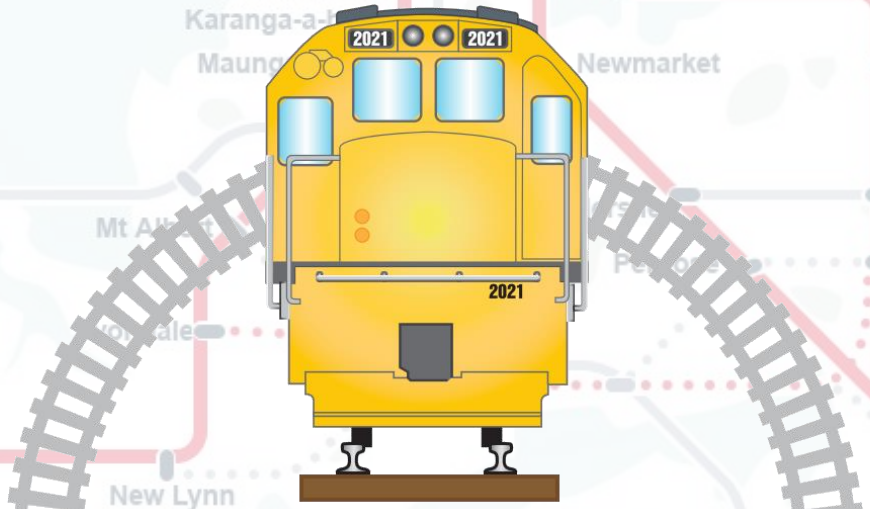
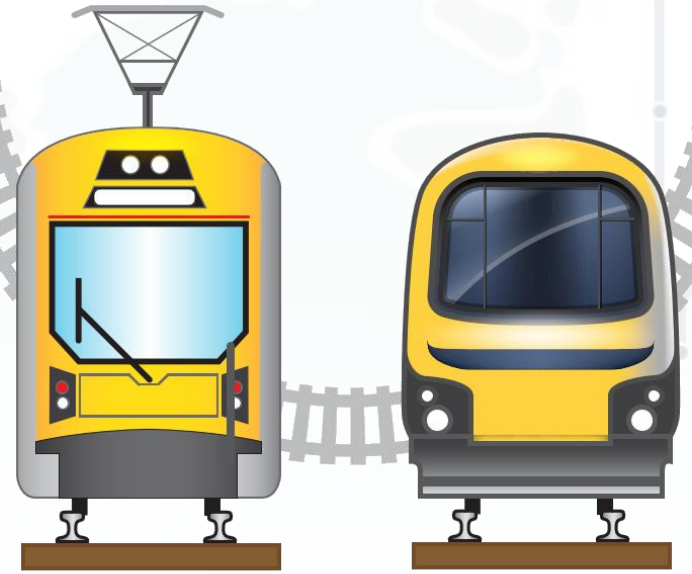
Auckland Rail Programme Business Case

Options Development Report Part II: Refinement and Phasing





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AUCKLAND RAIL PROGRAMME BUSINESS CASE
Options Development Report Part 2: Refinement and Phasing

WSP
Auckland
Level 3 The Westhaven
100 Beaumont St
Auckland 1010, New Zealand
+64 9 355 9500
wsp.com/nz

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Structure

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1 | Process

Scope and Process

Work undertaken in 2022 resulted in the development of a **preferred option** for the 2051 end state of the Auckland rail network. The process followed to develop this option is documented in the *Options Development Report Part I: 2051 Future State*

This report documents the development of a phasing of infrastructure and service improvements over the 30 year time horizon to achieve the 2051 end state. Through this process, some refinements were made to the 2051 end state, which are also documented in this report.

The outcome of this work is a Final Preferred Programme for the Auckland Rail Programme Business Case.

The structure of this report, follows the process that was undertaken to develop the Final Preferred Programme, which is described below and illustrated in Figure 1A.

- Phase 1: Confirming inputs and assumptions developed in the previous phase of optioneering with a key focus on the methodology used to assess capacity utilisation
- Phase 2: Refinements to the 2051 end state, on the basis of updated assumptions, and revised inputs, as well as a greater level of understanding gained through the subsequent phasing analysis
- Phase 3: Developing a phasing of infrastructure and service interventions required to meet projected growth under the base demand scenario for all markets, and their various service objectives (aka Conditional Outputs), culminating in the refined 2051 end state
- Phase 4: Adjustments to the demand-led phasing to reflect practical deliverability constraints including planning, consenting, and funding considerations. A key component of this phase is to assess the range of potential trade-offs that may be required during periods where the required infrastructure-enabled capacity, lags demand.

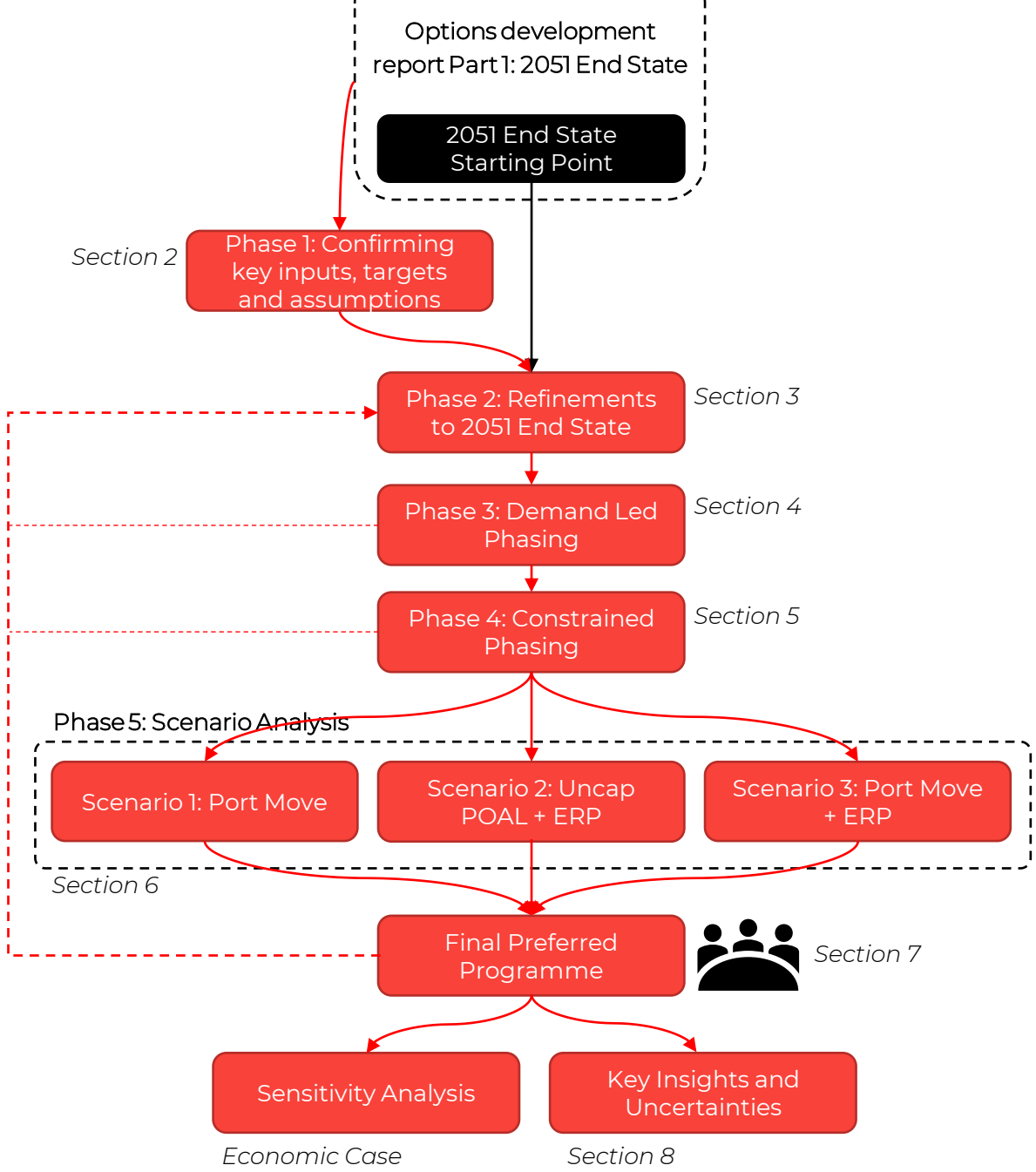


Figure 1A: Development process of programme phasing

Scope and Process

- Phase 5: Analysis of the phasing developed in Phase 4, over three different macro level scenarios:
    - Scenario 1: Auckland Port is closed, with freight flows shifted to North Port and Tauranga. Passenger demand is held constant.
    - Scenario 2: Strong policy interventions are put in place to achieve the targets set out in the Emissions Reduction Pathway for both freight and passenger markets. This scenario also considered the Ports of Auckland being uncapped (as opposed to the base scenario where growth is assumed to be capped at current volumes)
    - Scenario 3: A combination of the above scenarios – 'ERP-scale' growth in passenger demand, overlaid with the Port Move scenario for freight.
- On the basis of these analysis final refinements are made to the phasing to improve resilience to them.

The result of the above analysis is a Final Preferred Programme, that is achievable, robust against macro level logistic and policy uncertainties, and represent a reasonable set of trade-offs between markets in the interim stages where required infrastructure capacity lags demand. This programme is then further tested against a number of sensitivity tests in the Economic Case

An uncertainty log was maintained throughout this process which was used as a stage gate. At each stage of this process, all relevant uncertainties were required to either be resolved through adaptation of the programme, or sufficiently understood to provide confidence that these would not materially impact the programme. The residual uncertainties remaining at the end of this process form part of the formal documentation of the PBC and are documented in Section 8.

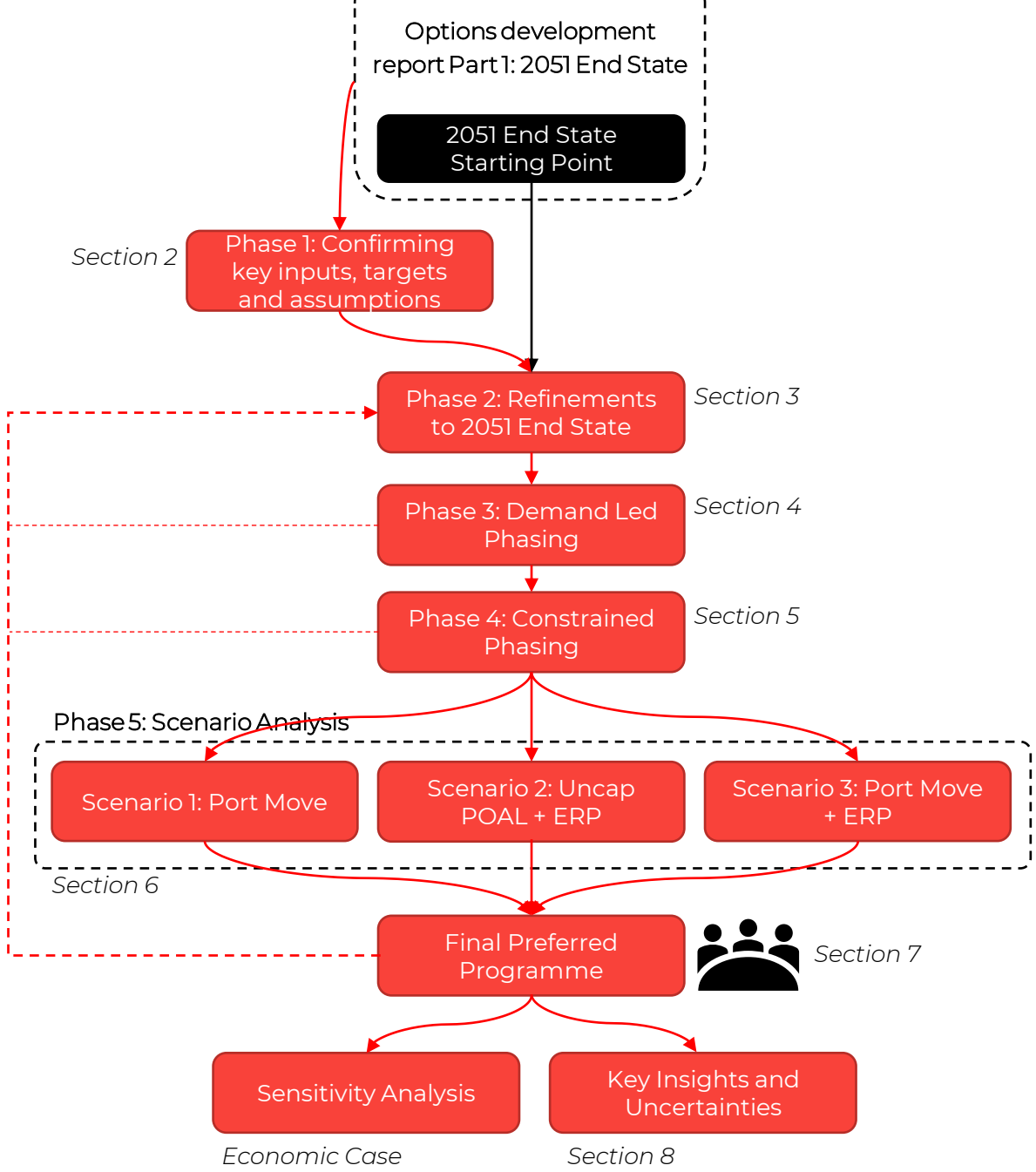


Figure 1A: Development process of programme phasing

Wayfinding

Overall PBC Document Map

The Document Map in Figure C1 shows how the Options Report Part 2 fits into a broader set of documents for the Auckland Rail PBC. Both Parts 1 and 2 are appendices to the Economic Case which is one of the five cases of the PBC. The Options Report Parts 1 and 2 are also appendices to the 30 Year Auckland Rail Plan report which is a separate document containing more details of the programme including asset level strategies over the next 30 years, and more detailed operational assessments that have influenced the planning

Phasing Iterations

The process described above results in a number of iterations of the end state service and infrastructure concept and the overall programme phasing. To guide the reader, each interim iteration is labelled as iteration # to make it clear that this is an interim step towards the final preferred programme.

Each iteration illustrated in Figure 1B, increases in detail with iteration 0 and 1 focusing on the network end state, iteration 2, 3 and 4 on the phasing of macro level infrastructure and service elements over time, and the final iteration detailing a full phasing of all asset classes.

Key findings and uncertainties

There are several topics that require further explanation and discussion but in order to maintain flow of the optioneering process, these have been placed in Section 8 and are highlighted through with the symbol.

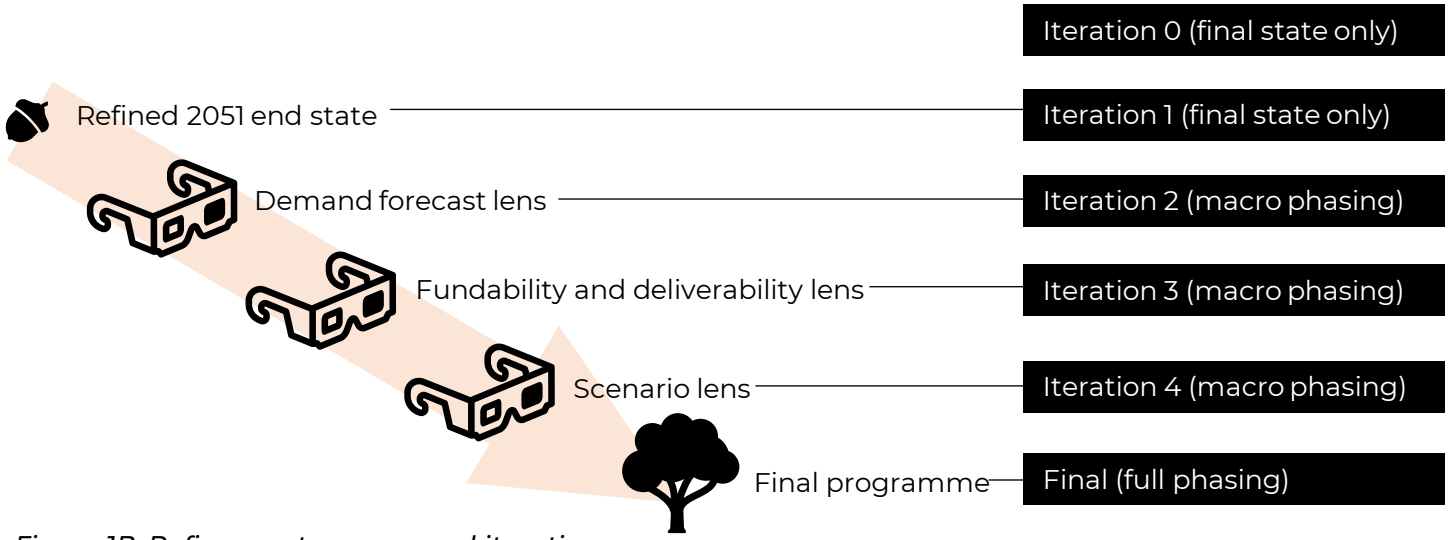


Figure 1B: Refinement process and iterations

Reading Notes

The development of this business case has been a relatively long process and various external changes have occurred over time that, while not material to the options selected, have resulted in changes in terminology or narrative. It was not practical to revisit all of the material developed through the optioneering process to correct for these changes and so they are listed here as general disclaimers:

1. **Naming of CRL and new Southern Stations.** The names of these stations have undergone a number of iterations over the course of the project, which have been adopted progressively over time. The following names are used interchangeably throughout this report.
    - Britomart, Waitematā
    - Aotea, Te Wai Horotiu, Te Waihorotiu
    - KR'd, Karanga-a-hape
    - Mt Eden, Maungawhau
    - Drury, Maketuu
    - Drury West, Ngaakooroa, Ngākōroa
    - Paerata, Paeraataa, Paerātā

2. **Naming of Auckland Rail Network Lines:** For the PBC analysis there is a need to segment the network geographically, however there are at least three ways that this can be done in the context of the Auckland Network:
    - By existing KiwiRail line names .e.g. the North Island Main Trunk (NIMT) runs from Pukekohe (in the context of the Auckland network) to Westfield junction
    - By corridor (for the purpose of breaking up the optioneering and analysis into logical areas of demands;
        - Southern
        - Eastern (including POAL) and
        - Western (including NAL and Avondale-Southdown)
    - By metro line (e.g. southern line, eastern line, western line)

- Generally, the corridor level grouping has been used, with the metro line grouping used when referring specifically to metro services. In some cases, the KR line names have been used however, so to aid the reader, a map of KR line names is provided in Appendix D.

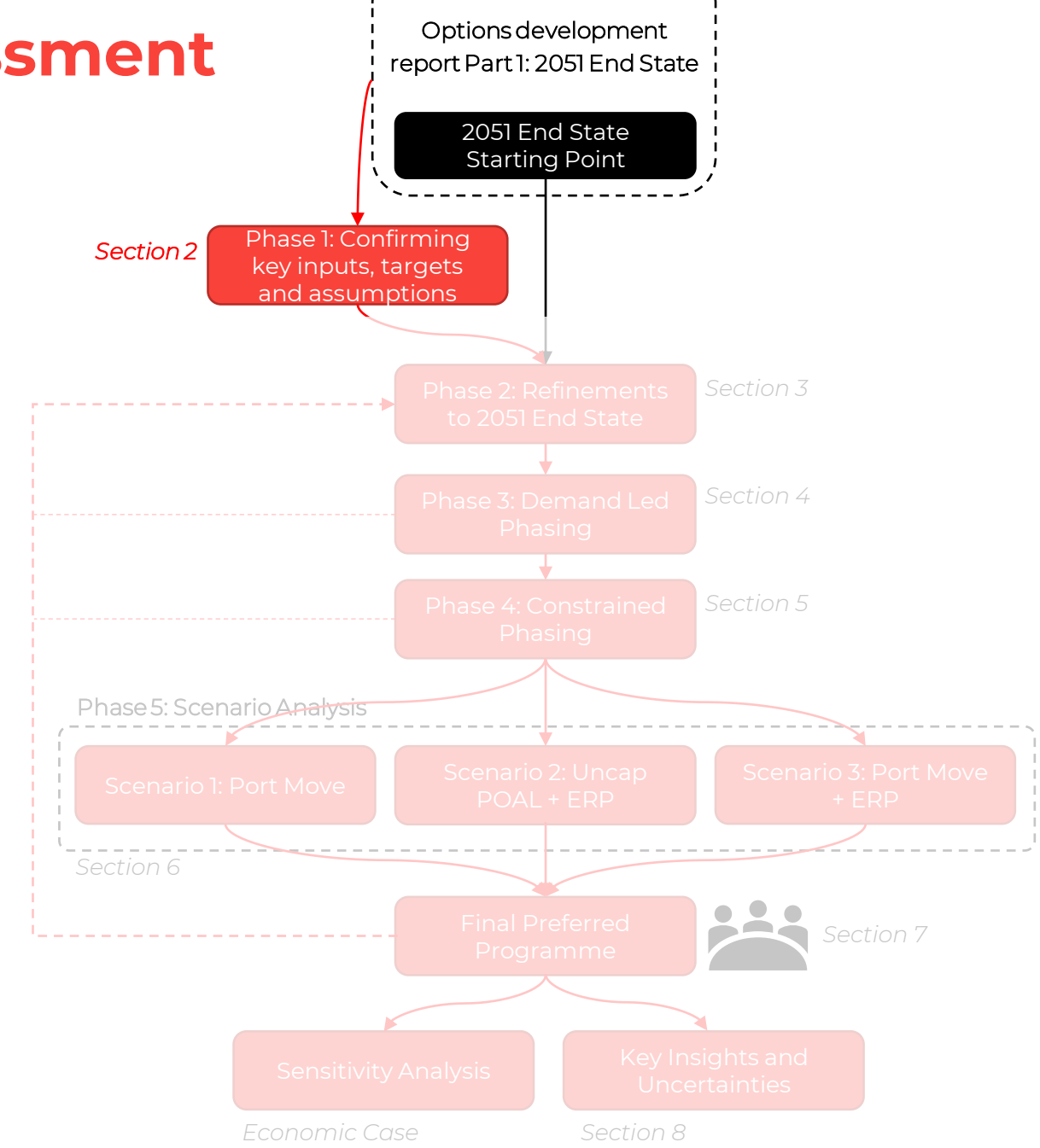
2 Assumptions, Inputs and Targets

Inputs, Assumptions and Assessment Methodology

This section documents key inputs, assumptions, methodologies and targets adopted in the development of the Final Preferred Programme, through the various phases described in Section 1.

This includes a description of:

1. Definition of demand for each market; freight, metro passenger and inter regional passenger
2. Service targets (also known as 'Conditional Outputs') for each market
3. Base state infrastructure and operations
4. Capacity planning methodology and assumptions
5. An Integrated Model developed as part of the PBC, to aid in the assessment of phasing options.



2.1 Demand definition

Demand definition
Freight

The Auckland PBC has drawn upon freight modelling used for rail decarbonisation and other KiwiRail studies. The KiwiRail freight forecasting model provides rail freight flow forecasts under a range of scenarios. It has been derived from the MoT Freight Futures model which forms part of the Ministry of Transport's Transport Outlook modelling suite.

Forecast train volumes are provided per day, for each of the major freight lines in on the network (depicted in Figure 2A in green, yellow and red highlight)

- NIMT freight, including MetroPort (MP) freight from Port of Tauranga and Westfield and domestic freight from various locations south of Auckland
- Ports of Auckland (POAL) freight, including movements from POAL to Southdown and Wiri inland port (WPOAL)
- Northland freight

Freight volumes were then translated into train movements under a number of scenarios representing various macroeconomic policy and logistical conditions. These include, closure of POAL, capping of POAL, and strong policy push for increasing rail mode share to support emissions reductions targets. Descriptions of each scenario are provided in Figure 2B, and the corresponding demand forecasts are presented in Figure 2C on the following pages.

Rail freight operates in a competitive market, where location of demand is largely driven by competition between ports and the wider global supply chains. Freight operators, including rail, must respond to this and hence none of the scenarios is likely to come to pass exactly. Some combination is more likely and hence the scenarios should be considered as providing the range of future freight demand that the network would need to be resilient to

Consistent with this, the PBC has taken a scenario-based approach that takes a base demand scenario for initial planning purposes, and then stress testing the base solution under a number of alterative scenarios to further refine it.

The base demand scenario for freight is Scenario B1.

For the NIMT line, forecasts have been produced for two lengths of domestic and MP trains; 750m/900m max and 1500m max. Given the significant growth expected on the NIMT under all scenarios, it is anticipated that lengthening trains as opposed to increasing train frequencies, will be a feature of freight requirements between Auckland and the Golden Triangle from the early 30s.

Other smaller volume moves using main line tracks exist on the network, which are also captured in planning. These are shown in Figure 2A and include bulk movements between Westfield/Southdown and the Mission Bush Line (MBL), Penrose Siding, Southdown Lane siding, and Tamaki siding. Forecasts for these movements were obtained via discussions with KiwiRail.

Further discussion on freight demand forecasting and port assumptions is provided in Section 8, item 1.

Demand definition
Freight

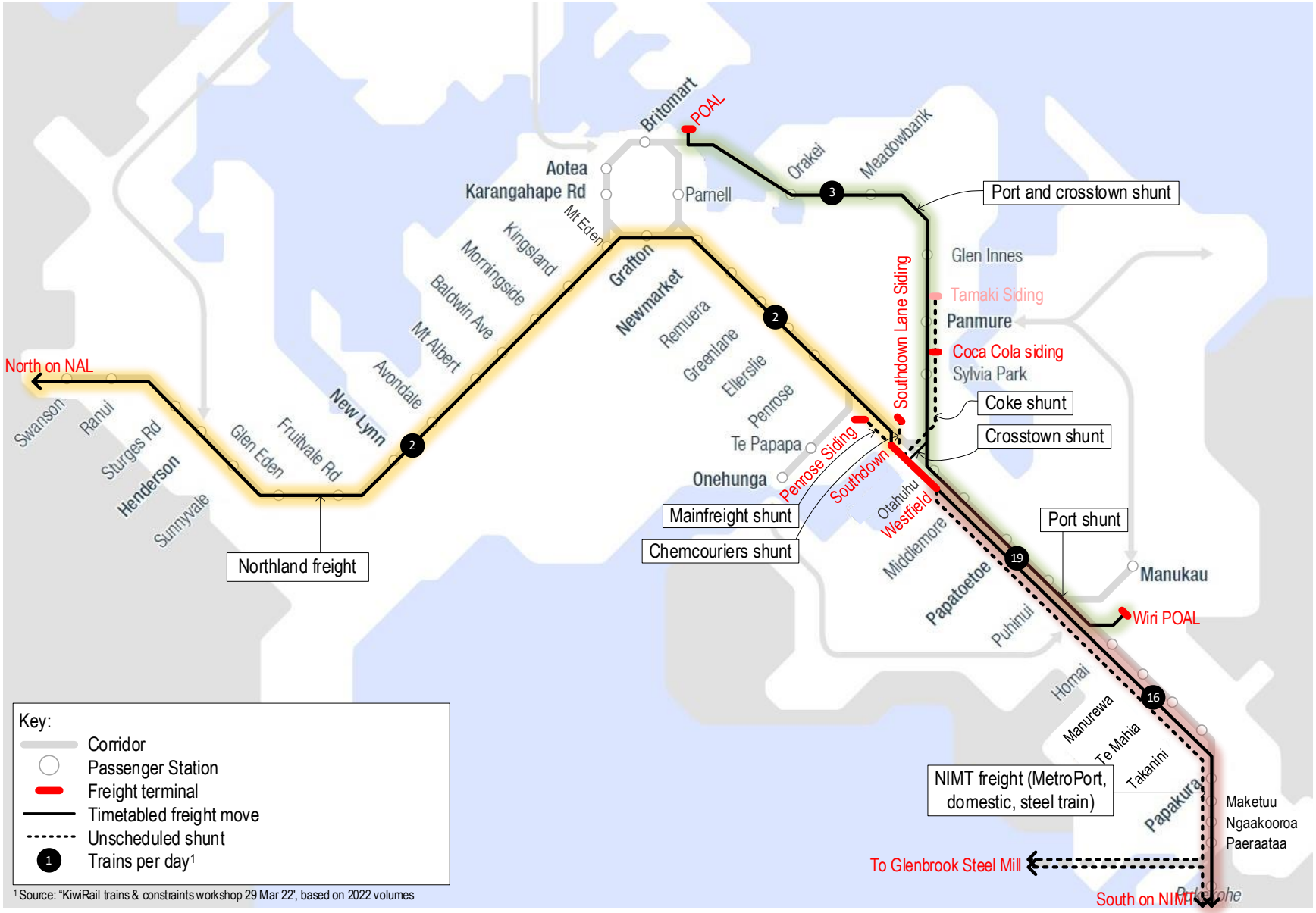


Figure 2A: Freight movements on the ARN

Demand definition
Freight

Freight scenarios have been designed to **investigate the impact of different competitive port futures in Auckland**, and (like the rail freight market) are national rather than local.

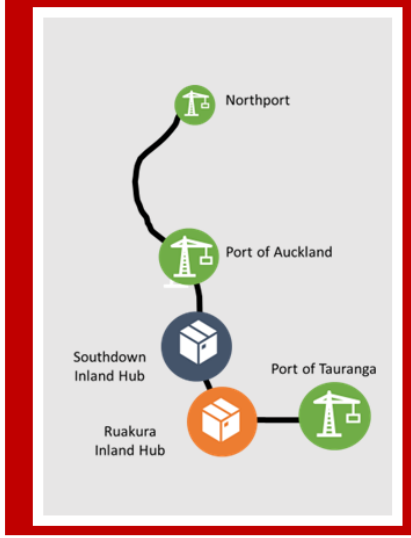
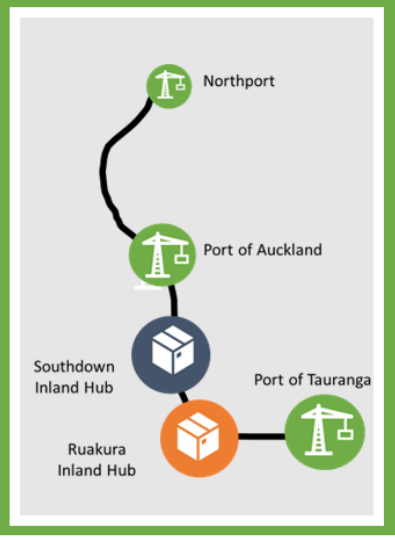
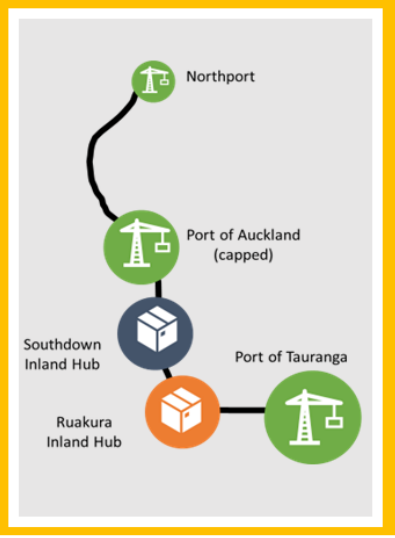
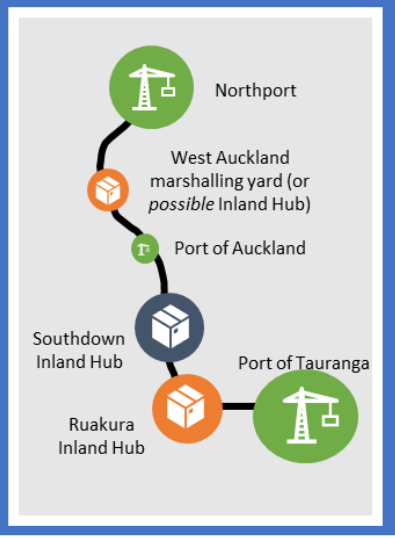
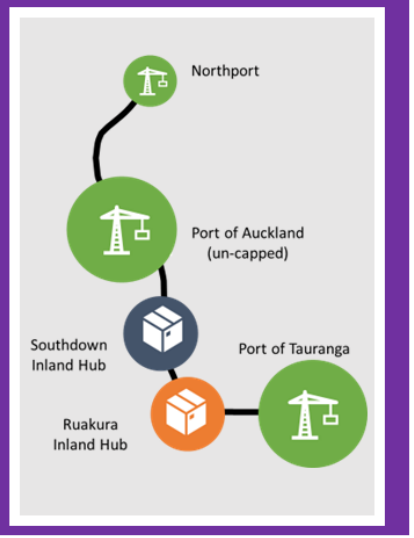
BAU	A	B1	B	D
BAU Policies	***Enhanced KR funding, uncapped POAL***	***Capped POAL, KR investment***	***POAL closed, KR Investment***	***Growing POAL, strong pro-rail policy***
				
No cap on POAL, but no enhanced investment. Assumes Marsden link built • Moderate- growth all lines • No significant change to current distribution	Enhanced KiwiRail investment to support faster growth, but BAU for government policies • Moderate+ growth all lines • No significant change to current distribution	POAL restricted and all growth goes south to Metroport: • Big PoT & NIMT-S demand • Med POAL & NIMT-E demand • Modest Northport & NAL demand	POAL closed - volumes and growth split between Northport and PoT • Big PoT and NIMT-S demand • Big Northport and NAL demand • Minor or nil NIMT-E demand.	Strong pro-rail policy drives higher national rail freight growth (but POAL uncapped is biggest driver in Auckland) • Big POAL and POT • Moderate NIMT-S demand • Increased NIMT-E demand

Figure 2B: Freight demand scenarios – descriptions

Demand definition
Freight

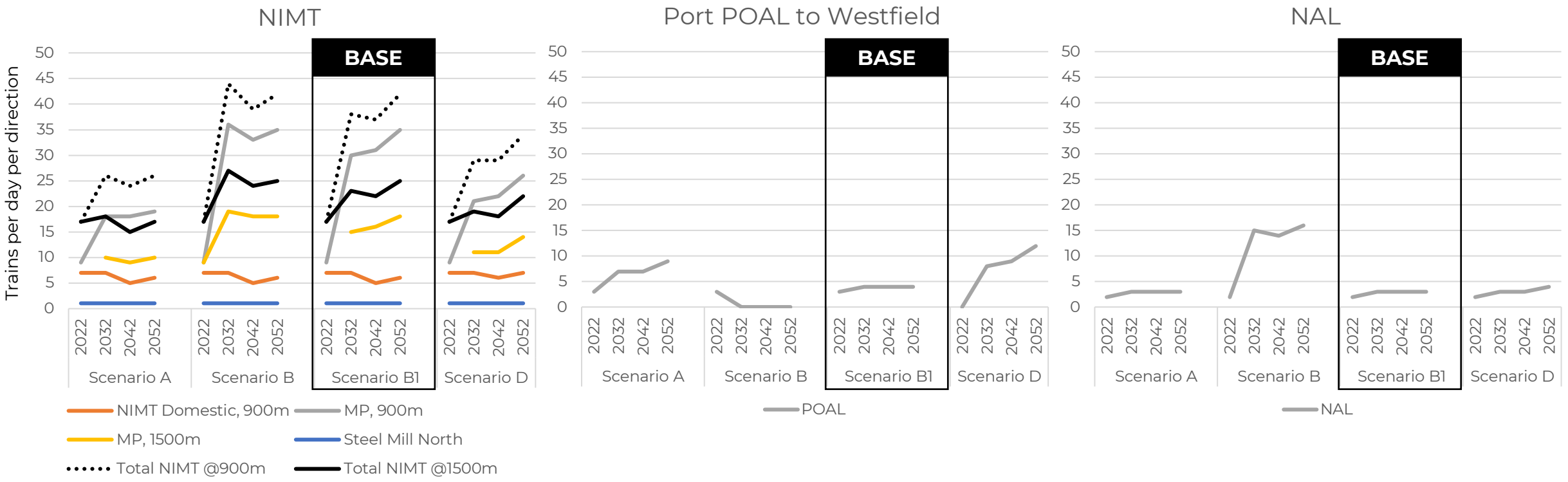


Figure 2C: Freight demand scenarios – forecasts

Note that the modelling upon which these forecasts are based on includes train assumptions about loading efficiency and load factor improvements which results in the reduction in freight train volumes (not tonnage) in 2042. For example, for NIMT domestic trains, in 2032 the trains are assumed to run at 35 wagons / 600m, whereas in 2042 they increase in size to 50 wagons / 855m (and the same in 2052). In practice the timing of load factor increases may vary slightly and lead to a smoother train volume.

While B1 (PoAL capped, growth to Tauranga) is used as the base case, the rail network needs to be resilient to a range of potential outcomes; represented by the scenarios above. These are scenarios and the real world is likely to fall somewhere in between them. As noted in the Strategic Case for example, the MPRL business case currently predicts that freight volumes on the NAL will reach 8 tpd by the mid-late 2040s which falls somewhere between scenarios B and B1.

Demand definition
Metro Passenger

Demand for metro passenger services have been determined based on demand modelling using the Auckland Forecasting Centre Macro Strategic Model (MSM). This is an iterative process as demand is impacted by the attractiveness and capacity of rail services provided, which is within the scope of the PBC to determine. Various other factors including the make up of the wider transport system, patterns of land use, and policy levers such as road pricing have an impact on demand for heavy rail, which are also captured in MSM including:

- Scenario11.6 land use
- 'Reference Case' transport network, which includes the proposed development of the rapid transit network (i.e. CC2M, NW, WHC, A2B) over time plus a few other improvements to major corridors (e.g. SH20 and SH16 widening).

MSM provides outputs that allow for the sizing of the service offering in terms of frequency, train lengths, and stopping patterns. A typical line load output is shown in Figure 2E. This plot shows the number of passengers on board trains between each station to station segment, relative to the provided seating and standing capacity.

MSM predicts AM, Inter Peak (IP), and PM peak demand aggregated over 2hr periods. In reality demand varies over these periods and in the case of the AM peak, 61% of the 2-hr demand occurs within a single high peak hour. The remaining 39% of demand occurs in shoulder peak periods which is an important consideration in early stages of the 30 year programme when capacity varies across the peak period due to varying train lengths in operation. Generally planning has focused on the AM peak as this results in the highest hourly loading on the network, and is therefore the key driver of capacity improvements.

The short term impacts of COVID-19 have not been accounted for in MSM modelling. Further discussion on this point is provided in Section 8, Item 2

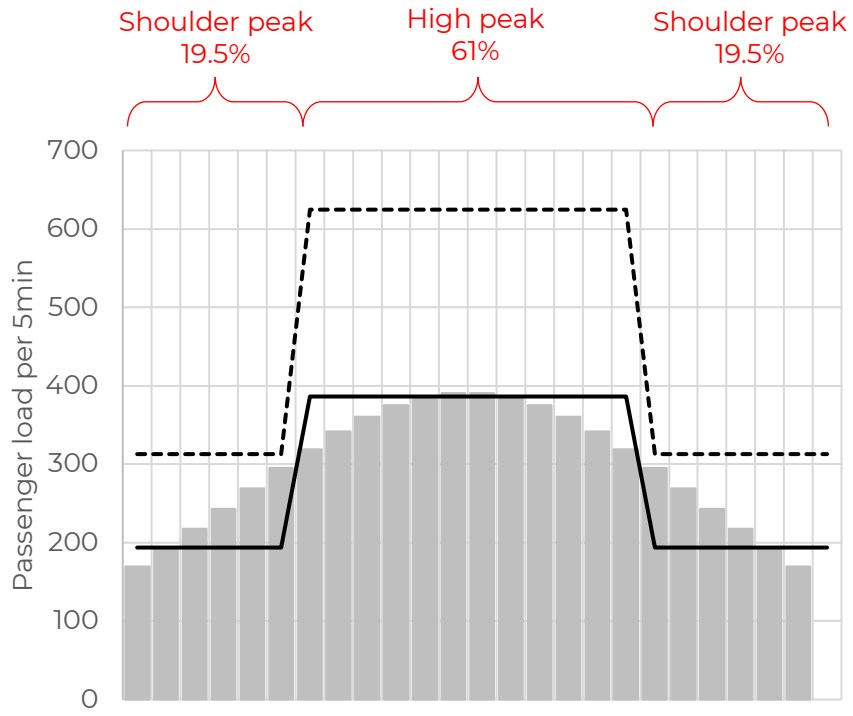


Figure 2D: Distribution of peak load point demand over 2hr period (x increments represents 5-min intervals)

Demand definition
Metro Passenger

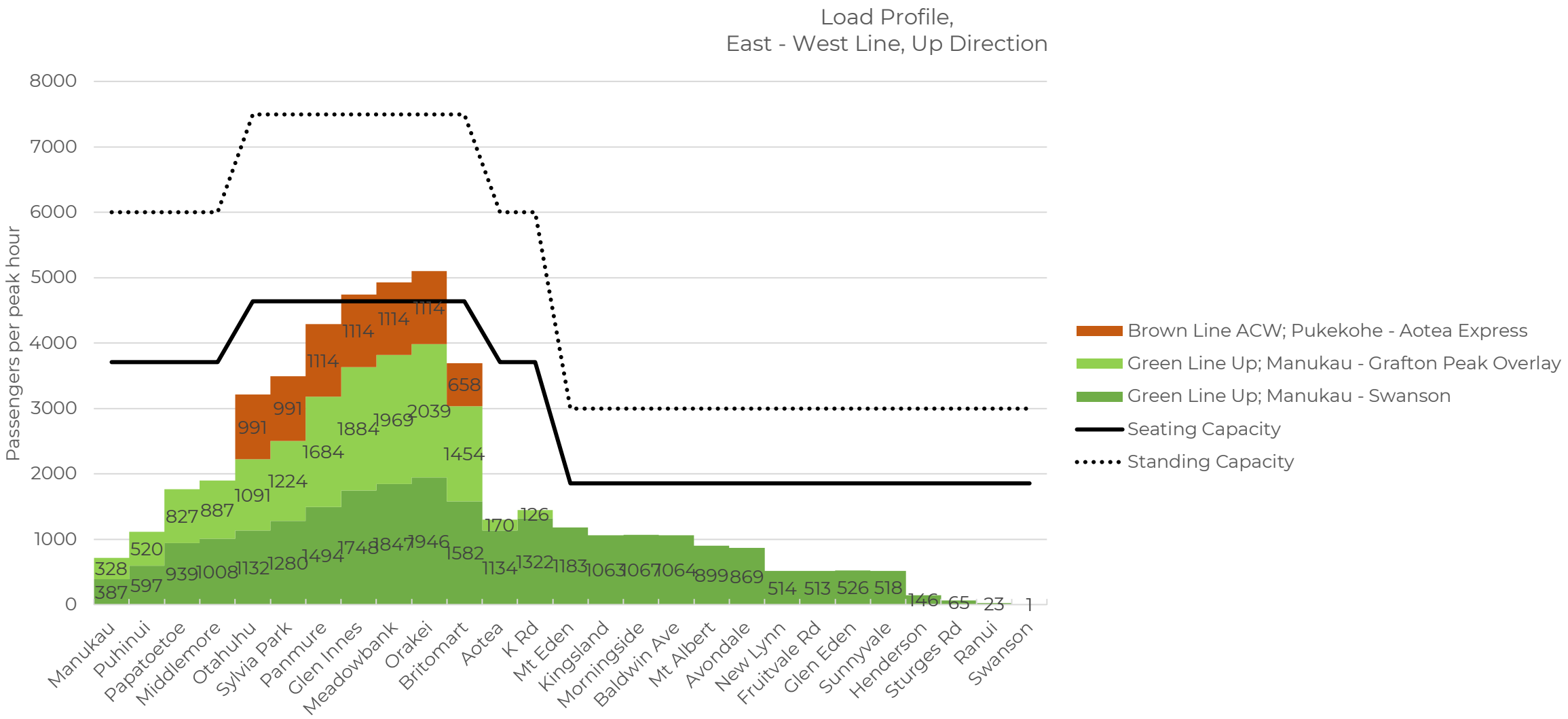


Figure 2E: Example line load profile for high peak period

Demand definition
Inter-Regional Passenger

Inter regional passenger demands provisioned for in the PBC include Hamilton to Auckland services, and the Northern Explorer tourism service operated by KiwiRail.

Objectives for Hamilton to Auckland in terms of service frequencies and stopping patterns, were provided by Waikato Regional Council as shown in Table 3A. Note that by 2041, the Te Huia service is assumed to be replaced by a new high speed rail service operating at higher frequencies - up to 30min headways during peak periods by 2051. Termination of a Waikato Regional Local service at Pukekohe is also accounted for in planning of the 2051 end state.

Tourism trains are assumed to grow to 12 trains per week by 2051, one up and one down per day.

It is acknowledged that further growth in interregional traffic could occur beyond these assumptions over the next 30 years. As will be discussed in subsequent sections, a long term planning target of 75% capacity utilisation has been adopted so that such growth is not be precluded in the future.

Table 3A: Hamilton to Auckland demand summary

Inter-regional Scenario		2025 (Base case)	2031	2041	2051
	Description	Te Huia's target level of service for CR: Day 1	Level of service post Te Huia rolling stock replacement and pre high speed rail. Services every 2 hours Northbound and Southbound during weekdays. Services every 3 hours during Weekends.	Level of service post completion of **Hamilton to Auckland high speed rail**. Services every 1 hour Northbound and Southbound during weekdays and every 2 hours during weekends.	Up to 30min frequencies in peak periods plus a **Waikato Regional Local** train terminating in Pukekohe
	Services per weekday -Peak	4	8	12	
	Services per weekday Off-Peak	2	6	14	
	Services per Saturday	4	8	14	
	Services per Sunday	2	8	14	
Stops in ARN	Pukekohe	No	No	No	No / **Yes (Local)**
	Drury	No	**Yes**	**Yes**	**Yes**
	Papakura	**Yes**	No	No	No
	Puhinui	**Yes**	**Yes**	**Yes**	**Yes**
	Strand	**Yes**	No	No	No
	CRL AKL Downtown stop	No	**Yes**	**Yes**	**Yes**

Demand scenarios

The various freight demand scenarios were combined with different scalings of the MSM outputs to generate a set of overall network demand scenarios. These scenarios are defined in Table 3B.

For ERP scenarios, Metro patronage levels that contribute to meeting the ERP targets in Auckland have been estimated. This demand scenario does not design the policy(s) required to reach that level of patronage but is intended to determine what service and infrastructure mix would be required to accommodate such a level if it were achieved.

Modelling was not undertaken to estimate these patronage levels, and in any case ERP targets are not mode specific. We worked with AT and AFC to estimate potential rail demand levels that allows Auckland to meet its overall ERP target. At a high level, this resulted in the Public Transport annual patronage levels and mode share shown in Figure 2F. For comparison the 86m annual rail boardings is compared to 2018 (pre COVID) ridership of 17m annual rail boardings i.e. represents a 5x increase to be achieved by 2035.

In the absence of specific planning scenarios for inter-regional, the same growth profile has been applied across all scenarios for this market but further growth is not precluded.

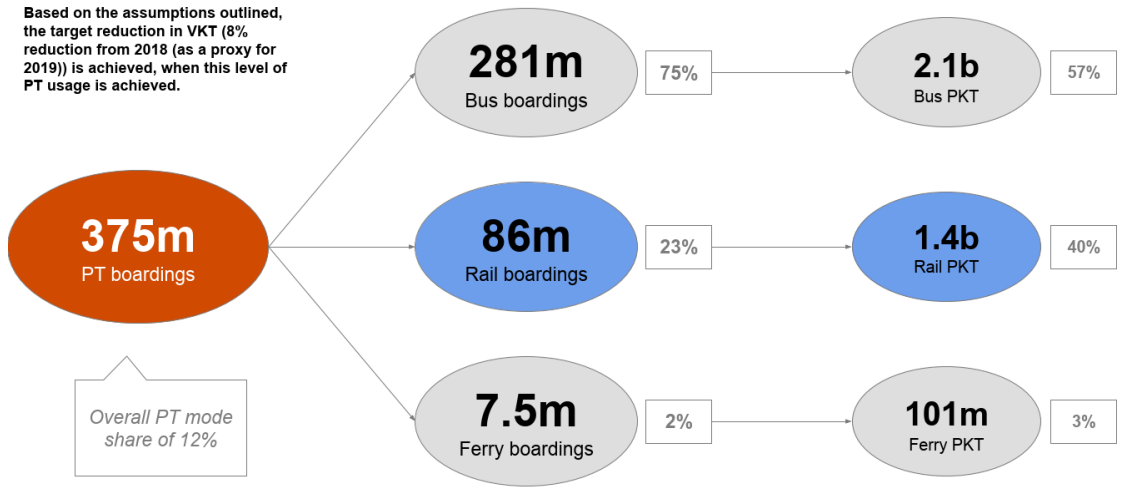


Figure 2F: Estimated rail patronage under ERP

Table 3B: Demand scenarios summary

MARKET	BASE SCENARIO	PORT MOVE SCENARIO	ERP + Uncapped POAL SCENARIO	ERP + PORT MOVE SCENARIO
Freight	KiwiRail scenario B1	KiwiRail scenario B	KiwiRail scenario D	KiwiRail scenario B
Metro	MSM forecast patronage without scaling	As per the Base Case	MSM forecast patronage scaled to represent ERP-level growth	As per ERP scenario
Interregional	As defined in Table 3A	As per the Base Case	As per the Base Case	As per the Base Case

2.2 Conditional Outputs

Conditional Outputs

In addition to providing sufficient capacity to meet the demands of the various markets, several other targets or Conditional Outputs are taken into account. These are summarised in Figure 2G below.

Conditional Outputs are a core element of the Long Term Planning Process (LTPP) used for rail planning in the UK. They are typically the result of a Market Study which seeks to understand how the attractiveness of rail service offerings on the network can be improved through investment. These targets are 'conditional' in the sense that they may turn out to be either infeasible (from an engineering or economic perspective) under further analysis and so should not be viewed as hard requirements but as targets or aspirations.

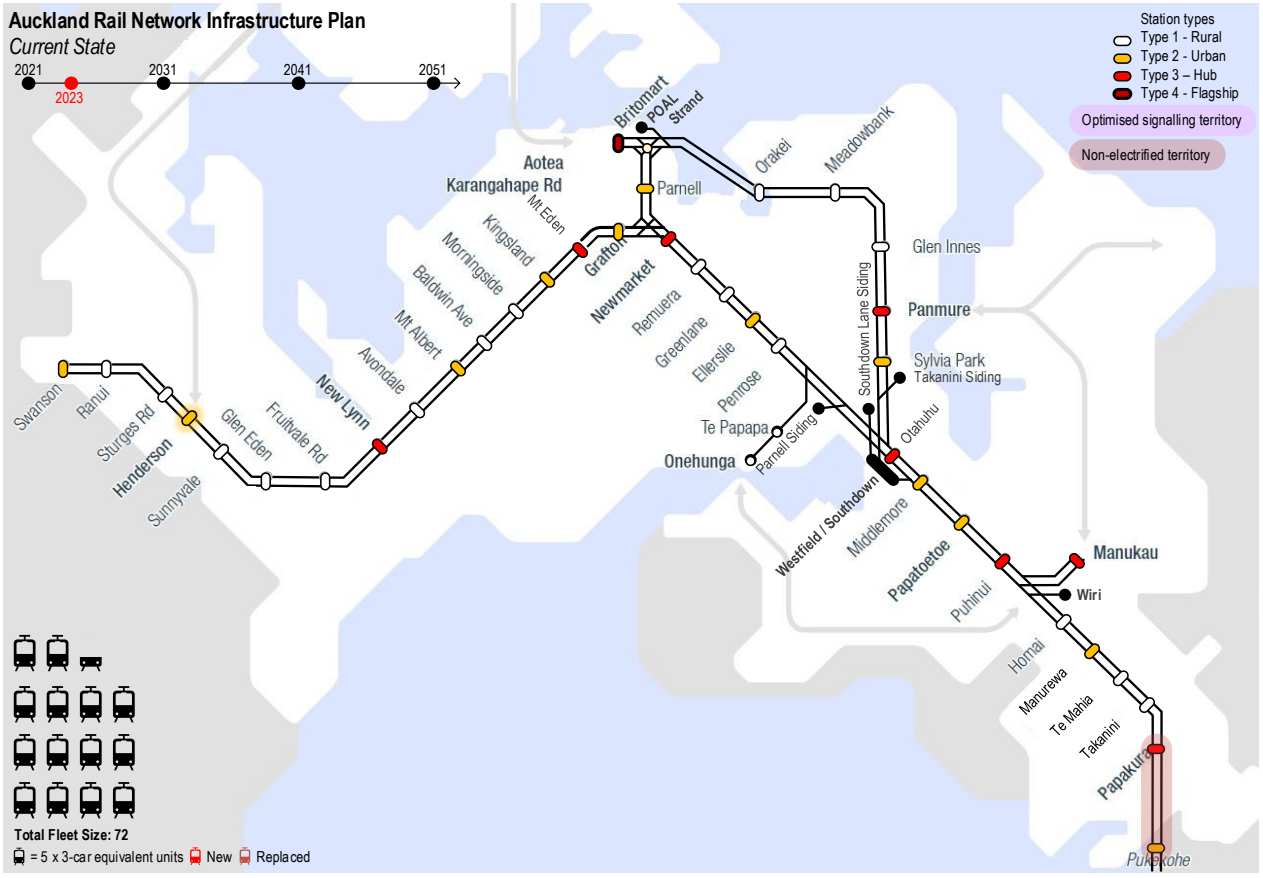
In the context of this PBC, the Conditional Outputs are a set of practical rail specific targets that are expected to support the overall Investment Objectives (IO) defined in the Strategic Case, upon which the success of the programme is ultimately be measured against.

The 75% peak network capacity target is of particular importance to the PBC, ensuring that future growth and future operators are not precluded from the open network in the long term. **Further discussion on this point is provided in Section 8, Item 3.**

Figure 2G: Conditional Outputs

2.3 Base Infrastructure and Operations

Base Infrastructure and Operations
Do Minimum



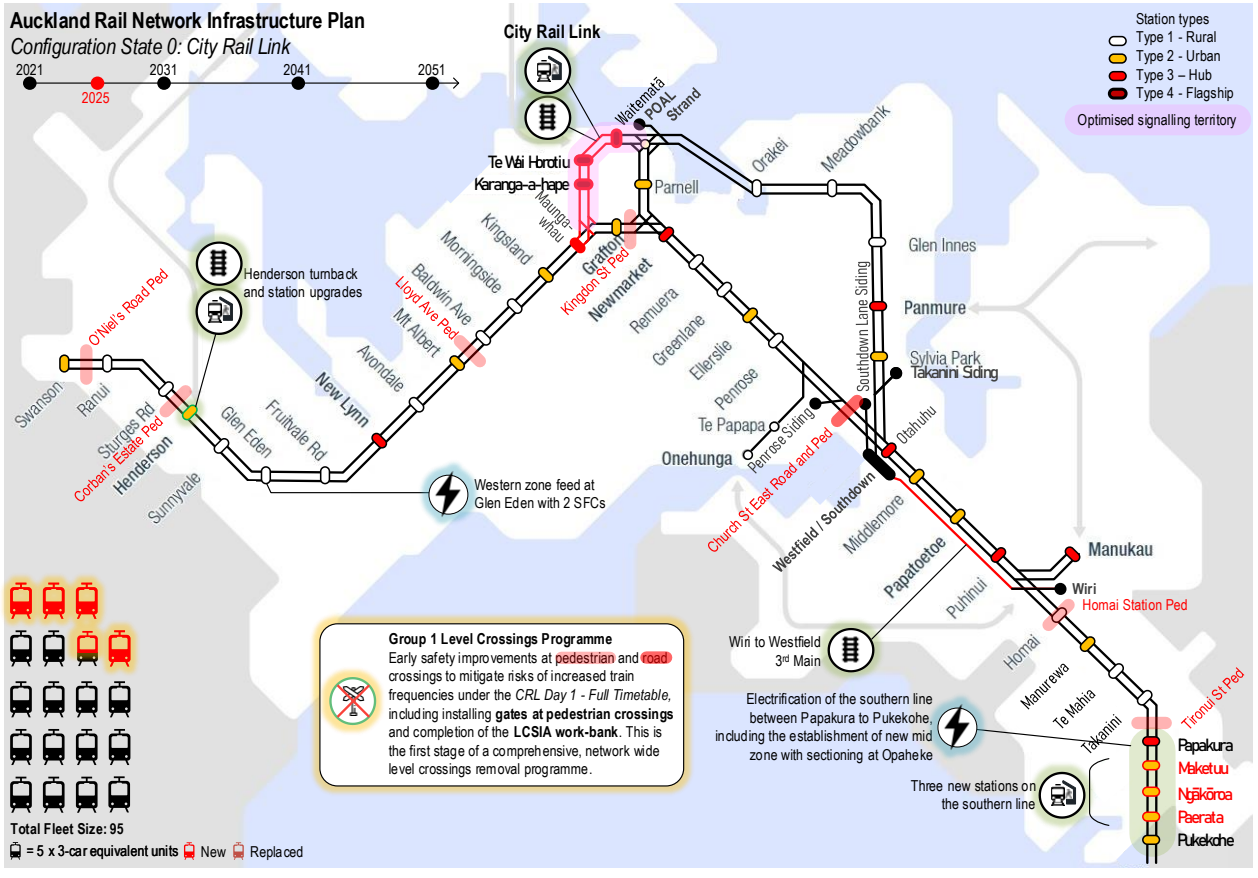


Figure 2H: Existing infrastructure and do-min infrastructure in 2025

This programme business case covers the 30 year period from 2021 – 2051. As is typical with planning on these horizons, investment priorities for the first 5 years of the programme have already been established and various existing projects are underway.

The Auckland Rail Network (ARN) will undergo a significant change with the completion of the City Rail Link in 2025 along with a number of other projects that will support and supplement it. This is the 2025 infrastructure state shown to the right in Figure 2H, often referred to as CRL Opening Day or CRL Day One. Note that this figure is a greatly simplified representation of the track plan and is not exhaustive in showing all current improvements to the network.

PBC planning assumes the do-min infrastructure state shown above as the base upon which future investments are required, and is referred here on in as Configuration State (CS) 0. The concept of configuration states will be discussed in Section 4.

Base Infrastructure and Operations
Infrastructure Capacity

Analysis was carried out early in the PBC to assess the capacity and capability of the ARN CS0 infrastructure, systems and equipment including track and signals, level crossings, tunnel ventilation (within the CRL), platforms, EMU fleet and stabling, and traction power. This work leveraged previous modelling and timetable development studies as well as simulations and analysis undertaken as part of the PBC for critical areas.

Track and signalling capacity is illustrated in Figure 2I. The majority of the ARN is double tracked with the exception of the single tracked Onehunga Branch Line (OBL) which can support a 20min single track operation (alternating up and down movements) and the triple tracked Wiri to Westfield (W2W) segment. The W2W segment will operate as metro only on the up and down mains with the 3rd main being freight only. The single freight track supports a 20-30min single track operation. Signalling headways shown in Figure 2I reflect the performance of the existing ETCS L1 fixed block signalling system. In some areas, the placement of signals is constrained by the presence of level crossings which results in low capacities in some segments (e.g. the Western Line is only capable of 5min headways which is the planned headway on CRL opening day. As such no significant service increases can be accommodated on this line until level crossing restrictions are resolved).

The **CRL** is expected to accommodate an ultimate volume of 24tph assuming that driver assistance and automatic door operation systems are implemented in the future.

It is important to note that while the CRL is capable of up to 24tph, other bottlenecks on the network will prevent this from being achieved without further investment. Furthermore, the 24tph limit applies to a homogenous metro only service, while in many other parts of the network the mixing of freight, long distance passenger and metro services places additional constraints on capacity utilisation.

Level crossings impose capacity restrictions on rail operations insofar as increasing train volumes across them results in an increase in the likelihood of collisions between trains and other road users. It has been assumed that the expected increase in train frequencies beyond current operation, will trigger the need to eventually remove the crossing either by grade separation or road closure. The level crossing capacities shown in Figure 2I should therefore be treated differently from signalling capacities, since the latter are physical limits while the former are risk based limits.

EMU Fleet size on opening day of the CRL will be 95 x 3-car units, which includes the current procurement of 23 x 3-car units. This places a limit on the maximum train frequencies and / or the max trains lengths that can run on the network. The adopted CRL day 1 timetable represents a solution where to achieve the desired service frequencies a combination of 3-car and 6-car trains needs to be operated, leading to shoulder peak capacity issues that will be described in sections ahead.

EMU Stabling is currently provided at Henderson (18), Strand (8), Wiri (28 stabling + 4 maintenance), Papakura (8), Britomart (4), and Manukau (2), supporting a total storage of 72 x 3-car units. By 2025 storage for 13 additional 3-car units will be provided at Pukekohe and 10 at Wiri for a total of 95 x 3-car units. Base storage is therefore expected to exactly accommodate the CRL opening day fleet of 95 but provide no room for growth and requires usage of platforms for train storage.

The **Traction power system** (TPS) supports CRL Day 1 operations with the addition of a new power feed currently being implemented at Glen Eden on the Western Line. However, the TPS will require further enhancement as metro services increase and freight and inter regional services are progressively electrified. The PBC has utilised separate KiwiRail modelling of the TPS to determine an upgrade programme to accommodate this growth.

Stations have been assumed to not place hard capacity limits on the network, but a programme of station upgrades has been developed to address existing deficiencies and improve service quality as patronage increases over time.

Separate **Asset Strategy Documents** have been prepared as part of this PBC which provide further detail on each of the asset classes listed above.

Base Infrastructure and Operations
Infrastructure Capacity

EMU Fleet

Fleet size on opening day of CRL: **95 3-Car units** (incl. current 23x3 3-Car units)

TPS

Supports with **Western Power feed** addition – but will require upgrades as metro services increase.

Freight & interregional services are gradually electrified.

EMU Stabling

Stabling size on opening day of CRL: **95 3-Car units**

- Henderson (18)
- Strand (8)
- Wiri (38 + 4 maint.)
- Papakura (8)
- Britomart (4)
- Manukau (2)
- Pukekohe (13)

Signaling

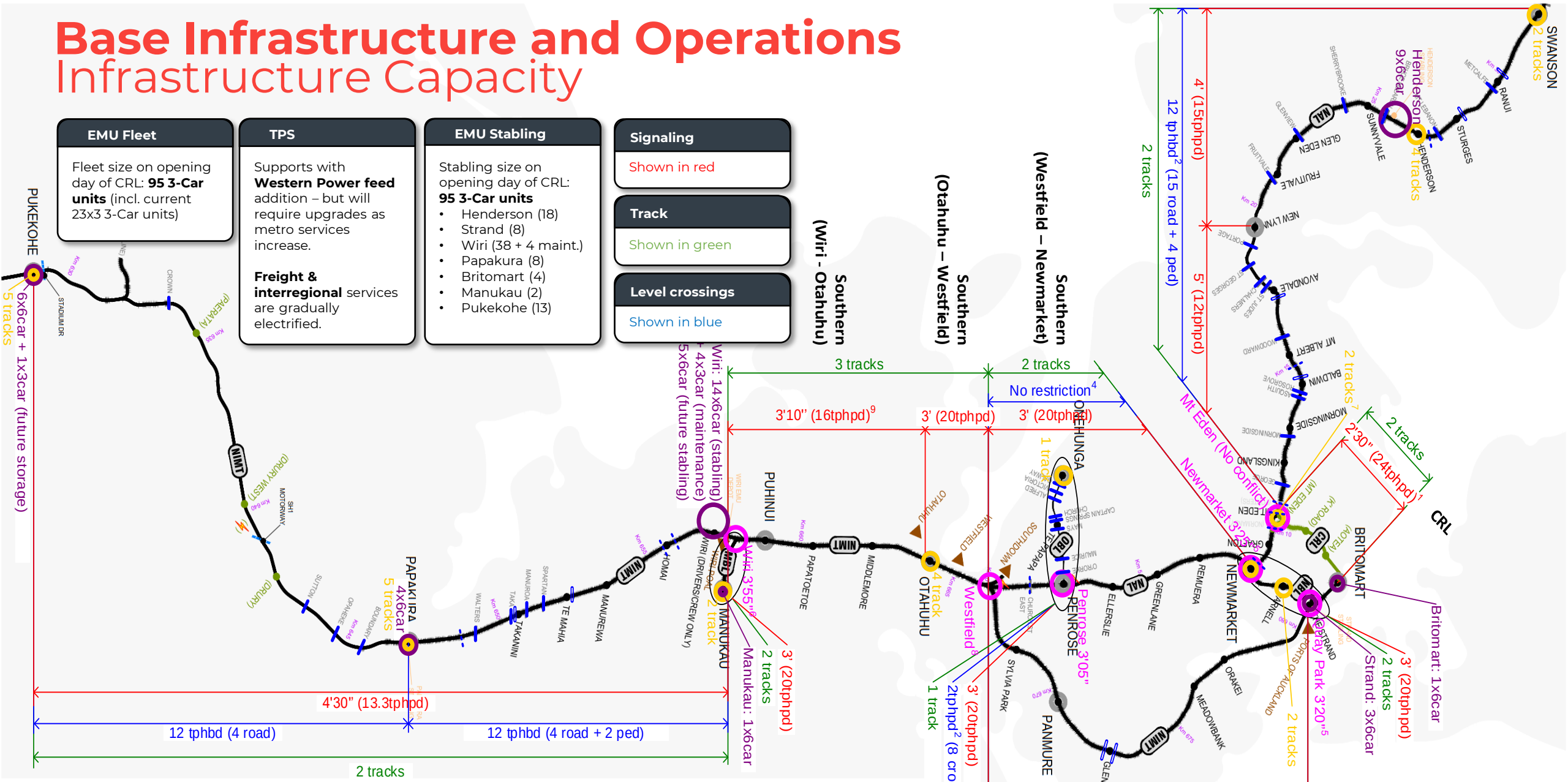
Shown in red

Track

Shown in green

Level crossings

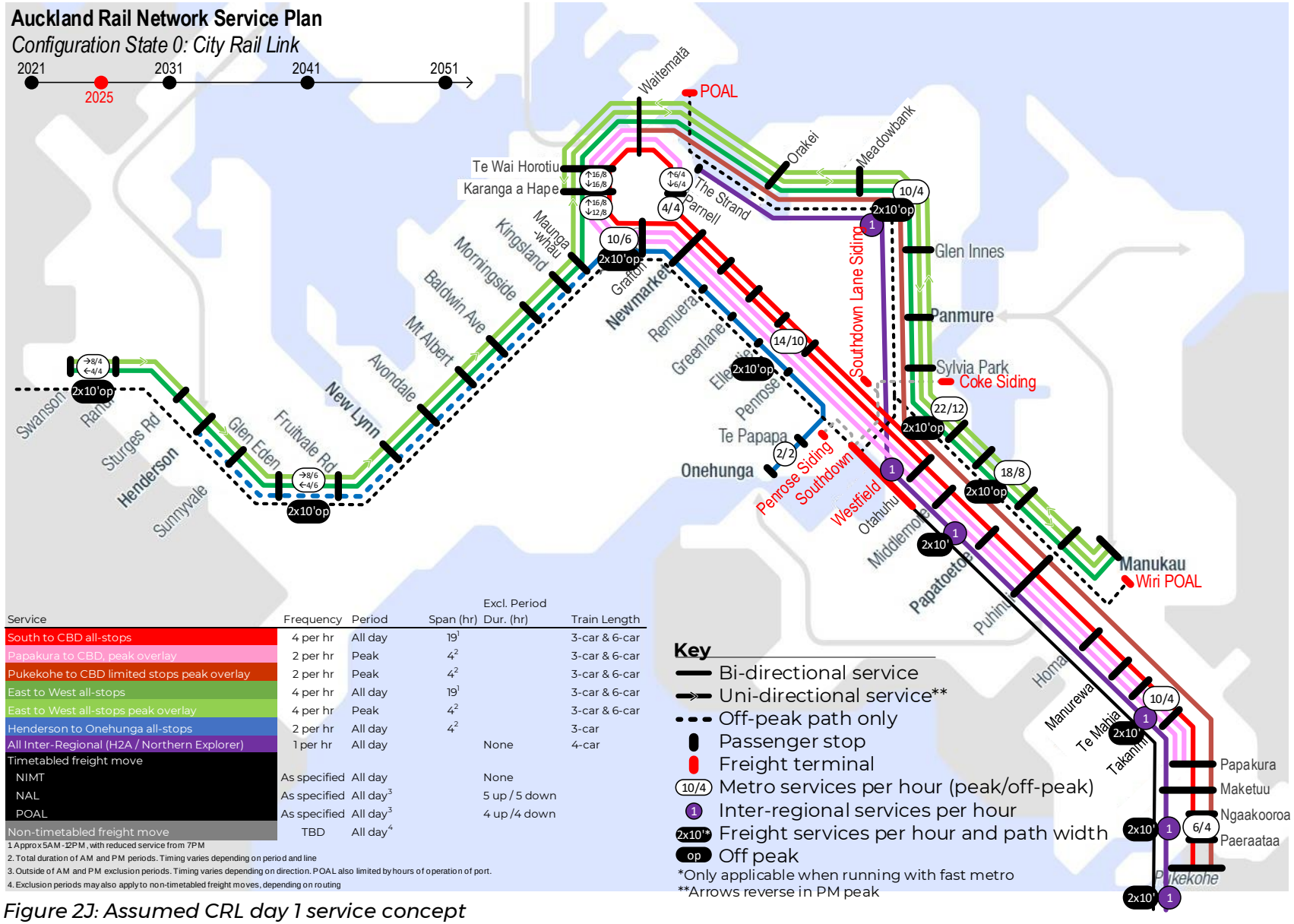
Shown in blue



The intent of this diagram is only to show the overall capacity limits of the network, and how different elements of the system impose different constraints. It is not meant to accurately represent the investment programme or the do-min.

Figure 2I: Base infrastructure - mainline capacity restrictions

Base Infrastructure and Operations
Base Operation



Service	Frequency	Period	Span (hr)	Excl. Period Dur. (hr)	Train Length
South to CBD all-stops	4 per hr	All day	19[1]		3-car & 6-car
Papakura to CBD, peak overlay	2 per hr	Peak	4[2]		3-car & 6-car
Pukekohe to CBD limited stops peak overlay	2 per hr	Peak	4[2]		3-car & 6-car
East to West all-stops	4 per hr	All day	19[1]		3-car & 6-car
East to West all-stops peak overlay	4 per hr	Peak	4[2]		3-car & 6-car
Henderson to Onehunga all-stops	2 per hr	All day	4[2]		3-car
All Inter-Regional (H2A / Northern Explorer)	1 per hr	All day		None	4-car
Timetabled freight move					
NIMT	As specified	All day		None	
NAL	As specified	All day[3]		5 up / 5 down	
POAL	As specified	All day[3]		4 up /4 down	
Non-timetabled freight move	TBD	All day[4]			

1 Approx 5AM -12PM , with reduced service from 7PM
2. Total duration of AM and PM periods. Timing varies depending on period and line
3. Outside of AM and PM exclusion periods. Timing varies depending on direction. POAL also limited by hours of operation of port.
4. Exclusion periods may also apply to non-timetabled freight moves, depending on routing

Figure 2J: Assumed CRL day 1 service concept

The CRL Day One service concept is depicted in Figure 2J. The following key points should be considered with respect to this:

- This service concept is not confirmed and is still under review in timetable committee. However the AT/KR project team agreed to use it as the starting point for PBC purposes?
- The ability for this timetable to support separate paths for all services depicted on the southern line (including metro, freight and inter regional) is one of the specific issues being considered.
- Two versions of the service concept exist. This is the **Reduced** version which limits train volumes on the Western Line to current day levels to minimise level crossing risks. The **Full** version of the timetable sees Western Line peak overlay services running as bi-directional, Henderson – Onehunga services operating all day including in peak periods, and an additional 2tph operating between Henderson and Newmarket during the peak. This full version of the timetable is assumed to require some early safety mitigations at level crossings before being acceptable for operation, and will also require review and approval via timetable committee.

Further discussion on the CRL day one timetable is provided in Section 8, Item 4.

2.4 Capacity planning methodology and assumptions

Capacity planning methodology and assumptions

Key Assumptions

A number of assumptions have been adopted in the PBC to assess the utilisation of capacity over time and were agreed with all relevant stakeholders in workshops. These are important in assessing the trigger points for when interventions are required, design of service concepts, and assessing the benefits of upgrades.

- Capacity utilisation
  - A simplified compression analysis based on UIC Leaflet 406 methodology is used to assess utilisation of capacity. See next page for further detail.
- Signalling headways
  - Existing signalling headways are based on previous studies and validated against OpenTrack simulations for critical segments. The ultimate signalling system (under ETCS L2 with signal block optimisation) is assumed to be capable of 2.5min headways between EMUs.
- Freight paths
  - NIMT:
    - 10min between all-stops passenger trains for 900m max train length
    - 15min between all-stops passenger trains for 1500m max train length
    - 12.5min between limited stop passenger trains for 1500m max train length
  - NAL: 10min between all-stops passenger trains
  - POAL: 10min between all-stops passenger trains
- Freight volume limits
  - The limit for reliable train operations entering and existing Auckland on the NIMT is around 30 trains per day per direction. Any growth beyond this will need to be accommodated by longer freight trains (planned 1500m on MP). Further discussion on this point in Appendix A.
  - The limit for the NAL is assumed to be 5 – 7 trains per day while the limit for POAL is assumed to be 6 – 8 trains per day. These limits are significantly less than the NIMT as they account for exclusion periods due to high density peak metro operation, port hours of operations, presence of light locomotive movements, cyclic patterns of operation, etc.
  - An indicative definition of freight exclusion periods on the eastern and western corridors is provided in Table 3C developed based on analysis of the CRL Day 1 timetable. The PBC has adopted the principal that these freight exclusion periods will either stay the same or reduce over the course of the 30 year planning period, but never increase

Table 3C: Definition of freight exclusion periods on the eastern and western corridors

Corridor	Freight Exclusion Periods										Metro Peak Durations	
	Down					Up						
	AM start	AM end	PM start	PM end	Total Dur	AM start	AM end	PM start	PM end	Total Dur	AM	PM
Western	6:30	9:00	15:30	18:00	5	6:00	8:30	15:30	18:00	5	2	2
Eastern	7:00	9:00	16:00	18:00	4	6:30	8:30	15:30	17:30	4	2	2

Capacity planning methodology and assumptions

Key Assumptions (continued…)

- Metro Rolling stock
  - Seating capacity per 3-car train 232
  - Total capacity per 3-car train 380 (standing plus seating)
  - Planning is based on multiples of 3-car units (up to 3 unit max – 9-car)
- Timetabling
  - Runtimes used in demand modelling and assessment of COs are based on
    - OpenTrack simulations, incorporating a travel time margin based on a performance factor setting of 90%
    - Incorporation of junction buffer estimated based on conceptual timetable development undertaken in the short list phase.
    - Dwell times based on existing dwells with adjustment for Driver Door Operation (DDO) which is assumed to result in nominal dwell times of 25s except at high volume stations, a 10s improvement over current nominal dwell times.

Capacity utilization methodology

- Capacity utilisation (or capacity consumption) is a measure of how much capacity is consumed by a given pattern of operation and equipment and is a reliable proxy for reliability of service.
- UIC leaflet 406 provides a methodology known as the compression method for assessing capacity utilization (aka capacity consumption) which has been adopted in the PBC analysis
- UIC 406 proposes buffers (in the form of occupancy time rates) for different modes and periods of operation. Of particularly relevance to the PBC is the Mixed-traffic operation buffer which characterises the most constrained areas of the network post CRL
- Incorporating these buffers allows for the calculation of utilisation where a value of 100% represent an acceptable quality of services. Note that depending the period over which capacity is measured, different occupancy time rates should be selected. 100% utilisation using peak hour rates would not be sustainable for long periods of time.
- The PBC takes the additional long term aim of protecting 75% utilisation to allow for future growth and flexibility in planning

Table 1 : Proposed occupancy time rates

Type of line	Peak hour	Daily period
Dedicated suburban passenger traffic	85 %	70 %
Dedicated high-speed line	75 %	60 %
Mixed-traffic lines	75 %	60 %

$$\text{Capacity Consumption [\%]} = \frac{\text{Occupancy Time} \times (1 + \text{Additional Time Rate})}{\text{Defined Time Period}} \times 100$$

In order for capacity consumption values to best represent the corresponding infrastructure, the following conditions can be used as a guideline:

- The capacity consumption values reflect the infrastructure characteristics of the defined train path line sections.
- The line section with the highest capacity consumption value along the train path line section is the representative line section for the train path line section.
- Acceptable quality of service is represented by capacity consumption values of up to and including 100 %.
- Capacity consumption values beyond 100 % represent a bottleneck, which means a lower quality of service, and should be subject to timetable or infrastructure improvement measures.
- Capacity consumption values below 100 % represent available capacity and thus the potential for additional train paths along the defined train path line section.

Figure 2K: UIC leaflet 406 extracts

2.5 Integrated Model

The Integrated Model

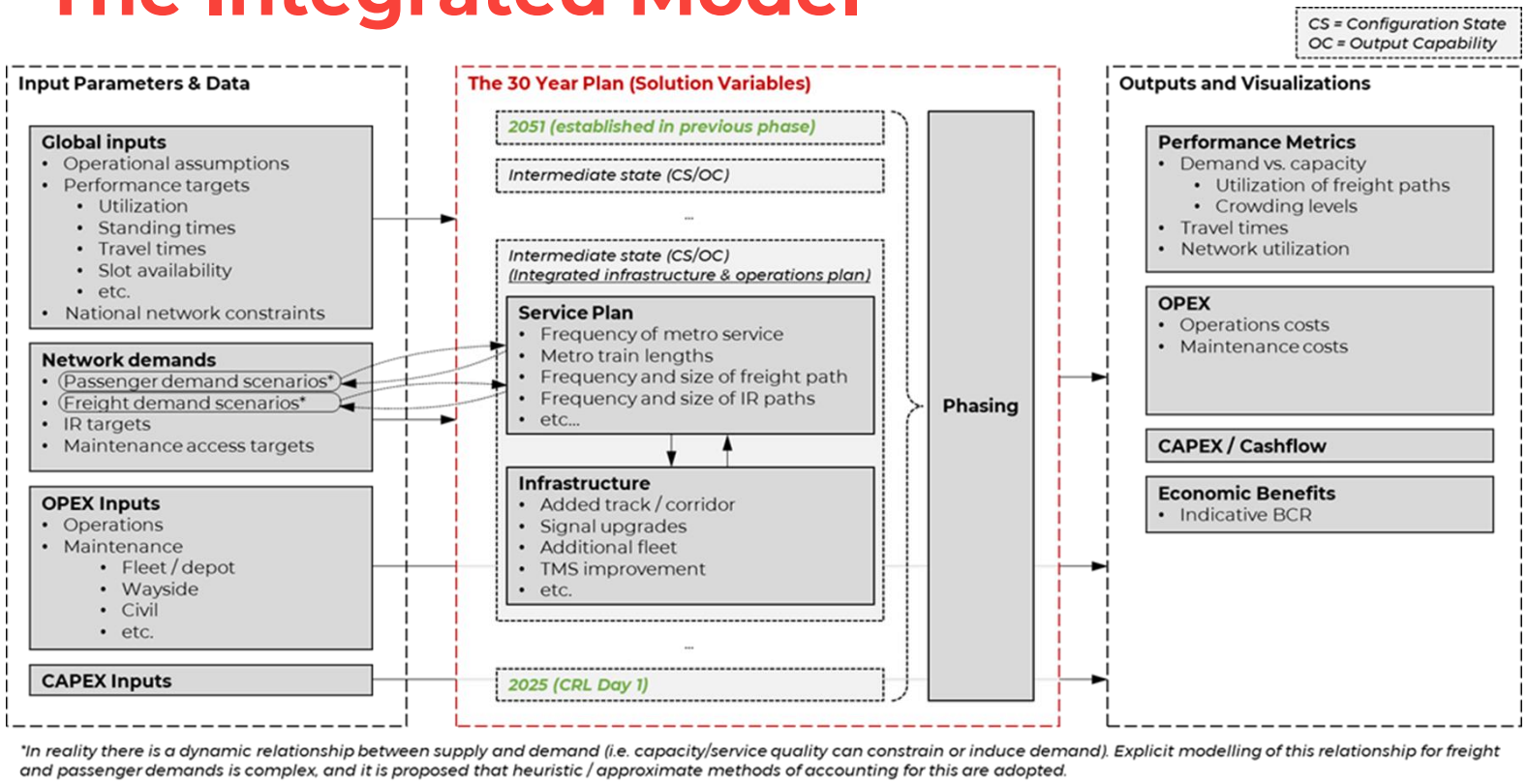
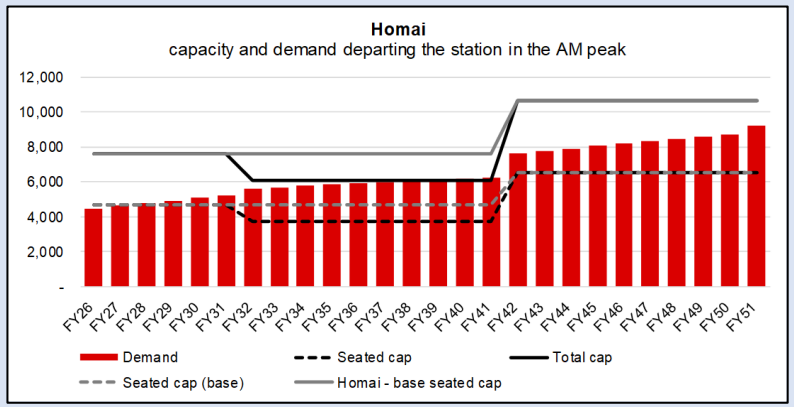


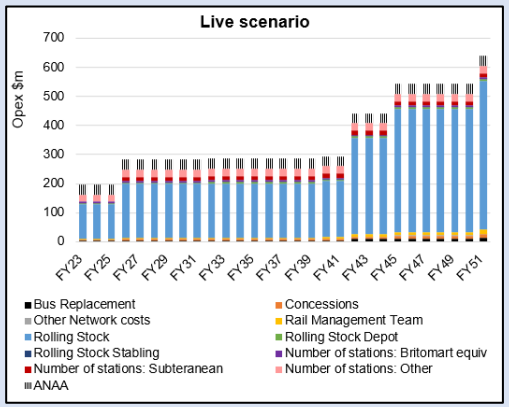
Figure 2L: IM structure

To help analyse and inform decisions as part of the process to develop the staged investment programme, an Integrated Model (IM) was developed.

The IM consists of both financial/economic (e.g. costs and benefits) and operational (e.g. network demand, capacity and utilisation) information. It allows transparency of input parameters, data and assumptions, as well as provide a test bed for scenario and sensitivity analysis and optioneering of the phasing of infrastructure and service plans. It is also used to provide a raft of outputs that support the final business case and for use by AT and KiwiRail, for example multiple views of the cashflow over time.

Figure 2L shows the basic structure of the IM. Figure 2M presents a selection of key outputs that were used at various phases of programme development.





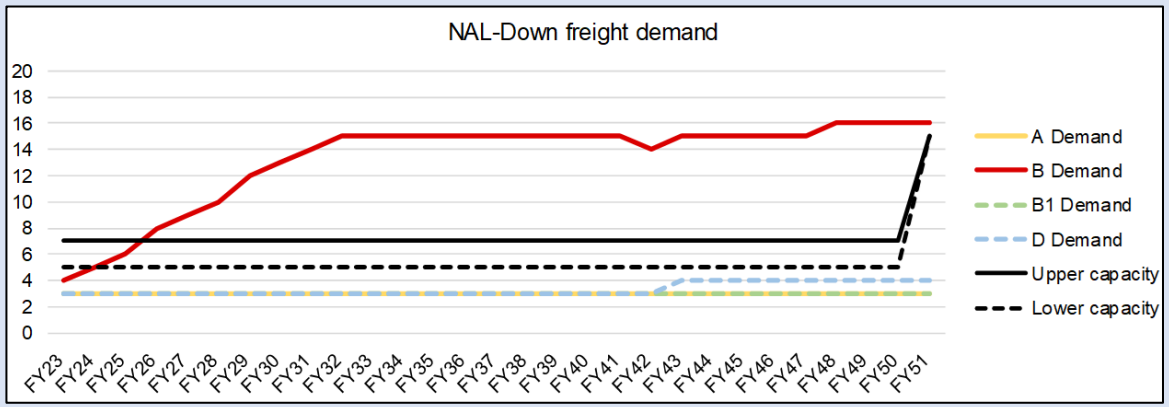
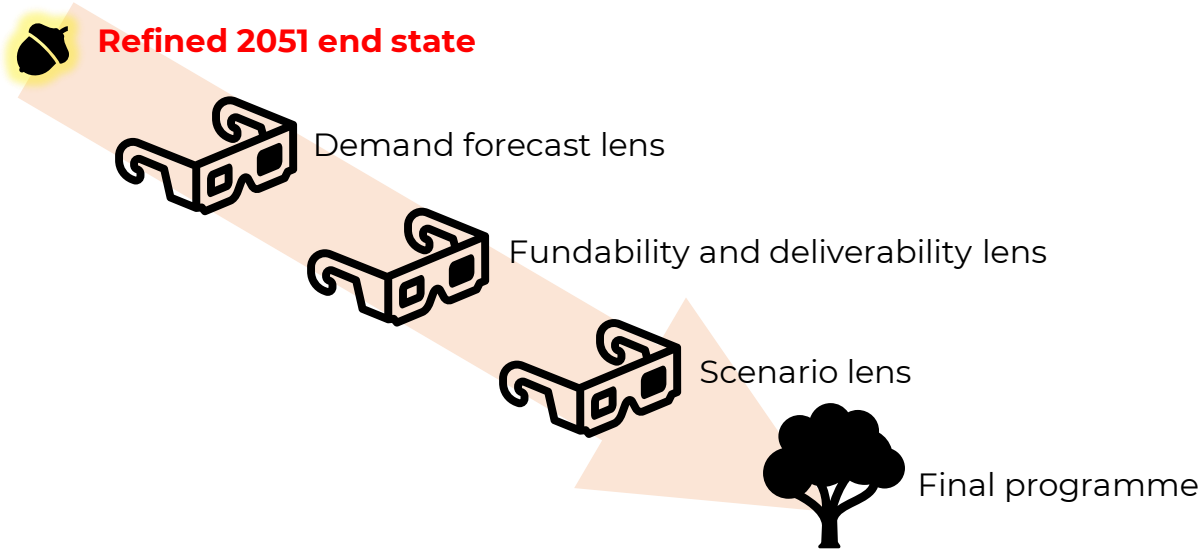


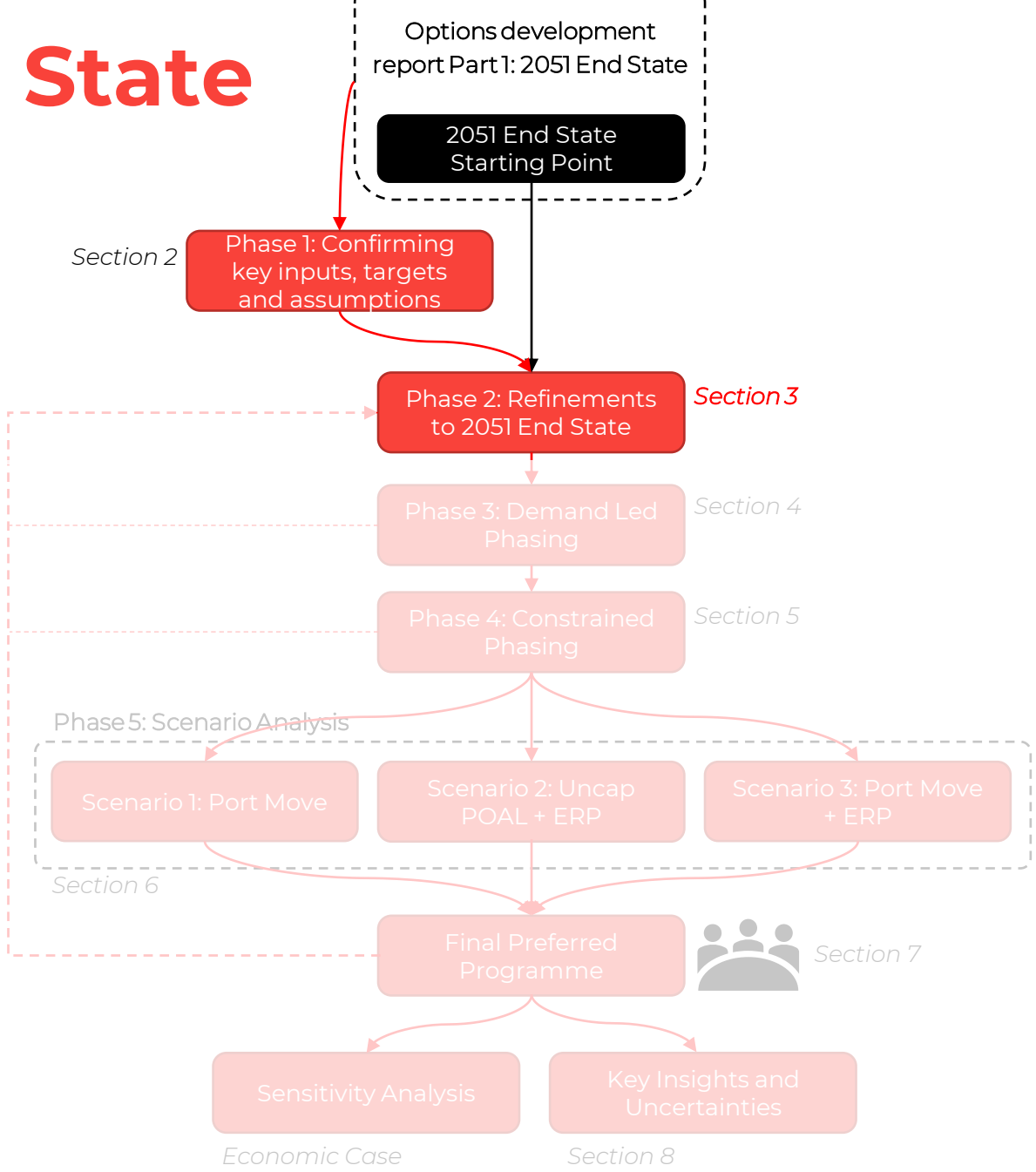
Figure 2M: Example IM outputs

3 | Refinement to 2051 End State

Refinements to 2051 End State

This section describes the 2051 end state developed as part of the optioneering process documented in the Options Development Report Part 1, as well as several initial refinements that were made on the basis of further analysis and testing.





Initial 2051 End State
Optioneering Process

The first phase of optioneering of the PBC focused on the development of a 2051 end state for the ARN. This process, documented in the Options Development Report Part 1, pursues a path from Initial Ideation to the Initial Preferred 2051 End State as illustrated in Figure 3A.

While adapted to the Long-Term Planning Process (LTPP) – appropriate for the complexity of planning a transformative programme of interventions on a complex rail network over 30 years, the process ultimately utilises a Waka Kotahi-compliant MCA framework, aligned with the PBC's benefit KPIs, investment objectives and Conditional Outputs.

The process essentially involved sifting of options from an initial set of 291 unique ideas to a ***long list*** set of thematic network wide service concepts to a ***provisional short list*** of specific network wide investment programmes down to a ***final short list*** of three options, and the final selection of ***an initial preferred end state***. A multi-criteria analyses (MCA) was completed at long list, and short list, to test the options against investment objectives, included operational assessments of Conditional Outputs.

The Preferred 2051 End State resulting from the final assessment, referred to as Ciii, was selected on the basis that, although it resulted in a lower BCR than the lowest cost alternative of Ai, the deficiencies of Ai in meeting overall programme investment objectives were too significant, particularly with respect to meeting emissions reductions targets.

A summary of the final assessment process leading the selection of Ciii is provided in Figure 3B, and the end state itself is described in more detail in the remainder of this section.

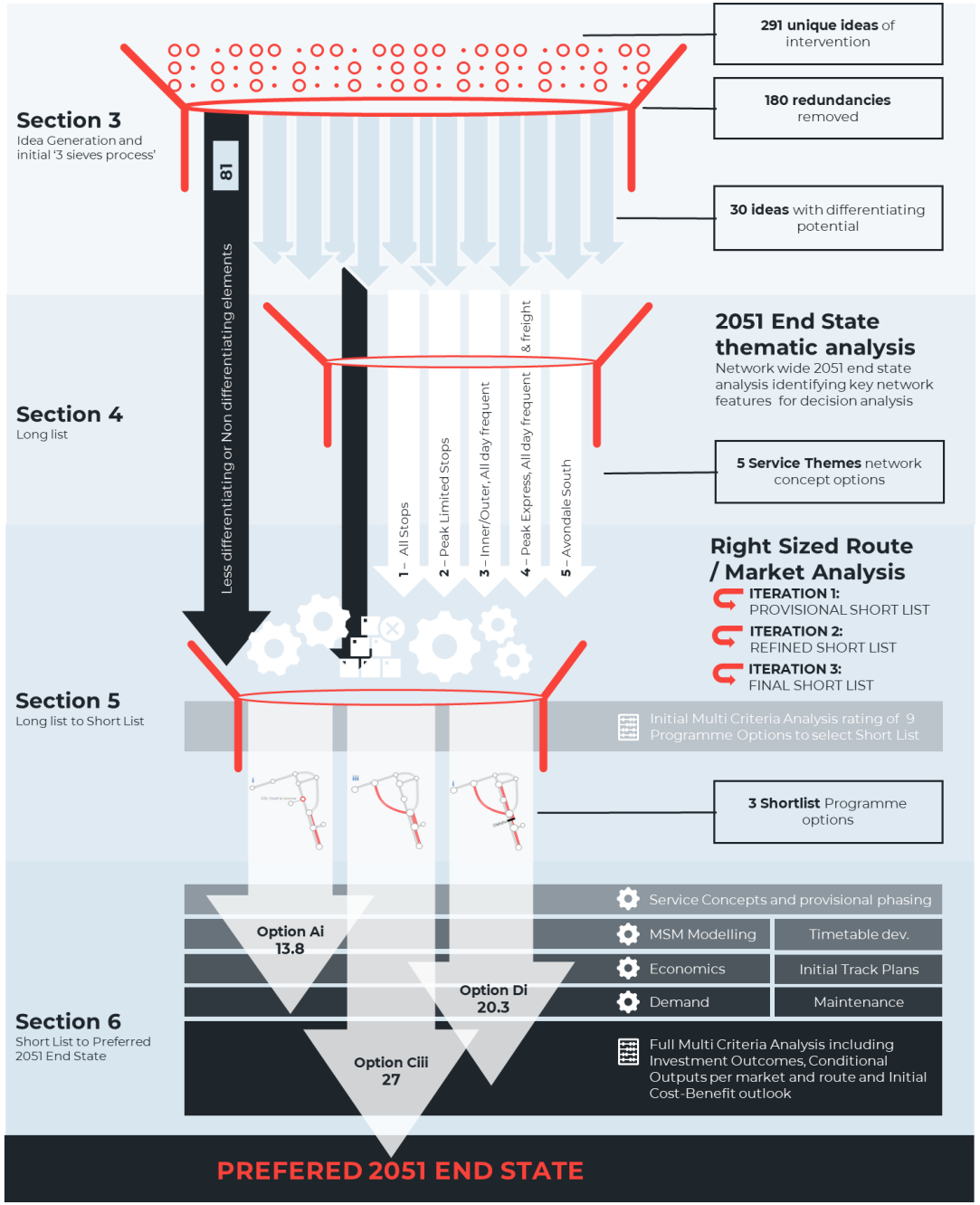
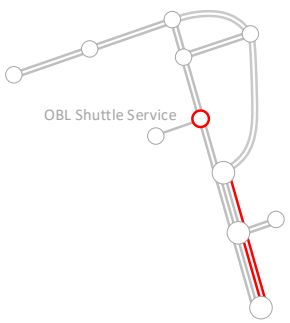
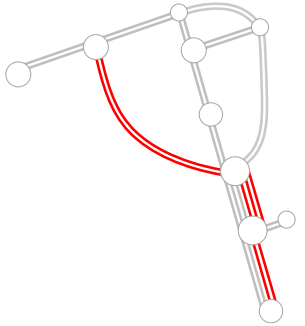
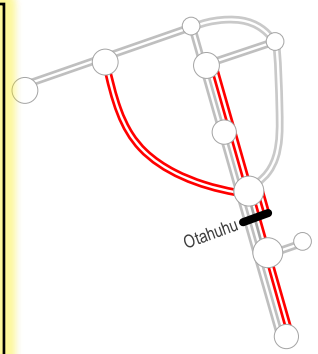


Figure 3A: Optioneering process to develop the 2051 end state

Initial 2051 End State
Optioneering Process







To be determined
Potentially compromised CO
Meets CO
Exceeds CO

Differentiating Benefits Summary	Ai	Ciii	Di
Passenger Benefits 60y NPV (2021$m, 4% DR)	**$5,480m**	**$6,520m**	**$6,420m**
	MCA Summary score 13.8	MCA Summary score 27	MCA Summary score 20.3
	45min RTN	45min RTN	45min RTN
Benefit of freight growth between DM and B1			
Freight outcomes	Constrained*	More supportive	Supportive
Freight benefits 60y NPV (2021$, 4% DR)	**$4,860m***	**$4,860m**	**$4,860m**
	1500m	1500m	1500m

Cost summary	Ai		Ciii		Di	
Total Capital Costs	lower	upper	lower	Upper	lower	upper
	$17bn	$25bn	$25bn	$35bn	$26bn	$37bn

Indicative Benefit Cost Ratio	Ai		Ciii		Di	
Limitations on Do Min, Phasing, Benefits, non-differentiating cost elements.	lower	upper	lower	Upper	lower	upper
	0.76	1	0.58	0.84	0.55	0.80

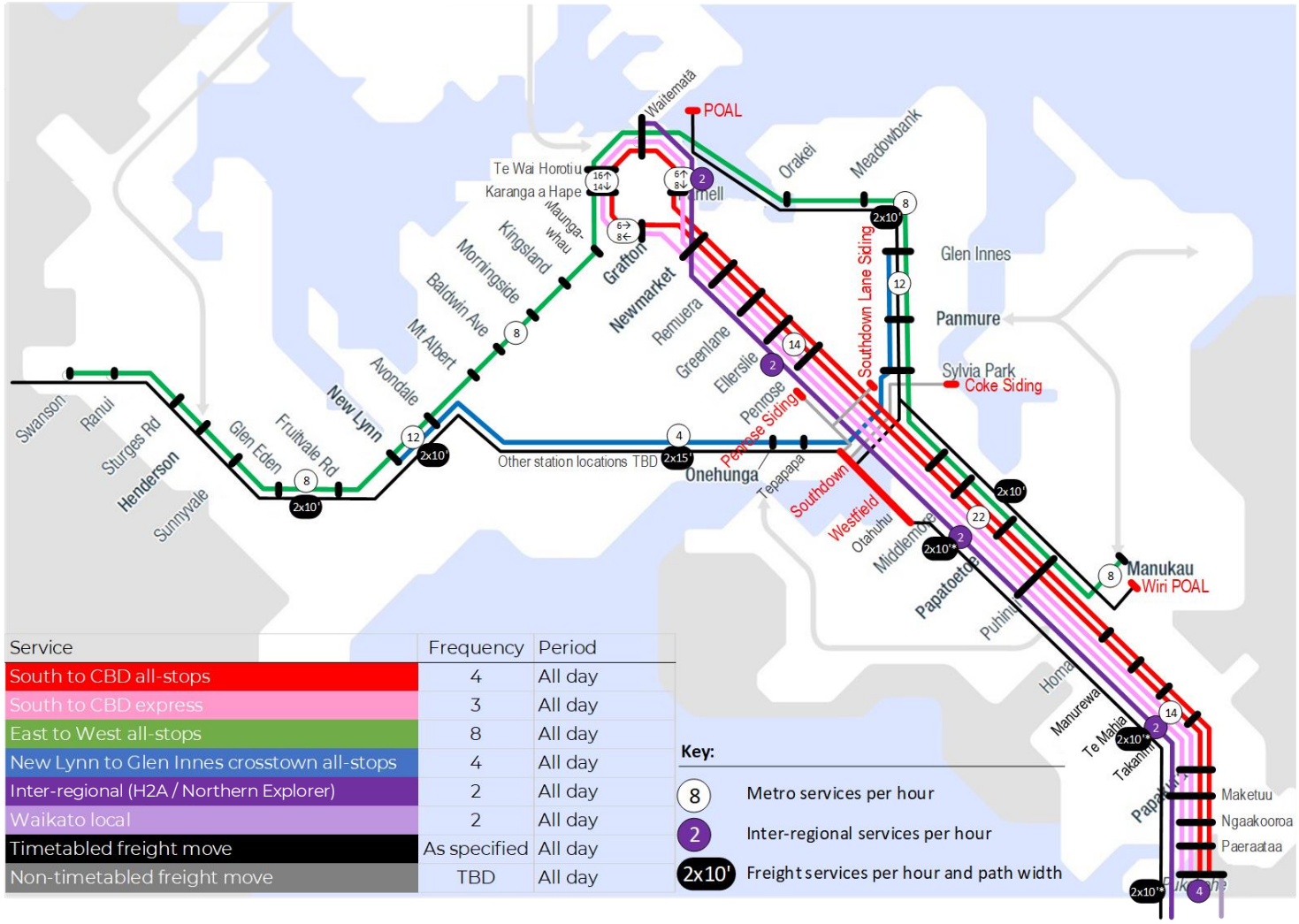
*While freight outcomes are noted as 'constrained' for option Ai, at the time of assessment these constraints were not well quantified economically. The quantification of freight benefits were based on an indicative analysis at short list stage, which when refined in later phases of optioneering indicated that Ai would not have provided sufficient capacity for freight scenarios other than the base scenario which assumed (an unrealistic) zero growth to Northport.

Figure 3B: Final analysis resulting in the selection of Ciii

Initial 2051 End State
Service and Infrastructure Concepts

The service and infrastructure concept selected as the emerging preferred option during the short list workshop is shown in Figure 3C. Several refinements were made to this concept over the course of the initial phasing assessment as described in the next pages.

Service Plan

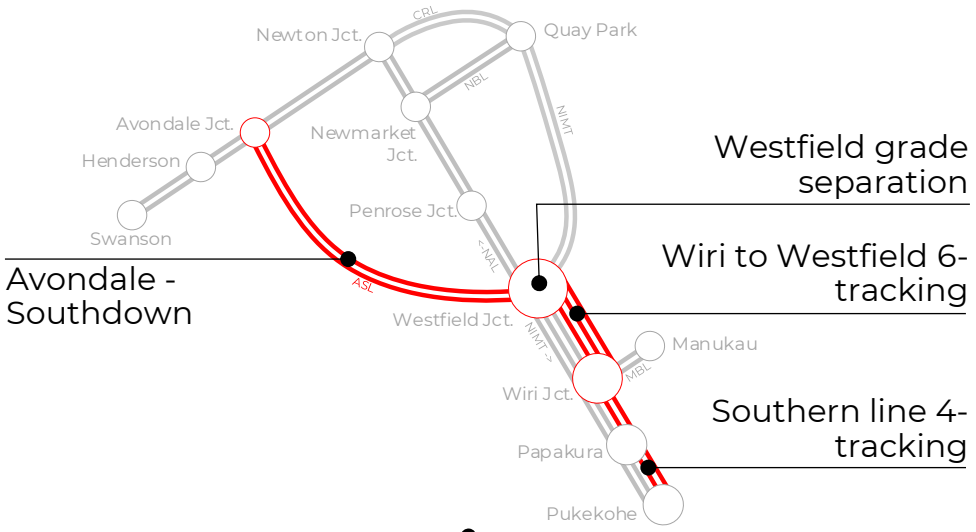


Service	Frequency	Period
South to CBD all-stops	4	All day
South to CBD express	3	All day
East to West all-stops	8	All day
New Lynn to Glen Innes crosstown all-stops	4	All day
Inter-regional (H2A / Northern Explorer)	2	All day
Waikato local	2	All day
Timetabled freight move	As specified	All day
Non-timetabled freight move	TBD	All day

Key:

- 8 — Metro services per hour
- 2 — Inter-regional services per hour
- 2x10' — Freight services per hour and path width

Infrastructure Plan



Avondale - Southdown

Westfield grade separation

Wiri to Westfield 6-tracking

Southern line 4-tracking

Network wide:

- Maintenance plant and equipment upgrades
- Signalling, train control and traffic management system upgrades
- Level crossing removal programme
- 9-car platform extensions on all lines
- New enhanced fleet to support increased services
- Station upgrade programme

Figure 3C: Initial 2051 service and infrastructure concept

Initial 2051 End State Refinements

The refinements described in this section are primarily service concept related (with the exception of some minor infrastructure changes) and are significant consistent with the base infrastructure agreed upon in the Final Preferred 2051 End State workshop held in 2022.

Onehunga Branch Line (OBL) and Mt Albert Starters

- Under the assumption that both Auckland Light Rail and Avondale – Southdown projects are delivered sometime over the next 30 years, the expectation is that the OBL should be able to be removed from the network (as no longer functionally required). However given considerable uncertainties with these projects, it was agreed that the blue line OBL service should be maintained in the programme end state with existing service levels of 2tph, 3-car trains (i.e. on requirement for platform extension or level crossing removal), with the decision to remove the spur to be reassessed once more certainty exists around these programme elements.
- The blue line services were modified to terminate at Mt Albert once Avondale-Southdown is implemented as opposed to Henderson, to avoid the need for additional tracks west of Avondale Junction
- An additional 2tph was also is added between Mt Albert and Remuera, consistent with the current plan for the CRL Day 1 Full timetable. This requires Remuera track and station upgrades given that the eventual lengthening of the Newmarket platforms to 9-car will remove the 3rd platform at this station and require a new turnback to be build further south (which is assumed to be at Remuera for the purpose of the PBC but alternatives could be considered in the next phase of project implementation)

Further discussion on this point is provided in Section 8, Item 5

Avondale-Southdown (A-S)

- *North-west tie-in:*
  - A-S services were decided to be routed to Henderson rather than New Lynn in recognition of the fact that for the previous 25 years of the plan, some form of crosstown service has been operating to Henderson, and the infrastructure will already exist to facilitate the turnback.
  - As described above, blue line services are maintained but terminated at Mt Albert (avoiding the need for quad tracking of the Western Line west of Avondale consistent with the previous optioneering of the 2051 end state). This requires Mt Albert track and station upgrades.
  - A grade separated junction with connections east and west (though eastern connection does not need to be grade separated) is assumed as the minimum requirement for the Avondale Junction. Design requirements will also need to include acceptable gradients for freight.
- *South-east tie-in*
  - It was reconfirmed that A-S service will be routed to Glen Innes via a grade separated connection through Westfield junction (and no transfer station to the Southern Line)
  - An at-grade connection between A-S and the NIMT-E is assumed, as opposed to a grade separated connection. This is due to the large expected increase in complexity, cost, and risk of impacts to areas of environmental sensitivity and importance to local Iwi, if a fully grade separated connection was pursued. This is sub-optimal from an operations perspective, but the negative impacts are expected to be mitigated by the low train frequency of the A-S cross-town service. This decision should be revisited as part of future work on the Avondale-Southdown project and/or the Westfield grade separation project.

Initial 2051 End State Refinements

- *Alignment*
  - A-S is assumed to follow the existing KR designation given that this results in less property cost, and a better residential catchment for Royal Oak and Onehunga.

It is noted that the impact of ALR on the A-S corridor cannot be determined at this time as a route for this project has not been confirmed. Further discussion on this point is provided in Section 8, Item 6.

- *Stations*
  - The initial plan was not specific on the number and locations of stations on the Avondale-Southdown corridor. The refined 2051 plan envisions 5 station within the following general zones:
    - Te Papapa (in order to maintain HR services to this area and connect to Mt Smart),
    - Onehunga (to maintain HR services to this community and integrate with wider PT network),
    - Mt Roskill (to achieve connectivity with ALR)
    - Wesley (to achieve connectivity with ALR)
    - Owairaka (new HR station adding catchment to the network)

Southern Line

- Express services were reduced from the 6tph previously assumed, to 4tph due to lack of confidence in ability to operate 10min headways with 1500m freight trains amongst limited stop passenger trains (metro and inter regional). This assumption was revised to 12.5min which limits the ability to run a 6tph metro express + 2IR + 2 1500m freight on the west mains with an acceptable headway pattern.

Penrose Siding Access

- A 3rd freight main was added in 2051 between Westfield/Southdown and Penrose siding to ensure access to this siding is not cut off by high density metro services including operation of all day express.

Inter-Regional Terminus

- With the selected routing of the preferred programme for Inter-Regional services, the desire for a central city interchange is well met by a planned stop at Newmarket, which provides a high degree of connectivity to the metro network. This makes provisioning for a terminus at Waitemata (as originally envisioned in the initial preferred 2051 end state) less important. Furthermore, conceptual timetable analysis suggests that terminating Inter Regional services at the Waitemata bay platforms will not be possible without compromise to the metro timetable. Further analysis should be undertaken to explore solutions in future project phases – however for now, the terminus is assumed to be maintained at the Strand with the main interchange at Newmarket.

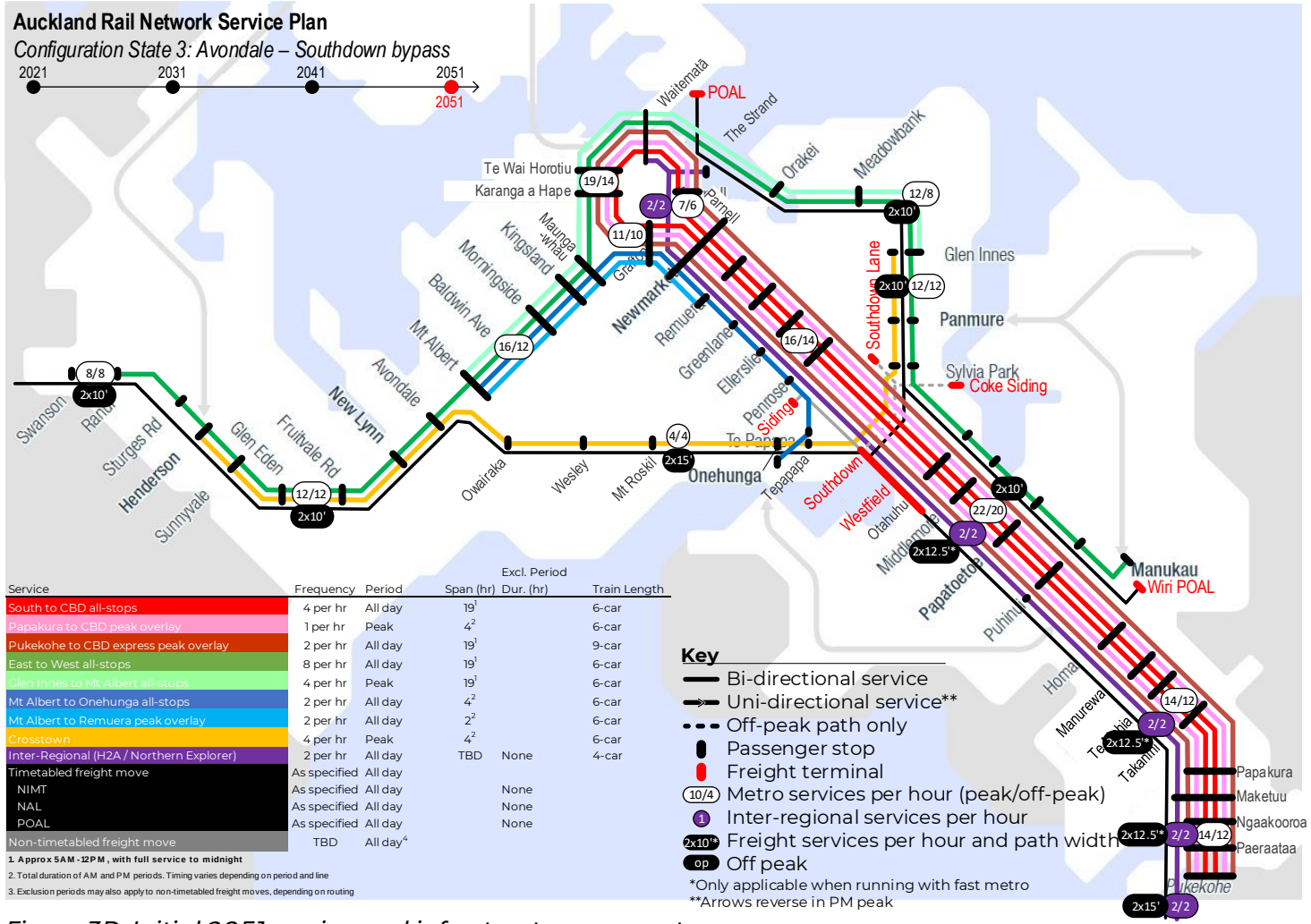
Further discussion on this point is provided in Section 8, Item 7

Initial 2051 End State
Refinements

Iteration 1 (final state only)

The refinements described above resulted in the revised service and infrastructure plan shown in Figure 3D. This is the first iteration described in this report, which is then used as the starting point for the development of a phasing of improvements over 30 years.

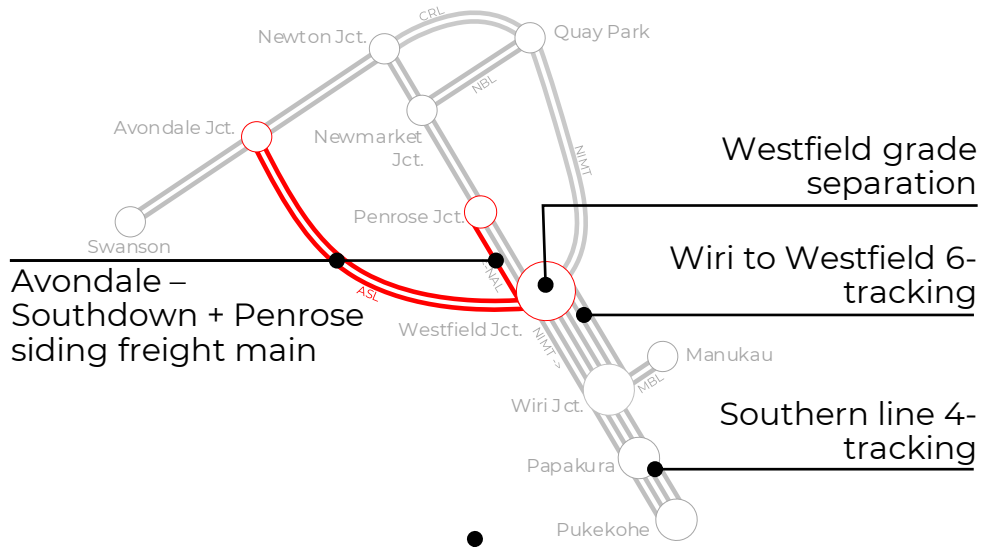
Service Plan



Service	Frequency	Period	Span (hr)	Excl. Period Dur. (hr)	Train Length
South to CBD all-stops	4 per hr	All day	19[1]		6-car
Papakura to CBD peak overlay	1 per hr	Peak	4[2]		6-car
Pukekohe to CBD express peak overlay	2 per hr	All day	19[1]		9-car
East to West all-stops	8 per hr	All day	19[1]		6-car
Glen Innes to Mt Albert all-stops	4 per hr	Peak	19[1]		6-car
Mt Albert to Onehunga all-stops	2 per hr	All day	4[2]		6-car
Mt Albert to Remuera peak overlay	2 per hr	All day	2[2]		6-car
Crosstown	4 per hr	Peak	4[2]		6-car
Inter-Regional (H2A / Northern Explorer)	2 per hr	All day	TBD	None	4-car
Timetabled freight move	As specified	All day			
NIMT	As specified	All day		None	
NAL	As specified	All day		None	
POAL	As specified	All day		None	
Non-timetabled freight move	TBD	All day[4]			

1. Approx 5AM - 12PM, with full service to midnight
2. Total duration of AM and PM periods. Timing varies depending on period and line
3. Exclusion periods may also apply to non-timetabled freight moves, depending on routing

Infrastructure Plan



Network wide:

- Maintenance plant and equipment upgrades
- Signalling, train control and traffic management system upgrades
- Level crossing removal programme
- 9-car platform extensions on all lines
- New enhanced fleet to support increased services
- Station upgrade programme

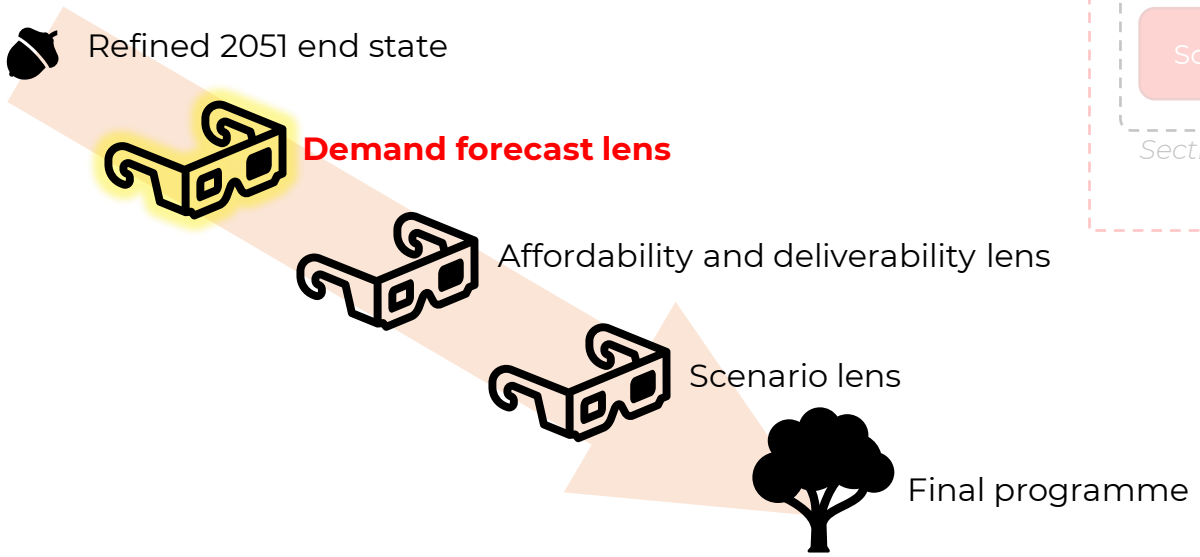
Figure 3D: Initial 2051 service and infrastructure concept

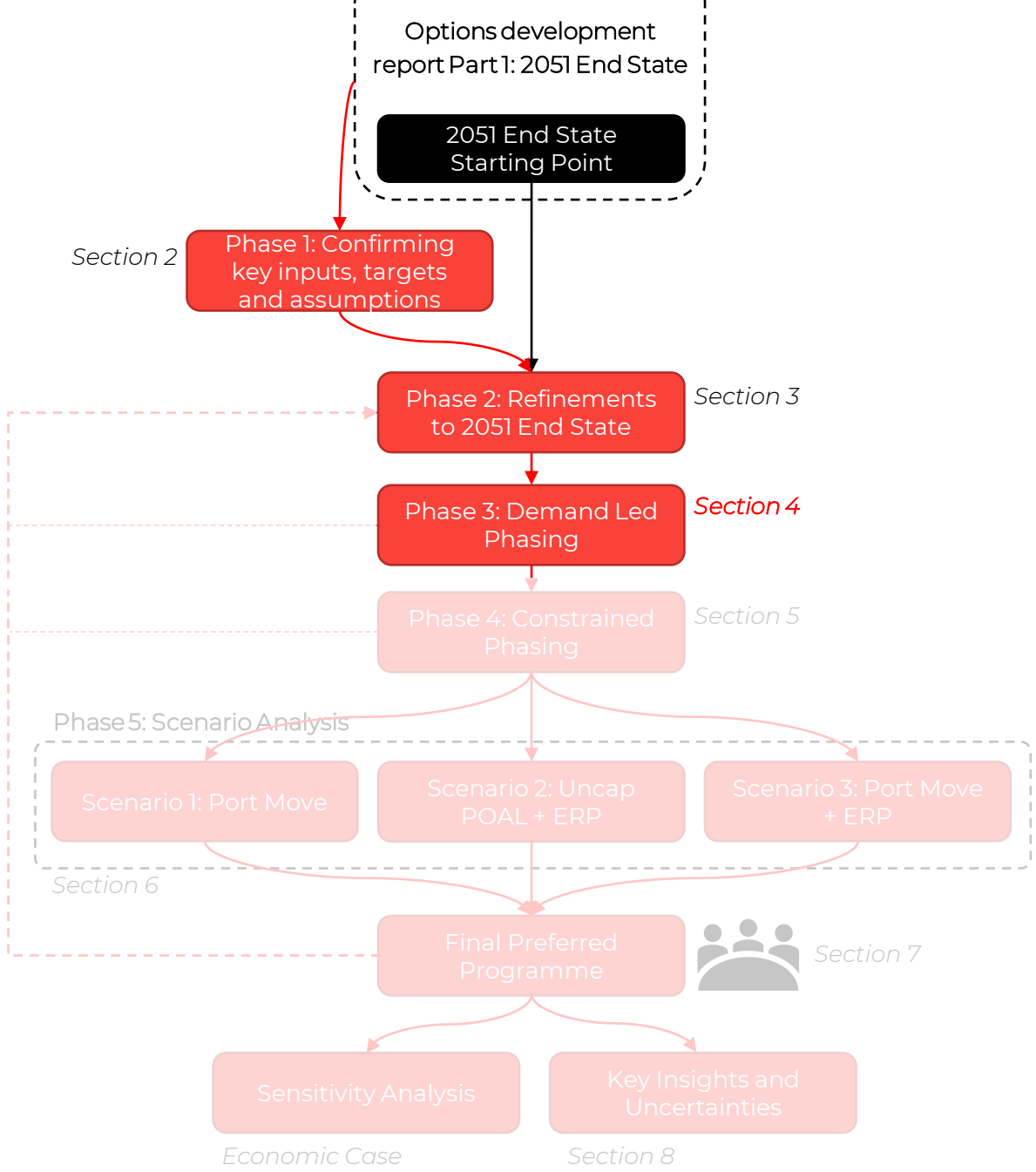
4 | Demand Led Phasing

Demand Led Phasing

This section describes the development of a demand led phasing

- This section focuses on the base demand scenarios defined in Section 1.1
- Analysis is separated into three primary corridors: Southern, Eastern (including POAL) and Western (including NAL and Avondale-Southdown)
- Within each corridor, the trigger dates for service enhancements are assessed for each market; Freight, Metro, and Inter Regional.
- Then the timing of the infrastructure and system improvements required to meet all market needs together is assessed.
- Finally, alternatives are discussed along with the rationale for why these were not preferred over the base concept. These alternatives include consideration for trade-offs between markets (for example running less metro services to accommodate more freight).
- The result of this analysis is a demand led phasing of service and infrastructure improvements over time.





Configuration States

In this phase of analysis, the delivery of major components of the 2051 plan need to be defined in time. For this activity, the PBC has adopted the concept of **Configuration States** which essentially represent a set of infrastructure investments that allow a set of service benefits (or Output Capabilities) to be achieved. In most cases, multiple benefits are provided by a single element of the infrastructure plan, which may be related to an increase in capacity or an improvement in service quality and efficiency, for one more markets. The concept is illustrated in Figure 4A. In the following sections, Configuration States are named according to the following convention:

- CS0, CS1, CS2,... represent major configuration states associated with a large track configuration change such as 4-tracking of the southern corridor
- CS0-1, CS0-2, CS0-3,... represent interim states between the major configuration states enabled by smaller scale infrastructure investments such as building turnback tracks to enable a peak overlay service, or procuring fleet to extend train lengths

Split over the following pages, Table 4A describes the output capabilities associated with each major infrastructure element of the 2051 service concept, as determined through modelling and analysis undertaken in the previous phase of optioneering. These are the basic building blocks upon which the configurations states are built and sequenced in subsequent phases.

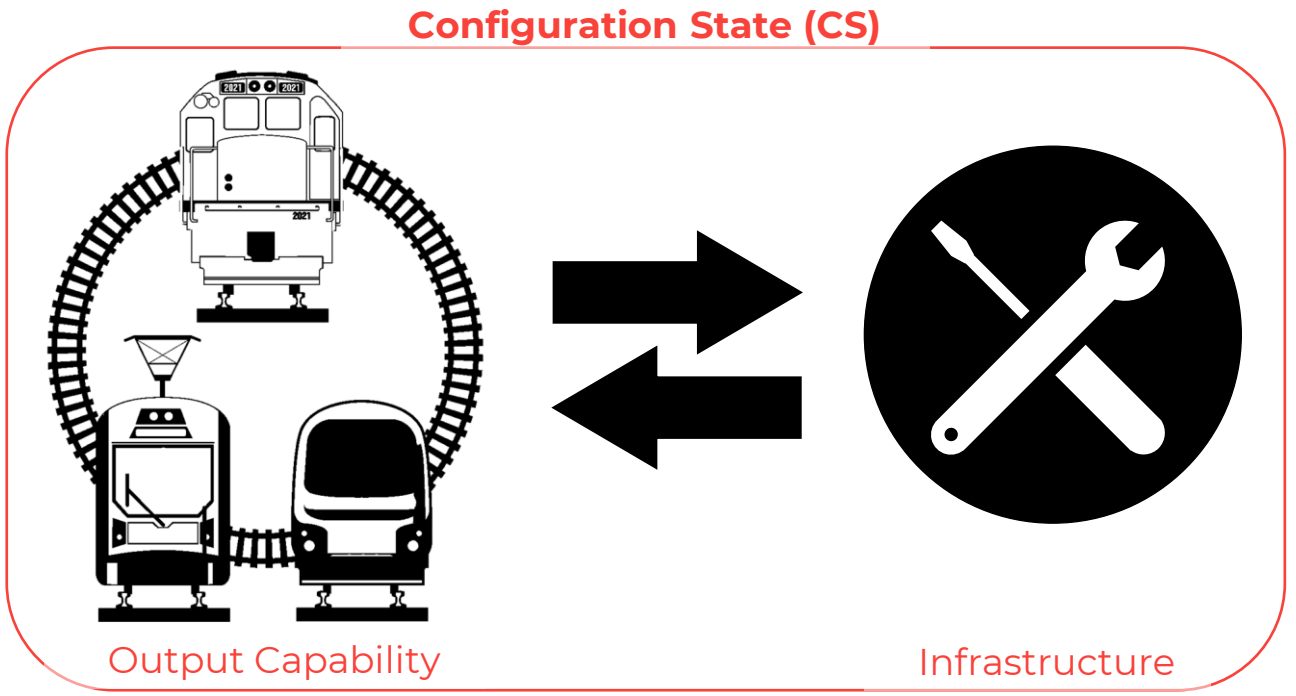


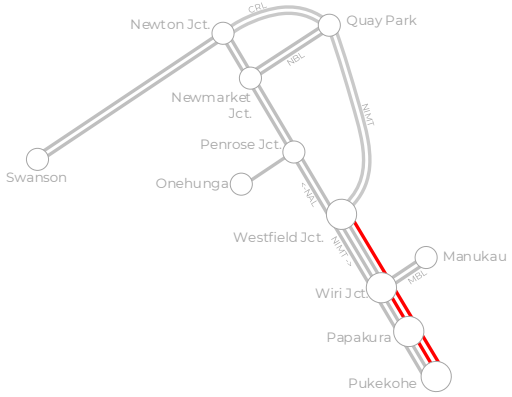
Figure 4A: Configuration State concept

Initial 2051 End State
Output capabilities of major elements

Table 4A: Output capabilities of major investment elements

Improved capability / *comparison to do min*

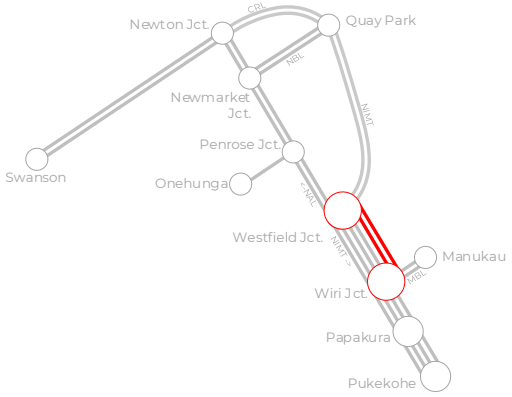
Element	Output Capability

4-tracking southern line
 
	• **Peak capacity:** Major improvement in peak train throughput capacity; accommodating;
	  • 2 x 1500m freight paths *(increasing from 2 x 900m max paths under do min)*
	  • 14 metro paths including 4 express paths *(increasing from 10 metro paths including 2 express paths under do min)*, and
	  • 2 inter regional paths *(increasing from 1 inter regional path under do min)*
	to run together in the peak period between Pukekohe and Westfield at an acceptable level of reliability with excess capacity to accommodate additional services in the future. The four track configuration allows for the separation of fast and slow services (pair by use operation) which also results in improved service reliability.
	• **Maintenance benefits:** giving the ability to run a full two track operation while two tracks are down for maintenance, *compared to the do min which requires full closure for major works resulting in cancelation of metro services, and single track operations for freight and inter regional*. By reducing the impact of maintenance on services, this will provide much greater flexibility for the maintainer to carry out critical activities.
	• **Travel time benefits**: Allowing metro express and Inter Regional services to access the city centre in less than 45min from almost every station on the network. This provides competitive journey times to private car trips in peak periods. *As an example the runtime between Pukekohe to Aotea is 52min compared to a do min travel time of 65min, a peak car travel time of 65 – 130min,*
	• **All day frequent service:** Allows for the minimum Rapid Transit Network (RTN) standard for 'frequent' services to met on the Southern Line with an 8tph frequency enabled all day (with the only restrictions being in evening periods to enable maintenance window targets). *This is compared to current off-peak frequencies of 4tph.*

Initial 2051 End State
Output capabilities of major elements

Table 4A: Output capabilities of major investment elements (continued…)

Improved capability / *comparison to do min*

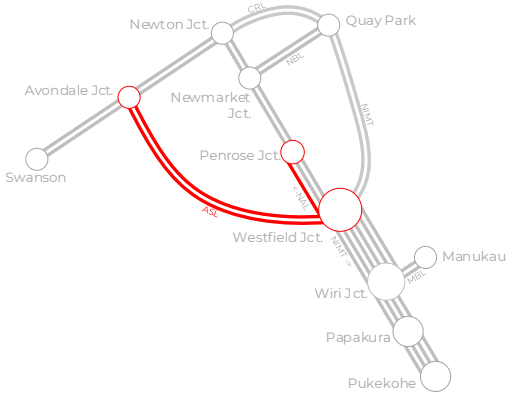
Element	Output Capability
6-tracking Wiri to Westfield 	• **Optimal freight timetable:** Freight exclusion periods for the Port Line are eliminated allowing all day access between POAL and WPOAL, allowing for more flexibility in timetable and thereby substantially increasing capacity to 27 trains per day, *from an estimated max volume of 6-8 trains per day under the do min.* • **All day frequent service:** Allows for RTN standard frequent services of 8tph to be operated on the Eastern and Western lines all day (with restrictions in evening periods to enable maintenance window targets). • **Network reliability improvements:** via deconflicting Wiri and Westfield junctions, including eliminating conflicts between POAL freight and passenger movements on the southern line. and 'de-interlining' the Eastern and Southern lines by providing separate pairs of tracks for each line. *This is compared to a situation under the do min where the most significant sources of delays originate in, or are amplified by, the Wiri to Westfield segment of the network, which experience the highest train volumes of the entire New Zealand rail network.* • **Travel time improvements:** In addition to improved reliability, de-interlining of the Eastern and Southern lines also allows junction buffer to be removed from the timetable, *resulting in a travel time saving of up to 7.5min on these lines.* • **Maintenance benefits:** giving the ability to run a three track operation (similar to the do min configuration) while the adjacent three mains are down for maintenance. Again, reducing the impact of maintenance on services, allows the maintainer much greater flexibility to carry out critical activities, which is particularly important for this segment of the network given the high traffic volumes and convergence the two major metro lines.

It is important to note that the 6-tracking concept is one solution to achieving objectives of PBC; namely providing: all-day freight paths between POAL and Wiri **AND** required metro peak and off-peak frequencies **AND** train paths to support inter-regional growth. This solution comes with substantial costs both financially and in terms of community disruption, which were deemed to be justified by the benefits of the intervention in the Initial Preferred Programme workshop. However, there may be variations on this concept that are less disruptive in nature and these should be explored further in the next phase of business case development – specifically within the scope of the Southern Line 4-Tracking project, and this point in time, **the 6-tracking concept should be treated as an illustrative solution only.**

Initial 2051 End State
Output capabilities of major elements

Table 4A: Output capabilities of major investment elements (continued…)

Improved capability / *comparison to do min*

Element	Output Capability
Avondale – Southdown 	• **Optimal freight timetable and capacity:** Freight exclusion periods for the North Auckland Line are eliminated allowing all day access between Northland and Westfield / Southdown, providing more flexibility in timetabling and substantially increasing capacity to 16 trains per day, *from an estimated max volume of 5-7 trains per day under the do min* without requiring compromise to metro services. The third freight main between Penrose and Westfield also improves access to the Penrose siding, allowing unimpeded freight access all day. • **Travel time and peak span improvements:** Allows express services to be run all day on the southern line without compromising freight access, which enables car competitive journey times from the south not only during peak periods, but all day including off peak periods. *As an example, with A-S in place the runtime between Pukekohe and Aotea will be 52min compared to an off-peak car travel time of 45 – 65min.* • **Additional crosstown metro line:** Provides a new crosstown metro line, improving connectivity of the wider PT network, enabling new trips, and increasing the catchment of the rail system. • **Maintenance benefits:** The A-S corridor provides alternative routings under maintenance or emergency mode operations, allowing for example Western Line traffic to be routed via A-S en-route to the city centre under closure of the inner Western corridor, or for southern line traffic to be routed via A-S en-route to the city centre under closure of the inner southern corridor.*
Grade separation of Westfield	• **Optimal freight timetable and capacity:** Allows all-day freight access between POAL/Tamaki siding and Southdown / Westfield. Note that this investment does not provided all-day freight access between POAL and WPOAL – that capability is provided by the 6-tracking project. Under the do min, this • This project is also required to support future connectivity of Avondale-Southdown
9-car extensions – all lines	• **Increased passenger capacity** reduced levels of crowding and resulting in standing times of less than 15min in all areas of the network. *Without 9-car extensions, long standing times of 40 – 55min are predicted to occur, particularly on the Southern Line, due to the high volume of boardings occurring in the outer southern area of the network.*

*Later more detailed analysis performed also suggests that the Avondale - Southdown corridor is an enabler of a clock face timetable on the southern line, allows the Glen Innes to Mt Albert service to operate all day, and enhances reliability by removing freight from the critical area of the network between Newton and Newmarket. Critically, it also resolves a capacity allocation trade-off between freight and metro services, that would result in significant impacts to one or more markets (including potential road network impacts if freight demand is shifted to truck) should freight growth exceed the estimated limit of 5-7 trains per day per direction.

Initial 2051 End State
Output capabilities of major elements

Table 4A: Output capabilities of major investment elements (continued…)

Improved capability / *comparison to do min*

Element	Output Capability
Signalling, Train Control and Network Control upgrades (includes R9K replacement, ETCS L2, ATO, signal block optimisation – network wide)	• **Network reliability:** Improved network reliability resulting from a less fault prone, virtualised signalling system, consistent speed profiles enabled by driver assistance technology, a more accurate and automated Traffic Management System and the optimisation of signalling blocks to achieve tighter headways. • **Travel time improvements:** The reliability improvements described above are expected to manifest in travel time improvements to metro and inter-regional services, with *conceptual timetable analysis estimating time saving up to 10min on the Southern Line with the introduction of these technology improvements.*
Level crossing removals – network wide	• **Capacity improvements:** Reduced / eliminates safety risks at road crossings, which allows for an increase in train volumes across them. The placement of signals is also often constrained by the presence of level crossings, and the removal of the crossing therefore allows the signal block layer to be optimised. improving signalling headways and increasing capacity.
Maintenance plant and equipment improvements	• **Network reliability:** Improved reliability, availability, maintainability and safety of all network assets, thereby improving the reliability of rail services for all markets

Demand Led Phasing
Assessment approach

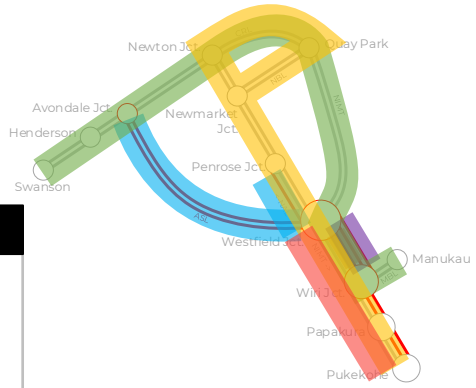
Figure 4B provides another representation of the linkage between infrastructure element and output capability, showing how each major service enhancement maps to the enabling infrastructure upgrades. The colours are used to map the output capability to the enabling infrastructure. For example, all of the red highlighted output capabilities for freight, metro and inter regional markets, are enabled by the southern corridor 4-tracking. It should be noted that:

- Some service improvements are not demand driven under base case demand, but conversely are driven by service targets that are meant to improve the attractiveness of the rail service offering and drive demand growth. However…
    - This analysis only considers the base demand scenario. Service enhancements that are attractiveness driven under one scenario can become demand driven under others. For example, under the Port Move scenario, growth on the NAL results in a clear date for when Avondale-Southdown would be required to meet demand.
- Infrastructure elements are focused on major configuration state changes however there are many other supporting improvements required to achieve the service improvement. For example, fleet procurement, signalling enhancements, traction power upgrades, expanded depot and stabling etc. These are not considered at this phase of analysis but will be in later phases once the macro level phasing concept is established.

Various plots and calculations are used to determine triggers for the service and infrastructure improvements outlined in Figure 4B, which are output from the Integrated Model. These are:

- **Metro peak load point plots:** Show how demand at the peak load point on the line grows over time, relative to the seating capacity of the available service interventions. Where demand exceeds capacity, this indicates that passengers on board trains will be standing.
- **Metro line load plots:** Show how demand is distributed along the line, showing the expected number of passengers on board trains between each station-to-station segment. Plotted against capacity of each intervention, this indicates the average duration of standing time.
- **Metro two-hour demand plots:** Show how demand is distributed over the peak 2-hr period, relative to capacity. This is particularly relevant for early configuration states where trains in the shoulder peak periods are shorter in length.
- **Freight demand vs capacity plots:** These plots show the projected growth of freight relatively to the capacity provided within the AMRN. In the case of the NIMT – these plots account for the enablement of 1500m train lengths, while on the NAL and POAL, they account for capacity improvements enabled by removal of peak exclusion periods
- **Track peak utilisation calculations:** For junction-to-junction segments, peak utilisation is calculated according to UIC 406 compression analysis incorporating suggested buffers. Under this methodology a value of 100% represents an acceptable level of service, while a value of >100% indicates risk of unreliable operation.
- **Clockface diagrams:** Show indicative cyclic headway patterns for specified segments of the network which show how the various services and markets will be timetabled together and what compromises this may entail under different infrastructure states.

Demand Led Phasing
Assessment approach



Service enhancement / output capability		Infrastructure enhancement	
Southern			
Metro		• 4 tracking the southern line (including 1500m enablement)	Demand driven
• Full 6-car operation	Demand driven	• 9-car platform extensions, South line	Demand driven
• 14tph services to Pukekohe	Demand driven	• Avondale – Southdown	Level of service driven
• 9-car operation, South line	Demand driven		
• RTN frequency	Attractiveness driven		
• All day express	Attractiveness driven		
Freight			
• Longer train lengths introduced in peak	Demand driven		
Inter-Regional			
• Increase to 2 paths per peak hour	Demand driven		
Western (including NAL and Avondale – Southdown)			
Metro		• Avondale – Southdown	Level of service driven
• CRL full timetable	Demand driven	• 9-car platform extensions, East-West line	Demand driven
• Full 6-car operation	Demand driven		
• 9-car operation, East-west line	Demand driven		
• RTN frequency	Attractiveness driven		
Freight			
• All day freight paths	Attractiveness driven		
Eastern (including POAL)			
Metro		• Wiri to Westfield 6-tracking	Level of service driven
• 9-car operation, East-west line	Demand driven	• 9-car platform extensions, East-West line	Demand driven
• RTN frequency	Attractiveness driven		
Freight			
• All day freight paths	Attractiveness driven		

Figure 4B: Major service and infrastructure triggers

4.1 Southern corridor

Metro demand triggers – Southern Line

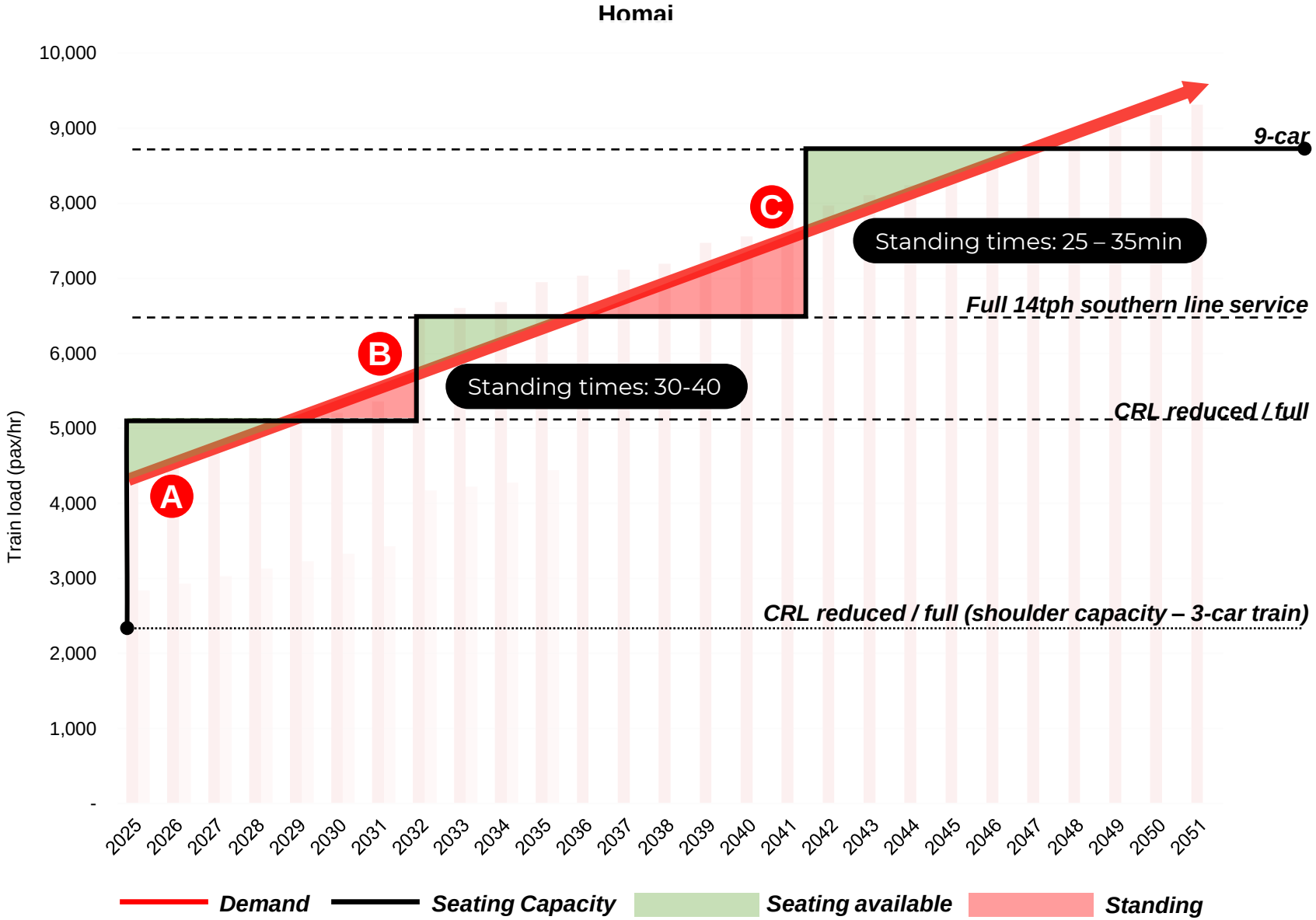


Figure 4C: Southern corridor peak load point plot (Homai)

Trigger Point A
See next slide

Trigger Point B
Peak demand exceeds capacity of the CRL Day 1 reduced and full timetables between **2030-2034** with standing between Papakura and Homai, approx. 30-40 min to the Newmarket and 45-55min to Aotea

Resolved by **increasing train frequencies on the southern line to 14tph with all trains starting at Pukekohe**.

Trigger Point C
Peak demand exceeds capacity of a 14tph X 6-car service on the southern between **2038-2042** with standing starting somewhere between Papakura and Homai, approx. 25-35 min to the Newmarket and 35-45min to Aotea*

Resolved by increasing **train lengths to 9-car**

* Accounting for expected runtime improvements achieved via signalling and train control upgrades

Metro demand triggers
Shoulder peak demand

With respect to trigger point **A**

Highest demand occurs in peak hour; 61% of 2-hour demand, with the remaining 39% in shoulder peak periods.

However due to lack of available units in the base fleet, only 3-car trains are run in the shoulder peak period, resulting in this period being capacity constrained as shown in plots to left (each column approximately represents the load of one train on average)

This shows that one or two 3-car trains on the shoulder of the peak period will be heavily loaded as early as 2025, with expected standing times > 40min, and will be leaving passengers being by 2032 (approximately 50-100 passengers per train)

This analysis assumes uniform headways and attractiveness of services. In reality these factors will result in some trains being more heavily loaded than others, with the potential for some passengers to be left behind as early as CRL opening day, **pointing to the need for additional fleet as soon as possible between 2025 and 2030**

Homai (Southern Line Peak Load Point)

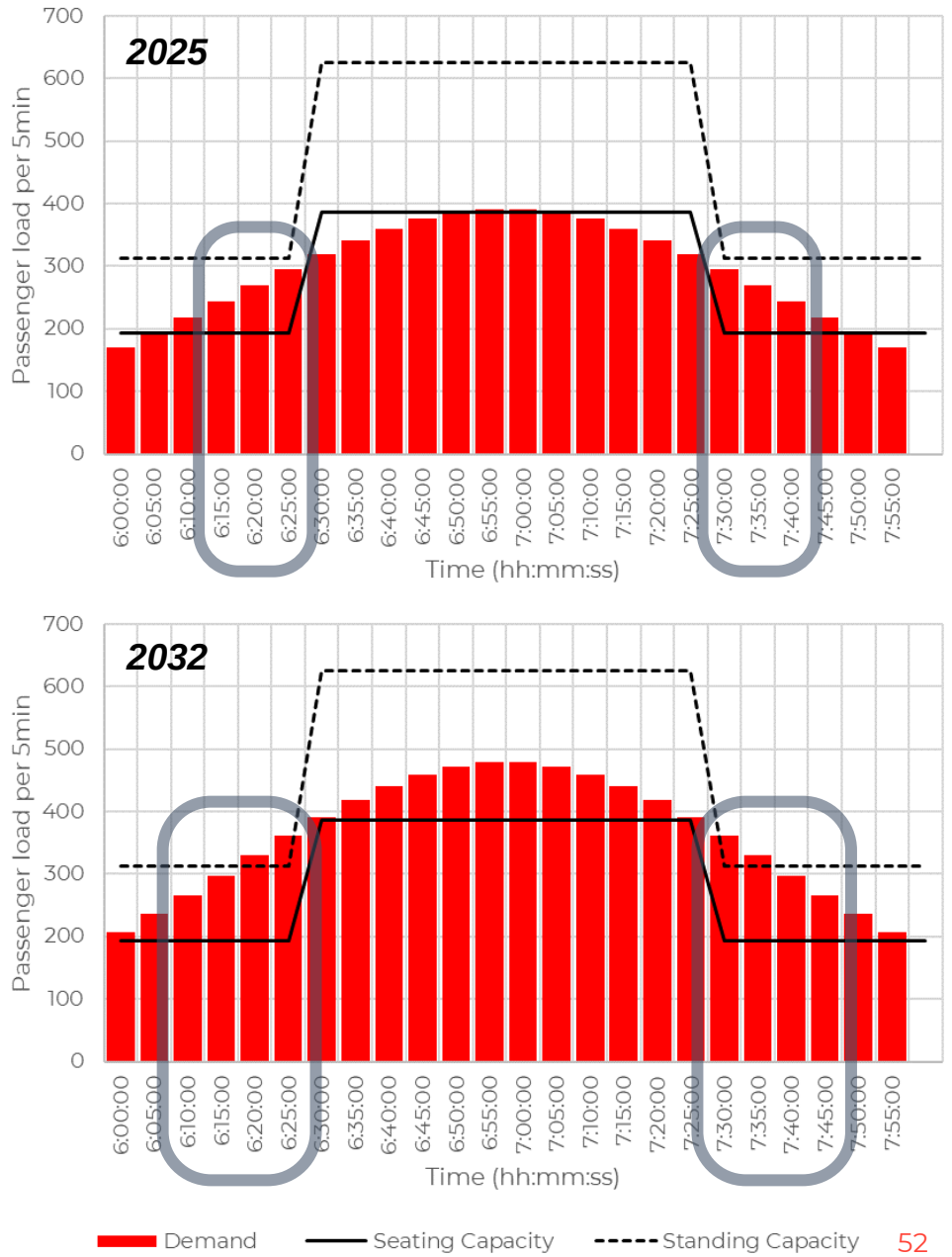


Figure 4D: Peak two hour load distribution at Homai

Freight demand triggers

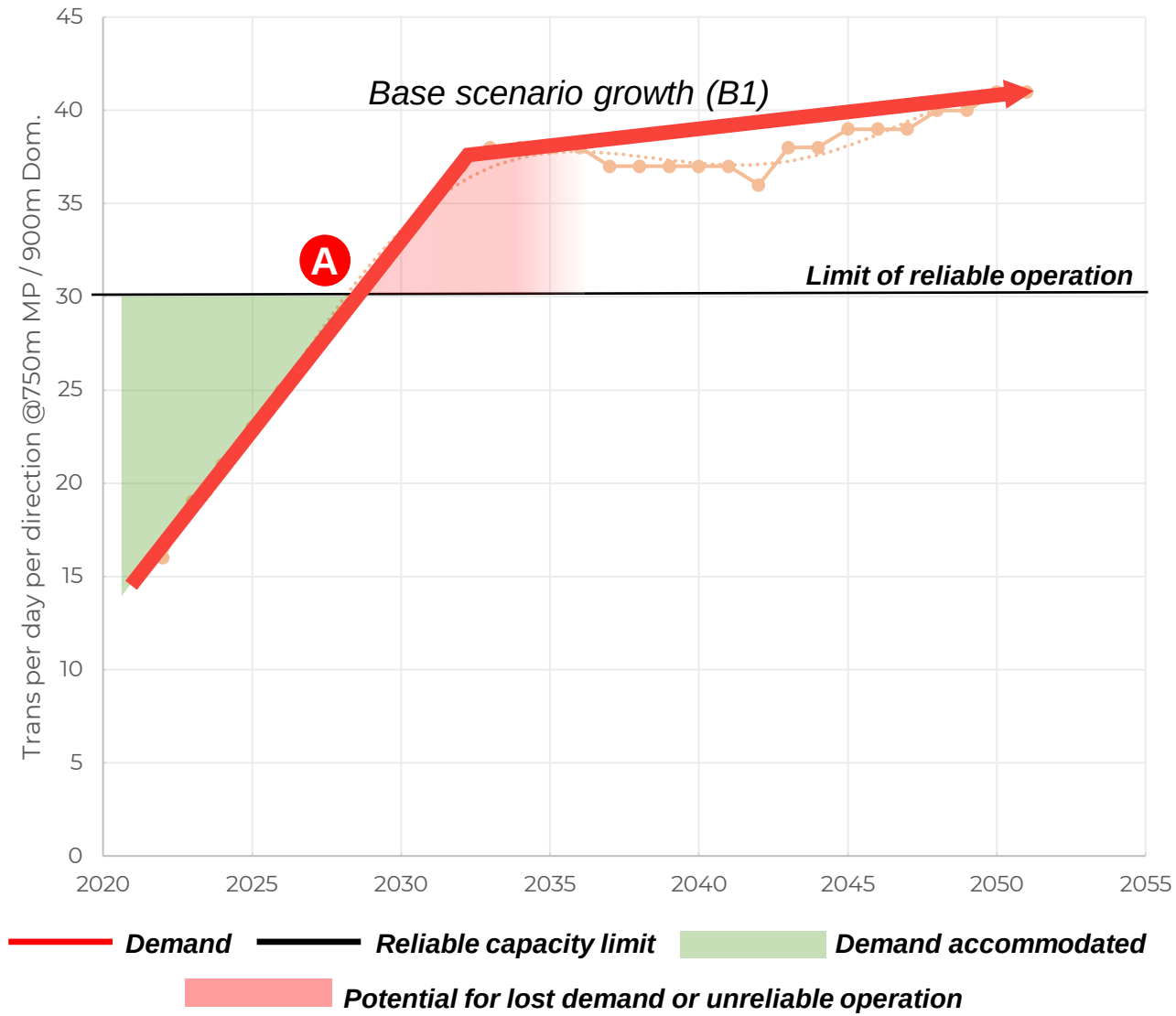


Figure 4E: NIMT Freight volume forecast

Freight growth forecast for the base demand scenario (B1) shows that 37tpd per direction will be required to operate in and out of Auckland from the South by 2032 and up to 80tpd by 2051 (~250% growth)

However, it is expected that practical network capacity is reached at around 30tpd per direction. This limit is reached by around 2028.

The only feasible strategy to accommodate growth beyond this point is to run longer freight trains. For the PBC the assumption has been to plan for a doubling of MP train lengths from 750m to up to 1500m.

As well as providing capacity to support required growth, operational efficiencies will be gained from moving to longer trains sets, which could lead to more competitive pricing and drive more mode shift to rail, further reducing emissions of the supply chain.

Trigger Point A
Limit of reliable freight operation with 750m MP / 900m domestic train lengths is reached by around **2030.**

Resolved by **introduction of longer freight trains into service**

Track capacity requirements

- All market demands considered together along the southern corridor (including interregional which includes Hamilton to Auckland aspirations to move to a 1tph between 2030 – 2040 and 2tph during peak periods by 2051, and northern explorer demands which will continue to consume paths on the network, with growth to 12 trains per week), results in a network timetable that exceeds capacity of the current 3/2-track layout, and signalling system.
- Based on the slides above, the system needs to accommodate the following train volumes by the early 2030s to meet demand

Market	Service improvement required	Required by
Metro	14tph (4 express* + 10 local)	2030 – 2034
Inter Regional	1tph	2030 – 2040
Freight	2tph x 1500m	2030

- Based on planning headway for the existing and future-upgraded signalling system, the entire line between Pukekohe and Wiri Junction** would be operating between104-166% capacity on a 2-track railway***, which is beyond limits of reliable operation, and well beyond the PBC 75% capacity target to allow for future flexibility and accommodate unplanned growth
- Key Conclusion: 4-tracking from Wiri to Pukekohe resolves this capacity issue and creates a more efficient railway operation with long distance / fast metro services segregated from all stops metros across the two pairs of mains

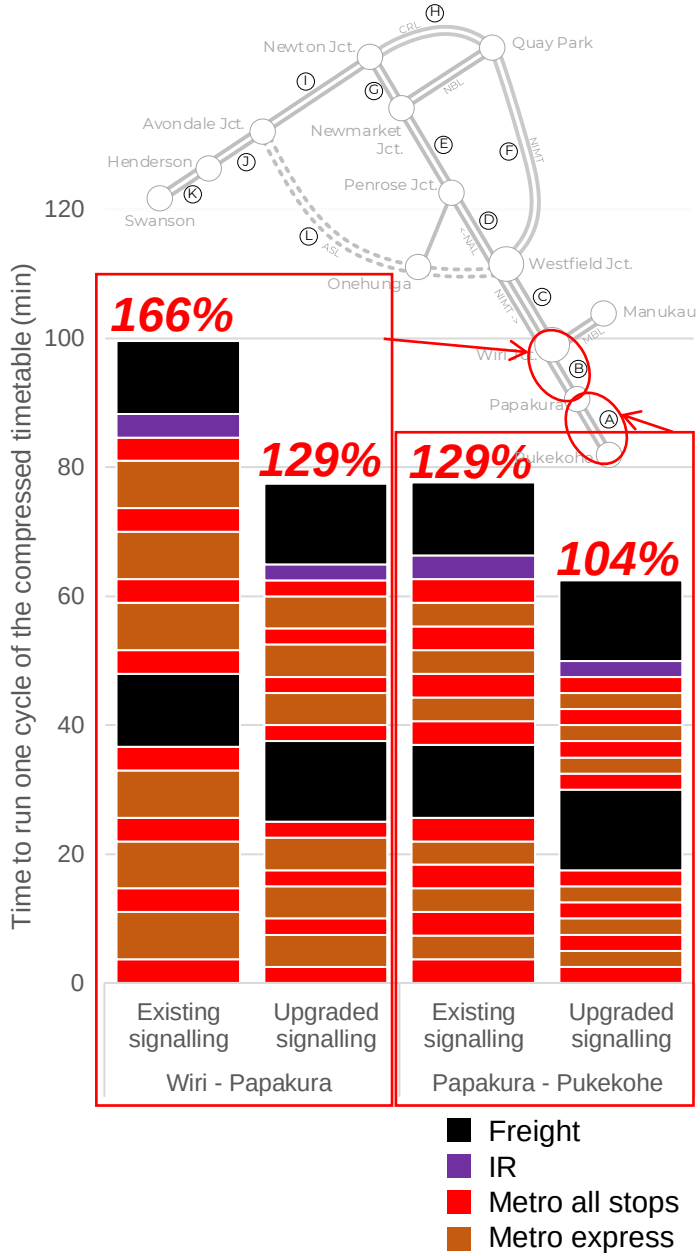


Figure 4F: Track capacity utilisation assessment 54

* Express services consume more capacity between Papakura to Wiri as they skip stations in this area
** The Wiri to Westfield segment of the network also requires upgrading from 3 to 4 mains. It is not shown here for simplicity, however the demands on this areas of the network are even higher as it needs to accommodate an additional 8thp East-west metro services and freight between Auckland Port and Wiri
*** Based on UIC methodology and recommended buffers

Alternatives and sensitivities considered

Pukekohe to Papakura (P2P) 2-track only: Could freight, metro, or inter-regional services be reduced between Pukekohe to Papakura such that a 2-track configuration would be sufficient in this segment?

Reducing track capacity between P2P would result in material trade-offs such as:

- Metro services would need to be reduced in volume south of Papakura resulting imbalanced loading and long-standing times, and need to operate with 15min headway gaps between P2P, creating heavy loading for some trains, with at least 2tph exceeding standing capacity south of Papakura, with knock-on impacts to following trains, or…
- Freight would be restricted to 750m/900m max, meaning that between 5-10 750MP worth of demand per day would be lost from late 2020s onwards (equivalent to between 270 – 540 truck trips each way between Auckland and Tauranga)

Further discussion on this point is provided in Appendix B.

Impact of less than forecast growth at new P2P stations: Does the above conclusion change if southern growth stations have less demand than expected?

A 40% demand reduction at stations between Papakura and Pukekohe was tested as a sensitivity. This reduced crowding levels under a 14tph service to Pukekohe in 2041 but still filled seating capacity by Homai, implying standing times of greater than 15min (30-45min). Furthermore, even with reduced demand, a 2-track P2P would still result in the need for a 15min headway gap in metro services to enable the 1500m freight train.

3 track P2P: Would a 3-track railway be sufficient between P2P to separate freight from passenger services similar to the current W2W 3rd main?

This configuration would create a new bottleneck on the NIMT south of Auckland for long distance services (freight and interregional), requiring single track operation over 18km. Given the high volumes of freight and inter-regional services anticipated, this bottleneck would likely need to be resolved soon after implementing the third main. Furthermore, in comparison to other segments of the southern corridor, P2P is relatively easy to quad track given its greenfield nature.

Note that the relationship between number of tracks and capacity is not linear – an additional 2 tracks will provide many multiples more capacity than a single additional track. E.g. the single track OBL accommodates 3tph while the double track MBL accommodates >16tph. A similar step change would be expected in moving from 2 tracks to 4 tracks.

Finally, the scale of investment and complexity required to add a 3rd main to the corridor would be of a similar magnitude to adding a 3rd and 4th at once, and it would be significantly more costly to retrofit a 4th main at a later date.

Mixed freight train lengths: Could MetroPort be restricted to operate shorter trains during the metro peak period, to reduce the 15min path requirement and thereby make a P2P 2-track corridor acceptable?

Such a trade-off would be operationally complex and economically challenging, likely leading to loss of demand. Freight customers will only choose rail if it is more productive and cost effective than road freight, and the additional costs imposed by more complex operation will compromise rail's ability to compete. Further, this would restrict metro to running a 4tph off-peak service and not meet aspirations of a RTN frequency of 10min or better all day.

Incremental freight train lengthening: Could MetroPort trains be gradually lengthened over time (instead of a step change to 1500m) to reduce track capacity impacts?

Longer trains, even if less than 1500m, would still require wider slots than the current 10min slots for 900m max lengths and would therefore still impact metro services.

Alternatives and sensitivities considered

Furthermore, motive power limits and consist weight are expected to drive step changes in length. 3 locos will be needed for 1 extra wagon over the 2 loco max weight, and all the draw gear will require upgrading by the same logic, to a 1500m design capacity. The return on investment will likely drive maxing the length/weight immediately.

Given the eventual need for 1500m, the high probability that this would be required (or at least highly desired) immediately, and the fact that there is really no way of providing the required capacity upgrades incrementally (as discussed previous with respect to 3-maining vs. 4-minaing), the 1500m target is considered a reasonable starting point.

Phasing of the four tracking: Could the Wiri-Pukekohe four-tracking project be phased in the programme to provide interim benefits?

Phasing of the four-tracking project is important and different phasings will produce interim benefits of varying degrees and to different markets. Generally:

- 4-tracking Wiri to Westfield provides early benefits to freight by eliminating the need for freight only single-track operation and presents an opportunity for additional runtime benefits to limited stops services.
- 4-tracking Wiri to Papakura provides the benefits of Wiri to Westfield 4-tracking plus allows additional Papakura starter metro services to be operated, and provides additional runtime benefits to limited stop services
- 4-tracking Pukekohe to Papakura provides potential benefits to Inter Regional services by providing an opportunity for IR trains to pass freight trains along this 9km segment, which allowing for faster travel times and dedicated slots without compromise to the metro timetable. It also provides a holding track for freight prior to merging with metro services.
- 4-tracking Papakura to Wiri provides additional runtime benefits to limited stop services.

All these factors should be considered as part of the four-tracking project. However, a key finding of the PBC is that these interim phasings a) produce benefits that are minimal in comparison to the benefits released on completion of the full 4-track corridor and b) if pursued without careful consideration and planning, could lead to a delay in the completion of the overall 4-tracking project which is ultimately required to meet demand which would likely result in a worse outcome.

As will be discussed in Section 5, the PBC has therefore taken the view that the best phasing is that which is likely to deliver the entire 4-tracking works in the shortest possible time frame. By treating the southern line 4-tracking as a single project, this gives flexibility in future planning to pursue the most advantageous phasing from the perspective of all markets and gain efficiencies in planning, consenting and construction.

Running longer metro trains: Could fewer metro trains be operated at longer lengths to provide more track capacity for freight and inter regional services?

As will be discussed in future sections, the PBC does plan on running longer 9-car trains for the highest demand services, and future proofing for more services to run at 9-car in the future. However, our programme prioritises improving metro service frequencies first for the following reasons; 1) passenger demand is expected to respond much more to improved frequency than to increased train capacities, so this approach supports the objective to drive mode shift to rail and thereby reduce emissions of the transport network overall, and 2) the investments required to run more metro services are the same investments that are needed to support increased capacity for all markets including freight and inter regional, particularly on the southern corridor. Therefore, the strategy to prioritise more frequent metro services is the best outcome for the network overall.

4.2 Western corridor

Metro demand triggers

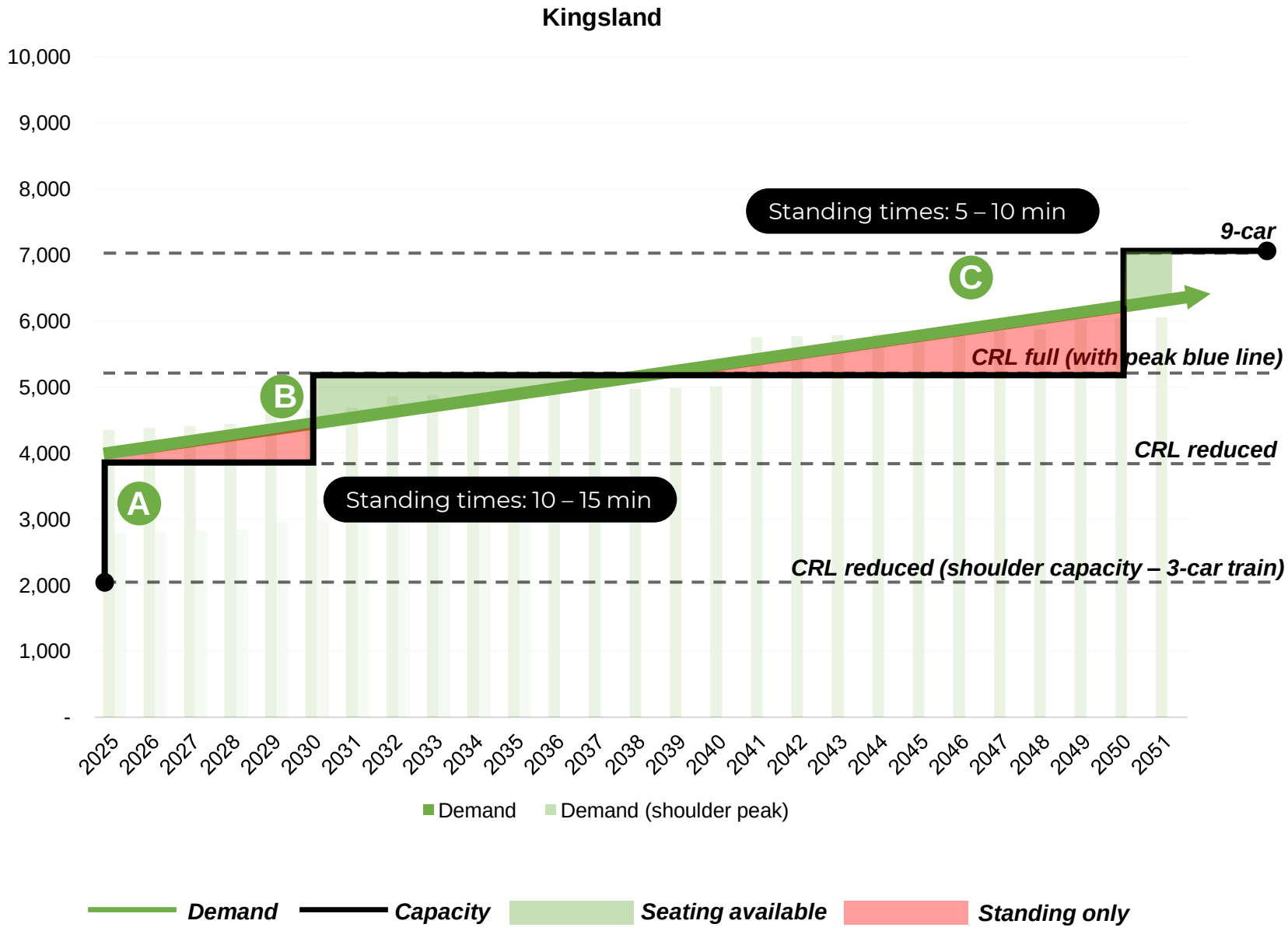


Figure 4G: Western corridor peak load point plot (Kingsland)

Trigger Point A
Shoulder peak demand exceeds capacity of the CRL Day 1 reduced timetable by approx. 2025

Resolved by lengthening of all trains to 6-car*

Trigger Point B
Peak demand exceeds capacity of the CRL Day 1 full timetables between 2028-2032 with standing starting somewhere between Avondale and Baldwin Ave, approx. 10-15 min to the KR'd and 15-20 min to Aotea

Resolved by implementing CRL full timetable with all trains operating at 6-car

Trigger Point C
Peak demand exceeds capacity of CRL Day 1 X 6-car service between 2048-2052 with standing starting somewhere between Avondale and Baldwin Ave, approx. 5-10 min to the KR'd and 10-15min to Aotea*

Resolved by increasing train lengths to 9-car, with a priority on limited stops stations

*Note that implementation of the CRL full timetable is expected to provide some relief to shoulder peak periods also. The order of CRL day 1 full and full 6-car interventions could be swapped and in fact, given the desire for CRL day 1 full to be implemented as early as possible, they are swapped in this iteration of phasing.
** Accounting for expected runtime improvements achieved via TMS, signalling and train control upgrades

Freight demand triggers

Scenario B1 (base case) shows minimal growth over the 30-year time horizon on the NAL (due to scenario assumption). This is unlikely to be realistic but enables us to test a bookend.

The primary constraint to growth in this market are the metro exclusion periods in which high frequency metro operation precludes the reliable operation of freight trains, particularly through Newmarket junction and on the NAL between Newmarket and Westfield junction. These are 2.5hrs per AM and PM periods per direction under the base timetable.

North of Auckland, the NAL could support up to 12 trains per day per direction, however given the constraint of the exclusion periods, and the economic importance of running a cyclic service to Northport, the NAL could accommodate 5-7tph before reaching its practical limits (a marshalling yard north of Auckland (e.g. Huapai or Kumeu) would help to optimise operations to the upper end of this limit)

Based on this, and as illustrated in Figure 4H, under the base demand scenario there is **no demand-based trigger for all-day freight paths on the NAL, however this would not be a resilient finding against all scenarios.**

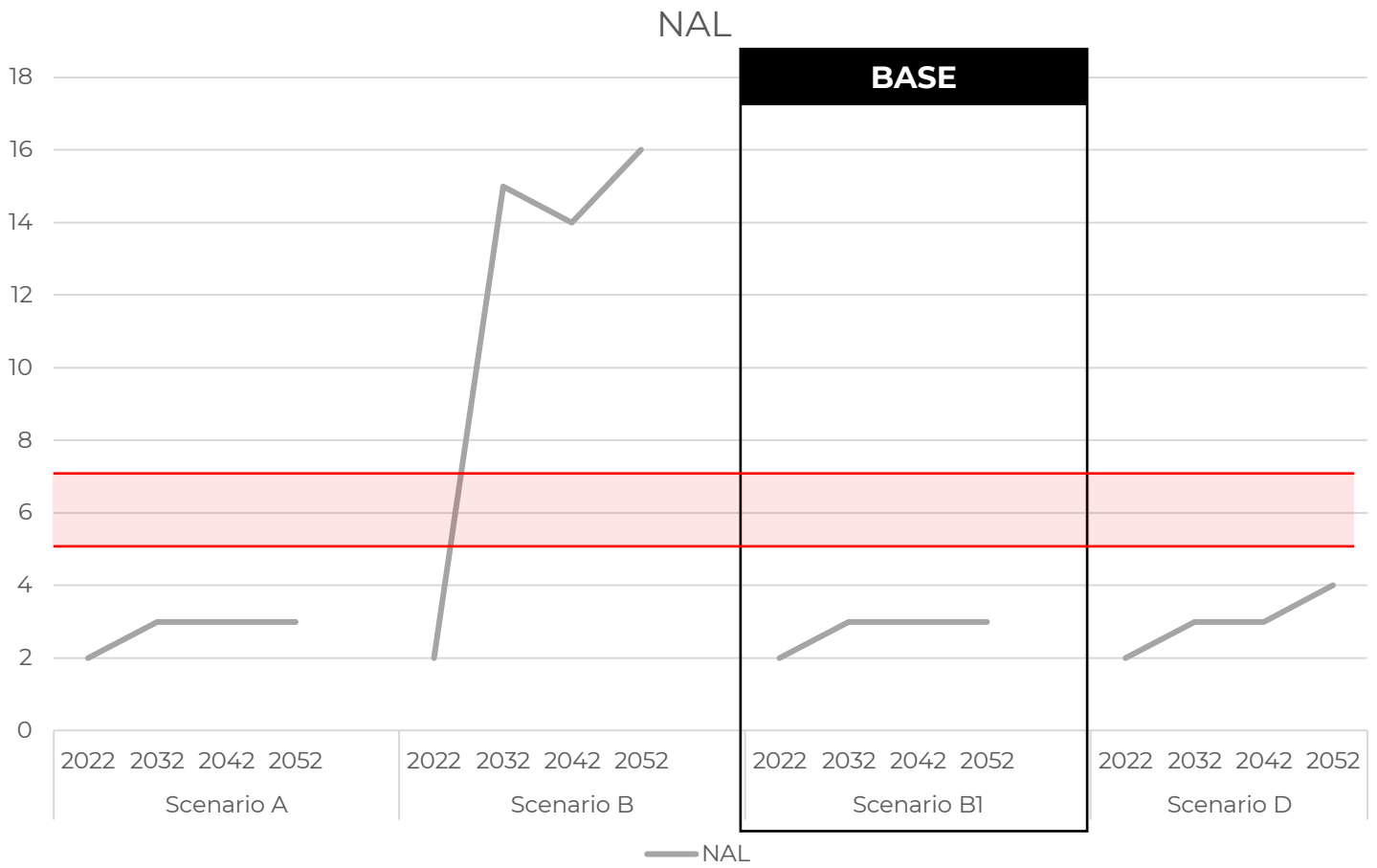


Figure 4H: NAL freight demand vs. capacity plot

4.3 Eastern corridor

Metro demand triggers

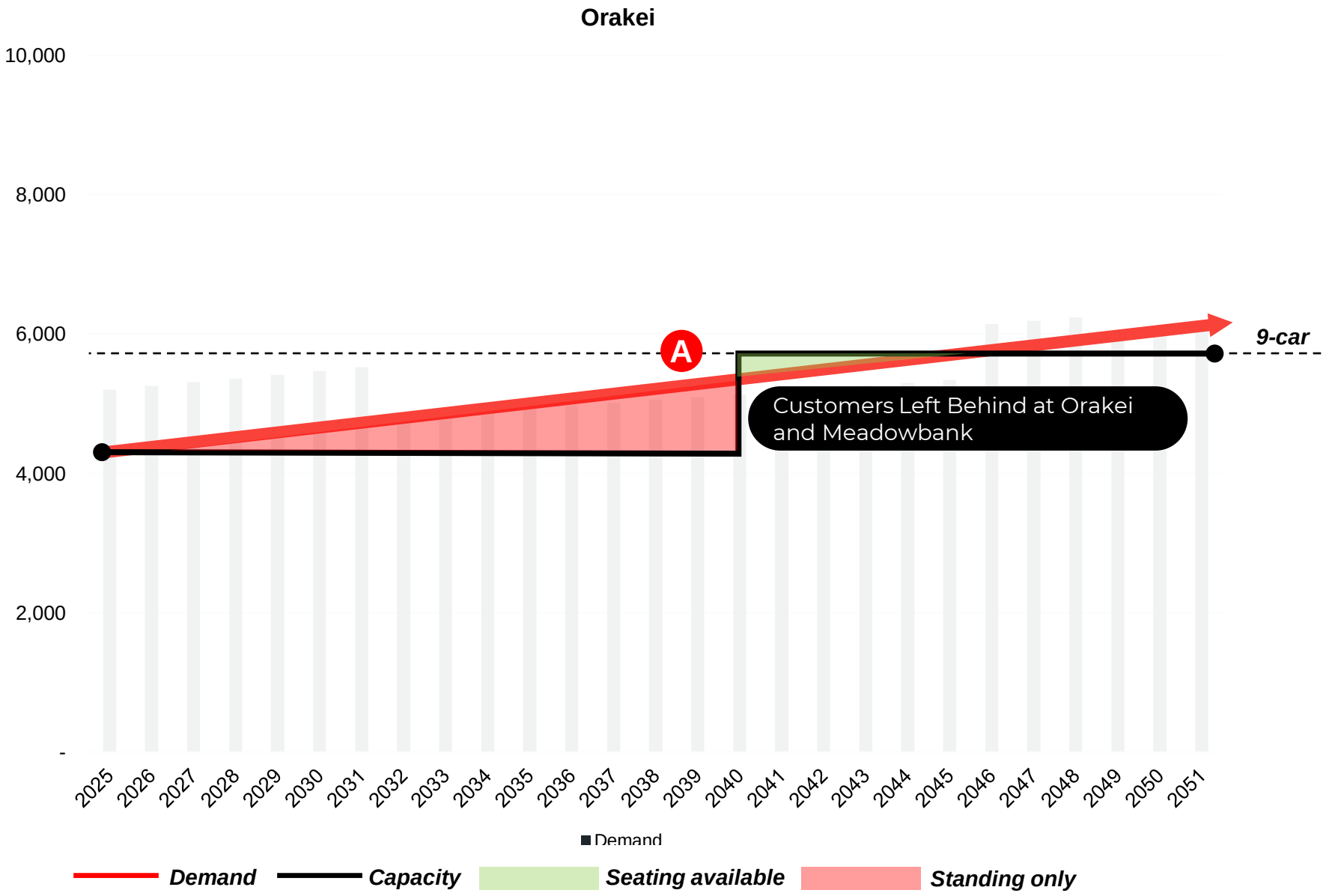


Figure 41: Eastern corridor peak load point plot (Orakei)

Trigger Point A

Uneven headways cause some 50% of trains to leave customers behind at Meadowbank and Orakei stations by 2038 - 2042 under a 6-car service.

Resolved by lengthening of all trains to 9-car

Freight demand triggers

Base demand scenario B1 assumes POAL is capped and therefore there is minimal growth in freight over the 30-year time horizon.

As with the NAL base case scenario, the primary constraint to growth in this market are the metro exclusion periods in which high frequency metro operation precludes the reliable operation of freight trains, particularly through Wiri and Westfield junctions. These are currently ~2hrs per AM and PM periods per direction.

Max growth for the POAL freight line under the restrictions of these freight exclusion periods, and also accounting for expected hours of operation of the port, is expected to be between 6-8 trains per day*.

Based on this, and as illustrated in Figure 4J, under the base scenario there is **no demand-based trigger for all-day freight paths on the eastern corridor.** This is due to the assumption built into Scenario B1 that Ports of Auckland is capped. This may not come to pass and indeed under Scenarios A and D (which are equally credible) there is a clear demand-based trigger date for investment on the eastern corridor.

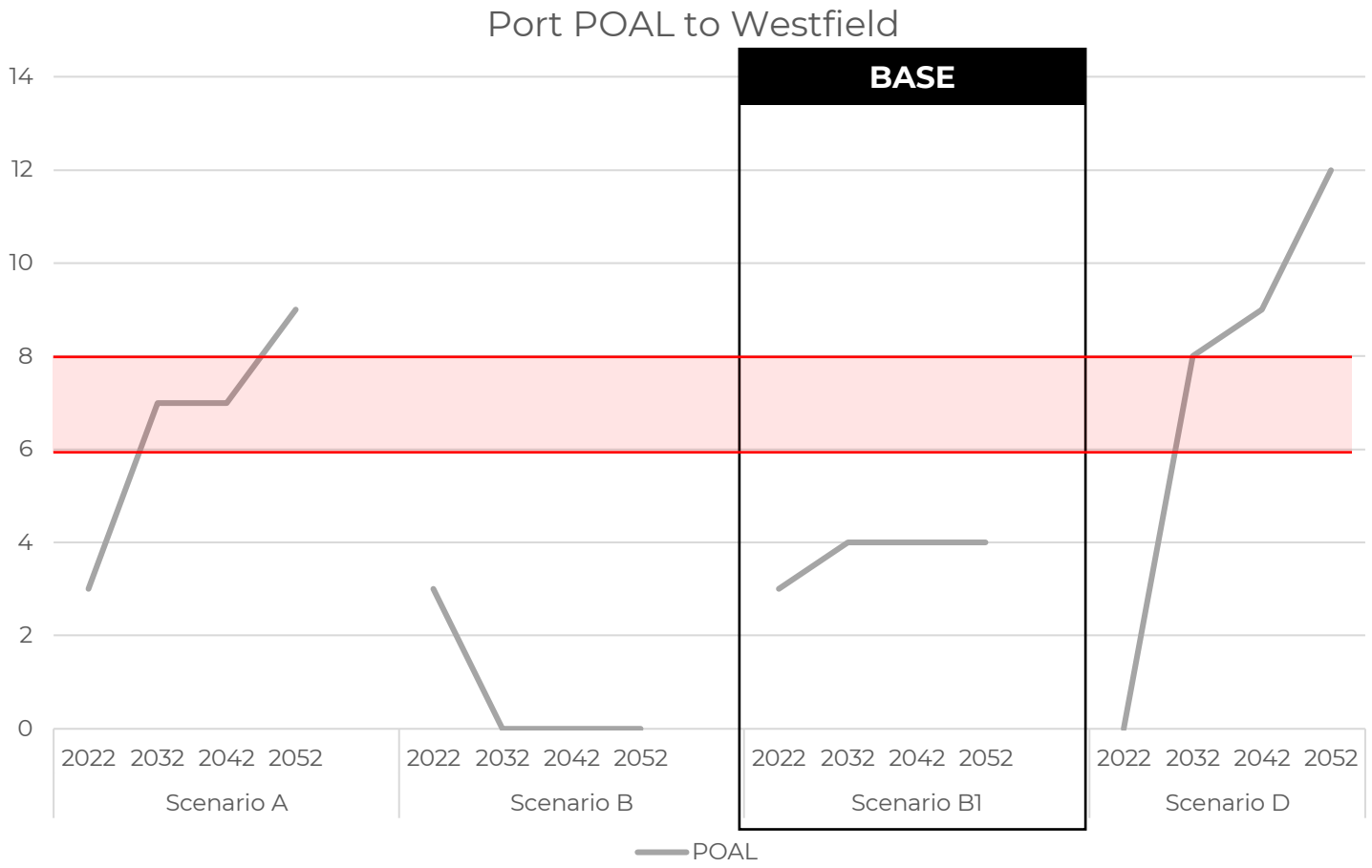


Figure 4J: POAL freight demand vs. capacity plot

*It should be noted that the 6-8 limit has been determined based on a high-level analysis of the distribution of freight demand and presence of exclusion periods and hours of port operation. Detailed timetabling was not undertaken.

4.4 Phasing

Macro Phasing Strategy

The analysis presented above dictates when specific investments need to be made in order meet the demands of all markets operating on the network.

However, as discussed, some elements of the 2051 plan are required to achieve service targets that aren't necessarily demand driven under the base scenario. Specifically, 6-tracking Wiri to Westfield is needed to enable both off-peak frequencies of 10min or better on the East-West line and all-day freight paths between POAL and Wiri; and Avondale-Southdown is required to enable all-day freight paths on the NAL, while also enabling a wider metro peak including all-day express services on the southern line. For these elements, target dates agreed to in previous iterations of phasing have been retained.

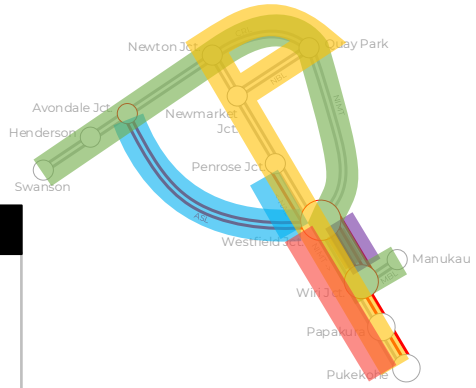
This then results in the macro phasing strategy presented in Table 4B. The feasibility of this depends on when the required infrastructure, systems, and equipment upgrades can actually be completed based on deliverability and fundability constraints considered in Section 6.

Figure 4K provides an alternative visualisation of this strategy.

Table 4B: Macro demand led phasing strategy

Date	Service and infrastructure upgrades
2025	• Address demand growth on the West via introduction of additional peak overlay services (CRL Day 1 full) by early safety mitigations at level crossings on the southern and western lines
2025-2030	• Improve overall network reliability by upgrading signalling and traffic management systems, and improved maintenance access / plant / equipment and outcomes AND address metro capacity issue in shoulder-peak periods via running all trains a 6-car equivalent length by procuring additional fleet (and depot and stabling)
Early 2030s	• Address demand growth on the south for passenger, freight and inter-regional via additional peak metro services and more frequent and longer 1500m MP trains, by 4-tracking Westfield to Pukekohe as quickly as possible (starting from Papakura to Pukekohe)
Late 2030s	• Address further metro growth on the south, east and west via progressive introduction of longer metro trains by extending stations to 9-car
Mid 2040s	• Further improve network reliability, uncap freight capacity between Auckland Port, Wiri, and Southdown, and allow for RTN frequency on the East-West line, by 6-tracking Wiri to Westfield and grade separating Westfield junction (potential for reprioritisation under scenario A and D)
Late 2040s	• Allow metro to widen the southern line peak period, including span of express services, by decanting freight from the inner network and providing potential for capacity between Auckland and Northland by implementing the Avondale-Southdown link (potential for reprioritisation under scenario B)

Demand Led Phasing



Service enhancement		Infrastructure enhancement	
Southern			
Metro • Full 6-car operation • 14tph services to Pukekohe • 9-car operation, South line • RTN frequency • All day express Freight • Longer train lengths introduced in peak Inter-Regional • Increase to 2 paths per peak hour	2025-2030 2030 – 2034 2038 – 2042 Level of service driven Level of service driven 2030 2040 - 2050	• 4 tracking the southern line (including 1500m enablement) • 9-car platform extensions, South line • Avondale – Southdown	Early 2030s Late 2030s Level of service driven (2051 targeted)
Western (including NAL and Avondale – Southdown)			
Metro • CRL full timetable • Full 6-car operation • 9-car operation, East-west line • RTN frequency Freight • All day freight paths	2025 2025 – 2030 2048 – 2052 Level of service driven Level of service driven	• Avondale – Southdown • 9-car platform extensions, East-West line	Level of service driven (2051 targeted) Early 2040s
Eastern (including POAL)			
Metro • 9-car operation, East-west line • RTN frequency Freight • All day freight paths	2038 – 2042 Level of service driven Level of service driven	• Wiri to Westfield Additional Capacity Expansion • 9-car platform extensions, East-West line	Level of service driven (2051 targeted) Early 2040s

Figure 4K: Major service and infrastructure triggers for demand led phasing

Demand-Led Phasing

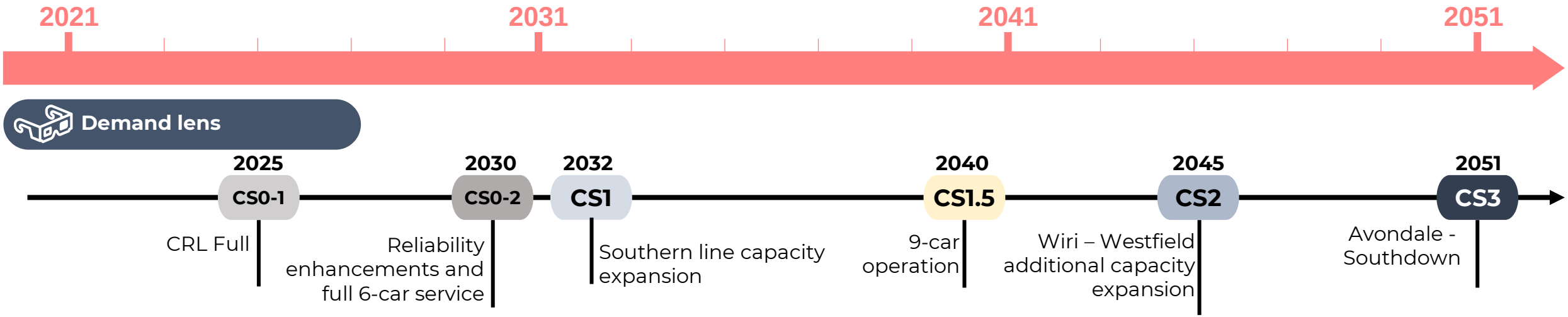


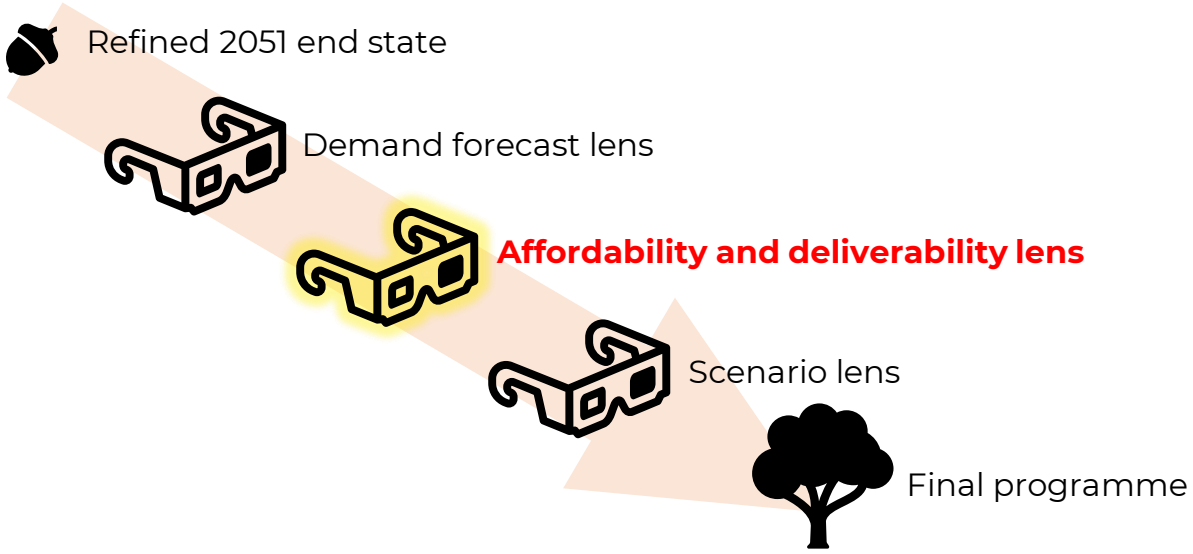
Figure 4L: Demand led phasing

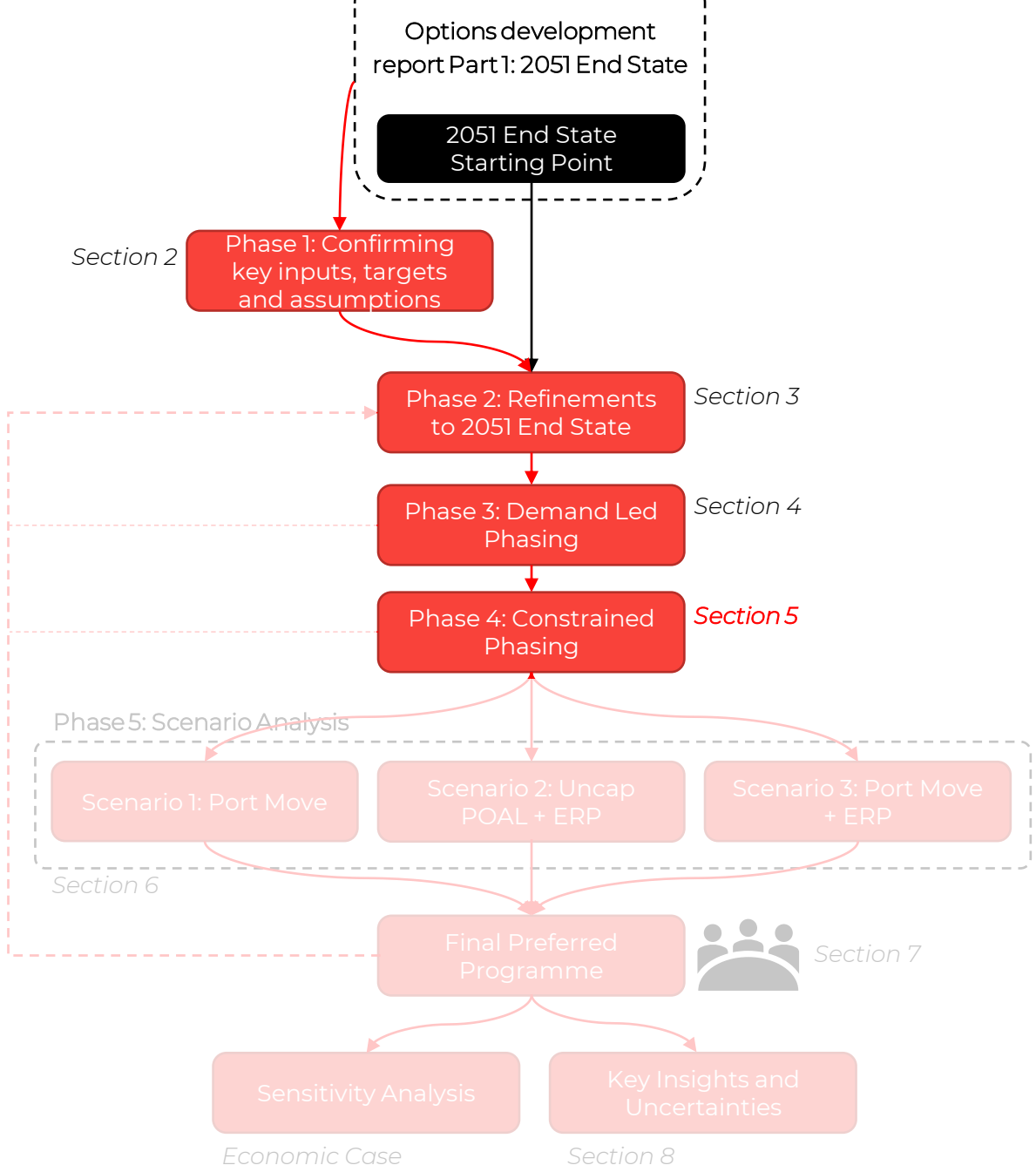
5 | Constrained Phasing

Constrained Phasing

This section describes the second iteration of phasing development which takes into account likely fundability and deliverability constraints. This step acknowledges a critical priority for this Programme Business Case is to produce a fundable programme. Key points:

- Fundability and deliverability considerations are documented in Section 5.1 along with their expected impact on the programme
- The analysis makes clear that, given the long lead times of rail infrastructure and tendency for benefits to be achieved in a step-change fashion – investment is very likely to lag demand across the next 15 – 20 years, particularly on the southern line in the base demand scenario.
- Within this period, access to the network will be constrained and decisions will be required on how best to allocate the available capacity between the markets. The PBC is not the vehicle to make such decisions but can provide information on the book ends of what potential trade-offs may be needed. These are described in Section 5.2.





5.1 Deliverability and fundability considerations

Funding / Deliverability Considerations
Southern Corridor Capacity Expansion

The previous iteration of phasing identified that the Southern Corridor 4-Tracking is required to meet demand by 2032. However, as this is a large brown field infrastructure project (requiring upgrades to nearly 40km of live railway) with a high degree of complexity across all phases, delivery by this date is not realistic.

A detailed conceptual 4-maining construction programme was developed as presented in Figure 5B (on the next page) to determine a realistic delivery timeline. Based on this, and further discussion on likely risks, it was agreed that a date of 2042 would represent both a fundable and deliverable programme, accounting for:

- Actual implementation times achieved for the currently in-construction Wiri-Quay Park 3rd main project
- Planning, consenting, designation and property acquisition times, accounting both for the likelihood of delays during these phases as well as the likely ability to optimise the timeline by overlapping these phases with civil works to some degree.
- An agreed two years of additional contingency

The impact on the configuration state phasing is presented in Figure 5A.

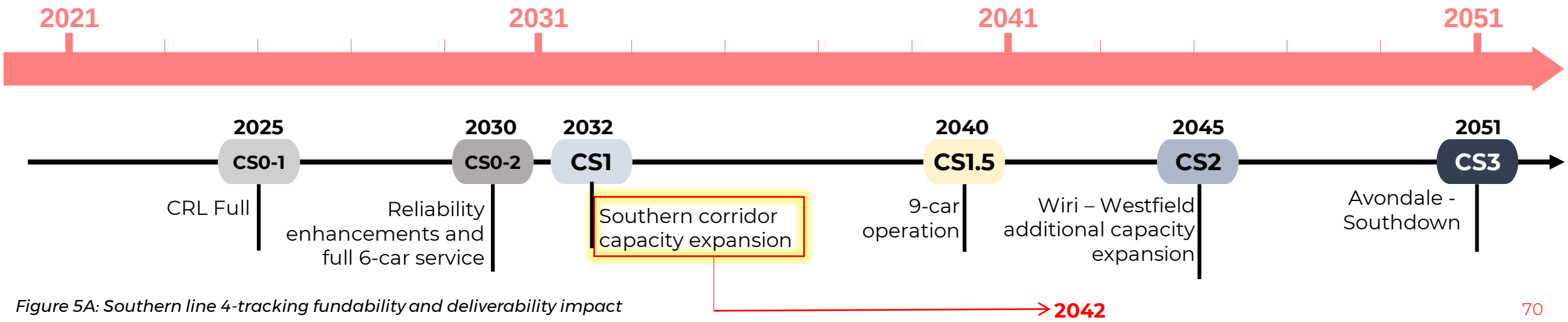


Figure 5A: Southern line 4-tracking fundability and deliverability impact

Southern 4-tracking

Conceptual construction programme

	Comments	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Southern Stabling	Sufficient Stabling to replicate Pukekohe and Papakura Stabling Areas which are lost when 4th Main is implemented																
Buisness Case																	
Design and Consenting																	
Property Purchase																	
Stabling Facility																	
4th Mains																	
Business Case																	
Design and Consenting																	
Pap - Puke																	
Property Purchase P2P																	
Structures P2P																	
Stadium Dr	Road Bridge																
Stadium Dr North	Road Bridge																
Rail Bridges																	
Cape Hill																	
McPherson Rd																	
Ngakoroa Stream																	
Hingaia Stream																	
Stream Rail Br																	
Hays Creek																	
Slippery Creek																	
Level Crossings																	
Grade Separations P2P	3No. Boundary Rd, Opaheke Rd, Crown Rd																
Road Closure P2P	1No. Sutton Rd																
Civil	Excavation, Formation, Drainage, Retaining Walls																
OLE																	
Structures																	
SPS																	
Wire and Register																	
Signals																	
Track																	
Stations 9Car - Below Ground	Paerata, Drury and Drury West																
Stations 9Car - Above Ground	Paerata, Drury and Drury West																
Pukekohe Station																	
Track																	
Station	Cut Back Existing & New Platform																
OLE	Structures, SPS, Wire and Register																
Commission Rail Systems																	
Westfield - Papakura																	
Property Purchase West - Wiri																	
Propery Purchaser Wiri - Pap																	
Level Crossings - Takanini																	
Grade Seperation	3No. Walters Rd, Taka St, Manuroa Rd																
Road Closure	1No. Spartan Rd																
Bridge Widening West - Wiri	5No. Taka St, Railway Lane, Massey Rd, Bridge St, George St																
Bridge Widening Wiri - Pap	2No. Browns and Jutland																
Rail Bridges	1No. Subway Rd																
Civil Works	Excavation, Formation, Drainage, Retaining Walls																
OLE																	
Structures																	
SPS																	
Wire and Register																	
Signals																	
Track																	
Stations 9 Car - Below Ground	Otahuhu, Middlemore, Papatoetoe, Puhinui, Homai, Te Mahia, Takanini																
Stations 9 Car - Above Ground	Otahuhu, Middlemore, Papatoetoe, Puhinui, Homai, Te Mahia, Takanini																
Commission Rail Systems																	
Programme Contingency																	

Southern 4-tracking Conceptual construction programme

	Comments	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Papakura Junction																	
Property Purchase																	
Clevedon Rd Bridge																	
Onslow Bridge																	
Settlement Rd Rail Bridge																	
Track & OLE																	
Northern Junction																	
East																	
Stage 1 Track																	
Stage 1 OLE																	
Stage 1 Civil	Excavation, Formation, Drainage, Retaining Walls																
Island Plaform - 9 Car	Deliver both Below Ground and Above Ground Scope																
Signals																	
Commission																	
West																	
Stage 2 Track																	
Stage 3 Civil	Excavation, Formation, Drainage, Retaining Walls																
Stage 3 OLE																	
Existing Island Plaform - 9Car	Lengthen Existing Plaform																
Signals																	
OLE Wire and Commission																	
Signals																	
Commission																	
Manurewa Station																	
Property																	
Weymouth Rd Bridge																	
Lupton Rd Bridge																	
Bus Interchange																	
Eastern Platform																	
Eastern Civils	Excavation, Formation, Drainage, Retaining Walls																
Eastern OLE																	
Eastern Track																	
Western Platform																	
Western Civils	Excavation, Formation, Drainage, Retaining Walls																
Western OLE																	
Western Track																	
Signals																	
Commissioning																	
Wiri Junction																	
Property Purchase																	
Track and OLE																	
Stage 1 Track																	
Stage 1 OLE																	
Stage 2 Track																	
Stage 2 OLE																	
Stage 3 Track																	
Stage 3 OLE																	
Signals																	
Commissioning																	

Figure 5B: Conceptual construction phasing of the southern corridor 4-tracking programme

Funding / Deliverability Considerations
9-car extensions

Previous phasing assumed 9-car operation would be required to address crowding issues on both the Southern and East-west lines in the early 2040s. However, it was acknowledged that

- With exception of the Eastern line, 9-car service provide significant excess standing capacity under base demands
- The cost and complexity of implementing full 9-car operations over the entire network is high, with a large increase in the number of additional fleet and size of stabling required, plus the need to extend all platforms on the East-West line to 9-car, with some of these stations being high constrained such as New Lynn and Manukau.
- On the Southern line long standing times under 6-car operations may be mitigated in reality by passengers transferring to the eastern line at Puhinui to get a seat, thus the crowding levels may be tolerable on the Southern Line till beyond 2051, though Eastern Line crowding would be exacerbated.

An alternative, lower cost solution was identified to run a peak overlay service between Mt Albert and Glen Innes on the East-west line. An additional 4tph provides the equivalent capacity of a full 9-car 8tph East-west service*, but targeted to the area where capacity is needed and with less infrastructure overhead, the primary infrastructure requirement being the construction of turnback platforms at Mt Albert and Glen Innes.

The basis for selection of the two terminals is as follows:

- **Mt Albert** is selected due to interaction with Avondale-Southdown. When Avondale-Southdown is built, freight will be enabled in the metro peak periods, and 4 additional metro trains per hour will run between Avondale Junction and Henderson. If the Mt Albert to Glen Innes peak overlay service extends west of Mt Albert, then the number of trains during the peak beyond this point would exceed reliable utilisation targets and trigger the need for additional tracks. This is the same logic that results in the blue line services being modified to terminate at Mt Albert in CS3. Anything east of Mt Albert would clearly not be as beneficial from a capacity perspective and demand modelling shows that standing on the Western Line can occur as far out as Baldwin Ave by 2051.
- **Glen Innes:** Demand modelling and network connectivity considerations would ideally have this service terminate at Panmure, however given that the Glen Innes terminal is planned to be eventually used for the Avondale-Southdown service, and that modifying Panmure station to have a turnback track would be complex and costly given its trenched configuration, Glen Innes was seen as preferred. This could be reconsidered in future phases of implementing the programme.

The Mt Albert – Glen Innes peak overlay was adopted as an alternative to full 9-car operation on provision that

- The service does not compromise 10min freight paths on the NIMT-E and NAL, and does not extend freight exclusion periods
- Post implementation of 6-tracking and Avondale Southdown, the service does not compromise all-day access for Port and NAL freight respectively.

Further discussion on these two points in particular is provided in Section 8, Item 7

The impact on the configuration state phasing is presented in Figure 5C (next page)

*Extending from 6-car to 9-car adds 50% capacity which is equivalent to adding 4tph to an 8tph service (also a 50% capacity increase)

Funding / Deliverability Considerations
9-car extensions

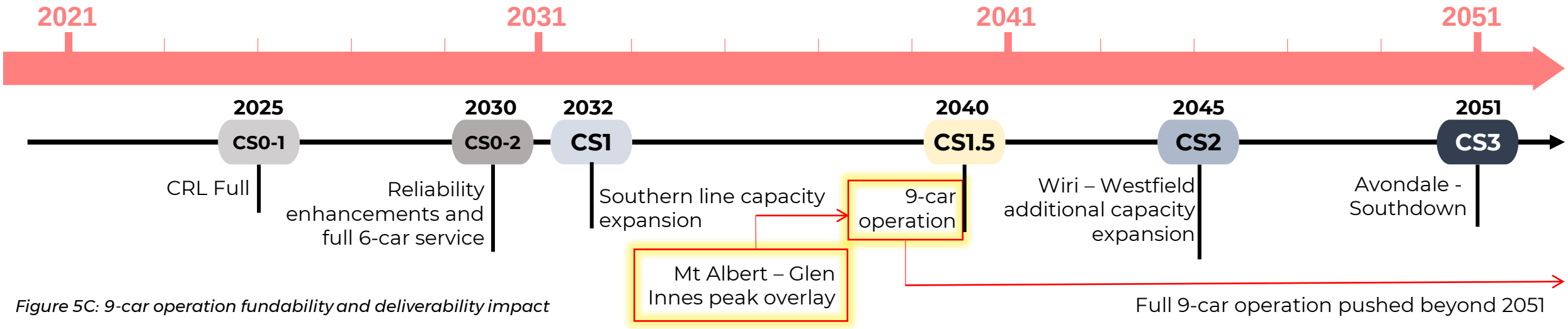


Figure 5C: 9-car operation fundability and deliverability impact

Funding / Deliverability Considerations
CRL Day One Full

Previous phasing assumed implementation of the CRL Day 1 full timetable in 2025 in order to resolve metro shoulder peak demand issues on the Western Line. However, it is noted that the CRL Day 1 full timetable represents a significant increase in train volumes across level crossings on the Western Corridor, with train volumes increasing from 12tph in the reduced timetable to between 16tph (west of Henderson) and 24tph (east of Henderson) under the full timetable.

The estimated percentage increases in barrier down time relative to existing operation of the two versions of the CRL day 1 timetable are presented in Figure 5D on the next page. Note that these numbers should be treated as indicative only – however they clearly reflect the significant increase in train volumes through level crossings between the reduced and full timetables on the Western Corridor.

Given this, it was suggested that a delay between implementation of the reduced and full timetables should be adopted in planning, to allow for initial safety mitigations to be completed first.

Based on work currently underway on the level crossing SSBC, a 'Group 1 - CRL Day One' programme of level crossing removals and mitigations has been defined, which includes the following:

- Closure of the Standalone Pedestrian Crossings and Church Street East.
- Completion of the LCSIA safety improvement work-bank,
- Completion of pedestrian gating programme including Glen Innes (as a high priority).

Group 1 Level Crossings will be removed prior to the opening of CRL. The PBC takes as an assumption that the completion of the Group 1 programme prior to CRL Day One along with a commitment to a broader programme of removals will allow the safety regulator to approve operation of the full timetable. The time between CRL opening (config state 0 reduced timetable) and moving to the full CRL timetable (config state 0.1) is still to be determined so an assumption has been made for the purposes of this PBC that it will be by 2028.

The impact on the configuration state phasing is presented in Figure 5E (next page)

Note that there is some uncertainty about whether the CRL Day 1 Full timetable represents an acceptable outcome for freight as it is expected to increase the peak exclusion period for the NAL freight line. This is particularly important for scenarios of growth on the NAL due to activation of Northport (which as discussed previously, is expected to occur despite not being in the base demand scenario) See Section 8, Item 4 for further detail.

Funding / Deliverability Considerations
CRL Day One Full

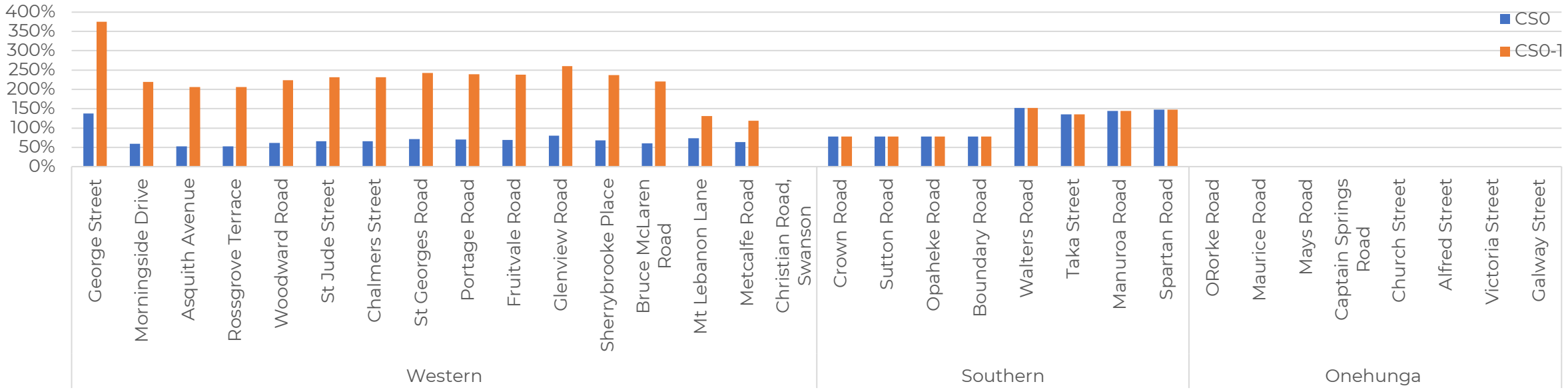


Figure 5D: Estimated % increase in barrier downtime (relative to current operation) at each level crossing between CS0 (reduced) and CS0-1 (full)

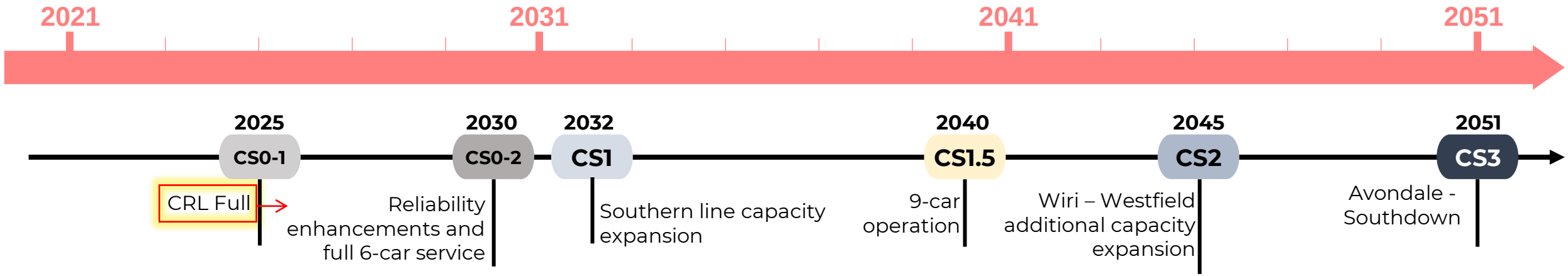


Figure 5E: CRL full fundability and deliverability impact

5.2 Constrained Phasing

Constrained Phasing

With the modifications described above, a new 'Constrained' iteration of the configuration state phasing was produced as illustrated in Figure 5F below and Figure 5G (next page). One further, more minor modification, was to shift the date of CS0-2 from 2030 to 2032 based on further analysis of the likely timing for procurement and delivery of the next tranche of EMUs.

This results in a situation, particularly on the southern corridor, where demand of all markets is expected to exceed capacity for several years. The implications of this are further described in Section 5.3.

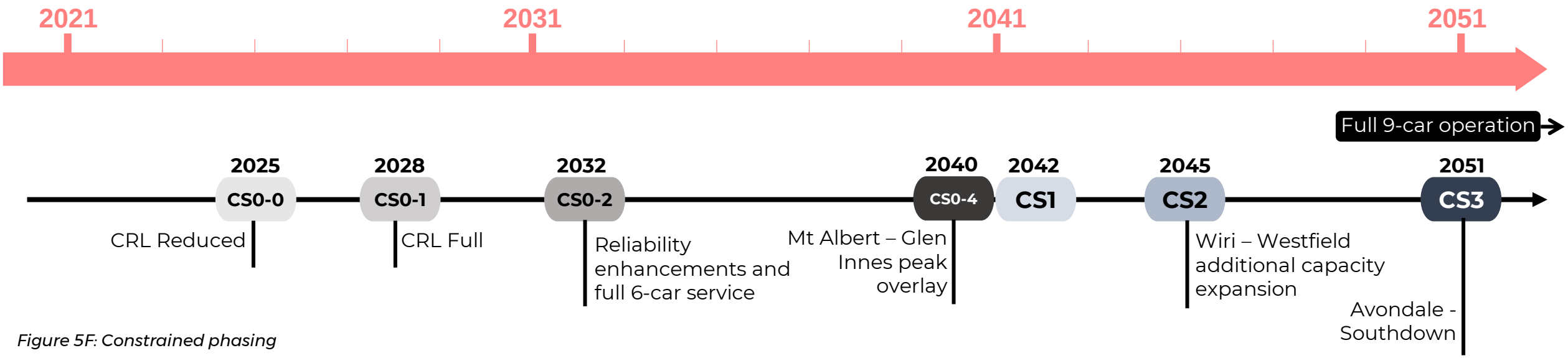
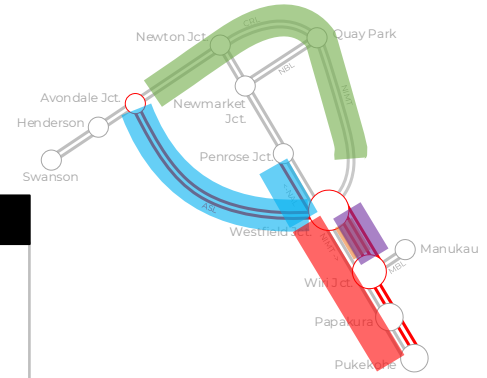


Figure 5F: Constrained phasing

Constrained Phasing



Service enhancement		Infrastructure enhancement	
Southern			
Metro		• 4 tracking the southern line (including 1500m enablement)	**2042**
• Full 6-car operation	2025-2030	• ~~9-car platform extensions, South line~~	**Beyond 2051**
• 14tph services to Pukekohe	2030 – 2034	• Avondale – Southdown	Level of service driven (2051 targeted)
• ~~9-car operation, South line~~	**Beyond 2051**		
• RTN frequency	Level of service driven		
• All day express	Level of service driven		
Freight			
• Longer train lengths introduced in peak	2030		
Inter-Regional			
• Increase to 2 paths per peak hour	2040 - 2050		
Western (including NAL and Avondale – Southdown)			
Metro		• Avondale – Southdown	Level of service driven (2051 targeted)
• CRL full timetable	**2028**	• **Mt Albert, Glen Innes turnbacks**	Early 2040s
• Full 6-car operation	2025 – 2030		
• **Mt Albert – Glen Innes peak overlay**	2048 – 2052		
• RTN frequency	Level of service driven		
Freight			
• All day freight paths	Level of service driven		
Eastern (including POAL)			
Metro		• Wiri to Westfield Additional Capacity Expansion	Level of service driven (2051 targeted)
• **Mt Albert – Glen Innes peak overlay**	2038 – 2042	• **Mt Albert, Glen Innes turnbacks**	Early 2040s
• RTN frequency	Level of service driven		
Freight			
• All day freight paths	Level of service driven		

Figure 5G: Major service and infrastructure triggers for constrained phasing

5.3 Potential Compromises

Service Compromises

The phasing iteration presented above results in the four-tracking project being delivered in 2042 while it is required by demand in the early 2030s. This will result in a roughly 10-year period of constrained access where service compromises will be required across all markets. Operation of the network during this time period will be determined based on future negotiation and coordination between operators, and different decisions could be taken to prioritize certain markets over others.

To provide an assessment of the range of potential trade-offs, three scenarios were analysed

- Scenario 1: Freight growth prioritisation
- Scenario 2: Metro growth prioritisation
- Scenario 3: Potential balanced approach

While inter regional prioritisation is not considered in a specific scenario, trade-offs between inter regional and other markets are discussed in each scenario as sub-scenarios.

It must be noted all these scenarios (particularly 1 and 2), are meant to illustrate the range of potential impacts on all markets. The reality will be somewhere in between, and several optimisations may be pursued in future phases of implementing the programme which will be discussed later.

Based on the operational analysis presented in this section, an economic assessment of the bookend scenarios (Scenario 1 and 2) has been provided in the Economic Case.

5.3.1 Trade-off Scenario 1: Freight growth prioritization

Service Compromises
Scenario 1: Freight growth prioritization

Under this scenario, 1500m trains would be accommodated in the network timetable starting around 2030 as required by demand, while the southern line is still (at least partially) a two-track configuration

Based on likely headway patterns*, the minimal impact of this would be to remove two Papakura starters per hour during peak periods (relative to the day 1 timetable) and restrict metro from further growth beyond this service until the implementation of 4-tracking in 2042.

As illustrated in Figures 5I and 5J on the next slide, this timetable would allow freight growth on the NIMT under all scenarios to be accommodated, while metro services would experience the following capacity issues

- ***Seating*** capacity reached at Homai by 2028
- ***Long standing times*** from Takani by 2032 (est. 37min to city centre) and Drury by 2041 (est. 45min to city centre).
- ***Standing*** capacity reached by 2037 with passengers expected to be ***left behind*** at Homai beyond this point.

These train loading issues are worsened by the need to run 2x15min headway gaps to accommodate wider freight paths. This will result in train loading imbalance where some trains have much heavier loading resulting in passengers being left behind and an unreliable network operation. Shoulder peak issues would also worsen between 2025 and 2032 (prior to the expanded fleet)

Additional compromises would be required under this scenario between Metro and Inter Regional to accommodate IR growth (i.e. the potential removal of 1 further metro slot)

Note: Headway patterns are indicative only. Particularly with respect to placement of inter-regional services relative to metro and freight paths

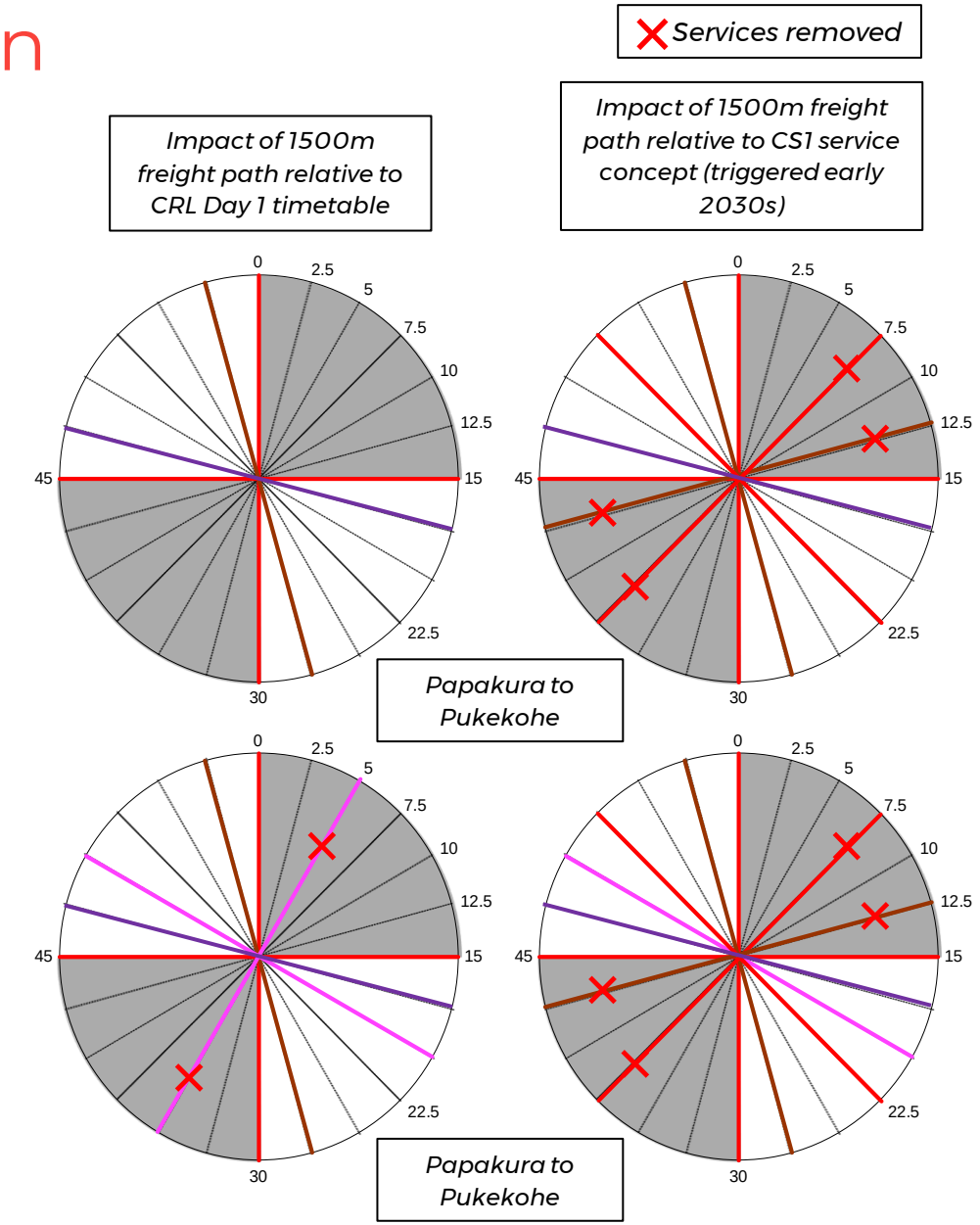


Figure 5H: Expected impact of 1500m freight paths on a two-track railway

Service compromises
Scenario 1: Freight growth prioritization

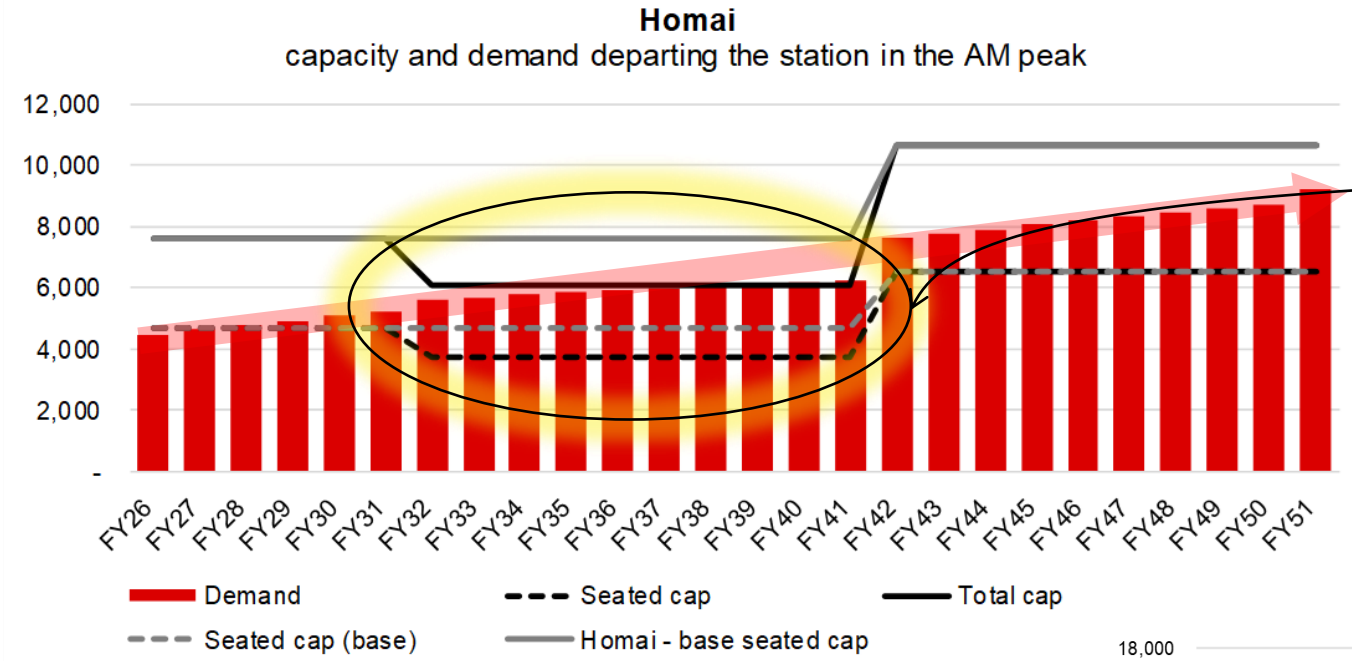


Figure 5I: Peak load point plot – southern line 2-track freight prioritisation scenario

High levels of crowding, long standing times, and passengers being left behind at platforms, due to removal of peak period trains starting at Papakura can be seen in the plots below.

Notice in the peak load point plot that demand (red bars) exceed seating capacity (back dotted line) significantly in 2032 and reaches total capacity (black solid line) around 2037.

In the line load plot, notice that the 2041 demand (grey bars) exceeds seating capacity (grey dotted line) at Drury with an estimated travel time of 45min to Newmarket and 60min to Aotea*. The 2051 demand exceeds total capacity (great solid line) at Puhinui.

Degraded service levels poses a risk of passenger demand / mode shift potential being lost

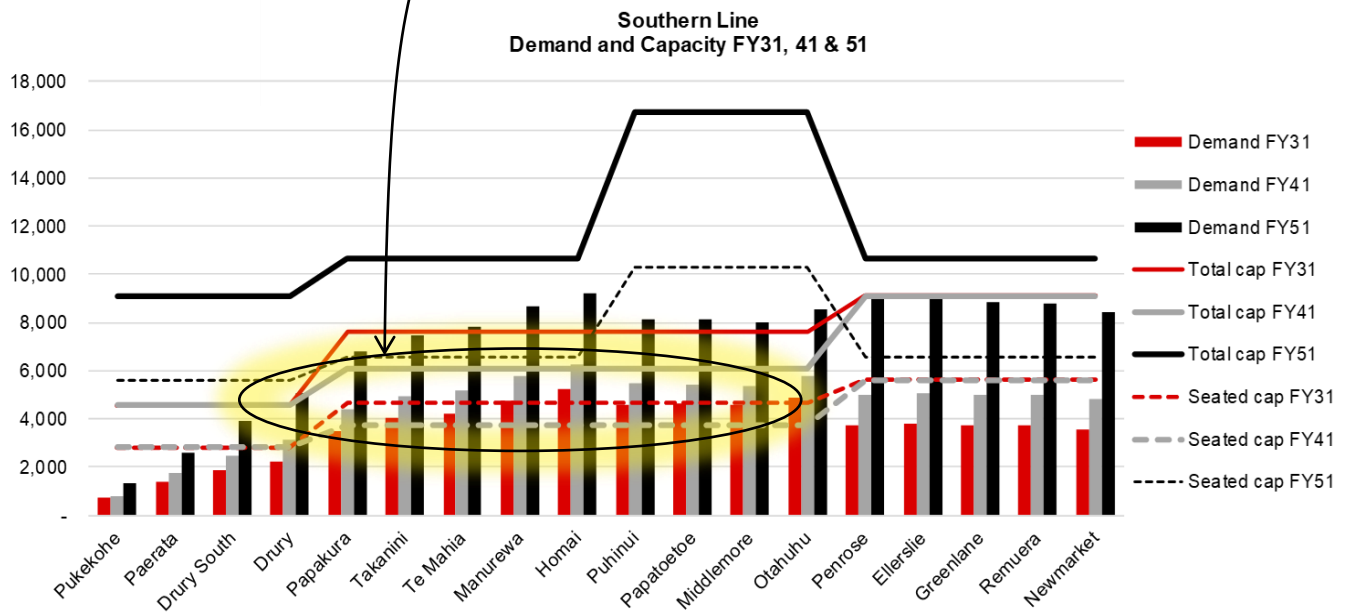


Figure 5J: Line load plot – southern corridor 2-track freight prioritisation scenario

Comparing the 2041 capacity to the 2031 demand indicates that standing is likely to extend back to Takanini by 2032 (when metro services are assumed to be cancelled to accommodate freight) with an estimated travel time of 37min to Newmarket and 51min to Aotea. The 2051 demand exceeds total capacity (great solid line) at Puhinui*.

*Runtimes based on CRL Day 1 timetable. Some improvements to this would be expected based on signalling and reliability enhancements delivered in the early phase of the programme.

5.3.2 Trade-off Scenario 1: Metro growth prioritization

Service compromises
Scenario 2: Metro growth prioritisation

Under this scenario, the full 14tph metro service to Pukekohe is operated by ~2030 as required by demand, while the southern line is still (at least partially) a two-track configuration

Capacity analysis undertaken to date indicates that, even with an enhanced signalling system capable of 2.5min metro headways, this would result in a utilisation of 104% between Pukekohe and Wiri

For the sake of this scenario, this would have the effect of:
- Reducing the number of freight slots available in the peak period from 2 to 1 (750m/900m: 10min slot)*, or
- In the worst case creating a freight exclusion period during metro peaks

The removal of 1-2 paths per hour for each of the 2hr AM and PM peaks (4hrs total) would reduce the upper limit of reliable operation from 30 to between 22-26 trains per day per direction (30 - 4hrs x [1 or 2] slots)

This results in:
- Metro demand being accommodated at acceptable level of service till ~2040 when the next intervention would potentially be required to avoid long standing times on the Southern Line
- As illustrated in Figure 5K, freight loss of potential freight demand of between approx. 12-16 x 750m trains worth of demand per direction per day

---

* There would be a significant reliability risk with only provisioning one freight path in the Auckland network per hour given the high likelihood of long-distance services arriving late onto the network. By current access rules, trains delayed for more than 30min would need to be dispatched into the network regardless of whether a timetabled slot exists. This is why two sub-scenarios are considered here.

Service compromises
Scenario 2: Metro growth prioritisation

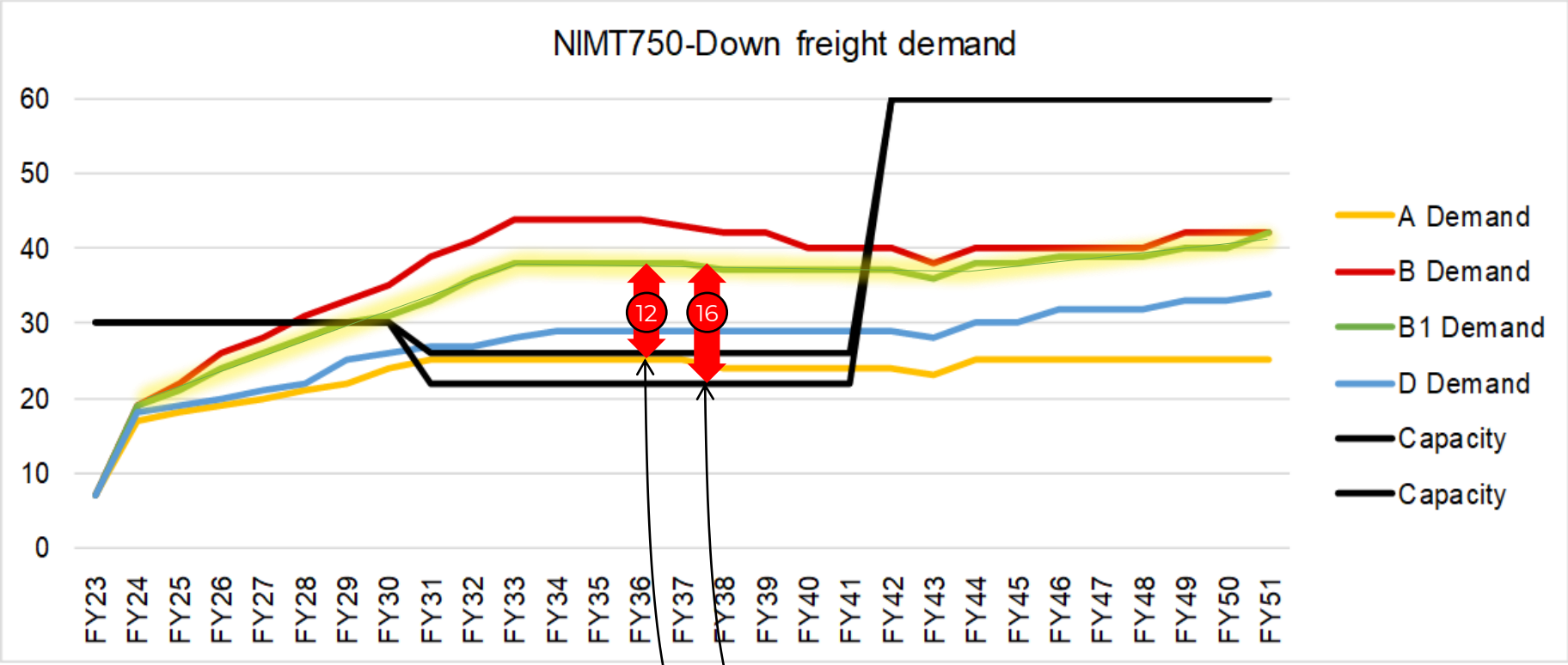


Figure 5K: Freight demand vs. capacity plot

Between 12-16 x 750m/900m trains worth of freight demand per day per direction due to removal of peak period freight slots

Note the delta between Scenario B1 demand (green solid line) and the two capacity lines in black (one representing the removal of 1 freight path per hour and the other representing the removal of 2 freight paths per hour), represents the potential loss of 12 – 16 x 750m trains worth of demand.

5.3.3 Trade-off Scenario 3: Potential balanced approach

Service compromises
Scenario 3: Potential balanced approach

Under this scenario, no metro frequency increases beyond CRL Day 1 timetable are implemented until the completion of southern corridor 4-tracking in 2042, and the introduction of 1500m freight trains is also delayed until 2042.

This results in the following impacts to metro (see Figure 5M, and Figure 5N) and freight (see Figure 5L):

- Metro
    - ***Seating*** capacity reached at Homai by 2026
    - ***Long standing times*** from Homai by ~2035 (est. 37min to city centre), extending to Takanini by 2041 (est. 44min to city centre)
- Freight
    - Results in a loss of forecast freight demand equivalent to 8 trains per day per direction (which will be forced to travel by road at higher costs and emissions)

Again, it should be noted that the estimated metro impacts are based on average loadings whereas variation in headways, difference in demand for express vs. local services, and reduced capacity in the peak shoulders would exacerbate these issues for some trains.

The PBC does not make decisions or recommendations on how the network should be operated during the period of constrained capacity on the southern corridor but adopts an **illustrative** service concept that represents what is believed to be a balanced set of compromises for the purpose of informing required infrastructure investments over the 30-year period and assessing benefits.

Scenario 3 has been adopted, however various optimisations should be pursued in future phases of implementing the programme to produce an optimal outcome during a period of sub-optimal infrastructure. For example:

- Early introduction of 9-car trains for limited stop services (even if not all platforms are fully 9-car capable – selective door opening could be employed as an interim solution)
- Compromise on headway homogeneity (and turn-up-and-go style services) to provide greater overall capacity. In other words, a non-uniform timetable could be used to allow more metro services to be operated while maintaining sufficient freight slots
- Running a mix of 1500m and 750m freight trains with 1500m freight trains restricted outside of metro peak periods
- Shorting of peaks or establishing a 1hr high peak period in order to minimise impacts on freight flows

Service compromises
Scenario 3: Potential balanced approach

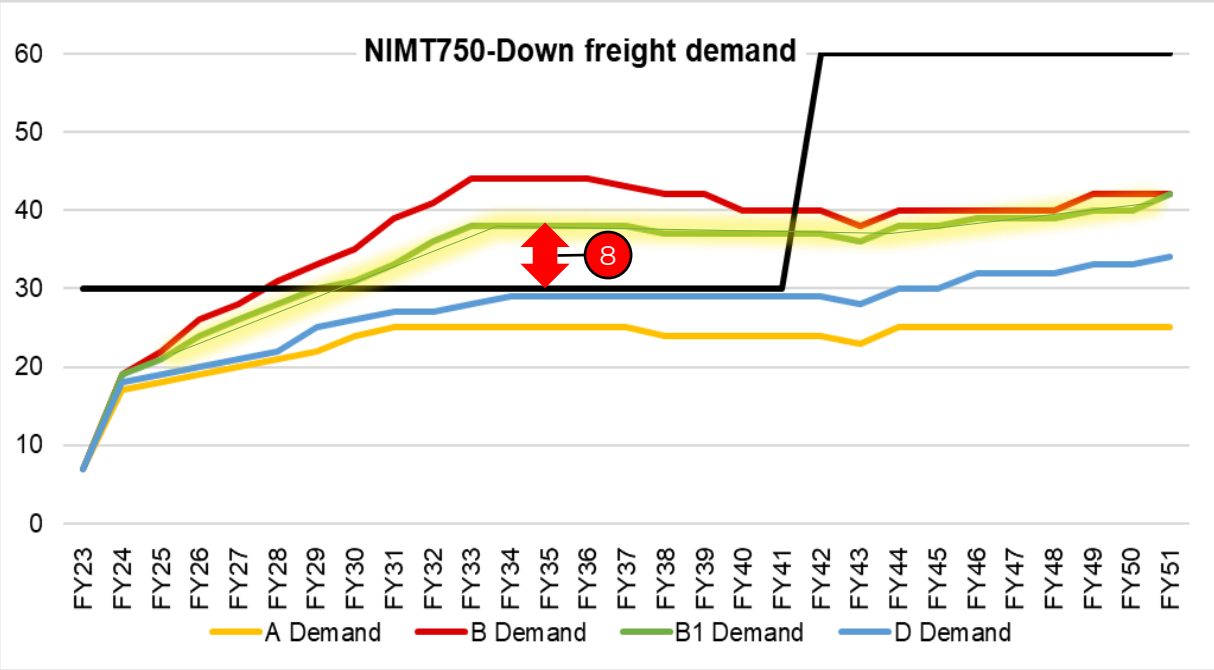


Figure 5L: Freight demand vs. capacity plot - southern corridor 2-track balanced scenario

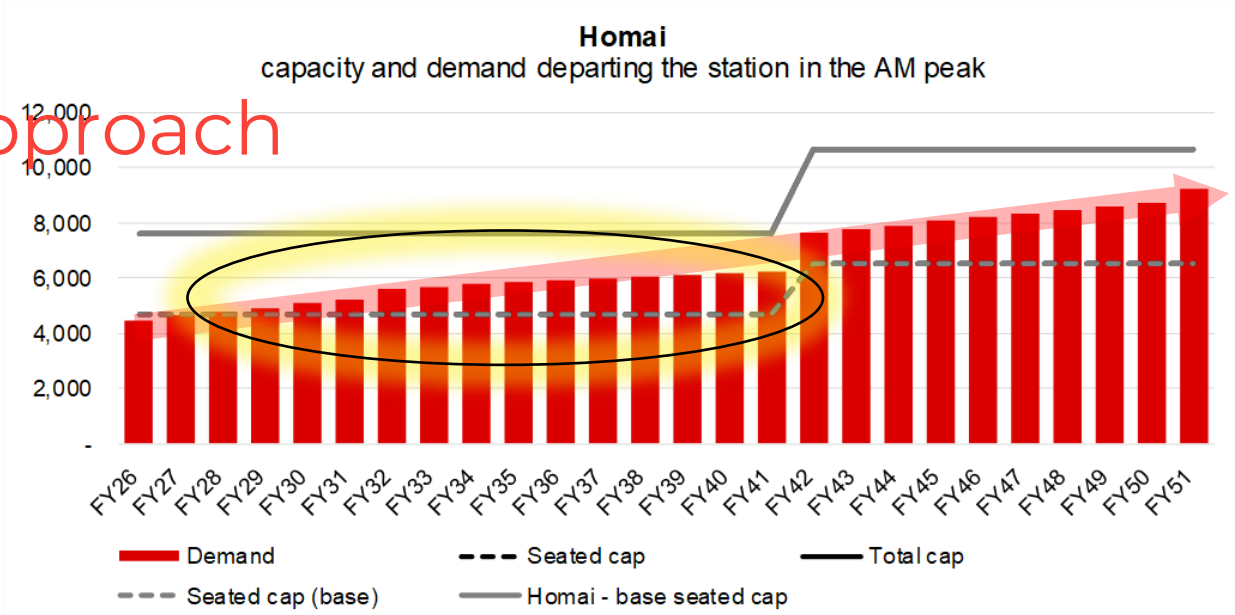


Figure 5M: Peak load point plot - southern corridor 2-track balanced scenario

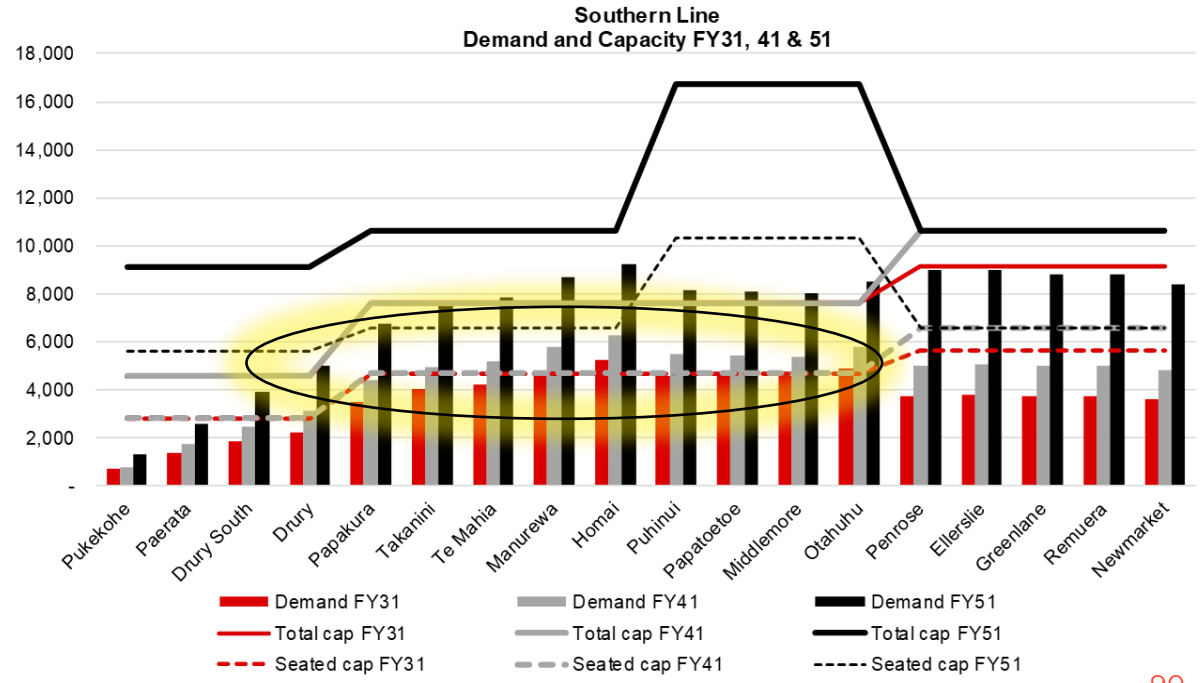


Figure 5N: Line load point plot - southern corridor 2-track balanced scenario

5.3.4 Summary and Conclusions

Summary and Conclusions

Table 6A: Summary of scenario impacts, illustrating theoretical service trade-offs

Scenario	Freight impacts	Metro impacts	Inter regional impacts
Scenario 1: Freight growth prioritisation	Forecast demand met	***Seating*** capacity reached at Homai by 2028 ***Standing*** capacity reached at Homai by 2037, with ***long standing times*** from Papakura (~47min) Passengers ***left behind*** between 2037 and 2042	No impact assumed – however metro impacts may be mitigated via trade-offs with IR.
Scenario 2: Metro growth prioritisation	12-16 x 750m trains worth of demand per direction per day	Forecast demand met	No impact assumed – however freight impacts may be mitigated via trade-offs with IR.
Scenario 3: Potential balanced approach	8 x 750m trains worth of demand per direction per day	***Seating*** capacity reached at Homai by 2028 ***Long standing times*** from Homai by ~2035 (~ 37min), extending to Takanini by 2041 (~44min)	No impact assumed – however both freight and metro impacts may be mitigated via trade-offs with IR.

Table 6A provides an overview of the results of the analysis. Note that passenger impacts are based on average loading. Actual impacts will be better or worse for different trains depending on headway patterns, demand differences between local and limited stop trains, and time within the peak period.

The analysis presented in this section highlights the criticality of the 4-tracking project to the Auckland Rail network. There is no service solution that can resolve satisfactorily the needs of all markets, even with the optimisations mentioned in Section 5.3.3, and the compromises required without this infrastructure may significantly limit the attractiveness of heavy rail and its ability to support required levels of mode shift to meet emissions reductions targets, if not urgently progressed.

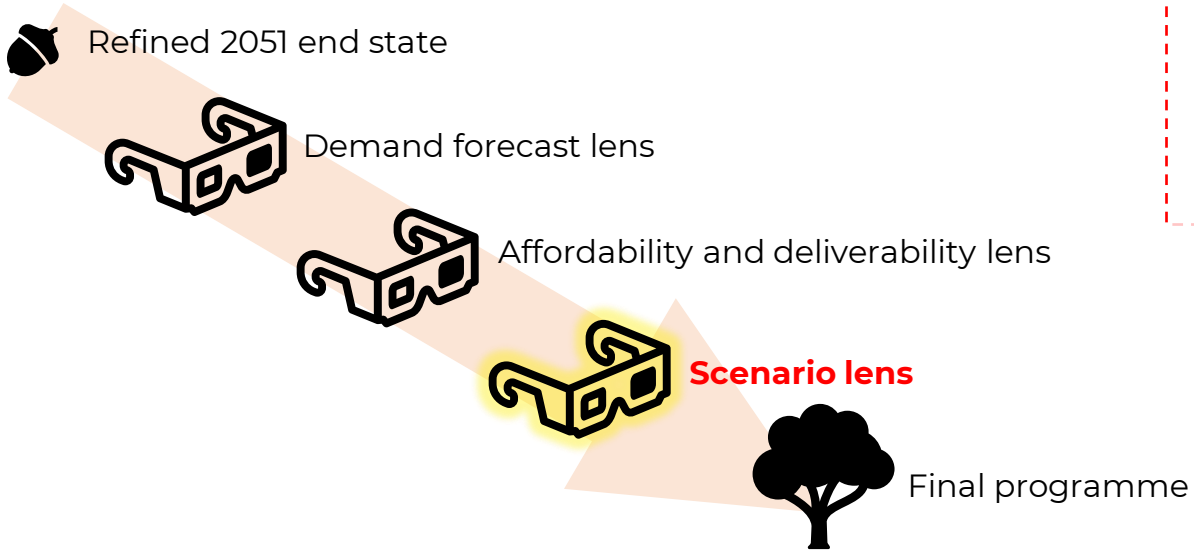
Beyond the four-tracking project, the other elements of the programme become critical, reinforcing the fact that Ciii is an appropriate long-term solution for the network, as opposed to the minimum investment option Ai which ends at the completion of the four tracking.

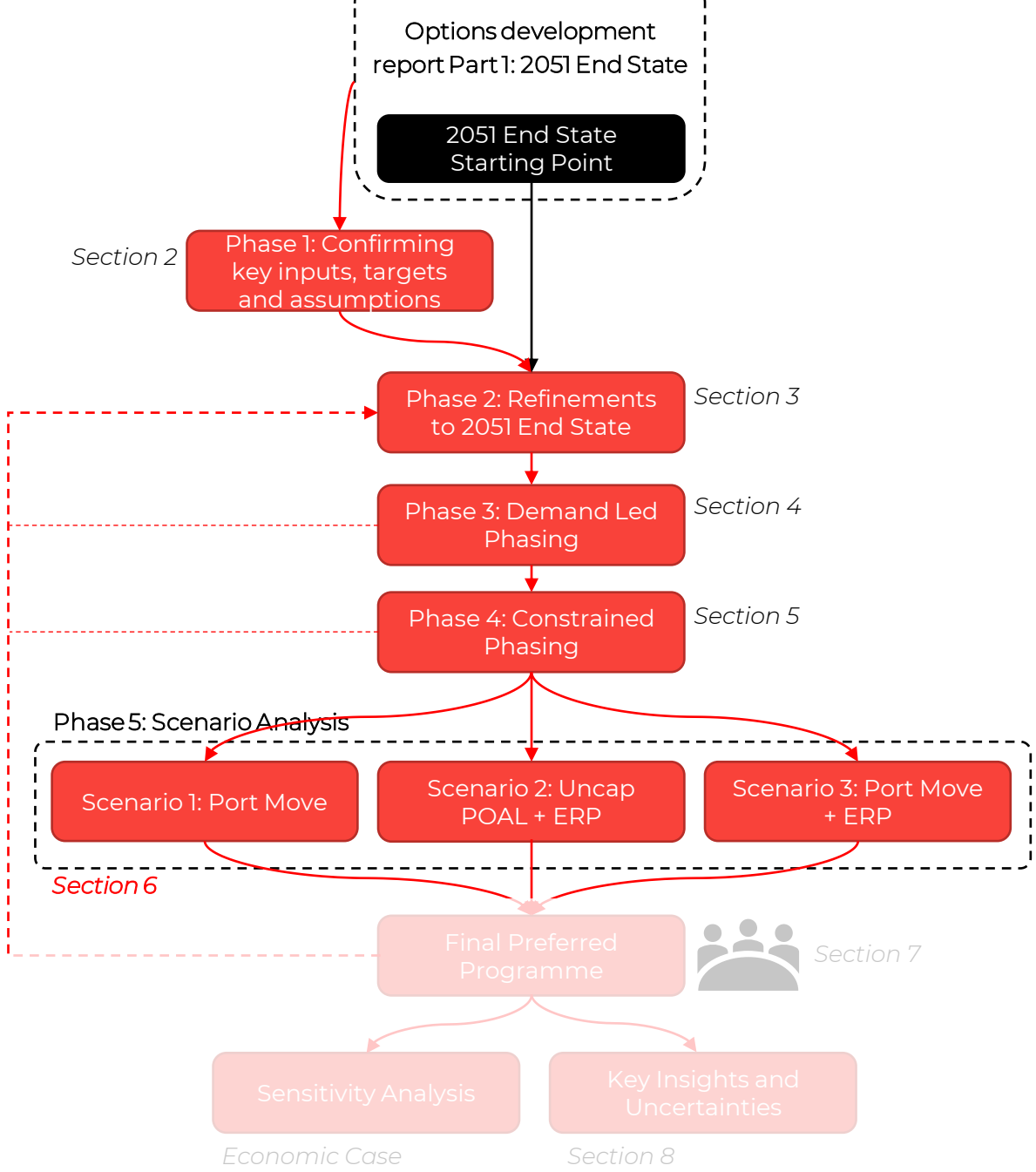
6 | Scenario Analysis

Scenario Analysis

This section describes the final iteration of phasing development which considers the impact of various scenarios on Iteration 3 developed in the previous phase. This step acknowledges that the future is uncertain and particularly in the case of freight, highly dependent on exogenous factors that a 30-year investment plan for rail must be resilient to. Key points:

- Three scenarios are considered as defined in Section 6, S1 Port Move, S2 Uncap POAL + ERP, and S3 Port Move + ERP
- For each scenario, analysis follows a similar approach to previous phases, with the demands on southern, eastern and western corridors assessed over the three markets. This leads to a revised set of demand triggers and therefore a revised set of infrastructure triggers for each scenario.
- The analysis also identifies additional infrastructure that is required under some scenarios or removes the need for certain infrastructure elements under others.
- Based on the likely impacts of each scenario, a final set of refinements is suggested to the base programme





6.1 SC1: Port Move Scenario

Scenario Definition
SC1 – Port Move

Under this scenario - POAL closes and rail freight volumes are redistributed to Northport and Tauranga. This represents a significant shift in freight flows on the network, with NAL seeing the most significant growth, though NIMT remains the highest volumes by a substantial margin. Metro and inter regional growth are unchanged from the base scenario.

MARKET	PORT MOVE SCENARIO
Freight	KiwiRail scenario B.
Metro	As per the Base Case
Interregional	As per the Do Min / Base Case.

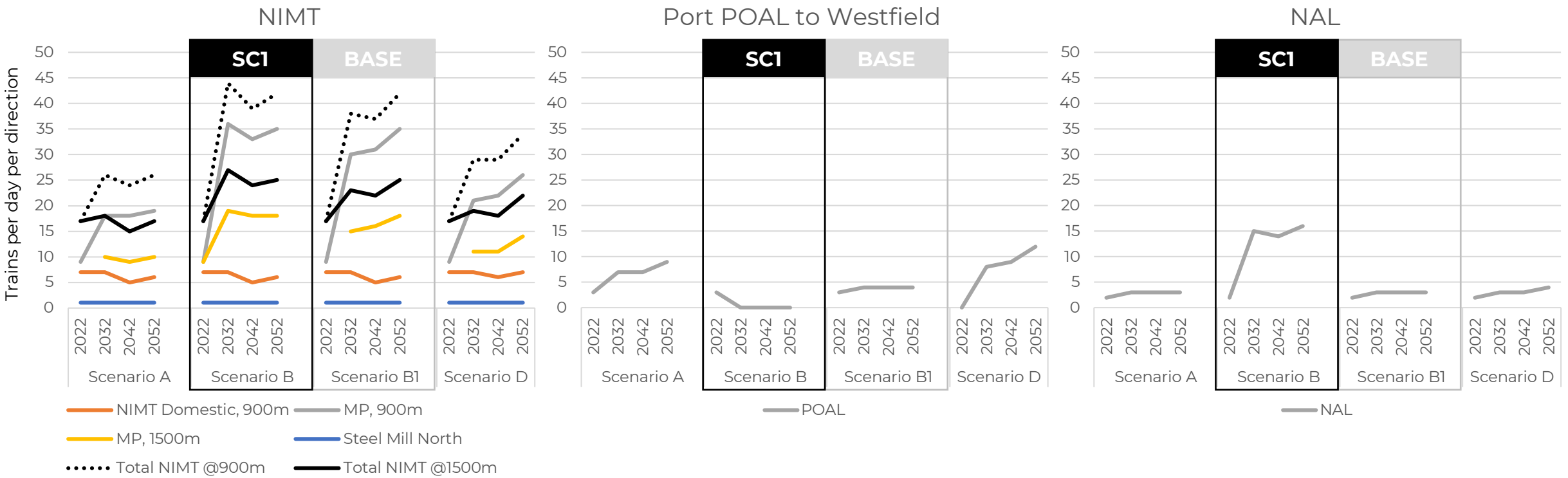


Figure 6A: Freight demand scenarios

Impacts
Western Corridor

The freight demand vs. capacity plot in Figure 6B, for the western corridor, shows that the estimated NAL capacity limit of 5-7 [1] trains per day is exceeded approximately on opening day CRL (~2025).

Under this scenario, network priority must change to accommodate more freight paths. If not, then 8-10 freight trains worth of demand (per direction) is lost per day (ramping up from 2025 – 2031 and further increasing to between 9-11 trains per day from 2032 – 2051, till implementation of Avondale-Southdown.*

The port move scenario is highly dependent on political and logistical decision making, which could result in a slower rate of growth or equally result in more growth overall. To test this the following sensitivities were also considered as shown in Figure 6B

- **B-i:** Northport activated by 2038
- **B-ii:** Northport activated by 2050
- **B-iii:** Northport activated by 2038 with growth up to 30tpd representing a scenario in which a higher percentage of Auckland Port traffic moves to Northport.

*If freight cannot travel on the rail network, it will be forced to travel on road (if sufficient capacity exists on the road network) - in turn forcing higher costs onto freight operators and ultimately consumers. Thus, there is a strong probability then is that metro trains will need to be deprioritised need to move over for freight.

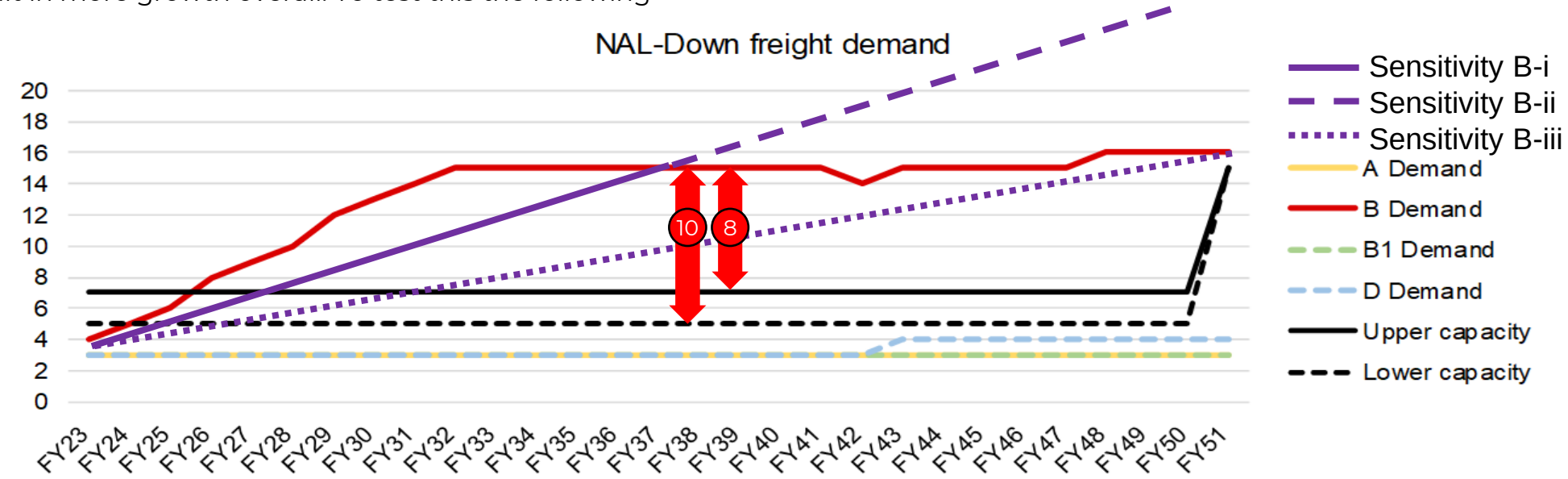


Figure 6B: Scenario 1 – western corridor freight demand vs. capacity plot

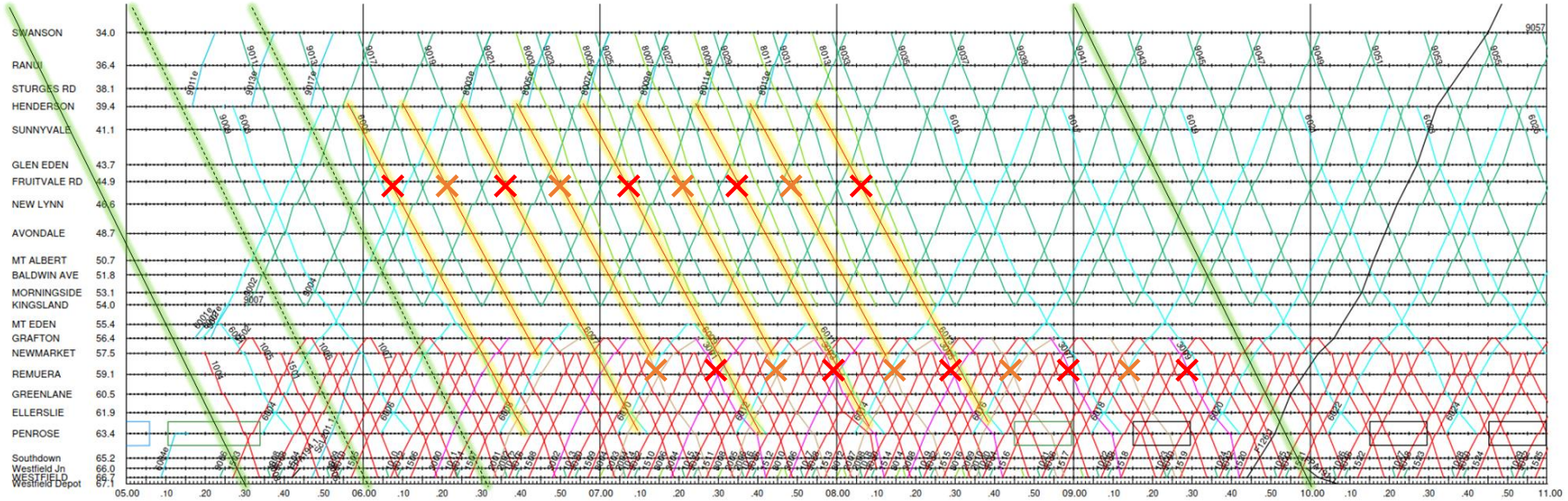
Impact Analysis
Western Corridor

The freight demand vs. capacity plot (Figure 6B, pervious page) indicates that the timing of the 'breaking point' (where growth exceeds the 5-7 train per day limit) is not particularly sensitive to the rate of growth of NAL traffic. The breaking point moves from 2025 under scenario B-i where the majority of growth is complete at 2030, to 2028 under B-ii, to 2030 under the scenario B-iii where growth is complete by 2050.

From this analysis it is clear that **under the Port Move scenario, growth in NAL freight will result in impacts to the metro timetable within a short time frame (starting sometime between 2025 – 2030 until implementation of Avondale – Southdown.** The potential impact on passenger services is assessed in Figure 6C, as follows:

- At least 2 tph (metro) in the peak would be required to be removed from the Western and Southern lines in order to remove the 5-6hr peak exclusion period and run up to 16tpd freight.
- Even with the removal of 2tph, from both Western and Southern, there would be a high reliability risk with routing freight trains through Newmarket junction during metro peak operation and further removal of 2tph on both lines may be required in order to ensure network stability.

The potential impact of these service reductions on passenger demand is described on the following page



NAL freight path

Peak Henderson starters

High likelihoodd of services removed to accommodate 10min NAL freight paths during peak

Risk of additional services removed to accommodate 10min NAL freight paths during peak

Figure 6C: Scenario 1 – western corridor freight and metro conflicts

Impact Analysis
Western Corridor

The following is a summary of demand analysis conducted using IM line load and peak load point plots. Depending on the degree to which services are cut to accommodate freight, the impacts on passenger service varies – this 4 sub-scenarios are considered.

Passenger impact scenario 1: Removal of 2tph Southern Line services (most likely Papakura starters) in order to provide enough paths on the inner South to accommodate the freight trains. Results in:

- Standing from Homai straight away (FY26)
- Standing as far back at Takanini by about 2030 (ie all seats full leaving Papakura)

Passenger impact scenario 2: Removal of 4tph Southern Line services (most likely Papakura starters) - to provide enough freight paths on the inner South and provide more reliability given freight paths through Newmarket junction. Results in:

- At or just over total capacity at Homai straight away (FY26)
- Standing only at Papakura, trains full from Manurewa in 2031 leaving passengers behind.

Passenger impact scenario 3: Removal of 2tph Henderson starters (most likely the Onehunga services). Results in:

- Not a detrimental capacity impact based on high peak data, however previous analysis has indicated a need for these services between 2025-2030 to accommodate shoulder peak capacity issues
- Loss of rail service to Onehunga during peak. As an alternative, the Henderson-Newmarket services could be removed, but this would have to be paired with removal of 2tph of the Southern Line express services rather than the Papakura starters. A shuttle service on the OBL could also be considered

Passenger impact scenario 4: Removal of 4tph Blue services on the Western/Inner South - to provide sufficient paths for freight through the core part of the network (effectively Newmarket junction). Results in:

- Quality of service degraded by 2030 - standing at Avondale (>15min), however previous analysis has indicated a need for these services between 2025-2030 to accommodate shoulder peak capacity issues
- Loss of rail to Onehunga and loss of rail connections from West to Newmarket during peak

In summary – the potential impact on metro demands under this scenario are significant, particularly on the southern line where high levels of standing are expected as early as 2030, reducing attractiveness of rail services. The risk of reliability issues with allowing freight through Newmarket in metro peak operation is more quantify but not less significant. This increases the urgency for Avondale – Southdown which is the infrastructure solution that would resolve these impacts. However similarly to the Southern corridor 4-tracking, this is not something that can be delivered quickly. One mitigation to this would be to build freight sidings or staging tracks on the northern end of the ARN (as close to Swanson as possible) to enable more precise and flexible dispatching of trains from Northland onto the network. This would allow higher freight volumes to be achieved before metro impacts occur (at the upper end of the 5-7 limit previously identified) in the interim period before Avondale – Southdown is completed.

Impacts
Southern and Eastern Corridors

On the **Southern Corridor**, the Port Move scenario sees increased freight growth on the NIMT compared to the base scenario (Scenario B in Figure 6D below). This is because the demand that would otherwise be served by POAL gets split between Northport and Port of Tauranga, therefore increasing demand both north and south. The volumes of freight south of Auckland compared to north of Auckland indicates that the priority for investment remains on the south, with accelerated growth pulling forward the **1500m trigger (and therefore trigger for 4-maining the southern line) into the late 2020s.**

On the **Eastern Corridor**, POAL freight reduces to zero under this scenario which removes reduced the need for the W2W 6-tracking as Southern line and East-west line all-stops trains (16tph in total) could operate together at an acceptable level of utilisation on the eastern mains, without needing to accommodate port trains. Thus, a four-track railway would be sufficient from a track capacity perspective between Wiri and Westfield.

It should be noted that the Wiri to Westfield 6-tracking solution still has benefits under this scenario (i.e., travel time improvements and reliability enhancements) but these are unlikely to justify the level of investment required and it is therefore assumed to be removed from the programme under this scenario

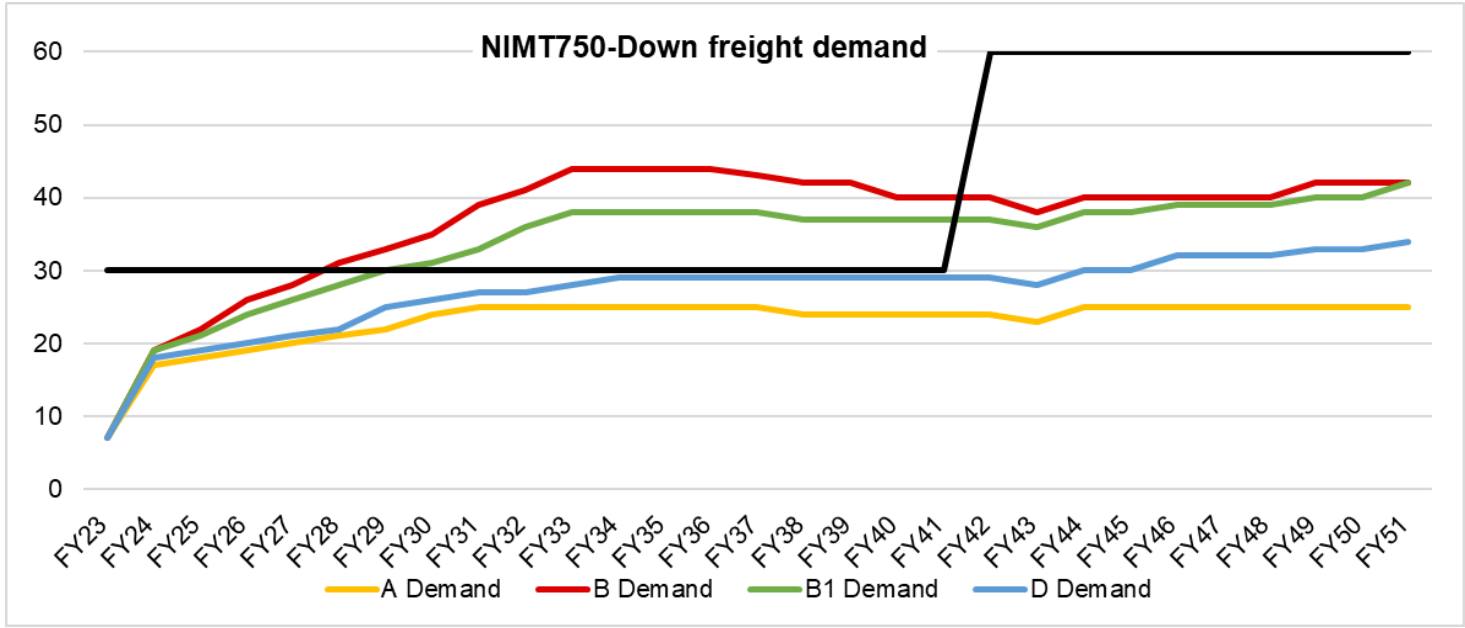


Figure 6D: Scenario 1 – southern corridor freight demand vs. capacity plot

Impacts – Port Move SC1
Summary

Analysis of the Port Move Scenario, presented in this section, leads to the following conclusions.

- The **demand trigger** for Avondale-Southdown under the Port move scenario is between **2025 – 2030**.
- Given likely delivery time for the A-S corridor (~10 years), this will create a period of constrained access where trade-offs will be required between markets, ranging from spilling 8-10 freight trains worth of demand per day per direction, to reducing the number of metro services on the Western Line by 2 and Southern Line by 2, creating crowding issues and leaving customers behind. Therefore, there is **urgency to delivery A-S as quickly as possible under this scenario**.
- An interim mitigation to these trade-offs would be to **build freight sidings or marshalling yard** at the northern end of the network, as close as practical to the Swanson terminal. This would allow reliable operation of up to 7tpd per direction.*
- The Auckland Port closure removes freight between POAL and Wiri which reduces the capacity burden on the Wiri to Westfield section and **removes the need for Wiri to Westfield 6-tracking.**
- Redevelopment around the Port area could prompt a need for an additional station in the vicinity of Quay Park (either in addition to or replacing the Strand).
- Finally, greater freight volumes on the NIMT (compared to base demand) **further increases the urgency of the southern corridor 4-tracking, and this would still be the priority for investment in the programme.**

It is important to note that these conclusions hold true not only under this specific Port Move scenario, but any scenario which exceeds the expected 5-7tpd per direction capacity limit, thought timings will differ depending on the rate of growth expected** If more growth occurred on the NAL than forecast (not unlikely given that the Port closure scenario assumed only 40% of volumes are distributed to Northport after POAL is closed and there is no reason to imagine that Northport's share couldn't be greater) then further investment may be required on the Western Line. The logic is as follows

- Growth beyond 16 trains per day (which would be required under such a scenario as illustrated in Figure 6B scenario B-iii) would not be possible given the current single-track structure of the NAL north of Auckland.
- To enable this growth there are then broadly two option 1) build more loops or double track segments, or 2) extend loops to allow for longer trains. The most likely outcome is considered to be option 2 as this would be more cost effective both from a capital and operational perspective
- This would then result in longer trains needing to be accommodated within ARN, consuming more capacity and potentially resulting in an unacceptable utilisation during metro peak periods on a 2-track railway
- Therefore, there is a potential need to add 3rd or 3rd / 4th mains between Avondale junction and Swanson if growth to Northland exceeds forecast.

These insights are summarised in Figure 6E and Figure 6F on the following slides.

*Note that the 5-7 limit has been determined based on a high-level analysis of the distribution of freight demand and presence of exclusion periods, and other constraints. Detailed timetabling was not undertaken to validate this.
** This is expected by mid-late 2040s if the MPRL is constructed (and that forecast assumes POAL stays).

Impacts – Port Move SC1
Summary

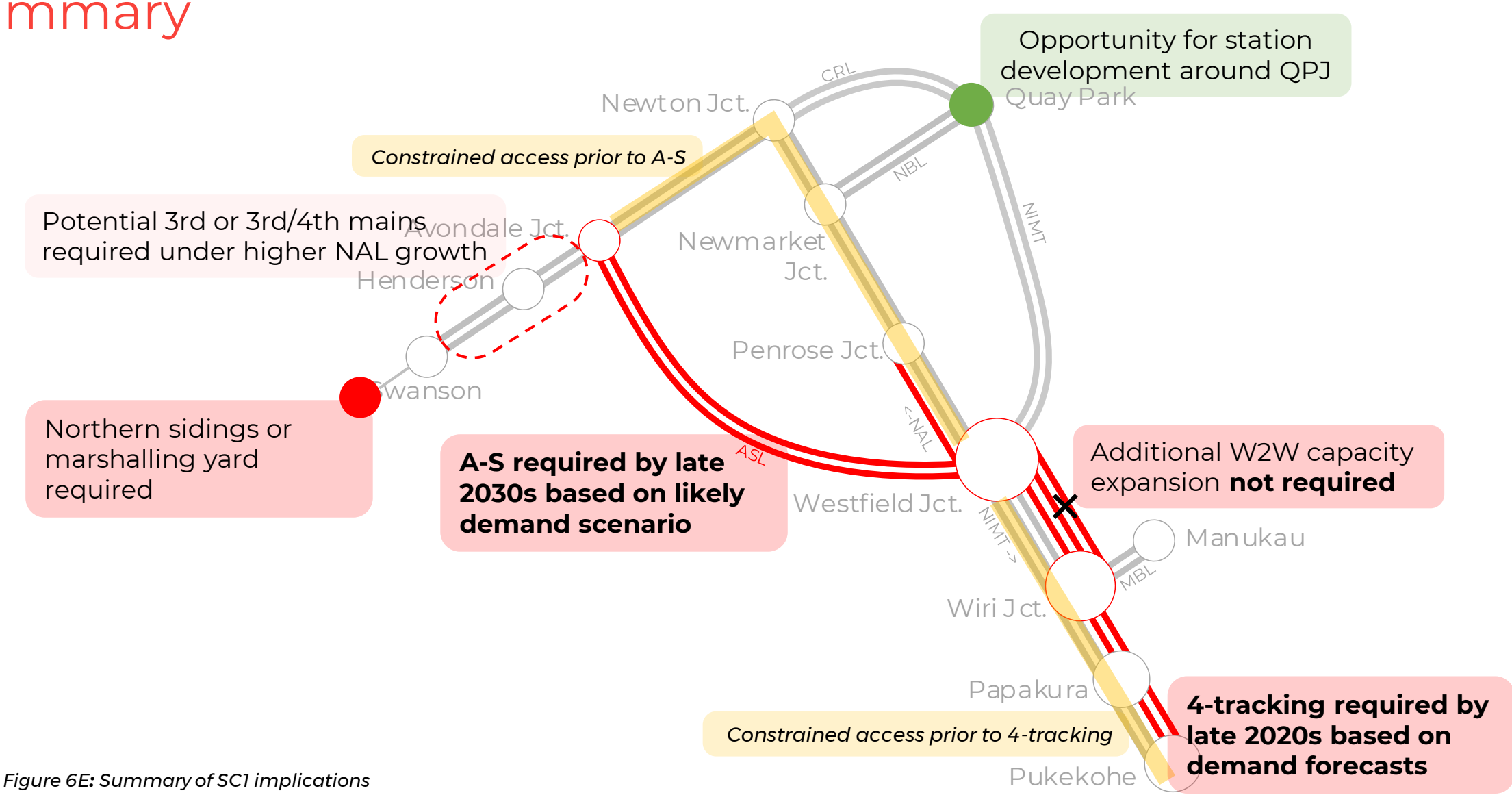
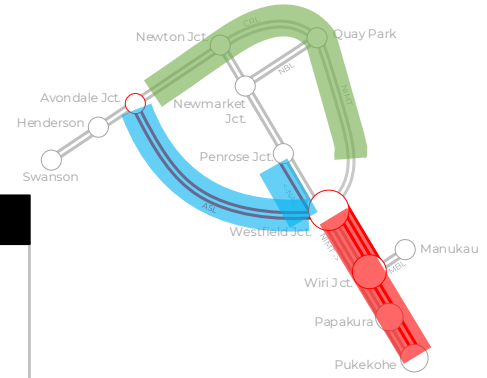


Figure 6E: Summary of SC1 implications

Impacts – Port Move SC1
Summary



Service enhancement		Infrastructure enhancement	
Southern			
Metro • Full 6-car operation • 14tph services to Pukekohe • 9-car operation, South line • RTN frequency • All day express Freight • 1500m train lengths introduced in peak Inter-Regional • Increase to 2 paths per peak hour	2025-2030 2030 – 2034 2038 – 2042 Level of service driven Level of service driven **2025 - 2030** 2040 - 2050	• 4 tracking the southern line (including 1500m enablement) • ~~9-car platform extensions, South line~~ • Avondale – Southdown	**Late 2020s** Beyond 2051s Level of service driven (2051 targeted)
Western (including NAL and Avondale – Southdown)			
Metro • CRL full timetable • Full 6-car operation • Mt Albert – Glen Innes peak overlay • RTN frequency Freight • All day freight paths	2028 2025 – 2030 2048 – 2052 Level of service driven **2025 – 2030**	• Avondale – Southdown • Mt Albert, Glen Innes turnbacks	**2030**
Eastern (including POAL)			
Metro • Mt Albert – Glen Innes peak overlay • RTN frequency Freight • All day freight paths	2038 – 2042 Level of service driven Level of service driven	• ~~Wiri to Westfield Additional Capacity Expansion~~ • Mt Albert, Glen Innes turnbacks	**Not required** Early 2040s

Infrastructure changes

Marshalling Yard north of Swanson **required** by Early 2030s)

Wiri to Westfield 5th and 6th mains **not required**

Figure 6F: Major service and infrastructure triggers for port scenario

6.2 SC2: Uncap POAL + ERP Scenario

Scenario Definition
SC2 – Uncap POAL + ERP

- Under this scenario – demand for freight and metro services is significantly increased via exogenous influences which drive mode shift to rail (both freight and passenger) to a degree that would enable ERP targets to be met.
- This scenario combines freight growth scenario D, and scales demand output from MSM under the base model configuration, to reflect a likely distribution of demand that would enable achievement of the proposed/draft ERP targets for Auckland in 2035 as described in Section 2.1.
- Travel pattern behaviours under ERP could occur in various forms and two sub scenarios have therefore been considered where 1) demand follows the same daily distribution as today (in terms of the ratio of peak to off-peak trips), and 2) where more demand growth occurs in the off-peak periods.
- **With respect to the selected freight scenario, it is important to note that this includes the assumption that Ports of Auckland remains and is unconstrained in growth. While this is a valid scenario to consider, it is completely independent of ERP policy settings. An equally likely scenario would include a combination of ERP policy settings AND a port move.** This is partially considered in Scenario 3 (with some limitations).

MARKET	PORT MOVE SCENARIO
Freight	KiwiRail scenario D
Metro	MSM forecast patronage scaled to represent ERP-level growth
Interregional	As per the Do Min / Base Case.

Scenario Definition
Freight Demands

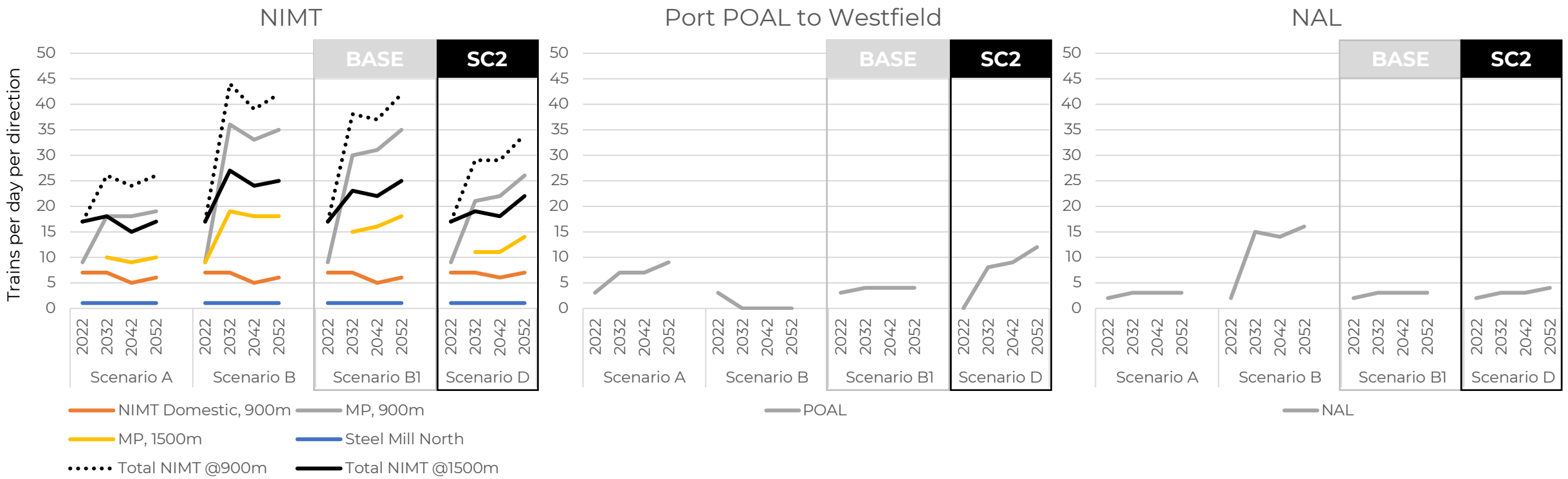


Figure 6G: Freight demand scenarios

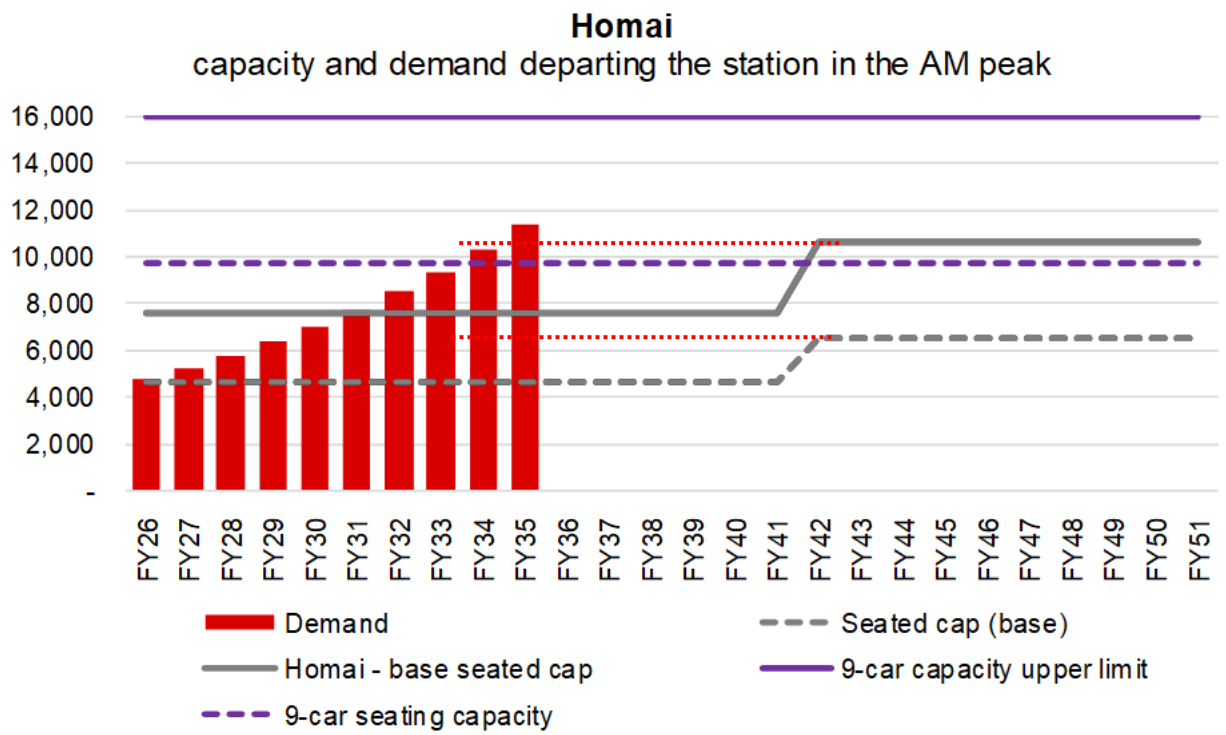
Impacts
Southern Corridor

The following analysis based on the IM, considers the impact of ERP growth (and uncapping of POAL) on the current base phasing (iteration 3), for each corridor, and each market (where relevant). Since the ERP targets for passenger are only defined till 2035, this analysis only focusing on the investment needs up till this point. However, a discussion is provided later as to the potential investment needs beyond 2035 assuming some level of 'post ERP' growth.

Metro demand triggers:

- Full 14tph service at 9-car provides capacity to meet demand on the Southern Line by 2035, but with considerable standing at Homai.
- The full 14tph service to Pukekohe would be required sometime around 2030.

Same demand distribution (AM peak : PM peak : Interpeak)



Additional demand shift into the interpeak

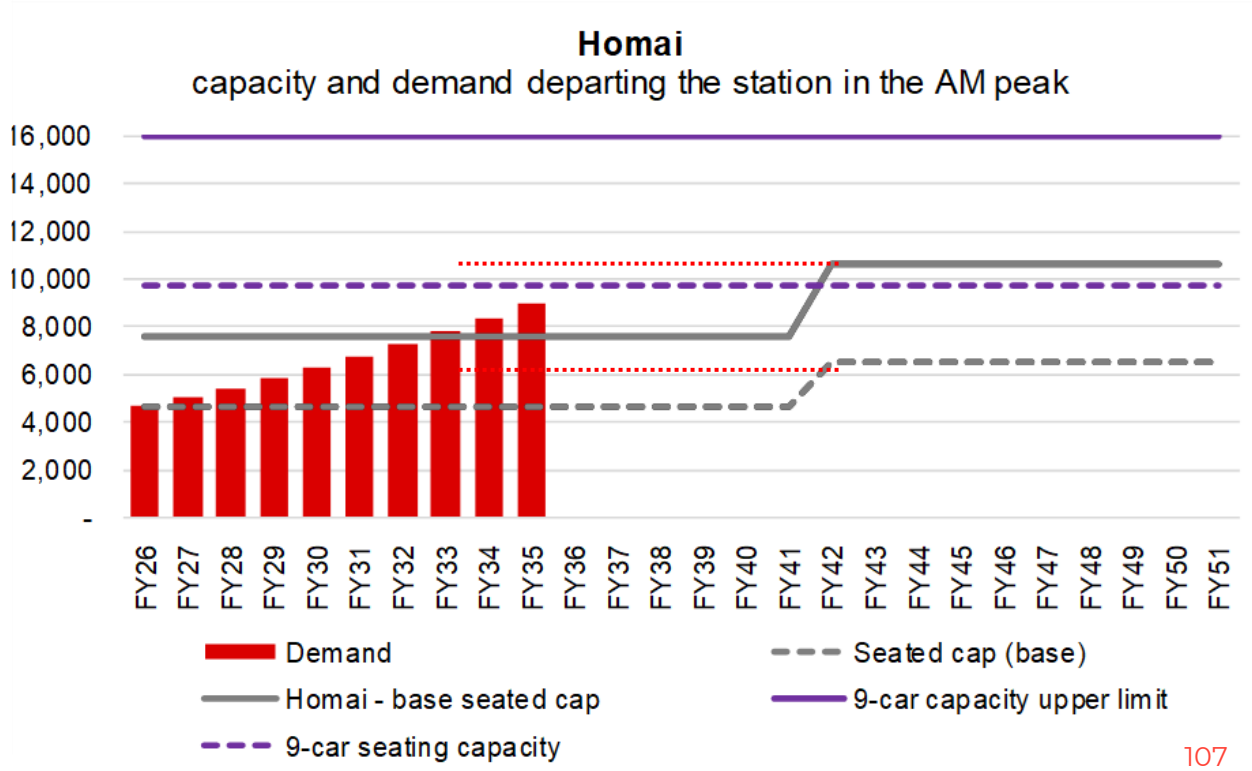


Figure 6H: SC2 southern corridor – metro peak load point plots

Impacts
Southern Corridor

Freight demand triggers:

- On the southern line, lower NIMT growth under scenario D suggests that the 30train per day limit would not be reached until sometime in the late 2040s
- **It is important to note that the reduced freight demand on NIMT-S seen in this scenario (as compared with B1) is not due to ERP policy but purely driven by the assumption in this scenario that POAL is allowed to grow unrestricted. If that assumption were not true, then the demand reduction would not occur.**

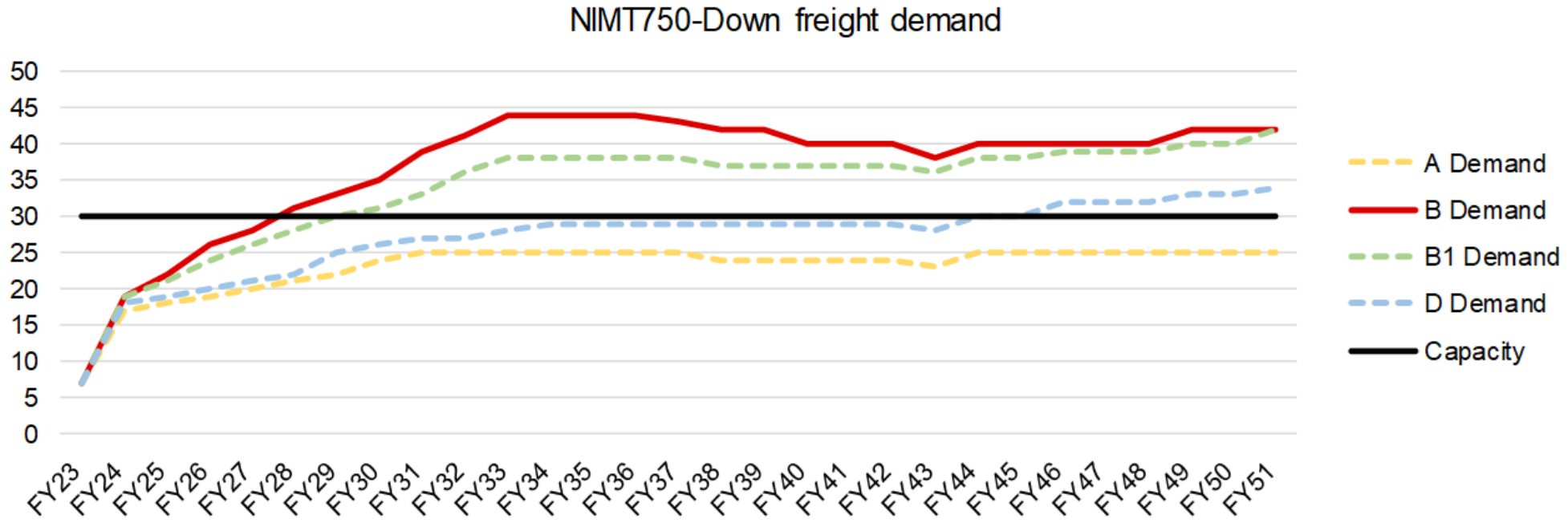


Figure 6I: SC2 southern corridor – freight demand vs. capacity plot

Infrastructure response

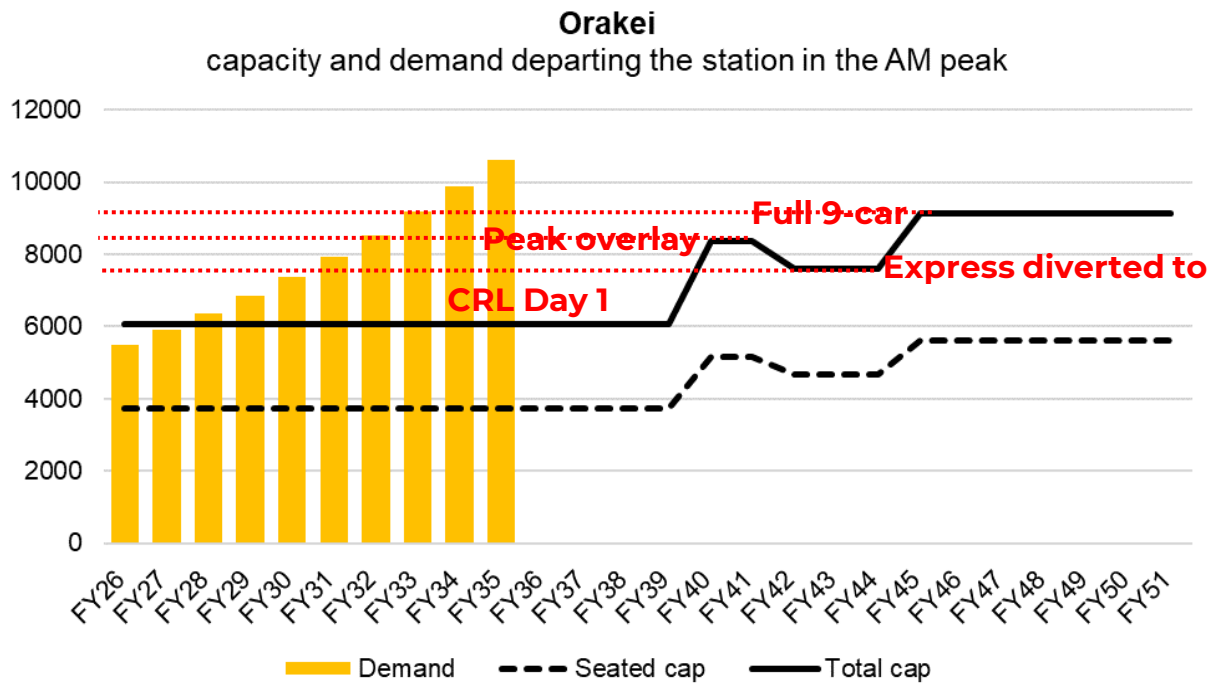
- The potential delayed need for 1500m freight trains may also reduce the urgency for the 4-tracking programme – however given the significant metro growth under this scenario which requires the full 14tph service to Pukekohe by 2030, the southern corridor 4-tracking is still considered to be the most urgent priority for the network.

Impacts
Eastern Corridor

Metro demand triggers:

- 9-car would be required on the Eastern Line by 2035 (and therefore on the Western line due to through running) in **addition** to the peak overlay services between Mt Albert and Glen Innes.

Same demand distribution (AM peak : PM peak : Interpeak)



Additional demand shift into the interpeak

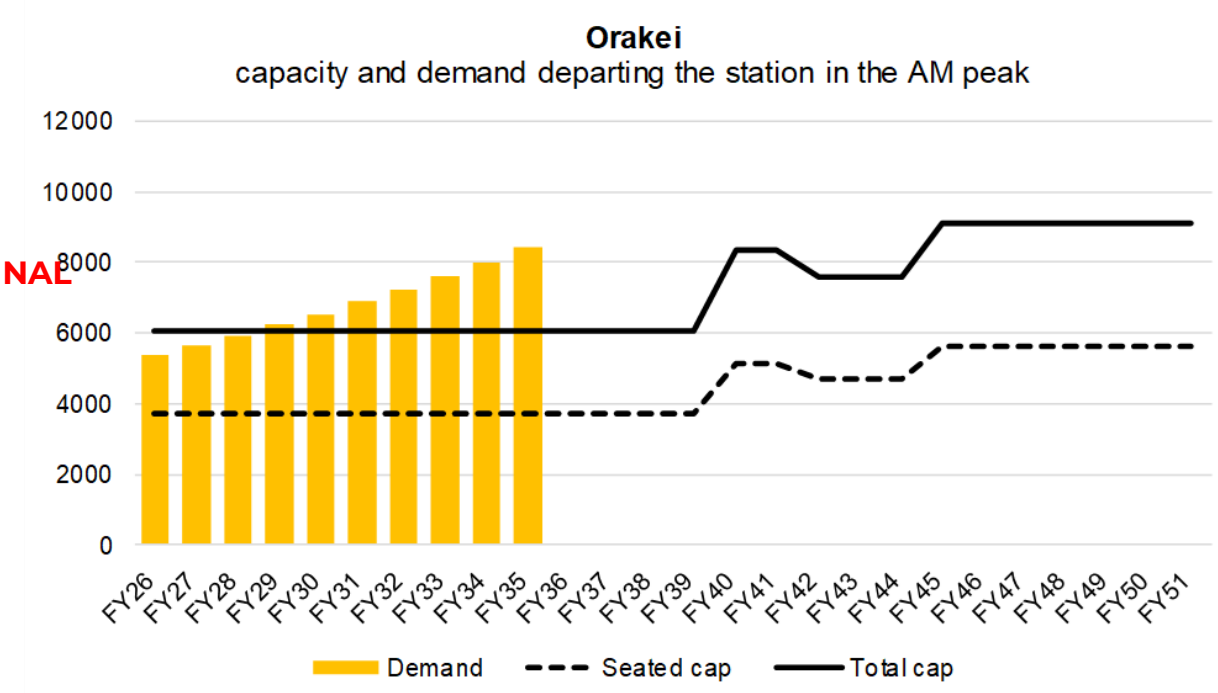


Figure 6J: SC2 eastern corridor – metro peak load point plots

Impacts
Eastern Corridor

Freight demand triggers:

- The most significant change in freight demand over the base case is growth in Auckland Port
- It is estimated that the maximum number of trains that could be cycled between POAL and Wiri is between 6-8 trains per day given the 2hr AM and PM exclusion periods plus limited hours of operation of the Port. Scenario D growth exceeds this limit sometime between 2028 – 2032*

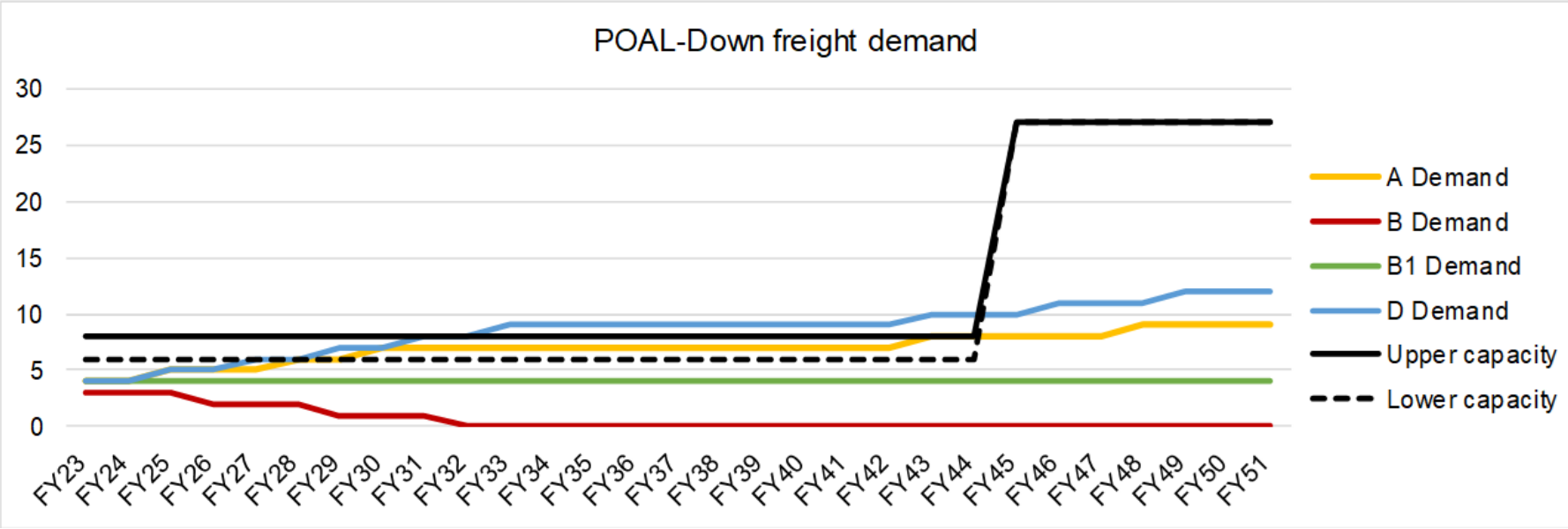


Figure 6K: SC2 eastern corridor – freight demand vs. capacity plot

*Again, it is worth noting that if freight cannot travel on the rail network, it will be forced to travel on road through central Auckland, which is unlikely to be acceptable - in turn forcing higher costs onto freight operators and consumers as well as imposing other external costs. Thus, there is a strong probability then is that metro trains will need to be deprioritised need to move over for freight.

**Wiri to Westfield 6-tracking in 2045 removes peak exclusion periods on POAL freight and thus removes the 6 - 8 train cap. The new 26 train cap is estimated based on assumptions around a practical utilisation of available slots, and hours of port operation. No consideration for terminal capacity is considered here, and further detailed analysis will be required in future phases to verify

Infrastructure response

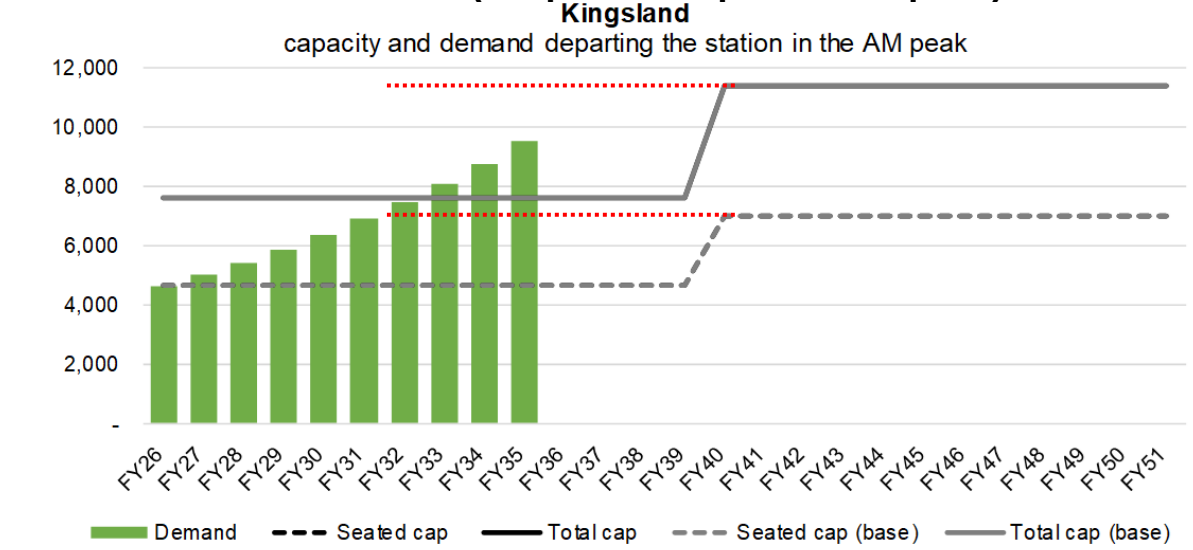
- Wiri to Westfield 6-tracking project becomes a more urgent requirement under this scenario, which is the enabler of all day freight access and improved capacity on the POAL line, by removing metro exclusion periods**. This is required around 2030 under this scenario.
- Given the need for full 9-car service on the Eastern Line in addition to the peak overlay service, there is a question on which element should be introduced first. Given the scale of the East-west 9-car programme brings significant risk of delay and it is considered preferable for the Mt Albert and Glenn Innes turnbacks to be prepared early as a mitigation against this.

Impacts
Western Corridor

Metro demand triggers:

- Based on demand, full 9-car services would not be required on Western Line by 2035 in addition to the Mt Albert to Glen Innes services,

Same demand distribution (AM peak : PM peak : Interpeak)



Additional demand shift into the interpeak

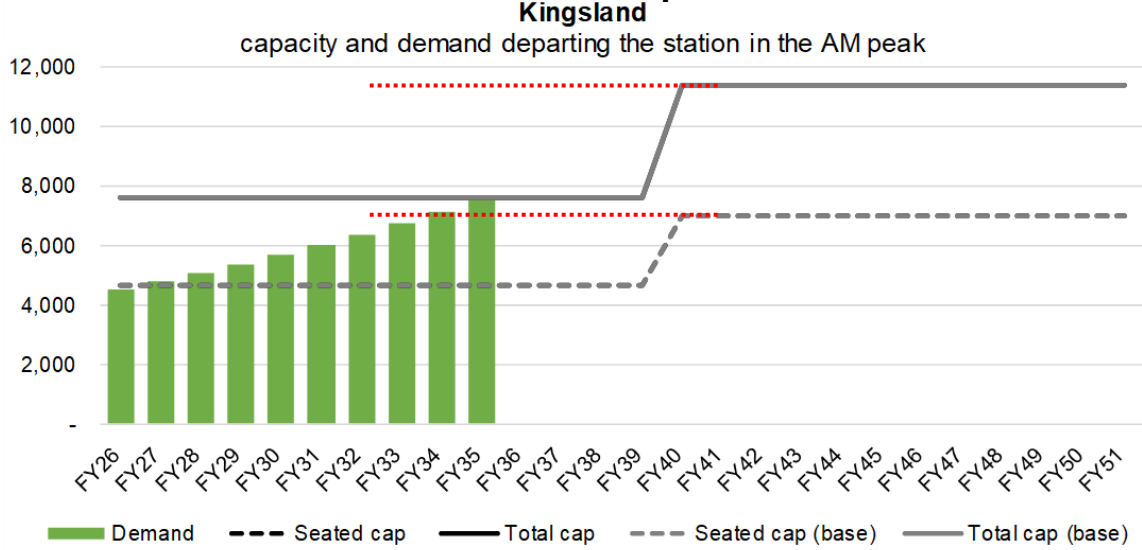


Figure 6L: SC2 western corridor – metro peak load point plots

Freight demand triggers:: There is no demand growth on the NAL under this scenario because all growth is imagined to occur at Ports of Auckland and Ports of Tauranga and none at Northport

Infrastructure response :

- Though not required by demand, 9-car operations on the Eastern Line, triggers the need for 9-car operation on the Western line as well, so would be required under this scenario.
- Given the lack of freight growth on the NAL under this scenario, Avondale – Southdown is driven more by the need for all day express services which are seen as important to contribute to the mode shift required under ERP. It is not possible to put an exact trigger date for this infrastructure under this scenario but would be required at least by 2035 to support ERP targets.

*Again, it is important to note that this is a scenario meant to define a bookend and is unlikely to occur in reality. The assumption inherent in the modelling of this scenario that there is zero growth to Northport, is unrealistic given current investments.

Impacts
Post ERP Growth

The analysis above focused on demand growth within the first half of the 30-year programme - up to 2035. It is unclear what level of growth should be expected/required under this scenario, post 2035 as ERP targets have only been defined up to 2035, however if ridership continues to increase either organically or at similar rates to the pre 3035 levels, it is likely that more services will eventually need to be run on the eastern and southern lines during the peak period. Further lengthening of trains is unlikely to be a viable option at this point given the constrains on train lengths within the CRL and 1500m limits for freight elsewhere on the national network.

- **Eastern Line:**
  - Given the ERP scenario also has high freight volumes on the Eastern line, which need to run all day, it is likely that additional tracks would be required to support peak frequency operation. A third main may be sufficient in this case because of the relatively short run between Westfield and POAL, but it would likely be more cost efficient in the long run to build 3rd and 4th mains as far as practical.
- **Southern Line:**
  - The increased train volumes on the southern line, paired with those on the east-west line, would likely create a bottleneck at Quay Park junction, requiring this to be grade separated.
- **Western Line:**
  - This is less likely on the Western line because we are able to run higher frequency services on the inner western line given that we've bypasses freight on A-S.

Impacts
9-car considerations

Setting aside the question of timing the above analysis indicates that the Constrained Phasing (which had delayed the introduction of 9-caroperations till beyond 2051) is not sufficient to meet metro ERP demand even by 2051 (with the exception of the Western Line which would have its demands accommodated by the peak Mt Albert – Glen Innes and Henderson – Newmarket overlays)

Introduction of 9-car operation on the Southern Line would accommodate the required level of growth within total standing capacity (though would still result in long standing times)

- Based on demand modelling to date, capacity issues will be most prevalent on limited stops services and so these should be prioritised over all stops services.
- Since these services require a smaller number of platform extensions, they can also be implemented earlier and thus could be used as a mitigation to the 10-year period in which capacity lags demand on the southern corridor as the 4-track programme is being implemented.
- The Pukekohe to Papakura (P2P) platform extensions will be completed in parallel with P2P quad tracking and Papakura Station upgrades. This will be completed by ~2035 - 2037
- The remaining platform extensions required for a viable limited stops service are Puhinui and Newmarket*. It should be feasible to prioritise these stations for 9-car extensions to be completed prior to 2037, which would then allow a 9-car express service to be introduced by this time
- There is an opportunity to couple the Newmarket 9-car extension project with station improvements that would allow re-routing of Inter Regional services to connect to Newmarket en-route to Strand which is part of the 2051 plan but was originally envisioned to be achieved only by 2042. Thus, early benefits would accrue to the Inter Regional market.
- As part of this work, Remuera would then be triggered as a 3-track station (to allow termination of the Henderson to Newmarket services when the 9-car extension removes the middle platform at Newmarket

*Fit-out of the CRL stations is also required however these are already 9-car enabled and it is anticipated these will be relatively easy to implement

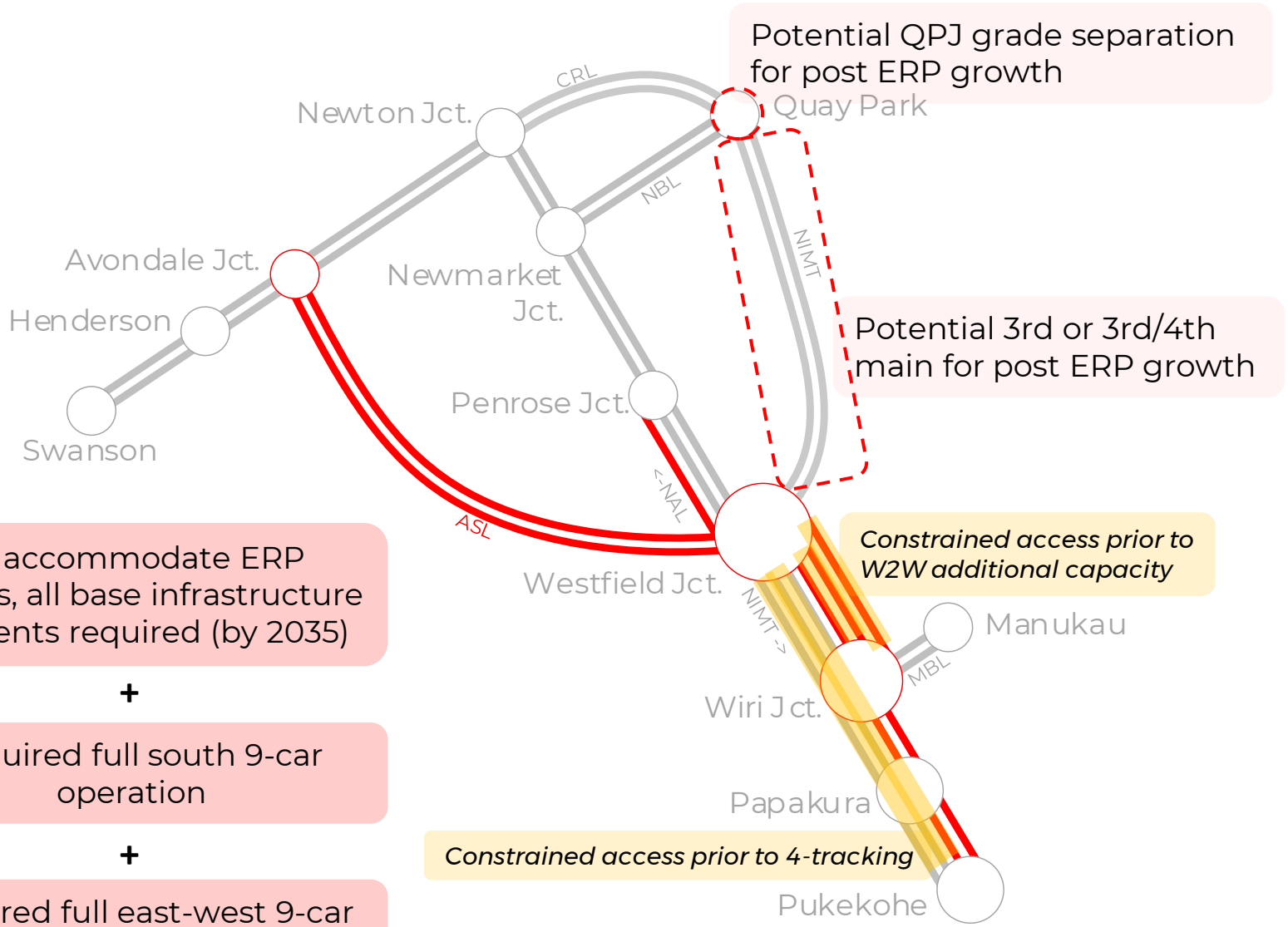
Impacts – Uncap POAL + ERP SC2
Summary

Analysis of the ERP Scenario, presented in this section leads to the following conclusions.

- **All investments of the PBC would be required with a much greater degree of urgency, with all elements needed by 2035.**
- The priorities of the base programme still hold with the southern corridor requiring the most urgent investment
- In addition, to meet demand, **full 9-car operation is required on the southern and eastern lines**, in addition to the Mt Albert to Glen Innes turnback's. Due to the through running structure of the timetable, **the Western Line will also require full 9-car operation** though this is not strictly required by demand in 2035. Platform extensions, and additionall fleet and stabling would be required to support this operation.
- On the southern corridor **9-car operation should be firstly implemented on express services** as previous demand modelling has indicated strong demand for these. This could be **achieved as early as 2037 based on efficiencies with the 4-tracking programme between Pukekohe and Papakura**.
- It is **unclear what level of growth should be expected/required under this scenario post 2035**, however it is certain that heavy rail growth will continue to some degree. To handle this growth it likely that more services will eventually need to be run on the eastern and southern corridors during peak periods. Further lengthening of trains is unlikely to be a viable option at this point given the constraints of the CRL, and 1500m limits elsewhere on the national network. **To accommodate increasing frequencies post ERP**:
    - **3rd / 4th mains on the Eastern corridor** would be required to support higher frequency metro services and all-day freight access between POAL and Wiri
    - **Grade separation of Quay Park junction would be required** to accommodate the increase in services on the East-west and Southern lines, with added benefits of removing a significant timetable constraint.

These insights are summarised in Figure 6M and Figure 6N on the following slides.

Impacts – Uncap POAL + ERP SC2
Summary



To accommodate ERP targets, all base infrastructure elements required (by 2035)

+

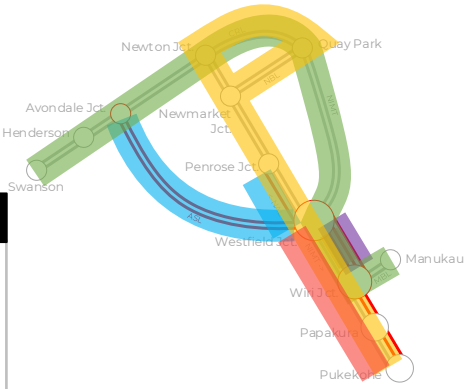
Required full south 9-car operation

+

Required full east-west 9-car operation

Figure 6M: Summary of SC1 implications

Scenario 2 Phasing – Uncap POAL + ERP



Service enhancement		Infrastructure enhancement	
Southern			
Metro		• 4 tracking the southern line (including 1500m enablement)	**Late 2020s**
• Full 6-car operation	2025-2030	• 9-car platform extensions, South line	**Early 2030s**
• 14tph services to Pukekohe	**2025 – 2030**	• Avondale – Southdown	**Early 2030s**
• 9-car operation, South line	**2030 – 2035**		
• RTN frequency	**2030 – 2035**		
• All day express	Level of service driven		
Freight			
• 1500m train lengths introduced in peak	**Late 2040s**		
Inter-Regional			
• Increase to 2 paths per peak hour	2040 - 2050		
Western (including NAL and Avondale – Southdown)			
Metro		• Avondale – Southdown	**Early 2030s**
• CRL full timetable	2028	• Mt Albert, Glen Innes turnbacks	**Early 2030s**
• Full 6-car operation	2025 – 2030		
• Mt Albert – Glen Innes peak overlay	**2025 - 2030**		
• RTN frequency	**2030 – 2035**		
Freight			
• All day freight paths	Level of service driven		
Eastern (including POAL)			
Metro		• Wiri to Westfield Additional Capacity Expansion	**Early 2030s**
• Mt Albert – Glen Innes peak overlay	**2025 - 2030**	• Mt Albert, Glen Innes turnbacks	**Early 2030s**
• RTN frequency	**2030 – 2035**		
Freight			
• All day freight paths	**Early 2030s**		

New infrastructure required (for post ERP growth)

- 3rd/4th main Eastern Line
- Quay Park Jct. grade separation

Figure 6N: Major service and infrastructure triggers for port scenario

6.3 SC3: Port Move + ERP Scenario

Impacts – Port Move + ERP SC3
Scenario Definition

- This scenario represents a combination of the previous two scenarios in which Auckland Port is closed, while at the same time demand for freight and metro services is significantly increased via exogenous influences which drive mode shift to rail enabling ERP targets.
- Demand scenario B is used for freight, while the scaled MSM demands developed for Scenario 2 are used for metro.
- This section provides a recap of the demand and trade-off analysis performed as part of the previous scenario analyses and assesses the likely impacts to the investment programme when considered in combination.
- This scenario is important to consider given the previously discussed limitations of Scenario 2 in combining ERP policy settings with a scenario in which Ports of Auckland is uncapped. As noted, these two components of the scenario are completely independent from one another, and the intent of Scenario 3 is to consider the opposite combination. However, the analysis is somewhat limited in that the effects of ERP are only considered on metro demands. To truly analyse a scenario in which ERP growth occurs and the port is capped or moves, this would require a separate set of demand inputs to study. It might be expected for example that NIMT volumes would be higher than predicted under Scenario B for an ERP + Port Move forecast.

MARKET	PORT MOVE SCENARIO
Freight	KiwiRail scenario B.
Metro	MSM forecast patronage scaled to represent ERP-level growth
Interregional	As per the Do Min / Base Case.

Freight Demands

Freight demands adopted in Scenario 3 are provided in Figure 60 below. The key feature of this scenario is the significant growth on the NAL and corresponding removal of Auckland port freight.

The trade-offs analysis undertaken for Scenario 1 indicated that prior to Avondale – Southdown either freight demand would be lost (in the order of 8-10 trains per direction per day worth of demand) or passenger services would need to be cut (or some combination thereof). The potential impact on metro demands under this scenario could be significant, particularly on the southern line where high levels of standing are expected as early as 2030 due to the requirement to cut peak services. Furthermore, the risk of reliability issues in allowing freight through Newmarket in metro peak operation was deemed to be significant.

This increases the urgency for Avondale – Southdown,, and an early mitigation of building a freight marshalling yard / siding on the northern end of the ARN to enable more precise dispatching and .achieve volumes of up to 7 trains per day per direction.

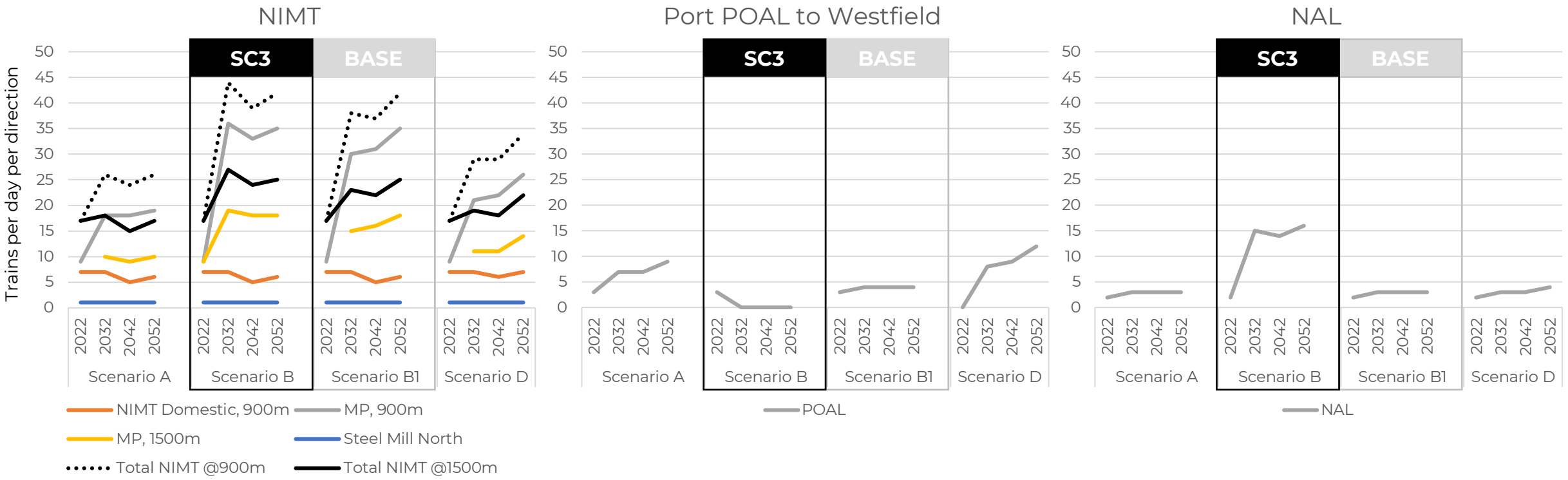


Figure 60: Freight demand scenarios

Passenger Demands
Southern Corridor

The previous analysis in Scenario 2 showed the impact of high passenger demands due to potential impacts of ERP policy levers. Key conclusions from this analysis for each corridor are provided below, which **in summary require all interventions of the PBC to be completed at a greatly accelerated rate, with the addition of 9-car extensions on all lines.**

Southern Corridor triggers:

- Full 14tph service at 9-car provides capacity to meet demand on the Southern Line by 2035, but with considerable standing at Homai.
- The full 14tph service to Pukekohe would be required sometime around 2030, triggering the need four tracking when considered in conjunction with freight growth by around the same timeframe.

Eastern Corridor triggers:

- 9-car would be required on the Eastern Line by 2035 (and therefore on the Western line due to through running) in **addition** to the peak overlay services between Mt Albert and Glen Innes.

Western Corridor triggers:

- Based on demand, full 9-car services would not be required on Western Line by 2035 in addition to the Mt Albert to Glen Innes services, however 9-car operations on the Eastern Line, triggers the need for 9-car operation on the Western line as well due to the trough running nature of the network concept

Impacts – Port Move + ERP SC3
Summary

Based on the insights described above, an increase in NAL and NIMT freight growth in conjunction with the large increase in passenger growth to meet ERP targets, this scenario points to similar responses to the previous scenarios but required in parallel, with different implications for the Wiri to Westfield 6-tracking. The primary conclusions of the analysis are:

- **Full programme required by 2035 with the exception of 6-tracking** which is not required due to removal of port traffic between Wiri and Westfield
- **9-car extensions are needed by 2035 on both the Southern and East/West lines**
- **Northern marshalling yard** to mitigate impacts on metro services during A-S implementation
- **Potential for 3rd and 4th mains on the outer western line to accommodate higher NAL growth**
- **Potential for QPJ grade separation to support post ERP growth**

These insights are summarised in Figure 6P on the following slides.

Impacts – Port Move + ERP SC3
Summary

Potential QPJ grade separation for post ERP growth

Opportunity for station development around QPJ

Potential 3rd or 3rd/4th main under higher NAL growth

Required northern marshalling yard

To accommodate ERP targets, 4-tracking and A- S required by 2035

+

Required full south 9-car operation

+

Required full east-west 9-car operation

Figure 6P: Summary of SC2 implications

6.4 Major Outcomes and Refined Phasing

Refinements and triggers

The scenario analysis shows that the previously developed phasing iteration is generally robust against scenarios. The following major conclusions and refinements are suggested on the basis of the analysis:

Conclusions and triggers

- Under all scenarios, 4-tracking of the southern corridor (and all supporting asset investments) is the priority for investment on the network, with increased urgency under alternative scenarios
- Avondale – Southdown is robust to scenarios but becomes more urgent under a Port Move scenario. This is because Avondale – Southdown has two potential triggers
    - 1) The desire to run more frequent, faster metro services all day (relevant to all scenarios and more urgent under ERP)
    - 2) An increase in freight train volumes impacting peak metro services on the West and South Lines (relevant under the port move scenario). A mitigation to these impacts was also identified in a marshalling yard to the north end of the network (which would allow for reliable operation of up to 7tpd per direction),
- Wiri to Westfield, additional capacity expansion is urgent under an uncapped port scenario but not required (though still providing benefit) under a port move scenario.
- 9-car extensions are required under ERP settings on all lines. Given the base demand scenario is closer to BAU growth, strategic inclusion / future proofing of 9-car extensions is therefore critical – see next slide.

Refinements for robustness

The scenario analysis shows that 9-car train operation will be required on all lines to meet ERP targets. In addition, even under the base demand scenario, 9-car operation on the southern line will likely be required very soon after 2051 if not earlier for the heaviest demand express trains. It was therefore decided that:

- The **southern line express services will be planned to run at 9-car**. These are the highest demand services on the network and likely to exceed acceptable crowding levels the earliest. The services can be implemented relatively early in the programme as many of the platform extensions required can be carried in in parallel with the 4-tracking project. Furthermore, implementing this service enhancement early acts as a mitigation against the constrained demand between 2030 and 2042. It is estimated that the 9-car express services can be enabled by 2037.
- **Eventual 9-car operations will be future proofing network wide.** The asset level phasing has adopted the principal that any time a platform at a station is touched (due to trackwork, level crossing removals, or some other reason) the platform will be lengthened to 9-car as part of this work

The final refined phasing is presented in Figure 6Q (next slide)

Refined Phasing

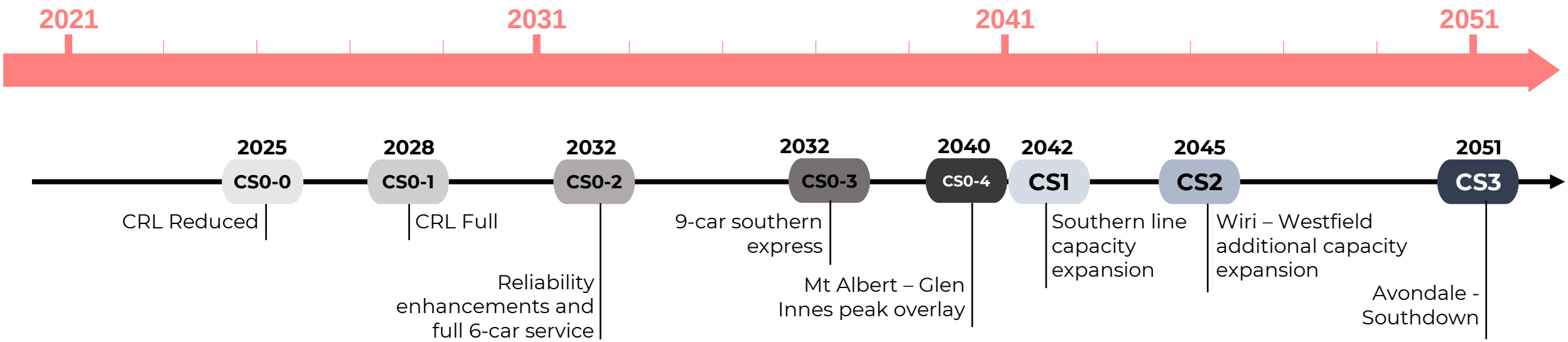


Figure 6Q: Refined phasing

7 | Final Preferred Programme

Final Preferred Programme

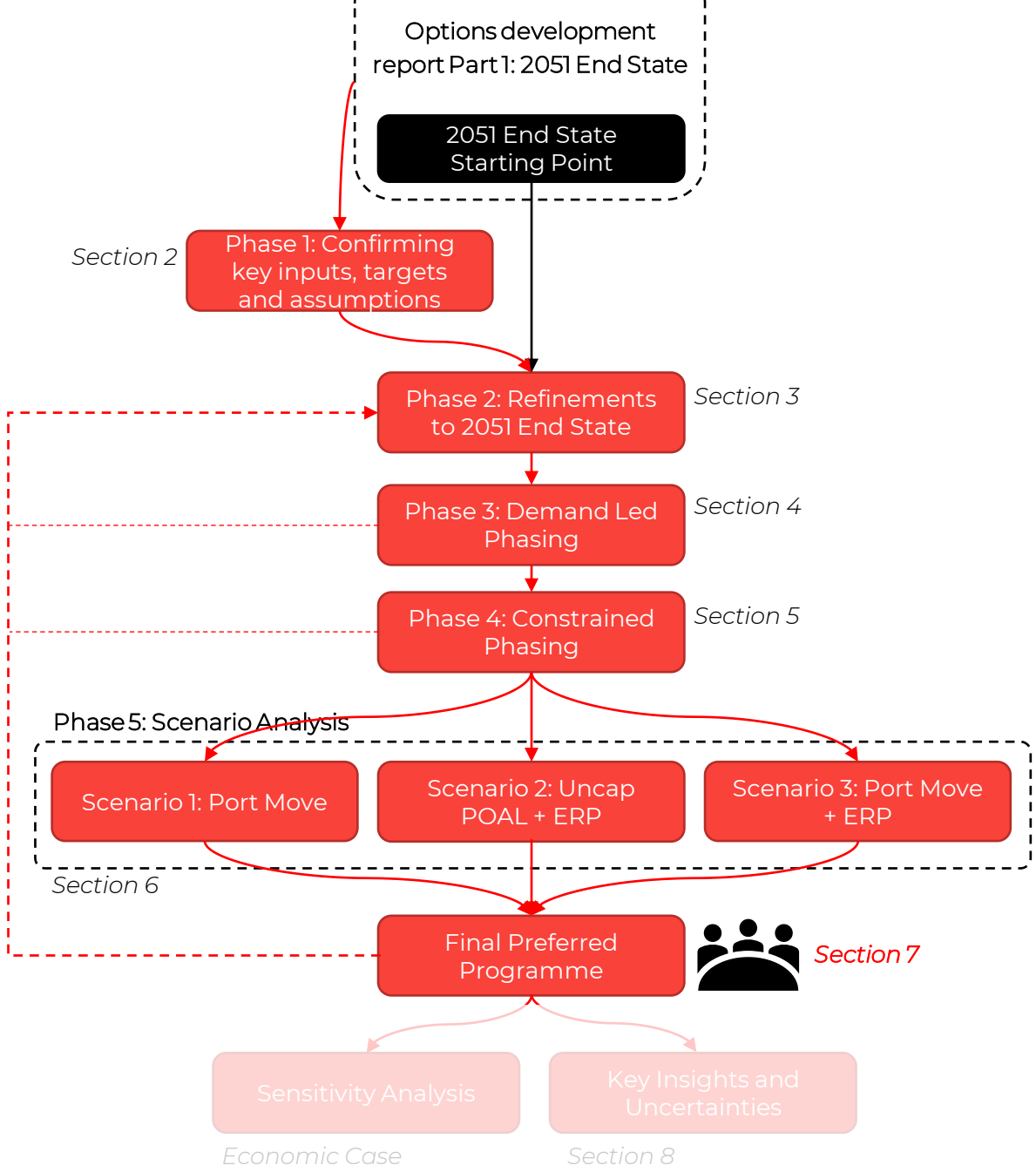
The configuration state phasing under presented in Section 6 is the final macro level phasing of the programme, which responds to demands within the likely constraints of deliverability and fundability and is robust against likely scenarios of demand growth.

The final programme however needs to consider the detailed phasing of all asset categories which are required to support the configuration states, including track, signalling, traction power and OLE, station upgrades, level crossing, fleet procurement, EMU depot, and maintenance depot, plant and equipment. There is optionality within each asset class however they are primarily driven by the configuration states and the any optionality to the extent that it does exist, will not have a major impact on the overall performance of the programme against its investment objectives, economically, or financially.

As part of the PBC, a more detailed asset level phasing has been developed as a starting point for future more detailed business cases. This was required to validate feasibility of the overall programme and assess realistic timings and costing. The results of this work are contained within various Asset Strategy repots, an overall 30 Year Rail Strategy report, and a Cost memo as shown in the overall ARPBC document map in Appendix C.

This detail is summarised at a high level in this section, via a more detailed asset level phasing diagram (Figure 7A) and a series of service and infrastructure schematics for each of the 8 configuration states

It is critical to note that the service concepts shown in this section are indicative only. They are developed for the purpose of assessing infrastructure requirements and benefits of the programme – but should not be considered as final or recommended. The operating service concept and timetable will be confirmed via established processes involving KiwiRail, AT and other stakeholders outside of the PBC



7.1 Programme Summary

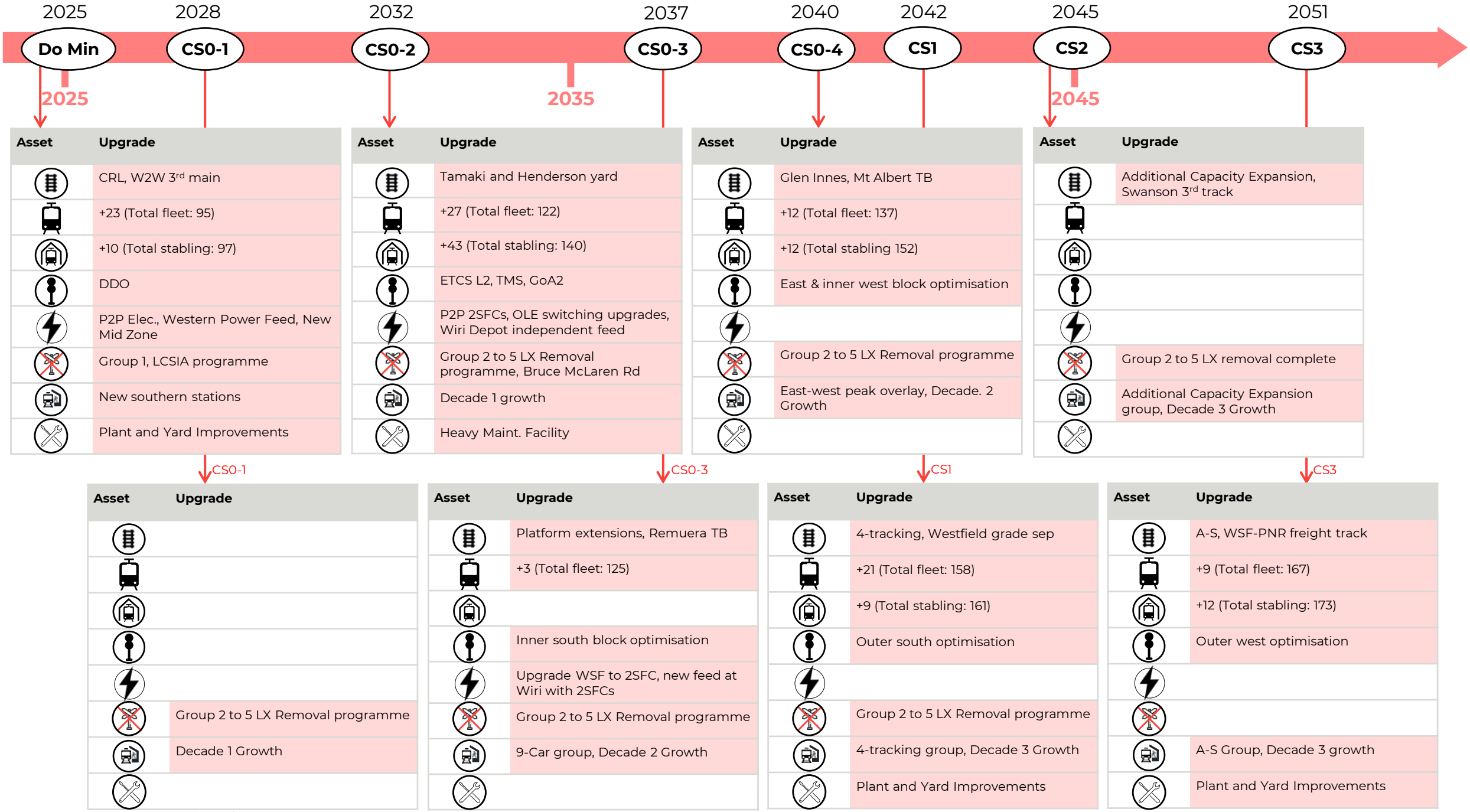
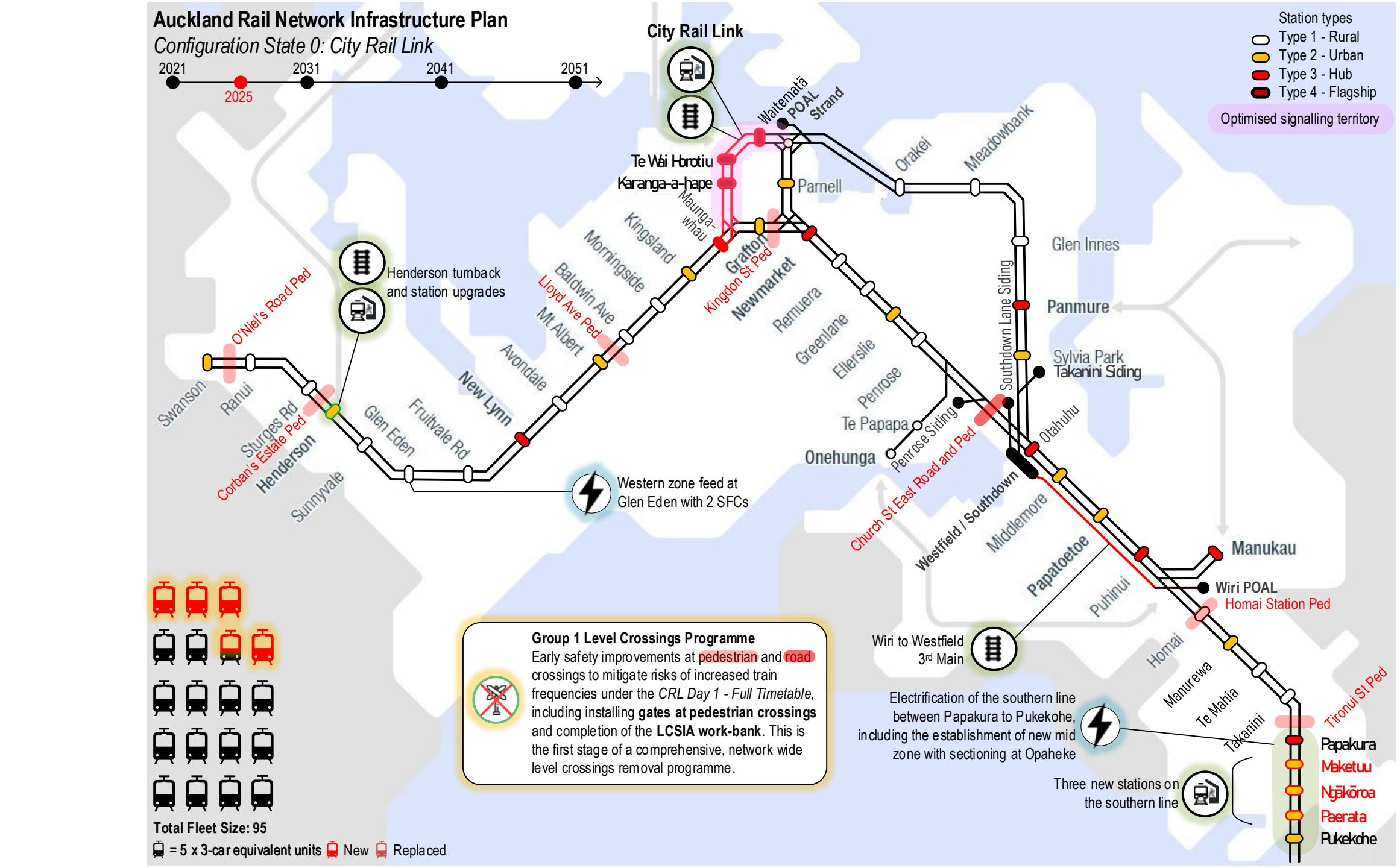


Figure 7A: Asset level phasing diagram

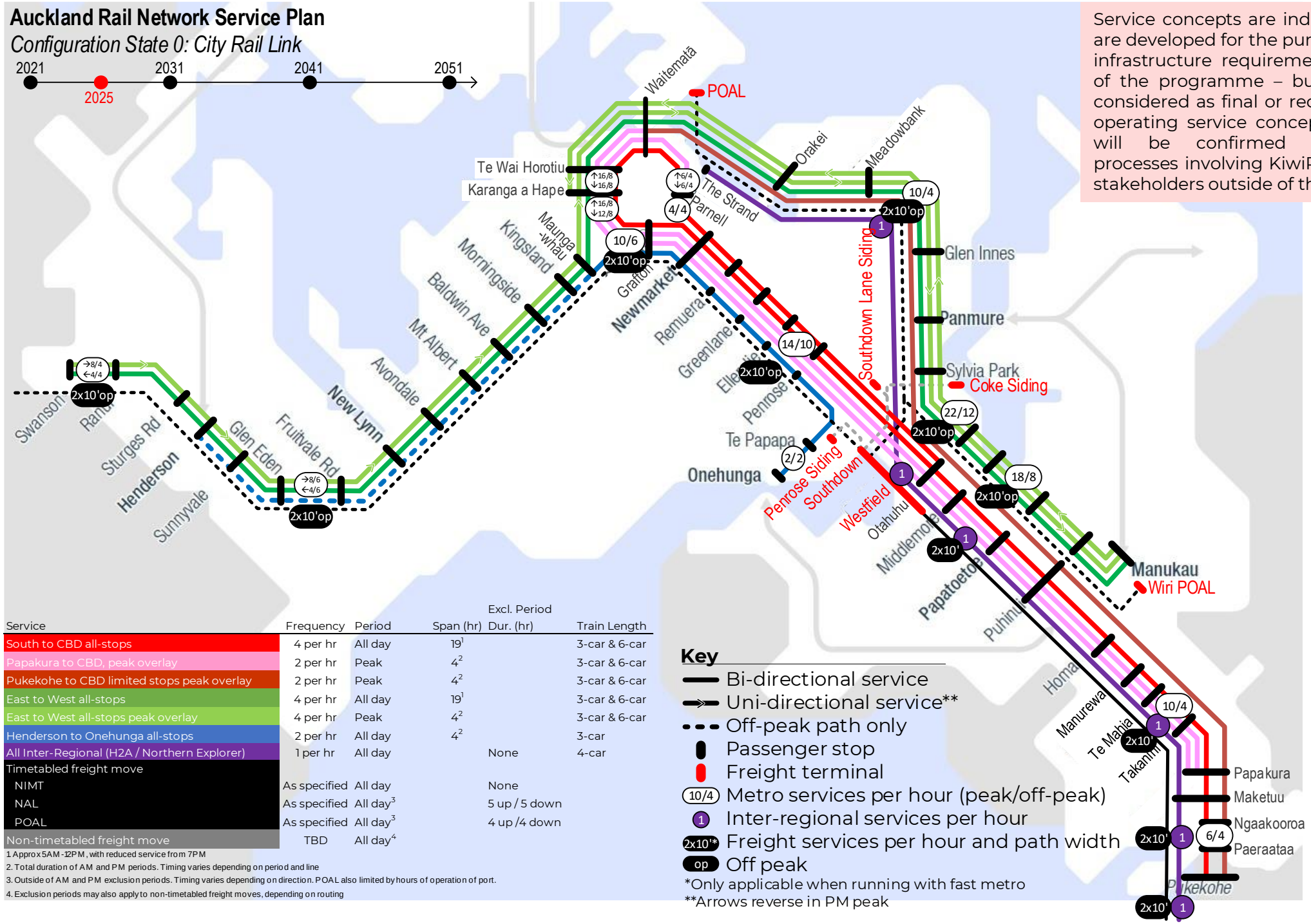

Auckland Rail Network Infrastructure Plan
Configuration State 0: City Rail Link
2021
2025
2031
2041
2051
City Rail Link
Station types
Type 1 - Rural
Type 2 - Urban
Type 3 - Hub
Type 4 - Flagship
Optimised signalling territory
Waitematā
POAL
Strand
Te Wāi Hōrotiu
Karanga-a-hape
Parnell
Orakei
Meadowbank
Maunga-whau
Kingsland
Morningside
Baldwin Ave
Mt Albert
Avondale
New Lynn
Fruitvale Rd
Glen Eden
Sunnyvale
Henderson
Sturges Rd
Corban's Estate Ped
Ranui
Swanson
O'Neil's Road Ped
Henderson turnback and station upgrades
Lloyd Ave Ped
Grafton
Kingdon St Ped
Newmarket
Remuera
Greenlane
Ellerslie
Penrose
Penrose Siding
Te Papapa
Onehunga
Western zone feed at Glen Eden with 2 SFCs
Glen Innes
Panmure
Southdown Lane Siding
Sylvia Park
Takanini Siding
Otahuhu
Church St East Road and Ped
Westfield / Southdown
Middlemore
Papatoetoe
Puhinui
Manukau
Wiri POAL
Homai Station Ped
Wiri to Westfield 3rd Main
Homai
Manurewa
Te Mahia
Takanini
Tironui St Ped
Papakura
Maketuu
Ngākōroa
Paerata
Pukekohe
Electrification of the southern line between Papakura to Pukekohe, including the establishment of new mid zone with sectioning at Opaheke
Three new stations on the southern line
Group 1 Level Crossings Programme
Early safety improvements at pedestrian and road crossings to mitigate risks of increased train frequencies under the CRL Day 1 - Full Timetable, including installing gates at pedestrian crossings and completion of the LCSIA work-bank. This is the first stage of a comprehensive, network wide level crossings removal programme.
Total Fleet Size: 95
= 5 x 3-car equivalent units
New
Replaced

Auckland Rail Network Service Plan

Configuration State 0: City Rail Link

2021 — 2025 — 2031 — 2041 — 2051

Service concepts are indicative only. They are developed for the purpose of assessing infrastructure requirements and benefits of the programme – but should not be considered as final or recommended. The operating service concept and timetable will be confirmed via established processes involving KiwiRail, AT and other stakeholders outside of the PBC



Service	Frequency	Period	Span (hr)	Excl. Period Dur. (hr)	Train Length
South to CBD all-stops	4 per hr	All day	19[1]		3-car & 6-car
Papakura to CBD, peak overlay	2 per hr	Peak	4[2]		3-car & 6-car
Pukekohe to CBD limited stops peak overlay	2 per hr	Peak	4[2]		3-car & 6-car
East to West all-stops	4 per hr	All day	19[1]		3-car & 6-car
East to West all-stops peak overlay	4 per hr	Peak	4[2]		3-car & 6-car
Henderson to Onehunga all-stops	2 per hr	All day	4[2]		3-car
All Inter-Regional (H2A / Northern Explorer)	1 per hr	All day		None	4-car
Timetabled freight move					
NIMT	As specified	All day		None	
NAL	As specified	All day[3]		5 up / 5 down	
POAL	As specified	All day[3]		4 up /4 down	
Non-timetabled freight move	TBD	All day[4]			

1 Approx 5AM -12PM, with reduced service from 7PM
2. Total duration of AM and PM periods. Timing varies depending on period and line
3. Outside of AM and PM exclusion periods. Timing varies depending on direction. POAL also limited by hours of operation of port.
4. Exclusion periods may also apply to non-timetabled freight moves, depending on routing

Key

- Bi-directional service
- Uni-directional service**
- Off-peak path only
- Passenger stop
- Freight terminal
- 10/4 — Metro services per hour (peak/off-peak)
- 1 — Inter-regional services per hour
- 2x10'* — Freight services per hour and path width
- op — Off peak

*Only applicable when running with fast metro
**Arrows reverse in PM peak

Auckland Rail Network Infrastructure Plan

Configuration State 0-1: Western Line frequency enhancements

2021 — 2028 — 2031 — 2041 — 2051

Station facility upgrades:
Upgrades required to meet TDM standards, support growth (Decade 1) and interface with other PBC works (additional tracks, platform extensions, and adjacent level crossing removals).

Station types
- Type 1 - Rural
- Type 2 - Urban
- Type 3 - Hub
- Type 4 - Flagship

Optimised signalling territory

Waitematā
POAL
Strand
Te Wāi Hōrotiu
Karanga-a-hape
Parnell
Orakei
Meadowbank
Maunga-whau
Kingsland
Morningside
Baldwin Ave
Mt Albert
Avondale
New Lynn
Fruitvale Rd
Glen Eden
Sunnyvale
Henderson
Sturges Rd
Ranui
Swanson
Grafton
Newmarket
Remuera
Greenlane
Ellerslie
Penrose
Te Papapa
Onehunga
Penrose Siding
Glen Innes
Southdown Lane Siding
Panmure
Sylvia Park
Takanini Siding
Otahuhu
Westfield / Southdown
Middlemore
Papatoetoe
Puhinui
Manukau
Wiri POAL
Homai
Manurewa
Te Mahia
Takanini
Papakura
Maketuu
Ngākōroa
Paerata
Pukekohe

Bruce McLaren Rd crossing removal underway to support Henderson depot extension

Group 2-5 Level Crossings Removal Underway
- South Level Crossing
- Glen Innes North & South
- Inner West Level Crossing
- Outer South Level Crossing
- Outer West Level Crossing

Total Fleet Size: 95

= 5 x 3-car equivalent units New Replaced

Auckland Rail Network Service Plan

Configuration State 0-1: Western Line frequency enhancements

2021 — 2028 — 2031 — 2041 — 2051

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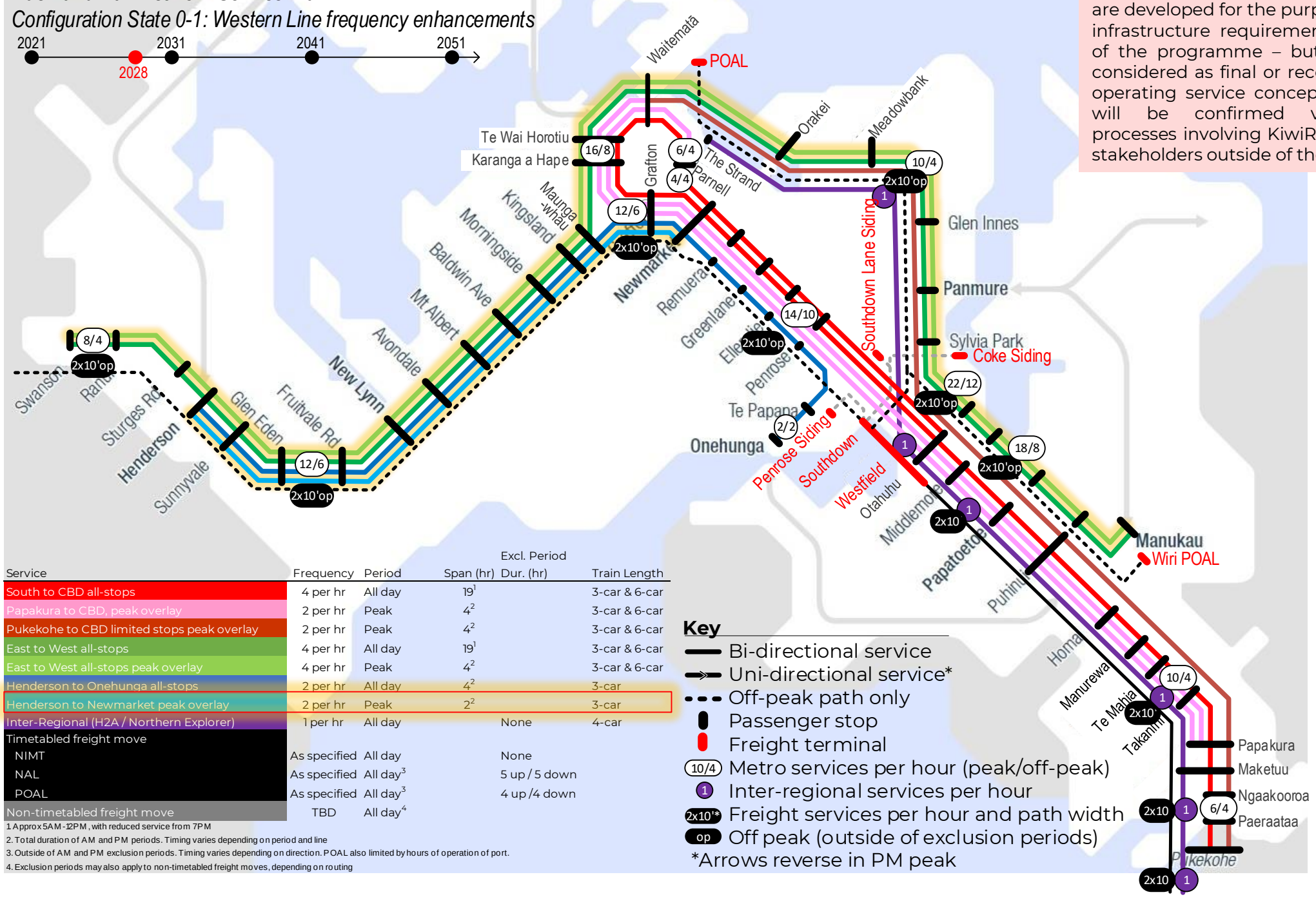


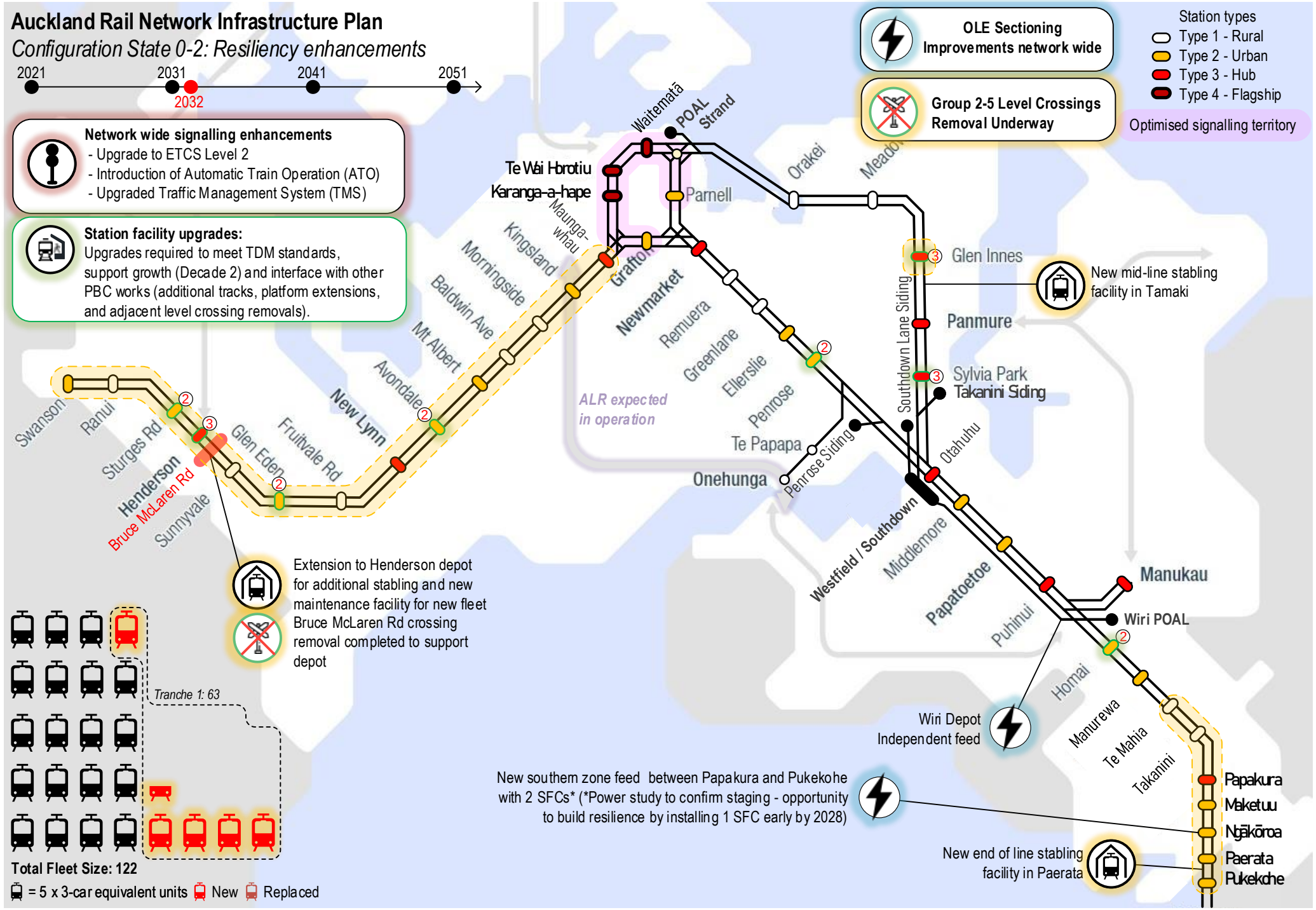
Service	Frequency	Period	Span (hr)	Excl. Period Dur. (hr)	Train Length
South to CBD all-stops	4 per hr	All day	19[1]		3-car & 6-car
Papakura to CBD, peak overlay	2 per hr	Peak	4[2]		3-car & 6-car
Pukekohe to CBD limited stops peak overlay	2 per hr	Peak	4[2]		3-car & 6-car
East to West all-stops	4 per hr	All day	19[1]		3-car & 6-car
East to West all-stops peak overlay	4 per hr	Peak	4[2]		3-car & 6-car
Henderson to Onehunga all-stops	2 per hr	All day	4[2]		3-car
Henderson to Newmarket peak overlay	2 per hr	Peak	2[2]		3-car
Inter-Regional (H2A / Northern Explorer)	1 per hr	All day		None	4-car
Timetabled freight move					
NIMT	As specified	All day		None	
NAL	As specified	All day[3]		5 up / 5 down	
POAL	As specified	All day[3]		4 up /4 down	
Non-timetabled freight move	TBD	All day[4]			

1 Approx 5AM -12PM , with reduced service from 7PM
2. Total duration of AM and PM periods. Timing varies depending on period and line
3. Outside of AM and PM exclusion periods. Timing varies depending on direction. POAL also limited by hours of operation of port.
4. Exclusion periods may also apply to non-timetabled freight moves, depending on routing

Key

- Bi-directional service
- Uni-directional service*
- Off-peak path only
- Passenger stop
- Freight terminal
- 10/4 — Metro services per hour (peak/off-peak)
- 1 — Inter-regional services per hour
- 2x10'* — Freight services per hour and path width
- op — Off peak (outside of exclusion periods)

*Arrows reverse in PM peak


Auckland Rail Network Infrastructure Plan
Configuration State 0-2: Resiliency enhancements
2021
2031
2032
2041
2051
Network wide signalling enhancements
- Upgrade to ETCS Level 2
- Introduction of Automatic Train Operation (ATO)
- Upgraded Traffic Management System (TMS)
Station facility upgrades:
Upgrades required to meet TDM standards, support growth (Decade 2) and interface with other PBC works (additional tracks, platform extensions, and adjacent level crossing removals).
OLE Sectioning Improvements network wide
Group 2-5 Level Crossings Removal Underway
Station types
Type 1 - Rural
Type 2 - Urban
Type 3 - Hub
Type 4 - Flagship
Optimised signalling territory
Waitematā
POAL
Strand
Te Wai Horotiu
Karanga-a-hape
Parnell
Orakei
Meadowbank
Maunga-whau
Kingsland
Morningside
Baldwin Ave
Mt Albert
Avondale
New Lynn
Fruitvale Rd
Glen Eden
Sturges Rd
Ranui
Swanson
Henderson
Bruce McLaren Rd
Sunnyvale
Grafton
Newmarket
Remuera
Greenlane
Ellerslie
Penrose
Te Papapa
Onehunga
Penrose Siding
ALR expected in operation
Glen Innes
Panmure
Sylvia Park
Takanini Siding
Southdown Lane Siding
Otahuhu
New mid-line stabling facility in Tamaki
Westfield / Southdown
Middlemore
Papatoetoe
Puhinui
Manukau
Wiri POAL
Homai
Manurewa
Te Mahia
Takanini
Papakura
Maketuu
Ngākōroa
Paerata
Pukekohe
Extension to Henderson depot for additional stabling and new maintenance facility for new fleet
Bruce McLaren Rd crossing removal completed to support depot
Tranche 1: 63
Total Fleet Size: 122
= 5 x 3-car equivalent units
New
Replaced
Wiri Depot
Independent feed
New southern zone feed between Papakura and Pukekohe with 2 SFCs* (*Power study to confirm staging - opportunity to build resilience by installing 1 SFC early by 2028)
New end of line stabling facility in Paerata

Auckland Rail Network Service Plan

Configuration State 0-2: Resiliency enhancements

2021 — 2031 — 2032 — 2041 — 2051

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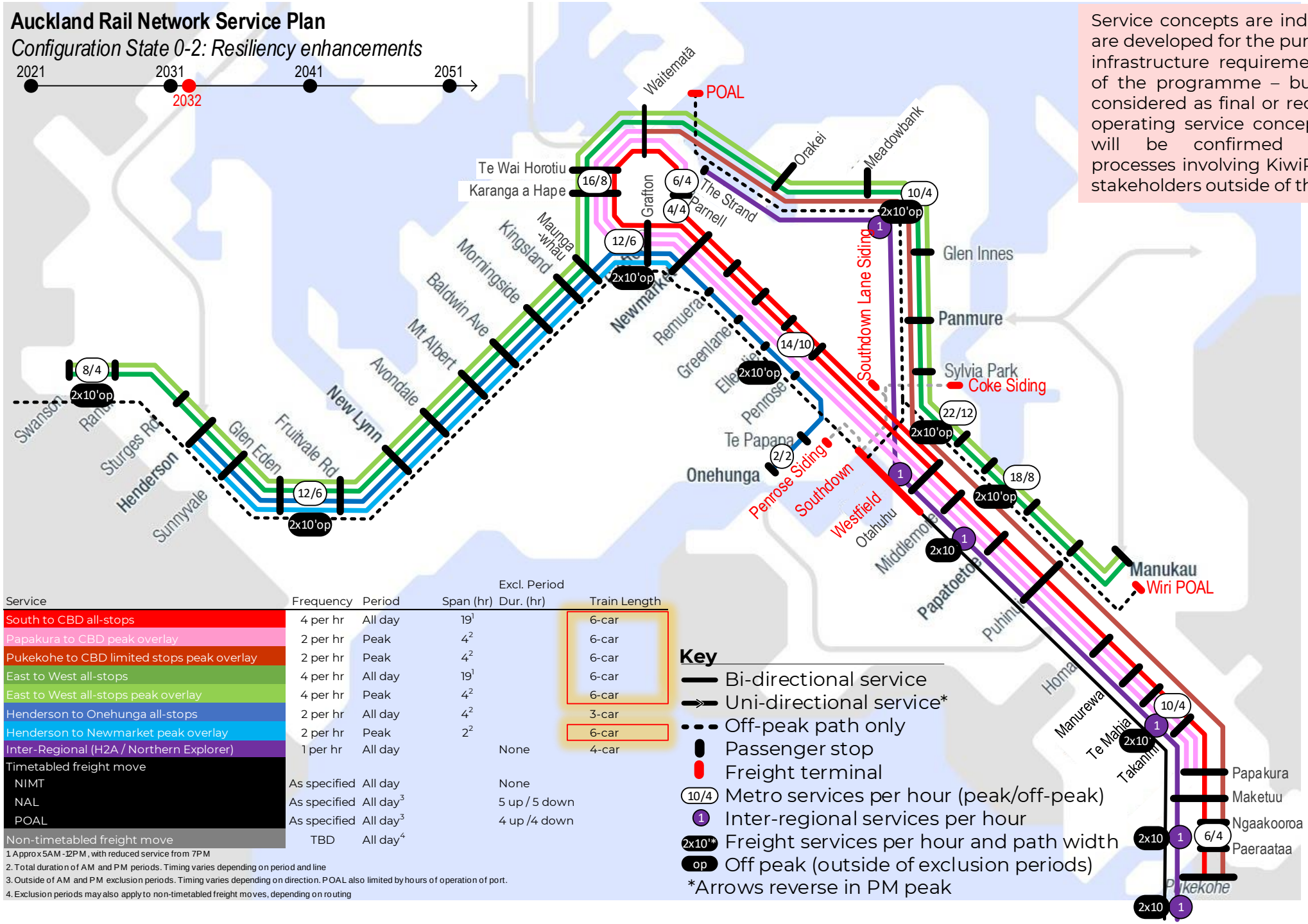


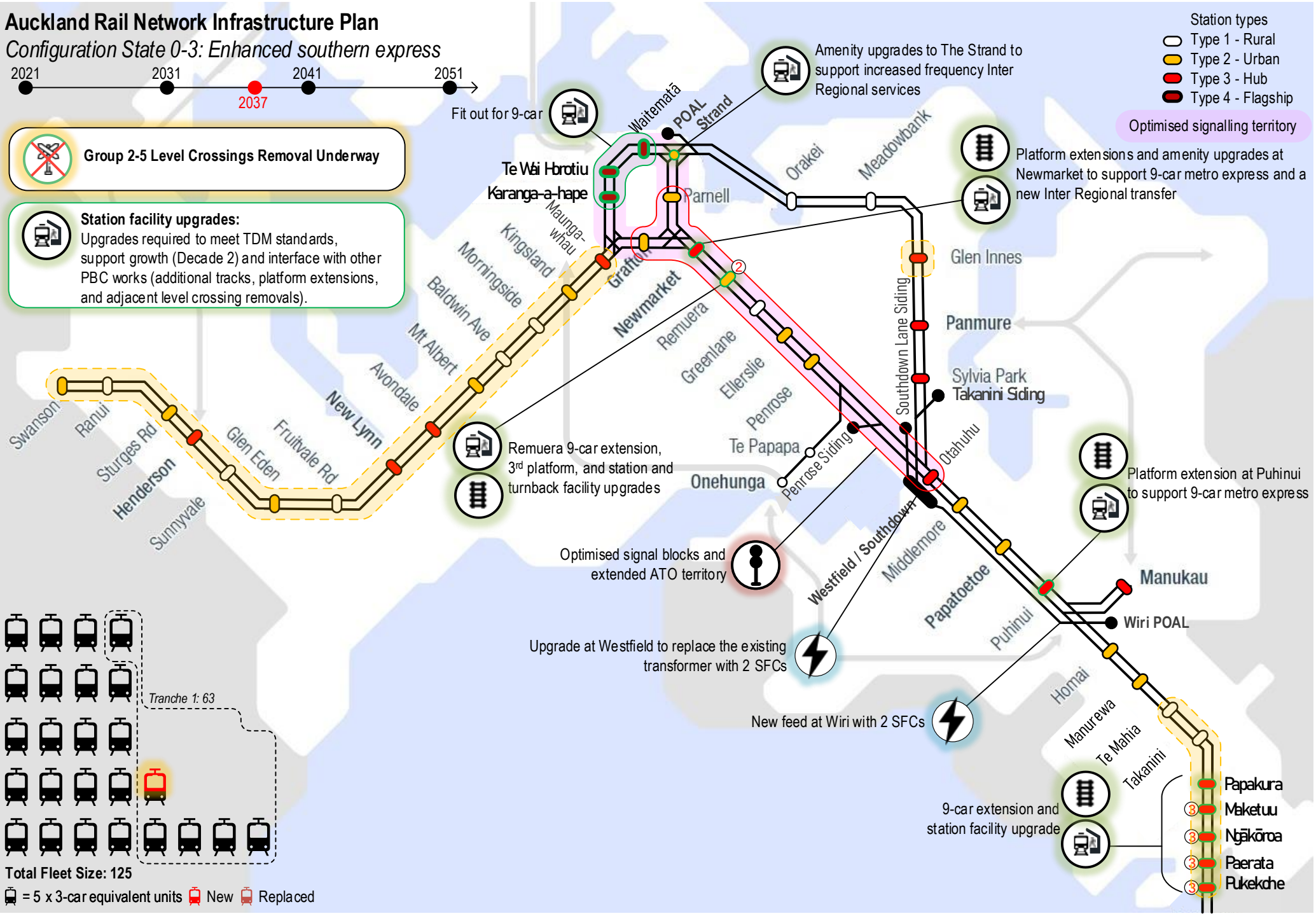
Service	Frequency	Period	Span (hr)	Excl. Period Dur. (hr)	Train Length
South to CBD all-stops	4 per hr	All day	19[1]		6-car
Papakura to CBD peak overlay	2 per hr	Peak	4[2]		6-car
Pukekohe to CBD limited stops peak overlay	2 per hr	Peak	4[2]		6-car
East to West all-stops	4 per hr	All day	19[1]		6-car
East to West all-stops peak overlay	4 per hr	Peak	4[2]		6-car
Henderson to Onehunga all-stops	2 per hr	All day	4[2]		3-car
Henderson to Newmarket peak overlay	2 per hr	Peak	2[2]		6-car
Inter-Regional (H2A / Northern Explorer)	1 per hr	All day		None	4-car
Timetabled freight move					
NIMT	As specified	All day		None	
NAL	As specified	All day[3]		5 up / 5 down	
POAL	As specified	All day[3]		4 up /4 down	
Non-timetabled freight move	TBD	All day[4]			

1 Approx 5AM -12PM , with reduced service from 7PM
2. Total duration of AM and PM periods. Timing varies depending on period and line
3. Outside of AM and PM exclusion periods. Timing varies depending on direction. POAL also limited by hours of operation of port.
4. Exclusion periods may also apply to non-timetabled freight moves, depending on routing

Key

- Bi-directional service
- Uni-directional service*
- Off-peak path only
- Passenger stop
- Freight terminal
- 10/4 — Metro services per hour (peak/off-peak)
- 1 — Inter-regional services per hour
- 2x10'* — Freight services per hour and path width
- op — Off peak (outside of exclusion periods)

*Arrows reverse in PM peak


Auckland Rail Network Infrastructure Plan
Configuration State 0-3: Enhanced southern express
2021
2031
2037
2041
2051
Group 2-5 Level Crossings Removal Underway
Station facility upgrades:
Upgrades required to meet TDM standards, support growth (Decade 2) and interface with other PBC works (additional tracks, platform extensions, and adjacent level crossing removals).
Station types
Type 1 - Rural
Type 2 - Urban
Type 3 - Hub
Type 4 - Flagship
Optimised signalling territory
Fit out for 9-car
Amenity upgrades to The Strand to support increased frequency Inter Regional services
Platform extensions and amenity upgrades at Newmarket to support 9-car metro express and a new Inter Regional transfer
Remuera 9-car extension, 3rd platform, and station and turnback facility upgrades
Optimised signal blocks and extended ATO territory
Upgrade at Westfield to replace the existing transformer with 2 SFCs
New feed at Wiri with 2 SFCs
Platform extension at Puhinui to support 9-car metro express
9-car extension and station facility upgrade
Te Wāi Hōrotiu
Karanga-a-hape
Waitematā
POAL
Strand
Parnell
Orakei
Meadowbank
Glen Innes
Panmure
Sylvia Park
Takanini Siding
Southdown Lane Siding
Otahuhu
Penrose Siding
Te Papapa
Onehunga
Penrose
Ellerslie
Greenlane
Remuera
Newmarket
Grafton
Maunga-whau
Kingsland
Morningside
Baldwin Ave
Mt Albert
Avondale
New Lynn
Fruitvale Rd
Glen Eden
Sturges Rd
Ranui
Swanson
Henderson
Sunnyvale
Westfield / Southdown
Middlemore
Papatoetoe
Puhinui
Manukau
Wiri POAL
Homai
Manurewa
Te Mahia
Takanini
Papakura
Maketuu
Ngākōroa
Paerata
Pukekohe
Tranche 1: 63
Total Fleet Size: 125
= 5 x 3-car equivalent units
New
Replaced

Auckland Rail Network Service Plan

Configuration State 0-3: Enhanced southern express

2021 — 2031 — 2037 — 2041 — 2051

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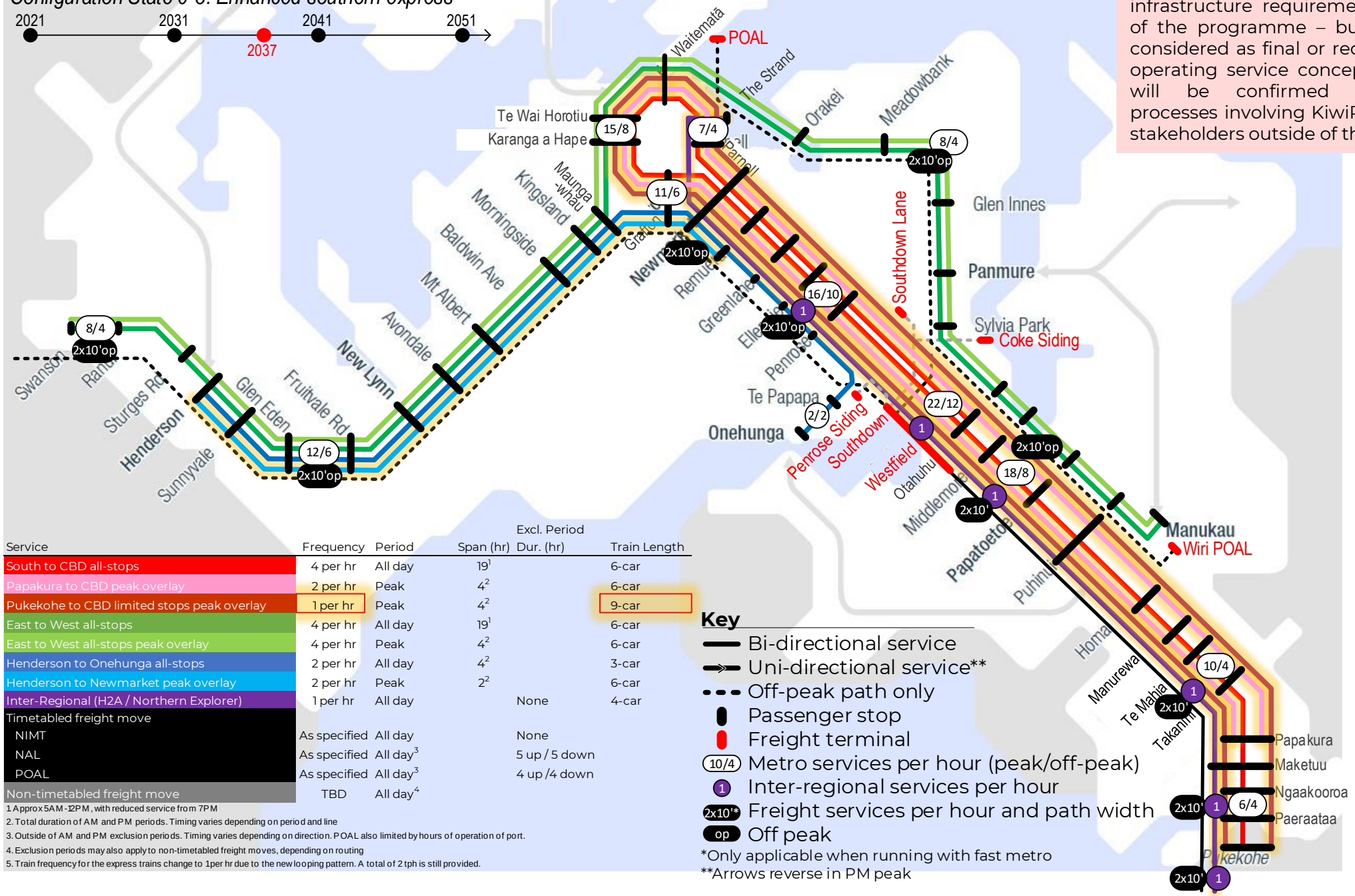


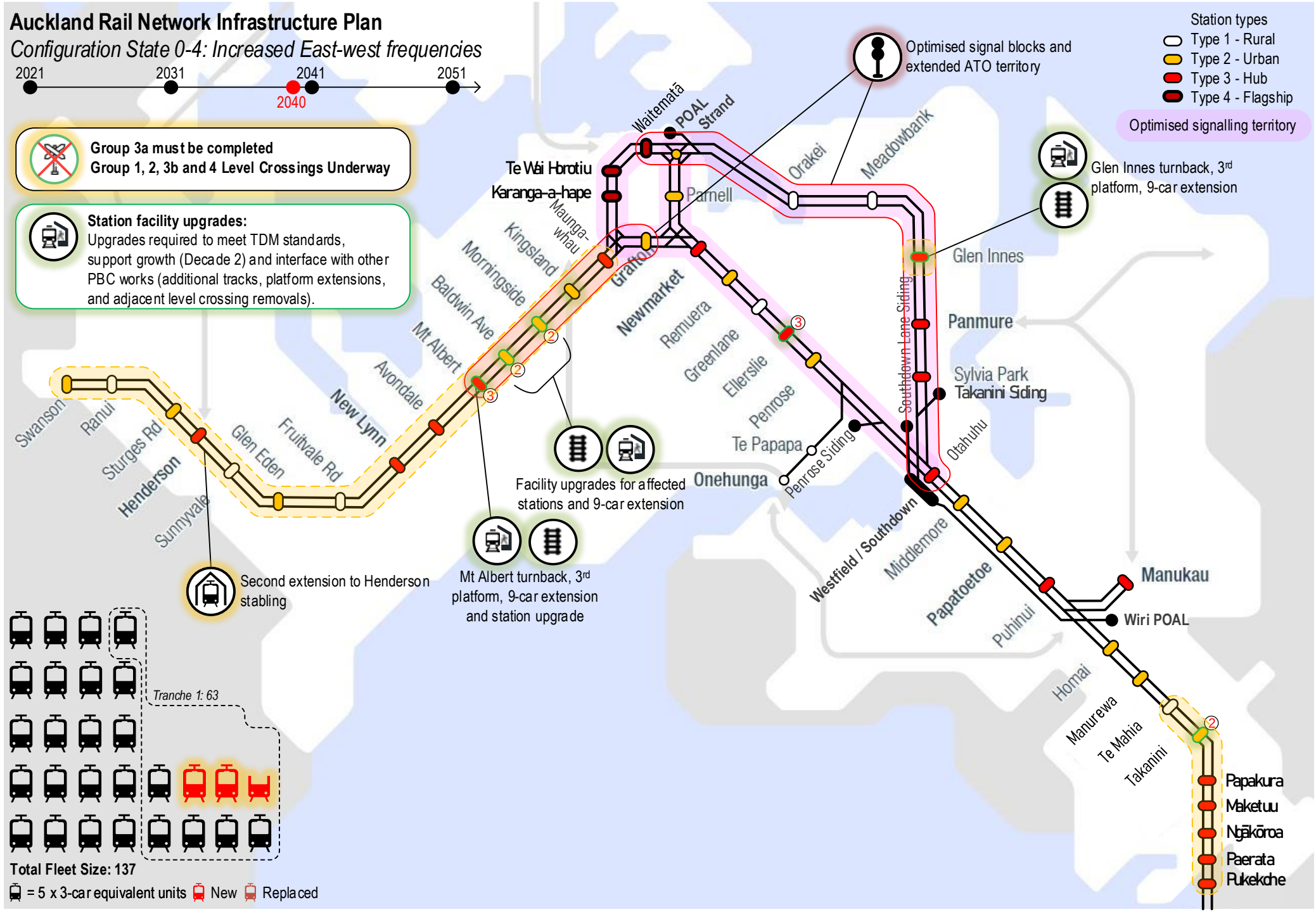
Service	Frequency	Period	Span (hr)	Excl. Period Dur. (hr)	Train Length
South to CBD all-stops	4 per hr	All day	19[1]		6-car
Papakura to CBD peak overlay	2 per hr	Peak	4[2]		6-car
Pukekohe to CBD limited stops peak overlay	1 per hr	Peak	4[2]		9-car
East to West all-stops	4 per hr	All day	19[1]		6-car
East to West all-stops peak overlay	4 per hr	Peak	4[2]		6-car
Henderson to Onehunga all-stops	2 per hr	All day	4[2]		3-car
Henderson to Newmarket peak overlay	2 per hr	Peak	2[2]		6-car
Inter-Regional (H2A / Northern Explorer)	1 per hr	All day		None	4-car
Timetabled freight move					
NIMT	As specified	All day		None	
NAL	As specified	All day[3]		5 up / 5 down	
POAL	As specified	All day[3]		4 up /4 down	
Non-timetabled freight move	TBD	All day[4]			

1. Approx 5AM-12PM, with reduced service from 7PM
2. Total duration of AM and PM periods. Timing varies depending on period and line
3. Outside of AM and PM exclusion periods. Timing varies depending on direction. POAL also limited by hours of operation of port.
4. Exclusion periods may also apply to non-timetabled freight moves, depending on routing
5. Train frequency for the express trains change to 1per hr due to the new looping pattern. A total of 2 tph is still provided.

Key

- Bi-directional service
- Uni-directional service**
- Off-peak path only
- Passenger stop
- Freight terminal
- 10/4 Metro services per hour (peak/off-peak)
- 1 Inter-regional services per hour
- 2x10'* Freight services per hour and path width
- op Off peak

*Only applicable when running with fast metro
**Arrows reverse in PM peak


Auckland Rail Network Infrastructure Plan
Configuration State 0-4: Increased East-west frequencies
2021
2031
2041
2040
2051
Group 3a must be completed
Group 1, 2, 3b and 4 Level Crossings Underway
Station facility upgrades:
Upgrades required to meet TDM standards, support growth (Decade 2) and interface with other PBC works (additional tracks, platform extensions, and adjacent level crossing removals).
Station types
Type 1 - Rural
Type 2 - Urban
Type 3 - Hub
Type 4 - Flagship
Optimised signalling territory
Optimised signal blocks and extended ATO territory
Glen Innes turnback, 3rd platform, 9-car extension
Facility upgrades for affected stations and 9-car extension
Mt Albert turnback, 3rd platform, 9-car extension and station upgrade
Second extension to Henderson stabling
Tranche 1: 63
Total Fleet Size: 137
= 5 x 3-car equivalent units
New
Replaced
Swanson
Ranui
Sturges Rd
Henderson
Sunnyvale
Glen Eden
Fruitvale Rd
New Lynn
Avondale
Mt Albert
Baldwin Ave
Morningside
Kingsland
Maunga-whau
Te Wāi Hōrotiu
Karanga-a-hape
Waitematā
POAL
Strand
Parnell
Grafton
Newmarket
Remuera
Greenlane
Ellerslie
Penrose
Te Papapa
Penrose Siding
Onehunga
Orakei
Meadowbank
Glen Innes
Southdown Lane Siding
Panmure
Sylvia Park
Takanini Siding
Otahuhu
Westfield / Southdown
Middlemore
Papatoetoe
Puhinui
Manukau
Wiri POAL
Homai
Manurewa
Te Mahia
Takanini
Papakura
Maketuu
Ngākōroa
Paerata
Pukekohe

Auckland Rail Network Service Plan

Configuration State 0-4: Increased East-west frequencies

2021 — 2031 — 2041 — 2051

2040

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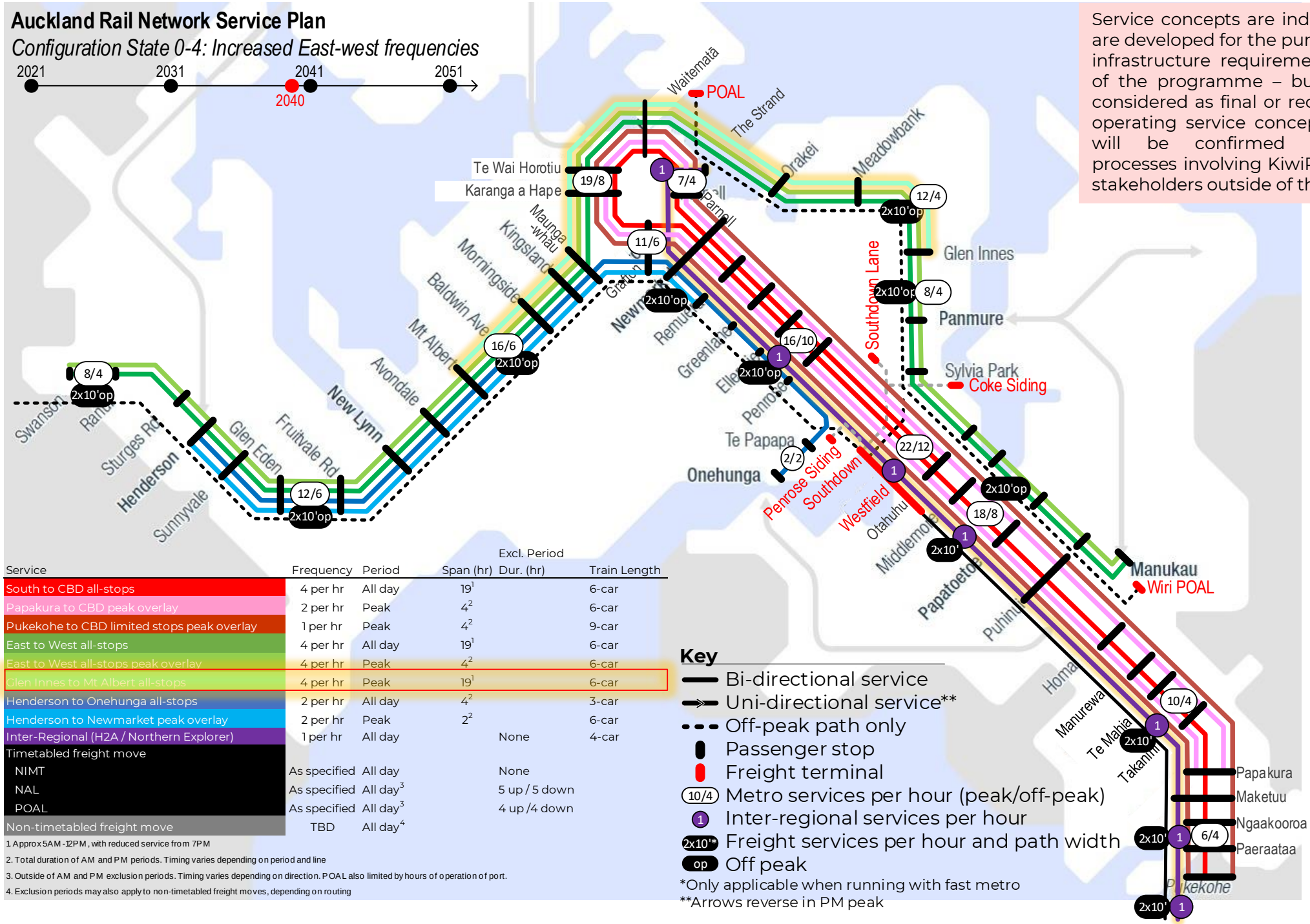


Service	Frequency	Period	Span (hr)	Excl. Period Dur. (hr)	Train Length
South to CBD all-stops	4 per hr	All day	19[1]		6-car
Papakura to CBD peak overlay	2 per hr	Peak	4[2]		6-car
Pukekohe to CBD limited stops peak overlay	1 per hr	Peak	4[2]		9-car
East to West all-stops	4 per hr	All day	19[1]		6-car
East to West all-stops peak overlay	4 per hr	Peak	4[2]		6-car
Glen Innes to Mt Albert all-stops	4 per hr	Peak	19[1]		6-car
Henderson to Onehunga all-stops	2 per hr	All day	4[2]		3-car
Henderson to Newmarket peak overlay	2 per hr	Peak	2[2]		6-car
Inter-Regional (H2A / Northern Explorer)	1 per hr	All day		None	4-car
Timetabled freight move					
NIMT	As specified	All day		None	
NAL	As specified	All day[3]		5 up / 5 down	
POAL	As specified	All day[3]		4 up /4 down	
Non-timetabled freight move	TBD	All day[4]			

1 Approx 5AM -12PM, with reduced service from 7PM

2. Total duration of AM and PM periods. Timing varies depending on period and line

3. Outside of AM and PM exclusion periods. Timing varies depending on direction. POAL also limited by hours of operation of port.

4. Exclusion periods may also apply to non-timetabled freight moves, depending on routing

Key

- Bi-directional service
- Uni-directional service**
- Off-peak path only
- Passenger stop
- Freight terminal
- 10/4 Metro services per hour (peak/off-peak)
- 1 Inter-regional services per hour
- 2x10'* Freight services per hour and path width
- op Off peak

*Only applicable when running with fast metro

**Arrows reverse in PM peak

Auckland Rail Network Infrastructure Plan

Configuration State 1: Southern capacity expansion

2021 — 2031 — 2041 — 2042 — 2051

Group 2 and 5 must be completed
Group 3b and 4 Level Crossings Underway

Station facility upgrades:
Upgrades required to meet TDM standards, support growth (Decade 3) and interface with other PBC works (additional tracks, platform extensions, and adjacent level crossing removals).

Station types
- Type 1 - Rural
- Type 2 - Urban
- Type 3 - Hub
- Type 4 - Flagship

Optimised signalling territory

Optimised signal blocks and extended ATO territory

Southern Line 4 tracking
- Adding two mains to the southern line between Pukekohe and Westfield junction, including all required corridor sanitisation.
- 9-car Extension from Otahuhu to Papatoetoe
- Grade separation of Westfield junction to separate freight and passenger movements
- Additional platforms on new tracks at all stations and associated vertical circulation

Extension to Paerata stabling

Tranche 1: 63

Total Fleet Size: 158

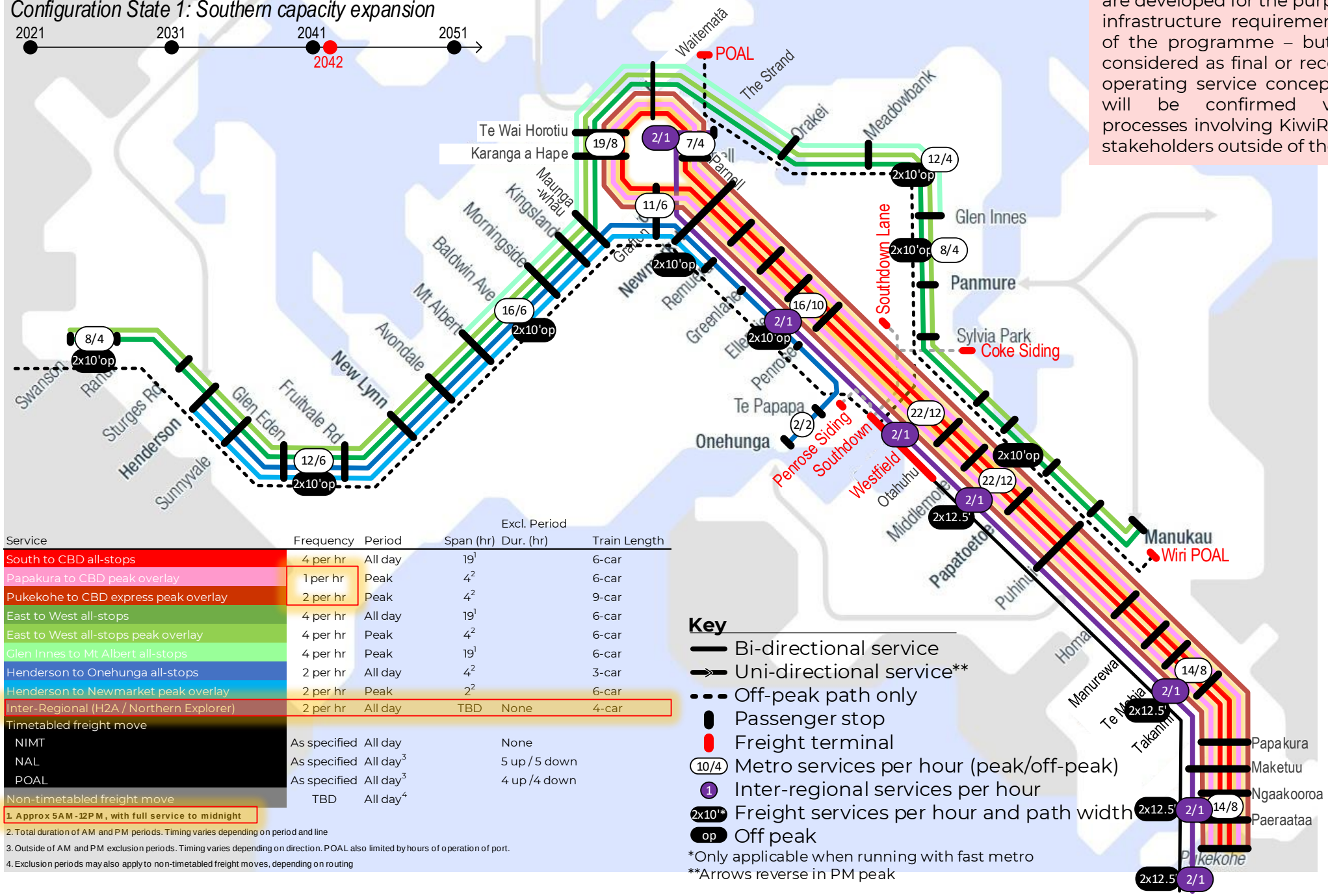
= 5 x 3-car equivalent units New Replaced

Auckland Rail Network Service Plan

Configuration State 1: Southern capacity expansion

2021 — 2031 — 2041 — 2042 — 2051

Service concepts are indicative only. They are developed for the purpose of assessing infrastructure requirements and benefits of the programme – but should not be considered as final or recommended. The operating service concept and timetable will be confirmed via established processes involving KiwiRail, AT and other stakeholders outside of the PBC



Service	Frequency	Period	Span (hr)	Excl. Period Dur. (hr)	Train Length
South to CBD all-stops	4 per hr	All day	19[1]		6-car
Papakura to CBD peak overlay	1 per hr	Peak	4[2]		6-car
Pukekohe to CBD express peak overlay	2 per hr	Peak	4[2]		9-car
East to West all-stops	4 per hr	All day	19[1]		6-car
East to West all-stops peak overlay	4 per hr	Peak	4[2]		6-car
Glen Innes to Mt Albert all-stops	4 per hr	Peak	19[1]		6-car
Henderson to Onehunga all-stops	2 per hr	All day	4[2]		3-car
Henderson to Newmarket peak overlay	2 per hr	Peak	2[2]		6-car
Inter-Regional (H2A / Northern Explorer)	2 per hr	All day	TBD	None	4-car
Timetabled freight move					
NIMT	As specified	All day		None	
NAL	As specified	All day[3]		5 up / 5 down	
POAL	As specified	All day[3]		4 up /4 down	
Non-timetabled freight move	TBD	All day[4]			

1. Approx 5AM-12PM, with full service to midnight
2. Total duration of AM and PM periods. Timing varies depending on period and line
3. Outside of AM and PM exclusion periods. Timing varies depending on direction. POAL also limited by hours of operation of port.
4. Exclusion periods may also apply to non-timetabled freight moves, depending on routing

Key

- Bi-directional service
- Uni-directional service**
- Off-peak path only
- Passenger stop
- Freight terminal
- 10/4 Metro services per hour (peak/off-peak)
- 1 Inter-regional services per hour
- 2x10'* Freight services per hour and path width
- op Off peak

*Only applicable when running with fast metro
**Arrows reverse in PM peak

Auckland Rail Network Infrastructure Plan

Configuration State 2: Wiri to Westfield additional capacity expansion

2021 — 2031 — 2041 — 2045 — 2051

Group 3b and 4 Level Crossings Underway

Station facility upgrades:
Upgrades required to meet TDM standards, support growth (Decade 3) and interface with other PBC works (additional tracks, platform extensions, and adjacent level crossing removals).

Station types
- Type 1 - Rural
- Type 2 - Urban
- Type 3 - Hub
- Type 4 - Flagship

Optimised signalling territory

Waitematā
POAL
Strand
Te Wai Horotiu
Karanga-a-hape
Maunga-whau
Parnell
Orakei
Meadowbank
Kingsland
Morningside
Baldwin Ave
Mt Albert
Avondale
New Lynn
Fruitvale Rd
Glen Eden
Sturges Rd
Henderson
Ranui
Swanson
Sunnyvale
Grafton
Newmarket
Remuera
Greenlane
Ellerslie
Penrose
Te Papapa
Penrose Siding
Onehunga
Glen Innes
Southdown Lane Siding
Panmure
Sylvia Park
Takanini Siding
Otahuhu
Westfield / Southdown
Middlemore
Papatoetoe
Puhinui
Manukau
Wiri POAL
Homai
Manurewa
Te Mahia
Takanini
Papakura
Maketuu
Ngākōroa
Paerata
Pukekohe

Major station upgrade at Panmure to support high ridership, comparable to city centre stations

Major station upgrade at New Lynn to support high ridership, comparable to city centre stations

Swanson third track with associated platform / station upgrade, 9-car extension

Wiri to Westfield 6 tracking
- Adding two mains between Wiri and Westfield junctions
- Additional platforms on new tracks at all stations and associated vertical circulation

Tranche 1: 63

Total Fleet Size: 158

= 5 x 3-car equivalent units New Replaced

Auckland Rail Network Service Plan

Configuration State 2: Wiri to Westfield additional capacity expansion

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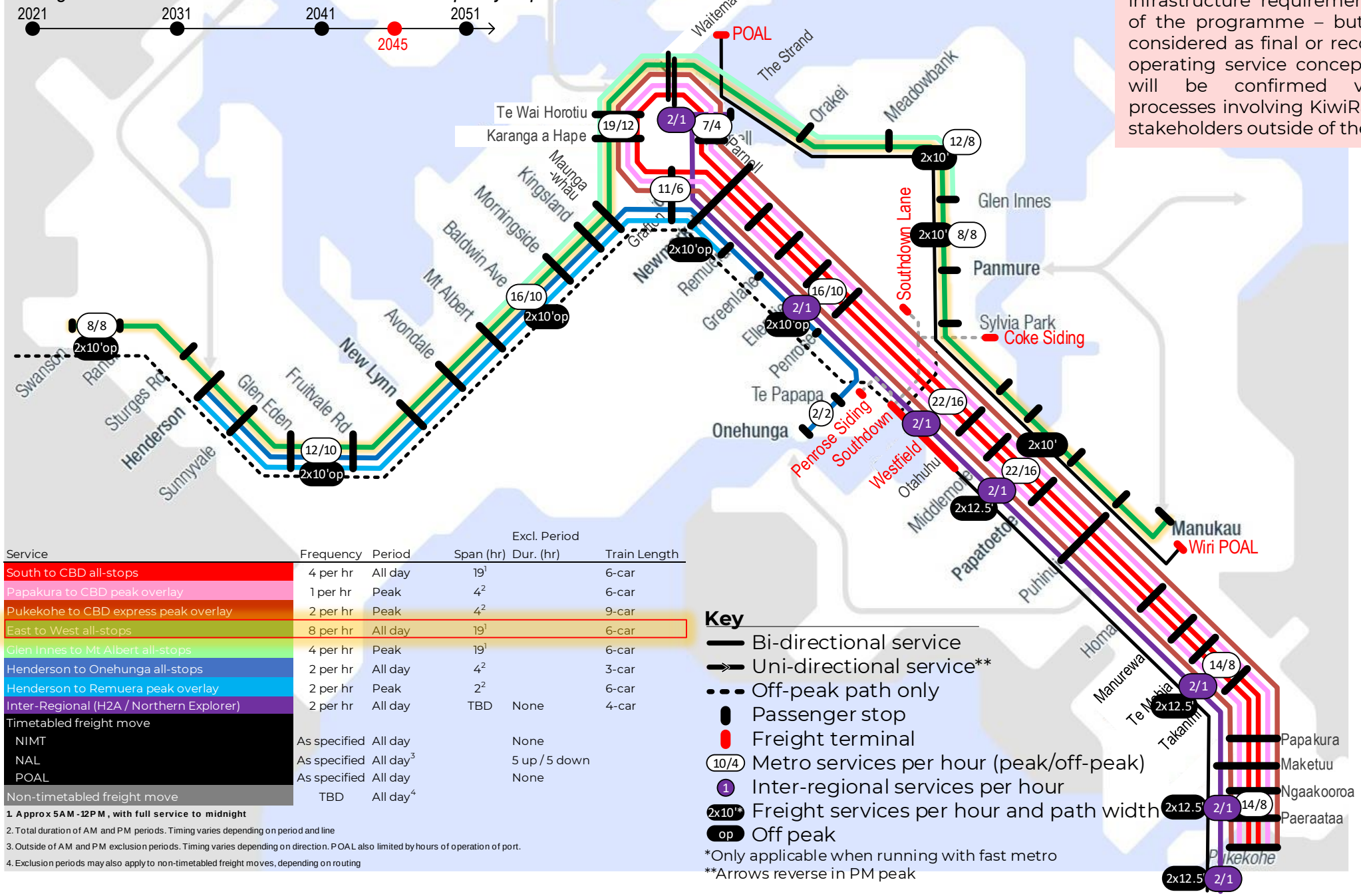


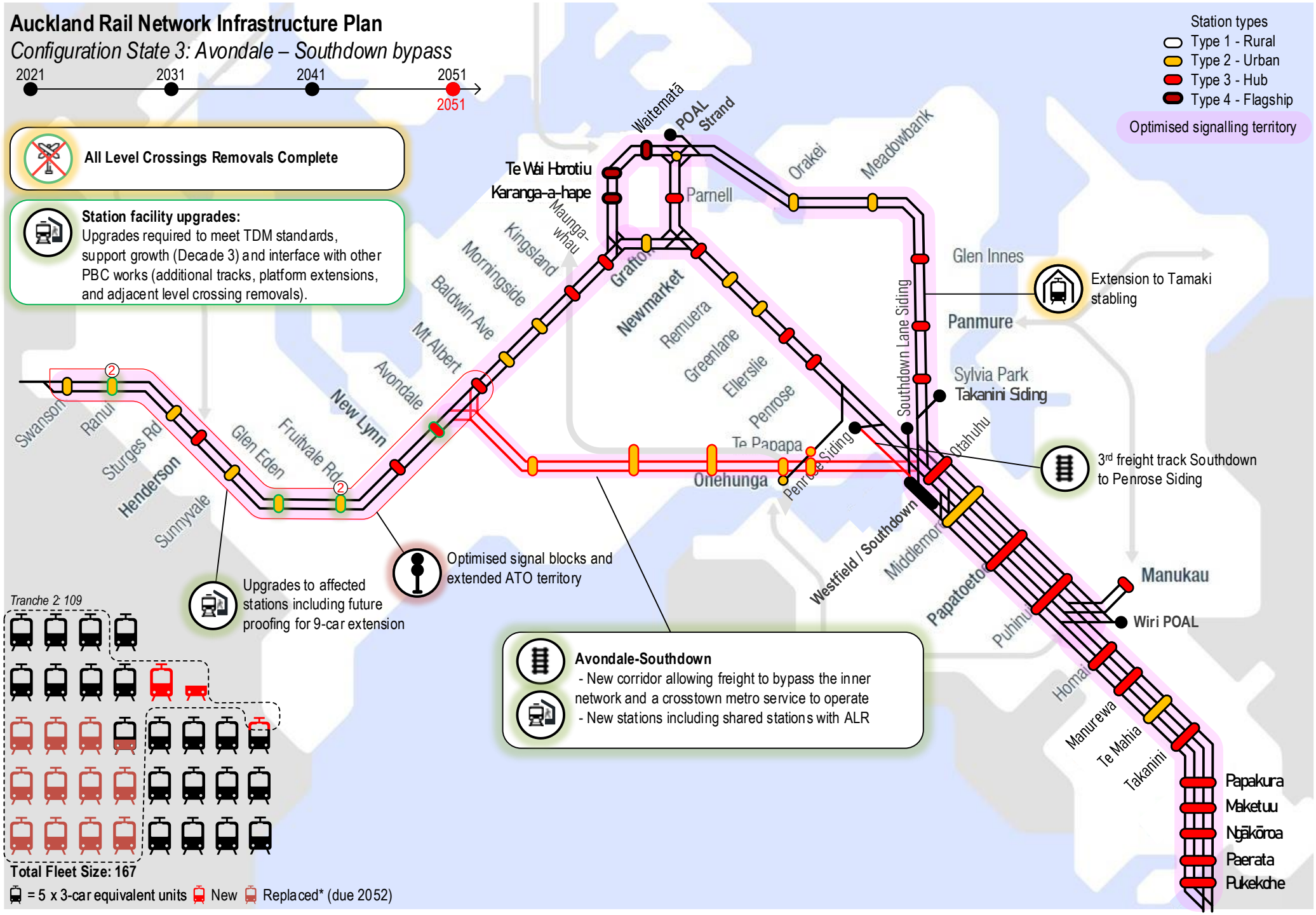
Service	Frequency	Period	Span (hr)	Excl. Period Dur. (hr)	Train Length
South to CBD all-stops	4 per hr	All day	19[1]		6-car
Papakura to CBD peak overlay	1 per hr	Peak	4[2]		6-car
Pukekohe to CBD express peak overlay	2 per hr	Peak	4[2]		9-car
East to West all-stops	8 per hr	All day	19[1]		6-car
Glen Innes to Mt Albert all-stops	4 per hr	Peak	19[1]		6-car
Henderson to Onehunga all-stops	2 per hr	All day	4[2]		3-car
Henderson to Remuera peak overlay	2 per hr	Peak	2[2]		6-car
Inter-Regional (H2A / Northern Explorer)	2 per hr	All day	TBD	None	4-car
Timetabled freight move					
NIMT	As specified	All day		None	
NAL	As specified	All day[3]		5 up / 5 down	
POAL	As specified	All day		None	
Non-timetabled freight move	TBD	All day[4]			

1. Approx 5AM-12PM, with full service to midnight
2. Total duration of AM and PM periods. Timing varies depending on period and line
3. Outside of AM and PM exclusion periods. Timing varies depending on direction. POAL also limited by hours of operation of port.
4. Exclusion periods may also apply to non-timetabled freight moves, depending on routing

Key

- Bi-directional service
- Uni-directional service**
- Off-peak path only
- Passenger stop
- Freight terminal
- 10/4 Metro services per hour (peak/off-peak)
- 1 Inter-regional services per hour
- 2x10'* Freight services per hour and path width
- op Off peak

*Only applicable when running with fast metro
**Arrows reverse in PM peak

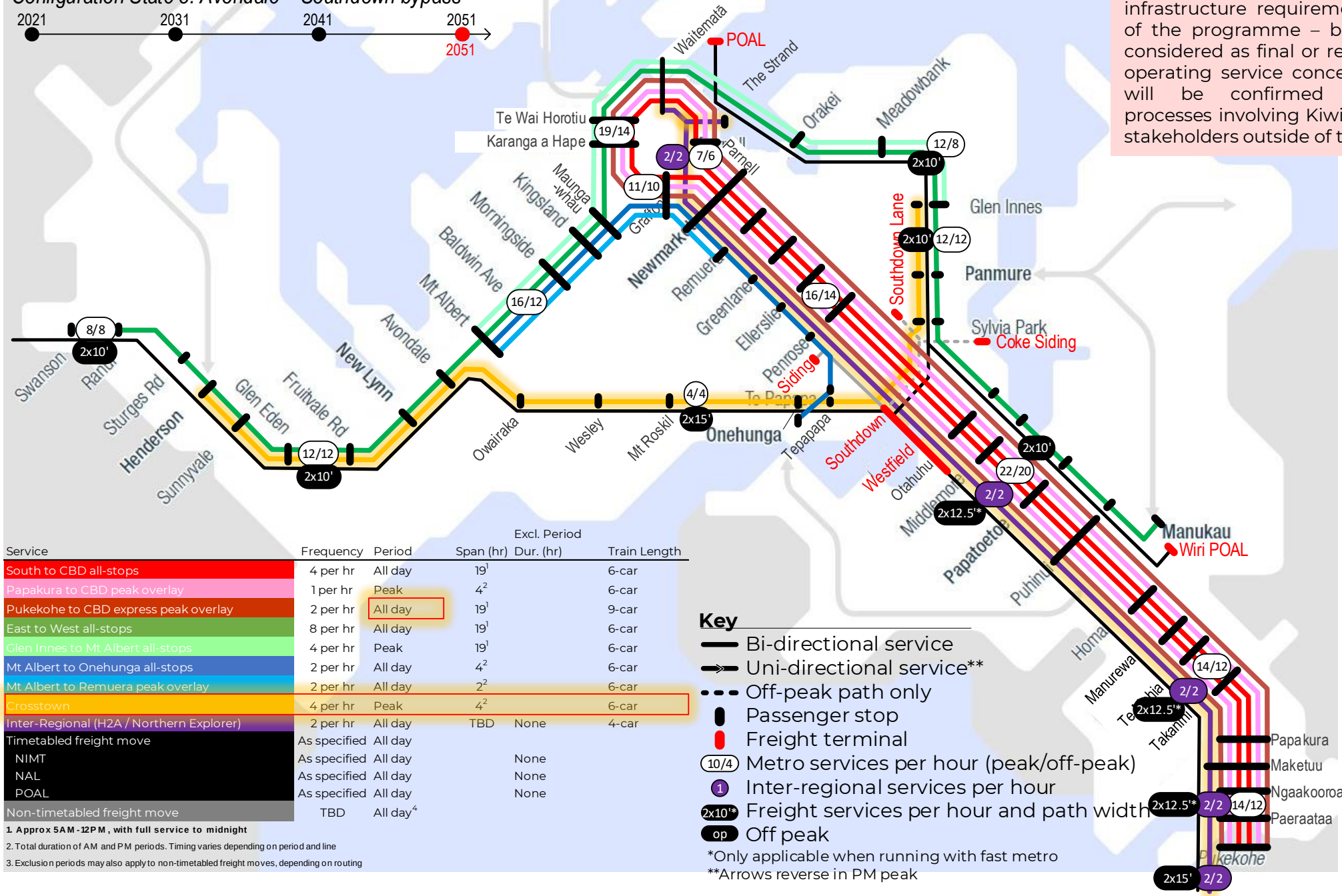

Auckland Rail Network Infrastructure Plan
Configuration State 3: Avondale – Southdown bypass
2021
2031
2041
2051
2051
All Level Crossings Removals Complete
Station facility upgrades:
Upgrades required to meet TDM standards, support growth (Decade 3) and interface with other PBC works (additional tracks, platform extensions, and adjacent level crossing removals).
Station types
Type 1 - Rural
Type 2 - Urban
Type 3 - Hub
Type 4 - Flagship
Optimised signalling territory
Waitematā
POAL
Strand
Te Wai Hbrotiu
Karanga-a-hape
Parnell
Orakei
Meadowbank
Maunga-whau
Kingsland
Morningside
Baldwin Ave
Mt Albert
Avondale
Grafton
Newmarket
Remuera
Greenlane
Ellerslie
Penrose
Te Papapa
Onehunga
Penrose Siding
Glen Innes
Extension to Tamaki stabling
Panmure
Sylvia Park
Takanini Siding
Southdown Lane Siding
Otahuhu
3rd freight track Southdown to Penrose Siding
Swanson
Ranui
Sturges Rd
Henderson
Sunnyvale
Glen Eden
Fruitvale Rd
New Lynn
Optimised signal blocks and extended ATO territory
Upgrades to affected stations including future proofing for 9-car extension
Westfield / Southdown
Middlemore
Papatoetoe
Puhinui
Manukau
Wiri POAL
Homai
Manurewa
Te Mahia
Takanini
Papakura
Maketuu
Ngākōroa
Paerata
Pukekohe
Avondale-Southdown
- New corridor allowing freight to bypass the inner network and a crosstown metro service to operate
- New stations including shared stations with ALR
Tranche 2: 109
Total Fleet Size: 167
= 5 x 3-car equivalent units
New
Replaced* (due 2052)

Auckland Rail Network Service Plan

Configuration State 3: Avondale – Southdown bypass

2021 — 2031 — 2041 — 2051

Service concepts are indicative only. They are developed for the purpose of assessing infrastructure requirements and benefits of the programme – but should not be considered as final or recommended. The operating service concept and timetable will be confirmed via established processes involving KiwiRail, AT and other stakeholders outside of the PBC



Service	Frequency	Period	Span (hr)	Excl. Period Dur. (hr)	Train Length
South to CBD all-stops	4 per hr	All day	19[1]		6-car
Papakura to CBD peak overlay	1 per hr	Peak	4[2]		6-car
Pukekohe to CBD express peak overlay	2 per hr	All day	19[1]		9-car
East to West all-stops	8 per hr	All day	19[1]		6-car
Glen Innes to Mt Albert all-stops	4 per hr	Peak	19[1]		6-car
Mt Albert to Onehunga all-stops	2 per hr	All day	4[2]		6-car
Mt Albert to Remuera peak overlay	2 per hr	All day	2[2]		6-car
Crosstown	4 per hr	Peak	4[2]		6-car
Inter-Regional (H2A / Northern Explorer)	2 per hr	All day	TBD	None	4-car
Timetabled freight move	As specified	All day			
NIMT	As specified	All day		None	
NAL	As specified	All day		None	
POAL	As specified	All day		None	
Non-timetabled freight move	TBD	All day[4]			

1. Approx 5AM-12PM, with full service to midnight
2. Total duration of AM and PM periods. Timing varies depending on period and line
3. Exclusion periods may also apply to non-timetabled freight moves, depending on routing

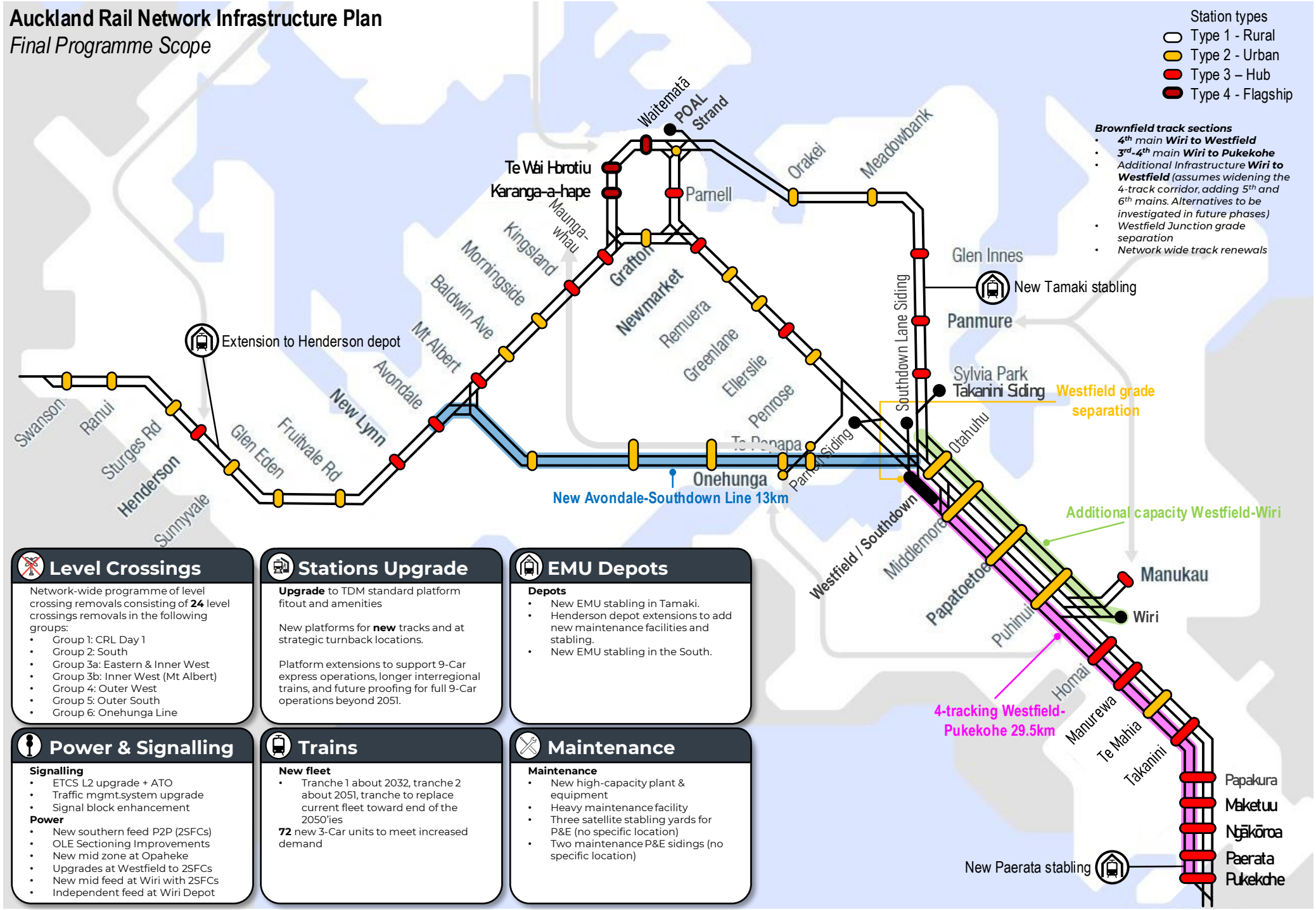
Key

- Bi-directional service
- Uni-directional service**
- Off-peak path only
- Passenger stop
- Freight terminal
- 10/4 Metro services per hour (peak/off-peak)
- 1 Inter-regional services per hour
- 2x10'* Freight services per hour and path width
- op Off peak

*Only applicable when running with fast metro
**Arrows reverse in PM peak

Auckland Rail Network Infrastructure Plan

Final Programme Scope



Level Crossings

Network-wide programme of level crossing removals consisting of **24** level crossings removals in the following groups:

- Group 1: CRL Day 1
- Group 2: South
- Group 3a: Eastern & Inner West
- Group 3b: Inner West (Mt Albert)
- Group 4: Outer West
- Group 5: Outer South
- Group 6: Onehunga Line

Stations Upgrade

Upgrade to TDM standard platform fitout and amenities

New platforms for **new** tracks and at strategic turnback locations.

Platform extensions to support 9-Car express operations, longer interregional trains, and future proofing for full 9-Car operations beyond 2051.

EMU Depots

Depots

- New EMU stabling in Tamaki.
- Henderson depot extensions to add new maintenance facilities and stabling.
- New EMU stabling in the South.

Power & Signalling

Signalling

- ETCS L2 upgrade + ATO
- Traffic mgmt.system upgrade
- Signal block enhancement

Power

- New southern feed P2P (2SFCs)
- OLE Sectioning Improvements
- New mid zone at Opaheke
- Upgrades at Westfield to 2SFCs
- New mid feed at Wiri with 2SFCs
- Independent feed at Wiri Depot

Trains

New fleet

- Tranche 1 about 2032, tranche 2 about 2051, tranche to replace current fleet toward end of the 2050'ies

72 new 3-Car units to meet increased demand

Maintenance

Maintenance

- New high-capacity plant & equipment
- Heavy maintenance facility
- Three satellite stabling yards for P&E (no specific location)
- Two maintenance P&E sidings (no specific location)

7.2 Comparison to the Final Preferred Programme

Final Preferred Programme

The final preferred 2051 end state arrived at through the optioneering process documented in the Options Report Part 1, differs from the final 2051 end state arrived at the end of the optioneering process described in this Part 2 report. The two end states are compared in Figure 7B (next page). This is due partly to the refinements documented in Section 3, and refinements resulting from the development of the phasing documented in Sections 4 - 6.

The differences are summarised in Table 7A below with an assessment on how these changes would impact the performance of the programme against the investment objectives.

This assessment shows that the benefits of the original 2051 end state have been largely retained, and in some cases enhanced.

The total cost of the Final Preferred Programme at short list assessment was estimated to be $25-35B where the revised programme currently sits at approximately $25B (P50).

The economic assessment undertaken at short list yielded a BCR of 0.58-0.84 while the latest assessment yields a BRC range of 0.82-0.93* under the base case, demonstrating the original benefits of the programme have been retained or enhanced through the refinement process.

* the BCRs reported here are not final. They are the interim values presented at the workshops to aid decision making. The final BCR is provided in the Economic Case

Table 7A: Comparison of 2051 end state of the Part 1 and Part 2 options report

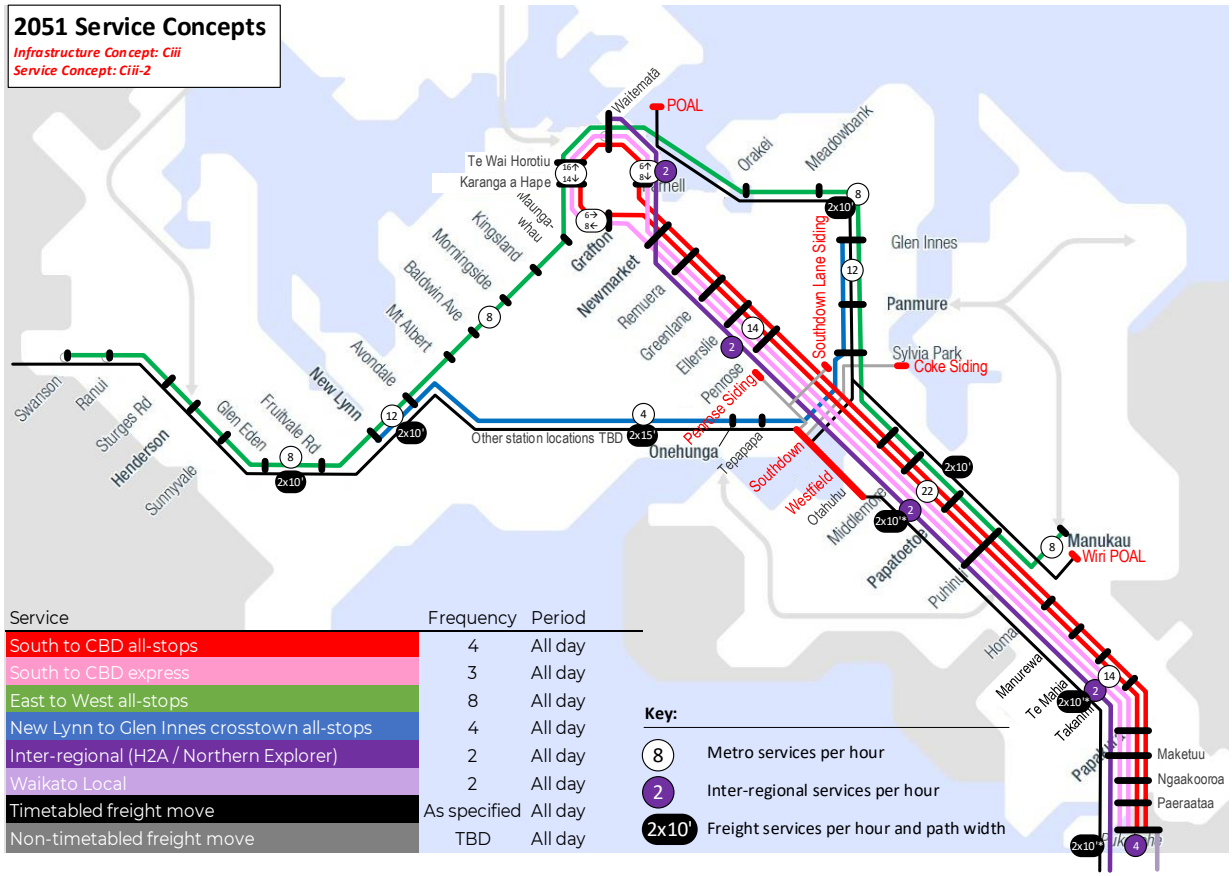
Element	Previous	Revised	Assessment
OBL	Removed in 2051	Retained in 2051 pending further assessment in later phases once there is greater certainty around the key interacting projects of ALR and Avondale – Southdown. The service is terminated in Mt Albert as opposed to the existing terminal at Henderson due to interaction with Avondale – Southdown west of Mt Albert, and adds 2tph to Newmarket	This results in a slight opex cost increase but improves attractiveness of rail for passengers on the Western Line, inner Southern line and the OBL,
Avondale-Southdown	Terminated at New Lynn	Extended to Henderson	Again, results in a slight opex increase but improves attractiveness of passenger rail and better supports denser urban form by expanding the A-S crosstown service catchment.

Final Preferred Programme

Table 7A: Comparison of 2051 end state of the Part 1 and Part 2 options report (continued…)

Element	Previous	Revised	Assessment
East-West Capacity	Full 9-car operation	6-car operation, but with a 4tph GI to Mt Albert overlay. The programme also makes provision for future 9-car operations by extended platforms where stations are impacted by other projects. (63% of all platforms are ultimately extended)	Provides the same level of capacity but more economically (as it requires less infrastructure and rolling stock investment) while also improves attractiveness of passenger rail by increasing frequencies through the CRL and on the East and West lines.
Southern Line Express	6tph operating all day	4tph operating all day	Slightly reduced level of attractiveness but overall Southern Line capacity still maintained at an acceptable quality of service and is better sized to demand (previous service concept provided a significant excess of capacity). Provides better reliability on the Southern Corridor western mains and therefore represents a better outcome over all markets.
Inter Regional	Terminated at Britomart	Terminated at the Stand	Reduced attractiveness, however routing of the Inter Regional service via Newmarket is expected to provide considerable connectivity benefits for Inter Regional customers.
Southern Line Capacity	Full 9-car operation	9-car only for express services	Not expected to have a significant impact on attractiveness. Southern Line capacity still maintained at an acceptable quality of service and is better sized to demand (previous service concept provided a significant excess of capacity) with 9-car provided on the services that are expected to be most attractive and experience over crowding earliest in the programme.

Final Preferred Programme



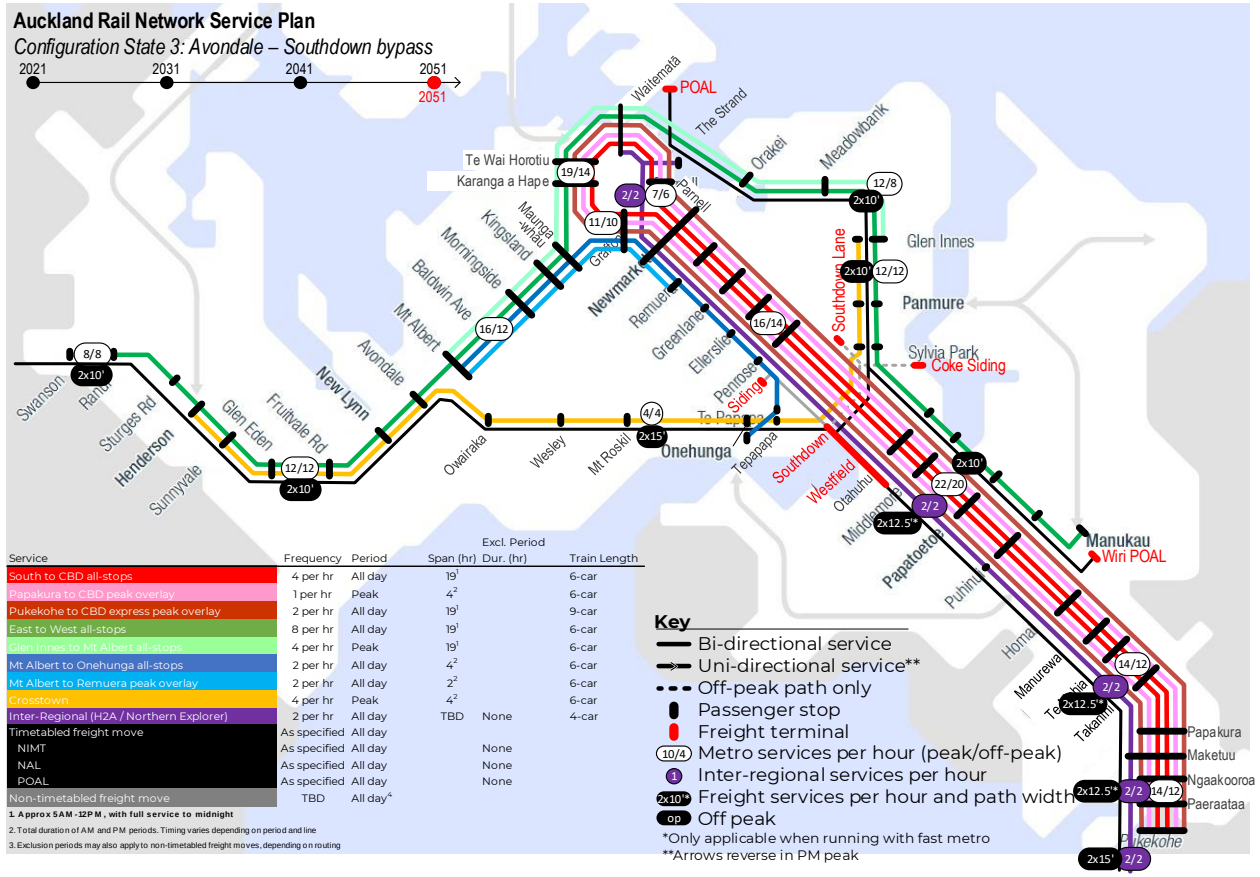


Figure 7B: Final preferred 2051 end state service concept in part 1 (left), and in part 2 (right)

8 Insights and Uncertainties

Key Insights and Uncertainties

1) Demand Modelling Freight / Port Assumptions

- Freight demand modelling for the PBC is drawn from the national freight demand model initially developed for the Ministry of Transport in 2017/18 and which has continued to be updated with new information.
- Based on this forecast freight demand, a range of future scenarios were developed for KiwiRail's concurrent Freight Decarbonisation Indicative Business Case (which have also been adopted for use in this PBC and other BCs).
- Port decisions are beyond the scope of the PBC but **are fundamental to road versus rail freight outcomes**. Hence, the scenarios enable us to understand the potential futures that may occur and the effect these have on demand on the rail network.
    - It is recognised that the scenarios provide a "triangulation" of different futures – and that the real world is most likely to be somewhere in between. This triangulation is important to allow us to understand the potential impacts to the investment programme.
    - The scenarios provide us with decade way-points 2032, 2042 and 2052. To enable alignment with metro projections, the PBC has extrapolated linearly between decades
    - Scenario development pre-dates the Transport relief package of fuel excise relief and RUC subsidies to road (shortly to end)
    - The PBC has used scenario B1 (cap PoAL) as the base case, consistent with other BCs
        - Not the highest volume, nor lowest overall.
        - indicates that demand will spill from approx. 2032 unless longer trains can be enabled, which is not expected to be possible until 4 tracking W-Puke can be fully implemented in 2042. Some pressure valves exist (e.g. Ruakura)
- **The major outcome of the scenario analysis is that 4-tracking of the southern corridor is the number one priority for investment in ALL scenarios, with different futures tending only to increase the need for its implementation.**
    - Even under the lowest freight demand scenario (high growth PoAL) 4 tracking is required as this is in any case also triggered by the need for metro express & inter-regional passenger services in a similar timeframe
    - Urgency for certain elements of the programme, such as Avondale-Southdown of the Wiri – Westfield additional capacity expansion, vary depending on scenario.
    - However, it is important to be careful to balance scenarios as B1 assumes no growth to Northport or POAL, which risks under-representing future demands on NAL and NIMT-E. Therefore, the PBC has performed a sense check on these recommendations for resilience across scenarios, as the actual state is likely to be somewhere in between
    - Any port move is a process and in practice it may take longer or be more gradual than the step change forecasts imply on their face.
- **Further discussion on the impact of scenarios will be provided in the Scenarios**.

Key Insights and Uncertainties

2) Demand impact of COVID 19

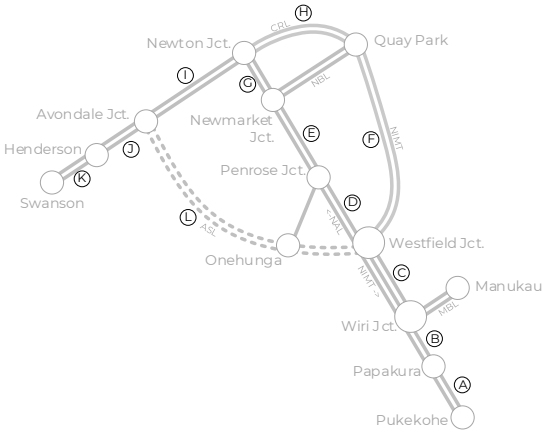
- Passenger demand modelling for the PBC does not account for the short-term impacts of the COVID 19 pandemic on ridership. These effects are being compounded by the current Rail Network Rebuild programme which is closing large parts of the network for long periods of time. The overall impact of these two effects is that rail patronage is sitting at around 65% of pre-COVID demand
- Relatedly, impacts to the freight network have also occurred due to transport relief package which has subsidised fuel and RUCs thereby adversely impacting rail freight by subsidising its road competitors
- The view adopted in the PBC is that COVID impacts are a short-term effect, which will be recovered from in the near to long term and has therefore essentially ignored its impact in demand modelling using MSM over the 30-year period.
- This is justified based on the following key features of the investment strategy:
    - In order to meet ERP targets, ridership will need to grow at a substantially higher rate that what has been assumed in base demands
    - The PBC puts forward a plan that is fundamentally constrained, acknowledging that infrastructure is unlikely to be delivered in time to meet demand, lagging demand by around 10 years under the base scenario. The long lead times and step change nature of the programme means that regardless of short-term impacts of COVID and closures, work needs to get underway as soon as possible

3) Capacity for future growth and & resilience

- In the short – medium term CRL will transform service levels for metro but the Auckland rail network will become quite constrained and forecast to operate close to 100% utilisation
- A core objective of the PBC is to enable growth in metro, freight and inter regional services operating on the network today, providing major economic, environmental and social benefits to the Auckland Region and nationally
- In addition, the PBC has adopted an approach to planning which acknowledges that the railway is an open network and that:
    - Smaller players seek access (e.g. heritage operators)
    - New operators / markets are likely to arise on the network over time that will require capacity to operate. This could include an expansion of inter-regional rail service for example.
- In the long-term (2051 state) the approach has been to protect 25% of capacity to support this growth (new users), and provide greater flexibility to existing users of the network to change plans according to changing conditions. Furthermore, the 25% spare capacity target accounts for a level of inaccuracy in planning at a PBC level. There will be train movements on the network that are beyond the scope of the PBC to quantify in detail but will nevertheless exist and consume capacity. For example empty EMU moves to and from stabling, light locomotive moves, work car moves, etc.
- In the interim, capacity is likely to be scarce and planning compromises to enable new operators could be needed. Critically, until 4 tracking of the southern corridor is complete, the mixed mode operation will suppress potential capacity due to diseconomies and limitations of running all stops, limited express, regional and freight on the same track

Key Insights and Uncertainties

- The PBC does not reach full segregation of less compatible customer services (e.g. all stops metro vs express/ freight) but continues to recommend increasing segregation over time. However in areas of the network where additional tracks are not provided to segregate traffic, higher levels of capacity (and therefore more efficient utilisation) are provided via signalling enhancements.
- It is also important to note that the PBC does not achieve the 75% target on all parts of the network and where it is achieved, it is not the primary driver for infrastructure intervention.
- The final peak utilisation of each segment of the network is shown in Table 8A. Note that the 75% utilisation target is exceeded on the eastern corridor (Segment F) and in the CRL (Segment H). On the eastern corridor capacity will be improved through signalling enhancements via ETCS Level 2, however, to meet the 75% target, additional tracks would need to be added to segregate port freight and metro services which was assessed as being poor value for money given the low marginal benefits for this particular segment. In the case of the CRL, achieving the 75% is clearly not feasible given the constraints of the tunnels and ventilation configuration.
- In the case of the southern corridor, the 75% target is achieved through the provision of four tracking. However it should be noted that the primary driver for four tracking is to provide capacity for all markets and meet reasonable standards of service in terms of crowding and headway homogeneity as described in detail in Section 4.1 and Appendix B. The 75% utilisation target is not a primary driver of the four-track investment but once achieved, does provide additional benefits in terms of flexibility and accommodation of future and unplanned growth which adds to the overall investment case for this 100 year asset.



NOTES:
- Segment C is divided in two; Wiri junction to Otahuhu and Otahuhu to Westfield junction.
- E=Eastern Main (for 4-track corridor), W=Western Main (for 4-track corridor), C=Centre Main (for 6-track corridor), Frt=Freight Main (for Westfield to Penrose siding only), M=Mains (for 2-track corridor)

Table 8A: Capacity utilisation in 2051

A		B		C-1				C-2			D		E	F	G	H	I	J	K	L
PUK-PAP		PAP-WIR		WIR-OTU				OTU-WSF			WSF-PNR		PNR-NMJ	WSF-QPJ	NMJ-NTJ	QPJ-NTJ	NTJ-AVJ	AVJ-HND	HND-SWN	WSJ-ASJ
E	W	E	W	E	C	W	3rd	E	W	3rd	M	Frt	M	M	M	M	M	M	M	M
58%	42%	42%	58%	58%	42%	58%	N/A	67%	58%	N/A	58%	N/A	75%	83%	55%	79%	67%	75%	58%	58%

Key Insights and Uncertainties

4) CRL Opening Day Timetable

- *Caveat – the decisions on timetabling sit outside of the PBC, as does the formal review and approval process. The assumptions made in the PBC are considered to be reasonable for the purposes of long-term planning but do not represent a commitment.*
- The City Rail Link allows for a step change improvement in frequencies, travel times, and access for metro rail services in Auckland, with a capacity of up to 24 trains per hour, however constraints in other areas of the network will prevent this from being achieved on Day 1.
- A number of uncertainties currently exist with respect to the CRL Opening Day timetable that the PBC acknowledges:
- **Southern corridor access**
    - Based on the objectives of PBC, The CRL day one timetable must be able to provide separate paths for at least 1 inter-regional service, and at least 2 freight services during peak periods amongst the metro timetable, in order to support the expected growth in these markets
    - The current version of AT's timetable proposal assumes freight and interregional services share one slot over the day in each of the AM and PM peaks – work is being undertaken outside of the PBC to address this.
    - The PBC assumes operational solutions enable this to be resolved and that the new timetable can provide for 1 inter regional service, and 2 freight services during peak periods from Day 1
    - Note: current inter-regional services are Northern Explorer (AKL-WLG) and Te Huia (AKL-HAM)
- **Level crossing impact**
    - There are broadly two versions of the timetable under consideration. A reduced version and a full version.
    - The reduced version essentially limits the total number of train volumes passing through level crossings
        - Eg the Western Line to be in line with current volumes (while simultaneously improving peak direction frequencies from 6 to 8tph). The full timetable would further increase frequencies to 12 tph in each direction
        - Southern line level crossings also relevant (e.g Takaanini)
    - It is clear that any significant increase above current levels will require a firm commitment to safety mitigations, and the PBC seeks to provide this via a comprehensive programme of level crossing removals network wide.
    - However exact requirements of the safety regulator are not currently known, and therefore the timing of when the full timetable can be run is not precisely known and has been assumed as 2028

Key Insights and Uncertainties

4) CRL Opening Day Timetable (continued…)

- **Freight access**
  - *The Henderson - Newmarket service added in CS0.25 increases the freight exclusion period on the NAL if run on a 2-hour span. On the other hand, demand analysis suggests that shoulder peak demand on the Western Line may exceed capacity at an unacceptable level of service (>15min standing) on year 1.*
  - Based on analysis undertaken, and subsequent discussions with AT and KR, the Henderson-Newmarket/Otahuhu service addresses an unacceptable crowding issue for metro which occurs as early as 2025 in the shoulder peak period (due to lack of fleet precluding full 6-car operation) and by late 2020's in high peak. Addition of this service, if run the full span of the peak, would extend the freight exclusion period for NAL freight by 30min per peak. For base demand scenario this would have no impact on freight demand but have an impact in the NAL high growth scenario and any scenario in which growth on the NAL exceeds the 5-7 train limit.
  - The impact is difficult to quantify at this level of planning as it relates to the reliability of freight arrival times into and out of the network. A marshalling yard has been suggested as a way to mitigate this issue and maximise the volume of freight volumes on the NAL prior to implementation of A-S.
  - On this basis it agreed to adopt the Henderson-Newmarket service, under the provision that this be investigated further in appropriate forums e.g. timetable committee.
- **Opening year**
  - The PBC assumes CRL opening day in 2025 however, it is noted that at the time of writing this report, the latest predicted opening day for CRL is 2026. The PBC will not be updated to reflect this date, given that this change has occurred late in the delivery of project. However it is not expected to materially change the options selected.

Key Insights and Uncertainties

5) Onehunga Branch Line

- The PBC shows the OBL line continuing in operation till 2051, however does not plan significant service improvements beyond the 2025 plan.
- This is in part because modelling shows a low demand for this line that will be satisfied by current service levels for next the 30 years, and in part because the investments required to improve services on the OBL are quite significant. To achieve RTN frequencies for example, this would require the removal of 8 level crossings, and widening the corridor to provide one additional track.
- On implementation of Avondale-Southdown and with the assumed implementation of a Light Rail connection to the city centre, communities on the OBL will see a significant improvement in public transport connectivity over the course of the next 30 years. This is one of the reasons why demand for the Heavy Rail OBL service is predicted to be low.
- This may present an opportunity to remove the OBL or convert it to a shuttle service, freeing up network capacity on the rest of the network to improve higher demand services, but such a decision needs to be made as part of a broader transport planning initiative
- **The PBC provisions for an '*Onehunga Route Connectivity Study*' to explore such opportunities in later phases once there is greater certainty around the key interacting projects of ALR and Avondale – Southdown**

6) Avondale Southdown

- The PBC assumes consistent with current policy that light rail will be implemented in phases over the 30-year programme with the City Centre to Mangere portion delivered in the second decade
- **The Rail PBC concludes that the A-S is strategically critical to the network.** It is not just about creating a corridor, it is completing a network that has local, regional and national consequences.
    - The primary function of Avondale – Southdown corridor is to free up the inner network for exclusive metro use, thereby allowing more frequent, and faster metro services to and from the South over a longer span of the day and increasing reliability & resilience throughout the network - while also providing more freight capacity to Northland. This is done by decanting any freight services over 5-7 per day.
    - The secondary function is to provide a high-capacity crosstown corridor from Avondale to the East.
    - Glenn Innes has been adopted to complement the RTN and ALR proposal
    - **The alternative of 4 tracking the inner network does not provide these same benefits.**

The Rail PBC assumes the KR-owned and designated corridor is used and the critical path is to renew the designation this decade.

Key Insights and Uncertainties

In all existing ALR design options, there will be a portion of the corridor shared with the A-S route between Sandringham and Hillsborough Road. The PBC provisions for early investigation and civils works within the shared corridor to ensure that ALR does not preclude or materially increase either risks or costs for HR to use its own corridor in the (currently expected) scenario where ALR precedes A-S.

If ALR is delayed

- There would be a small increase in demand to heavy rail, particularly on the Western Line at Kingsland which will not fundamentally change the HR plan

Co-ordination with ALR is essential. The PBC provisions for early investigations on the A-S corridor to be undertaken so that this interaction can be properly executed, and any risks and opportunities are captured and addressed early.

If ALR is delayed the timing of the A-S in the Rail PBC would stand (as it is not driven by ALR (but the approach to integrating with the airport / RTN could be revisited)

7) Inter Regional CBD Terminal

- The PBC aims to significantly improve the attractiveness and capacity of inter-regional services from Hamilton, taking into account WRC targets for frequencies, span of service, travel times, and access to the central city.
- The four tracking project, targeted platform extensions on the southern corridor, station improvements, and general network reliability enactments all support these objectives with the final service plan **achieving more than 10min in travel time savings within Auckland and providing access to a 9-car enabled Newmarket station,** which is envisioned as a new IR hub providing connectivity to the rest of the metro network with metro trains arriving every 3-4min serving the city centre and the western line.
- The PBC also investigated the possibility of further access improvements by allowing Inter Regional trains to terminate at Waitemata station bay platforms but has not been able to arrive at a suitable solution due to complex timetabling challenges.
- **The current plan maintains the final termination of IR trains at Strand for operational turnback (via Newmarket), which is planned to receive facility and access improvements. The PBC also earmarks future studies to investigate opportunities for refinements to the timetable to allow this access to occur.**
- **The base case does not include PoAL closure – any decision of that nature could have implications for the Strand. It is treated as an opportunity for the future.**

Key Insights and Uncertainties

7) Glen Innes to Mt Albert Turnbacks

- There are two general solutions to the capacity problems on the East-west line in late 2030s/early 2040s.
    - Lengthen trains (i.e. 9-car extensions currently adopted)
    - Run more frequent services (i.e. Mt Albert-Panmure peak overlay service).
- The issue with option 1) is that it is expensive to implement and provides excess standing capacity (though this may be advantageous when considering the ERP scenario). Option 2) provides incremental capacity improvements (better scaled to demand) at lower cost, however two potential concerns were identified
    - timetabling 8 green Swanson-Manukau trains, + 4 blue Mt Albert-Onehunga/Newmarket trains + 4 Mt Albert-Penrose trains would likely comprise the ability to provide a 10min path on the Eastern Line for port trains. A 7.5min headway would likely be min possible.
    - Conceptual timetabling to date has shown that Newmarket and QPJ junctions constrain the timetable and may make timetabling these additional 4 services difficult. Considered in isolation, the junction should have spare capacity, but when considered as part of the broader network, there is a risk that this option would require grade separation of QPJ to provide an acceptable timetable.
- Based on further group discussions and analysis it was suggested by AT that the 4tph could be run such that 2 x 10min freight slots would be protected in the peak. The 5/10 pattern provides 4x10min paths per hour. By running 2 overlay trains in one 10min slot and 2 overlay trains in the other, this would leave the 2 remaining 10min slots for freight. Implemented in this way, the overlay service is expected to have no impact on freight. On this basis the peak overlay was adopted noting also that this only becomes a problem when either POAL freight starts to operate in the peak, or the Mt Albert to GI service starts to run in the off peak.
- It should be noted that POAL has requested to increases to its volumes on rail from 12% (current) to about 30%. This would mean about 12 port trains daily, and the increase is starting in 2023. This needs to be monitored closely as it would create conflicts between metro and freight (exceeding the estimated 6-8 tpd per direction capacity limit) which may compromise the ability to run this overlay service.

Appendices

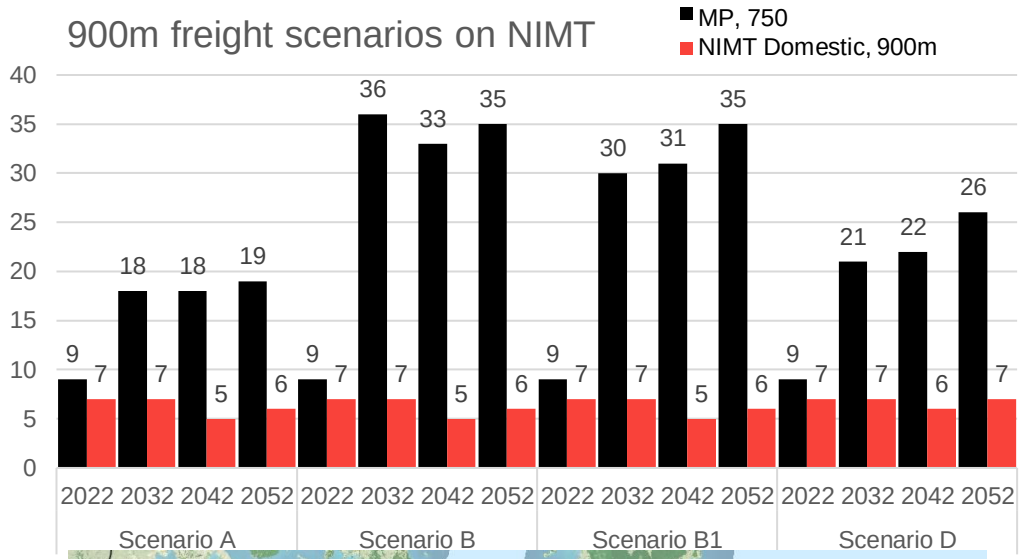
A

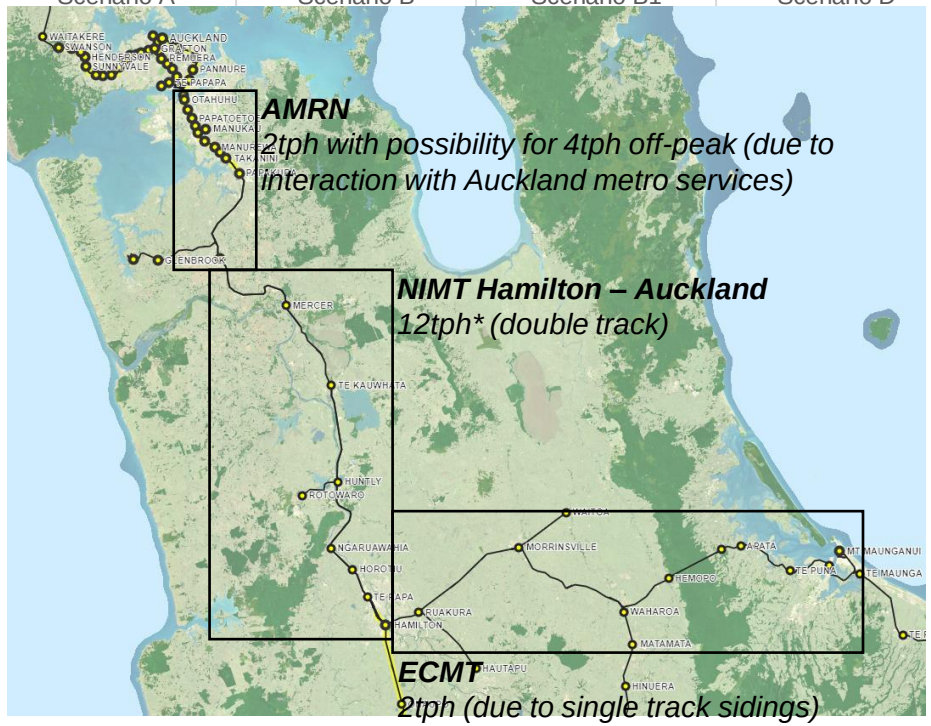
Practical limits of NIMT train volumes

Practical limits of NIMT train volumes

The following constraints suggest a ~60tph (30tph per direction) limit for reliable freight operation into and out of Auckland

- ECMT constraint:
  - Majority of growth on NIMT (over all scenarios) is associated with Metro Port traffic
  - MP traffic uses the ECMT which is a single-track line with passing loops.
  - Sidings are spaced at an approx. 15min travel time interval, which supports a 2tph cyclic MP service.
  - A service of this density would not be possible to run over a 24 period of operation as it would preclude required routine maintenance works and would likely need to protect a 5-hr daily maintenance window.
  - This would provide a theoretical capacity of 38 trains per day, however not all of this capacity should be used in order to maintain a reliable level of service. Allocating 25% trains slots for resilience leads to a limit of ~28tpd per direction.
  - Under B1 a MP traffic reaches 30tpd per direction prior to 2032
- AMRN constraint
  - Particularly during metro peak periods, similar constraints apply within AMRN – i.e. two freight paths are provisioned per hour within the network timetable
  - Lower frequency metro services in off-peak periods allow 4 freight trains per hour but the practicality of using this capacity is limited given the cyclic nature of the MP service, time sensitive nature of domestic freight, and IR services sharing tracks south of Auckland
  - Therefore a ~28tpd limit in Auckland is reasonable to assume with optimisations possible only if growth could be accommodated in off-peak metro periods
- Previous analysis from KR has estimate this limit to be around 32 trains per day.
- Based on the above discussion the limit of reliable operation is expected to be somewhere between 28 – 32 trains per day. This is based on mainline constrains and does not consider terminal constraints which could reduce this limit further. For simplicity the PBC has adopted a single date of 2030 in developing the phasing plan.





B

The need for four tracking to Pukekohe

The need for four tracking to Pukekohe
Overview

Initial 'unconstrained' demand modelling indicated that 7x9car trains per hour would be sufficient to meet demand just prior to Papakura at seating capacity (See Options Report Part 1, Section Figure 4-3). This calculation assumed a perfectly even loading of trains (i.e. a uniform headway and uniform attractiveness between services). Demand modelling on the final preferred programme has largely confirmed these initial estimates with some increase in demand due to the addition and improvement of express services that was not included in the initial modelling. It might therefore be imagined that metro services could be reduced south of Papakura, thereby reducing utilisation to less than 100% and removing the need for four-tracking this segment.

This section explores this idea further – firstly assessing options for service reductions and their viability with respect to PBC IOs, and secondly assessing the hypothesis that such service reduction would remove the need for four tracking.

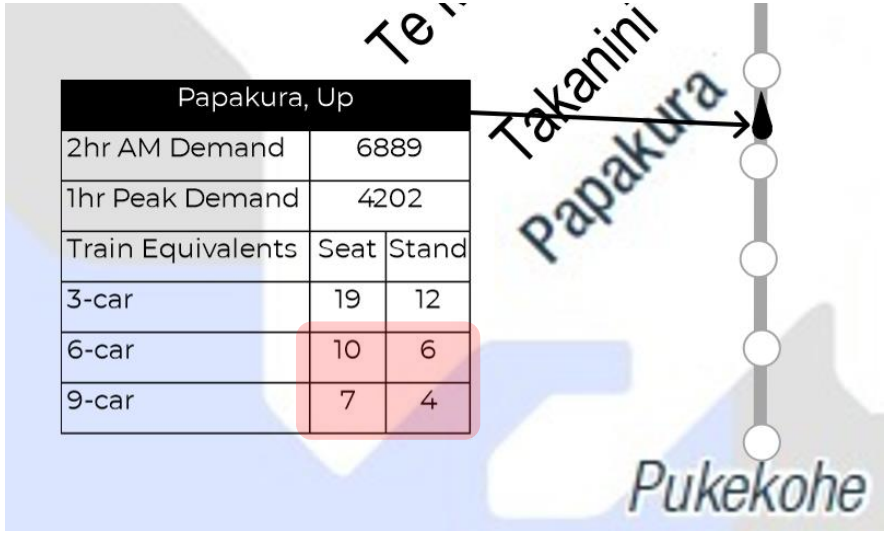


Figure B1: Unconstrained demand estimate south of Papakura

The need for four tracking to Pukekohe
Viability of service reductions south of Papakura

There are three general options for reducing services south of Papakura 1) running longer trains, 2) turning back services at Papakura, 3) reducing level of service targets for standing times (i.e. increasing the effective capacity per EMU), and travel time (i.e. removing the need for express services, thereby reducing the overall track capacity consumed by metro services). Each option is considered in turn below.

1) Running Longer Trains

All trains 9-car car: Running all trains on the southern line at 9-car involves significant cost, disruption, and time to extend platforms. Running more trains (at shorter length) also requires significant investment (adding tracks) however this investment benefits all markets, not only metro. For this reason and considering likely funding constraints (as discussed in Section 5.1), the final programme does not include 9-car operation for all-stops services on the southern line but focuses on limited stop services which are expected to experience highest crowding levels, earliest.

9-car express only to Pukekohe: Another option would be to only run 9-car trains south of Papakura, with all-stops services running at 6-car length, starting at Papakura. Capacity analysis has shown that the maximum viable number of metro express services that can be operated on the western mains along with freight and inter regional services north of Pukekohe is 4tph. Even at 9-car lengths, this would be insufficient to meet demand, and furthermore would require customers travelling to anywhere else on the southern corridor to make a transfer to an all-stops train north of Papakura, increasing journey times and degrading service quality for these passengers.

Based on this options analysis, it is concluded that the service between Pukekohe and Papakura should be a mix of 6-car and 9-car trains to meet demand to an acceptable level of service.

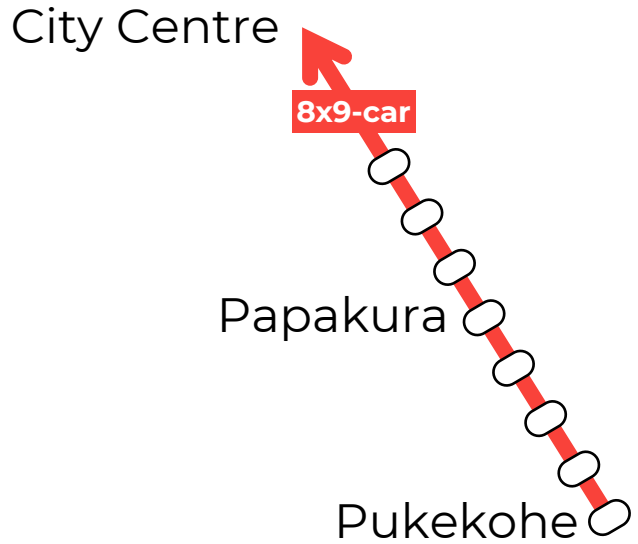


Figure B2: Service reduction option – all trains at 9-car

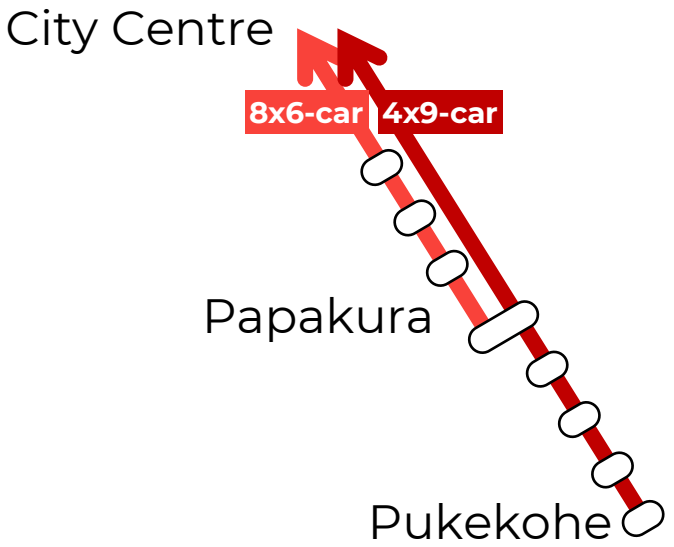


Figure B3: Service reduction option – 9-car express only to Pukekohe

The need for four tracking to Pukekohe
Viability of service reductions south of Papakura

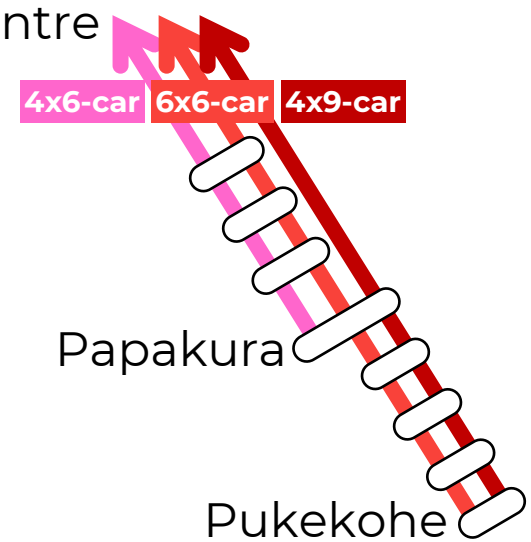


Figure B4: Service reduction option – 4 turnback trains at Papakura

2) Turn backs at Papakura

Demand modelling suggests a strong market for express services from the south and therefore these services should be maximised to 4tph. This means that an additional 5x6-car, all-stops trains would be required to meet overall demand south of Papakura, resulting in a total of 9tph passenger service. In practice however, given the symmetric timetable concept used on the network, this would likely lead to a 4tph express + 6tph all stops service, totalling 10tph.

The remaining 4tph could then in theory be turned at Papakura, however modelling has also shown that this results in a significant loading imbalance on southern line trains. Since the service has been designed to exactly match seating capacity under this scenario, all trains arriving at Papakura from the south would be full. Therefore, any additional passengers boarding these trains would be unlikely to get a seat, resulting in standing from Papakura to the city centre. The four trains per hour starting at Papakura would provide full seating capacity, however customers will have to time their trips to meet these trains. undermining the aspiration to provide a 'turn up and go' service. In effect, the train service provided at Papakura is only 4tph. The average train loading profile shown in Figure B5 illustrates this effect*. Note that this was an analysis performed on 2041 demands. The issue is more significant under 2051 demand.

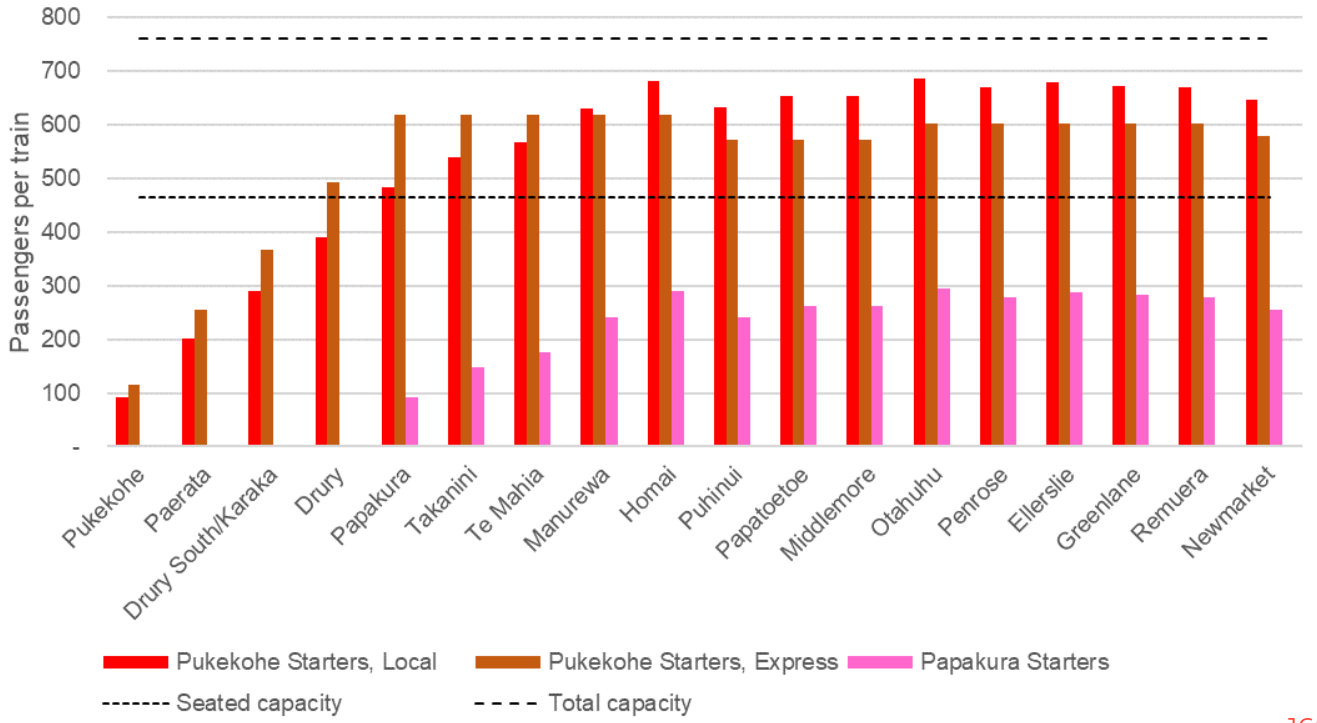


Figure B5: Average train load analysis for a 4tph turnback service at Papakura, 2041 demand

* This analysis assumes uniform arrival rate of passengers, and applies a weighting to represent the attractiveness of express over all-stops services based on MSM results

The need for four tracking to Pukekohe
Viability of service reductions south of Papakura

3) Reducing level of service requirements

There are 2 key service level requirements that have the potential to impact the service requirements for the P2P section, which correspond to the Conditional Outputs listed in Table B1.

Maximum standing length: Increasing the maximum standing target has the potential to reduce the number of trains required between P2P as it effectively allows higher crowding levels. However due to the specific pattern of demand on the southern line, where the peak load point occurs at Puhinui, trains tend to exceed seating capacity a long way out from the city centre i.e. when standing is allowed to occur on the southern line, it typically occurs for longer than 15min. This is evidenced by Figure B5 in the previous slide which shows the loading estimate of a service concept where 4 trains per hour are turned back at Papakura. As shown, Pukekohe starters will on average reach seating capacity at Papakura resulting in standing occurring approximately 45 min from the city centre. Therefore, even a tripling of the target would have no impact on the service requirements for P2P, and anything beyond this would represent a poor, unattractive level of service.

45 min journey time target: Duplication of track provides the opportunity for express tarins to pass all-stops trains, thereby providing a runtime advantage. However, as discussed in Section 4.1, express services are planned to serve all P2P stations given the strong demand shown in the modelling. Under this service concept there is no real travel time difference between a four track and a two-track configuration of P2P*, and therefore the case for four tracking is largely independent of the 45 min journey time target and not sensitive to changes to it.

Table B1: COs relevant to the case for four tracking

	Maximum length of standing (target <15mins)
45min	Journey time to central business district area should not be more than 45mins. This has typically been defined as a trip from anywhere on the network to Aotea and vice versa .

* Other than the fact that additional complexity in operations at Papakura junction (the transition from two to four tracks) would likely result in timetable constraints that increase runtimes in comparison to the four-track configuration.

The need for four tracking to Pukekohe
Viability of a two-track railway based on service comprises

For the reasons described above, it is considered strongly preferable to plan for a metro service that runs all services on the southern line to Pukekohe.

However, even if the 10 trains per hour concept were adopted (despite the disbenefits described above), this does not remove the need for four tracking this segment of the network. This is because operating 10tph metro services, 2tph inter regional services (12tph passenger trains in total) and provisioning two freight paths for trains of up to 1500m in length, will result in a significantly asymmetric timetable with headway gaps of 15min based on the assessments undertaken in the PBC.

These 15min gaps create a highly lopsided service in which certain trains within the hour will be very heavily loaded resulting in high levels of crowding and the potential for customers to be left behind on platforms, longer standing times, longer and more erratic journey times and cascading effects to other services making network management complex. All of which results in a significantly degraded level of service for customers. A further compromise could be considered to alleviate these passenger issues by limiting freight trains in peak periods to shorter lengths. However, this would be operationally complex and less economic as it would result in an inefficient operation that would compromise the ability for freight to provide an attractive service to customers. Furthermore, in off peak periods this would restrict metro to running a 4tph off-peak service and not meet aspirations of a RTN frequency of 10min or better all day.

A further compromise could be considered to alleviate these passenger issues by limiting freight trains in peak periods to shorter lengths. However, this would be operationally complex and less economic as it would result in an inefficient operation that would compromise the ability for freight to provide an attractive service to customers. Furthermore, in off peak periods this would restrict metro to running a 4tph off-peak service and not meet aspirations of a RTN frequency of 10min or better all day.

Conclusion

From the analysis summarized above, it is clear that a two-track railway between Pukekohe to Papakura will result in a number of material tradeoffs across multiple markets.

Furthermore, four-tracking of Pukekohe to Papakura not only resolves these trade-offs but also brings a number of additional significant benefits including improved travel times, more efficient maintenance, better degraded mode operation (i.e. when there is an outage on one pair of tracks), and ultimately, when considered in combination with Avondale-Southdown, will result in the complete segregation of the southern corridor between metro and freight services.

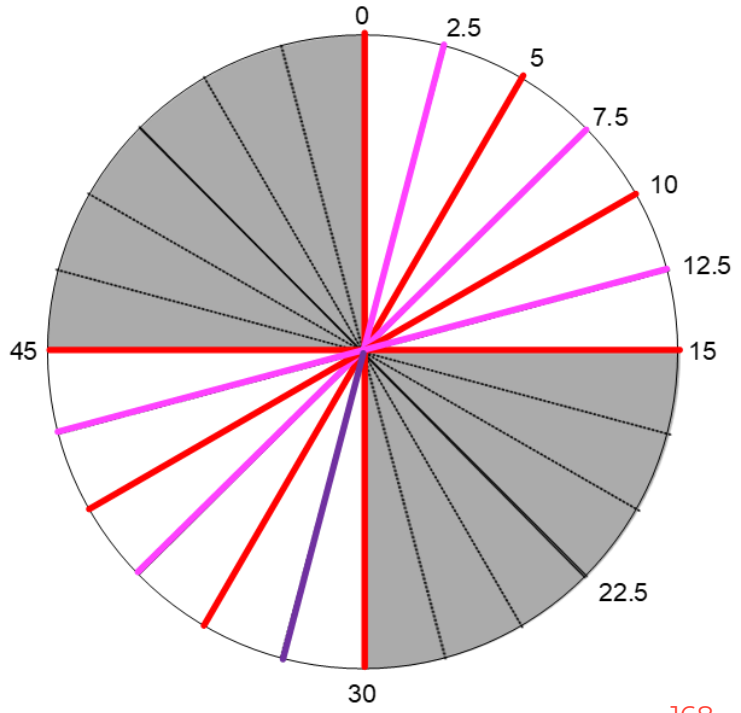
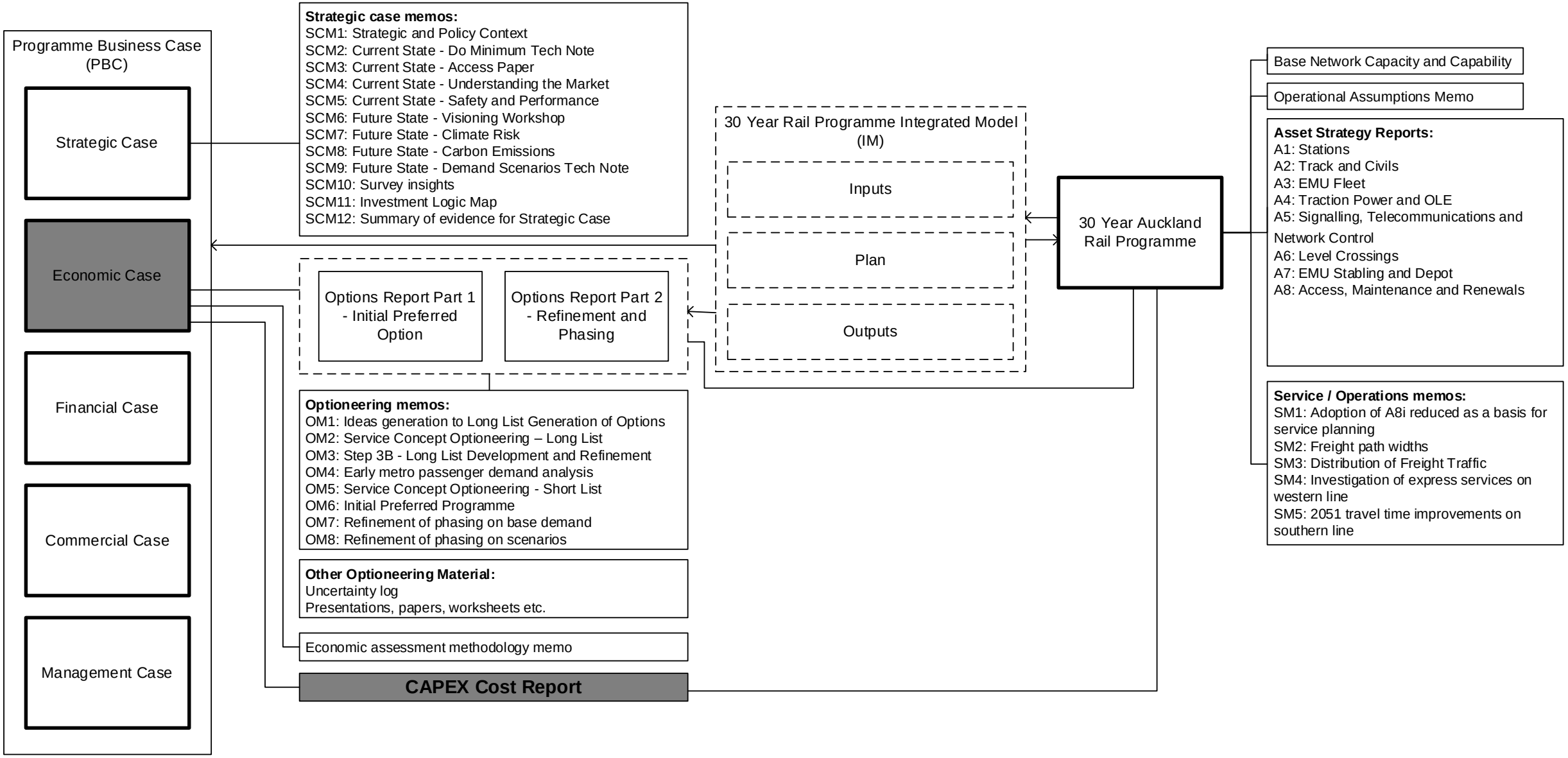


Figure B6: Clockface required to support 1500m freight on a 2-track railway

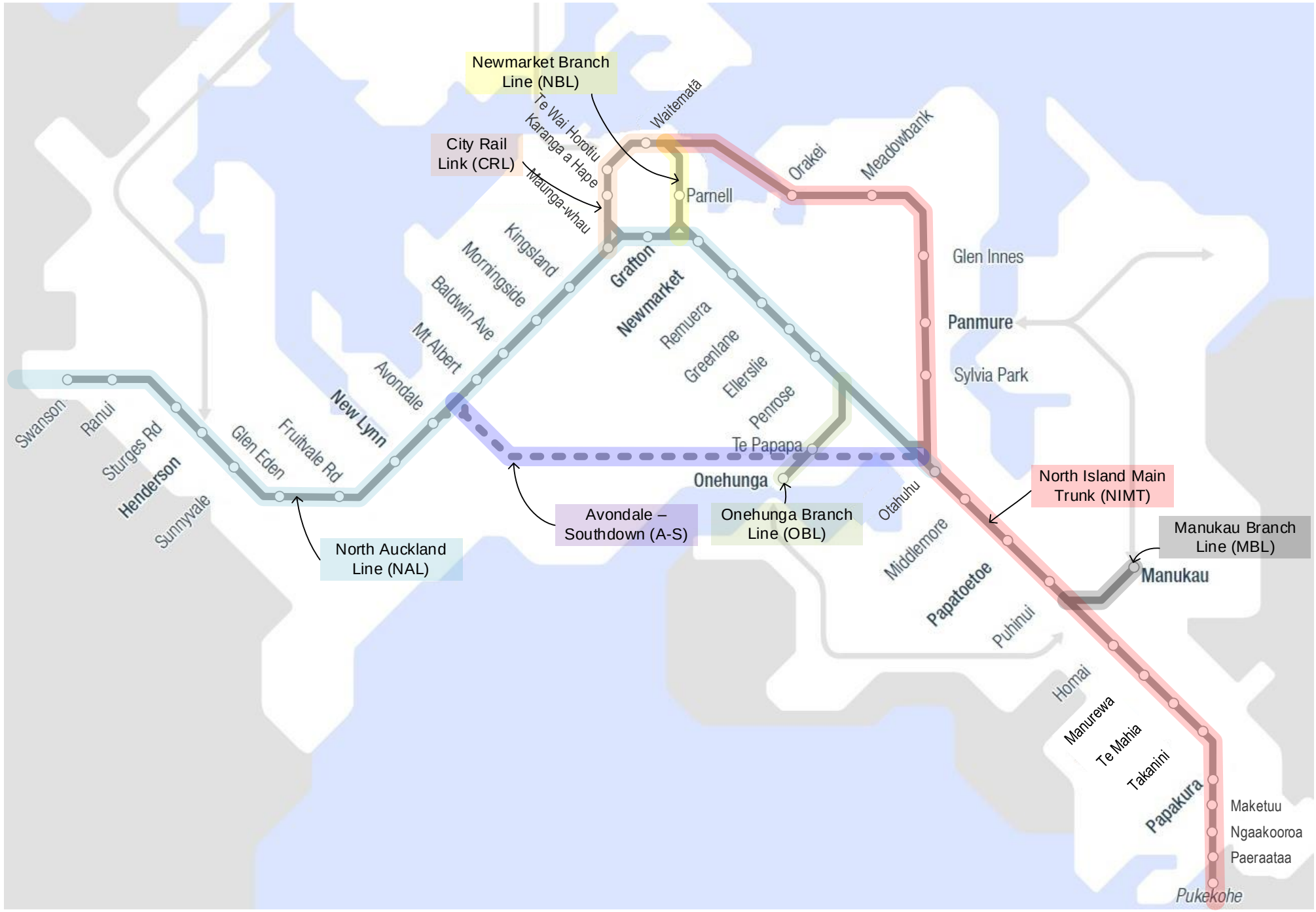
C

ARPBC Document Map


Programme Business Case (PBC)
Strategic Case
Economic Case
Financial Case
Commercial Case
Management Case
Strategic case memos:
SCM1: Strategic and Policy Context
SCM2: Current State - Do Minimum Tech Note
SCM3: Current State - Access Paper
SCM4: Current State - Understanding the Market
SCM5: Current State - Safety and Performance
SCM6: Future State - Visioning Workshop
SCM7: Future State - Climate Risk
SCM8: Future State - Carbon Emissions
SCM9: Future State - Demand Scenarios Tech Note
SCM10: Survey insights
SCM11: Investment Logic Map
SCM12: Summary of evidence for Strategic Case
Options Report Part 1 - Initial Preferred Option
Options Report Part 2 - Refinement and Phasing
Optioneering memos:
OM1: Ideas generation to Long List Generation of Options
OM2: Service Concept Optioneering – Long List
OM3: Step 3B - Long List Development and Refinement
OM4: Early metro passenger demand analysis
OM5: Service Concept Optioneering - Short List
OM6: Initial Preferred Programme
OM7: Refinement of phasing on base demand
OM8: Refinement of phasing on scenarios
Other Optioneering Material:
Uncertainty log
Presentations, papers, worksheets etc.
Economic assessment methodology memo
CAPEX Cost Report
30 Year Rail Programme Integrated Model (IM)
Inputs
Plan
Outputs
30 Year Auckland Rail Programme
Base Network Capacity and Capability
Operational Assumptions Memo
Asset Strategy Reports:
A1: Stations
A2: Track and Civils
A3: EMU Fleet
A4: Traction Power and OLE
A5: Signalling, Telecommunications and Network Control
A6: Level Crossings
A7: EMU Stabling and Depot
A8: Access, Maintenance and Renewals
Service / Operations memos:
SM1: Adoption of A8i reduced as a basis for service planning
SM2: Freight path widths
SM3: Distribution of Freight Traffic
SM4: Investigation of express services on western line
SM5: 2051 travel time improvements on southern line

D

Nomenclature for Auckland Rail Network Lines


Newmarket Branch Line (NBL)
City Rail Link (CRL)
Te Wai Horotiu
Karanga a Hape
Maunga-whau
Waitematā
Parnell
Orakei
Meadowbank
Glen Innes
Panmure
Sylvia Park
Kingsland
Morningside
Baldwin Ave
Mt Albert
Avondale
New Lynn
Fruitvale Rd
Glen Eden
Sturges Rd
Henderson
Sunnyvale
Ranui
Swanson
Grafton
Newmarket
Remuera
Greenlane
Ellerslie
Penrose
Te Papapa
Onehunga
Otahuhu
Middlemore
Papatoetoe
Puhinui
Homai
Manurewa
Te Mahia
Takanini
Papakura
Maketuu
Ngaakooroa
Paeraataa
Pukekohe
North Auckland Line (NAL)
Avondale – Southdown (A-S)
Onehunga Branch Line (OBL)
North Island Main Trunk (NIMT)
Manukau Branch Line (MBL)
Manukau