess of 1:40 and follows a torturous route with sharp curves. There are 7 tunnels on the line with restricted clearances such that specialised EMU rollingstock must be utilised. The line operates through reasonably dense, mature residential areas and this would most likely frustrate any attempt to improve and extend the track.

Given that existing Northern Trunk Route through the Tawa tunnels is double track and does not present a capacity issue for the Western Corridor there is little reason to consider reconnecting the Johnsonville line.

7.1.15 RT20 Kapiti Coast Loop (Raumati-Waikanae section)

The establishment of a new passing loop between Raumati and Waikanae is conditional on electrification extension to Waikanae. The need for this element will therefore be considered as part of the element RE1 Extension of Electrification to Waikanae in Section 7.2.1 below.

7.1.16 RT21 Akatarawa rail route

This is a conceptual rail route that branches off the North Island Main Trunk line in the vicinity of Waikane and travels through the Akatarawa Valley via Cloustonville towards Brown Owl where it would connect with the Wairarapa line to allow trains to enter Wellington via Upper Hutt.

There are a number of reasons why this solution should not be considered further in this study as listed below:

- The alignment traverses difficult terrain which will require expensive tunnelling and bridging to provide suitable gradients
- The route is about 25km long and could cost more than $300M to construct
- The route does not provide an alternative for commuter rail traffic because it branches from the Northern Trunk too far to the north, beyond the main catchment area for commuter traffic and suburban development
- The route would provide an alternative access to Wellington for freight trains but the torturous route and the need to interface with the suburban operations out of Upper Hutt provides little advantage over the Northern Trunk access.

7.2 Electrification extension

7.2.1 RE1 Electrification Extension to Waikanae

Waikanae is the next major town to the north of Paraparaumu and is seen by many as the next potential extension to the suburban electrified area along the Northern Trunk.

According to the 2001 Census, the population of the Waikanae area (including Waikanae Beach) was around 9,500 people with a growth rate of about 2% per annum. This also represents a fairly geographically dispersed population. It is quite small for justifying the costs of an electrification extension, especially if track duplication is also required. By example, in Melbourne, an extension of the electrified network from Dandenong to Cranbourne (12km) was undertaken as single track (electrification of an existing track) when the population base was low, about 15,000 in the early 1990's. It was recognised however that this area would become a significant urban growth corridor. By 1996 the population had increased to 25,000, by 2001 it had reached 34,000 and it is expected to reach 125,000 by the year 2020. No such growth is expected in the Waikanae area.

Paraparaumu to Waikanae Option

Waikanae is currently serviced by a range of transport choices during the peak hour including one rail service operated by locomotive hauled rollingstock, 4 bus services connecting to electric trains at Paraparaumu, and three commuter bus services direct to Wellington (arriving before 8.00am). These services are summarised below:

Table 5: Waikanae public transport – morning peak services

Service Origin	Type	Depart Waikanae	Arrive Wellington	Journey Time
Waikanae Beach	Commuter bus direct	05.55	07.15	1hr 20mins
Waikanae Beach	Commuter bus direct	06.15	07.30	1hr 15mins
Waikanae Beach	Commuter bus direct	06.25	08.00	1hr 35mins
Waikanae Beach	Bus feeder to electric train	06.40	07.52	1hr 12 mins
Waikanae Beach	Bus feeder to electric train	07.03	08.08	1hr 5mins
Otaki	Bus feeder to electric train	07.05		
Waikanae Beach	Bus feeder to electric train	07.22	08.32	1hr 10mins
Palmerston North	Locomotive hauled train	07.27	08.21	54 mins
Waikanae Beach	Bus feeder to electric train	07.44	08.51	1hr 7mins

There are some interesting service anomalies such as the 06.25 direct bus arriving Wellington 8 minutes after the 06.40 bus link to the electric train, and the 07.22 bus link to the electric train arriving 11 minutes later than the 07.27 locomotive hauled train.

If the railway line was to be electrified and the suburban train services extended, then there would be a reasonable expectation that the new service would be as good as, or better than, the service currently offered. Service quality can be defined as a combination of the following factors.

Passenger Amenity – the differential between bus and train will be predominantly related to the portion of the journey between Waikanae and Paraparaumu, assuming an interchange will be required at the railway station in both cases. Generally, passengers express a preference towards rail travel over bus so it is reasonable to assume that extension of the electrification will be regarded as an improvement. In fact, passengers living within the Waikanae station area may no longer need to have involvement with buses or the interchange process and will perceive a substantial improvement in amenity. On the other hand, most people using the locomotive hauled train will regard the special environment as providing a level of comfort over and above the suburban trains with larger more comfortable seats and other facilities, and as a result may be reluctant to transfer services.

Journey Time – Journeys involving a bus feeder to a train service takes on average 1hr 7mins between Waikanae and Wellington compared to an estimated peak hour rail time from Waikanae of 57mins (assuming a 5 minute running time between Waikanae and Paraparaumu) giving a journey time saving of around 10mins. In the case of comparing the journey time for the direct bus service from Waikanae to Wellington, the train service could offer journey time improvements of between 18mins and 38mins, however walking distances in Wellington will vary depending on the final destination within the city for rail passengers as opposed to the bus dropping off in Courtney Place which is much more central (for people destined for Courtney place the bus may be about 10 minutes slower but it avoids the effort of the lengthy walk from the station).

Service Frequency – Waikanae passengers have a choice of 7 suburban services and one regional train service during the morning peak. This provides an average service frequency of about 20 minutes.

Service design will be critical to maintaining the existing passenger base and potentially attracting additional ridership. The ability to provide an acceptable level of train frequency will be constrained by the capacity of the rail track, with specific reference to the existing sections of single track.

The analysis in Appendix B identifies that the most frequent service level that could be provided out of Waikanae on the existing track infrastructure is 35 minutes or 4 trains during the morning peak (note that in this simplistic preliminary approach, consideration has not been given to the timetabling solution required in order to maintain service levels to other stations on the line). This would represent a significant reduction in service frequency and it would be necessary to retain some bus services to fill the gaps. Whilst this may initially appear attractive, a very irregular service pattern would be set up as a result of the bus service being 10 minutes slower than the train service. An example is produced in Table 6 below showing some clear difficulties with scheduling issues:

Table 6: possible public transport timetable without rail infrastructure improvements

Mode	Depart Waikanae	Arrive Wellington	Departure Service Gap
Electric Train ex Waikanae	06.03	07.00	n/a
Bus/Electric Train ex Paraparaumu	06.10	07.17	7mins
Electric Train ex Waikanae	06.38	07.35	28mins
Bus/Electric Train ex Paraparaumu	06.45	07.52	7mins
Electric Train ex Waikanae	07.13	08.10	28mins
Bus/Electric Train ex Paraparaumu	07.20	08.27	7mins
Electric Train ex Waikanae	07.48	08.45	28mins

The simplified approach to train scheduling ignores the likely service level impacts for other stations along the line. For example Paraparaumu currently enjoys a service frequency of around 25 minutes. In order to maintain a symmetrical timetable the service frequency would need to be either reduced to 35 minutes (using the trains originating at Waikanae, or improved to 17 minutes with every second train originating from Paraparaumu (thus providing an improved service level compared to the existing 25 minute frequencies). Appendix C shows one possible nested timetable solution that delivers this latter outcome using existing infrastructure. Note that it would be necessary to provide double track or a crossing loop between MacKays crossing and Paraparaumu in order to accommodate a regional passenger train through this peak hour pattern. It would also be necessary to install one additional stabling at Paekakariki to accommodate the additional train set anticipated to be required in order to operate the extended services.

An alternative service frequency scenario would be to provide the necessary infrastructure to enable a service frequency of 20 minutes at Waikanae (equivalent to the existing service level at Paraparaumu) potentially allowing the removal of all buses between Waikanae and Paraparaumu. This effectively means the extension of all train services that currently terminate at Paraparaumu through to Waikanae. Analysis in Appendix B identifies that it would most likely be necessary to duplicate the track between MacKays Crossing and Paraparaumu.

Note that the cost of such a service could be reduced if the double track is terminated about 1 km short of Waikanae thus avoiding the cost for new bridges across State Highway 1 and the Waikanae River and reducing the extent of new track alignment. This would not prohibit train timetabling but could reduce flexibility to recover from out of course operations.

There is a further option to develop a 20 minute service frequency by placing sufficient train stabling at Waikanae and avoiding the counter peak flow train operation requirements. A possible timetabling solution is explored in Appendix D. This would avoid the need to duplicate the track but a passing loop would be required at Paraparaumu Station.

The final issue to consider is the off peak service pattern requirements. Whatever infrastructure is provided for the peak period frequency must also serve to accommodate the off peak frequency requirements. The timetabling difficulty that arises that where the off peak frequencies do not match the peak frequencies therefore the location where opposing trains pass each other will change thus creating a different interaction within the single track sections. Current off peak rail services to Paraparaumu are scheduled at 30min frequencies but no consideration to date has been given to the service to be provided to Waikanae. The option could include:

- Operating a bus shuttle to connect to trains that terminate at Paraparaumu. This is dismissed because it does not utilise the new electrification extension and marginalises the benefits
- Reduce off peak rail service levels for the whole corridor to 35 minutes. Appendix B identifies that such an operation could be implemented without any additional track duplication costs. However this solution is dismissed due to the reduced service provision imposed on all off peak passengers in the entire corridor
- Operate trains at 30 minute frequencies to Waikanae. The analysis in Appendix B indicates that this level of service would require a short extension (about 1km) of the double track north of MacKays Crossing. This solution is not consistent with any of the solutions developed above for electrification to Waikanae
- Improve off peak service levels to match proposed peak hour Waikanae service levels. This will ensure that the same infrastructure requirements will suffice but will increase operating costs. This may not be justified against the potential to generate more patronage and hence revenue.

Conclusion

The recommended solution to apply for the extension of electrification of train services to Waikanae is as follows:

Table 7: Preferred Waikanae electrification option

Infrastructure/Operations Component
Apply a 20 minute service frequency (requires one additional train set)
Electrify the existing track configuration between Paraparaumu and Waikanae
Modify Paraparaumu station and provide a crossing facility (island platform)

Extend the double track about 1 km to the north of MacKays Crossing (to facilitate off peak frequencies)
Provide a new station at Waikanae
Construct 2 train stabling sidings at Waikanae

Paraparaumu to Lindale Option

Extension of the electrified rail service only as far as Lindale is discussed further in Section 7.3.10, RS10 - Bus interchange at Lindale.

7.2.2 RE2 Electrification extension to Otaki

In order for electrification to be extended to Otaki, it is first necessary to justify extension from Paraparaumu to Waikanae (refer to Section 7.2.1). There are large areas of undeveloped flat land around, and to the north of, Waikanae that one would expect to be developed first rather then the development of Otaki which is a further 15km from Wellington.

The cost of electrification will make it difficult to justify and options such as buses and perhaps diesel rail services should be considered as an initial stage to development of the transport services to Otaki.

In 2001, Otaki had a population of around 5,600 residents with population growth between 1996 and 2001 being 1.1%, whereas the Kapiti Coast District grew by 11.5% with Waikanae Beach for example growing at 22%. Immediately to the north of Otaki, populations are falling in the vicinity of 2 %pa.

These statistics indicate that Otaki cannot be seriously considered as having a strong enough population base to justify electrification of the rail line.

7.3 Rail stations and modal interchanges

7.3.1 RS1 - New rail station at Lindale

Considered to be an option to providing additional car parking spaces at Paraparaumu, where there is limited ability to provide additional parking. Requires an extension of the electrified rail network and could form part of a project to electrify to Waikanae. Refer to discussion in RS10.

7.3.2 RS2 - New rail station at Raumati

This is an alternative approach to providing additional park and ride capacity to supplement Paraparaumu. Has some benefit in that it may capture additional ridership as people from the Raumati area need to travel ‘backwards’ to join train services at Paraparaumu.

7.3.3 RS3 - New rail station at Aotea

Aotea is located between Paremata and Porirua. There is potentially a very small catchment area with one side of the line bounded by Porirua Harbour. There will be significant access issues with the residential areas being separated from the station by the freeway and ramps for a major road interchange.

7.3.4 RS4 - New rail station at Glenside

This proposed station site is adjacent to the northern portal of No2 Tunnel, south of Takapu Station. There appears to be little hinterland from which this station can draw patronage. It would take significant development to occur north of Glenside in an area that is not necessarily suitable for urban development due to terrain and flora reservations.

7.3.5 RS5 - New rail station at Newlands

Newlands is located directly above the middle of No2 Tunnel. It would require the construction of an underground station with significant vertical distance issues. There will be significant costs associated with excavating the station site.

7.3.6 RS6 - New rail station at MacKays Crossing

There is currently a lack of any significant population base in this area and its distance from Raumati, its nearest source of significant population, would be better served by RS2, a new rail station at Raumati.

Conclusion relating to new stations

Modelling using the GWRC Transport Model has indicated that the benefits in patronage demand improvement generated by the presence of each of the new stations is insufficient to offset the loss of modal share from stations further along the track as a result of the resultant increase in journey time, and as a result is unlikely to justify the capital investment involved. It would appear that the major issues contributing to this outcome are:

- Low population densities in the areas surrounding the proposed stations
- Some stations, such as Raumati, have a high transferral of passengers from existing stations rather than generating new demand
- Each time a train is stopped it adds about 1 minute to the transit time of all passengers on the train from further along the line
- A typical station is likely to cost in the order of $3M to provide.

For these reasons, the establishment of additional stations is not a recommended solution.

7.3.7 RS7 - Removal of Muri/Pukerua Bay Station

These stations are located very close together, separated by less than 900m. Muri station has no parking facilities and as such can only service residential areas within walking distance. There is only low density housing in the immediate area of Muri Station and as a result there is very low patronage history for the station. It is not easy to access Muri Station from the main road and it cannot provide a park and ride function.

It is considered that the closure of Muri Station could be supported in order to reduce the transit times of passengers on trains originating from Paekakariki in the peak (Paraparaumu trains run express), and for all stations to the north during off peak periods.

The estimated time saving is expected to be in the order of one minute per train.

7.3.8 RS8 - Removal of Redwood/Takapu Station

These stations are located very close together, separated by less than 1km. Takapu station has limited parking facilities and as such can only service residential areas within walking distance. There is only low density housing in the immediate area of Takapu Station and as a result there is very low patronage history for the station.

It is considered that the closure of Takapu Station could be supported in order to reduce the transit times of passengers on trains originating from Porirua in the peak (Paekakariki and Paraparaumu trains run express) and for all stations to the north during off peak periods.

The estimated time saving is expected to be in the order of one minute per train.

7.3.9 RS9 - Park and ride capacity improvements

The provision of park and ride facilities is an enabler to capturing people who use cars to commute. There is a strong relationship between train patronage and the number of car parking spaces provided at a station. However providing limited spaces will not boost train ridership but if insufficient spaces are provided then this will limit ridership.

It will be necessary to determine the number of additional park and ride spaces that will need to be funded as a result of patronage growth flowing from the solution adopted. The methodology proposed is to establish the ratio of existing parking spaces to outward journeys and to apply this to the forecast patronage to calculate the future requirement.

7.3.10 RS10 - Bus interchange at Lindale

The establishment of a new station and bus interchange at Lindale could be conditional on electrification extension to Waikanae, or could be provided as an alternative to terminating trains at Paraparaumu. Extension of Electrification to Waikanae is considered as part of the element RE1 in Section 7.2.1.

There is a view that further development of Paraparaumu station as a major interchange may be constrained by the poor access for buses and other vehicles through the rail crossing and across the main highway if SH 1 was to remain at grade.

It is possible to consider the role of Lindale Station as a new transport hub with a short extension of the electrified rail network beyond Paraparaumu. The concept would be to reroute the regional bus services to Lindale instead of

Paraparaumu. The development of Lindale station would then include a significant modal interchange facility. It would also be necessary to construct a spur off the mainline into the back platform to allow trains to stand clear of the mainline whilst being turned back.

This approach may appear attractive to passengers on buses originating from Waikanae and Otaki because there is a potential to provide much improved facilities. Also journey times may be reduced marginally by removing the need to negotiate congested roads into Paraparaumu. However, diverting the Paraparaumu and Raumati buses out to Lindale will take them in the opposite direction of travel to the peak commuter flows and will therefore add time to the journey (perhaps as much as 3 or 4 minutes).

Finally, the movement of the terminating station further to the north will place further pressure on the now longer single track section between Lindale and MacKays Crossing and may add weight to an argument to extend double track to the north of MacKays Crossing in order to maintain service reliability.

The likely high cost of this solution and the disadvantages it poses over the current arrangement, suggests that better value for money may be obtained from upgrading Paraparaumu instead, even if this involves the establishment of a multi-storey transport facility.

7.3.11 RS11 - Bus interchange at Porirua

There is already a significant bus interchange at Porirua with buses connecting with some trains during the peak period. Upgrading of the facility could provide a high level of passenger comfort and reduce the possibility of people choosing to use motorcars instead. The upgrade of modal interchange facilities generally is important to ensure that rail patronage is retained when the road is upgraded.

The nature of improvements could include provision of covered walkways to link the bus stops to the station and a more substantial weather protection in the area where buses load and unload.

7.3.12 RS12 - Improved bicycle storage at stations

This is a fairly small issue given the low degree of bicycle usage. This could be due to the distances involved, the hilly nature of much of the corridor and the weather conditions.

The upgrade of bicycle facilities forms part of a more general upgrade of modal interchange facilities and the costs used for these facilities would be sufficiently large to incorporate bicycle requirements.

7.4 Train upgrades

7.4.1 RU1 - Upgrade of EMU trains

The upgrade of the existing train units is interpreted to mean refurbishment of the electrical and mechanical system and fittings. This type of upgrade can be regarded as a 'hygiene' factor that keeps the system operating without providing any new functionality or capacity.

Upgrade of train units will come about in three different ways:

- Refurbishment of existing trains to extend their life
- Replacement of existing train sets as they become life expired
- Purchase of additional train sets to meet demand growth.

In January 2005 an announcement was made that an additional $225M would be made available by the government for the funding of the Wellington transport system over the next ten years. Greater Wellington Regional Council (GWRC) is expected to contribute a further $95M.

Agreement has been reached between the Crown and GWRC for the money to be prioritised as follows:

- Maintenance of passenger transport mode share – ensure existing rail and bus services can continue to serve growing demand
- Reducing road congestion and improving access.

Individual projects will be decided by GWRC, Transit New Zealand and the region's territorial authorities through the Regional Land Transport Committee process in consultation with local people with final decisions being made by Land Transport New Zealand.

Not withstanding this process yet to be followed, it is expected that the following funding for rollingstock used on the Western Corridor will be confirmed:

- Purchase of 58 new electric units at an expected cost of $160M, mainly to replace the old English Electric Units on the Hutt Valley Line but also to increase passenger capacity
- Refurbishment of all existing Ganz Mavag units at an expected cost of $60M. These units are used on all Paraparaumu Line services as well as other services.

Given the age and general condition of rollingstock, it is expected that any improvement will be well received by the travelling public. It is noted however, that the magnitude of improvement provided to the Western Corridor will not be as great as that experienced on the other corridors. The reason for this is that the most modern of the Wellington rollingstock currently operates the services, and these will be refurbished rather than replaced in the foreseeable future. Only a small proportion of the new rollingstock is likely to be utilised on the line to supplement the Ganz Mavag units, if at all.

It is therefore concluded that the current investment program will not deliver significant demand increases from improvements in the standard of rollingstock equipment. Replacement of the Ganz Mavag units is not likely to occur (after the refurbishment investment) for 15 or more years and therefore will provide only marginal benefits towards the Western Corridor evaluation.

One issue that may have relevance to this study is that at some point within the study period it will become necessary to replace the train sets. At this stage, the introduction of modern design rollingstock may produce small improvements in transit times as a result of improved acceleration and braking performance and higher maximum speeds. This is unlikely to occur until late in the corridor evaluation period and therefore the benefits are likely to be significantly discounted in the analysis.

There may be a progressive introduction of new rollingstock to satisfy service capacity increases, however, it would be difficult to apply faster schedules for a few services when availability of the new rollingstock at the right time and place to run those particular services will be difficult to achieve. Instead, it is likely that the improved performance will be absorbed into the existing timetables and used to improve service reliability as required (ie a better ability to recover from late running).

It is suggested that rollingstock performance improvements will not be significant to the study.

7.5 Railway management

7.5.1 RM1 - Improved rail frequency on existing infrastructure

Train frequency in the corridor is constrained by the:

- The section of single track between North and South Junctions
- The section of single track from Paraparaumu and MacKays Crossing
- The double track section between Kaiwharawhara shared with the Wairarapa Line
- The junction on the approach to Wellington Station.

The cost of improving the infrastructure at these points in order to allow greater train frequency is expected to be expensive and is only likely to be considered after the capacity of the existing network has been fully exploited. Therefore the following sections examine options that provide additional capacity within the boundary of these constraints.

Longer Trains

The electrical multiple units (EMU) operating on this line are permanently coupled in pairs containing one power car and one trailer car, as a two car set. These pairs can be coupled together to form bigger train sets. Examination of inbound peak hour working in the Western Corridor has identified that of the 14 EMU services arriving Wellington between 0700 and 0900hrs, eleven are run with 4 car sets and three are run with 6 car sets. During off peak periods, most services are run by two car sets.

Clearly, it is possible to increase the 4 car sets to 6 car sets without changing track infrastructure. Furthermore, the same design EMU’s are operated in 8 car sets configuration on the Upper Hutt line. The ability to deliver the operation of longer train sets will be determined by:

Adequate platform length

All platforms between Wellington and Paraparaumu are of a suitable length to accept 6 car trains, although the length of the outbound platform at Redwood seems to be tight.

Only minor platform extensions are required in order to accommodate 8 car sets between Wellington and Plimmerton as follows:

- Takapu Rd - inbound platform (see comment in Section 7.3.8) 12m
- Takapu Rd - outbound platform (see comment in Section 7.3.8) 12m
- Redwood - outbound platform (see comment in Section 7.3.8) 60m

For trains operating beyond Plimmerton the following platform lengthening works required are:

- Pukerua Bay - island Platform 37m
- Muri - inbound platform (see comment in Section 7.3.7) 22m
- Muri - outbound platform (see comment in Section 7.3.7) 40m

Traction power supply capacity

Details have not been obtained on the capacity of the traction power supply system to handle additional train volumes.

Given the unit nature of EMU's, an 8 car unit will draw double the power requirements of a 4 car unit.

Generally, the upgrading of DC traction supply systems is not particularly difficult or expensive. The process involves adding additional substations and/or tie stations or fortifying supply from existing substations. Typical substation spacing is about 10 km apart, so it could be expected that there are 4 or 5 substations feeding the line.

Availability of rollingstock

It is understood that there are no spare EMU's available in order to build up the size of train sets on the Paraparaumu line.

The estimated cost of acquiring new rollingstock is expected to be around $3M per car. Therefore the cost of increasing train sizes can be summarised below:

Table 8: Expected cost of building up EMU train sets to 8 cars (assuming $3M per car)

Current Cars per Train	Proposed Cars per Train	Cost Per Train Set
4	6	$6M
4	8	$12M
6	8	$6M

To calculate the total cost of upgrading, it is first necessary to consider the number of train services operated and the utilisation obtained from each train. For example, trains from Paraparaumu take 2 hours to undertake a return trip and can therefore be used for only one trip during the peak, on the other hand, trains originating at Porirua need only one hour and therefore can be used twice for inbound services during the morning peak. It is also necessary to consider the total patronage that may be presented to rail in order to match train capacity and it is unlikely that it will be necessary to increase all train sets to 8 cars.

Availability of train stabling facilities

The provision of longer trains implies the acquisition of additional rollingstock, which will need to be stored somewhere during the evenings and outside of peak hours. Current train stabling located at Wellington Yard and at Paekakariki is currently fully utilised therefore the construction of addition sidings will be required.

Capacity of train maintenance facilities

As the number of trains that are lengthened is significant then the availability of workshop capacity may become scarce and additional facilities may need to be provided.

Exploiting remaining scheduling capacity

Another approach to increasing service capacity on the existing infrastructure is to schedule additional trains between existing services.

Paraparaumu to Plimmerton Section

The track between Paraparaumu and Plimmerton is heavily constrained by single track sections between Paraparaumu and MacKays Crossing and between North and south Junctions.

Current peak train service frequency out of Paraparaumu is irregular with about five EMU trains being originated over the two hour peak period, as well as provision for two regional passenger trains and one freight train.

Train operation analysis detailed in Appendix A identifies that it is not possible to increase EMU service frequency to 3 trains per hour (ie 20 minute service frequency) without either:

- Accepting a low level of service reliability as a result of a tight cross at MacKays Crossing and compressed turnaround times at Paraparaumu, or
- Duplicating at least some of the track between Paraparaumu and MacKays Crossing, with the preference being to extending the double track at the MacKays crossing end, or
- Flighting trains schedules, by bringing trains into service during the peak from a new storage sidings at Paraparaumu, thus reducing the number of counter peak moves on the single track section, or
- Combining two outbound trains to be split at Paraparaumu to form two separate departures, thus reducing the number of counter peak moves on the single track section. This may require the provision of additional stabling capacity at Paekakariki.

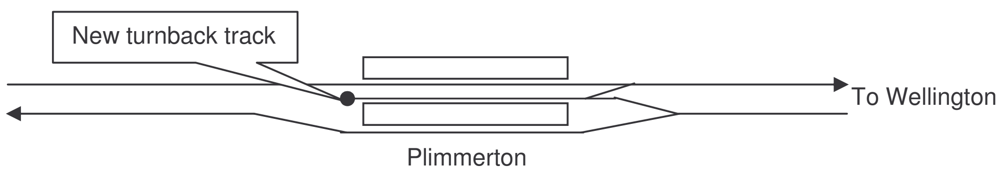
It will be necessary to acquire additional rollingstock in order to support any new service.

Plimmerton to Porirua Section

Additional train capacity can generally be provided in this section by extending existing Porirua originating trains. To achieve this it will be necessary to schedule earlier the outbound services that form the inbound trains, as a result of the additional distance (running time) involved.

Without undertaking a full timetabling review, it is considered that the extension of more trains to Plimmerton will increase the probability of the passage of a through train whilst the platform is occupied by a turnback service. In order to overcome this scheduling conflict it may be necessary to construct a new turnback platform on its own siding between the two mainlines as indicated in the diagram below.

Figure 4: Suggested layout of Plimmerton Station to allow increased train turnbacks



Porirua to Wellington Section

The rail corridor between Porirua and Wellington is double track where a theoretical track capacity of about 24 trains per hour is achievable. Currently during the 2 hour peak the track usage is 16 trains or an average of 8 trains per hour. Whilst the conclusion can be drawn that there is ample spare track capacity for additional services, the operation of express train services from Paraparaumu and Plimmerton significantly reduces the available capacity.

Analysis of schedules reveals that it is possible to insert an additional Porirua originating train into the timetable around 0810hrs without any additional infrastructure requirements. It may be necessary to shift other trains by a few minutes in order to create a suitable pathway.

It is noted however, that the section of track between Kaiwharawara and Wellington, including Wellington Junction, is shared with the Wairarapa line. This could become a constraint to timetabling for additional Paraparaumu line services. Issues in this area are complex and would require a level of detailed analysis that is beyond the scope of this study.

It is possible to schedule a train at the front end of the peak (say 0700hrs) without the need for additional rollingstock, however at other times of the peak then it is likely that an additional train set will be required. It is possible that an examination of train working on the Upper Hutt line will reveal a train set available at an appropriate time but this is expected to be unlikely.

7.5.2 RM2 - Management of rail priorities – freight vs. commuter trains

The issue of access for freight trains through commuter peak periods is one that is addressed by most suburban rail networks. The general management treatment that is adopted is to prioritise access with commuter trains being allocated first priority followed by regional passenger trains and then freight trains. Effectively freight trains are tolerated whist the capacity exists in the network. Issues of reliability of freight trains are also an important consideration from both the angles of on-time presentation at the suburban boundary and probability of incident generation once in the suburban area. As additional track capacity is demanded by commuter needs, pressure is placed on the decision to allow continued access by freight trains. The typical order of decision-making is as follows:

- Free access for freight services – few suburban networks operate at this level of management
- Negotiated pathway(s) and service agreements – appears to be the current status in Wellington although there is perceived movement to the next stage
- Agree to admit the freight train on an agreed pathway only if it presents at the suburban boundary on-time, unless there is a suitable later pathway – Melbourne is operating at this level for interstate freight trains but increasingly introducing curfews. Note that interstate train access is via an independent track
- Prohibit freight trains from entering the suburban area during peak periods – Sydney is currently operating at this level but with significant opposition from freight operators
- Construct a dedicated freight track separate to the suburban network – Sydney will shortly commence work on providing a dedicated freight track through its southern suburbs for all freight trains. Melbourne operates its interstate trains on tracks independent to the suburban system.

The cost of providing an independent freight track can be extremely high and is expected to make this option prohibitive.

As a result it is predicted that as track capacity in the Western Corridor is soaked up by suburban services, curfews will be applied that exclude freight trains entering the suburban area during peak periods.

Apart from the benefits that will be derived from improved network service reliability, the removal of the one freight train pathway through the morning peak will release capacity for additional suburban train services. It is estimated that a further three suburban service pathways could be created as a result of removing the freight train. The way that timetables are currently structured, these additional service would arrive in Wellington between 0710hrs and 0740hrs which is quite early in the peak period. The question must be asked as to whether there is likely to be sufficient demand at this time to justify the services.

The main benefit of excluding freight trains from the peak period mainly stems from issues of service reliability resulting from poor on-time presentation of the freight train at the suburban boundary, and delays it incurs after entering the suburban area (slow running, vehicle defects etc)

7.5.3 RM3 - Fare levels and structures and integrated ticketing

Integrated ticketing is an enabler for demand growth and not a prerequisite for operating the rail network. The main effect is to remove some of the barriers to changing modes and thus make more attractive the option to use more than one mode of transport between the trip origin and destination.

Implementation of such schemes is difficult because it requires many issues to be resolved between transport operators however it improves the perception of public transport as an alternative to road and as such is worthwhile pursuing.

7.5.4 RM4 - Freight rail diversion through Wairarapa

There is a potential alternative route from Palmerston North to Wellington. The route diverts from the Northern Trunk just to the north of Palmerston North and travels via Woodville, Wairarapa and Upper Hutt to Wellington. The route has the following characteristics:

- Climbs from 30 m at Palmerston north to 286m south of Newman before falling to sea level at Wellington, compared to the highest point on the Northern Trunk of about 80m
- There are numerous steep grades and 5 tunnels on the route, the longest being Rimutaka Tunnel (8.8km)
- Route distance from Palmerston is 201km compared to 136km via the Northern Trunk
- Freight trains would still need to mesh in with suburban train services on the Upper Hutt line in order to gain access to Wellington. Track capacity is scarce during peak periods.

It would be extremely difficult to sell to Toll NZ that this route offers any benefit over the Northern Trunk route and as such no further analysis will be undertaken of this option.

7.5.5 RM5 - Integrated scheduling

This element is about ensuring seamless connection between trains and buses. Very few people in the Western Corridor live within walking distance of a station therefore they must either use a motorcar to access the station, or rely upon public transport (bus) for that purpose.

Stations with bus/train modal interchange are detailed in Table 9 below.

Table 9 Details of bus/train modal interchange stations

Station	Details of service
Porirua	Served by buses from most surrounding areas including Ascot park, Ranui Heights, Seivers, Castor, Whitby, Papakowhai, Titahi Bay. Buses do not connect with all trains during the morning peak.
Paremata	Served by buses from the Whitby area only during peak hours and connections are not made with all trains
Paraparaumu	Served by buses from Otaki, Paraparaumu Beach, Raumati South, and Waikanae Beach. Buses do not connect with all trains during the morning peak.
Waikanae	All buses serving Waikanae also travel to Paraparaumu station. Buses do not connect with all trains during the morning peak.

It is noted that bus timetables are extremely good at identifying connections with rail services, normally showing the departure time of the train and its arrival time at Wellington. Rail schedules are not as good at identifying connecting bus services.

Some examples of current bus scheduling in the Western Corridor are provided in Table 10 below.

Table 10: Connectivity between trains and buses

Route 66 Whitby to Paremata Station			Route 67 Whitby to Porirua Station		
Bus Arrival Time	Interchange Time	AM Peak Train Times	Bus Arrival Time	Interchange Time	AM Peak Train Times
6:35	4 mins	6:39		No service	6:44
	No service	7:04	7:00	8 mins	7:08
7:12	5 mins	7:17		No service	7:22
7:22	4 mins	7:26		No service	7:23
7:37	5 mins	7:42	7:25	6 mins	7:31
8:03	7 mins	8:10		No service	7:33
	No service	8:30		No service	7:39
				No service	7:46
				No service	7:51
			7:50	4 mins	7:54
				No service	8:14
				No service	8:20
			08:30	4 mins	8:34

Route 71 Paraparaumu Beach to Paraparaumu Station			Routes 75/77 & 76/77 Waikanae to Paraparaumu Station		
Bus Arrival Time	Interchange Time	AM Peak Train Times	Bus Arrival Time	Interchange Time	AM Peak Train Times
6:30	5 mins	6:35	Buses prior to this run direct to Wellington		
6:55	5 mins	7:00	6:50	5 mins	7:00
7:13	5 mins	7:18	7:14	5 mins	7:18
7:33	4 mins	7:37 Capital Connection	7:33	4 mins	7:37 Capital Connection
	7 mins	7:40		7 mins	7:40
7:55	5 mins	8:00	7:55	5 mins	8:00

The provision of bus feeder services is an extension of the rail network. The operation of these services affects the quality of door-to-door provision of public transport services in the following ways:

- Frequency of service – in a situation where trains arrive at a station at 10 minute intervals and buses only meet every second train then the effective level of service frequency for those who use the bus is 20 minutes. Increasing bus services to match train service frequencies will improve service levels and will require no capital investment other than for additional buses where required. The cost that needs special consideration is the operating cost for the additional services. In reality, these additional services may be hard to justify unless sufficient patronage is generated.
- Area of coverage – Typically people will only walk about 400m to catch a bus service. Therefore the routing of the buses will be important to ensure maximum capture of the potential market. Once again there will be a trade-off between market penetration and operating costs.
- Total travel time – people will perceive total travel time as the time from leaving home to reaching their destination, including the modal

interchange time. Bus routing needs to take people in the direction of their travel. Buses that need to operate northwards against the peak flow will add time to a commuting journey and will be regarded unfavourably in respect to travel time. It is noted that buses from Raumati South fall into this category by connecting with trains at Paraparaumu. This is discussed further when considering demand for new stations at Raumati South and Lindale.

The conclusion drawn is that there is already a high degree of timetable co-ordination between bus and train in this corridor but not all trains have a connecting bus service, which effectively reduces travel time choice for people in affected areas. Increasing bus frequency in these areas could have a similar affect to increasing train frequencies for these people but not have the potentially high infrastructure costs sometimes associated with rail infrastructure options related to increasing train frequencies.

It is important to also consider what happens at the Wellington end of the train journey as this forms part of the total public transport experience and is considered by travelers in their perceptions of total travel time. Timetables do not currently suggest connecting bus services from Wellington Station to the city centre. It is noted that many passengers choose to walk for this last portion of the journey, which may in fact provide comment on passenger perceptions about the accessibility of buses.

7.5.6 RM6 - Free carriage of bicycles

Likely to be a small issue in the overall planning of the corridor and therefore is not worth pursuing in the context of this study. Nonetheless, the ability to utilise a bicycle upon arrival in Wellington has some advantages given the non-central location of the station from the Central Business District.

7.5.7 RM7 - Passenger real time information

Passenger real time information systems are an enabler to provide travellers with better knowledge about their journey. Technology is now at a stage of development whereby it is possible to:

- Advise people before they leave home/work of details of their intended public transport journey, and any anticipated delays via email and SMS
- At a bus stop, provide continuously updated information regarding the wait time for the next service
- At a modal interchange point, provide information about the next connecting service and the duration of the wait time
- At a railway station, provide continuously updated information regarding the wait time for the next service
- On board a train, provide details about the journey including next station, and the cause and duration of any delay.

Real time information is often installed in conjunction with initiatives associated with reducing the probability of delay. An example of this is the

SmartBus program currently being rolled out in Melbourne. The system involves real-time' tracking technology to give late running buses priority at traffic signals, and redesigned intersections to afford buses priority in traffic queues, all designed to assist drivers in keeping to schedule.

The use of real time passenger information in conjunction with a SmartBus type program has the potential to increase the attractiveness of public transport relative to use of the private vehicles.

7.6 Light rail

7.6.1 LT1 - Light rail beyond Plimmerton on existing track

The idea of converting low patronage railway lines to light rail (tram) operation is not new, with the Port Melbourne and St.Kilda lines in Melbourne having been converted in this manner. The advantages flow from:

- The use of smaller units of rollingstock that are less expensive to purchase than trains
- Lower maintenance costs for track resulting from lower axle loadings
- Lower operating costs
- Faster service due to reduced stop dwell times and better acceleration rates
- More frequent service due to smaller rollingstock units.

However there is a significant cost associated with the conversion. Traction wiring needs to be changed, rails may need reprofiling, platform heights need to be altered, level crossing and signalling systems need modification.

A significant issue to be overcome is the fact that the track is currently at 1064mm gauge. Most light rail systems are built to 1435mm gauge (including Australia) but 1000mm gauge is also popular, particularly in older cities where streets are narrow (tram bodies are generally narrow). To increase the Wellington gauge to 1435mm would involve a complete relay of the track because the sleepers (ties) will not be long enough for the wider track gauge. Another barrier to altering gauge is the fact that the Northern Trunk is the main link between Wellington and Auckland and is used by diesel hauled passenger and freight trains. Even if the gauge issues are resolved then there would be considerable safety concerns associated with mixing light rail vehicles with heavy freight trains. Note also that the issues associated with the single track sections will need to still be resolved and in fact may be more pressing as the density of tram operation would most likely to be higher.

From a passenger perspective, journey times will increase (by at least 5 minutes because there will be more trams arriving than trains departing) as a result of the need for an additional modal interchange between tram and train at Plimmerton.

The opportunity to improve public transport services beyond Plimmerton by utilising light rail cannot be supported for further investigation.

7.6.2 LT2 - Whitby light rail

Whitby is a small but developing residential area to the east of Paremata. The area is currently serviced by three bus routes:

- Route 65: Whitby (Crows Nest) to Porirua Station via Ascot Park – service is run during peak periods only at an approximate half hour service frequency
- Route 66: Whitby to Paremata Station – service is run during peak periods only at an approximate 15 minute service frequency
- Route 67: Whitby to Porirua Station via Papakowhai at a 20 minute service frequency during the peak and hourly during off peak periods
- Note: Routes 66 and 67 run a similar route within the Whitby area so if a person doesn't mind which station they go to then service frequency is actually about 10 to 15 minutes.

The existing bus service has the capacity to move about 300 people per hour out of the Whitby area in the peak and 40 per hour in the off peak periods. Not all buses will be full, especially in the off peak, therefore the patronage number will be lower again. Furthermore, it would be necessary to agree on a single route for the trams whereas the buses cover a variety of origins and destinations. A modern articulated tram holds 100 people. The conclusion is that there is insufficient patronage to justify a tram operation.

Tram route construction costs can be in the order of magnitude of $5m per kilometre resulting in construction costs of $15M (for 3km) plus the purchase of the trams at about $2M each. This is extremely expensive as compared to purchasing and operating buses with little additional benefit.

It is difficult to accept that the level of patronage from the Whitby area could support the high capital cost of constructing a tram route or the ongoing operating costs of such a service.

7.6.3 LT3 - Paraparaumu Beach light rail

The proposed route for this tram has not been defined but as a minimum it would replace Bus Routes 71 & 72 between Paraparaumu township and Paraparaumu Beach (about 3 to 6km depending on routing). There is a possibility of also extending the route to include the Raumati Beach area serviced by Bus Routes 73 & 74 (a further 5km). Currently these bus services operate schedules that connect with each train service, which seems to be the main source of travel demand in the area, but it is believed that bus patronage levels are fairly low and the services struggle with viability. Whilst there is normally an increase in public transport usage when trams are provided instead of buses, it is unlikely that this will be sufficient to justify the capital investment or the ongoing operating/maintenance costs.

There are few examples of where tram services have been constructed as feeders to a rail network, particularly where this is at the end of the network where population density and patronage demand is low. Currently patronage from Paraparaumu station is only about 1000 passengers in the morning peak and many of those come from areas that will not be accessed by a tram route. Buses are a much better option in these circumstances.

7.6.4 LT4 - Sky rail

This element implies the rail tracks will be raised in order to overcome space constraints. Examples of this application may include:

- Duplication of North/South Junction with the new track perched above the existing track
- Placement of the rail line on a new alignment over the top of the road where corridor width is insufficient to accommodate all transport rights of way side by side
- Elevated light rail or some other form of mass transit above the road corridor.

The cost of undertaking this solution will be very high and careful consideration to the needs of freight trains (gradients and weight) will be required. Cost could be slightly lower if the solution involves light rail.

This type of solution should only be considered if it is not possible to design conventional solutions.

7.6.5 LT5 - Paekakariki-Lindale tram

This is variation on "LT1 Light Rail Beyond Plimmerton on Existing Track" which was rejected on a number of grounds. This element can be dismissed for the same reasons.

7.7 Summary of Elements

The following table categorises the elements into those that could value to the development of rail services in the Western Corridor (dependent on patronage demand assessment), and those that have been identified as adding little value or providing poor value for money.

Table 11: Summary of elements

Reference	Element Description	Could add value to the Corridor	Not important to the Corridor
RT1	Double Track between North and South Junctions	✓	
RT2	Double Track between MacKays Crossing and Raumati	✓	
RT3	Double Track between Raumati and Paraparaumu	✓	
RT4	Double Track between Paraparaumu and Waikanae	✓	
RT5	Double Track between Waikanae and Otaki		✗
RT6	Double Track between Otaki and Auckland		✗
RT7	Passing Loops at Various Locations	✓	
RT8	3rd Dedicated Freight Track		✗
RT9	4th Track		✗
RT10	Grade Easing		✗
RT11	Curve Easing		✗
RT12	Heat Restrictions		✗
RT13	Weight Restrictions		✗
RT14	Improve Structure Gauge for Freight Tunnels/Veranda		✗
RT15	Improve Signalling		✗
RT16	New Stabling North of Waikanae	✓	
RT17	Rail Corridor Along Transmission Gully Route		✗
RT18	Porirua – Hutt Valley Route		✗
RT19	Connect Johnsonville Line to Northern Trunk Route at Tawa		✗
RT20	Kapiti Coast Loop (Raumati-Waikanae section)	✓	
RT21	Akatarawa Rail Route		✗
RE1	Extension of Electrification to Waikanae	✓	
RE2	Electrification Extension to Otaki		✗
RS1	New Rail Station at Lindale	✓	
RS2	New Rail Station at Raumati	✓	
RS3	New Rail Station at Aotea		✗
RS4	New Rail Station at Glenside		✗
RS5	New rail Station at Newlands		✗
RS6	New Rail Station at MacKays Crossing		✗
RS7	Removal of Muri/Pukerua Bay Station	✓	
RS8	Removal of Redwood/Takapu Station	✓	

Reference	Element Description	Could add value to the Corridor	Not important to the Corridor
RS9	Park and Ride Capacity Improvements	✓	
RS10	Bus Interchange at Lindale	✓	
RS11	Bus interchange at Porirua	✓	
RS12	Improved Cycle Storage at Stations	✓	
RU1	Upgrade of Train Units	✓	
RM1	Improved Rail Frequency on Existing Infrastructure	✓	
RM2	Management of Rail Priorities – Freight Secondary to Commuter Trains	✓	
RM3	Fare Levels and Structures – Integrated Ticketing		✗
RM4	Freight Rail Diversion Through Wairarapa		✗
RM5	Integrated Scheduling	✓	
RM6	Free Carriage of Bicycles		✗
RM7	Passenger Real Time Information	✓	
LT1	Light Rail Beyond Plimmerton on Existing Track		✗
LT2	Whitby Light Rail		✗
LT3	Paraparaumu Beach Light Rail		✗
LT4	Sky Rail		✗
LT5	Paekakariki-Lindale Tram		✗

8. Determining future rail capacity requirements

8.1 Methodology

The calculation of travel demand for this study is being undertaken using the GWRC Transport Model. The model uses a wide range of inputs such as population forecasts, demographics, origin/destination matrices, and travel time information to allocate trips between modes. Outputs from the model are responsive to the assumptions adopted in regard to the extent of upgrade to both the road and rail network. In order to establish the upgrade requirements for rail it is necessary to understand the magnitude of change in demand so that an appropriate scale of solution is identified. Hence, this presents a situation whereby the definition of the infrastructure issues is influenced by the magnitude of demand, and the magnitude of demand is responsive to the nature of the infrastructure solution applied.

In order to quantify the expected range of infrastructure options required, the model has been used to generate a best and worse scenario for rail patronage as described below:

Rail best case

This is based on significant rail expenditure on upgrades whilst the road corridor is retained as at present. Assumptions included:

- Enhancement of park and ride facilities at Paraparaumu, Paremata and Porirua to ensure that rail usage is not constrained by this feature
- Electrification extension to Waikanae to capture an expanded market
- Closure of Muri and Redwood stations to reduce journey times
- New stations at Lindale, Raumati, Aotea, Glenside and MacKays (note this actually reduced patronage due to the additional travel time inserted into the majority of trips. This will be explored further later in this report)
- Improved modal interchange at Porirua to make transfers more attractive
- Improved rollingstock quality to make the journey more attractive
- Station facility upgrades to make waiting for trains more acceptable.

Rail worst case

This is based on major upgrade to the road corridor to remove any impediments to journey time whilst leaving the rail corridor as it is today.

8.2 Modelling outcomes

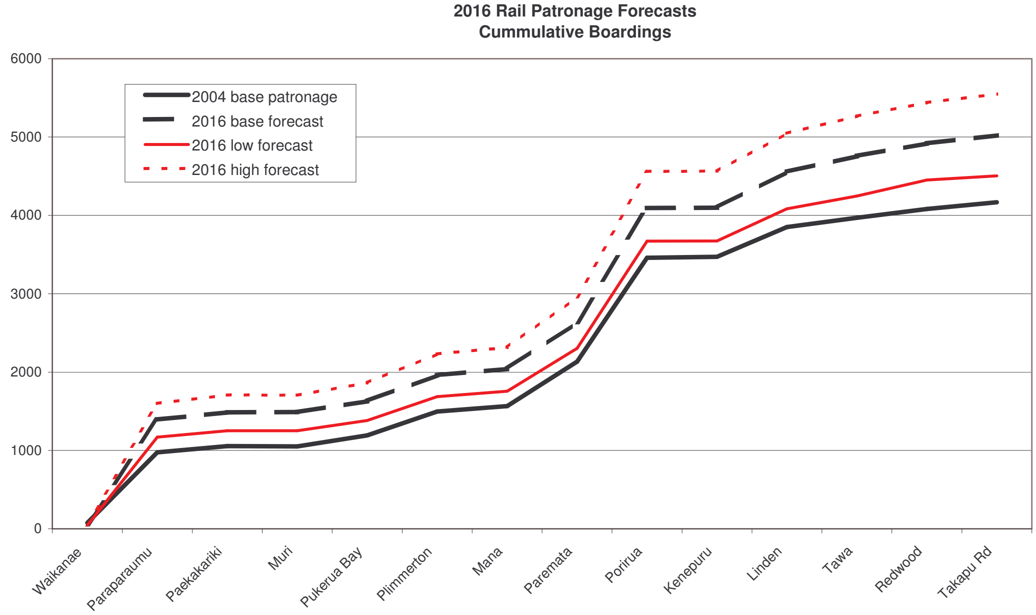
The information below shows the net impact of patronage as a result of the Model runs and the results are also presented in Figure 5.

Table 12: Cumulative rail patronage forecasts (including high and low bounds)

Station	2001 Base	2004 Base	2016 Base	2026 Base
Waikanae	79	76	62	105
Paraparaumu	897	976	1394	1482
Paekakariki	973	1056	1488	1607
Muri	969	1052	1488	1594
Pukerua Bay	1108	1191	1628	1719
Plimmerton	1406	1496	1962	2070
Mana	1475	1567	2041	2140
Paremata	2037	2135	2639	2682
Porirua	3330	3459	4093	3902
Kenepuru	3341	3470	4098	3883
Linden	3705	3852	4557	4262
Tawa	3803	3969	4759	4457
Redwood	3907	4082	4920	4625
Takapu Rd	3989	4168	5022	4638

Bounding Scenarios	
2016 Low	2016 High
45	60
1170	1600
1251	1707
1251	1705
1382	1865
1686	2231
1757	2315
2304	2962
3671	4562
3674	4564
4083	5049
4247	5266
4451	5440
4505	5548

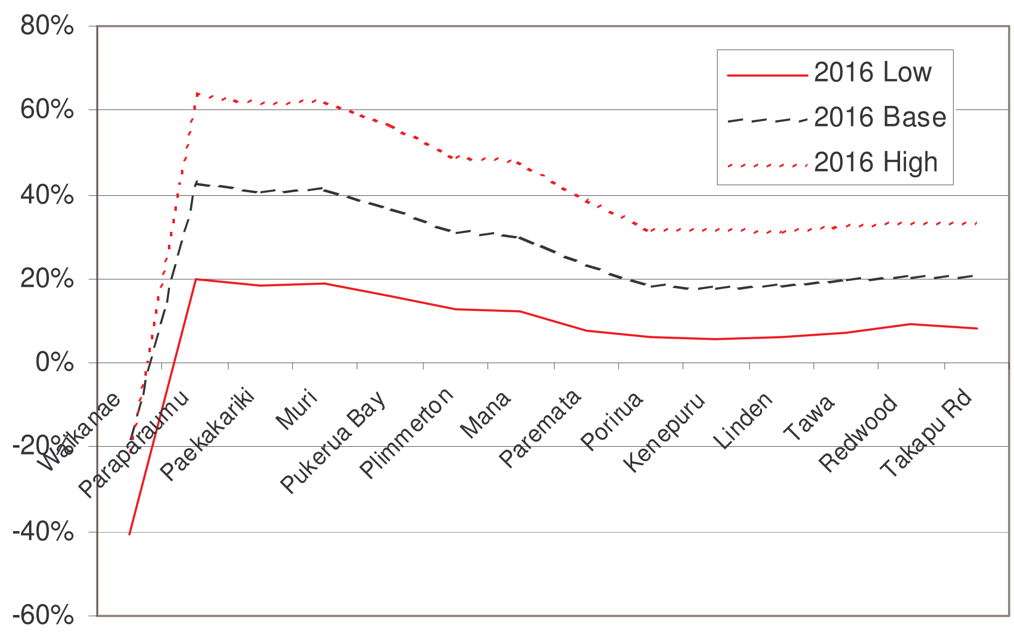
Figure 5: Graph showing the range of forecast 2016 patronage



Important points to note from the above data include:

- Forecast patronage falls between 2016 and 2026 as a reflection of population forecasts
- Maximum corridor patronage in 2016 is approximately 4,500 for the low case, 5,000 for the base case and 5,500 for the high case
- Patronage growth between 2004 and 2016 is expected to be 8% for the low case, 20% for the base case, and 33% for the high case
- Patronage growth is strongest on the section of line beyond Porirua but it is coming off a lower base than stations to the south of Porirua. Refer to Figure 6 below.

Figure 6: Patronage Growth Rates



8.3 Train capacity requirements

In order to assess the train service level requirements for the Western Corridor, the patronage forecasts developed above have been converted into equivalent carloads by assuming a peak loading factor of 70 passengers per car. This is low compared to the actual capacity of the cars used on the line (seating capacity of 74 and crush capacity of 100) but reflects current loading, and hence passenger comfort, levels currently being experienced.

Table 13: Number of train cars required over the 2 hour morning peak to carry the passenger load

Station	Train Capacity (Cars per Peak)				
	Existing	2004	2016 Low	2016 Base	2016 High
Waikanae	0	2	1	1	1
Paraparaumu	24	14	17	20	23
Paekakariki	24	16	18	22	25
Muri	24	16	18	22	25
Pukerua Bay	24	18	20	24	27
Plimmerton	43	22	25	29	32
Mana	43	23	26	30	34
Paremata	43	31	33	38	43
Porirua	62	50	53	59	66
Kenepuru	62	50	53	59	66
Linden	62	56	59	66	73
Tawa	62	57	61	68	76
Redwood	62	59	64	71	78
Takapu Rd	62	60	65	72	80

Upon converting this data into 4 car EMU equivalents in Table 14, it becomes much clearer as to where additional train services are required.

Table 14: Requirements for additional 4 car train services during the 2 hour morning peak

Station	Additional 4 Car Trains Required (per Peak)				
	Existing	2004	2016 Low	2016 Base	2016 High
Waikanae	0	1	1	1	1
Paraparaumu	7	0	0	0	0
Paekakariki	7	0	0	0	1
Muri	7	0	0	0	1
Pukerua Bay	7	0	0	0	1
Plimmerton	11	0	0	0	0
Mana	11	0	0	0	0
Paremata	11	0	0	0	1
Porirua	16	0	0	0	2
Kenepuru	16	0	0	0	2
Linden	16	0	0	2	3
Tawa	16	0	0	2	4
Redwood	16	0	1	3	5
Takapu Rd	16	0	1	3	5

Based on 70 people per rail car

Interesting conclusions that can be drawn from this table include:

- The current and forecast passenger volumes from Waikanae do not fill one EMU train. Note that Waikanae is currently serviced by one diesel hauled service. Also note that the additional patronage from Waikanae is likely to be a diversion of existing patronage from Paraparaumu
- Although it has been identified that patronage growth is strongest beyond Porirua, there is generally sufficient capacity in the existing trains to cater for this. The exception is that under the high patronage case, one additional train would be required
- Under the low patronage case, the only requirement is for one additional train originating from Porirua
- Under the base patronage case, the requirement is for three additional trains originating from Porirua
- Under the high patronage case, the requirement is for one additional train to originate from Paraparaumu and 5 additional trains to originate from Porirua, assuming that the additional Paraparaumu service runs express.

The following section of this report examines the infrastructure changes required in order to deliver rail service scenarios to address the three patronage scenarios identified above.

9. Infrastructure scenario development

9.1 Introduction

In this Section, the forecast train capacities identified in Section 8 are developed into operational scenarios in order to assess infrastructure requirements.

Observations from other rail systems indicate that a peaking of demand occurs over a shorter period than the two hour period with about 60% of patronage occurring in the peak one hour period within the two hour peak. This does not seem to be a significant issue in relation to the Wellington situation, nonetheless, where additional train services are to be added these have been focused where possible towards the middle of the peak period rather than at the edges in this analysis.

9.2 Low patronage scenario

9.2.1 Service requirement

One additional 4 car train service originating from Porirua during the morning peak period.

9.2.2 Proposed method of delivery

The rail corridor between Porirua and Wellington is double track where a theoretical track capacity of about 24 trains per hour is achievable. Currently during the 2 hour peak the track usage is 16 trains or an average of 8 trains per hour. Whilst the conclusion can be drawn that there is ample spare track capacity for additional services, the operation of express train services from Paraparaumu and Plimmerton significantly reduces the available capacity.

Analysis of schedules reveals that it is possible to insert an additional Porirua originating train into the timetable around 0810hrs without any additional infrastructure requirements. It may be necessary to shift other trains by a few minutes in order to create a suitable pathway.

It is noted however, that the section of track between Kaiwharawhara and Wellington, including Wellington Junction, is shared with the Wairarapa line. This could become a constraint to timetabling for additional Paraparaumu line services. Issues in this area are complex and would require a level of detailed analysis that is beyond the scope of this study.

It is possible to schedule a train at the front end of the peak (say 0700hrs) without the need for additional rollingstock. However at other times of the peak then it is likely that an additional train set will be required. It is possible that an examination of train working on the Upper Hutt line will reveal a train set available at an appropriate time but this is expected to be unlikely.

Alternatively, instead of finding an additional pathway, the preferred option may be to increase the length of trains. Increasing the length of two trains by two cars will achieve a similar outcome. The advantage to this is that operating costs will be lower (no need for an additional driver) but the disadvantage is that service frequency will not improve and passengers will not benefit from a better choice of travel time.

9.2.3 Expected cost implications

- No infrastructure costs are incurred
- Allowance should be made for the provision of an additional 4 car train set (subject to the potential to cross working with the Upper Hutt services)
- New stabling siding for the additional train (nominally at Paekakariki)
- Increased operating costs related to driver wages, and track and train maintenance costs.

9.3 Base patronage scenario

9.3.1 Service requirement

The capacity equivalent to 12 car loads originating from Porirua during the morning peak period.

9.3.2 Proposed method of delivery

The solution options for this scenario are very similar to those discussed in Section 9, Infrastructure scenario except that more passenger capacity needs to be added to the corridor.

Adding three additional train services between Porirua and Wellington is expected to be difficult given other timetabling constraints, however it may be possible with a major revamp of timetables in the corridor. The solution is likely to therefore be a combination of adding additional train services and increasing the length of other trains.

It is recommended that

- One additional 6 car train service be added (the same as for the Low Patronage Scenario)
- The length of three train sets be increased by two cars each (introducing 8 car set operation).

9.3.3 Expected cost implications

- No infrastructure costs are incurred
- Allowance should be made for the provision of an additional 12 cars (subject to the potential to cross work with the Upper Hutt services)
- New stabling siding for the additional train and additional cars (nominally at Paekakariki)
- Increased operating costs related to driver wages, and track and train maintenance costs.

9.4 High patronage scenario

9.4.1 Service requirement

- One additional 4 car train service originating from Paraparaumu
- The addition of the equivalent of 20 car loads capacity originating from Porirua during the morning peak period (in addition to the extra Paraparaumu service which is assumed to operate as an express service).

9.4.2 Proposed method of delivery

Paraparaumu Services

The options for the introduction of an additional train service from Paraparaumu will be limited by the capacity of the single track sections between Paraparaumu and MacKays Crossing and between North and South Junctions.

Current train service frequency out of Paraparaumu is irregular with about five EMU trains being originated over the two hour peak period, as well as provision for two regional passenger trains and one freight train.

The lowest cost option is to couple two EMU trains together for the outbound service and split them at Paraparaumu. The combined length of the train sets is constrained by the length of the available platform track at Paraparaumu. The most likely scenario is that a double consist (2x4 cars) is worked from the stabling tracks at Paekakariki during the early part of the peak. Additional storage capacity will be required at Paekakariki to accommodate the additional train set. This would involve the construction of an additional siding track and modifications to the security compound.

Porirua Services

The solution options for the additional Porirua services are very similar to those discussed in the previous Patronage Scenarios, only that a greater amount of train capacity needs to be added to the corridor. The solution is likely to be a combination of additional train services and longer trains. A maximum of two additional train services could be scheduled within the existing timetable and this would need to be supplemented with the expansion of the length of six trains by two cars each (this may include the new services). Realistically, it becomes difficult to add more than two new schedules due to the time it takes to turn trains around at Porirua Station on the mainline without affecting through services. This could be overcome with the provision of a third platform between the two main lines, but given the likely cost, it is more appropriate to build up the length of existing services as a first option.

The longer trans will draw additional power and this is expected to place additional strain on the traction power supply system. Little information has been sourced on the capacity of the traction power supply network so it is assumed that it will be necessary to install two additional rectifiers, allocated to existing substations in the Porirua and Wellington section.

It is recommended that:

- One additional 4 car train be added originating from Paraparaumu
- Two additional 8 car train services be added from Porirua
- The length of two further train sets be increased by two cars each (introducing 8 car set operation)
- New stabling facilities be constructed north of Paraparaumu to reduce counter peak train flows on the single track sections
- Additional train stabling for 4 cars be provided at Paekakariki.

9.4.3 Expected cost implications

Assuming the option of providing train stabling at Paraparaumu is chosen as the solution for the additional Paraparaumu service then the infrastructure cost implications are expected to be as follows:

- It is assumed that it would be necessary to install two additional rectifiers into existing substations

- Allowance should be made for the provision of an additional 24 cars (subject to the potential to cross work with the Upper Hutt services)
- Provide new train stabling north of Paraparaumu
- Expanded train stabling sidings at Paekakariki (or another nominated location)
- Increased operating costs related to driver wages, and track and train maintenance costs.

9.5 Other infrastructure scenarios

The following infrastructure scenarios have been developed in response to specific requests.

9.5.1 Scenario A: Extension of electrification to Lindale Station – 15 minute service

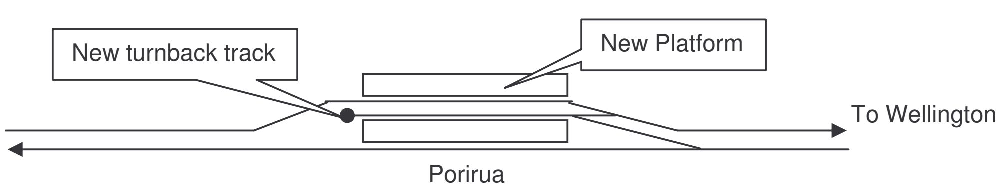
Service Requirement

15 minute scheduling for trains originating out of Lindale Station. Trains will need to stop all stations in order to provide sufficient service frequency to stations between Porirua and Wellington. This will slow down journey times by about 3 minutes for all passengers beyond Porirua compared to the existing express schedules that apply.
15 minute scheduling for trains originating out of Porirua Station giving a service frequency to stations between Porirua and Wellington of 7.5 minutes.

Proposed Method of Delivery

To support this proposed operation it will be necessary to extend the electrification from Paraparaumu to Lindale and to provide a new station complex. The diagram in Appendix E indicates a need to duplicate the track between Raumati South and Paraparaumu to facilitate suburban train crosses and the provision of a new platform track at Porirua to allow the turn back of suburban trains clear of the main through tracks.

Figure 7: Suggested layout of Porirua Station to allow increased train turnbacks



In addition it is expected that one additional train set will be required to support the increased service frequency to Lindale, but this will be offset by the reduction in service frequency to Plimmerton. This may be further offset by the need to increase train sizes in order to deliver sufficient capacity. A judgement has been made that no additional rollingstock will be required but this will need to be confirmed with additional fleet working analysis if this option is to be pursued further.

9.5.2 Scenario B: Extension of electrification to Lindale Station – 10 minute service

Service Requirement

- 10 minute scheduling for trains originating out of Lindale Station. Trains will need to stop at all stations in order to provide sufficient service frequency to stations between Porirua and Wellington. This will slow down journey times by about 3 minutes for all passengers beyond Porirua compared to the existing express schedules that apply
- 10 minute scheduling for trains originating out of Porirua Station giving a service frequency to stations between Porirua and Wellington of 5 minutes.

Proposed Method of Delivery

The scheduling for this option (as shown in Appendix E) suggests the need for suburban trains to cross each other on the single track to the north of MacKays Crossing. Extension of the double track from MacKays to Raumati South would resolve this issue and allow a limited window for the scheduling of a regional passenger train pathway, albeit that the passenger train would need to be slowed down to follow behind the stopping all stations train out of Waikanae. In order to accelerate the passenger train then it would be necessary to extend the double track the full distance from MacKays Crossing to Paraparaumu, and even then the schedule will need to be slowed down, but to a lesser extent.

To support this proposed operation it will be necessary to extend the electrification from Paraparaumu to Lindale and to provide a new station complex. It will also be necessary for the provision of a new platform track at Porirua to allow the turn back of suburban trains clear of the main through tracks.

Whilst no statistical analysis has been undertaken of train fleet requirements, it is expected that 3 additional 6 car train sets will be required in order to support the increased timetable frequency out of Lindale.

9.5.3 Scenario C: Extension of electrification to Waikanae – 15 minute service

Service Requirement

- 15 minute scheduling for trains originating out of Waikanae Station. Trains will need to stop all stations in order to provide sufficient service frequency to stations between Porirua and Wellington. This will slow down journey times by about 3 minutes for all passengers beyond Porirua compared to the existing express schedules that apply

- 15 minute scheduling for trains originating out of Porirua Station giving a service frequency to stations between Porirua and Wellington of 7.5 minutes.

Proposed Method of Delivery

This scenario relies upon electrification of the track between Paraparaumu and Waikanae with provision for a new station at Lindale. Analysis in Appendix E indicates that it is possible to schedule suburban trains over a single track corridor. However, a regular cross situation is set up between MacKays crossing and Paraparaumu which may best be resolved with the construction of a crossing loop. This is a minimum infrastructure solution and is likely to increase scheduling unreliability due to the need to schedule tight crosses not only in this new loop but also at Waikanae and south of South Junction (this may result in consideration of a longer crossing loop, or double track between MacKays Crossing and Paraparaumu).

It will also be necessary for the provision of a new platform track at Porirua to allow the turn back of suburban trains clear of the main through tracks.

In addition, it is expected that 2 additional train sets will be required.

10. Summary

Table 15 below summarise each of the Infrastructure Scenarios identified as providing solutions to a range of Patronage Scenarios.

Table 16 on the following pages provides a summary for each of the management elements short listed for further investigation in this report.

Table 15: Summary of infrastructure scenarios

Scenario	Description	Scope of Works
Scenarios Produced in response to patronage modelling		
Low Patronage Case	No rail upgrade but full road upgrade	• Add one additional 4 car train from Porirua • Provide additional train stabling
Base Patronage Case	Maintenance of existing rail market share	• Add one additional 6 car train from Porirua • Increase the size of three trains from 6 to 8 cars • Provide additional train stabling
High Patronage Case	Unrestricted rail upgrade but no road upgrade	• Add two additional 8 car trains from Porirua • Increase the size of two trains from 6 to 8 cars • Reinforce traction power supply • Provide additional train stabling
Scenarios produced based on perceived infrastructure needs		

Infrastructure Case A	15 minute train frequency out of Lindale and 7.5 minute train frequency out of Porirua	• Extend electrification on single track to Lindale • Duplicate from Raumati South to Paraparaumu • Install additional platform and train turnback siding at Porirua • One additional train set
Infrastructure Case B	10 minute train frequency out of Lindale and 5 minute train frequency out of Porirua	• Extend electrification on single track to Lindale • Duplicate from MacKays Crossing to Raumati South • Install additional platform and train turnback siding at Porirua • Three additional train sets
Infrastructure Case C	15 minute train frequency out of Waikanae and 7.5 minute train frequency out of Porirua	• Extend electrification on single track to Waikanae • New crossing loop between MacKays Crossing and Paraparaumu • Install additional platform and train turnback siding at Porirua • Three additional train sets

Table 16: Summary of infrastructure projects

Element ID	Element Description	Comment
RT1	Double Track between North and South Junctions	Not essential in order to increase capacity on the corridor. Its major impact is on service reliability, particularly when out of course running occurs
RT2	Double Track between MacKays Crossing and Raumati	Extension of double track
RT3	Double Track between Raumati and Paraparaumu	Incremental extension of the double track from RT2 Stand alone piece of double track south of Paraparaumu
RT4	Double Track between Paraparaumu and Waikanae	Refer to RE1
RT7	Passing Loops at Various Locations	A typical passing loop on a single track section
RT16	New Stabling North of Waikanae	Refer to RE1
RT20	Kapiti Coast Loop (Raumati-Waikanae section)	Refer to RT7 and RE1
RE1	Extension of Electrification to Waikanae	Single track electrification (35min frequency with Paekakariki stabling) Double track electrification (20min frequency with Paekakariki stabling) Single track electrification (20min frequency with Waikanae stabling)
RS1	New Rail Station at Lindale	Refer to RS10
RS2	New Rail Station at Raumati	Not supported by passenger modelling
RS4	New Rail Station at Glenside	Not supported by passenger modelling
RS6	New Rail Station at MacKays Crossing	Not supported by passenger modelling
RS7	Removal of Muri/Pukerua Bay Station	Train operating cost savings of one minute per train
RS8	Removal of Redwood/Takapu Station	Train operating cost savings of one minute per train
RS9	Park and Ride Capacity Improvements	This is an enabler to patronage growth
RS10	Bus Interchange at Lindale	Two scenarios have been considered • Extension of electrification and establishment of station • Inserting a new station if track is already electrified
RS11	Bus interchange at Porirua	Improving the existing facility
RS12	Improved Cycle Storage at Stations	Not costed separately to station and interchange upgrades
RU1	Upgrade of Train Units	Already funded by Government

RM1	Improved Rail Frequency on Existing Infrastructure	Issues include: • traction power supply capacity • train fleet availability • train stabling siding capacity • capability of train maintenance depots to handle a larger fleet • inserting additional schedules into existing timetables • running 8 car trains instead of 4 or 6 car (lengthen platforms)
RM2	Management of Rail Priorities – Freight Secondary to Commuter Trains	Apply a freight train curfew as an alternative to upgrading infrastructure to accommodate these trains
RM5	Integrated Scheduling	Improves service delivery. Requires more buses and higher operating costs
RM7	Passenger Real Time Information	Improves passenger perceptions. Requires additional work before a cost can be allocated

Appendix A

Paraparaumu service frequency limitations

Paraparaumu Service Frequency Limitations

Analysis of the capacity to operate trains out of Paraparaumu has been undertaken by examining scheduling options with 5 minute service frequency increments. The train graphs on the following pages demonstrate the interactions between train scheduling and the infrastructure configuration of the corridor. The following table summarises the findings.

Table 17: Summary of Paraparaumu service frequency analysis

Service Frequency	Capacity Delivered (4 car/8 car)	Service Frequency Impact			Infrastructure Improvements Required to Support Service Frequency	Scope for Regional Passenger Train Pathway	Scope for Freight Train Pathway
		Waikanae	Paraparaumu - Plimmerton	Plimmerton - Wellington			
5 mins	4800/9600	Current	Improvement	Improvement	Full track duplication	If slowed down	Not available
10 mins	2400/4800	Current	Improvement	Current	Full track duplication	If slowed down	Not available
15 mins	1600/3200	Current	Improvement	Reduction	**Min:** Track duplication MacKays to Paraparaumu **Preferred:** Full duplication in order to provide service reliability	If slowed down, but still may need duplication of North/South Junctions for reliability	Not available without duplication of North/South Junctions
20 mins	1200/2400	Current	Current	Reduction	**Min:** Nil, but service reliability will be poor **Preferred:** Short track duplication north of MacKays (nominally 1km)	Available	Only available if there is a suitable holding track at Paekakariki
25 mins	800/1600 plus	Current	Reduction	Reduction	Nil	Available	Only available if there is a suitable holding track at Paekakariki
30 mins	800/1600	Current	Reduction	Reduction	Nil	Available	Available
35 mins	less than 800/1600	Current	Reduction	Reduction	Nil	Available	Available
40 mins	~600/1200	Current	Reduction	Reduction	Nil	Available	Available

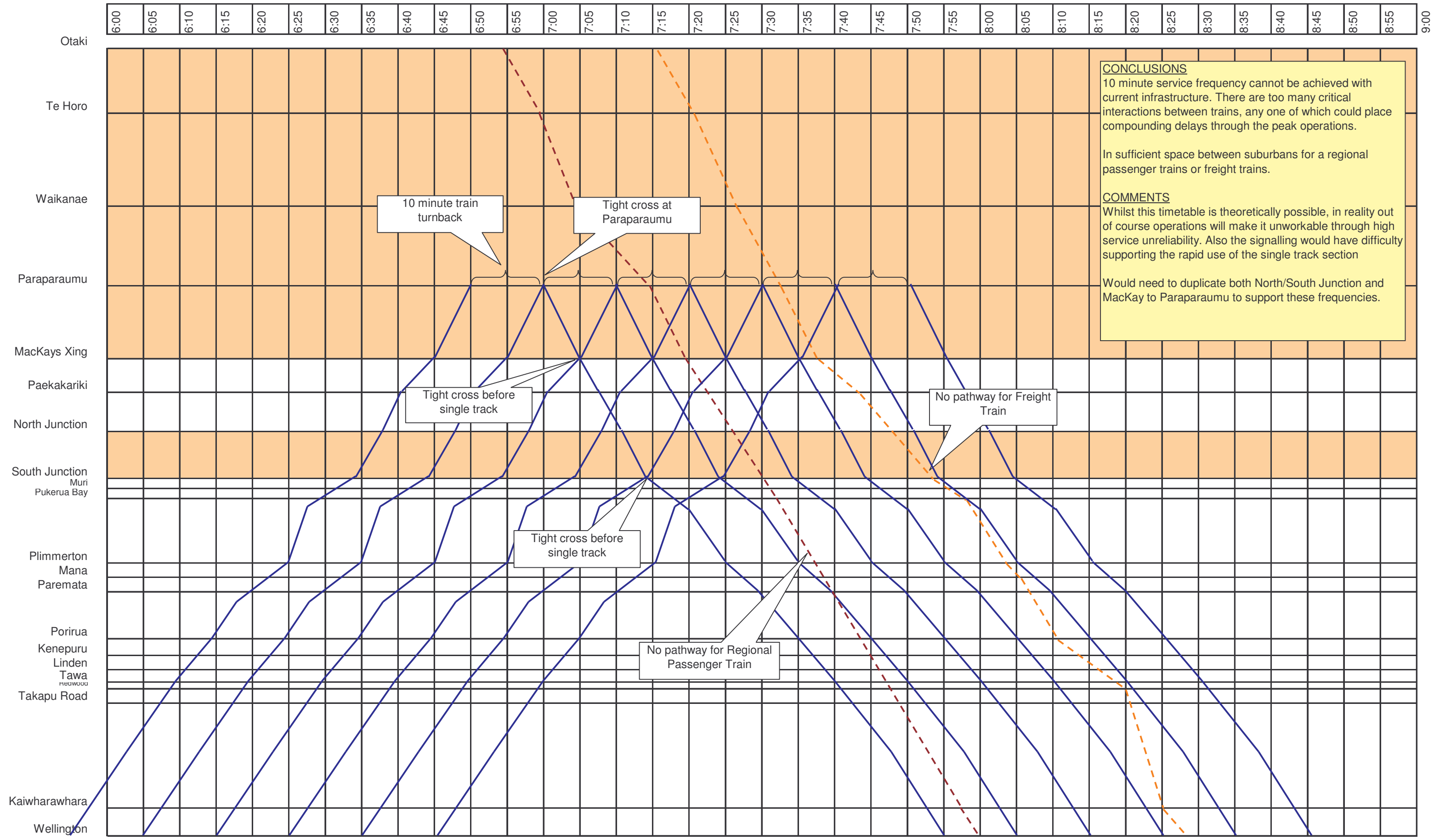
The conclusion drawn from this work is that a schedule frequency of better than 20 minutes is not sustainable with the existing infrastructure and where trains from Paraparaumu are formed by services worked out of Wellington. In order to sustain 20 minutes it is preferable to undertake a short extension of the double track north of MacKays Crossing.

Marginal improvements to service frequency can be achieved when trains, which have been stabled at Paraparaumu, are brought into operation to run one or more of the peak hour services nested between the base 20 minute pattern. This is demonstrated on the last train graph in this Appendix. In order for this to occur, it would be necessary to provide suitable train stabling sidings at Paraparaumu.

Western Corridor transportation study

WELLINGTON: NORTHERN TRUNK RAILWAY - AM PEAK *10 Minute Paraparaumu Service Frequency*

Legend
- Single track sections
- Paraparaumu - suburban: stopping all stations
- Paraparaumu - suburban: express Plimmerton to Wellington
- Plimmerton - suburban: stopping all stations
- Porirua - suburban: stopping all stations
- Regional Passenger Service
- Freight Train



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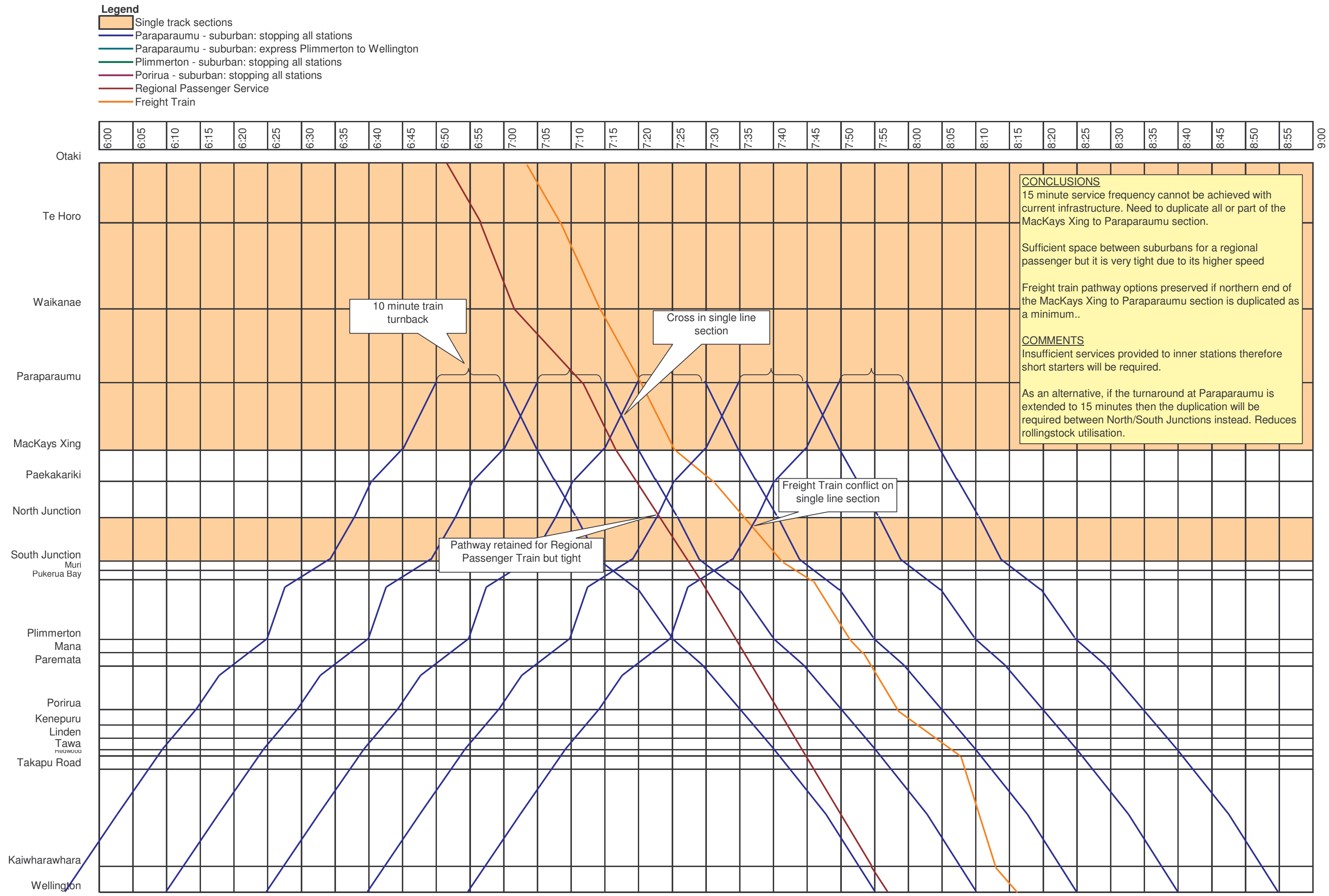
Western Corridor transportation study

WELLINGTON: NORTHERN TRUNK RAILWAY - AM PEAK

15 Minute Paraparaumu Service Frequency



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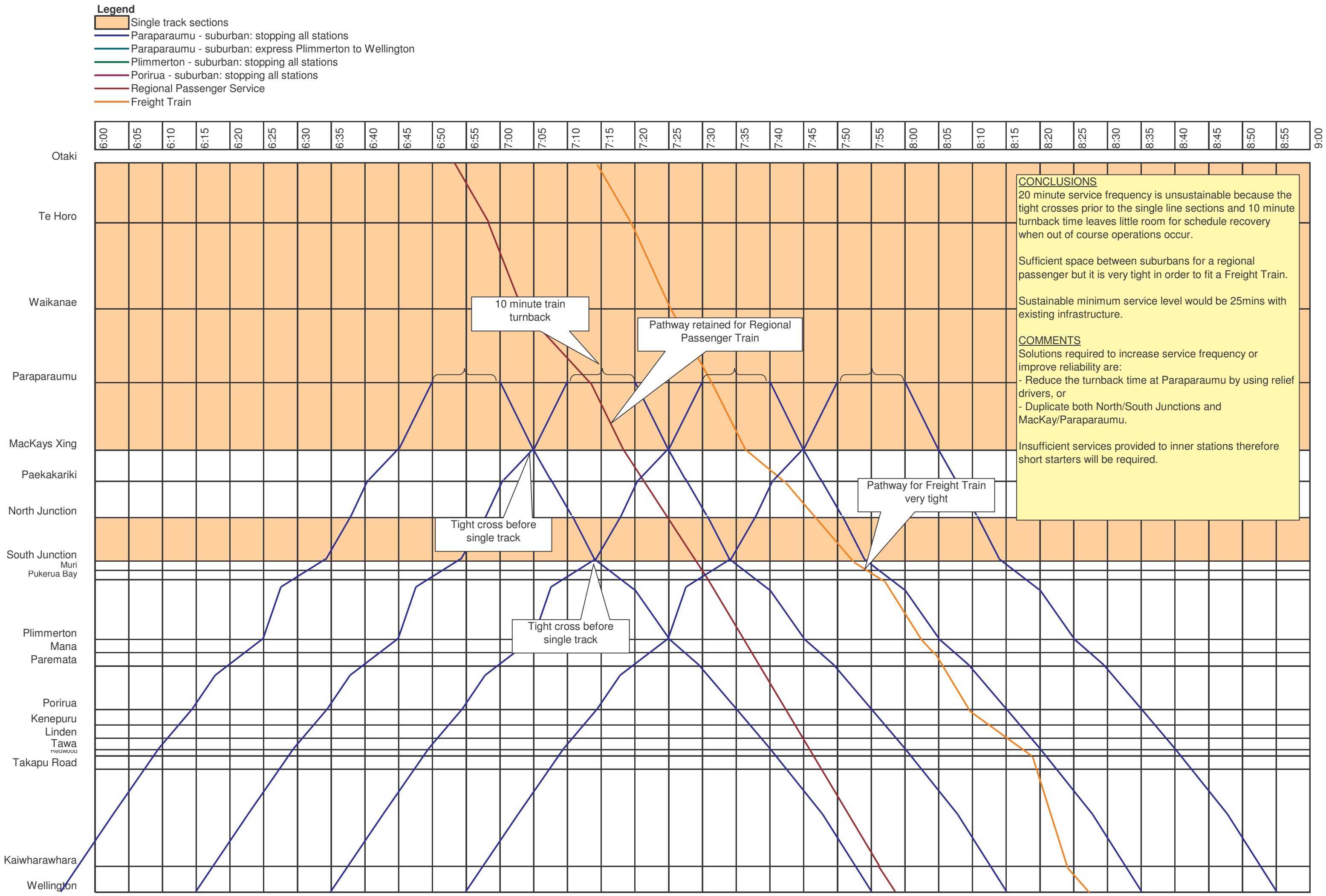
Western Corridor transportation study

WELLINGTON: NORTHERN TRUNK RAILWAY - AM PEAK *20 Minute Paraparaumu Service Frequency*



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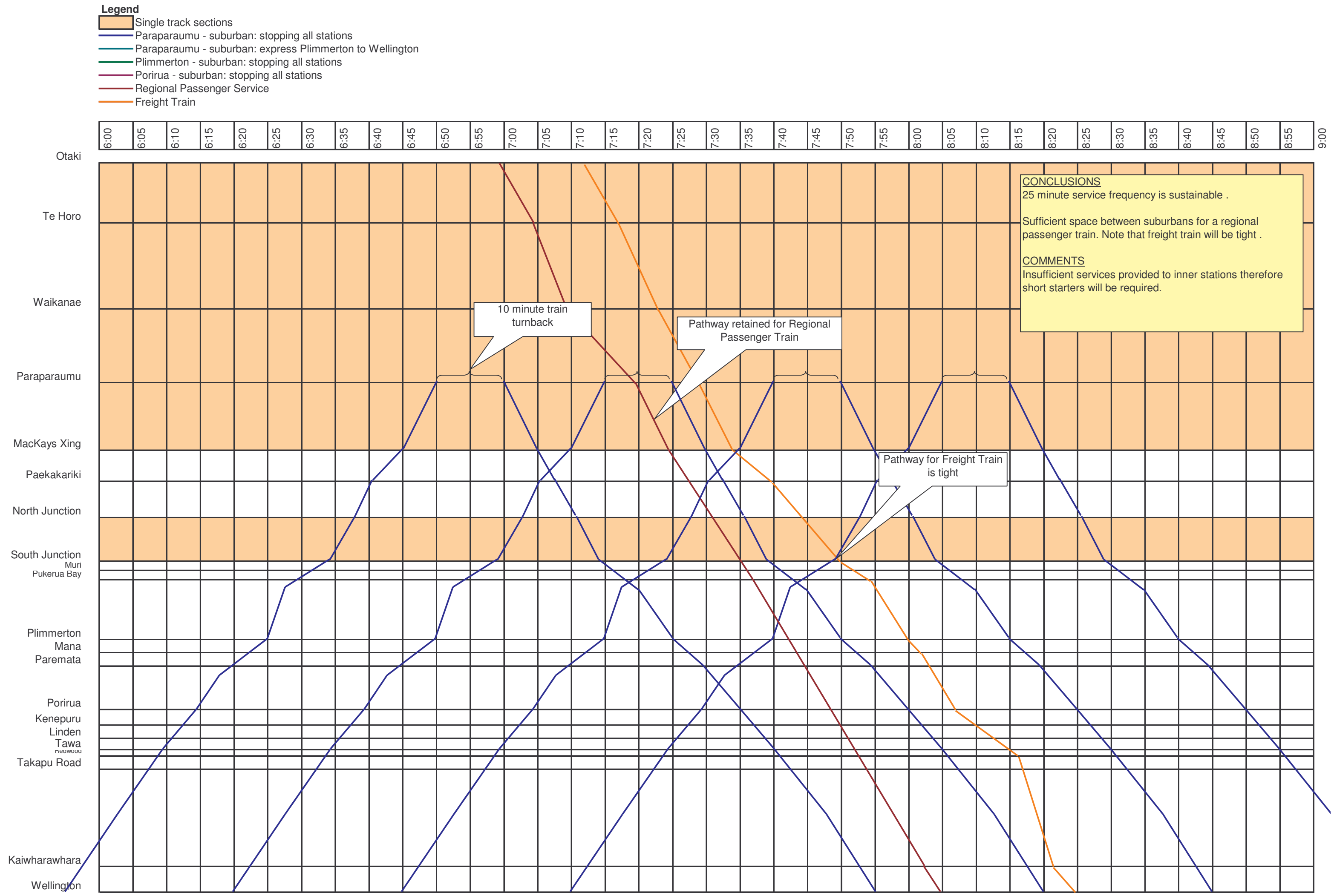
Western Corridor transportation study

WELLINGTON: NORTHERN TRUNK RAILWAY - AM PEAK *25 Minute Paraparaumu Service Frequency*



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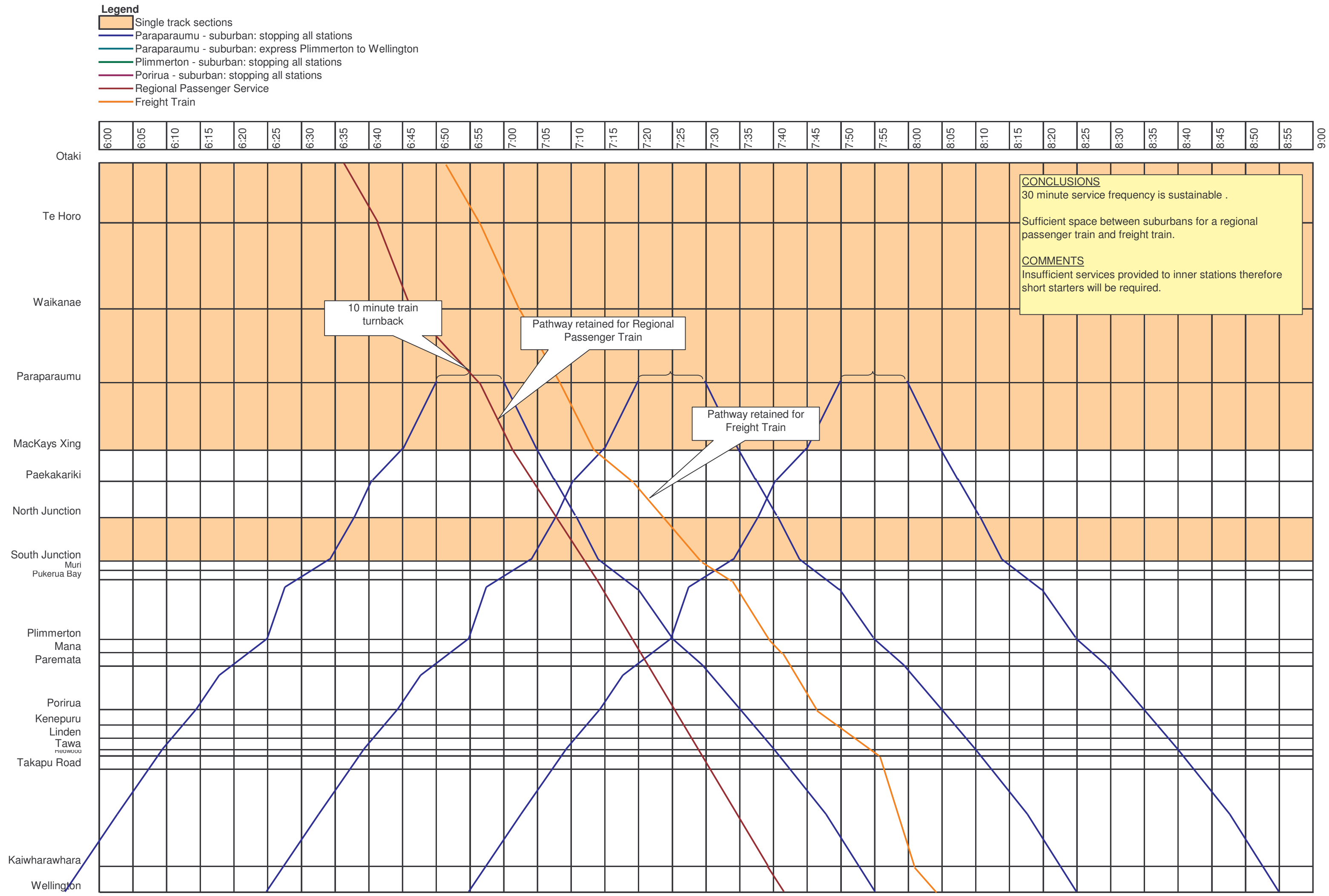
Western Corridor transportation study

WELLINGTON: NORTHERN TRUNK RAILWAY - AM PEAK ***30 Minute Paraparaumu Service Frequency***



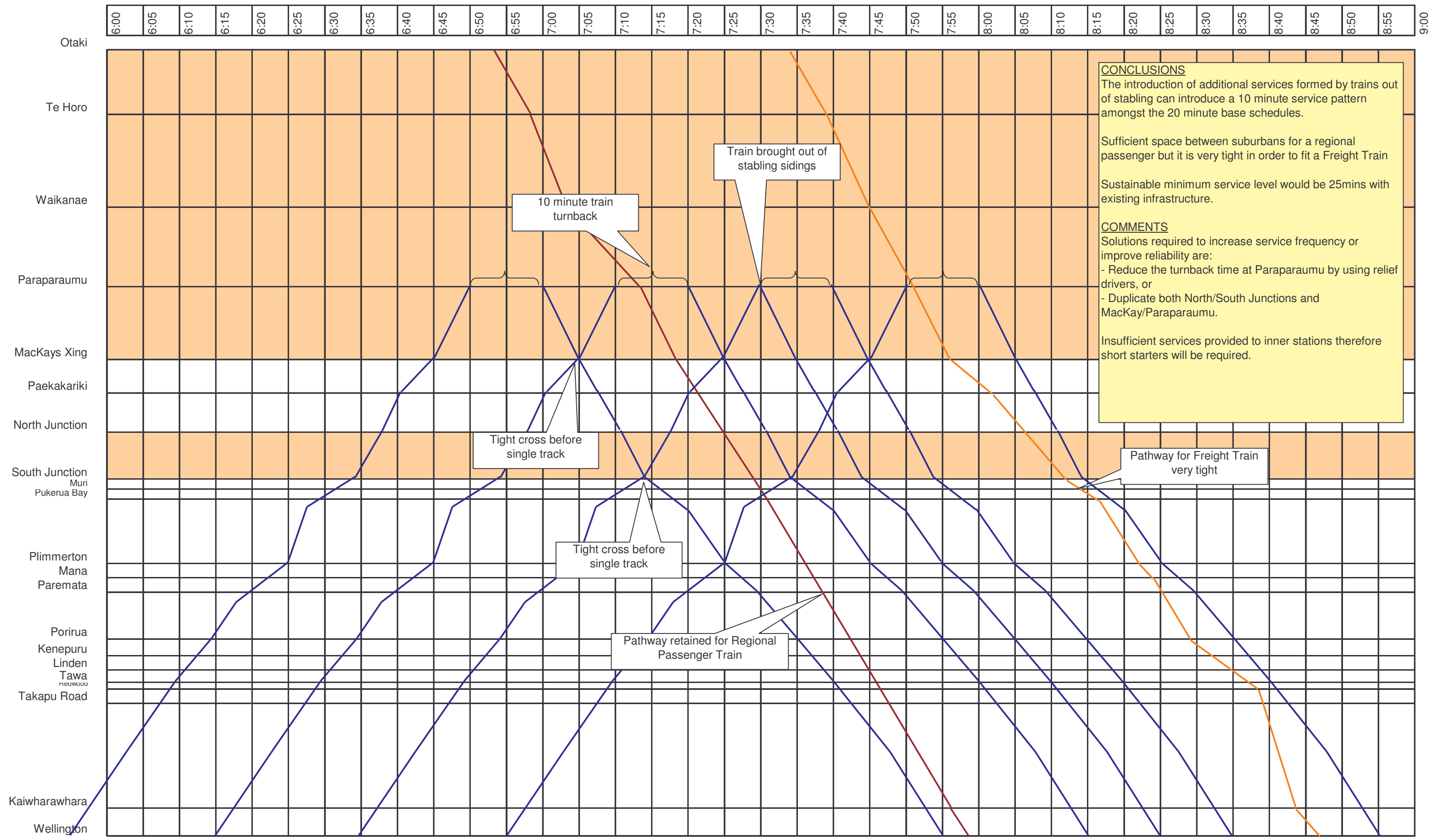
Western Corridor transportation study

WELLINGTON: NORTHERN TRUNK RAILWAY - AM PEAK

20 Minute Paraparaumu Service Frequency introducing stabled trains

Legend

- Single track sections
- Paraparaumu - suburban: stopping all stations
- Paraparaumu - suburban: express Plimmerton to Wellington
- Plimmerton - suburban: stopping all stations
- Porirua - suburban: stopping all stations
- Regional Passenger Service
- Freight Train



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Appendix B

Waikanae service delivery options

Waikanae Service Delivery Options

Analysis of the capacity to operate trains out of Waikanae has been undertaken by examining scheduling options with 5 minute service frequency increments. The train graphs on the following pages demonstrate the interactions between train scheduling and the infrastructure configuration of the corridor. Note that the following analysis applies with electrification extended from Paraparaumu to Waikanae. The following table summarises the findings.

Table 18: Summary of Waikanae service frequency analysis

Service Frequency	Capacity Delivered (4 car/8 car)	Service Frequency Impact			Infrastructure Improvements Required to Support Service Frequency	Scope for Regional Passenger Train Pathway	Scope for Freight Train Pathway
		Waikanae	Paraparaumu - Plimmerton	Plimmerton - Wellington			
5 mins	4800/9600	Improvement	Improvement	Improvement	Full track duplication	If slowed down	Not available
10 mins	2400/4800	Improvement	Improvement	Current	**Min:** Crossing facility at Paraparaumu Preferred: Full track duplication	Only with track duplication MacKays to Paraparaumu	Not available
15 mins	1600/3200	Improvement	Improvement	Reduction	Track duplication MacKays to Paraparaumu	Not available without duplication Paraparaumu to Waikanae	Not available without duplication of North/South Junctions
20 mins	1200/2400	Improvement	Current	Reduction	**Min:** Crossing facility at Paraparaumu Preferred: Track duplication MacKays to Paraparaumu	Not available without duplication MacKays to Paraparaumu	Only available if there is a suitable holding track at Paekakariki
25 mins	800/1600 plus	Improvement	Reduction	Reduction	**Min:** Crossing facility between MacKays and Paraparaumu Preferred: Track duplication MacKays to Paraparaumu	Not available without duplication MacKays to Paraparaumu	Only available if there is a suitable holding track at Paekakariki
30 mins	800/1600	Improvement	Reduction	Reduction	**Min:** No change Preferred: Short track duplication north of MacKays (nominally 1km)	Available	Available with track duplication, still some reliability risk at South Junction
35 mins	less than 800/1600	Improvement	Reduction	Reduction	Nil	Available	Available
40 mins	~600/1200	Improvement	Reduction	Reduction	Nil	Available	Available

The conclusion drawn from this work is that a schedule frequency of better than 35 minutes may not sustainable with the existing infrastructure and where trains from Waikanae are formed by services worked out of Wellington. In order to sustain more frequent service levels then some degree of track duplication will be required.

Marginal improvements to service frequency can be achieved when trains, which have been stabled at Waikanae, are brought into operation to run one or more of the peak hour services nested between the base 35 minute pattern. This is demonstrated on the last train graph in this Appendix. In order for this to occur, it would be necessary to provide suitable train stabling sidings at Waikanae.

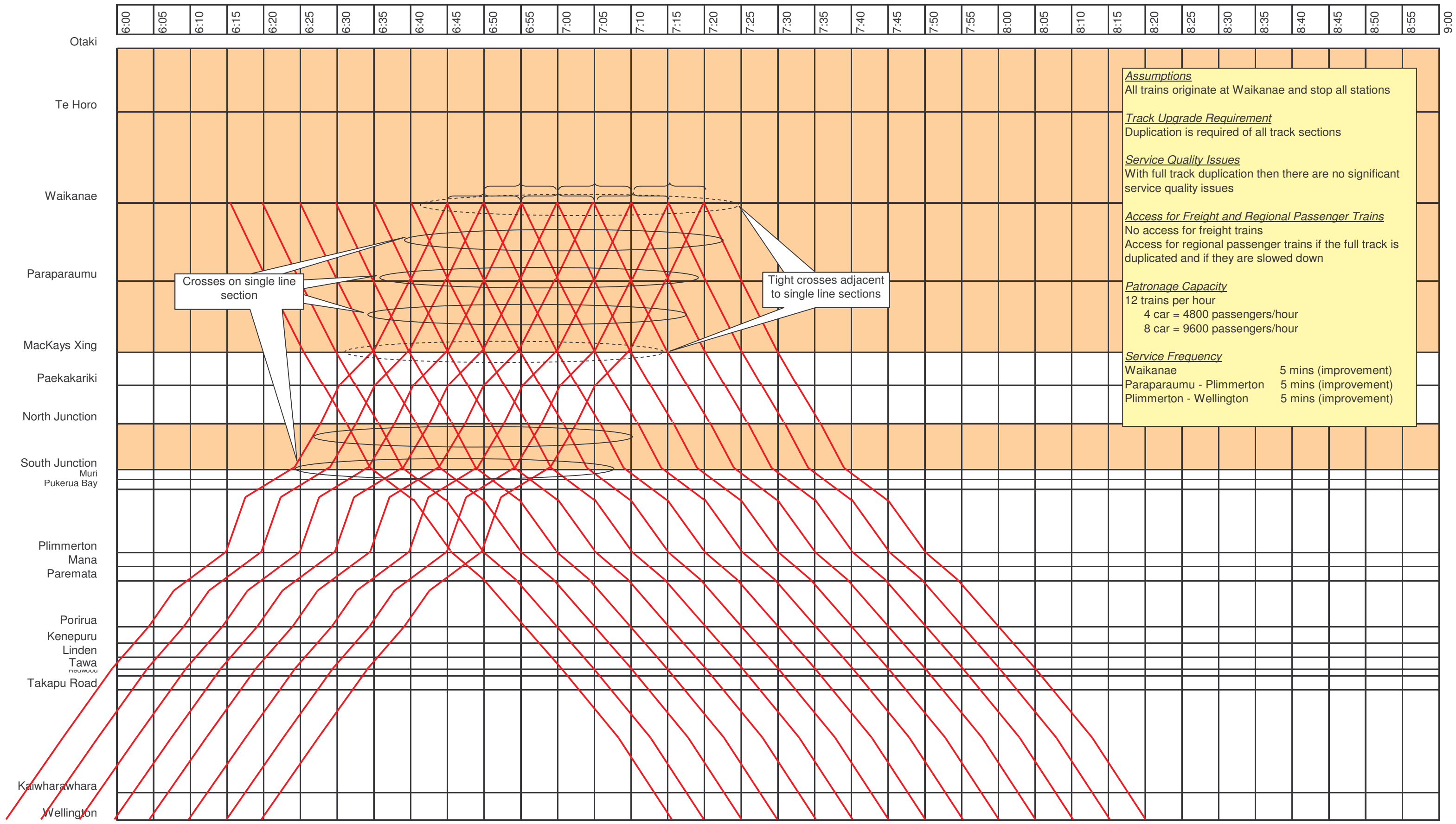
Western Corridor transportation study

WELLINGTON: NORTHERN TRUNK RAILWAY - AM PEAK

WAIKANAE ELECTRIFICATION EXISTING TRACK
5 Minute service frequency

Legend

- Single track sections
- Paraparaumu - suburban: stopping all stations
- Paraparaumu - suburban: express Plimmerton to Wellington
- Paraparaumu - suburban: stopping all stations
- Paraparaumu - suburban: express Plimmerton to Wellington
- Plimmerton - suburban: stopping all stations
- Porirua - suburban: stopping all stations
- Regional Passenger Service
- Freight Train



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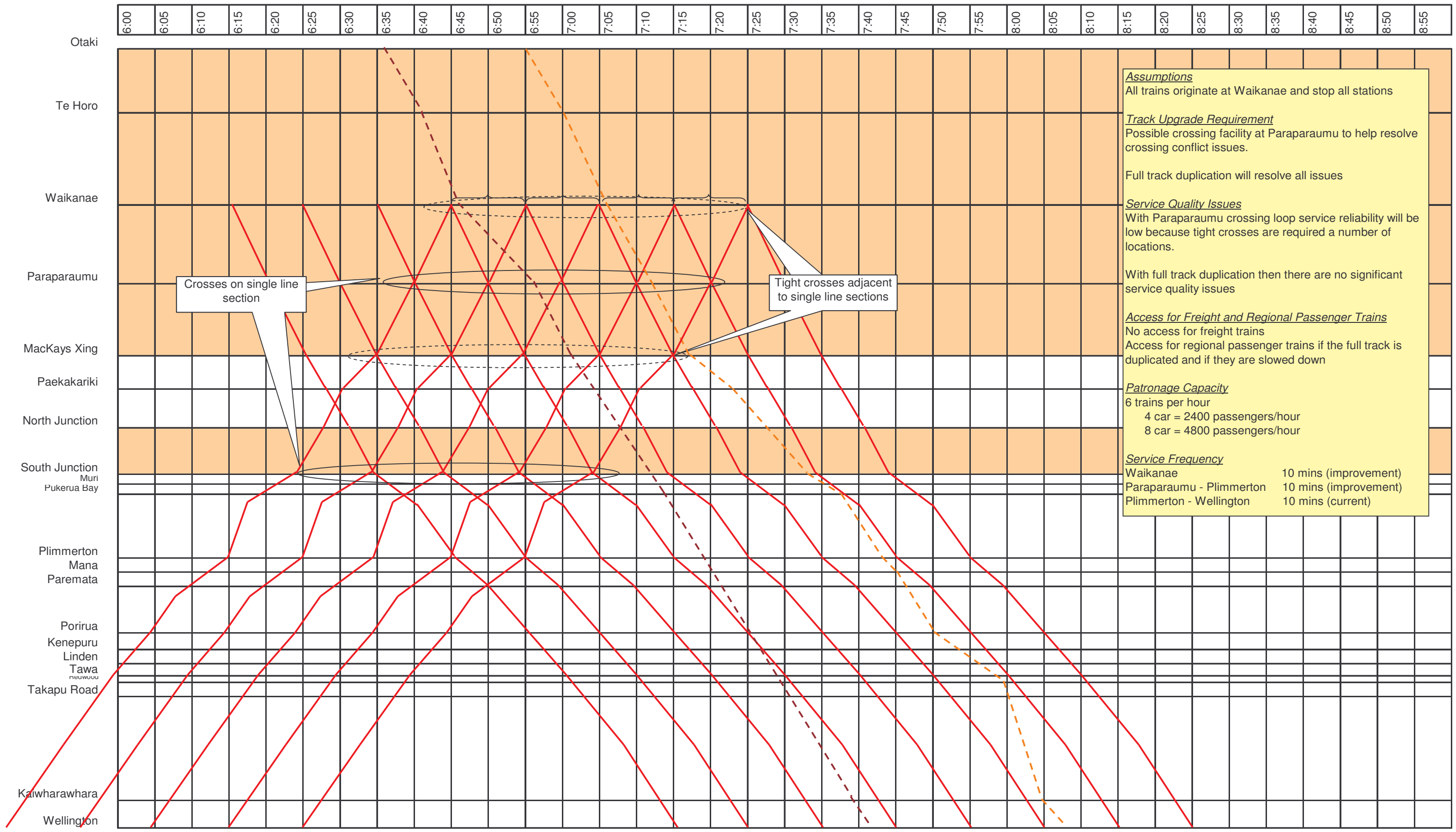
Western Corridor transportation study

WELLINGTON: NORTHERN TRUNK RAILWAY - AM PEAK

WAIKANAE ELECTRIFICATION EXISTING TRACK
10 Minute service frequency

Legend

- Single track sections
- Paraparaumu - suburban: stopping all stations
- Paraparaumu - suburban: express Plimmerton to Wellington
- Paraparaumu - suburban: stopping all stations
- Paraparaumu - suburban: express Plimmerton to Wellington
- Plimmerton - suburban: stopping all stations
- Porirua - suburban: stopping all stations
- Regional Passenger Service
- Freight Train

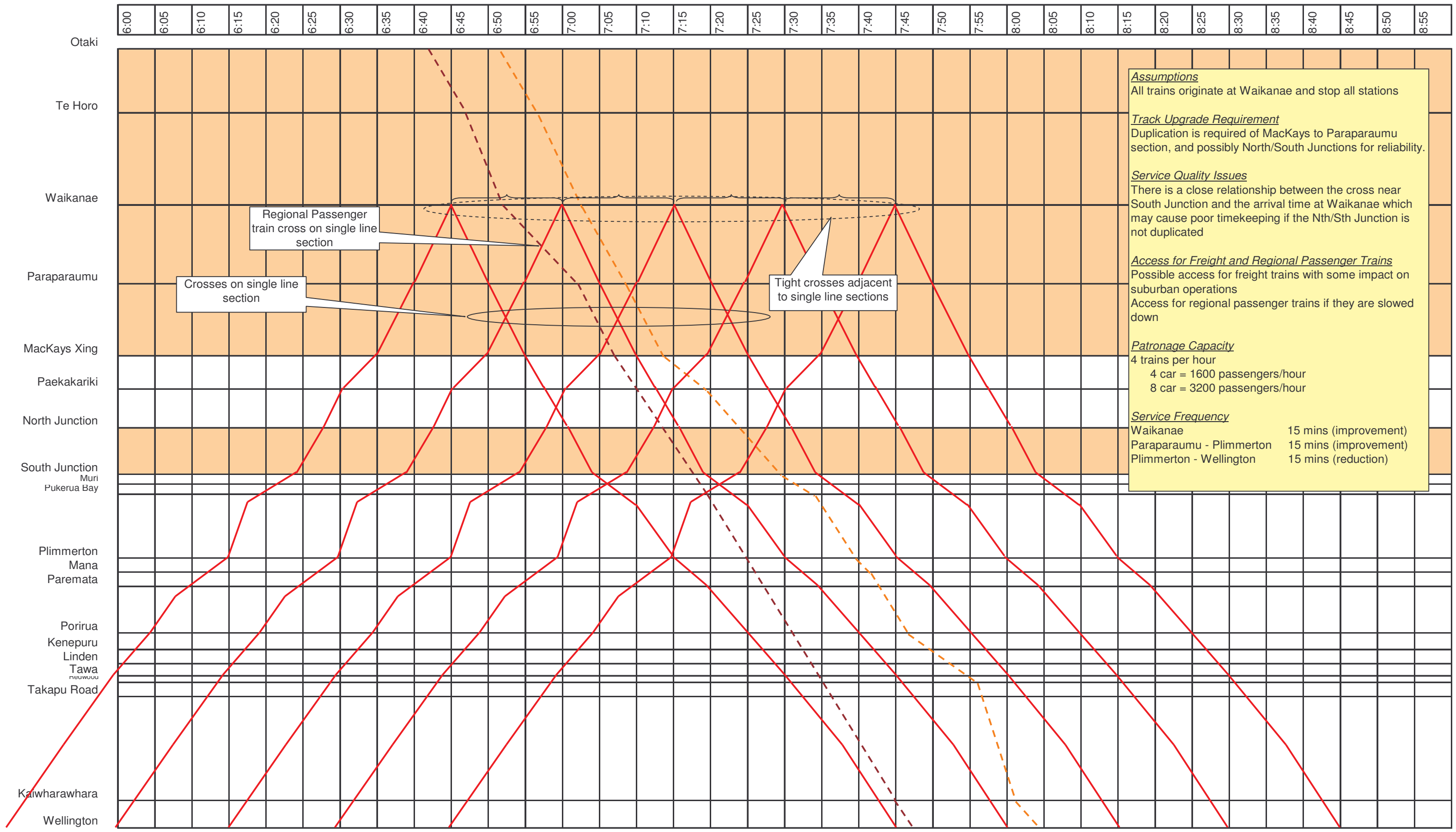


Western Corridor transportation study

WELLINGTON: NORTHERN TRUNK RAILWAY - AM PEAK

WAIKANAE ELECTRIFICATION EXISTING TRACK
15 Minute service frequency

Legend
- Single track sections
- Paraparaumu - suburban: stopping all stations
- Paraparaumu - suburban: express Plimmerton to Wellington
- Paraparaumu - suburban: stopping all stations
- Paraparaumu - suburban: express Plimmerton to Wellington
- Plimmerton - suburban: stopping all stations
- Porirua - suburban: stopping all stations
- Regional Passenger Service
- Freight Train



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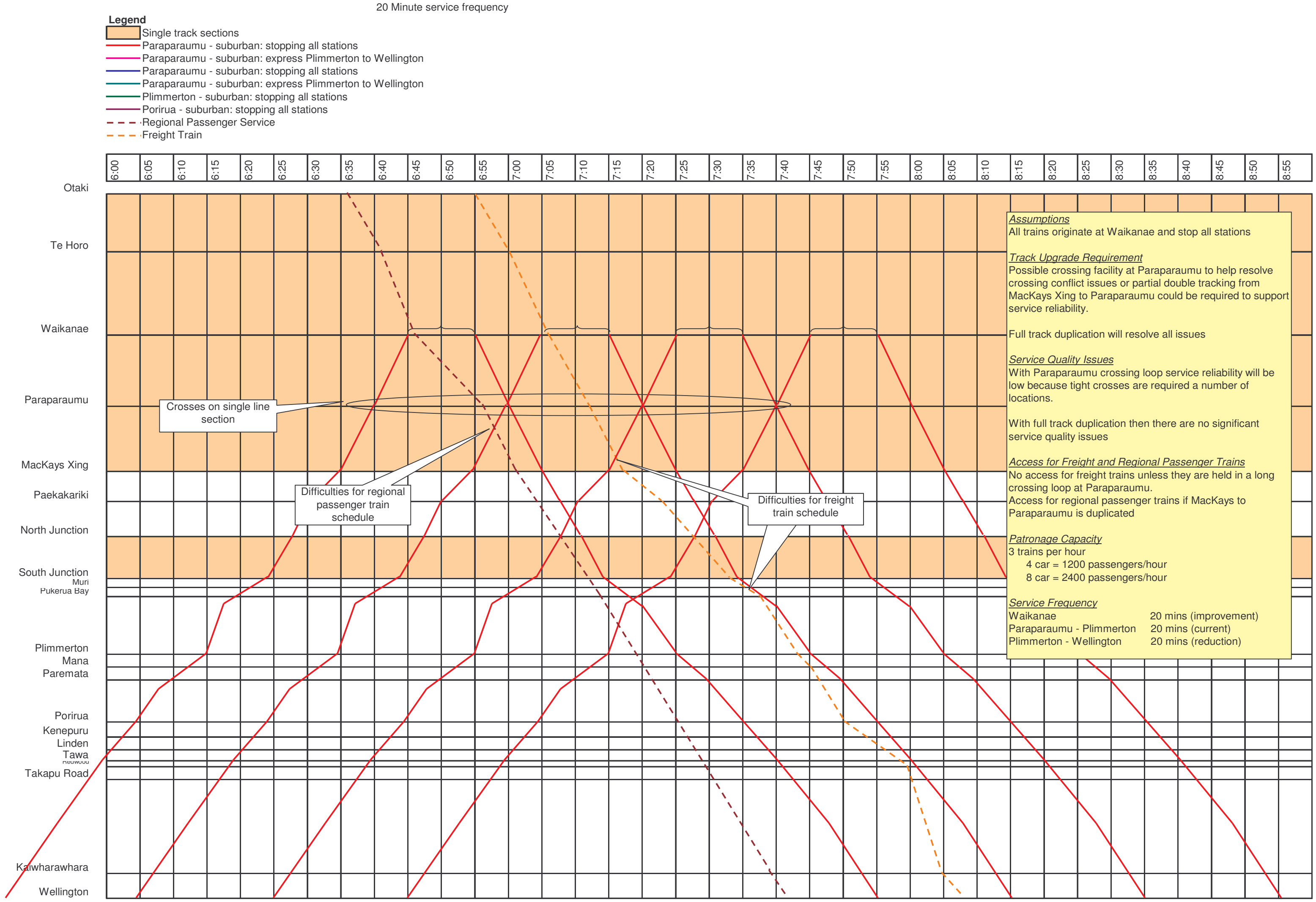
Western Corridor transportation study

WELLINGTON: NORTHERN TRUNK RAILWAY - AM PEAK

WAIKANAE ELECTRIFICATION EXISTING TRACK
20 Minute service frequency



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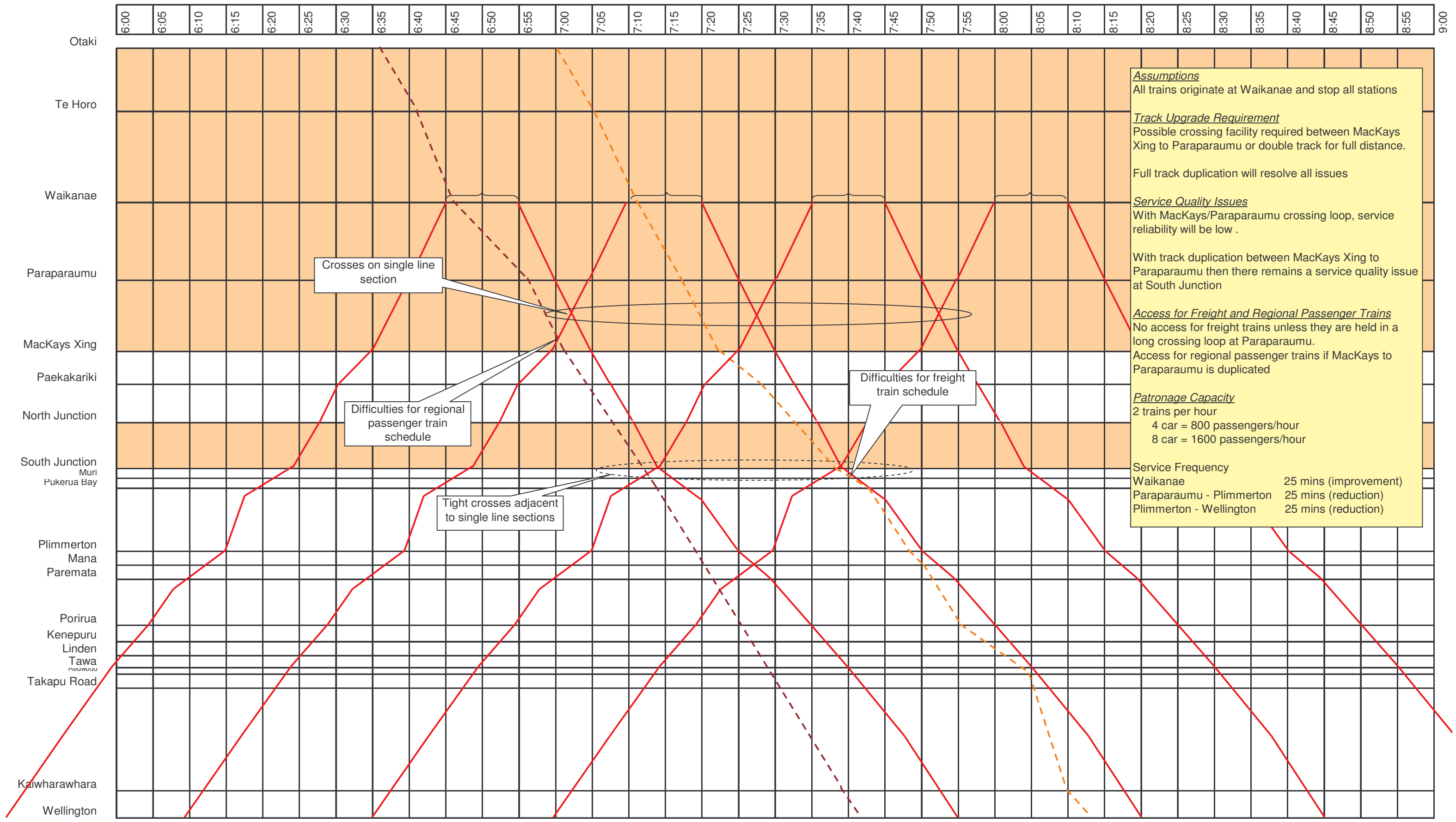
Western Corridor transportation study

WELLINGTON: NORTHERN TRUNK RAILWAY - AM PEAK

WAIKANAE ELECTRIFICATION EXISTING TRACK
25 Minute service frequency

Legend

- Single track sections
- Paraparaumu - suburban: stopping all stations
- Paraparaumu - suburban: express Plimmerton to Wellington
- Paraparaumu - suburban: stopping all stations
- Paraparaumu - suburban: express Plimmerton to Wellington
- Plimmerton - suburban: stopping all stations
- Porirua - suburban: stopping all stations
- Regional Passenger Service
- Freight Train



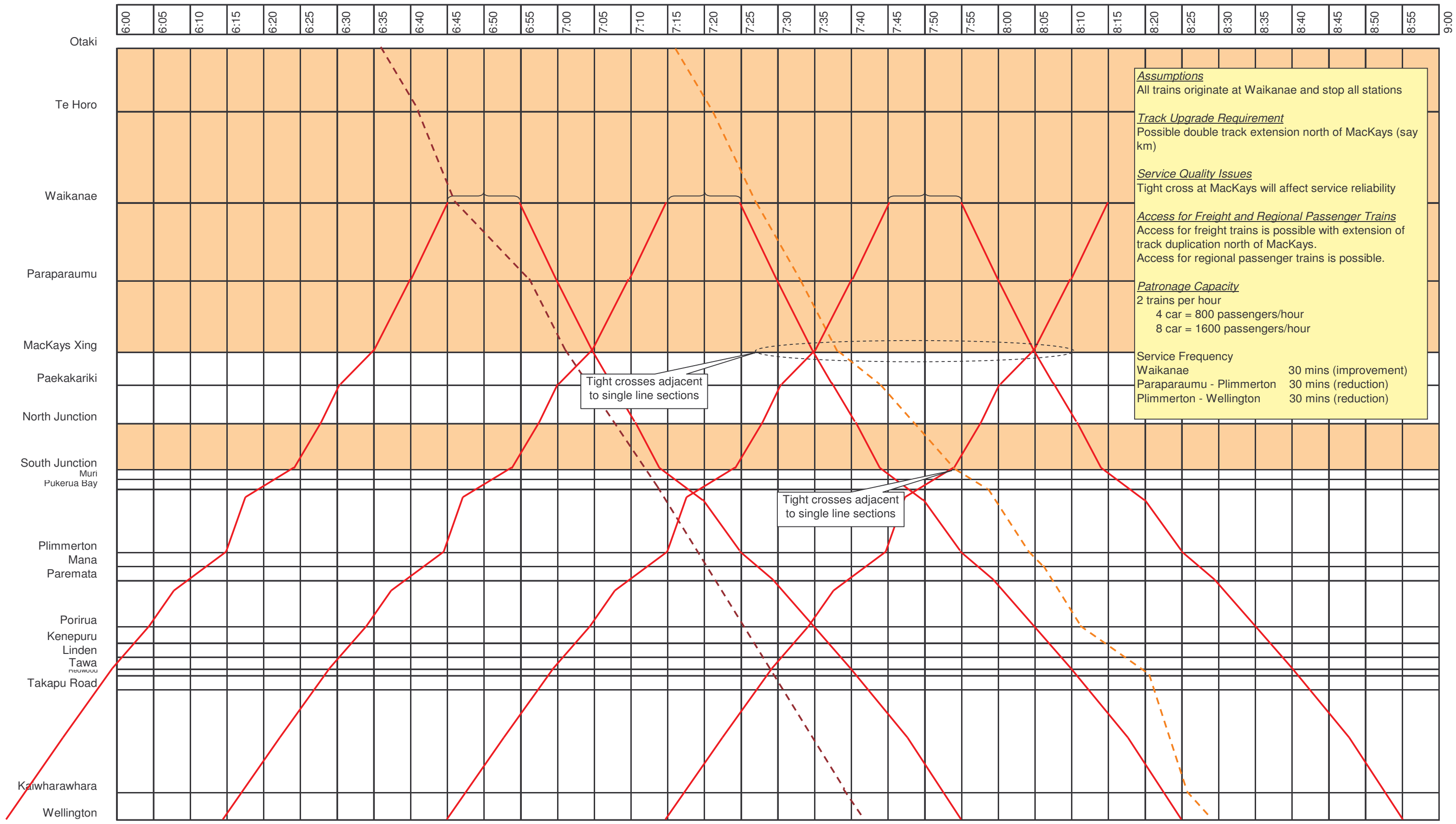
Western Corridor transportation study

WELLINGTON: NORTHERN TRUNK RAILWAY - AM PEAK

WAIKANAE ELECTRIFICATION EXISTING TRACK
30 Minute service frequency

Legend

- Single track sections
- Paraparaumu - suburban: stopping all stations
- Paraparaumu - suburban: express Plimmerton to Wellington
- Paraparaumu - suburban: stopping all stations
- Paraparaumu - suburban: express Plimmerton to Wellington
- Plimmerton - suburban: stopping all stations
- Porirua - suburban: stopping all stations
- Regional Passenger Service
- Freight Train



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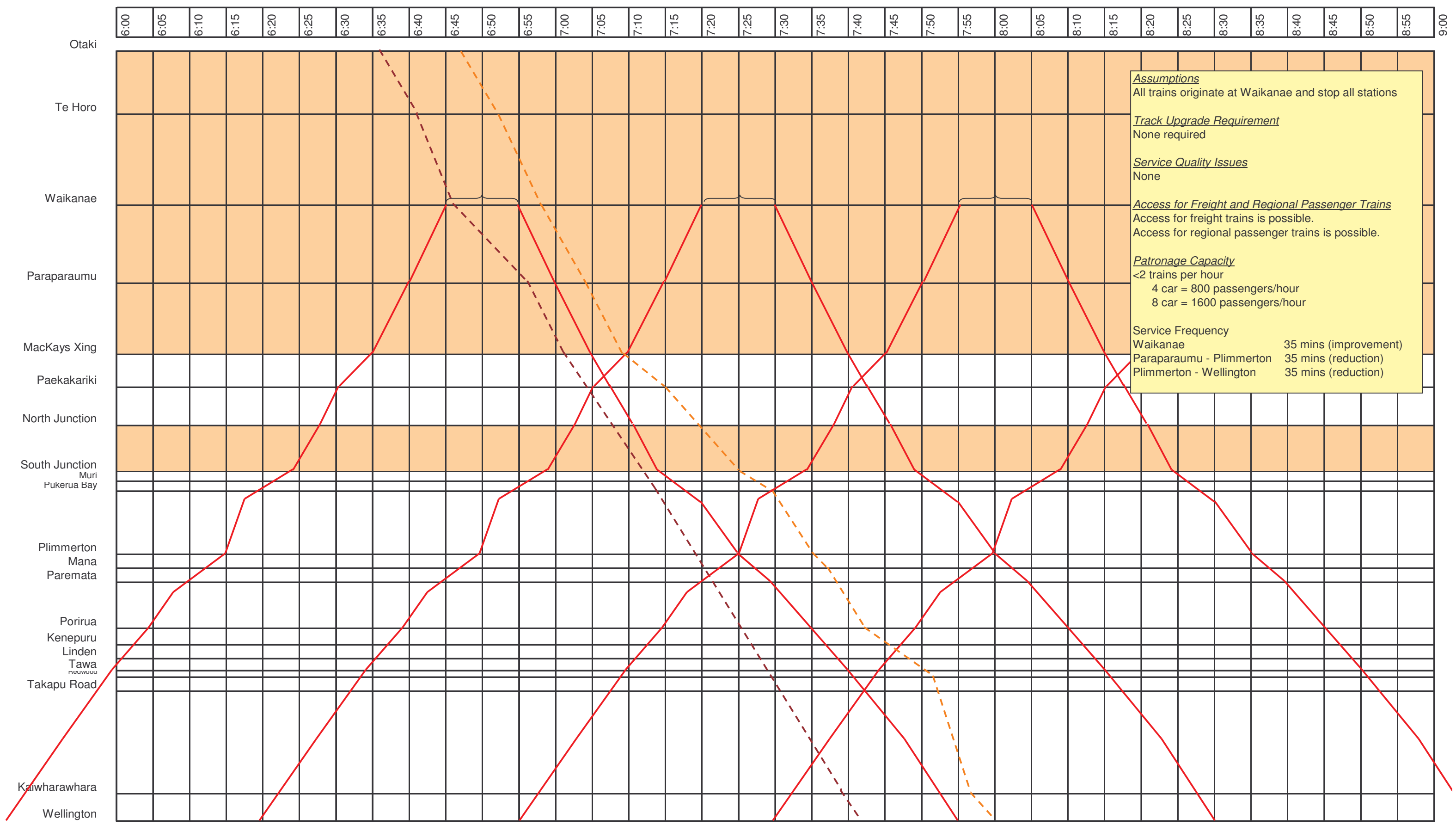
Western Corridor transportation study

WELLINGTON: NORTHERN TRUNK RAILWAY - AM PEAK

WAIKANAE ELECTRIFICATION EXISTING TRACK
35 Minute service frequency

Legend

- Single track sections
- Paraparaumu - suburban: stopping all stations
- Paraparaumu - suburban: express Plimmerton to Wellington
- Paraparaumu - suburban: stopping all stations
- Paraparaumu - suburban: express Plimmerton to Wellington
- Plimmerton - suburban: stopping all stations
- Porirua - suburban: stopping all stations
- Regional Passenger Service
- Freight Train

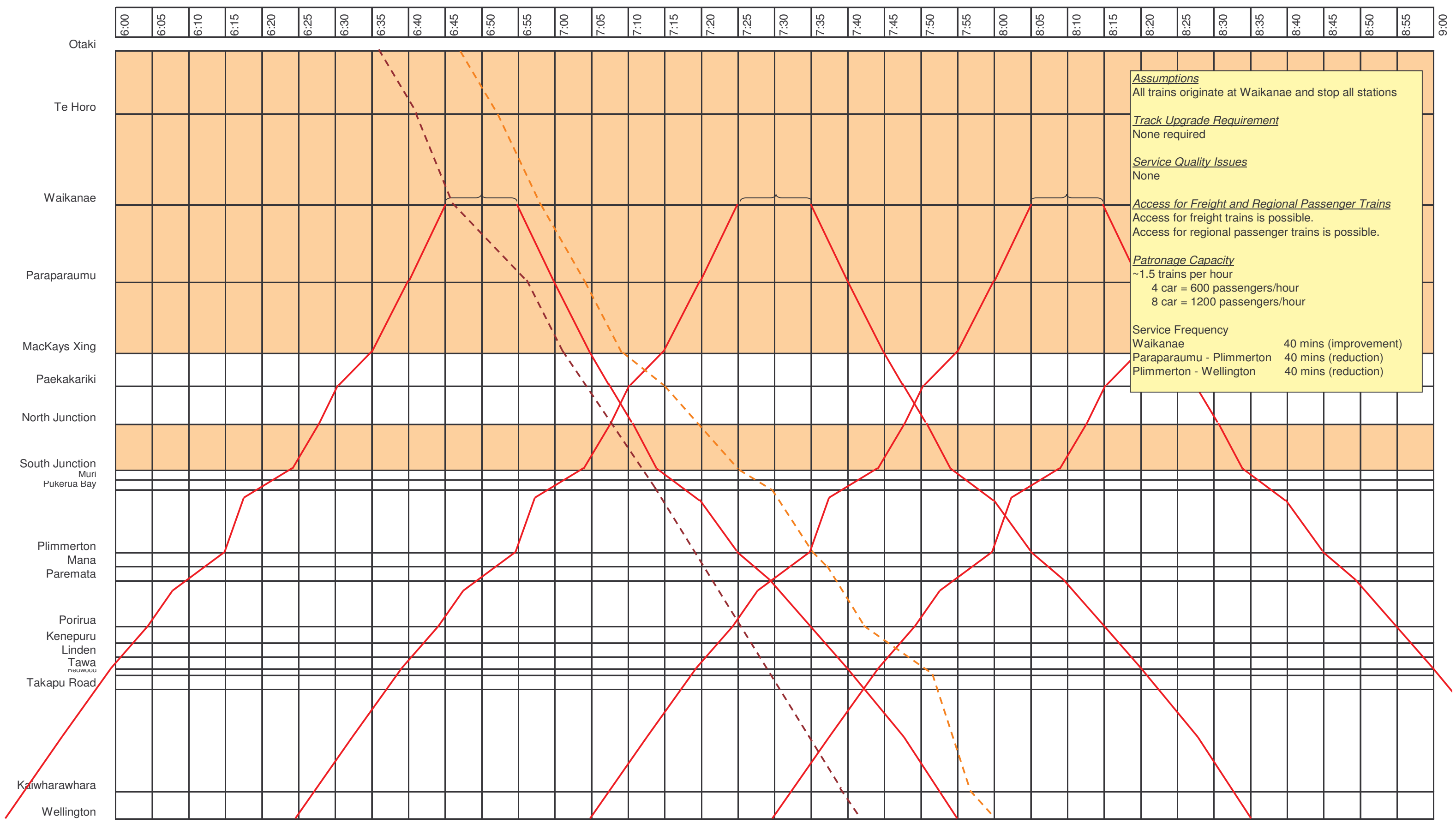


Western Corridor transportation study

WELLINGTON: NORTHERN TRUNK RAILWAY - AM PEAK

WAIKANAE ELECTRIFICATION EXISTING TRACK
40 Minute service frequency

Legend
- Single track sections
- Paraparaumu - suburban: stopping all stations
- Paraparaumu - suburban: express Plimmerton to Wellington
- Paraparaumu - suburban: stopping all stations
- Paraparaumu - suburban: express Plimmerton to Wellington
- Plimmerton - suburban: stopping all stations
- Porirua - suburban: stopping all stations
- Regional Passenger Service
- Freight Train



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Appendix C

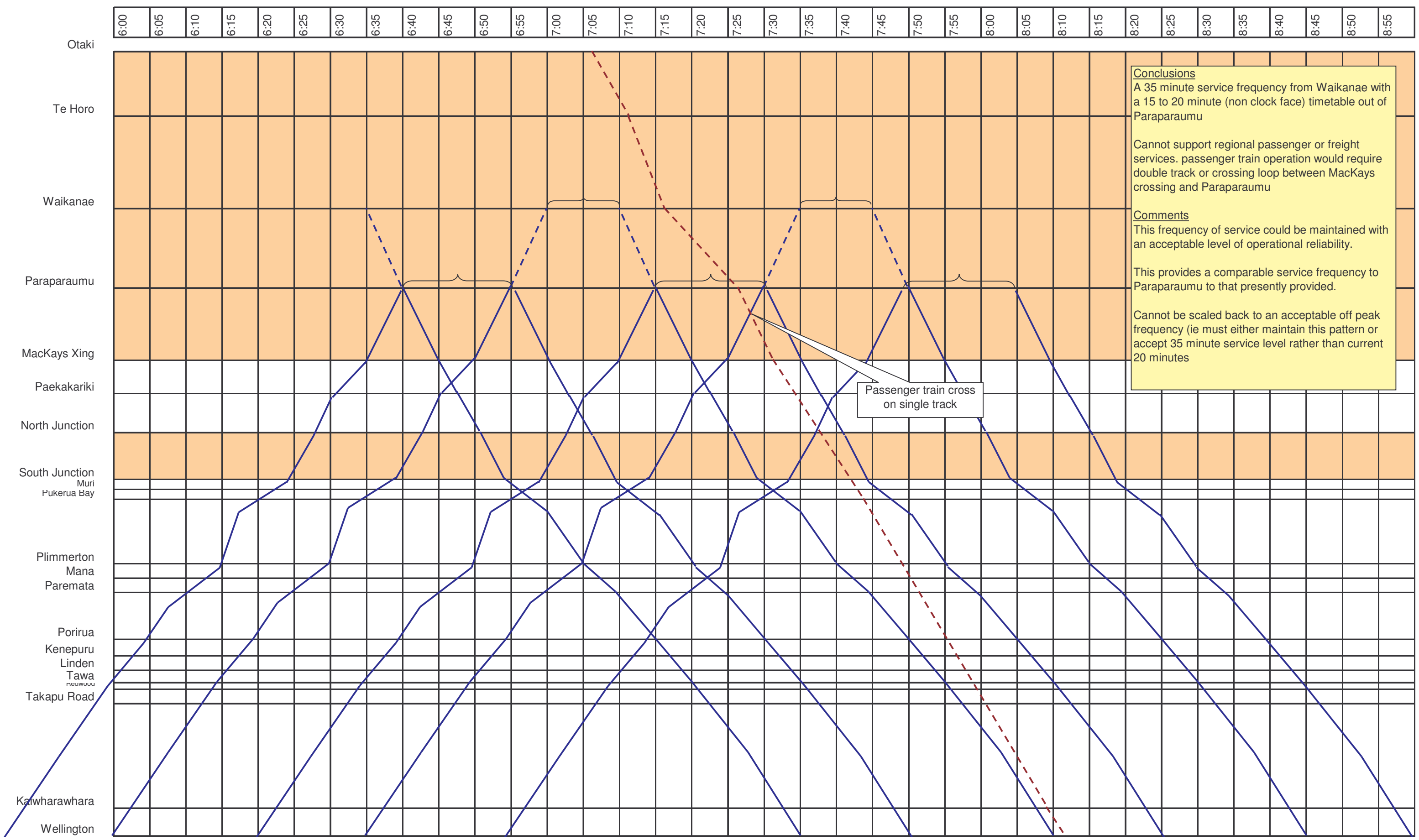
Waikanae electrification – 35min nested frequency solution

Western Corridor transportation study

WELLINGTON: NORTHERN TRUNK RAILWAY - AM PEAK

Electrification to Waikanae
Existing track configuration
Waikanae 35 minute schedule frequency
Paraparaumu 15 to 20 minute schedule frequency

Legend
- Single track sections
- Waikanae - suburban: stopping all stations
- Waikanae - suburban: express Plimmerton to Wellington
- Plimmerton - suburban: stopping all stations
- Porirua - suburban: stopping all stations
- Regional Passenger Service
- Freight Train



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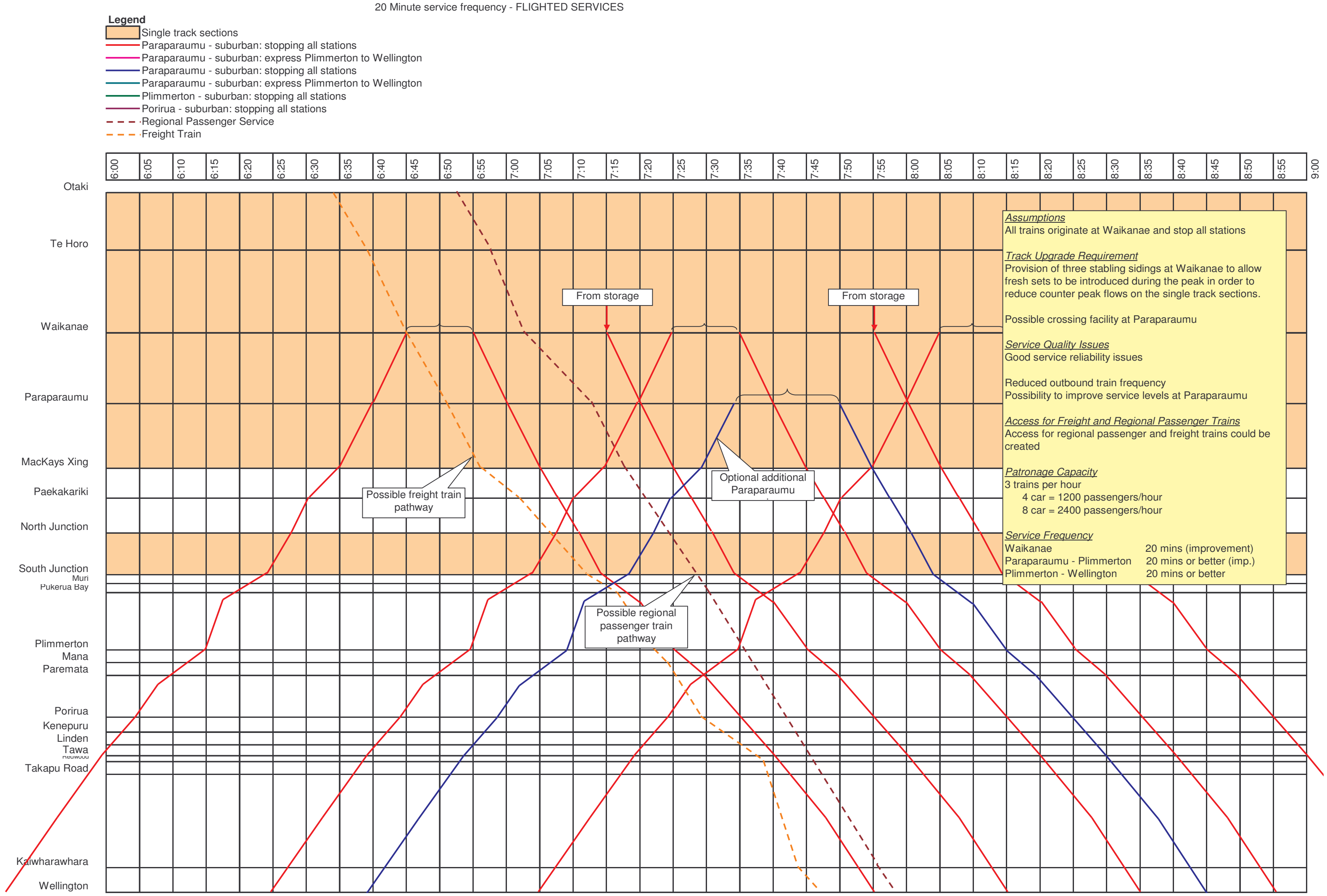
Appendix D

Waikanae electrification – 20min frequency solution with train stabling at Waikanae

Western Corridor transportation study

WELLINGTON: NORTHERN TRUNK RAILWAY - AM PEAK

WAIKANAE ELECTRIFICATION - STABLING AT WAIKANAE
20 Minute service frequency - FLIGHTED SERVICES



Western Corridor transportation study

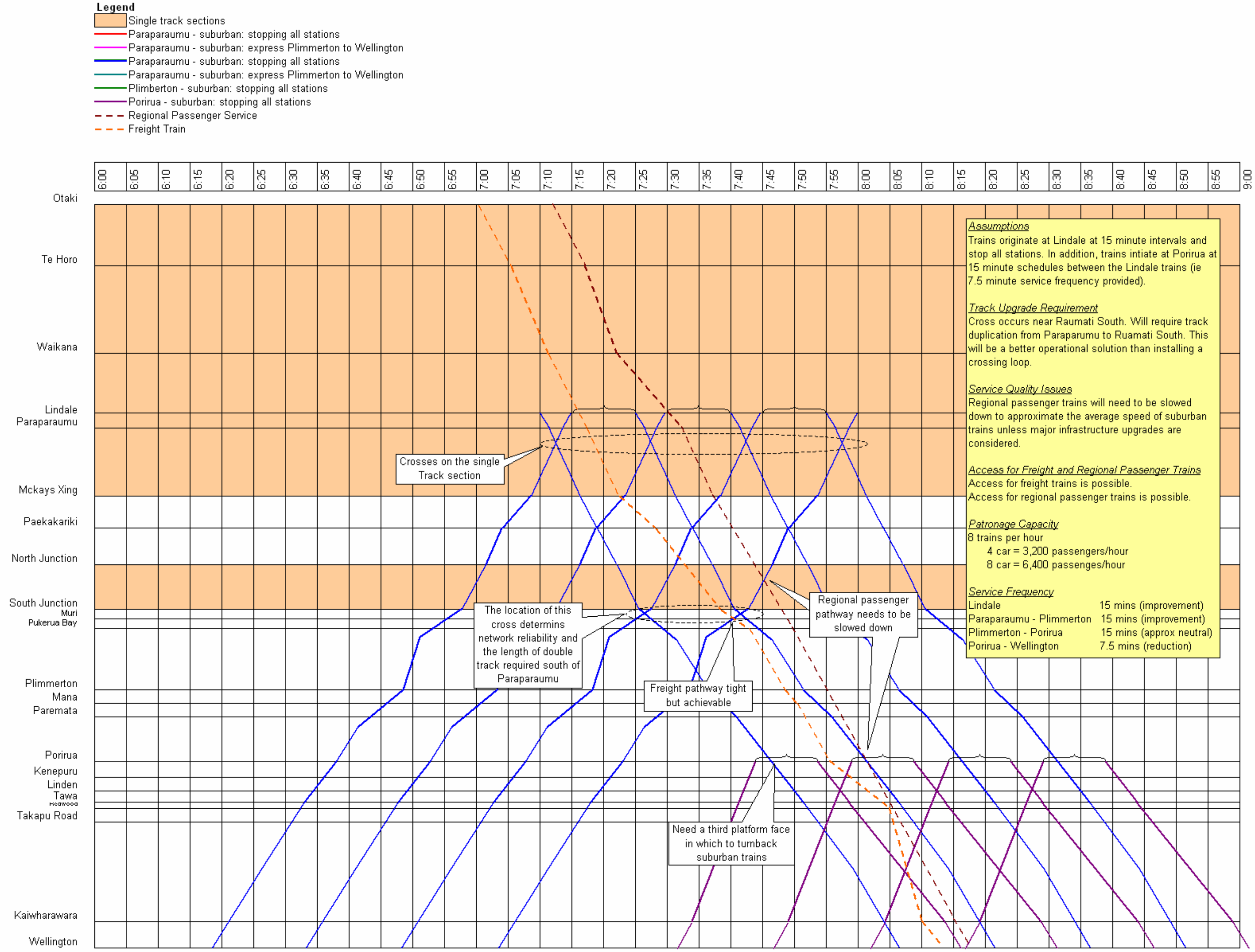
Appendix E

Other Infrastructure Scenarios – Operations Concepts

Western Corridor transportation study

WELLINGTON: NORTHERN TRUNK RAILWAY - AM PEAK

15 minutes Service from Lindale
7 minute Service from Poriua



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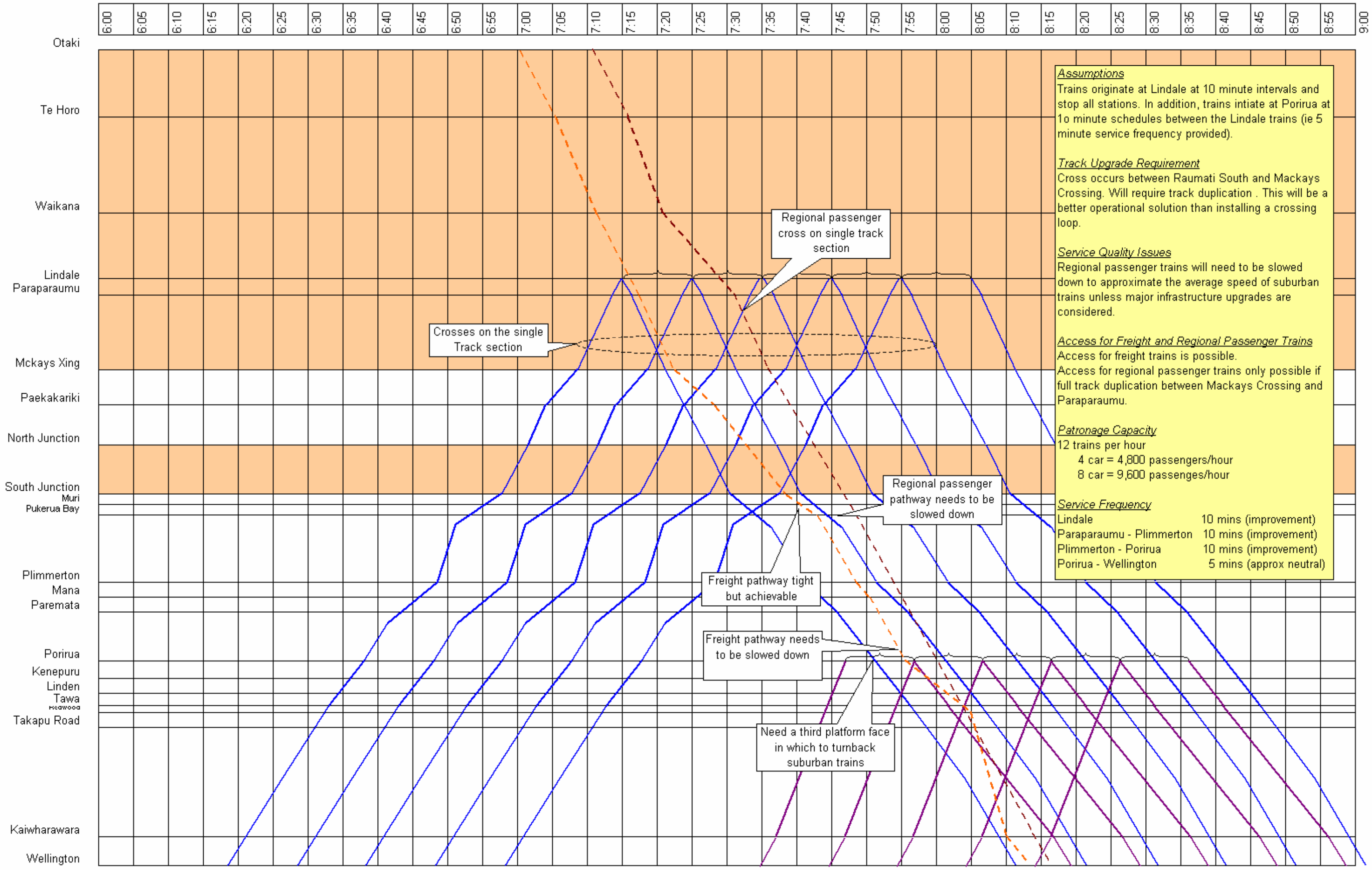
Western Corridor transportation study

WELLINGTON: NORTHERN TRUNK RAILWAY - AM PEAK

10 minutes Service from Lindale
5 minute Service from Poriua

Legend

- Single track sections
- Paraparaumu - suburban: stopping all stations
- Paraparaumu - suburban: express Plimmerton to Wellington
- Paraparaumu - suburban: stopping all stations
- Paraparaumu - suburban: express Plimmerton to Wellington
- Plimberton - suburban: stopping all stations
- Porirua - suburban: stopping all stations
- Regional Passenger Service
- Freight Train



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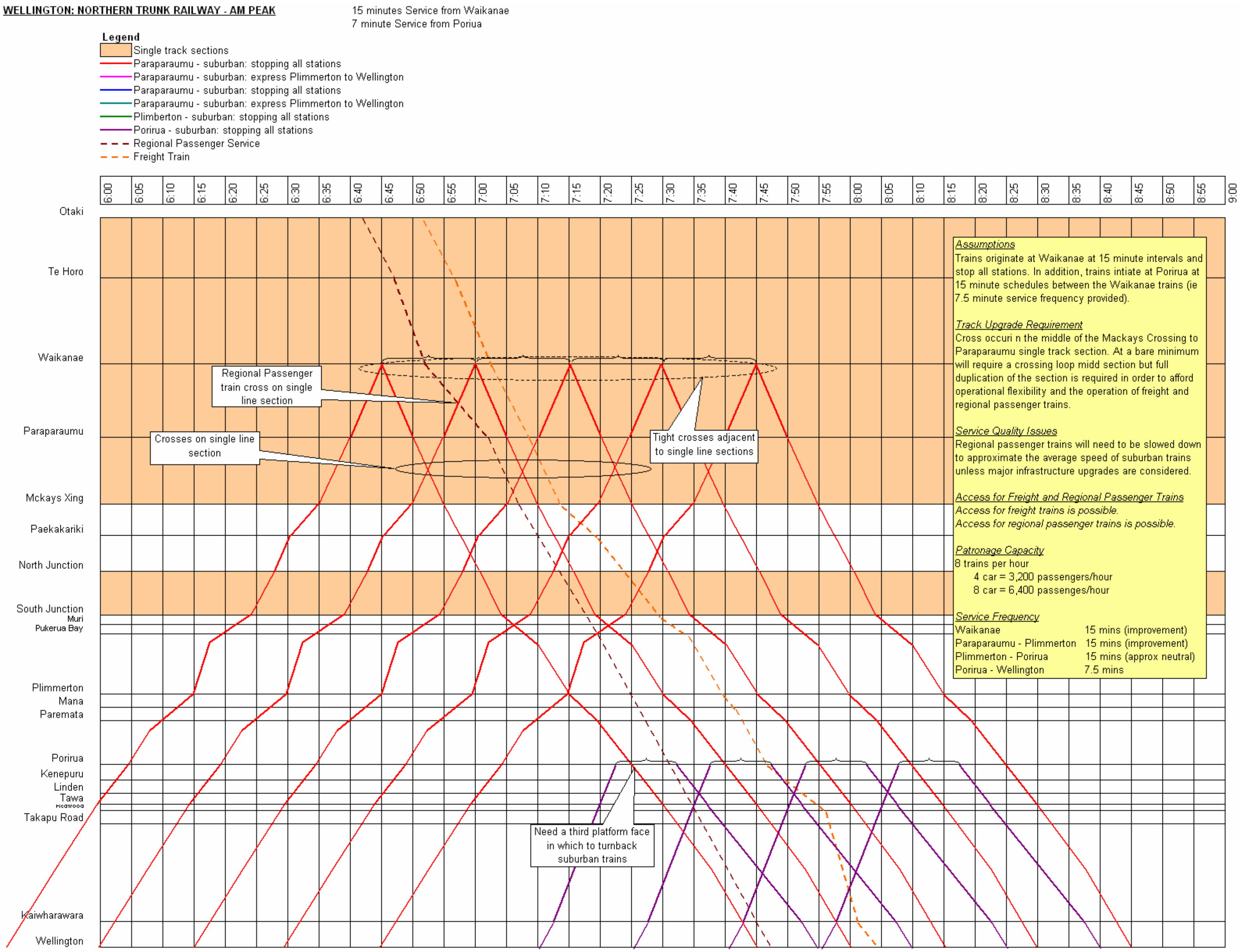

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