AUCKLAND RAIL PROGRAMME BUSINESS CASE

OPTIONS DEVELOPMENT REPORT PART I – 2051 END STATE

7 SEPTEMBER 2023

wsp

RAIL INFRASTRUCTURE CONSULTANTS (NZ)

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AUCKLAND RAIL PROGRAMME BUSINESS CASE
OPTIONS DEVELOPMENT REPORT PART 1 – 2051 END STATE

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1 INTRODUCTION

1.1 PURPOSE

This Options Development Report outlines the process followed and assessments undertaken to determine an Initial Preferred 2051 End State for the Auckland Rail Programme Business Case (PBC). A second report covers the phasing of service and infrastructure improvements over time as well as several refinements to the 2051 end state. This report is the *Options Development Report Part 2– Refinement and Phasing*.

1.2 OPTIONEERING FRAMEWORK

The key steps followed in developing this PBC fit within the Better Business Cases framework[1] and follow the prescribed Waka Kotahi sifting approach for alternatives and options assessment described in Figure 1-1.

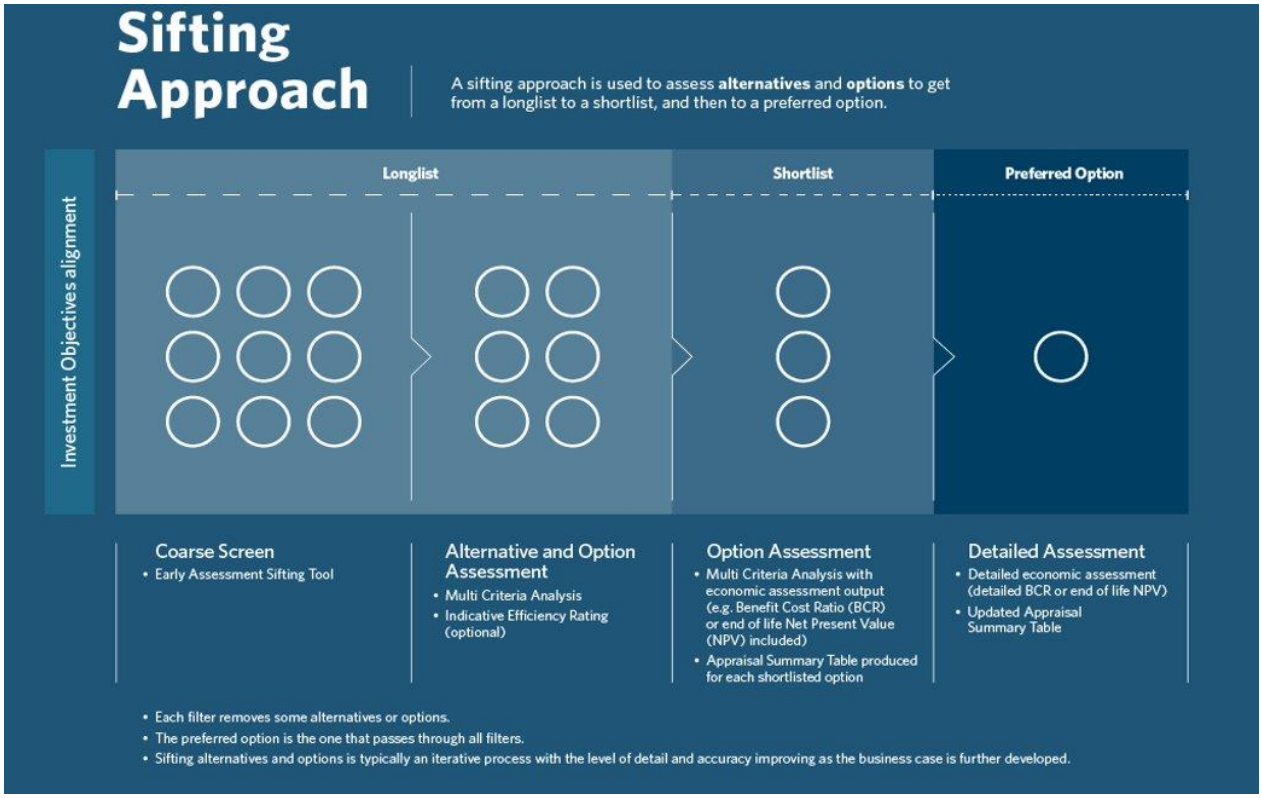


Figure 1-1: Waka Kotahi Sifting Approach[2]

[1] https://www.nzta.govt.nz/planning-and-investment/learning-and-resources/business-case-approach-guidance/what-is-the-business-case-approach/

[2] https://www.nzta.govt.nz/planning-and-investment/funding-and-investing/optioneering/optioneering-overview/

The complexity of a 30-year programme, consisting of dozens of interventions across a complex rail network, with direct impact on at least four markets (including the needs of maintenance) would overwhelm a linear sifting approach. An adapted process, focusing on the value of potential interventions in reaching toward a desired vision for the network was developed from the sifting process and guided by the Long-Term Planning Process (LTPP) framework used by Network Rail in the UK. In particular, the logical sequence of

- developing Conditional Outputs,
- assessing existing network capacity constraints,
- developing an end state service and infrastructure concept, and finally
- developing a phasing of improvements over time discretised into Configuration States,

has been followed by the PBC.

The LTPP concept of Conditional Output (COs) is particularly important in the context of this PBC. COs are key rail-specific objectives defined for each primary markets of freight, metro, interregional, and maintenance. Within the LTPP process COs are developed as part 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 infeasible (from an engineering or economic perspective) under further analysis and so should not be viewed as hard requirements but as targets or aspirations.

For simplicity of documentation LTPP-specific reports such as the Market Study and Route / Network Study have not been developed as part of the PBC. However, COs were developed as part of the Strategic Case and have been used extensively to aid in the evaluation and refinement of options. These are defined in Section 2.2.

It is important to note that, while the process followed by this PBC is adapted to the LTPP and makes use of COs in assessment phases, the process followed is ultimately a Waka Kotahi-compliant MCA framework, aligned with the PBC's benefit KPIs, and investment objectives Regular engagement with stakeholders was undertaken throughout the process and is documented throughout this report and appendices.

1.3 PROGRAMME DESIGN PRINCIPLES

Our team has approached this project with a clear understanding of the Investment Objectives as laid out by the Strategic Case. These objectives have been transformed into KPIs and then translated into Conditional Outputs that are the key rail-specific objectives for each of the primary markets of freight, metro, interregional, and maintenance. Some COs are demand objectives, similar to standard transport modelling metrics, while others are aspirational, driven by the broader objectives of encouraging mode shift.

The nature of this project and the scale of the potential programme of works is significant. Though small in scale by international standards, the Auckland Metro Rail Network is a complex system. Its complexity is due to the high degree of mixed traffic (it is both a freight network and a heavy rail passenger network), the presence of multiple interconnected and highly trafficked 'flat' junctions, and the degree to which the network itself has been historically underinvested in. Thus, a detailed rail planning approach, which considers the network infrastructure, systems and operations in a holistic way is required to ensure an efficient, reliable, regular, scalable, and maintainable service is provided for both passenger and freight customers.

The following principles have been fundamental in advancing the Auckland Rail PBC:

- Service-led planning: Benefits that satisfy the customer needs are provided through the provision of services, so it is key to understand the level of service to be provided first. Focusing on a customer needs led planning approach minimises the risk of overinvestment in infrastructure, or worse, investment in the wrong infrastructure.
- Long Term Focus: Analysis and network planning starts with developing an understanding of the desired operational end state for the network. That is to say, "what would our optimum service in 2051 look like?" Based on this principal, early phases of optioneering focus heavily on the development of service concepts to meet demands and aspirations, rather than infrastructure concepts, the latter being understood as an implication of the former. This approach enables accurate identification and justification of the interventions required to solve the problems identified in the ILM.
- Future Proofing: Rail infrastructure is expensive and has a long asset life. To enable the maximum value of this investment, it is important to understand the longer-term state of the railway and continually design for this e.g., consideration of the number of tracks when bridges are widened.
- Scenario Planning: Demand for rail services is impacted by a number of factors outside of our control. The two key factors are time (when and how often customers travel and how this increases) and space (where customers want to travel from and to). Based on this principal, the initial preferred programme will be tested and refined against different demand scenarios to ensure it is robust and can respond changes in these factors. This will be considered in the Options Development Report Part 2.
- Configuration States: A combination of infrastructure interventions to deliver a service can be considered as a configuration state. It is important to understand the triggers for these infrastructure interventions and how they integrate to enable a step change in service. Monitoring these triggers enables the programme to adapt over time to ensure it remains relevant and best value for money.
- Enable Step Change: A programme of works needs to be cognisant of and respond to specific customer needs. As part of the process towards an initial preferred programme, we first developed a base case demand in 2051. To go past the limitations of a *Predict and Provide* approach towards a *Vision and Validate* approach, we considered the transformative potential of interventions beyond base case demand. This allowed the testing of the established potential programme against other demands, so as to quantify its ability to adapt and support the required step change.
- Micro and macro analysis: Our approach includes an iterative, back and forth, micro to macro analysis to fully identify the trade-offs related to key selection decisions on localised issues and Network wide issues. When specific routes can be isolated, network consideration at the micro level start with an analysis of specific lines (e.g.: Central, Southern, Eastern, Western, Onehunga), for specific markets (Freight, Metro services, Maintenance services or regional services). Potential change is also examined at a macro, whole-network level, ensuring that localised service changes will work across the broader network, for all markets. Where necessary and possible, interventions are designed to "ring-fence" their impact, to reduce network complexity and the need for "knock-on" change.
- Solution elegance and simplicity: While all infrastructure asset classes are required to deliver levels of service, core network assets like track and signalling are given greater priority for network planning given that these significant investments provide the most potential to effect step changes in capacity and quality of service. Other asset classes and related interventions were considered later in the process, for example level crossing removal and station design interventions. Considering these less-differentiating

interventions later in the planning process improved the elegance of the Initial Preferred Programme by simplification of the end case network backbone.

1.4 PROCESS OVERVIEW

This report is structured according to the optioneering process followed to identify the Initial Preferred 2051 End State. Figure 1-2 summarises the process and how each section of the report maps to it. Summaries of the analysis undertaken in each phase of optioneering are also provided below. Note that the first phase of the optioneering process starts in Section 3 – Sections 1 and 2 establish overall methodology and inputs.

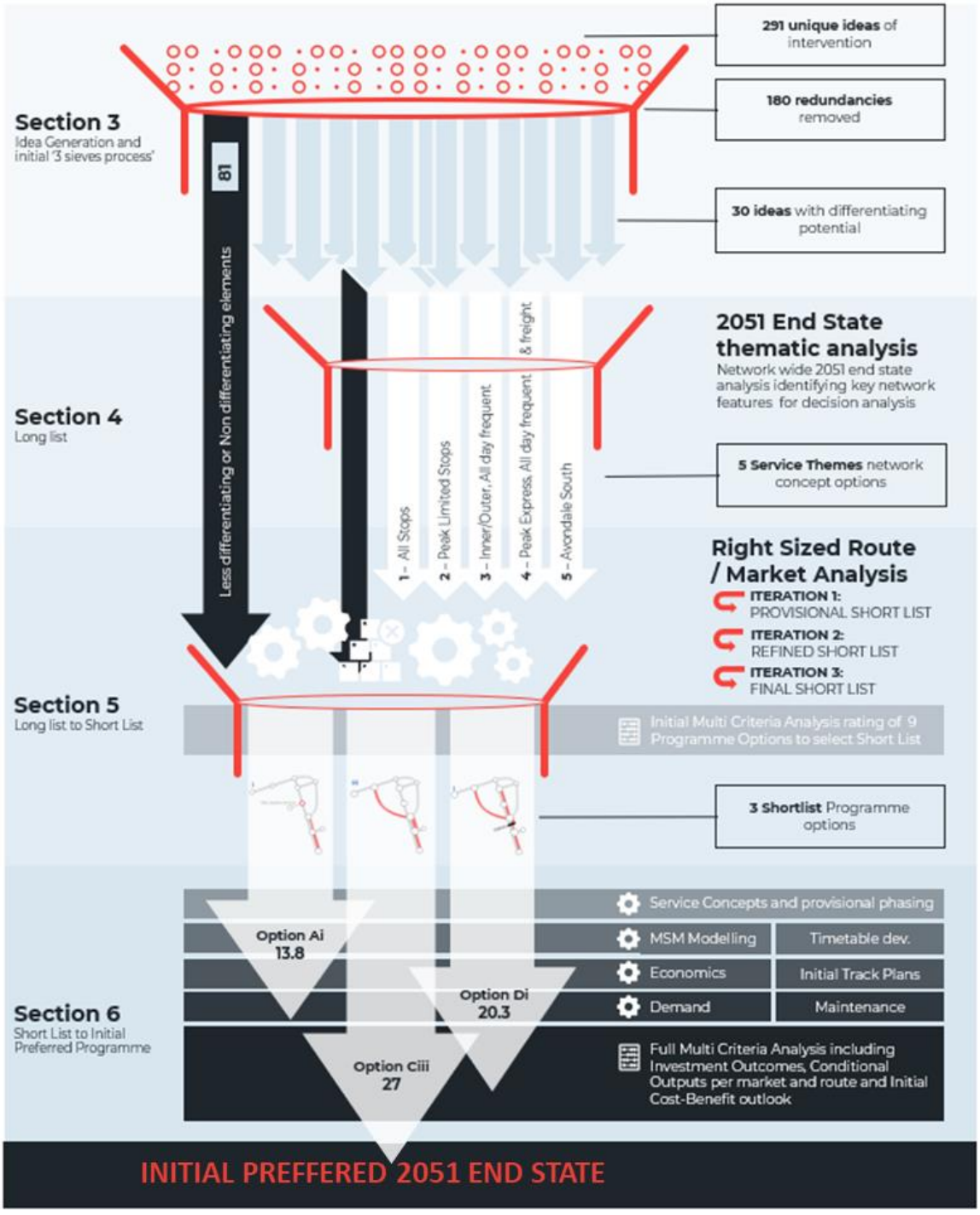


Figure 1-2: Optioneering Process Diagram

Section 2: Optioneering inputs

This section provides an overview of how Investment Logic Mapping (ILM) was used to develop the Multi-Criteria Assessment (MCA) framework used in optioneering. It also presents a summary of related documentation providing further technical assessments and analysis and describes the do min state for the network.

The creation of this framework was fundamental to the process because it provided the methodology whereby the initial Long List (Section 4), several iterations of the Short Lists (Section 5) and, finally, the shortlist programmes (Section 6) were formally assessed and documented. The MCA underpins the assessment and selection processes against the selected Do Minimum scenario. This incremental assessment approach identifies the programme option that best delivers on the validated investment objectives and conditional outcomes, per route, and for each market.

Section 3: Idea Generation

This section outlines the process from initial idea generation, through a filtering process, leading to a long list of differentiating and non-differentiating components. An initial set of 291 blue sky ideas formed via a stakeholder workshop were ultimately refined to a long list of 30.

The project team and key stakeholders started with an initial blue-sky workshop. The purpose of this meeting was to generate a list of ideas which may have a potential bearing on, or be part of, the rail plan for Auckland over the 30 years up to 2051. The question central to deliberations was "what can be tested and what can be changed to deliver the client's investment objectives?" This process generated 291 ideas.

The second element of the initial ideation process, was to remove duplications and sort the remaining ideas based on three filter questions:

1. Is the idea within the scope of the PBC and in line with the Investment Objectives? (if not, remove it)
2. Is the idea more generic in nature, in that it could apply to any future programme? (if so, it is deemed non-differentiating and may be considered at a later stage in the PBC process)
3. Will the idea influence the provision of services for customers (passengers & freight)? (if so, it is deemed differentiating and will, therefore, be taken forward as a long list option)

The filtration process provided by these three questions served to narrow the blue-sky ideas down to a manageable list of 30 ideas which were then summarised into four service ideas and taken forward for long list assessment at the next stage.

Section 4: Ideas Generation to Long List

This section outlines how the differentiating option components identified in Section 3, were applied to the network via the development of thematic long list options, and how these options and their component parts were tested using the MCA framework.

The 30 differentiating service ideas combining routes and markets result in a large solution space when a traditional, linear approach is taken. This becomes overwhelming to SMEs and Stakeholders and impedes clear decision making.

The approach taken was therefore to produce a manageable number of *thematic service concepts* that captured the general philosophies of how the network could be operated, while also incorporating many of the differentiating service ideas across them.

It was also important that the long-list focused on network-wide service themes as opposed to route specific themes. This limited options and decisions to a manageable level of complexity and ensured that potential solutions had the broadest applicability-impact across the network. The long list assessment also considered how passenger demand responded to improvements in metro passenger services using the Auckland Forecasting Centre Macro Strategic Model (MSM).

Analysis of the thematic service concepts resulted in the best parts of each option to be taken forward and further combined into specific 2051 network wide options for assessment in the short list. The adopted 'pick and mix' process provided a right-sized approach that ensured a wide range of options were considered in the context of each market and geography.

Section 5: Long List to Short List

This section outlines how technical assessment and further multi criteria analysis was used to refine outputs from the thematic long list to a short list of network-wide programme options. The multi-step process expanded the initial five thematic concepts, to a set of nine specific infrastructure programmes which were assessed using the MCA framework as a Provisional Short List, to general the final Short List of three options.

Using the best performing elements of the thematic long list programmes as a starting point, our technical analysis of the interventions delivering the best outcomes led to new service performance insights, coalescing into a series of specific network wide infrastructure investment plans. In turn, each further step in understanding what made an option preferable to another, allowed a further analysis of all programmes presenting similar features. This investigative approach resulted in an iterative process of technical analysis and evaluation, as well as the gradual validation of findings and priorities through stakeholder engagement.

As a result, the candidate programmes for short list selection were sufficiently understood and, when practicable, quantified, to inform their assessment through the MCA framework. Our approach to identify a shortlist of programmes from a long list of service themes revealed the importance of phasing in the relative value of programme options. In this temporal perspective, a lower investment programme option could be largely defined as a step towards another, heavier investment option.

Section 6: Short List to Initial Preferred 2051 End State

This section outlines further refinements and technical assessments of the Short List options to enable the ultimate selection of an Initial Preferred 2051 End State for the network via a final MCA assessment.

Technical analysis was undertaken to evaluate each of the Short List options and their potential to deliver on the Investment Objectives and Conditional Outputs.

The technical analysis included primarily:

- further operational network analysis, building on work detailed in supporting service memos,
- initial phasing assumptions and development,
- conceptual timetable development for each option,
- updated demand analysis, based on MSM modelling outputs,
- cost estimation refinements,
- indicative economic analysis, and
- planning and environmental assessments.

The analysis was used to inform the client and SMEs for the selection of the Initial Preferred 2051 End State at a workshop on 6th October 2022.

1.5 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 the material developed through the optioneering process to adjust 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 and Part 2.
    a. Britomart, Waitematā
    b. Aotea, Te Wai Horotiu, Te Waihorotiu
    c. KR'd, Karanga-a-hape
    d. Mt Eden, Maungawhau
    e. Drury, Maketuu
    f. Drury West, Ngaakooroa, Ngākōroa
    g. Paerata, Paeraataa, Paerātā
2. [Additional Capacity Wiri to Westfield: PBC modelling indicates that additional capacity will be required from Westfield to Wiri (under all considered scenarios except if POAL is fully closed). For the purposes of the PBC the costs of this are an approximation and have used 6 tracks (two additional adjacent at grade tracks). During next phase business casing optioneering will need to look at alternatives to additional adjacent at grade tracks, and station footprint. In practice the issue is not the number of tracks, but where these will be located, a matter that is sensitive and that is not possible for the PBC to confirm].

1.6 ACRONYMS

ACRONYM	DEFINITION
AKL	Auckland
AMRN	Auckland Metro Rail Network
AT	Auckland Transport
AWHC	Alternative Waitemata Harbour Connections
BAU	Business As Usual
BCR	Benefit Cost Ratio
CBD	Central Business District
CO	Conditional Output

CRL	City Rail Link
DM	Do Minimum
EMU	Electric Multiple Unit
ERP	Emissions Reduction Pathway
ETCS	Electronic Train Control System
ETS	Emissions Trading Scheme
GI	Glenn Innes
H2A	Hamilton to Auckland (Inter Regional Rail)
ILM	Investment Logic Mapping
IMEX	Import Export (freight market)
IO	Investment Objective
IP	Inter Peak
IR	Inter-Regional
KPI	Key Performance Indicator
KR	Kiwi Rail
LTPP	Long Term Planning Process
MCA	Multi Criteria Analysis
MSM	Macro Strategic Model
MTMV	Mobile Track Maintenance Vehicle
N2N	Newton to Newmarket
NAL	North Auckland Line
NIMT	North Island Main Trunk
NLTF	National Land Transport Fund
NPS-UD	National Policy Statement on Urban Development
NPV	Net Present Value
OBL	Onehunga Branch Line
OPEX	Operational Expenditure
P2P	Pukekohe to Papakura
PBC	Programme Business Case
POAL	Ports of Auckland
PT	Public Transport
RLTP	Regional Land Transport Plan
RNGIM	Rail Network Growth Impact Management
RPTP	Regional Public Transport Plan
RTN	Rapid Transit Network

SB	Southbound
SME	Subject Matter Expert
TT	Travel Time
VKT	Vehicle-Km Travelled
W2QP	Wiri to Quay Park
W2W	Wiri to Westfield
WB	Westbound
WPOAL	Wiri Ports of Auckland

2 OPTIONEERING INPUTS

2.1 OVERVIEW

This section provides an overview of how Investment Logic Mapping (ILM) was used to develop the Multi-Criteria Assessment (MCA) framework used in optioneering. It also presents a summary of related documentation providing further technical assessments and analysis and describes the do min state for the network.

2.2 INVESTMENT LOGIC MAPPING (ILM) AND CONDITIONAL OUTPUTS

An Investment Logic Map (ILM) workshop was held on 10th March 2022 with Auckland Transport, KiwiRail, Auckland Council, and Waka Kotahi. The ILM outlined the problems, benefits, and investment objectives that the PBC will consider, as shown in Figure 2-1.

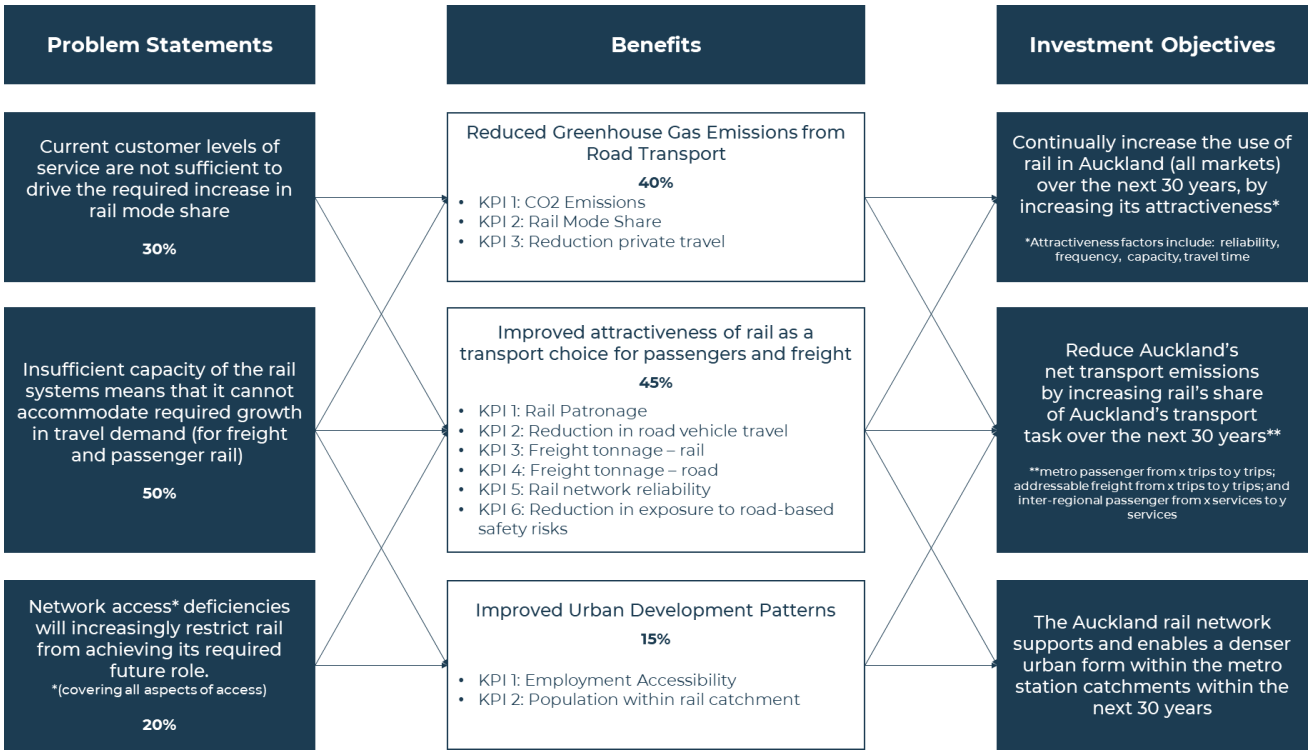


Figure 2-1 - ILM Mapping Summary

In addition to the investment objectives, Conditional Outputs (COs) were developed as a further set of criteria to aid the optioneering process. As described in Section 1.2, in the context of this PBC, the COs are a set of practical rail specific targets that are expected to support the overall Investment Objectives (IOs) defined above, upon which the success of the programme is ultimately measured against. In other words, the COs are a useful tool in developing, refining, and selecting options but not a substitute for the IOs.[3]

The COs summarised in Table 2-1 below cover a range of objectives from achieving strategic policy targets to meeting forecast demand targets.

[3] There are several instances where CO's have been relaxed based on value for money assessments, which can be found throughout the Part 1 and 2 operations development reports, and which demonstrate the 'conditional' nature of these targets. These include relaxation of the standing time CO on the southern line to reduce costs associated with 9-car platform extensions (see Economic Case Section 3.2.1.2), relaxation of the 45min journey time and off-peak car competitiveness COs where 4-tracking of the inner southern corridor was ruled out (see Economic Case Section 2.4.5), and relaxation of the RTN frequency CO to allow uneven headways on the western line and avoid four tracking the outer western corridor (see Economic Case Section 2.3.3.2). Additionally, all COs have been relaxed to some degree in that, to the extent to which they are achieved, this often occurs much later than would be desirable or required. For example, the peak capacity COs are not met for the southern line till much later than demand (see Economic Case Section 3.2.1.1)

Table 2-1 - Conditional Outputs

MARKET	*CONDITIONAL OUTPUT*	
Metro Passenger		Provide peak period capacity for base demand (metro passenger)
		Maximum length of standing (target <15mins)
		Enable incremental journey time improvements. This is particularly relevant for the phasing of the programme in that it establishes the principal that journey times, for all trips, should not be made worse when moving from one configuration state to another.
		Point-to-point journey time comparable to off-peak car trips.
		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.
		Comply with 2018 Regional Public Transportation Plan (RPTP) Rapid Transit Network (RTN) aspirations for services of 10 min (or better) minimum frequency between 6am and midnight
Freight		Provide peak period capacity for base demand (per forecasts provided)
		Provide optimal timetabling with freight destinations (i.e., ports, ferries, logistic industries etc.)
		Enable transition to 1500m freight trains from south of Auckland to Westfield / Southdown
Interregional		Provide peak period capacity for base services (interregional passenger; # slots)
		Enable incremental journey time improvements.
Reliability		Enable 6hrs of productive maintenance per night (on average)
		Enable 30-minute evening service with one main closed (for maintenance)
		Peak network capacity utilisation (target <75%). Utilisation refers to the percentage of available capacity allowed by infrastructure, that is utilised by rail services. A 75% target provides flexibility in future planning and allows for growth beyond what is predicted in the inputs to the PBC

2.3 MCA FRAMEWORK

Multi-Criteria Analysis (MCA) was used throughout the optioneering process as a key tool for the assessment options at long list and short list phases. A project-specific MCA framework was developed which includes elements from the Waka Kotahi sample framework, investment objectives and Conditional Outputs. The assessments were scored using a seven-points scale shown below. At each stage, the options were compared against the Do Minimum which assumes a neutral score of 0 for all criteria. The assessment wording and the considerations used for assessment are summarised in Table 2-2.

-3	-2	-1	0	1	2	3
Major adverse effect	Moderate adverse effect	Slight adverse effect	Neutral / No change	Slight positive effect	Moderate positive effect	Major positive effect

Table 2-2 MCA Framework

MCA TOPIC	ASSESSMENT	CONSIDERATIONS
Investment Objectives	IO1: Continually increase the use of rail in Auckland (all markets) over the next 30 years, by increasing its attractiveness (e.g., reliability, frequency, capacity and travel times)	Alternatives and options need to be assessed for their ability to deliver against investment objectives. Investment objectives are derived from problem statements and benefit maps as part of investment logic map (ILM) sessions, as shown in Figure 2-1. Each investment objective was further assessed against multiple criteria, such as against each rail market (passenger, freight and inter-regional).
	IO2: Reduce Auckland's net transport emissions by increasing rail's share of Auckland's transport task over the next 30 years	
	IO3: The Auckland rail network supports and enables a denser urban form within the metro station catchments within the next 30 years	

MCA TOPIC	ASSESSMENT	CONSIDERATIONS
Critical Success Factors	Potential Achievability/Deliverability (Programme Business Case only)	**Technical:** What are the technical or practical considerations that may prevent an option from achieving investment objectives, for example local site geography or existing contracts/project interfaces? What are the technical risks involved in developing or implementing this option? **Safety and design:** Are there significant health and/or safety risks associated with the option in its design, implementation, operation or maintenance? Does this option comply with the safe system approach? Can the risks be addressed in the design process to control it? **Consentability:** What is the level of consenting complexity/difficulty? Are there risks of this adversely impacting on required project timeframes or other aspects of delivery?
	Potential affordability	**Capital/operational/maintenance:** Does the cost of the option fit within the likely funding available? What factors might affect the ability of the project owner to afford the cost to operate and maintain the option over its projected life?
	Supplier capacity and capability	Any external resourcing challenges, for example dependency on local construction firms, including interdependencies across projects
	Scheduling/programming	When the alternative/option could be delivered and other timing requirements
Opportunities and Impacts	Environmental Effects	What environmental effects are associated with this option? Environmental effects could include those related to ecology, water quality, stormwater, noise and vibration, visual impact, urban design, natural hazards, contaminated land, landscape, heritage (including archaeology), biodiversity, resource efficiency and air quality.

MCA TOPIC	ASSESSMENT	CONSIDERATIONS
	Social and Cultural Impacts	What social or cultural impacts are associated with this option? Social or cultural impacts may include, for example, human health, impacts on community in relation to jobs, recreation, services, and severance, impacts on farming and business operations.
	Climate Change Mitigation	What is the long-term carbon emissions impact of the alternative or option? That is, consistent with carbon budgets once available.
	Climate Change Adaption	Is the alternative or option exposed to climate change risk or other natural hazards over time?
	Cumulative Impacts	What cumulative impacts are there, if any, are associated with the option? Cumulative effects may be insignificant on their own but may accumulate over time or space with other effects to become significant. Consider implementation, operation, and maintenance phases.
	Impacts on Te Ao Māori	What, if any, impacts are there on Te Ao Māori? This includes areas of significance for Māori, Māori land and Kaitiakitanga (recognition that the environment is a taonga).
	Property Impacts	How does the option impact on property? Can the necessary property rights be obtained?
	Impacts on Road Safety	Extent to which the option reduces exposure to road-based safety risks
Conditional Output Assessment	Metro Passenger	Conditional Outputs are statements of the long-term aspirations for the level of service provision desired to inform future investment decisions. Assessment has been undertaken for each conditional output which are categorised by market
	Freight	

MCA TOPIC	ASSESSMENT	CONSIDERATIONS
	Inter-regional	(metro passenger, freight, inter-regional and reliability). To ensure robustness of assessment across the network, options throughout were broken down by four geographical locations across Auckland to assess the impact on each major rail line segment.
	Reliability	
Project Specific Critical Success Factors	Capital Cost	Does the cost of this option fit within the likely funding available? What factors might affect the ability of the project owner to afford the cost to operate and maintain the option over its projected life?
	Impacts on Operating Costs	

2.3.1 CONDITIONAL OUTPUT GROUPING

Throughout the analysis, the conditional output assessment criteria have been duplicated across corridors on the network to provide a higher level of granularity in the assessment and enable the optimisation of investments between markets across geographies given that demands, operational characteristics, and strategic considerations are highly varied across the network. The definition of corridors is not exact and evolved throughout the process, but generally follows the structure below.

- Western corridor: including the metro Western Line from Swanson to the city centre, the metro Onehunga services between Henderson and the Onehunga Branch Line, and North Auckland Line (NAL) freight between Southdown/Westfield and Northland. In later phases of optioneering, the Western corridor also includes analysis of the Avondale – Southdown corridor.
- Eastern corridor: including the metro Eastern Line from Manukau to the city centre, and the Ports of Auckland freight line between the port and Wiri inland port, as well as Southdown. This corridor also sometimes includes analysis of the Southern Line express and inter regional services as these services are routed via the Eastern corridor under certain options.
- Southern corridor: Generally, split into two segments.
    - Outer southern corridor: Which includes the metro Southern Line from Pukekohe to the city centre, freight on the North Island Main Trunk including domestic and IMEX (MetroPort) services, and inter regional services from Hamilton.
    - Inner southern corridor: Which covers the segment of the network from Wiri junction (where the Manukau Branch Line begins) to Newmarket along the NIMT and NAL. This includes the Wiri to Westfield segment of the network in which the metro Southern line, metro Eastern line, NIMT freight, POAL freight, and inter regional services all converge.

2.4 TECHNICAL ASSESSMENTS

Throughout the optioneering process, technical assessments have been undertaken to inform the MCA and test options at different levels of detail and from different perspectives, so that they can be assessed and compared within the MCA framework. Technical assessments typically related to rail operations and planning, include service concept and timetable development, track plan development, fleet plan development, operational modelling, and demand modelling as well as more general methods of assessment including economic analysis and planning.

These assessments were documented and shared in memos, technical reports, presentations, spreadsheets, and drawings throughout the optioneering process to develop a common understanding of the network, its problems and the options for improving it over the wider stakeholder group. The key findings of these technical assessments are summarised in the body of this report and the accompanying Part 2 report and included as full appendices where relevant.

Throughout the option development and selection process, specific technical topics appeared significant and required a detailed and focused analysis in order to inform other analyses and decision making. This resulted in the development of several additional service memos covering a range of topics. These supporting service memos are listed below in Table 2-3.

Table 2-3: Summary of supporting service memos

Supporting Service Memos
Adoption of A8i reduced as a basis for service planning
Definition of freight paths on the AMRN
Distribution of freight traffic in 2051
Investigation of express services on western line
Southern Line Travel Time Benefits
Operation patterns for a 4-track railway (on the Southern Line)
Early metro passenger demand analysis

2.5 DO MINIMUM SUMMARY

The purpose of the 'Do Minimum' is to be used as a base for assessment to decipher how effects of each option compare and to inform the BCRs. This includes assumptions about what the rail network and wider transportation network will look like and how they perform if no additional investment is undertaken aside from what is already committed and funded by 2051. This section provides a summary of what has been assumed in the DM for the PBC.

2.5.1 HEAVY RAIL PROJECTS

The following heavy project were included as part of the DM assumptions for heavy rail network in particular.

Table 2-4. Rail Projects to be included in the 'lean' DM.

CRL (including Otahuhu 3rd platform, Strand crossover, Newmarket crossover, infill signals)	Papakura to Pukekohe electrification (P2P), including Southern Stations (3 new stations)
Western Power Feed	AT EMU Batch 3 (including Wiri Depot upgrades)
RNGIM (Phase 1 - discussed further below)	Pedestrian level crossing removal (x7)
Integrated Rail Management Centre	Church St level crossing removal
Wiri to Quay Park and 3rd main (W2QP)	KiwiRail fencing programme
Henderson Station 3rd platform	

Note that at this time the inclusion KiwiRail maintenance plant, equipment and depots improvements in the DM is still to be confirmed (agreed as being required, amount and timing TBC)

2.5.2 LAND USE

Land use scenario I-11.6 is used for the DM as illustrated in Figure 2-2. Note that Auckland Council is undertaking a separate planning exercise to update I-11.6. The exercise will look at likely changes to land use given the NPS-UD and other workstreams, however this was not completed in time for inclusion in the PBC process.

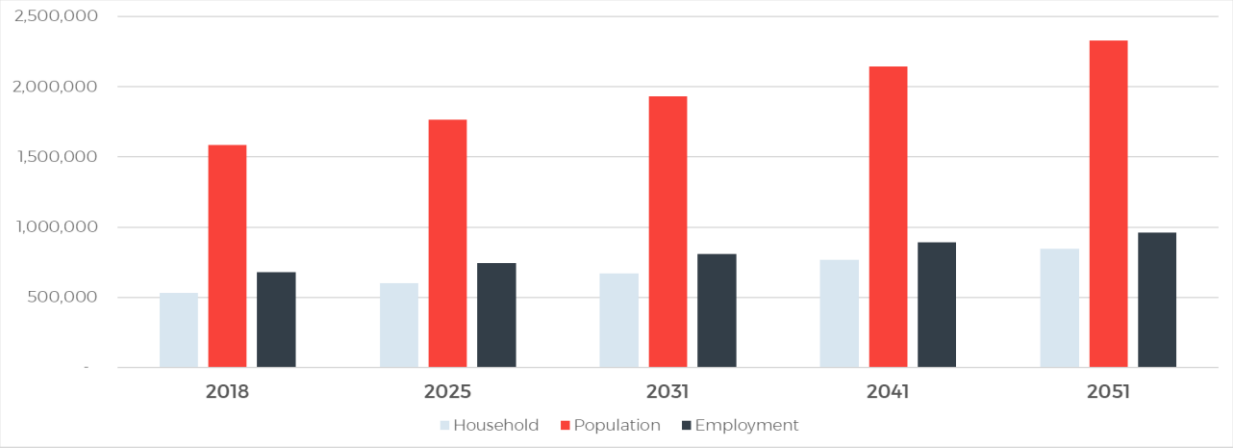


Figure 2-2. I11.6 household, population and employment forecast for horizon years.

2.5.3 RAIL SERVICES, MAINTENANCE AND RENEWALS

2.5.3.1 PASSENGER TRAIN NETWORK

Metro services under the DM in 2025, 2031, 2041, and 2051 reflect the proposed 2025 Train Plan for CRL Day One, A8i (reduced) illustrated in Figure 2-3[4]. It was deemed that no improvements beyond this would be possible without further investment on the network.

[4] Note that the CRL Day 1 Timetable referenced above and is still undergoing review and is not yet confirmed and agreed by all parties. It has been adopted as an assumption in the PBC.

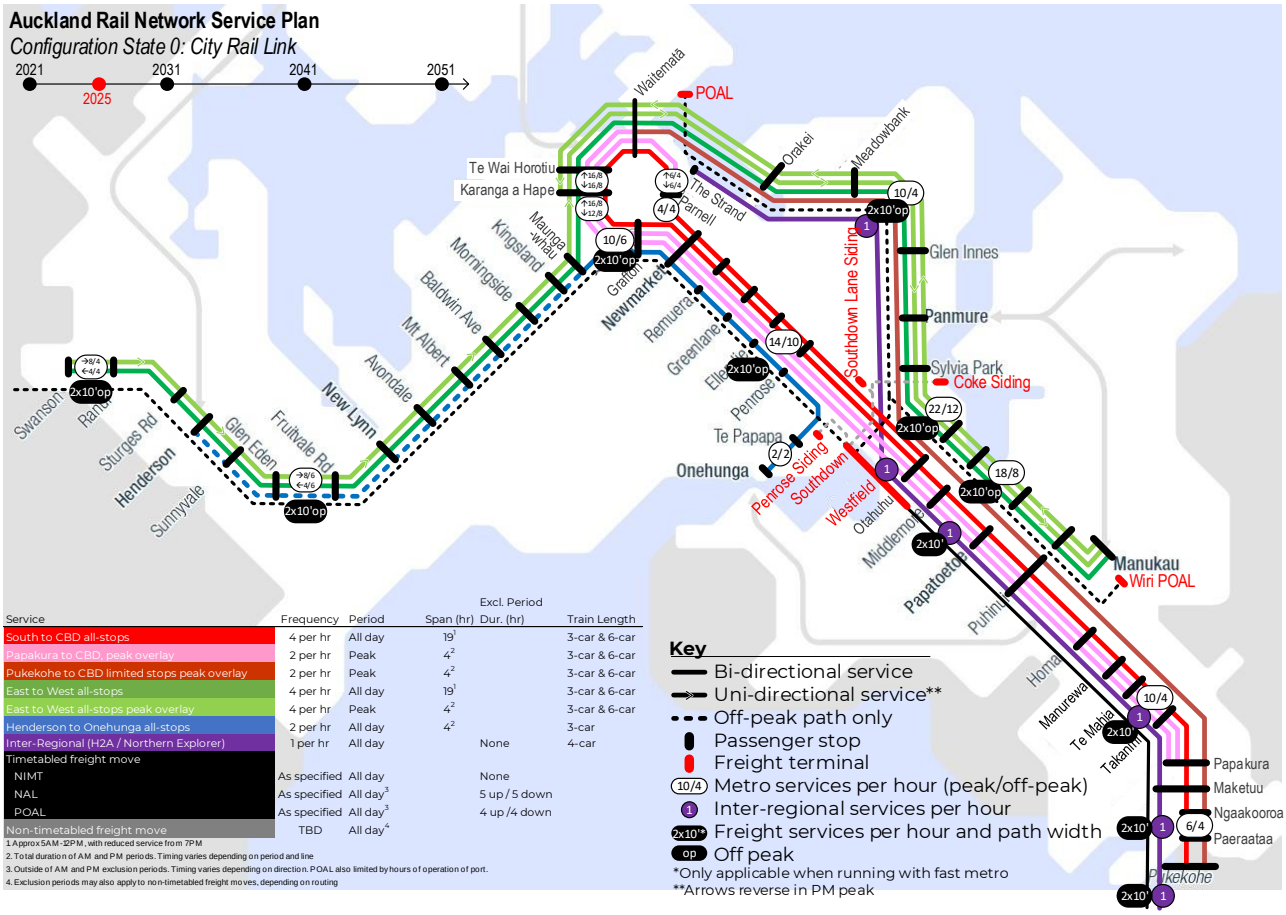


Figure 2-3: DM Peak Train Plan

2.5.3.2 FREIGHT TRAIN NETWORK

Freight volumes in the DM represent the 'Business As Usual' (BAU) scenario developed by KiwiRail using a freight forecasting model derived from the MoT Freight Futures model which forms part of the Ministry of Transport's Transport Outlook modelling suite.

BAU forecasts consider the position going forward for the rail network where only schemes that are committed and confirmed policy changes occur. These include: -

- Specific improvements to rail services incorporating the construction of the link to Marsden Point, increased frequency on Metroport trains, and increased capacity on the Cook Strait with new IIL ferries.
- Already announced increases in the carbon charge included in the price of fuel via the ETS coupled with an expanded use of biodiesel in line with Government policy. Because the share of fuel in rail costs is lower than that for road transport, this would give rail a competitive advantage which is assumed to be translated into an increased modal share.

2.5.3.3 INTER-REGIONAL TRAIN NETWORK

At present, Te Huia train services connect the Waikato and Auckland. Te Huia runs return services from Hamilton to Auckland twice a day during the week (one AM service and one PM service), and once on Saturdays.: The DM assumes an hourly return service between Hamilton and The Strand.

Northern Explorer services run between Auckland and Wellington with six trips per week: three up and three down. This service is assumed to double to 12 trains per week by 2051.

2.5.3.4 MAINTENACE AND RENEWALS

A maintenance access window of around 3 hours per night (average) has been adopted as representative for the Do Min based on a review of recent operational data.5 Various initiatives are underway to improve maintenance access including the addition of 6 signalled on-tracking pads as part of RNGIM, and delivery of lineside access tracks and walkways as part of current works being undertaken at Westfield, Wiri, Third Main and Quay Park. However, significant improvements to maintenance access are required beyond this to achieve a reliable network operation.

and implementation of additional crossovers, signalling and OLE sectioning, which will enable single line operation while the adjacent main is closed for maintenance.

From a renewal's perspective, KiwiRail have developed a base level of annual renewals across 30 years that has been agreed to include in the Do Min. While the assumed renewal spend is not fully committed or currently funded, it is agreed amongst the project partners as being necessary to ensure the network can sustain the operation of the CRL day-1 timetable without adding to existing backlog renewals. It is assumed that the necessary equipment and changes to methods of working to support such a change to the renewal's regime will be possible.

AT rail-related renewals to include in the Do Min are aggregated in its public transport renewals forecast. This includes station renewals and rolling stock renewal costs for the current fleet. For the next 10 years, these are treated as committed, and will be projected forward for the 30 years on the same basis as above (i.e., necessary but not currently funded).

TRANSPORT NETWORK ASSUMPTIONS

The PBC developed two broader transportation network alternatives for the DM in early phases of the project a Lean DM scenario and a Reference Case DM scenario. A list of the assumed interventions in each DM scenario are provided in Table 2-5 and Table 2-6 below. The final PBC DM uses the Lean DM configuration for modelling years 2025, 2031, and 2041, and the Reference Case DM for 2051.

Table 2-5: Transport network assumptions - Lean DM

Project	2025	2031	2041
SH1 Southern Motorway widening south of Papakura	Y	Y	Y
SH1: Six lane SH1 from Albany to Silverdale	N	N	N

[5] The difference between first departure and last arrival on the Southern Line in the current metro timetable is around 5 hours 25min on a weekday but this is very different to a 'productive' maintenance window (which requires at least 1 hour for set up / set down) and is further constrained by empty train moves and freight services. Section 6.3.6 of the Strategic Case presents data between 2018 – 2021 that shows an average access time of 3hrs, with significant variance between network segments. Refer to this section for further discussion

Penlink	N	Y	Y
SH1 Extra NB Lane from Akoranga to Constellation	N	N	N
SH1 Extra SB Lane from Tristram to AWHC	N	N	N
SH1: AWHC	N	N	N
SH18: Extra WB lane on upper harbour bridge	N	N	N
SH16: 8 laning between Te Atatu and Westgate	N	N	N
SH20: 8 laning between SH20A and MHX	N	N	N
SH1: Additional NB lane from SEART to Penrose	N	N	N
2X East West Links to Highbrook	N	N	N
SH20A: six laning	N	N	N
SH1: 8 laning between Orams Rd and Takanini I/C	N	N	N
SH1: 6 laning from Drury up to Bombay I/C	N	N	N

Table 2-6: Transport network assumptions - Reference Case DM

Project	2051
Auckland Light Rail	Y
Rapid transit to North-west	Y
Rail rapid transit to North Shore (AWHC)	Y
The Eastern busway (Panmure-Botany)	Y
Airport to Botany	Y
Auckland Transport Connected Communities programme	Y
AWHC	Y
Penlink	Y
SH16: 8 laning between Te Atatu and Westgate	Y
SH20: 8 laning between SH20A and MHX	Y
SH1: 8 laning between Orams Rd and Takanini I/C	Y

2.5.3.5 BUS NETWORK

The following assumptions have been taken with respect to the bus network in the DM.

2031 Do-minimum network: The Auckland Rail PBC Do Minimum PT frequencies reflect the service pattern contained within the 2031 RLTP scenario.

2041 & 2051 Do-minimum network: For the 2041 and 2051 scenarios resembles the 2031 network structure (i.e., no allowance for enhancements to the rapid transit network beyond what is available in the 2031 RLTP Scenario). Additional bus services were also included for the greenfield networks to service new developed areas.

This bus frequencies have been adjusted to meet the uncrowded demand for PT services based on the 2031 network structure (i.e., volume of capacity less than 1).

3 IDEA GENERATION

3.1 OVERVIEW

This section outlines the process from initial idea generation, through a filtering process, leading to a long list of differentiating and non-differentiating components. An initial set of 291 blue sky ideas formed via a stakeholder workshop were ultimately refined to a long list of 30.

3.2 PROCESS AND OUTCOMES

This section outlines the process and summarises the outputs at each phase, culminating in a list of 30 differentiating service elements that were taken into the next phase of optioneering.

3.2.1 INITIAL IDEATION: BLUE SKY IDEATION

On 4 April 2022 a group of subject experts and stakeholders from Auckland Transport, KiwiRail, Waka Kotahi, Waikato Regional Council and WSP convened to draw up a long list of options for the Auckland Rail PBC.

Given the project's significance and complexity, it was vital to approach the PBC with the broadest set of potential levers and components. This workshop was a blue-sky opportunity to generate an unconstrained list of ideas that might impact or form part of Auckland's 30-year rail plan.

At the initial workshop, ideas were formulated and grouped to align with the investment objectives and the Waka Kotahi Intervention Hierarchy, which is outlined in Figure 3-1.

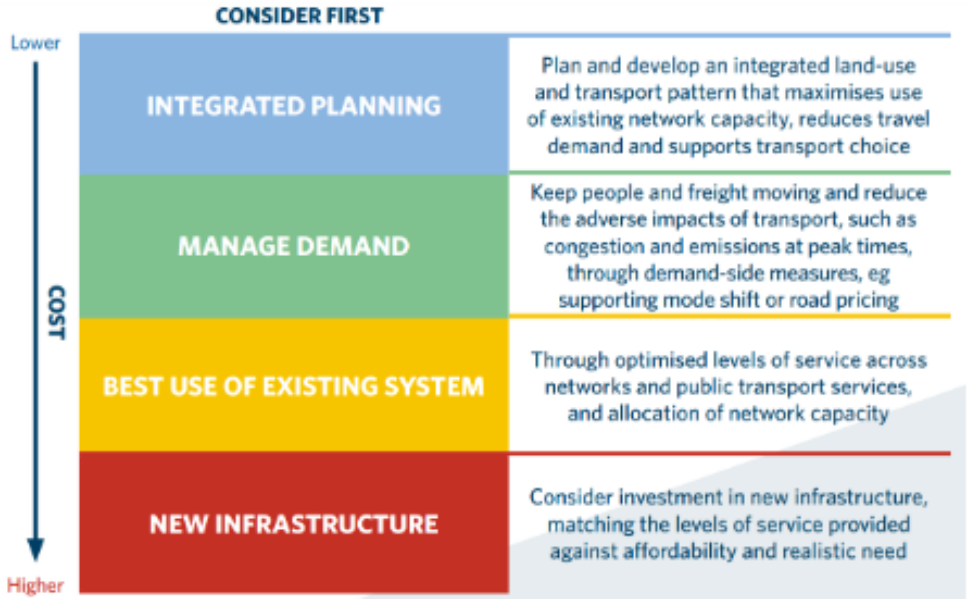


Figure 3-1: Intervention hierarchy

A filter was applied to all ideas, where these were placed into Themes within each of the four interventions. This resulted in a list of 291 ideas generated across the four intervention areas and 28 themes which are further detailed in Appendix A.

3.2.2 INITIAL IDEATION: 3-STEP SIEVING PROCESS

Following this work, ideas were tested and refined based on a **3-Step Sieving Process**:

1) Is the idea within the scope of the PBC and in line with the Investment Objectives?
2) Is the idea more generic in nature (If so, **Non-differentiating/Common Elements**)
3) Will the idea influence the provision of services for passenger & freight customers? (If so: **Differentiating**)

Based on these questions, 180 redundancies, duplicates, out of scope ideas, or ideas not enhancing service provision were identified and removed from the discussion. A further **81 suggestions** were deemed to be **non-differentiating.** These ideas, while relevant for the PBC to consider at some point, will not help to provide differentiation between broad programme options. For example, the following idea pertains to future rolling stock design. "lighter units for faster acceleration and deceleration". New fleet will be required under all options – so while it is important to consider options for different types of fleets eventually, such decision making should be made at a later stage once the macro level elements of the phasing have firstly been determined. These 81 suggestions were therefore set aside to be tested and evaluated at the Initial Preferred Programme stage.

The remaining **30 suggestions** were deemed to be **differentiating** factors, fulfilling Step 3's criteria. They were filtered by service type (options and sub-option), as summarised in Table 3-2**.**

It is noteworthy that all the ideas outlined in this table relate to metro services, but as will be shown in future sections of this report, the demands of freight and inter regional markets are equally influential in selecting a 2051 end state. In part, this was due to the fact that freight and inter regional services were considered largely as fixed inputs at this stage of analysis. However, some service ideas were raised in ideation sessions which, despite not appearing in the differentiating ideas table below, did ultimately become influential in the development of options. These included:

- improved time access to the network for freight,
- potential for running longer freight trains,
- segregation of freight and passenger services
- selection of inter-regional terminals
- improvement of inter-regional stations.

Other ideas recorded such as fitment of ETCS L2 and electrification for these services were considered as required inputs to the PBC rather than options for consideration. The full list of 291 ideas, their categorisation against the intervention hierarchy and their filtering against the 3-step sieving process, are provided in **Appendix A.**

Table 3-1: Categorisation of differentiating service ideas

SERVICE IDEAS BY TYPE (OPTION)	NUMBER OF SUGGESTIONS	SUB-OPTIONS
Faster Services	16	▪ More Express Services ▪ Less Express Services ▪ Reduced Dwell Times

Longer Trains	6	▪ 9 Car Express ▪ 9 Car West ▪ 9 Car South ▪ Reduced Dwell Times
More Frequent Services	5	▪ Frequent All Day (10 min or better) ▪ All-Stops Peak Overlays (West) ▪ All-Stops Peak Overlays (South) ▪ All-Stops Peak Overlays (East)
New Routes	4	▪ South to West Route ▪ Manukau from South ▪ OBL as Alternative Mode
TOTAL	30	

3.2.3 STRATEGIC ALTERNATIVES

The groupings of the NLTF intervention hierarchy, along with the assumptions that were discussed during the workshop are summarised below. This discussion highlights that the potential strategic alternatives (along the intervention hierarchy) are limited as, in the broader context of Auckland, integrated planning and demand management in particular are focused on increasing the use of public transport, including rail.

The purpose of the Auckland Rail PBC is to determine the best course of action for rail to support those wider decisions and policy shifts. The focus of the Auckland Rail PBC is therefore necessarily on the latter two interventions – making best use of the existing system and then considering what new investment might be needed to ensure that Auckland's rail network is fit for its growing future role

Appendix A. provides further commentary on this topic.

3.3 NEXT STEPS

Within the 3-step sieving process, **81** non-differentiating (or less-differentiating) components were identified as needing to be part of the eventual preferred programme (i.e.: station access improvements, additional rolling stock etc.).

The 30 **differentiating factors** summarised in Table 3-1 were taken forward for testing within the longlist (Section 4) but it is noted that this initial list of factors lacked relevance to all markets including freight and inter regional – an issue that was addressed in the next phase of optioneering.

4 IDEAS GENERATION TO LONG LIST

4.1 OVERVIEW

This section outlines how the differentiating option components identified in Section 3, were applied to the network via the development of thematic long list options, and how these options and their component parts were tested using the MCA framework.

4.2 PROCESS

Given the complexity and interconnected nature of the network, and the fact that the 30 differentiating service interventions determined in the previous phase could be combined to a practically infinite number of ways, a more exploratory approach was taken whereby a set of 'thematic service concepts' was developed. These thematic service concepts were intended to represent a range of service strategies and infrastructure requirements for the network. Analysis of the service concepts would allow the best parts of each option to be taken forward and further combined into specific 2051 network wide options for assessment in the short list. The adopted 'pick and mix' process provided a right-sized approach that ensured a wide range of options were considered in the context of each market and geography. It also mitigated the need to test and assess the huge number of individual combinations of the component parts.

Development of the initial thematic concepts was based on a typical rail planning process, illustrated in Figure 4-1.

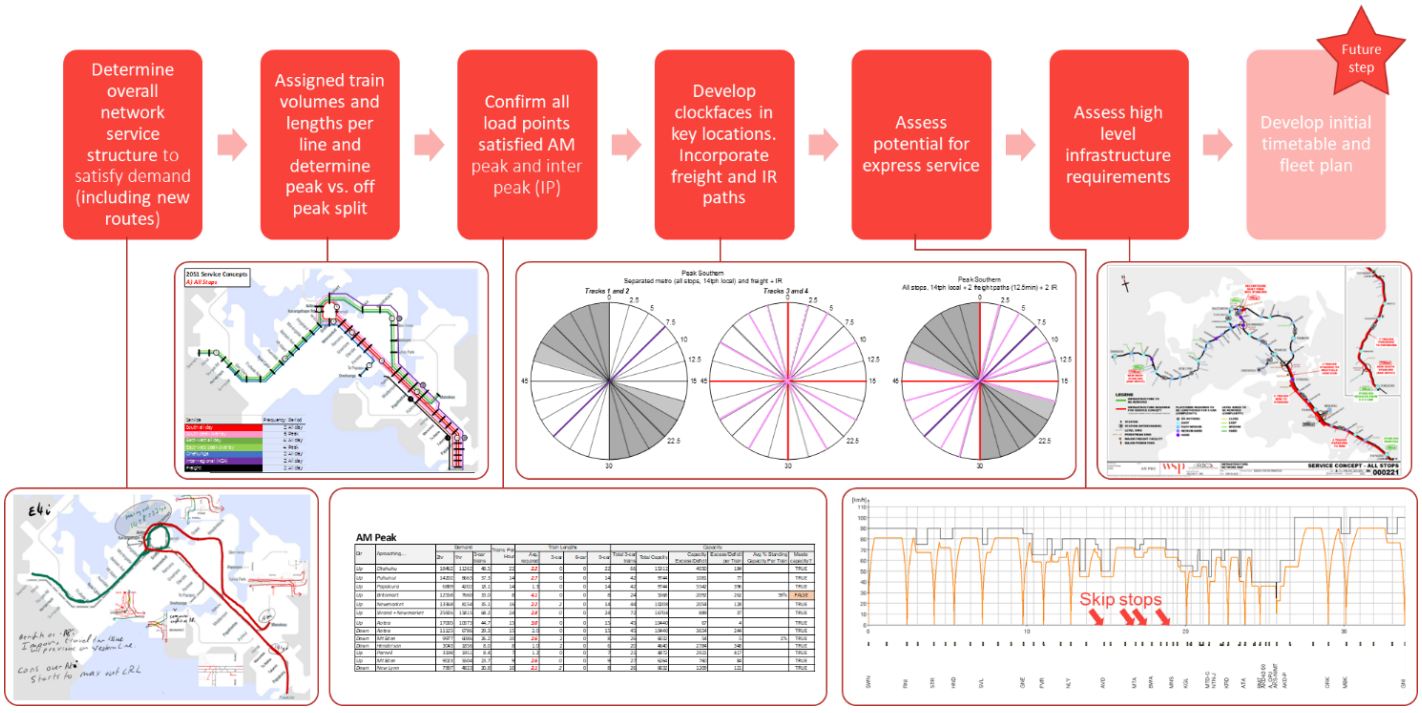


Figure 4-1: Service concept development process

This process was augmented with the aim of capturing all the 30 service ideas generated in the previous phase of optioneering, across a number of thematic options, which resulted in a set of 5 thematic long list options. The long list options are described in Section 4.3 along with considerations made in their development.

It is worth noting that the process in this phase of the PBC focused on the development of network wide **service concepts**, covering the three key markets of freight, interregional and passenger metro. Infrastructure was treated as an implication of the service option rather than being the focus of the optioneering. For example, an express service on the southern line along with other market demands, may require the addition of 3rd and 4th tracks based on the operational assessment undertaken. Thus the focus of the options development is on the degree to which express services are operated (in this example), with the implication of additional tracks being considered in the options assessment.

To assess these options, the MCA framework detailed in Section 2.3, was used alongside several interactive workshops. There were three primary long list workshops undertaken in this phase, as outlined in Table 4-1: Key focus areas at the workshops were:

- what do rail users expect of the Rail network?
- what is the potential nature of the network in 2051?

Table 4-1: Long List Workshops, June-July 2022

Preparatory Workshop: - 10 June, 2022	At this virtual, workshop, the process and MCA were introduced to stakeholders. Initial comments and observations on the long list options were collected and used for refinement in the next workshop. These outputs fed into the overall long list MCA and informed Workshops 1 & 2.
Long List Workshop 1 - 30 June, 2022	This in-person workshop tested and refined the ideas and MCA scoring of the long list options. Following the workshop, further sessions were undertaken to further refined the commentary, and confirm the team's assessment.
Long List Workshop 2 – 21 July, 2022	This in-person workshop reviewed the long list themes and started developing an initial short list. MCA scoring feedback identified several different options with differing levels of intervention.

4.3 LONG-LIST THEMATIC OPTION DEVELOPMENT

The process described in Section 4.2 resulted in the development of five thematic service concept options. These are listed below and illustrated in Table 4-2 along with a narrative of the service themes of the option, the implied infrastructure requirements, and some general pros and cons. These service concepts represent possible end states of the network and services have been scaled accommodate the demands forecasts for 2051.

1. All Stops – similar to the base case, with services stopping at every station for passenger services
2. Peak Limited Stops – express and limited stops services implemented to test benefits associated with faster travel time

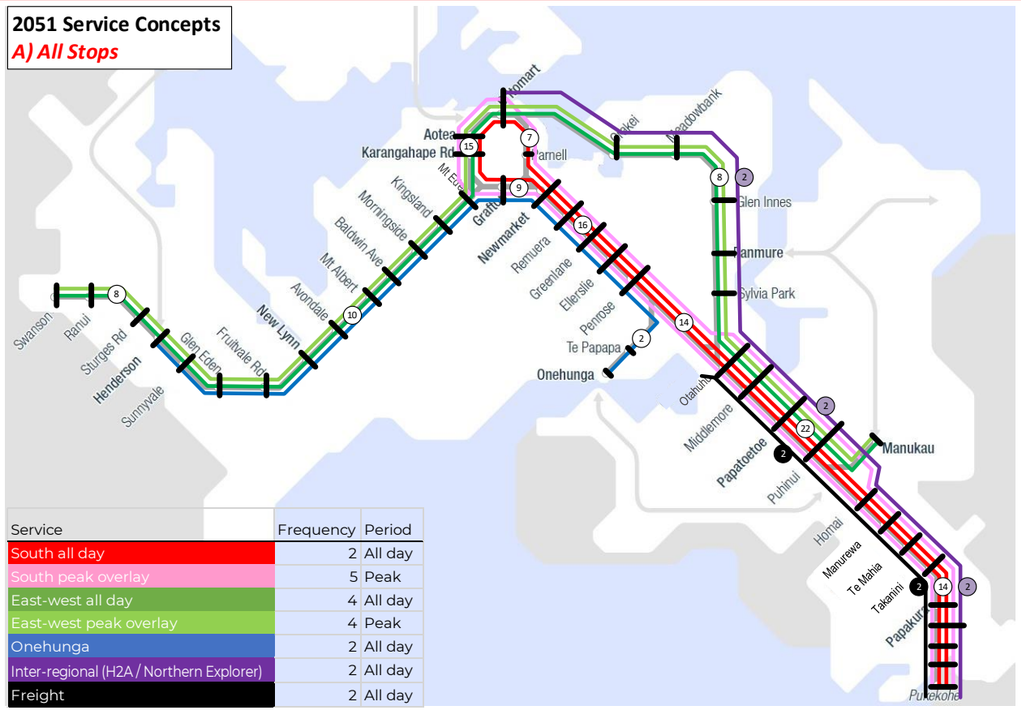
3. Inner-Outer, All Day Frequent - express and limited stops services implemented to test benefits associated with faster travel time, with additional services in the inter-peak
4. Peak Express, All Day Frequent, All-Day Freight – similar to Options 2 and 3, with further infrastructure interventions tested to improve capacity and resilience
5. Avondale Southdown – similar to Option 4, with the addition of Avondale-Southdown as a major piece of infrastructure included in the network

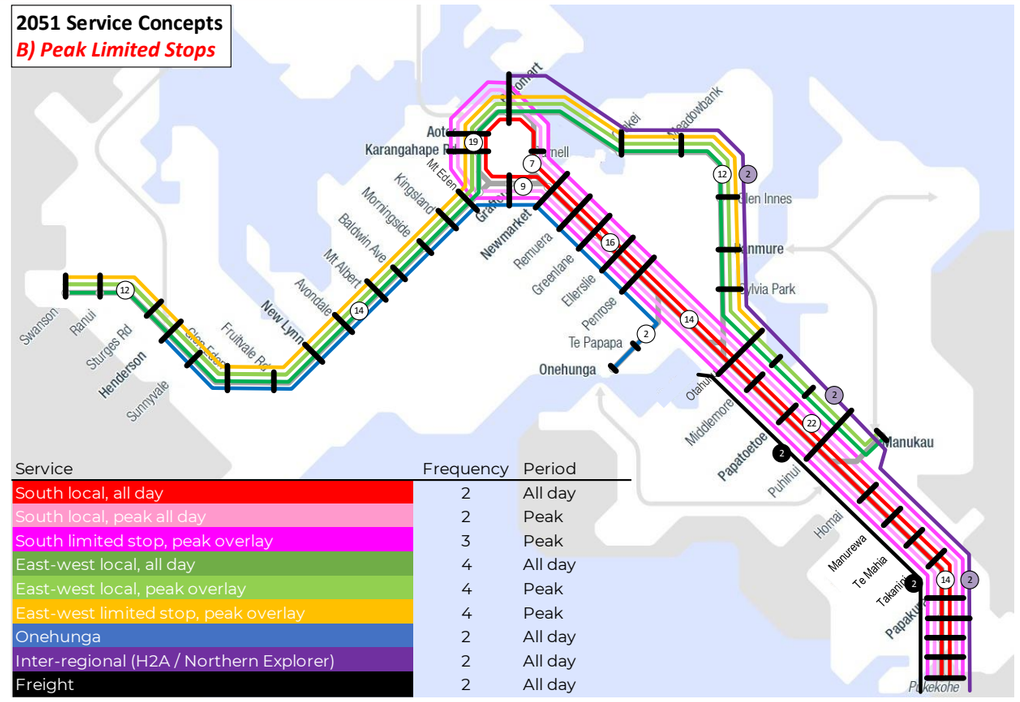
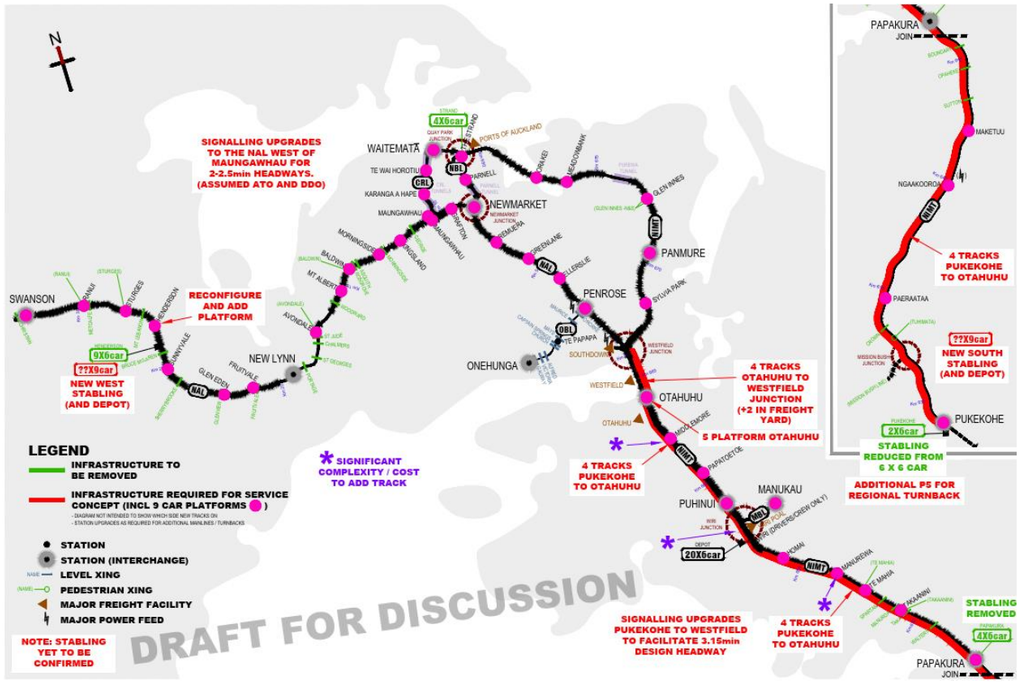
The themes selected represent a range of philosophical approaches to rail service planning and design. The all stops concept is similar to a German S-Bahn style operation with homogenous stopping patterns, while the Inner-outer concept represents something more akin to areas of the over ground railway in the UK. A peak express service concept is similar in style to the JR East systemin Japan which contains a variety of stopping patterns to serve diverse markets, and the Avondale-Southdown service broadly represents the idea of a freight bypass around a dense urban centre.

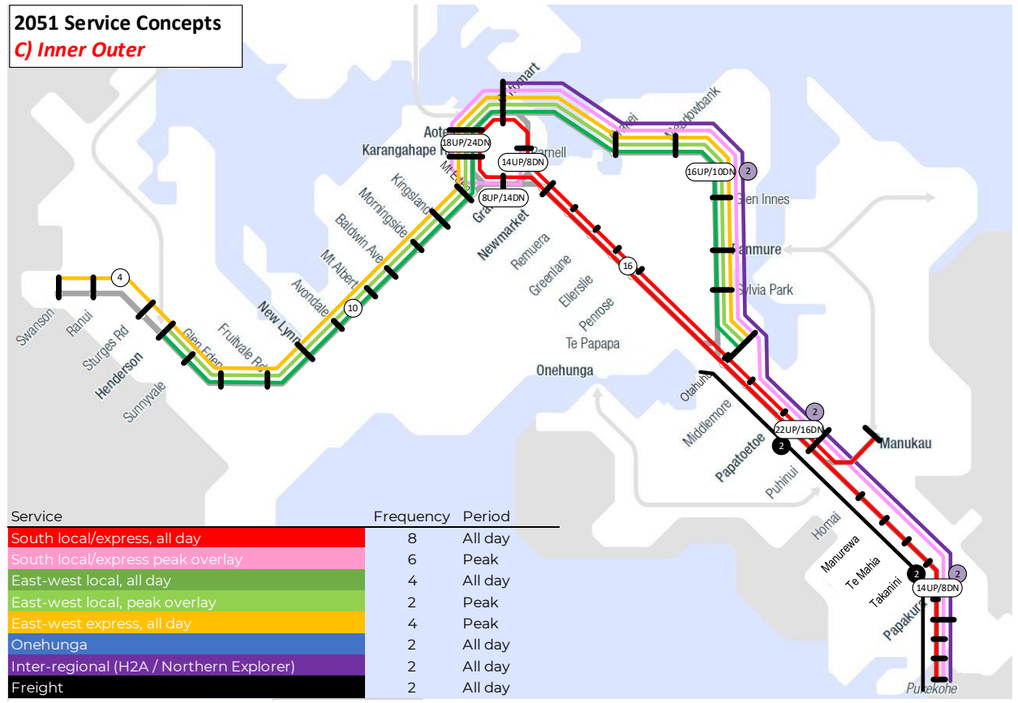
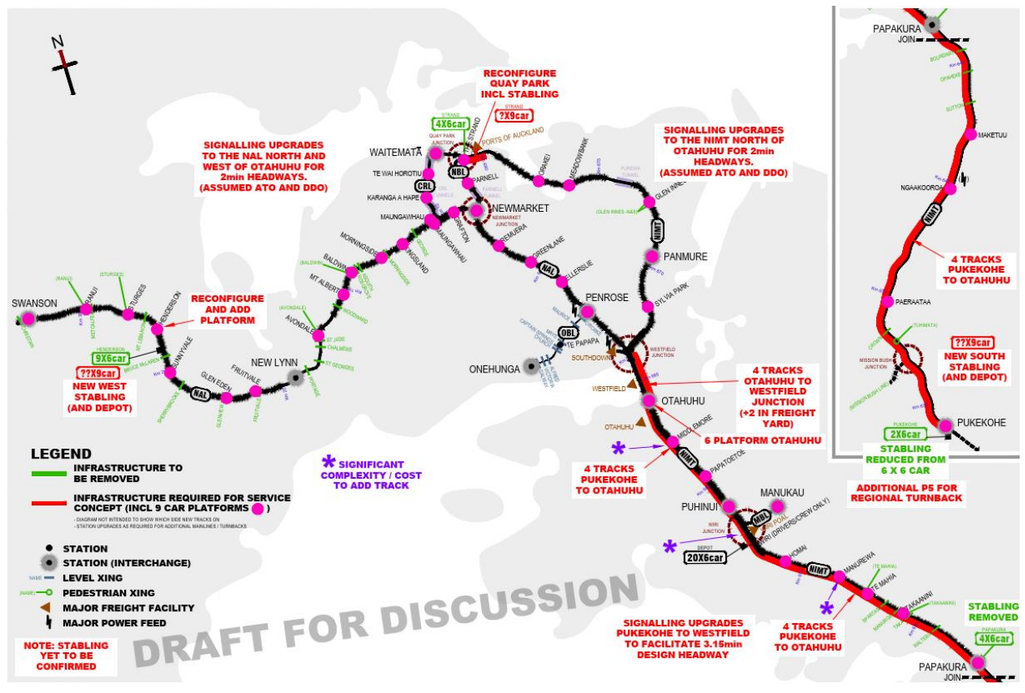
As in the initial ideation phase, the thematic options developed in the long list phase relate primarily to metro – but not exclusively. Specifically, options are differentiated by considering all-day (D, E) vs. off-peak only freight access (A, B, C), use of A-S as a freight bypass (E), and adoption of different trade-offs between freight path width, metro headway homogeneity, and additional track capacity. There are also options considered for different routings of inter-regional services.

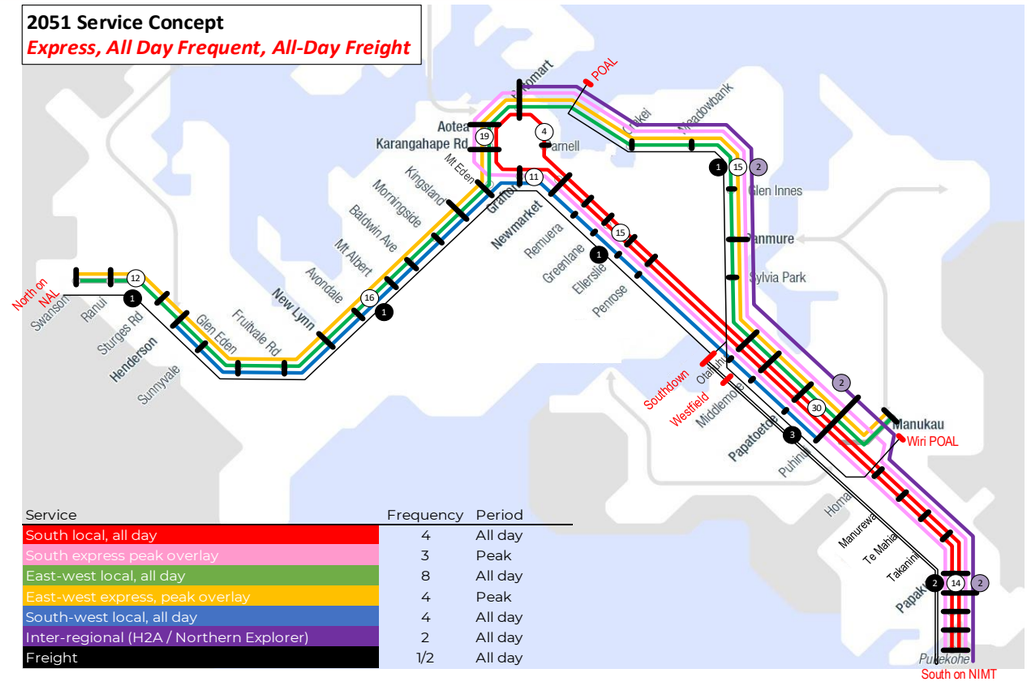
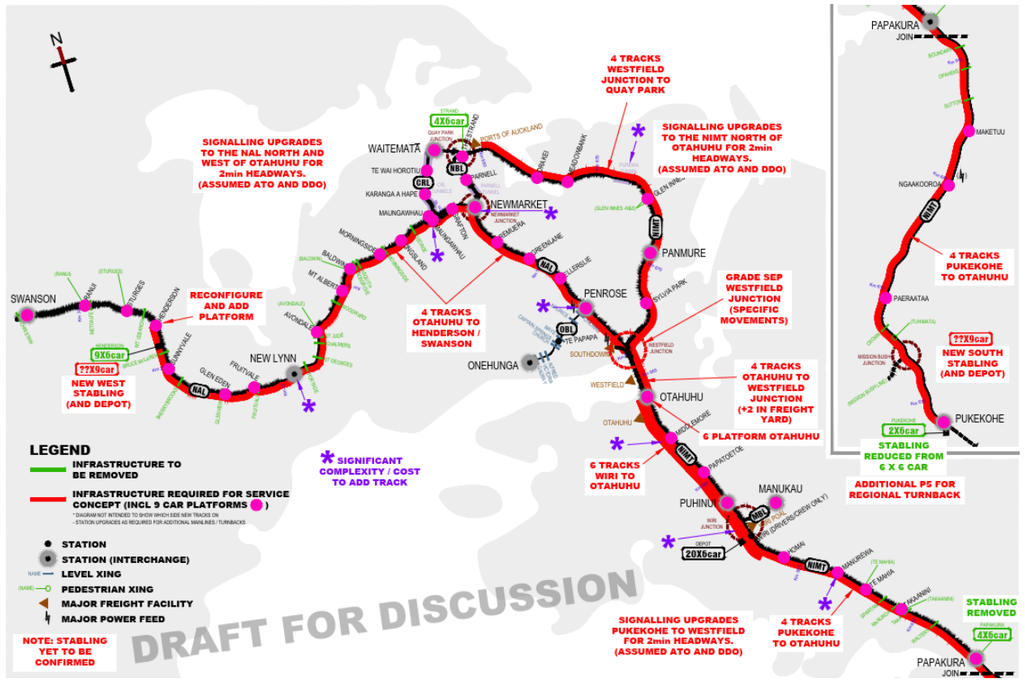
Details of the development of these service concepts along with a description of inputs, assumptions, methodology and calculations is provided in **Appendix B - 'Service Concept Long List Thematic Optioneering'.**

Table 4-2: Thematic Concept Summary

Concept Narrative		Pros & Cons	Pros and Cons
A) ALL STOPS		Service Summary This concept provides a simple all-stops operation to meet passenger demand with 9-car trains (with the Onehunga service continuing to operate 3 car trains), and a low base all day frequency of 4 tph to accommodate off-peak freight paths and inter regional trains without needing additional track or uneven headways. It would provide a complete separation of metro passenger from peak freight on NIMT Infrastructure Summary — Four-track railway from Pukekohe to Wiri — Six-track from Wiri to Westfield (required to meet capacity utilisation target of 75% - if four-track, eastern mains are at 92% utilisation) — Upgrades to support 9-car trains — Level crossing removal, — Signaling upgrades to support tighter (2.5min at min) headways on the NIMT between Pukekohe and Otahuhu — Additional rolling stock and stabling.	Pros — Complete separation of Freight/Interregional from Metro services allows for more efficient and flexible freight operation, potential for faster interregional service, and overall improved network resilience — Low off-peak frequencies allow for off-peak freight paths without comprising symmetric passenger timetable — Six-tracking between Wiri and Westfield means East-west and South lines can be completely segregated, leading to reliability benefits (reduced potential for cascading delays) and timetable efficiencies (reduced need for buffer to coordinate movements through Wiri and Westfield). Cons — Six-tracking between Wiri and Westfield presents challenges from an infrastructure perspective — Not providing competitive travel times with car, particularly south of Puhunui — Doesn't provide journey time of less than 45 minutes from south of Papakura Doesn't conform to future RTN aspiration's definition of frequent service

Concept Narrative		Pros & Cons	Pros and Cons
B) PEAK LIMITED STOPS	 	Service Summary This concept provides a peak, limited stop 9-car services, plus all-day, all-stops services. It would provide improved peak travel times (~4.5min from South & ~3min from West) and compete with equivalent car trips, particularly from the outer region of network. Mixed metro (limited stops), freight and inter-regional (IR) on NIMT in peak. Infrastructure Summary Same as Concept 1 with following exceptions: — Wiri to Westfield only requires 4-tracks (due to shifting some metro services to western — mains to run express, thus reducing utilisation of eastern mains to <75%) — added signal upgrades on NAL to support 2.5min headway between Mt Eden & Swanson.	Pros — Utilizes 3rd and 4th mains to run faster metro services on the South — Provides faster service to the West without need for additional trackage — Low off-peak frequencies allow for off-peak freight paths without compromising symmetric passenger timetable (except on the Western Line) — Lower utilization of Wiri-Westfield and CRL provides headroom for capacity growth without requiring 6 mains Cons — Doesn't conform to future RTN aspiration's definition of frequent service — Travel time improvements are relatively small and may not result in significant demand uplift Travel time improvements on Western Line rely upon uneven headways (alternating 5min and 10min) which may reduce perceived service quality and result in uneven loads

Concept Narrative		Pros & Cons	Pros and Cons
C) INNER OUTER		**Service Summary** This concept provides a 9-car all-day mix of faster express trains and all-stops services, significantly improving travel times to drive PT mode shift. It provides a minimum 8tph service all day on all routes, as per AT's RTN aspiration, but not all stations get 8tph off-peak due to mix of express and local services. Removes the Onehunga service, allowing wider headway slots for express trains. **Infrastructure Summary** — Same as A except Wiri to Westfield only requires 4-tracks (due to East-West terminating at Otahuhu) & signal upgrades required on most of the network to support 2min headways — Tidal south peak express requires mid-day stabling near the CBD — Stated runtime improvements may be difficult to achieve on only 2-tracks.	**Pros** — Utilises 3rd and 4th mains to run faster metro services on the South, and attempts to run faster service on the — East and West lines without need for additional trackage — All day express service in recognition of significant demand growth in outer regions of network — Consistent with future RTN aspiration – at least 10min headways all day – on South and East lines (not on West) — Separation of South and East-west lines between Wiri and Westfield improves service reliability and reduces need for timetable buffer — Tidal express is efficient from an operational perspective **Cons** — Maxes out capacity of the CRL in 2051. No headroom for growth — Travel time improvements rely upon uneven headways (alternating 5 and 10min) reducing service quality and resulting in uneven loads — Off peak freight will be very challenging to incorporate without additional track on the NAL between Otahuhu and Newmarket, and without some element of grade separation at Westfield and Wiri — Diversity of trip types may lead to an unreliable service Midday stabling potentially requires additional land within CBD
			

Concept Narrative		Pros & Cons	Pros and Cons
D) PEAK EXPRESS, ALL-DAY FREIGHT, ALL-DAY FREQUENT	 	Service Summary This concept provides a frequent all-day service at all stations, a peak express service for significantly improved travel times to drive PT mode shift, and all-day freight paths. It incorporates a new West-South service to replace the Onehunga service. The service would feature 9-car trains and provide tidal peak express, potentially saving ~7-9[6]min from South & ~7min from West. Infrastructure Summary — Six-track railway from Wiri to Otahuhu — Four-track railway from **Pukekohe to Wiri** and from **Otahuhu to New Lynn or Henderson** and from **Otahuhu to Britomart** — Grade separation of Westfield for specific moves (and potentially Wiri) — Signal upgrades, stabling, fleet, level crossing removal, etc. per previous options.	PROS — Additional tracks allow for accommodation of all-day freight paths without compromising symmetric — passenger timetable and ability to run express services that are not constrained by all-stops services, with faster and more reliable journey times — Better than future RTN aspiration – 7.5min headways all day — New South-West line provides higher frequency for local trips within southern and western zones, a more direct cross-town service, and a release valve for the CRL CONS Capital costs associated with additional tracks and grade separations need to be weighed against network / service benefits.

[6] further investigation showed that indicative runtimes were difficult to achieve on only 2-tracks, and this was considered in the development of further options

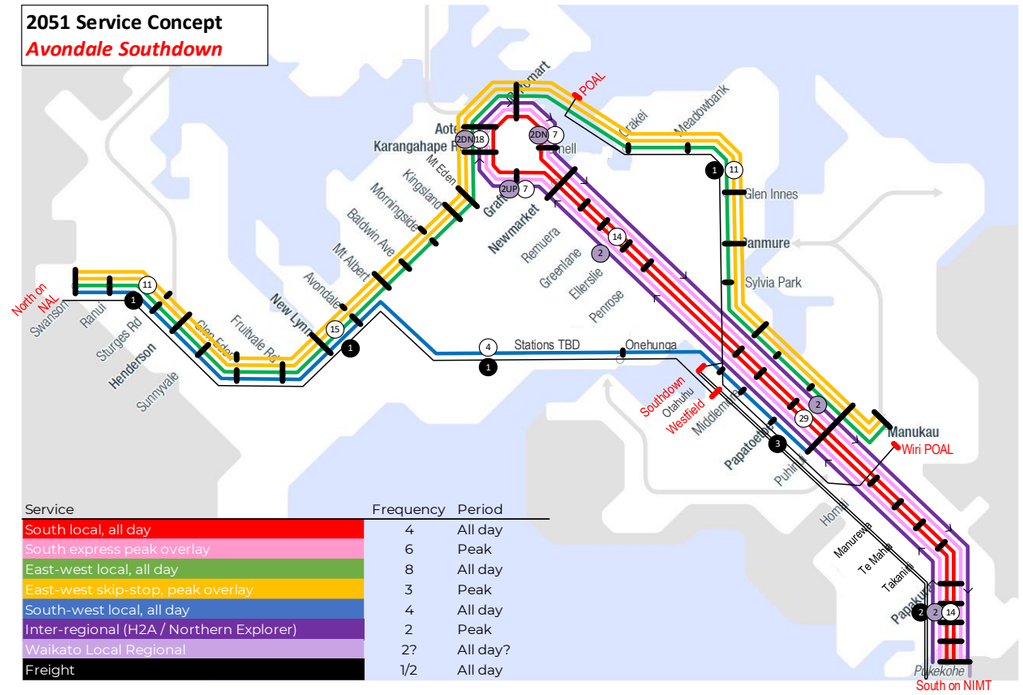
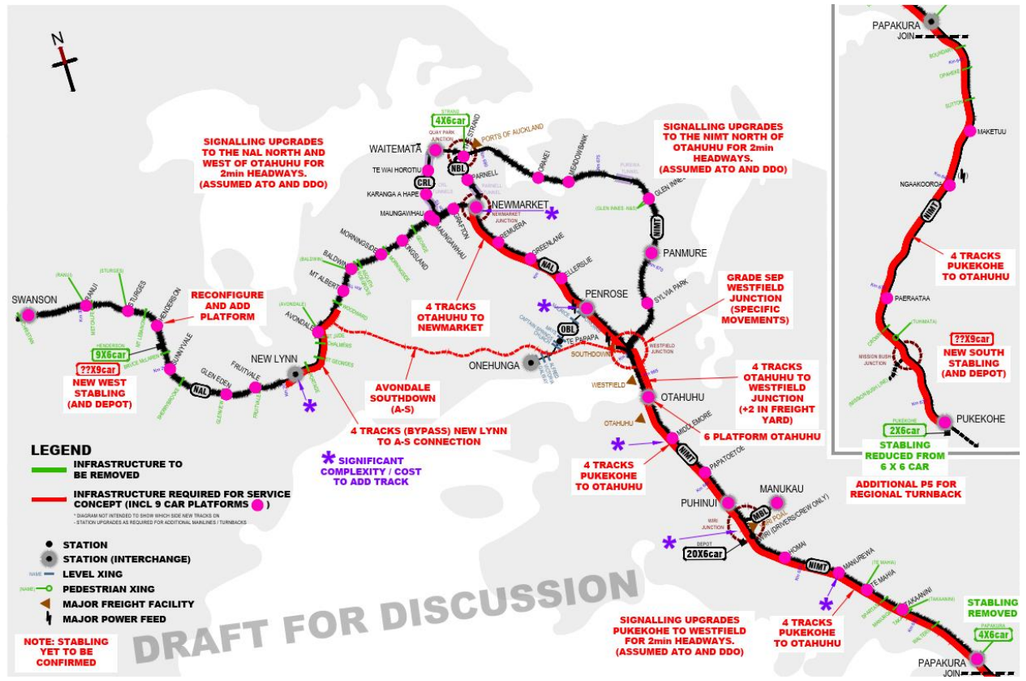
Concept Narrative		Pros & Cons	Pros and Cons
E) PEAK EXPRESS, ALL DAY FREQUENT, ALL-DAY FREIGHT WITH AVONDALE SOUTHDOWN	 	Service Summary This concept provides a frequent all-day service at all stations, all-day freight paths for all freight lines, peak express services on the Southern line and peak skip stop services on the East-West line. Operating 9-car trains, there would be peak express services savings of ~9 min from South and ~3 min from West. Inter-Regional trains (i.e.H2A) would run through the CRL. Northport freight paths would be accommodated via Avondale Southdown which would also be utilised to run the West-South service introduced in Concept 4. Infrastructure Summary — Four-track railway from Pukekohe to Newmarket; six-tracks between Wiri and Westfield — Two-track Avondale-Southdown — (Two-track NAL south and NIMT east are sufficient for this concept) — Potential grade separation of Westfield for POAL crosstown-shunt — Signal upgrades, stabling, fleet, level crossing removal, etc. per previous options.	Pros — Four tracking of the southern line from Pukekohe to Newmarket allows peak express services to be provided saving close to 10min in journey time. — Avondale-Southdown allows for some separation of freight and metro traffic and opens up a new catchment and connection opportunities for the metro network. As with previous concept South-West line also provides a more direct cross-town service, and a release valve for CRL — Better than future RTN aspiration – 7.5min headways all day — Six-tracking Wiri-Westfield allows for segregation of South and East-west services. Cons — Capital costs associated with additional tracks and grade separations need to be weighed against network / service benefits — Mixed metro and freight still required on the Western Line (west of Mt Albert). This requires paths be provided in the passenger timetable, resulting in uneven headways (however this also provides an opportunity to run skip stop services) Potential reliability issues with H2A trains running through the CRL at close to capacity, with long dwell times

Table 4-3 shows how the five thematic concepts map to the general types of service ideas identified in the ideation phase: Faster Services, More Frequent Services and New Routes. The longer trains category of ideas is not included in Table 4-3 for reasons described in Section 4.3.2. It is important to note that at this point in the process the key ideas of freight / passenger segregation, and provision of all-day freight paths for all major freight lines were incorporated into the analysis as central themes. This was based on the recognition that freight demand is highly sensitive to macro level economic and logistical decision making beyond the control of the freight operations and network planning. It was seen as imperative that the future network be resilient to these potential major shifts in demand patterns and volumes.

Table 4-3: Summary of Options

SERVICE OPTIONS	CONCEPT 1 *ALL STOPS*	CONCEPT 2 *PEAK LIMITED STOPS*	CONCEPT 3 *INNER-OUTER, ALL DAY FREQUENT*	CONCEPT 4 *PEAK EXPRESS, ALL DAY FREQUENT, ALL DAY FREIGHT*	CONCEPT 5 *AVONDALE SOUTHDOWN*
Faster Services					
No express, all-stops only	●				
Limited stops peak overlays		●			●
Express peak overlays				●	●
All day express			●		
Tidal Express			●	●	
More Frequent Services					
Frequent all day (10min or better)			●	●	●
All-stops peak overlays West	●	●			
All-stops peak overlays South	●	●			
All-stops peak overlays East	●	●			
Freight					
Full Separation of Freight & Passenger on NIMT South	●				
All-Day Paths on NAL and NIMT East (i.e. POAL)				●	●
New Routes					
Onehunga Branch Removed			●		
Onehunga ranch replaced by South-west Route				●	●
South & East-West Segregation			●		●
Avondale-Southdown					●

The process of developing these service concepts (outlined in Appendix B) led to some early insights prior to the MCA evaluation, which are presented in subsections 4.3.1 through 4.3.3

4.3.1 SOUTHERN GROWTH AND REQUIREMENT FOR FOUR TRACKING

Initial demand analysis undertaken in this phase of the PBC revealed that the southern area of the network was forecast to see the most significant growth in train volumes. This included:

- freight, with substantial increases in both domestic and import/export volumes from Tauranga forecast; and
- passenger, with the southern growth stations from Pukekohe to Papakura driving substantial ridership increases driven by the planned transit-oriented development around these stations.

Early analysis determined that during the peak, 14 metro trains + 2 freight paths accommodating 1500m trainsets + 2 inter regional trains needed to be accommodated south of Puhinui. Under the assumption that a 10min path between all stops metro services would be acceptable for the 1500m freight train (an assumption later realized to be insufficient based on detailed simulations, and updated to 15min), it was assessed that while this could theoretically be accommodated on a two-track railway, in practice it would result in large headway gaps in the passenger services (leading to high levels of crowding and an unattractive service) and the inability to operate fast metro and inter regional services.

The clockface timetables shown in Figure 4-2, developed on Long List Option 1, illustrate this concept. These diagrams show the likely network timetable in a visual format with lines representing the arrival times of trains at a particular location, colors representing their service type, and grey shaded segments representing freight paths. One diagram is provided for each pair of mains given that the pattern in one direction is generally the same as the pattern in the other. The clockface on the left represents the situation under a two-track railway, whereas the two diagrams on the right represent the situation under a four track railway, with each diagram showing the pattern on the two pairs of mains.

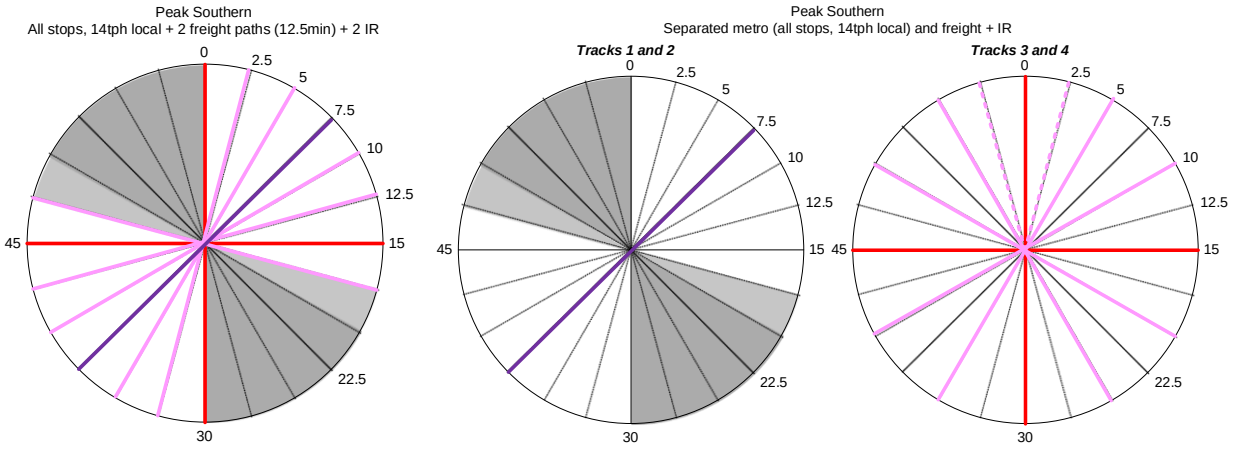


Figure 4-2: Clockface patterns under 2-track (left) vs. 4 track (right) southern corridor for option 1

The analysis suggested the need for a four-track railway from Pukekohe to Puhunui, even for the least ambitious metro service concept (the all-stops concept). Adding the third and fourth tracks then has the advantage of greater flexibility to freight, faster metro and IR travel times, and improved overall network resiliency. By similar argument, the section of the NIMT from Wiri to Westfield was also assessed to need at least four-tracks to accommodate the high volume of trains due to the interlining of south and east-west lines.

At this stage, it was also debated as to how the four tracks would be best be utilised, with either a 'pair by direction' or 'pair by use' operating concept possible. Pros and cons of these options are documented in "Service Memo Operation patterns for a 4-track railway (on the Southern Line)" which concluded that a pair by use operation would be most beneficial for the network. This concept has freight, inter regional and fast metro services on one set of mains, while slower all-stops metro services use the other set. The argument is mostly applicable to the southern corridor and relates to the fact that the major freight nodes (with the exception of Wiri) are on the west side of the corridor.

The extent of four tracking required on the southern corridor is between Pukekohe and Westfield junction in all options, however Options D and E require additional four tracking to Newmarket. Since the volume of freight growth is lower in this segment of the network (under base demand scenario) the primary drivers for four tracking to Newmarket are:

- The provision of express services (four tracking allows fast trains to pass slow trains) and,
- improved maintenance access (allowing maintenance work to be carried out while service is maintained on adjacent mains).

In stakeholder workshops held during the long list stage, the challenge was raised as to whether the extent of four tracking could be reduced to run only as far south as Papakura by looking at the potential for metro service reduction south of Papakura, considering whether the 10min freight path requirement could be reduced, and whether higher levels of utilization could be accepted in this area of the network. This is further investigated in Options Report Part 2, Section 4.1.

4.3.2 TRAIN LENGTHS

Demand analysis undertaken at this stage of analysis allowed for an initial sizing of the 2051 metro service concept. Figure 4-3 provides a summary of the passenger loading of trains over the network. Each callout in the diagram shows the expected number of passengers riding in trains at the specified location and direction, over the two-hour peak and one-hour high peak, and the equivalent number of trains per hour of varying lengths that would be required to accommodate that volume of passengers at max seating and max standing capacities of the trains (based on agreed crowding levels for service planning).

This analysis led to the early insight that the volume of trains required to move the forecast passenger demand in 2051 with 6-car train lengths would overwhelm capacity of the CRL if trying to protect seating capacity. Allowing some level of standing could reduce the volumes but it was anticipated that long standing times would occur, especially on the southern line where the peak load point of Puhinui is much further than 15min from the city centre as indicated by the red shading in the figure. It was therefore determined that longer trains would likely be required on all lines under all options.

A key assumption was made that it would be prohibitively costly to expand the CRL past the current future proofing for nine-car equivalent units. NB. It would be possible to expand the length of train greater than a nine-car equivalent, however this would lead to the requirement for selective door opening impacting station dwell times and service reliability. It was not considered appropriate for consideration as part of a longer-term planning process.

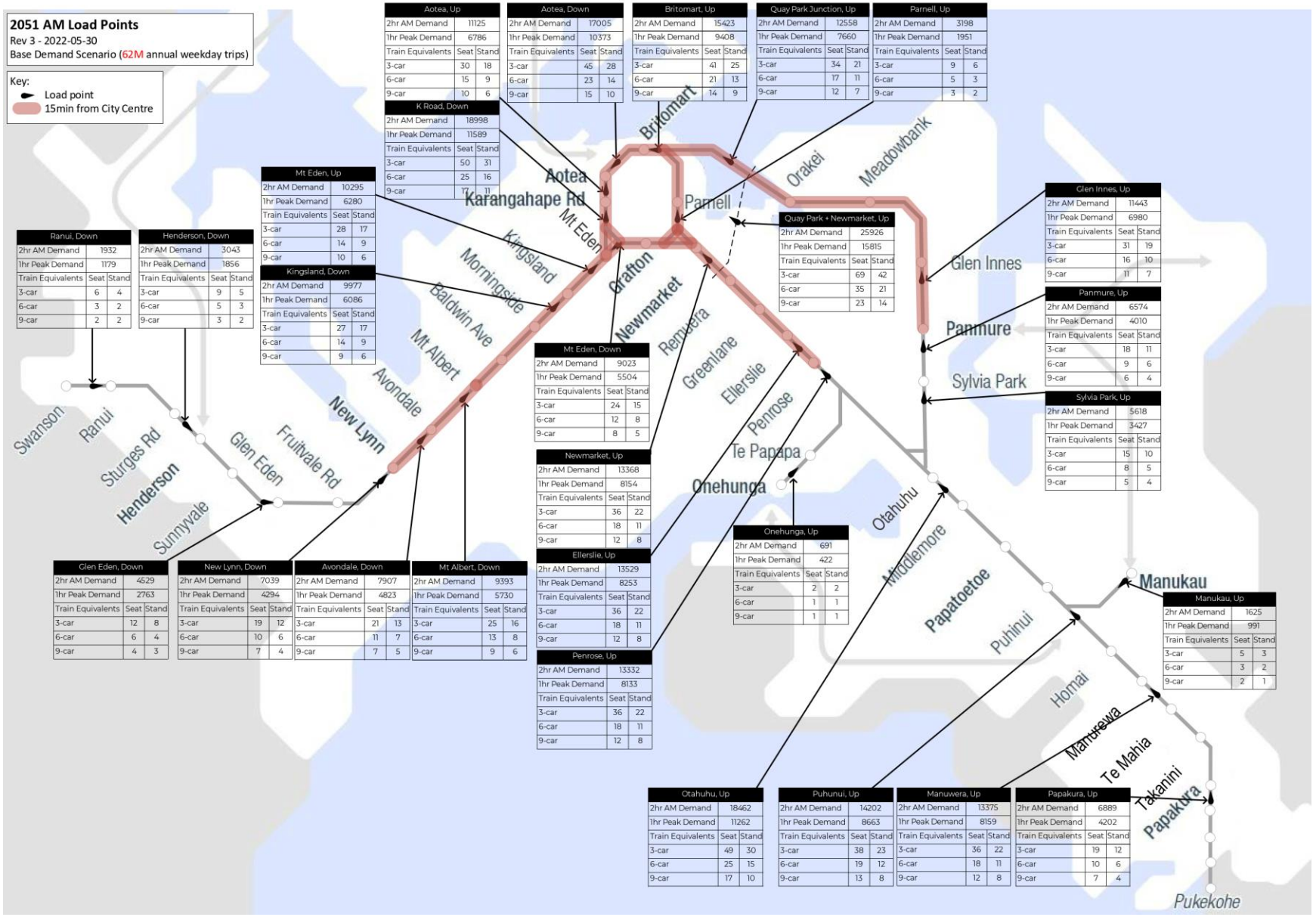


Figure 4-3: 2051 AM passenger load point analysis from long list optinos developmnt

4.3.3 WIRI TO WESTFIELD

In this early phase of assessment, it became apparent that the Wiri to Westfield segment of the network would likely be the next major bottleneck after the Britomart stub end terminal bottleneck is resolved through the CRL. Train volumes in this segment of the network are in fact higher than within the CRL due to the addition of freight and inter regional traffic, and the mixed mode nature of the traffic means the capacity utilisation is inherently less efficient. It was identified that a 4 track solution would be an absolute minimum requirement, with a 6-track solution potentially required to achieve the 75% utilisation Conditional Output

4.4 OUTPUTS AND OUTCOMES

This section provides a summary of the MCA analysis developed and refined through the workshops outlined in Section 4.2 and accompanying narratives. Note that due to the large number of criteria, particularly the Conditional Output assessment criteria which are duplicated across the three major corridors, the full MCA table is quite large and has therefore been provided as an appendix rather than a table in the body of the report. Hyperlinks have been included to easily navigate to the full commentary.

Section 4.4.1 provides a summary of the MCA scoring, while Sections 4.4.2 through 4.4.5 provide a summary of the assessments and how these allowed for the selection of components of the thematic concepts to take forward to the next phase of optioneering.

4.4.1 MCA SUMMARY

Table 4-4 provides a summary of the scoring of the MCA, with **the full Long List MCA provided in Appendix E**. Each line item in Table 4-4 corresponds to one or more rows of the MCA as indicated in brackets. Where aggregating scores over multiple criteria, the average is taken. The conditional output analysis criteria are particularly important at this stage, as they allow a granular assessment of how elements of each thematic option perform across geography and market. Note that inter regional services appear under the Outer Southern corridor.

Table 4-4: Full Long list MCA Summary

OPTIONS	1	2	3	4	5
Investment Objectives					
IO 1 (1-6)	1	1	2	3	3
IO 2 (7)	1	1	2	3	3
IO 3 (8)	0	1	2	3	3
Critical Success Factors					
Potential achievability/deliverability (9)	-1	-1	-2	-3	-3
Potential affordability (10)	-1	-1	-1	-3	-2

OPTIONS	1	2	3	4	5
Supplier capacity and capability (11)	Not scored nor deemed necessary at this level of the PBC				
Scheduling/programming (12)					
Opportunities and impacts					
Environmental effects (13)	-1	-1	-1	-1	-2
Social and cultural impacts (14)	2	2	1	1	1
Climate Change mitigation (15)	2	1	1	3	3
Climate change adaptation (16)	-1	-1	-1	-2	-2
Cumulative impacts (17)	Not assessed at this stage				
Impacts on Te Ao Māori (18)	Equity issues discussed through 'social and cultural impacts'. Scoring to be undertaken on subsequent assessment during the shortlist stage				
Property impacts (19)	-2	-1	-1	-3	-2
Impacts on road safety (20)	2	2	2	3	3
Conditional Output Assessment					
Network Wide					
Maintenance (21-22)	2	2	2	3	2
75% Utilisation (23)	1	2	1	3	2
Western					
Metro (24-27)	1	1.75	2	2.25	2
Freight, NAL (42-43)	0.5	0.5	0.5	1.5	1.5
Eastern					
Metro (28-31)	1	1.25	1.5	1.75	1.75
Freight, POAL (44-47)	0.5	0.5	0.5	2	1
Inner Southern					
Metro (32-35)	1	1.25	1.25	1.75	1.5
Outer Southern					
Metro (36-39)	1	2	2	2.5	2.5

OPTIONS	1	2	3	4	5
Freight, NIMT (40-41)	2	1.5	1	1.5	1.5
Inter-regional (48,49)	1	1	1	1.5	2
Project-specific Critical Success Factors					
Capital cost (50)	-1	-1	-1	-3	-2

4.4.2 INVESTMENT OBJECTIVES SUMMARY

Investment objectives were scored and commented on in the Long List MCA and associated workshops. However, given that the options developed in this phase are thematic in nature, and that the IOs relate to the programme as a whole, these criteria were not particularly instructive for the long list assessment. Instead, it is the conditional output assessment criteria that provide the most valuable information at this stage of analysis, as these present the required level of granularity to assess how different elements of the plan perform across geography and markets. They also represent a reasonable proxy for the Investment Objectives – being the rail specific targets that are expected to enable them.

With this in mind, assessment of the IO criteria at this phase of analysis broadly revealed:

- A preference for separation of metro and passenger services, allowing for greater flexibility in freight timetabling, and more efficient network operation. This is evidenced by the higher scoring of D and E
- A preference for options that provided a wide span of high-quality service – specifically options that allowed for all day high frequency metro services and all day freight paths.
- A preference for some level of express services on the network, providing a more attractive service offering to enable greater mode shift. This is evidenced by the low scoring of Option A and progressive increase the scores with higher levels of express

Further discussion on these points is provided in 4.4.5. In the short list phase, where specific network wide investment programmes are considered, the investment objectives will be assessed in detail.

4.4.3 CRITICAL SUCCESS FACTORS SUMMARY

Potential Achievability/Deliverability (9) concerns were raised with the following option elements

- Wiri to Westfield: Options 1, 4, and 5 with respect to the 6-track requirement between Wiri and Westfield based on the high degree of land take and sensitive areas along the corridor (particularly Middlemore hospital). The project team were challenged to look at changes to the network service concept which would reduce train volumes and conflicts in this area, allowing for a more efficient infrastructure solution. This led to a revisiting of the base network service concept, which ultimately led to a potential variant being identified with the east-west line terminating at Otahuhu and the southern line being terminated at Manukau and Pukekohe – a concept that is tested and discussed further in the next phase of optioneering.

- Four tracking Eastern and Western Lines: Options 4 which includes significantly more 4-tracking than other options – across the majority of the network. Very significant / potentially infeasible infrastructure pinch points were identified at New Lynn Trench, CRL Connections to the NAL, Newmarket, the Purewa Tunnel on the Eastern Corridor, and Penrose Junction.
- Avondale – Southdown: Option 5 which includes the Avondale – Southdown corridor. It was noted that this area is not used to rail noise and construction which may present issues in planning and that the current alignment through the densely populated residential area of Onehunga could be challenging.

None of these option elements were considered to be fatal flaws but presented an early indication of the likely high costs of expanding track capacity in these areas, which would require high levels of benefit to justify in absence of other lower cost alternatives.

Potential affordability (10) was assessed as being primarily correlated with the capital costs at this stage of analysis. Details on potential funding envelops were not available and the level of detail that would be required to assess likely funding sources or splits was not available at this time.

Supplier capacity and capability (11) and Supplier capacity and capability (12) were considered not relevant at this stage of PBC and therefore not scored.

4.4.4 OPPORTUNITES AND IMPACTS SUMMARY

The primary differentiators in this category of criteria were Climate Change mitigation (15) and Property Impacts (19).

From a climate change perspective, it was identified that Options 4 and 5 had the most potential to create mode shift to rail (in freight and passenger markets) and therefore contribute the most to emissions reduction targets. The significant infrastructure expansion involved in these options was acknowledged to create high embodied/construction carbon, but their enablement of all day freight access and all-day frequent passenger services was assessed as enabling longer term mode shift that offsets this. This was particularly true of Option 5 which was seen as achieving similar benefits with less construction.

From a property impacts perspective it was again identified that Options 1, 4, and 5, which involve significant corridor expansion, or in the case of Option 1 expansion to 6-tracks in the constrained Wiri to Westfield section, would likely result in significant property impacts relative to the other options.

4.4.5 CONDITIONAL OUTPUT SUMMARY

Table 4-5 provides a summary of the MCA scoring and commentary for the Conditional Output analysis criteria, with a particular focus on how this assessment enabled an initial screening of service elements to enable the development of specific programme options (as opposed to thematic) in the next phase of analysis. The table follows roughly the same grouping of elements as shown in Table 4-4 (split by geographical line and market), with the exception of some additional commentary on the Inner South corridor which includes some additional commentary on freight given that all major freight lines pass through this segment.

Additional commentary on key points is provided in subsections below. Appendix D 'Long List MCA Summary' contains the original version of this table with additional commentary.

Table 4-5: Long list – conditional output assessment criteria analysis

CRITERIA	TAKE FORWARD [OPTION/ OPTION ELEMENT]	DISCOUNT [OPTION/ OPTION ELEMENT]
WEST		
Metro (24-27)	**Option 1: Local stopping pattern** Better suited to demand patterns on the line, and provides competitive journey travel times for more journeys. See Section 4.4.5.3 for further discussion Option 4, 5: All-day frequent service Meets AT RTN standards for frequent service. See Section 4.4.5.2 for further discussion. **Option 4: Direct cross-town service** Connection to Newmarket, capacity relief for CRL while serving local demand **Option 5: Avondale-Southdown service** Additional journey option from west to Airport, resulting in a more equitable network. Also, potential to add new stations and increase catchment, and increase network connectivity	**Option 2, 3, 4, 5: Skip-stop or express stopping pattern** Not considered beneficial since travel times from West already car competitive. See Section 4.4.5.3 for further discussion. **Option 1, 2, 3: non-frequent off-peak services** Does not meet AT RTN standards for frequent service See Section 4.4.5.2 for further discussion.
Freight, NAL (42-43)	**Option 4, 5: All day freight paths** Sufficient slots to service demand reliably (with some flexibility), including during peak. Preferred infrastructure solution to be assessed in more detail (4 tracking NAL per Option 4, A-S per Option 5, or other). See Section 4.4.4.1 for further discussion. **Option 5: Avondale-Southdown** New line allows separation of freight and metro traffic in congested area of NAL, resulting in freight being able to travel during peak periods. Adds resiliency to network.	**Option 1, 2, 3: Off-peak freight paths only** Doesn't meet KiwiRail requirement for all-day freight paths. No substantial difference to today's operation. See Section 4.4.4.1 for further discussion. **Option 3: Freight mixed with local and express metro on two tracks** even off-peak freight paths challenging without additional track
Inter-Regional	NA	NA
Access & Maintenance (21-23)	To be assessed further at next stage	NA
EAST		
Metro (28-31)	**Option 1, 2, 3: Local stopping pattern** Provide competitive journey travel times for local demand. See Section 4.4.5.3 for further discussion. **Option 3, 4, 5: All-day frequent service** Meets AT RTN standards for frequent service. See Section 4.4.5.2 for further discussion.	**Option 4, 5: Skip-stop or express stopping pattern** Not considered beneficial since travel times on Eastern Line already car-competitive. See Section 4.4.5.3 for further discussion. **Option 1, 2: non-frequent off-peak services**

		Does not meet AT RTN standards for frequent service. See Section 4.4.5.2 for further discussion.
Freight, POAL (44-47)	**Option 4, 5: All day freight paths** Sufficient slots to service demand reliably (with some flexibility), including during peak. Preferred infrastructure solution to be assessed in more detail (4 tracking NIMT East per Option 4, improved signalling headways per Option 5, or other). See Section 4.4.4.1 for further discussion.	**Option 1, 2, 3: Off-peak freight paths only** Does not meet KiwiRail requirement for all-day freight paths. No substantial difference to today's operation. See Section 4.4.4.1 for further discussion.
Inter-Regional	NA	NA
Access & Maintenance (21-23)	To be assessed further at next stage	NA
INNER SOUTH		
Metro (32-35)	**Option 2, 3, 4, 5: Skip-stop or express stopping pattern** Journey time savings. Difficult to differentiate between options at this point (without having specific travel time estimates and targets to compare against) but generally faster travel times preferred from south. See Section 4.4.5.3 for further discussion. **Option 3, 4, 5: All-day frequent service** Meets AT RTN standards for frequent service. See Section 4.4.5.2 for further discussion. **Option 1, 4, 5: 6 mains Wiri to Westfield (W2W)** Ability to de-interline **Option 5: Avondale-Southdown service** Potential to add new stations, increase catchment, and increase network connectivity	**Option 1, 2: non-frequent off-peak services** Does not meet AT RTN standards for frequent service. See Section 4.4.5.2 for further discussion.
Freight, NAL, POAL, and NIMT (42,43,44-47, 40,41)	**Option 1, 4, 5 | 6: mains W2W** W2W close to capacity, therefore extra separation provides for a more flexible freight operation. Also removes crossing conflict for port shunt to Wiri POAL **Option 1, 2, 3, 4, 5: All day freight paths** Sufficient slots to service demand reliably (with some flexibility), including during peak. Preferred infrastructure solution to be assessed in more detail. See Section 4.4.4.1 for further discussion. **Option 5: Avondale-Southdown** New line allows separation of freight and metro traffic in congested areas of NAL, resulting in	**Option 1,2, 3: Off-peak freight paths only for NAL freight** Does not meet KiwiRail requirement for all-day freight paths on NAL. No substantial difference to today's operation. See Section 4.4.4.1 for further discussion.

	freight being able to travel during peak periods. Adds resiliency to network.	
Inter-Regional (48,49)	**Option 1, 2, 3 and 4: Improved travel time** Faster routes with journey time savings are preferable. See Section 4.4.5.3 for further discussion	**Option 5: Inter regional via CRL** Reliability issues given interface with CRL. However, option to route H2A trains via Newmarket - Parnell should be considered further.
Access & Maintenance (21-23)	To be assessed further at next stage	NA
OUTER SOUTH		
Metro (36-39)	**Option 2, 3, 4, 5: Skip-stop or express stopping pattern** Journey time savings. Difficult to differentiate between options at this point but faster travel times preferred from outer south areas. See Section 4.4.5.3 for further discussion. **Option 3, 4, 5: All-day frequent service** Meets AT RTN standards for frequent service. See Section 4.4.5.2 for further discussion.	**Option 1: Local stopping pattern only** Travel time unlikely competitive with car, which is more important for long journeys. See Section 4.4.5.3 for further discussion **Option 1, 2 | non-frequent off-peak services:** Does not meet AT RTN standards for frequent service. See Section 4.4.5.2 for further discussion.
Freight, NIMT (40-41)	**Option 2, 3, 4, 5: Skip-stop or express stopping pattern** Journey time savings. Difficult to differentiate between options at this point but faster travel times preferred from outer south areas. See Section 4.4.5.3 for further discussion. **Option 3, 4, 5: All-day frequent service** Meets AT RTN standards for frequent service. See Section 4.4.5.2 for further discussion.	**Option 1: Local stopping pattern only** Travel time unlikely competitive with car, which is more important for long journeys. See Section 4.4.5.3 for further discussion. **Option 1, 2 | non-frequent off-peak services:** Does not meet AT RTN standards for frequent service. See Section 4.4.5.2 for further discussion.
Inter-regional (48,49)	**Option 2, 3, 4, 5: Skip-stop or express stopping pattern** Journey time savings. Difficult to differentiate between options at this point but faster travel times preferred from outer south areas. See Section 4.4.5.3 for further discussion. **Option 3, 4, 5: All-day frequent service** Meets AT RTN standards for frequent service. See Section 4.4.5.2 for further discussion.	**Option 1: Local stopping pattern only** Travel time unlikely competitive with car, which is more important for long journeys. See Section 4.4.5.3 for further discussion. **Option 1, 2 | non-frequent off-peak services:** Does not meet AT RTN standards for frequent service. See Section 4.4.5.2 for further discussion.
Access & Maintenance (21-23)	To be assessed further at next stage. See Section 4.4.5.4 for general discussion	NA

4.4.5.1 ALL DAY FREIGHT PATHS

A key decision at the ideas generation to long list phase was to push back on elements of the thematic network service concepts which relegated freight to off-peak metro periods.

This is the status quo on the existing network, where freight access to Port of Auckland and Northland is prevented in peaks periods[7] outside of which metro frequencies are reduced to low levels (4tph) to sufficiently accommodate freight in off-peak periods. These constraints, if kept in place, limit the ability of the investment programme to support freight demands in a competitive ports environment in which patterns of demand are inherently uncertain. As an example, in the base demand scenario, there is no growth in traffic to Northport - however in the Port Move scenario (considered in the Part 2 Report Section 6.1) growth exceeds practical capacity on the NAL by 2030. Indeed, a scenario such as this is potentially more likely to occur based on current plans for activation of Marsden Point which is forecast to generate growth to 8 trains per day between Northport and Auckland by the mid-2040s (see further discussion in the Strategic Case Section 5.7.2.1). Similar uncertainties exist for the Ports of Auckland. An investment programme that is not robust against these scenarios, will fail to meet the demands of freight customers, and thus fail to meet key investment objectives of the programme to support growth in rail freight demand and reduce supply chain emissions.

A further

A strong push was therefore made in this phase of optioneering to provision access to freight on all major lines, at all times of the day, to a high degree of reliability. Two key parameters were discussed and interrogated in detail to this end:

- The number of freight paths per hour: to accommodate the anticipated volumes of freight; provide resiliency against delays and disruptions, and importantly to give freight customers the access they needed at the times they needed it most. Analysis on this topic was documented in Service Memo: Distribution of freight traffic in 2051
- The width of the freight paths provided, i.e. the gap between passenger trains that is required for a freight train to slot into, without causing disruption to the overall network. Analysis on this topic was documented in Service Memo: Definition of freight paths on the AMRN

The provision of dedicated freight paths in the network timetable became a key principle of the PBC, reflecting the dual function of the network as both a freight and passenger railway. Complete segregation of freight and passenger services via dedicated tracks, was pursued but was not always achieved based on value for money considerations – therefore freight access is provided in options via a combination of timetable and infrastructure interventions.

4.4.5.2 RTN *Frequency*

The post CRL timetable plans for service frequencies to be reduced to 4tph (15 min headways) in off-peak periods; partly to accommodate freight paths; and partly to reflect the status quo assumption that demand in the off-peak does not warrant a high level of service. However, accepting the status quo in this case implied that the rail network, as the backbone of the rapid transit network, failed to meet Auckland Transports own definition of a rapid transit service (being 10min headways or better) and is inconsistent with other rapid transit corridors in Auckland in operation or planning, such as the Northern Busway, Eastern Busway, Light Rail and many

[7] Freight from south of Auckland can travel in the peak

frequent bus services. This implies that predicted/modelled demand should not necessarily be a constraint on service frequency where there are wider policy objectives

Therefore while it was recognised that the base forecast didn't strictly require services more frequent than every 15min, it was nevertheless agreed that elements of the thematic service concepts that were not compliant to the RTN frequency service standard (which in the case of the rail network effectively implies a minimum 8tph service all day[8]) should be discounted as they would not support the overall Investment Objectives of the project to increase rail mode share, and reduce emissions. The Conditional Outputs were updated to include the requirement for RTN frequencies as a result of these discussions.

4.4.5.3 EXTENT OF EXPRESS SERVICES

Another key dimension tested and discussed in the MCA analysis, was the extent to which express services would be required on the network in the future. Conditional Outputs were initially defined to target rail services being competitive with 85th percentile peak periods car journeys; however, the project partners agreed during this phase of optioneering, that benchmarking travel times against congested motorway conditions where cars might be at a standstill for long periods of time, lacked considerable ambition, would be difficult to measure, and ultimately didn't properly align with the Investment Objectives of the programme to achieve mode shift and reduce emissions. This was based on the understanding that travel time is a key driver of passenger rail attractiveness and that providing better service to areas on the network further out from the city centre, have the greatest potential for VKT and therefore emissions reduction. This is particularly true on the southern corridor which serves long distance metro trips as well as inter regional trips from Hamilton.

The Conditional Output was therefore updated to be comparable with an off-peak car trip and a new Conditional Output was introduced to enable a 45min journey time to the CBD from any part of the network. This allowed the CO criteria of the MCA to better differentiate between options and align to IOs.

The City Rail Link provides significant journey time improvements over the entire network, and it was identified that the East and West lines in particular, would already meet this target by default. Catchment and runtime analysis carried out at this stage, concluded that express services on the Western Line would be of limited utility to customers and therefore unlikely to significantly improve rail attractiveness and induce mode share for the following reasons:

- The trade-off between travel time benefit and reduced catchment of skipping stops, means that large travel time savings (>5min) are generally not beneficial on the Western Line (as they can necessarily only benefit a small number of passengers given the large number of stops that need to be skipped in order to achieve the benefit).
- There is significant demand on the Western Line for local trips which are not well served by an express service

[8] While the minimum frequency to meet RTN targets would be 6tph this is difficult to achieve on the rail network. This is effectively because peak period demands call for a service pattern that is built on overlays of 4tph which then makes it difficult to transition to a 6tph service in the off peak.

- The all-stops travel time post CRL is already expected to meet the 45 minute condition target for all stations

This led to the decision that an exclusively all-stops service on the East and West lines would be suitable for the 30 year plan. Acknowledging that extensions of the network beyond Swanson, and/or the introduction of inter-regional services to northland may change this assumption in the future. Analysis on this topic was documented in Service Memo: Investigation of express services on western line

The southern line was identified as missing the 45 min target by a substantial margin with a trip from Pukekohe taking over 70 min in the off peak and only as low as 65 min in the peak. Initial travel time testing (estimated that the 45 min target would be very difficult to achieve without significant track speed improvements (potentially 140 – 160km/h) which was a concept that had already been ruled out in the ideation phase as being very likely infeasible. However express stopping patterns and a reduction in timetable buffer through improvement network reliability may come close to this target – leading to a decision to pursue varying degrees of express service on the south. Analysis on this topic was documented in Service Memo: Southern Line Travel Time Benefits. The significant growth projected for the southern areas of the network along with early results from MSM demand modelling showed a significant market for express services on the Southern Line, and the fact that these trips can be over 50km in length, indicated a strong potential for improved rail attractiveness, and emissions reduction via the provisioning of express services on the south.

4.4.5.4 MAINTENANCE

In general maintenance related criteria were not considered as major differentiating criteria at this stage of analysis, except for the following general observations

- Typically a four-track railway provides access opportunities for maintenance as the operator can work on two mains, while two remain open for service. However, more infrastructure increases the maintenance burden which needs to be considered.
- Options that require underground infrastructure create an additional maintenance burden and are not preferred from this perspective.
- Avondale – Southdown provides the ability to route (freight) trains during the nightly maintenance window and provides better access to Newmarket – Avondale section. There may also be opportunities to use the corridor to operate around future blocks of line.

4.4.6 PROJECT-SPECIFIC CRITICAL SUCCESS FACTORS

From a Capital Cost (50) perspective, Options 1, 2, and 3 were evaluated similarly insofar as they consist of the same primary infrastructure upgrade, being the southern corridor four-maining and network wide 9-car platform extensions. Option 4 includes much more extensive 4-tracking of the network, through key pinch points identified above in Section 4.4.3 which lead it being scored the worst. Of note, Option 5 which includes Avondale-Southdown, scored better than Option 4 from a capital cost perspective – partly due to the fact that the Avondale-Southdown corridor was seen as a lower cost alternative to 4-tracking of the Western and Inner Southern corridors at this point.

4.5 NEXT STEPS

At the conclusion of the work on the long list thematic options, a variety of key decision points were highlighted for further analysis:

- Future RTN frequencies: Some long list concepts do not meet future RTN frequency aspirations. Future refined concepts should take this as a minimum requirement.
- All day freight paths: Concepts 1 – 3 assumed some freight lines to be accommodated in off-peak periods only. After the long list analysis, such options were understood to be unacceptable for a number of reasons including network reliability, timetable flexibility, customer service and productivity perspectives (customers will only choose rail if it can operate when they need it and be sufficiently productive to be competitive).
- Homogenous headways for local service: A consequence of the RTN requirement for frequent service all day and the requirement for all day freight paths, is that an uneven headway pattern for local service will be required on a two-track railway. Further analysis is required to assess trade-offs etc.
- Express vs Local Service: Options for express, particularly on the Western Line, may not be beneficial from a passenger perspective given the distribution of demand, and already close proximity to the CBD. On the other hand, provisioning for express protects for future network extensions and new inter-regional services.
- Mix of train lengths: A mix of 6 and 9-car trains could be considered to better match service capacity to demand, particularly in off peak periods.
- De-interlining of the south and east-west lines: There are potentially major reliability and efficiency benefits to separating the main passenger lines between Wiri and Westfield, by service design. additional tracks, or a combination of both. De-interlining within the CRL is unlikely to be achievable.
- Opportunities for optimizing number of tracks: Opportunities should be considered to optimize four-tracking via turnback's to reduce the extent of four-tracking, removing four-tracking through infrastructure pinch points, consideration of three-tracking, or use of loops (potentially as a staging/phasing consideration).
- Junction grade separations: Grade separations may be needed to ensure an adequate level of reliability in future operation, and achieve travel time targets.
- Mixing of freight and fast passenger service: 1500m freight trains are predicted to require large headways of up to 15min between all-stops EMUs. However, it is suggested that a tighter headway may be acceptable with a mix of freight and fast passenger trains. This needs to be tested via simulation in more detailed phases of analysis.
- Avondale Southdown considerations: How this line ties into the rest of the network needs to be carefully considered (for example east and west facing connections at Avondale).
- Wiri to Westfield capacity: Post CRL, the Wiri to Westfield segment of the network becomes the next major bottleneck, with a higher number of passenger trains per direction than the CRL, coupled with freight and inter-regional services. Six-tracking is a potential infrastructure response, however operational / service design responses should also be considered, for example a Pukekohe to Puhinui turnback service, and terminating the East-West line at Otahuhu.
- Manukau turnback: A possible service from the southern part of the network, direct to Manukau should be considered as a future refinement.
- Onehunga Branch Line: It needs to be considered whether the OBL is retained in its current form (single track, 2-3 services per hour), upgraded to support acceptable service

frequency and capacity moving forward, replaced with a more effective PT mode, or obviated by the Avondale Southdown line.

- Maintenance considerations: Maintainability needs to be considered in all options moving forward, particular with the aim of providing 6hrs average productive maintenance time per day.

5 LONG LIST TO SHORT LIST

5.1 OVERVIEW

This section outlines how technical assessment and further multi criteria analysis was used to refine outputs from the thematic long list to a short list of network-wide programme options. The multi-step process expanded the initial five thematic concepts, to a set of nine specific infrastructure programmes which were assessed using the MCA framework as a Provisional Short List, to general the final Short List of three options.

5.2 PROCESS

The PBC follows an iterative process to refine network service / infrastructure concepts, via a combination of stakeholder engagement, technical analysis, and evaluation. Starting from the initial long list, which was agreed upon in workshop *Long List Workshop 2, July 21st 2022*, three major iterations of the short list were developed over the course of this process. These are as summarized in Figure 5-1 and below:

- Iteration #1 Provisional short list options: A set of 9 options composed of the major infrastructure elements
- Iteration #2 Refined short list options: A refined / rationalized version of these 9 options to be taken forward for MCA analysis
- Iteration #3 Final MCA scored short list options: A final set 3 of short list options, arrived at via an MCA sieving process, and further refinements based on client feedback

The steps from Long List to Iteration #1 "Provisional Short List Options", are discussed in detail in a separate memo *"3B Long List Development and Refinement"*. This memo covers in more detail, the steps from Provisional Short List Options to the Final MCA scored Short List.

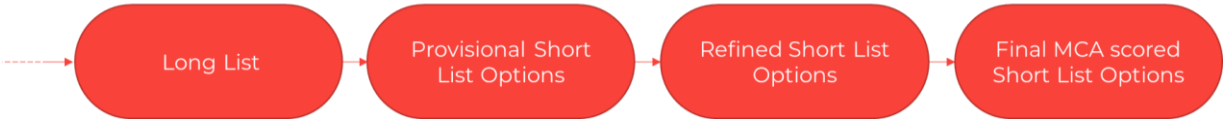


Figure 5-1: Major phases of the short list development process

5.2.1 VISUAL REPRESENTATION OF OPTIONS

In the following subsections, a graphical representation of the infrastructure options will be used as shown in Figure 5-2. The major infrastructure elements considered at this phase are corridor widening / adding tracks to increase capacity and improve service quality. Therefore, the diagram focuses on the number of tracks on each corridor, with existing tracks shown in grey and new tracks shown in red. The network is divided at key junctions as indicated in the figure.

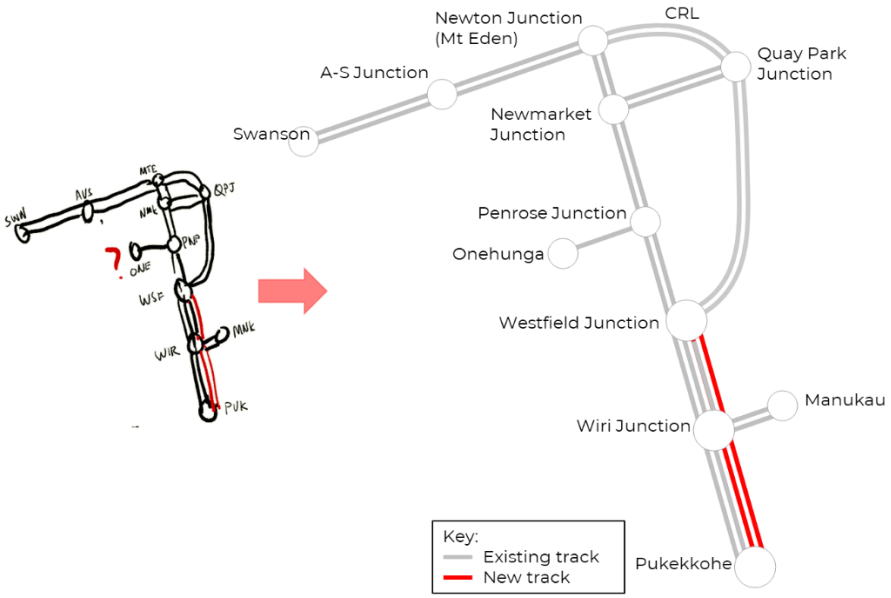


Figure 5-2: Visual representation of options

5.3 PROVISIONAL SHORTLIST OPTION DEVELOPMENT

5.3.1 ITERATION 1: PROVISIONAL SHORT LIST OPTIONS

The workshop *AR PBC - Drop in session - Review of Long list themes and development of provisional short list of programmes* held on July 21st 2022, resulted in the development of nine provisional short list options. The options development largely focused on selecting combinations and permutations of major infrastructure elements, primarily focusing on track capacity expansions, informed by the knowledge gained from the long list development and assessment process on the service benefits that these infrastructure elements were likely to enable, and focusing on those service elements that were selected as preferred in the Long List assessment.

The nine options, summarized graphically in Figure 5-3, were categorized into four buckets: ordered by level of expected capital cost, with Bucket A containing the lower cost options and Bucket D containing the highest.

- Bucket A: Includes only one option of four tracking the southern line to Westfield junction, with sub-options to upgrade or remove the Onehunga Branch Line (OBL)
- Bucket B: Includes two options to add two tracks between Westfield Junction and the CBD, either on the inner southern line (i.e. NAL South) or the eastern line (i.e. NIMT East). Each option also includes sub-options to upgrade or remove the Onehunga Branch Line (OBL).
- Bucket C: Includes three options centered around either activating the Avondale Southdown corridor, or four-tracking the NAL. Again, the OBL is an open decision on some options.
- Bucket D: Three options which primarily introduce six-tracking between Wiri and Westfield junctions.

These initial network wide options were essentially the seed ideas that initiated a process of further refinement through more fulsome analysis as described in sections ahead.

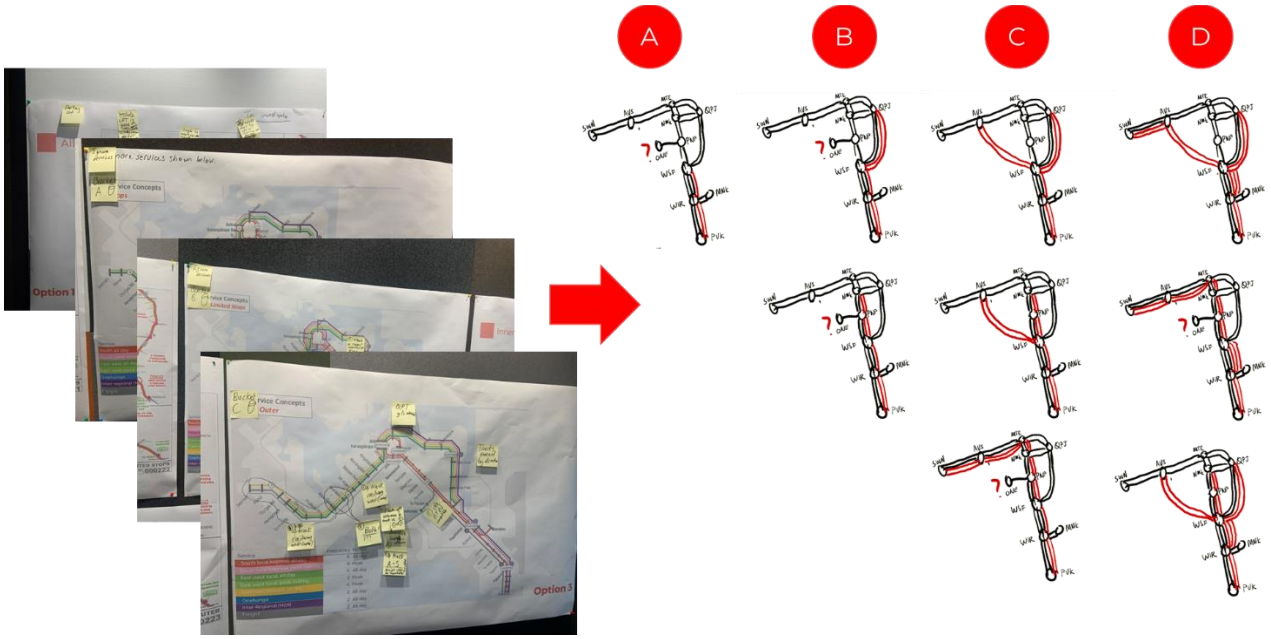


Figure 5-3: Nine provisional short list options

5.3.1.1 FOCUS ON PAIRS OF TRACKS

A key principal used in the development of the provisional short list options and subsequent refinement of the programme, was to focus on adding pairs of tracks to improve capacity as opposed to adding a single track.

The majority of the AMRN is dual track with the notable exception of the Onehunga branch line, which is single tracked, and Wiri to Westfield which has three tracks. These segments illustrate the relatively limited benefit of main line track configurations with uneven numbers of tracks. On the Onehunga line, only a 30min metro service can be operated due to the fact that trains can only pass each other at one location on the branch. Similarly, the Wiri to Westfield 3rd main only allows a single direction of travel at a time, thus making it only practically useful for freight services and even then, at limited capacity. Another potential use case for a third main is to run tidal express services, but this becomes less attractive in a mixed traffic railway where such a service would rule out segregation of freight and passenger in peak periods. The cost delta between three and four mains is generally considered marginal (due to a similar scale of land acquisition), while the difference in benefit and flexibility is significant. It was therefore decided to assume any track expansion would be implemented in multiples of double track, with an opportunity flagged to consider reducing by one track if well matched to the service concept and resulting in significant savings.

5.3.2 ITERATION 2: REFINED SHORT LIST OPTIONS

Next, analysis was undertaken on the nine provisional options to assess their relative benefits from a service/operational and cost/deliverability perspective, broadly testing their performance against the conditional output evaluation criteria and the critical success factor criteria of the MCA.

A first principle's approach was adopted in this analysis by asking the question *'what are the critical problems (deficiencies, constraints) that need to be addressed to achieve the future*

desired benefits of the rail network. The problems identified and potential responses identified to addressing them are summarised in Table 5-1.

Table 5-1: Major findings of differentiating issues analysis

Differentiating issue	Key findings	
Insufficient capacity on the south	**Section F1** There is insufficient capacity to meet projected demand in 2051 on the southern part of the network. The only viable solution to this capacity problem is to four track the corridor between Pukekohe and Westfield Junction.	
Inadequate freight access to the north	**Section F4** The issue of unreliable and insufficient freight access on the NAL (Inner southern and western corridors) centers around the Newton to Newmarket (N2N) segment of the corridor where freight trains have to merge and diverge between multiple metro services, and negotiate the high volume, flat junction at Newmarket. The three main options to address this bottleneck are 1. to accommodate freight on a two-track railway via timetabling and precise operation 2. activate Avondale-Southdown as a mixed passenger and freight corridor to bypass N2N, or 3. build a shorter (and cheaper) freight only bypass of N2N, likely a single-track tunnel.	
	Uneven Headway	**Section F4 and F5**. In all three of the options identified above, mixing of freight and passenger services on a two-track railway occurs at some locations along the western corridor, which forces an uneven headway metro service (5/10min alternating) on at least the East and West lines, and in some cases the South line as well. To address this problem, additional track can be added to fully separate freight and passenger service on the NAL however given the extent of corridor widening required, this solution would likely be paired with the Avondale-Southdown corridor (pairing with N2N results in more widening for less benefit). It is noted that the major constraints of New Lynn and Henderson make this a costly solution.
	Avondale Southdown	**Section F4** Pragmatically it was agreed to take the base assumption that A-S is a mixed freight and passenger corridor, with an opportunity for a freight only by-pass to be considered as a sensitivity. Analysis of a mixed-use corridor will generate information on the costs and benefits of a passenger service on A-S which can then easily be factored out to analyze the alternative.
45min from the south not achieved	**Section F6**. The 45min journey time to the CBD target is not achievable under any option (without track speed upgrades) but express services routed on the eastern or inner southern corridors can get close to this target if four tracking is implemented. However, four tracking the inner southern corridor will result in a better travel time to the CBD and is expected to be less costly with fewer environmental impacts, therefore this solution should generally be given preference over the eastern corridor.	

Differentiating issue	Key findings
Wiri to Westfield high utilization	Section F7. The Wiri to Westfield segment of the network will be a critical capacity bottleneck in 2051 due to a high volume of passenger services, and the requirement to provide access to the WPOAL for the port shunt move, along the eastern side of the corridor (typically designated for passenger services). Solutions have been identified as 1) four tracking W2W which requires the port shunt slot a potentially insufficient 5 min headway gap, 2) building turn-backs at Otahuhu and Puhinui to reduce metro train volumes between W2W, thus providing a wider headway gap for the port shunt. Further discussion on this point in Section 5.3.2.1. 3) building 5 tracks to provide a dedicated mainline for the port shunt, and 4) 6 tracking W2W to de-interline the red and green lines while also providing a wider headway gap for the port shunt. At this time, no options can be obviously taken off the table.
	Freight access on the NIMT E: Section F8 From a freight access perspective, a two-track railway on the eastern corridor has sufficient capacity to provide reliable access to the port and crosstown shunt moves, due to the ability of these shorter trains to slot a tighter headway gap of 5min.[9]
Onehunga capacity and poor crosstown connection	Section F9. The Onehunga Branch Line (OBL), as a single-track branch line with short platforms, only supports a 2 x 3-car tph service which takes up capacity on other parts of the network and does not conform to RTN standards. An upgrade of this section to double track with nine car equivalent enabled stations would be extremely expensive due to land take and also the eight level crossings to be removed. After discussion, two solutions were taken forward: • Convert the OBL to a shuttle service with a connection to the southern line, allowing the service to continue at 2x3-car tph, without consuming valuable capacity on the main line, and deferring a decision to upgrade or remove the OBL as part of a wider PT network plan. • To remove the OBL completely on implementation of Avondale-Southdown which would provide an alternative heavy rail service to the neighborhoods served by the existing branch.
Insufficient maintenance access	Section F10. Improving maintenance access on the network while protecting passenger and freight operations to an acceptable level of service and availability, will require a number of improvements in plant, systems, work practices, planning, and infrastructure. From a macro

[9] Note that the 5min target was later adjusted based on further analysis, ultimately to 10min. However, the conclusions of Section F6 are unchanged by these changes in input.

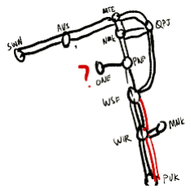
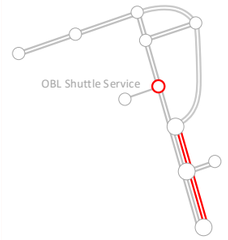
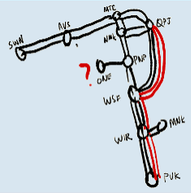
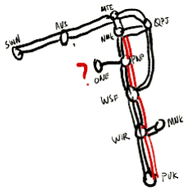
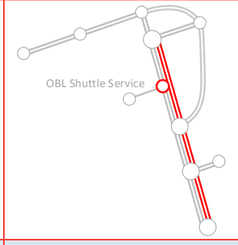
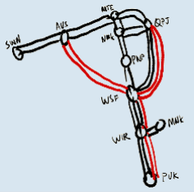
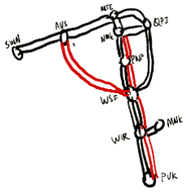
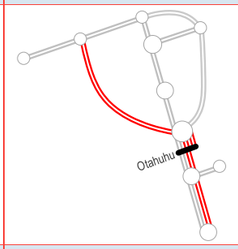
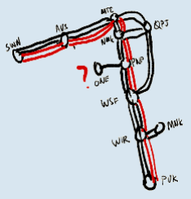
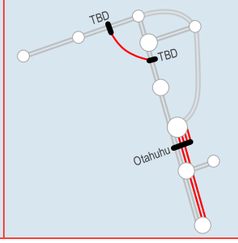
Differentiating issue	Key findings
	infrastructure perspective, two main strategies were identified to support improved maintenance in the long term: 1. Provide four tracking on all major corridors (in order to close two tracks for maintenance while continuing operation on the adjacent pair) or 2. provide diversity of routing (where one corridor can be closed for maintenance while continuing operation on an alternative corridor). The solutions proposing to four track most of the network were considered too costly for the expected benefit, whereas a combination of both strategies may be feasible.[10]

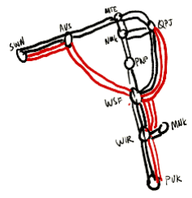
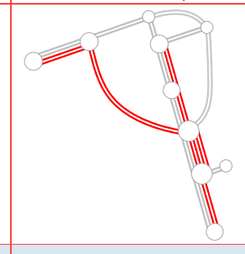
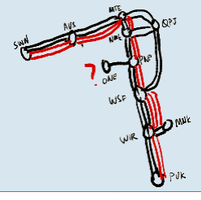
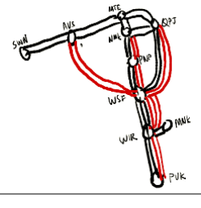
Based on the insights gained from the critical issues analysis, a refinement of the provisional short list options was undertaken. Table 5-2 presents a brief overall analysis of each option and suggests a refinement to the concept where relevant. Some options were screened out at this stage, while others were recommended to be carried forward for full analysis based on the MCA framework.

It is noted that Table 5-2 does not include a discussion of Inter Regional benefits. This was on the basis that benefits to metro services on the south generally accrue to Inter Regional services also (H2A will generally be treated as a metro express train within the timetable) and therefore the metro column can be taken as a proxy for IR benefits, Maintenance performance was also not considered in Table 5-2, as it was not considered to provide significant differentiation between options. It was however noted that maintenance access will generally benefit from increased four tracking (allowing a pair of mains to be maintained while operation continues on the adjacent pair) and diversity of routing e.g. adding A-S (which allows a corridor to be closed while operation is maintained on the other)

[10] In the long list to short list workshop meeting held August 11th, the initial MCA screening had already factored out the option of providing four tracking on all major corridors for the reasons provided in Sections A-9. There was general agreement on this point, however it was decided to add this option back into the MCA (as Option Diii) to provide more thorough documentation of the decision.

Table 5-2: Screening and refinement of the provisional short list

Theme	Option	Initial Concept	Freight	Metro	High level analysis	Refined Concept
Minimum investment to meet demand	Ai		- Provides reliable freight access from south - Potential issues with reliability of freight path access, particularly for port shunt (5 min path W2W). To be tested further	- Provides reliable freight access from south - Constraints imposed on passenger timetable to provide NAL freight access through N2N and Port shunt access through N2N. Adds buffer (increased runtime) and potential reduction in reliability - >45min journey times from the south - Uneven all-day service headways (5/10min)	**Carry forward** but modify OBL to be a shuttle service. Further testing required to validate feasibility. **Note significant initial upgrades are required to provide required capacity and service levels in 2051 across all options.**	
Improving passenger journey times	B(i)		- Potential issues with reliability of freight path access per Option Ai	- Express journey time improvements from the south, but less than option B(ii) - Constraints at N2N and W2W still exist - Uneven all-day service headways (5/10min)	**Park for now** in favour of B(ii) since routing on NAL provides better journey times for express services from the south and there are limited additional benefits to 4-tracking the eastern line; freight access is sufficient, and maintenance can be handled by diversity of routing.	
	B(ii)		- Potential issues with reliability of freight path access per Option Ai	- Express journey time improvements from the south, - Constraints at N2N and W2W still exist - Uneven all-day service headways (5/10min)	**Carry forward** but modify to have OBL as a shuttle service but the issues of port shunt and northland freight access remain.	
Separating freight and passenger at critical bottlenecks	C(i)		- Similar to C(ii)	- Similar benefits to C(ii) except - less journey time improvements from the south than C(ii)	**Park for now** in favour of C(ii) for the same reason as B(i) vs B(ii)	
	C(ii)		- Improves reliability of northland freight access - Doesn't address reliability of port shunt access	- N2N freight conflict resolved, reduces timetable buffer and improves reliability - New AS service - Constraints at W2W still exist - Uneven all-day service headways (5/10min)	**Carry forward** but modify to 1) remove 4 tracking on NAL S in line with updated theme for Series C, 2) add 6-tracking Westfield to Otahuhu to address freight access for the port shunt. W2W solution requires restructuring of metro network with turn-backs at Otahuhu and Puhinui	
	C(iii)		- Similar to C(ii) but with a different solution to the N2N bottleneck	- Similar to C(ii) except - removes the A-S passenger service.	**Carry forward** but modify to 1) replace 4 tracking NAL with N2N bypass 2) add 6-tracking Westfield to Otahuhu 3) OBL as a shuttle service Similar issues with W2W for metro service	

Theme	Option	Initial Concept	Freight	Metro	High level analysis	Refined Concept
A combination of improved journey times, and freight / passenger separation.	D(i)		- Improves reliability of northland freight access and port shunt access	- Address all major issues without the W2W service compromises. - Solves the uneven headway issue (provided A-S is a 4tph service) - less journey time improvements from the south than D(ii)	**Carry forward** but modify to have four tracking on NAL South. An opportunity to reduce W2W to 5 tracks could also be considered.	
	D(ii)		- Improves reliability of northland freight access and port shunt access	- Address all major issues without the W2W service compromises. - Solves the uneven headway issue (provided A-S is a 4tph service) - Best journey time improvements from the south	**Park for now** based on the fact that there is no benefit to this option over D(i) as it requires more quad tracking (and therefore higher cost) to achieve the same benefit as D(i) (i.e. eliminating uneven headways) while also losing the potential benefits of A-S for passenger service.	
	Diii				**Park for now** based on no benefit (but considerable cost) of four tracking both NIMT E and NAL S.	

The five refined options arising from the analysis above (Ai, Bii, Cii, Ciii, and Di in Table 5-2 were then supplemented with four further variants based on workshop discussions, to cover a wider range of future states, and allow for a more complete documentation of the decision-making process. These were:

- **A variant of Cii** which adds 6-tracks between W2W to the C series to resolve the Manukau turnback issue
- **A lower cost variant of Di** providing express from the south and freight / passenger separation but compromising on even passenger headways.
- **A variant of Bi** which 4-tracks the NIMT-E as an alternative route for express trains (though there was general agreement on screening this options out at a high level, it was decided to add it back into the MCA to provide more thorough documentation of the decision making process)
- **A higher cost variant of Di** which adds 4-tracks to the NIMT-E on top of the corridors already 4-tracked in option D(i), to provide more flexibility for maintenance. Again, this option was initially screened out, but added back for documentation purposes.

The final set of short list options to be taken forward for MCA analysis, are presented in Figure 5-4 and described below. Note that the ID scheme used in Table 5-2 is not consistent with the final scheme used in Figure 5-4. For reference the options are mapped as follows (old→new): Ai→Ai; Bii→Bi; Bii(variant)→Bii; Cii→Ci; Ciii→Cii; Cii(variant)→Ciii; Di(variant)→Di; Di→Dii; Di(variant)→Diii.

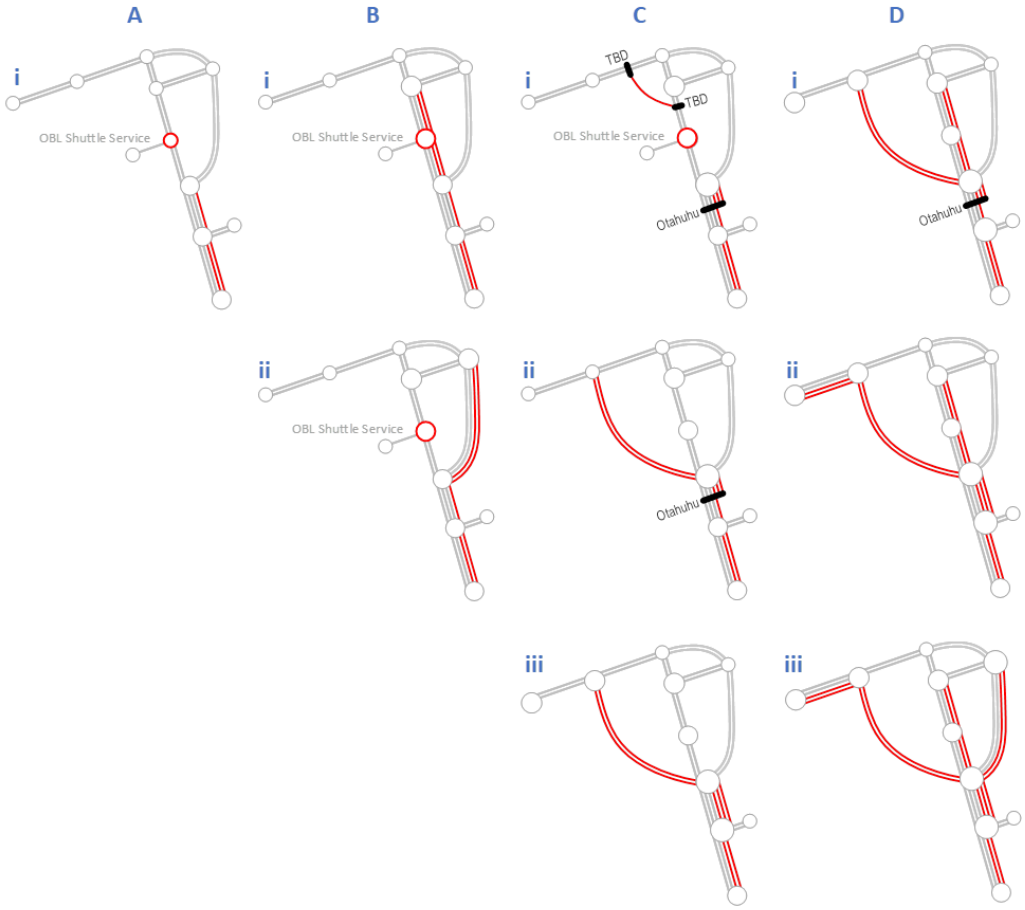


Figure 5-4 Refined provisional short list of options

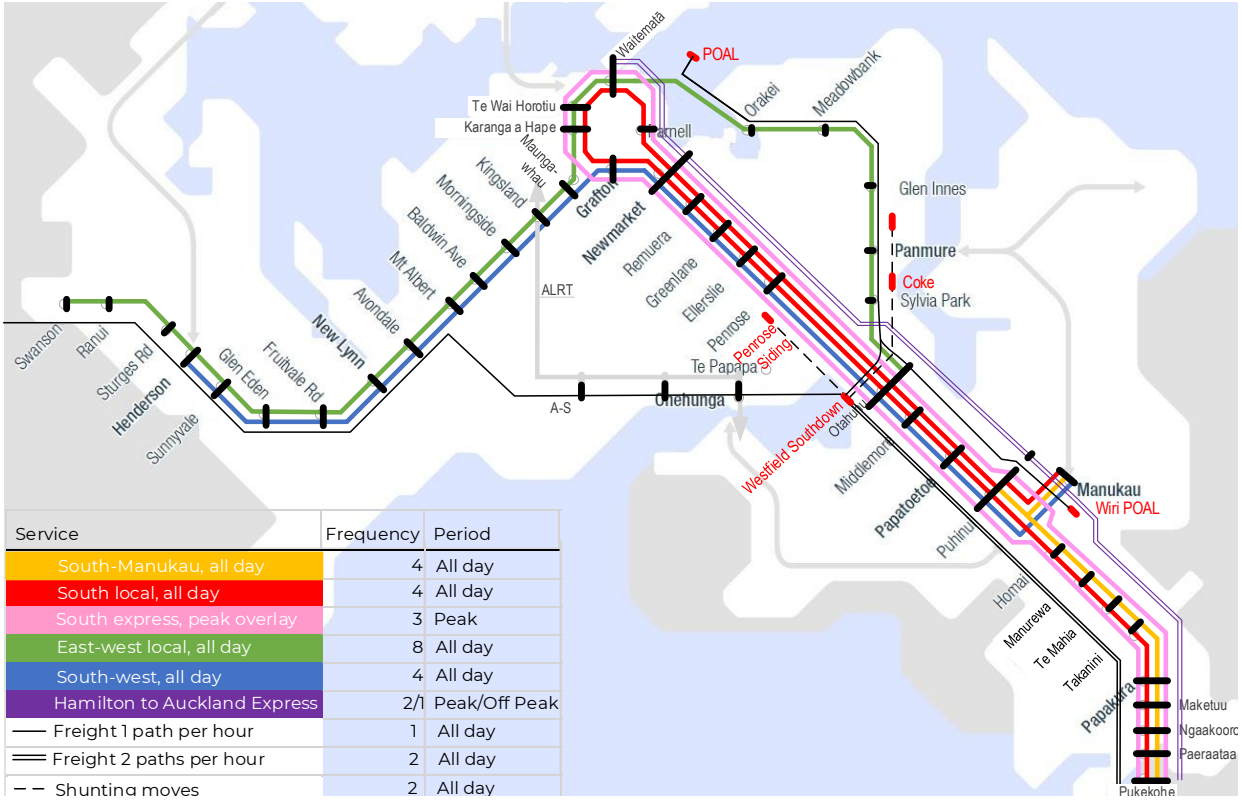
Provisional Short List Options

- Ai: Minimal investment option. 4track south of Westfield, OBL as a shuttle
- Bi: 4-tracking south of Westfield + Inner South widened to achieve passenger travel time savings. OBL as a shuttle
- Bii Variant of Bi where the NIMT-E is 4-tracked as an alternative route for express trains (though there was general agreement on screening these options out at a high level, it was decided to add it back into the MCA to provide more thorough documentation of the decision-making process.
- Ci: 4 tracking south of Westfield and 6-tracks from Westfield to Otahuhu, with the East West line terminating at Otahuhu and a South to Manukau service in operation, avoiding the need for full W2W 6-tracking. A Newton to Newmarket (N2N) bypass to allow all day freight access without compromise to peak metro services.
- Cii: Variant of Ci with Avondale-Southdown as an alternative to the N2N bypass.
- Ciii) Variant of Cii with 6-tracks W2W, thereby resolving expected passenger convenience and infrastructure complexity issues with the Manukau turnback (analysed further in the next phase of optioneering)
- Di) A variant of Dii which provides a lower cost option of providing both express from the south and freight / passenger separation, by compromising on even passenger headways.

- Dii): Avondale – Southdown plus 6track Westfield-Wiri, plus widening of the Inner South for metro and inter regional travel time savings, plus widening of the outer Western corridor to achieve even headways
- Diii) A variant of Dii which adds 4-tracks to the NIMT-E, to provide more flexibility for maintenance. Again, this option was initially screened out, but added back for documentation purposes.

5.3.2.1 WIRI TO WESTFIELD ISSUE – SERVICE BASED SOLUTION

The concept of adjusting services to reduce the need for a 6-tracked Wiri to Westfield corridor was raised in the Long List assessment, and a solution was developed as part of the provisional short list option development. The option involves building turnbacks at Otahuhu and Puhinui, with a short 6-track section from Westfield junction to Otahuhu. This infrastructure supports a service where the green line is terminated at Otahuhu, reducing train volumes on the eastern mains between W2W and thereby providing a larger gap for the port shunt. The side benefit of eliminating two junctions and a long segment of corridor where the green and red lines 'interline' is also quite significant in the context of the overall network. However, achieving the reduction in train volumes while maintaining a frequent service to Manukau requires some further service changes including a new south to Manukau service, which also drives the need for significant upgrades at Puhinui station. This represents a fairly significant re-structuring of the network service pattern as illustrated in Figure 5-5 below, which is the subject of further scrutiny in the MCA.



Service	Frequency	Period
South-Manukau, all day	4	All day
South local, all day	4	All day
South express, peak overlay	3	Peak
East-west local, all day	8	All day
South-west, all day	4	All day
Hamilton to Auckland Express	2/1	Peak/Off Peak
Freight 1 path per hour	1	All day
Freight 2 paths per hour	2	All day
Shunting moves	2	All day

Figure 5-5: Example Service Plan incorporating the Otahuhu and Puhinui turnbacks

5.3.3 ITERATION 3: FINAL MCA SCORED SHORT LIST

The nine refined short list options presented in Figure 5-4 were then put through an MCA to sieve down to a final Short List of three. The outcomes of the MCA analysis are documented in the next section. To inform the MCA workshop, high level costing was also undertaken on each option during this phase as described below.

5.3.3.1 COSTING

Costs developed for each of the 9 options are presented in Table 5-3 below. Note that these were indicative and meant only to show the relative costs between options – thus they are presented as incremental costs in relation to the minimum investment option Ai (further discussion on this point in Section 5.4.1), and only the differentiating elements of the infrastructure are shown. The total option costs are also shown in the final row (NB these are not the summation of rows above)

Table 5-3: Incremental cost analysis on provisional short list (numbers in $B)

OPTION	Ai	Bi	Bii	Ci	Cii	Ciii	Di	Dii	Diii
4T Westfield Jcn - New Market		3,040					3,040	3,040	3,040
4T Westfield Jcn - Quay Park (NIMTE)			5,760						5,760
6T Otahuhu - Westfield Jcn				580	580		580		
6T Wiri Jcn - Westfield Jcn						2,520		2,520	2,520
4T Swanson - Avondale								5,350	5,350
2T Avondale - Southdown					4,160	4,160	4,160	4160	4,160
1T Newmarket - Newton Jcn				1,070					
Cost difference to Option Ai		3,040	5,760	1,650	4,740	6,680	7,780	15,070	20,830
Total Option Cost	**13,590**	**16,630**	**19,350**	**15,240**	**18,330**	**20,270**	**21,370**	**28,660**	**34,420**

5.4 OUTPUTS AND OUTCOMES

This section provides a summary of the MCA analysis developed and refined through a client workshop held on August 11th 2022. and accompanying narratives. Again, the MCA table is quite large, particularly the number of options evaluated in this phase, and has therefore been provided as an appendix rather than a table in the body of the report. Hyperlinks have been included to easily navigate to the full commentary.

Section 5.4.1 provides a summary of the MCA scoring, while Sections 4.4.2 through 4.4.5 provide a summary of the assessments and how these allowed for the sieving of options.

Whereas in the previous stage of analysis, the conditional output assessment criteria were the central focus, as providing the required granularity to assess individual components of the options, the focus at this stage leans more heavily on the Investment Objectives (of which the Conditional Outputs represented an initial proxy) since the options can now be better evaluated at a network wide level and sufficient information was available to tie directly to the IOs. Thus commentary in this section is centered around the IO's rather than the CO's, but scoring for all criteria is provided in the summary table and full commentary on all criteria is provided in the Appendix G.

5.4.1 MCA SUMMARY

Table 5-4 provides a summary of the scoring of the MCA, with **the full Provisional Short List MCA provided in Appendix G**. Each line item in Table 5-4 corresponds to one or more rows of the MCA. Where aggregating scores over multiple criteria, the average is taken. The key insights from the MCA workshop and follow up analysis were as outlined below.

In this assessment, Option Ai was used as the Reference Option, with other options scored relative to it. This approach was adopted as it provided an agreed option that was to be used as a reference point to help determine whether additional investment was likely to be justified. The analysis up to this point had demonstrated the need for Option Ai as a bare minimum to meet demand via four tracking of the southern corridor to Westfield. By using this reference option, as opposed to the (actual) Do Min as the yardstick, it provided more scope to utilize the 7 point scale (up and down from 0) in the MCA, and thus help provide more granularity for differentiating the other options.

This was widely discussed and agreed with project partners at the time. If the DM was used as the comparator in scoring, there would have been minimal differentiation between any of the greater investment options as Option Ai was already a material improvement (in relation to the benefits side of the MCA) than the DM. An alternative approach discussed was to recreate the scoring scale (using an 11-point scale for example) but when you go to more points on the scale, it infers more accuracy (a perception challenge). We agreed to adopt the use of a reference option instead and retain consistency through the MCA.

Once the best performing provisional shortlist options had been identified, the MCA defaulted back to an assessment against the do-minimum in the final short list assessment.

Table 5-4: Provisional short list MCA summary

OPTIONS	Ai	Bi	Bii	Ci	Cii	Ciii	Di	Dii	Diii
Investment objectives									
IO 1	0	2	2	1	2	2	2	3	2
IO 2	0	2	2	1	2	2	3	3	3
IO 3	0	2	2	1	2	2	3	3	3
Critical Success Factors									
Potential Achievability/Deliverability	0	-1	-2	-3	-1	-2	-1	-3	-3
Potential affordability	0	Not scored. See discussion in Section 5.4.3.							
Supplier capacity and capability	0	Not scored nor deemed necessary at this level of the PBC							
Scheduling/programming	0								
Opportunities and impacts (insert N/A if not relevant)									
Environmental effects	0	0	-2	-1	-2	-2	-2	-2	-3
Social and cultural impacts	0	1	1	-1	1	1	1	1	1
Climate Change mitigation	0	3	3	1	2	2	3	3	3
Climate change adaptation	0	0	1	0	1	1	1	1	2
Cumulative impacts	0								
Impacts on Te Ao Māori	0	1	0	-1	1	1	1	1	0
Property impacts	0	-2	-2	-2	-2	-3	-3	-3	-3
Impacts on road safety	0	2	2	1	2	2	3	3	3
Conditional output assessment									
Network Wide									
Maintenance	0	0	0	0	0	0	0	0	0
75% Capacity Utilisation	0	0	0	1	1	1	1	1	1
Western Line									

OPTIONS	Ai	Bi	Bii	Ci	Cii	Ciii	Di	Dii	Diii
Metro passenger	0	0	0	0	1	1	1	2	2
Freight, NAL	0	0	0	1	3	3	3	3	3
Maintenance	0	0	0	0	1	1	1	2	2
Eastern Line									
Metro	0	0	1	-1	-1	0	-1	0	0
Freight, POAL	0	0	1	2	2	3	2	3	3
Inter-regional	0	3	3	1	1	1	3	3	3
Maintenance	0	1	1	0	0	0	1	1	2
Inner Southern (North of Wiri)									
Metro	0	0	0	1	1	2	1	2	2
Freight. NIMT	0	0	0	1	2	3	2	3	3
Maintenance	0	1	1	0	0	1	1	2	2
Outer Southern (South of Wiri)									
Metro	0	2	2	1	1	1	3	3	3
Freight, NIMT	0	0	0	0	0	0	0	0	0
Inter-regional	0	2	2	1	1	1	3	3	3
Maintenance	0	0	0	0	0	0	0	0	0
Project-specific Critical Success Factors									
Capital Cost (incremental on Ai)		3.04	5.76	1.65	4.74	6.68	7.78	15.07	20.83
Summary									
Aggregate MCA Score (raw)	0	26	25	8	27	31	41	47	47
Incremental Cost to Ref Ai ($b)	0	3.04	5.76	1.65	4.74	6.68	7.78	15.07	20.83
Total Cost	13.59	16.63	19.35	15.24	18.33	20.27	21.37	28.66	34.42

5.4.2 INVESTMENT OBJECTIVES SUMMARY

The assessment focused primarily on the attractiveness of the services to passengers and freight users, and the reliability of the network as a whole, on the basis that a more attractive and reliable service offering is best able to induce mode shift and thus lead to more reduction in VKT and emissions. From a road safety perspective, all options assume that a full level crossing removal programme is required. Thus, the main driver of safety improvement was deemed to be correlated to attractiveness as this drives mode shift leading to less private vehicle and heavy truck use, thereby improving road safety.

5.4.2.1 PASSENGER ATTRACTIVENESS

The degree to which options were deemed to increase the attractiveness of metro services, differentiated options in two main areas:

1) **Manukau connection:** Options which required the modified Manukau Branch Line service (Options Ci, Cii, and Di) were seen as likely to have a net negative impact on attractiveness of the rail service for passengers on the Eastern Line and Southern Lines due to the removal of direct connections between Manukau and the city. Options that removed this connection (C1, C2, and D1) were less preferred.

2) **Express services**: Based on the results of modelling, it was generally agreed that routing of express services via the southern line would result in the best travel times (due primarily to it being a more direct route to the CBD where demand modelling showed most trips were tied to), and thus lead to a more attractive services. Options which only enabled routing express services on the Eastern Line by adding track capacity to the Eastern Corridor (Option B2) was scored lower than other options. Another observation captured in commentary on COs and IOs is that the option containing N2N (Ci) was likely to compromise the ability to run express services given that all day freight paths on the two tracked inner southern corridor, would consume the slots that these would otherwise run in.

3) **Uneven headways**: Options enabling an even headway on the East-West lines by adding track capacity from Avondale Junction to Swanson, were generally scored higher on relevant Conditional Output Assessment criteria[11] but the impact of this to overall attractiveness of the heavy rail metro network was not considered significant and did not influence the assessment of the overall IO.

5.4.2.2 FREIGHT ATTRACTIVENESS

Options providing higher degrees of operational reliability and more separation between freight and metro services throughout the day were most strongly preferred. This differentiated options in two main areas

1) **NAL:** Options containing the A-S corridor (C2, C3, D1, D2, D3) were preferred over the N2N bypass given that while the N2N bypass addressed most freight/passenger conflicts, it was not as flexible due to a higher degree of mixed use on the high traffic section of the inner southern line. The N2N bypass option (C1) was in turn preferred over options with no separation of NAL freight and metro passenger (Ai, Bi, Bii) as these would not enable all day freight access.

[11] There is no CO specific to headway homogeneity (evenness), however this feature of the metro services was assessed to be important to the overall investment objectives of providing an attractive passenger service offering. Generally commentary and scoring on this point was captured under the incremental journey time improvement CO.

2) **POAL:** Options separating metro and freight through the W2W segment of the network were deemed to result in the highest degree of flexibility and reliability for freight. Whether this was achieved via a full 6-track solution (C3, D2, D3) or a modification in metro service patters (C1, C2, D1) was not generally considered differentiating from a freight perspective.

All options provided a 4-track corridor on the NIMT and therefore consideration of NIMT freight was not differentiating in this MCA assessment.

5.4.2.3 NETWORK RELIABILITY

A key consideration in this phase of analysis was how investments could improve maintenance access on the network while protecting passenger and freight operations to an acceptable level of service and availability, thus leading to a more reliable network operation.

On the one hand, track expansion can provide benefits from this perspective, allowing for one pair of mains to be closed for maintenance while continuing operation on the adjacent pair. Or allowing one corridor to be closed for maintenance while continuing operation on an alternative route.

On the other hand, adding additional track and associated assets to the network increases the overall maintenance burden of the network. For example, there were several discussions about whether future network sectionalization should provide single track running headways of 15min rather than the initial 30min target. This was ruled out as it would require excessive special track work (crossovers) which would increase maintenance burden, thus compromising the original purpose of the intervention to improve maintainability.

It was therefore assessed that the benefit of Option Diii which quad tracks both the eastern and the inner southern line, from a maintenance perspective may not be significant and therefore wouldn't warrant investment on this point alone. It was identified that other improvements in plant, systems, work practices, and planning would likely be more beneficial for maintenance, and these could be implemented largely unrepentantly of the network option selected.

5.4.2.4 SUPPORTING DENSER URBAN FORM

Options with the most travel time improvements were deemed to best support dense urban form, as these options would provide the best access opportunities for public transport users. Options providing full 4-tracking of the southern line to Newmarket (B1, D1, D2, D3) scored highest on this metric at they were deemed to have the greatest potential for a skip stop services.

Options including the Avondale – Southdown corridor were also scored higher on this criteria as the creation of a crosstown link will improve PT network connectivity and access particularly for non CBD centric trips.

5.4.3 CRITICAL SUCCESS FACTORS SUMMARY

Discussion and analysis of the criteria in this category centered around consideration for achievability and deliverability. This differentiated options in a number of ways:

1. **N2N Bypass:** The N2N bypass option (C1) was assessed as having a high potential for geographical challenges (particularly around the Mt Eden volcanic cone) as well as a significant level of uncertainty around the proposal when compared to the much more well-established and cost-effective alternative of A-S for which KiwiRail already own the land and have the designation.

2. Outer Western Line 4-tracking: To address the problem of uneven headways on the East-West Line, the solution of adding third and fourth mains to fully separate freight and passenger service on the NAL was considered in Options D2 and D3. However given the extent of corridor widening required and the significant constraints of the New Lynn and Henderson areas along the corridor, it was ultimately decided that the benefits of such expansion (as discussed in section 5.4.2.1 bullet 3) would not be justified against the significant cost and complexity of this work. This service compromise is not insignificant as it may lead to uneven train loading and potential overcrowding in peaks. It may also compromise the ability of network planners to schedule a fully integrated PT network. An opportunity to reduce the 10' window for freight and get closer to a fully homogenous passenger headway was identified through introduction of ETCS level 2 signalling and improved signal spacing on the Western line enabled by removal of level crossings as well as enhanced Traffic Management Systems. Additionally in the Options Report Part II, a peak overlay service will be considered to alleviate these issues.
3. Inner-south corridor four tracking vs. eastern corridor four tracking: Short options variously consider to four track the eastern corridor (B2) or the inner southern corridor (B1, D1, D2) to achieve travel time benefits for express services or both to achieve greater maintenance and resiliency benefits (D3). It was generally agreed that expansion of the NAL S would have an expected lower cost (being a shorter corridor), with fewer expected deliverability challenges, particularly considering the constraints of the Purewa tunnel, the causeway, and the Glen Innes to Mt Wellington section.

Potential affordability was again assessed as being primarily correlated with the capital costs at this stage of analysis, given specific funding envelops were not known. From an OPEX perspective, all options are relatively similar as services would be scaled to the same set of demands from a metro perspective, and would accommodate the same volumes of freight and inter regional services. One potential differentiating consideration raised in the discussion is as follows:

4. Maintenance burden: Options with more track expansion and civil structures will increase the maintenance burden of the network which could lead to higher, potentially unaffordable OPEX costs. This was a consideration for Option Diii in particular.

Supplier capacity and capability (11) and Supplier capacity and capability (12) were considered not relevant at this stage of PBC and were therefore not scored.

5.4.4 OPPORTUNITES AND IMPACTS SUMMARY

The primary observation in this category of criteria was that options including four tracking of the Eastern corridor (B2, D3) were flagged as significant environmental concerns with impact to Hobson Bay and the Orakei Basin.

5.4.5 PROJECT-SPECIFIC CRITICAL SUCCESS FACTORS

Qualitative capital costs provided in Section 5.3.3.1, were used in the MCA workshop assessment to differentiate between options.

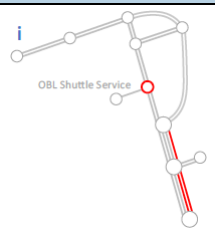
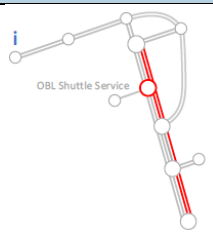
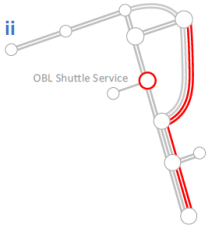
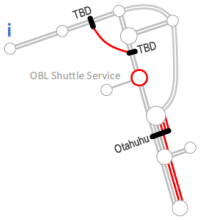
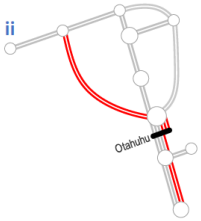
5.4.6 SELECTION

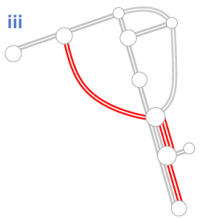
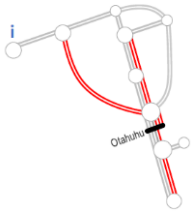
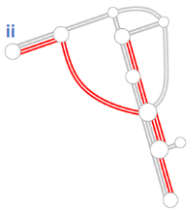
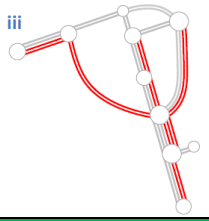
Based on the analysis and observations described above, supported by an aggregate scoring of the MCA and the incremental costing, a selection of short list options was made per Table 5-5.

Note that one mechanism used to sieve options in this phase was the rationale that some options represent subsets or phasings of others – for example Option Bi is an interim phasing of Option Di. Therefore consideration of the more advanced option Di, would allow for an assessment of Bi within its phasing analysis. This rationale was used to discount options Bi and Cii.

Another key theme in the selection of options was coverage of the three treatments for Wiri to Westfield; 4 tracking (under Ai), 6 tracking (under Ciii) and a hybrid infrastructure and service based option (under Di). At the conclusion of the long list there was no obvious way to rule out or prioritise between these options, and therefore they were all taken forward.

Table 5-5: Provisional short list MCA final assesment

Option	Ai (Reference Option)	Bi	Bii	Ci	Cii
					
MCA Score (raw)	0	26	25	8	27
Incremental cost to Ref Ai ($B)	0	3.04	5.76	1.65	4.74
Total cost ($B)	13.59	16.63	19.35	15.24	18.33
Recommendation	Take Forward	Discount	Discount	Discount	Discount
Rationale	Minimum investment option	Effectively **a phasing of Option Di** – phasing and scenario analysis will identify when this infrastructure state will occur or what could trigger it	**Option Bi preferred as a direct alternative** due to lower potential to improve rail attractiveness for passengers (See Section 5.4.2.1), significant deliverability concerns (See Section 5.4.3), environmental risk (see Section 5.4.4), and higher cost (+2.36b) of the eastern corridor track expansion.	**Options Cii preferred as a direct alternatives**, given the lower potential for freight attractiveness (see Section 5.4.2.2) and passenger attractiveness (see Section 5.4.2.1), and the high levels of uncertainty around deliverability (see Section 5.4.3). This resulted in a very low overall MCA score of 8 which did not justify the cost savings over Cii of -3.09B.	Effectively **a phasing of Option Di** – phasing and scenario analysis will identify when this infrastructure state will occur or what could trigger it

	Ciii	Di	Dii	Diii
Option				
MCA Score (raw)	31	41	47	47
Incremental cost to Ai ($B)	6.68	7.78	15.07	20.83
Total cost ($B)	20.27	21.37	28.66	34.42
Recommendation	Take Forward	Take Forward	Discount	Discount
Rationale	Adds Avondale-Southdown and captures the Wiri to Westfield 6-tracking option	Adds Avondale-Southdown and captures the Wiri to Westfield service adjustment option and the additional express benefits option of the inner NAL	Incremental change of 4-tracking the outer western line rejected on the basis of low benefit from an overall passenger rail attractiveness perspective (see Section 5.4.2.1) vs. significant deliverability concerns (see Section 5.4.3) and high cost (estimated to be $5.3B see Section 5.3.3.1)	Discounted for similar reasons as Dii as well the fact that the maintenance benefits of adding Eastern corridor 4-tracking were not expected to justify the high delta in cost and environmental risk (see Section 5.4.2.3 for discussion). This is reflected in the fact that there is no improvement to the overall MCA score between Dii and Diii

5.5 NEXT STEPS

The short list options were taken forward into a more detailed analysis (outlined in **Section 6**), including refinement of:

- service concepts,
- infrastructure requirements (including the non-differentiating factors left out of earlier analysis),
- associated costing,
- updated demand and economic modelling, and
- phasing of the options over the three decades from 2025 to 2051.

In addition to this a number of items were raised in the Long List to Short List meeting, to be looked at in further detail during the next phase of analysis. These items are summarised below:

- Use of the 25% reserve capacity for work trains, tourist trains, etc, needs to be explored in further detail to ensure that sufficient capacity is being planned for. This reservice capacity also accounts for operators or services that have not been predicted in this PBC, such as additional interregional services, and serves to provide added resilience and improve the networks ability to recover from disruptions
- Partial four tracking of in NIMT-E from Westfield to Panmure should be investigated for degraded / maintenance mode operations, and improved access to the Coke siding
- All options assume grade separation at Westfield Junction for the crosstown shunt move, and other movements from Southdown to the NIMT-E. Further thought should be given alternatives that do not require a full grade separation.
- Moving WPOAL to the West side of the corridor, to improve freight access and open up potential land for ideally situated EMU stabling facility
- Penrose station upgrades required for the only OBL shuttle to facilitate an efficient passenger transfer.
- Additional infrastructure needed for maintenance scenarios to be determined in the next phase of analysis. This may include sidings for staging work cars, additional crossovers to allow faster access to work zones, etc. as well as completing the triangle at Penrose to enable South-West movements, and the triangle at Westfield junction to enable North-East movements
- Merging and diverging of express and local services needs to be looked at in more detail to determine infrastructure needed to support (e.g., grade separation)
- Quay-park upgrades including potential grade separation, may be required
- Route protection should be considered for corridor expansion that is likely required in the future but potentially not within the 30-year time horizon.

6 SHORT LIST TO INITIAL PREFERRED PROGRAMME

6.1 OVERVIEW

This section outlines further refinements and technical assessments of the Short List options to enable the ultimate selection of an Initial Preferred 2051 End State for the network via a final MCA assessment.

6.2 PROCESS

The analysis undertaken to assess the short list and ultimately select Initial Preferred 2051 End State involved evaluation from a number of perspectives as illustrated in Figure 6-1 below.

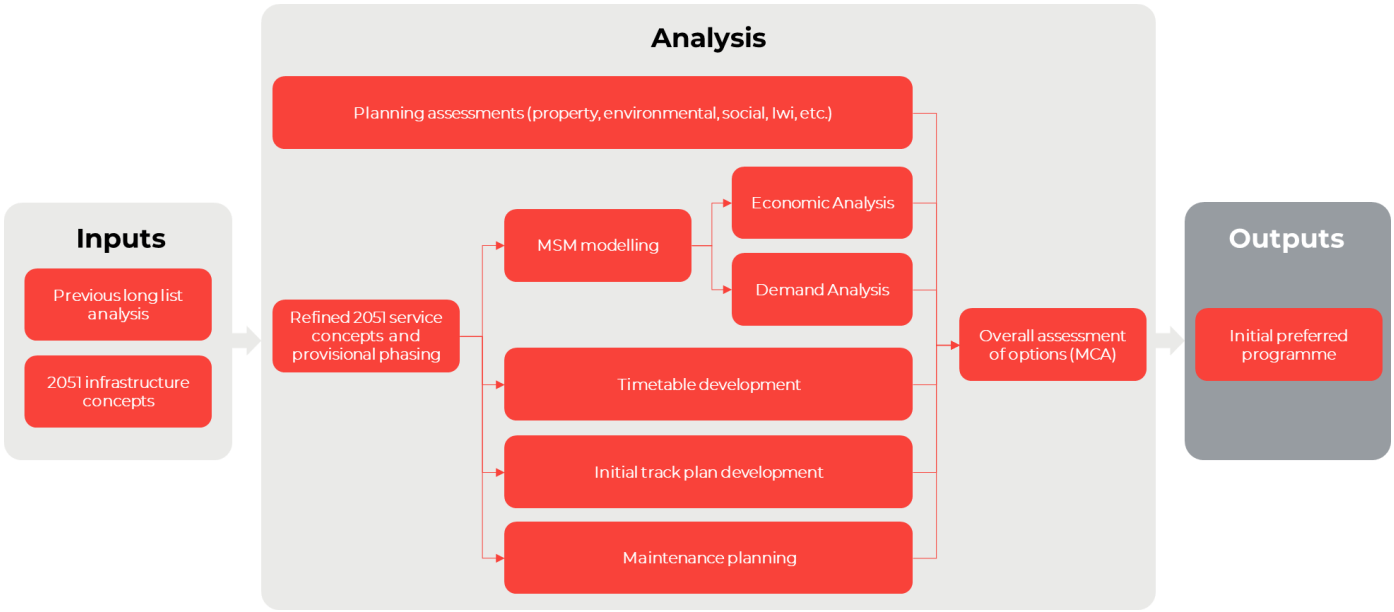


Figure 6-1: Short list assesment process

Given that the short list was primarily a set of infrastructure options, the first phase of analysis was to develop specific service concepts associated with each option. The service and infrastructure concepts were then used analyse options. This included:

- Development of a simplified timetable to test potential conflicting movements across junctions and impact on journey times

- Utilising the MSM Model to understand the impact of each service concept on passenger demand[12]
- Macro level track plan development to identify risks and differentiators between options
- Consideration of maintenance and access implications to ensure reliability targets are achieved[13]
- Economic modelling based on the outputs of the MSM model along with other inputs related to freight benefits.
- Planning assessments including property, environmental, social and Iwi impacts
- High level cost estimations and benefit calculations

The three shortlist options were assessed through a workshop on 13th October 2022 with technical specialists and stakeholders from Auckland Transport, KiwiRail and WSP.

For the workshop, specialists were briefed on what each of the shortlist options were and technical components were discussed, such as assessed options against Conditional Outputs.

6.3 SHORT LIST OPTION REFINEMENT AND ASSESMENT

This section provides a summary of key results and conclusions of the analysis conducted on the short list options, according to the process described above. This information, along with various other datapoints, was provided to participants of the optioneering workshops in presentation form, for background, allowing for an informed decision-making process.

6.3.1 INITIAL INFRASTRCUTURE CONCEPTS

The three options selected from the evaluation of the provisional short list represent a set of potential infrastructure schemes for the network. These are summarised in Figure 6-2. In this phase of optioneering, these infrastructure states are interrogated in further detail along with the service and operational benefits they enable.

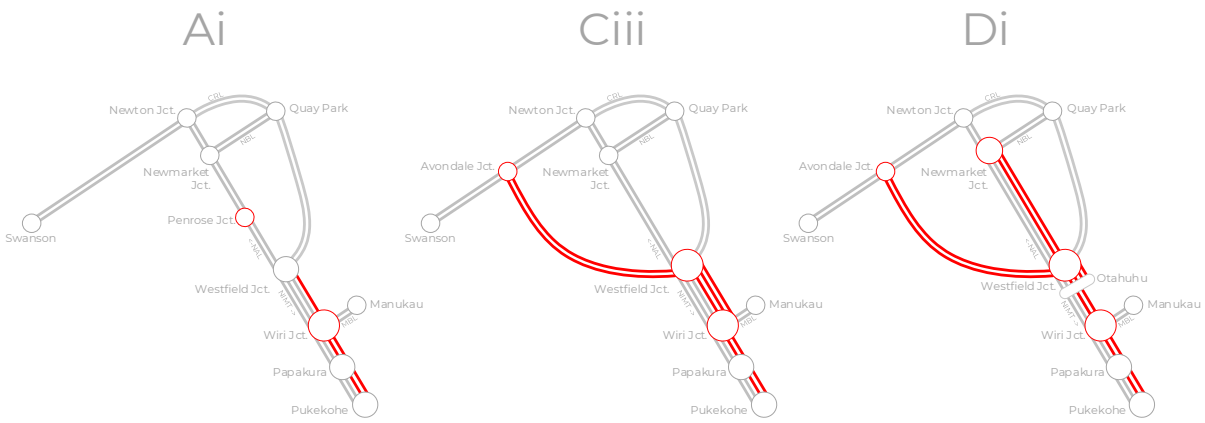


Figure 6-2: Short list initial infrastructure concepts

[12] Noting that Freight and Interregional demand is based on train paths rather than trips so are treated as a minimum requirement

[13] Noting that degraded mode operation would be considered during refinement of Initial Preferred 2051 End State

6.3.2 TIMETABLE AND SERVICE CONCEPT DEVELOPMENT

At this stage of optioneering conceptual timetables were developed to further inform the service and infrastructure concepts for the network. The updated service concepts resulting from this analysis are presented in Table 6-1 along with high-level commentary of key features which are further discussed in subsections below.

The timetable analysis focused the co-ordination of train movements through junctions and at terminal stations using the WSP RailOps Toolkit, and OpenTrack simulations to estimate runtimes. This tool allows for timetables to be constructed using a visual clockface representation for all entry and exit movements over all tracks and all approaches, as well as conflict matrices to show where conflicting movements occur at junctions. An illustration of outputs are provided in Figure 6-3 below. Note that freight paths are not shown visually but can easily be inspected using the tool

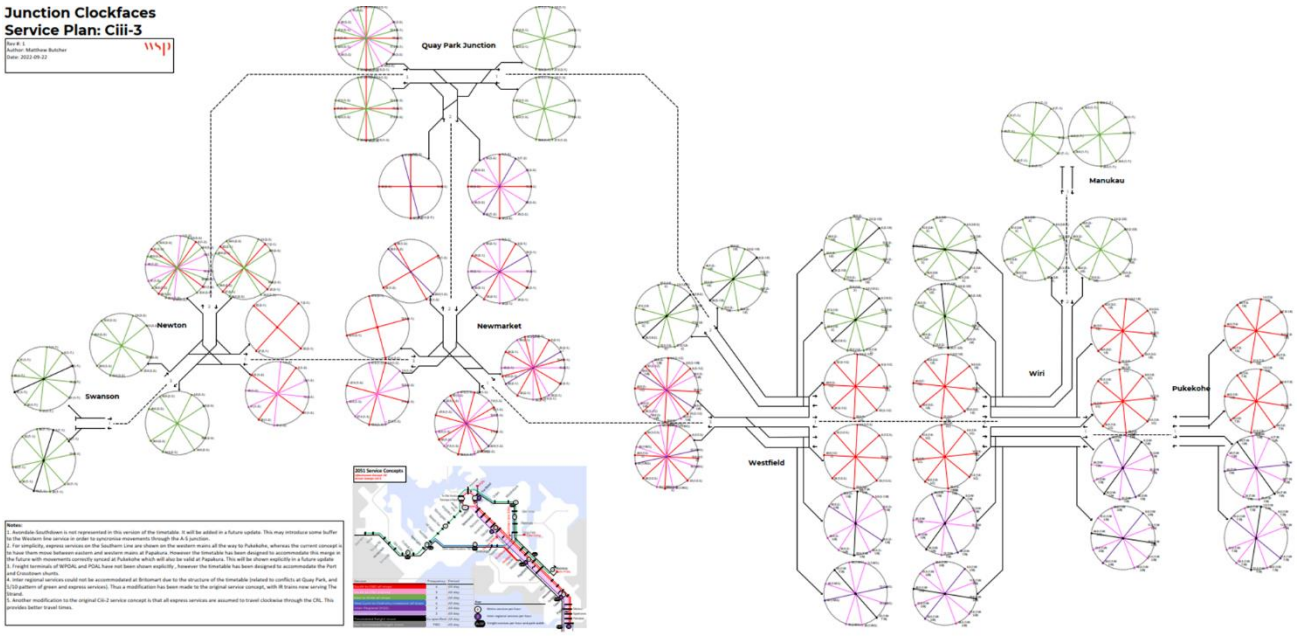


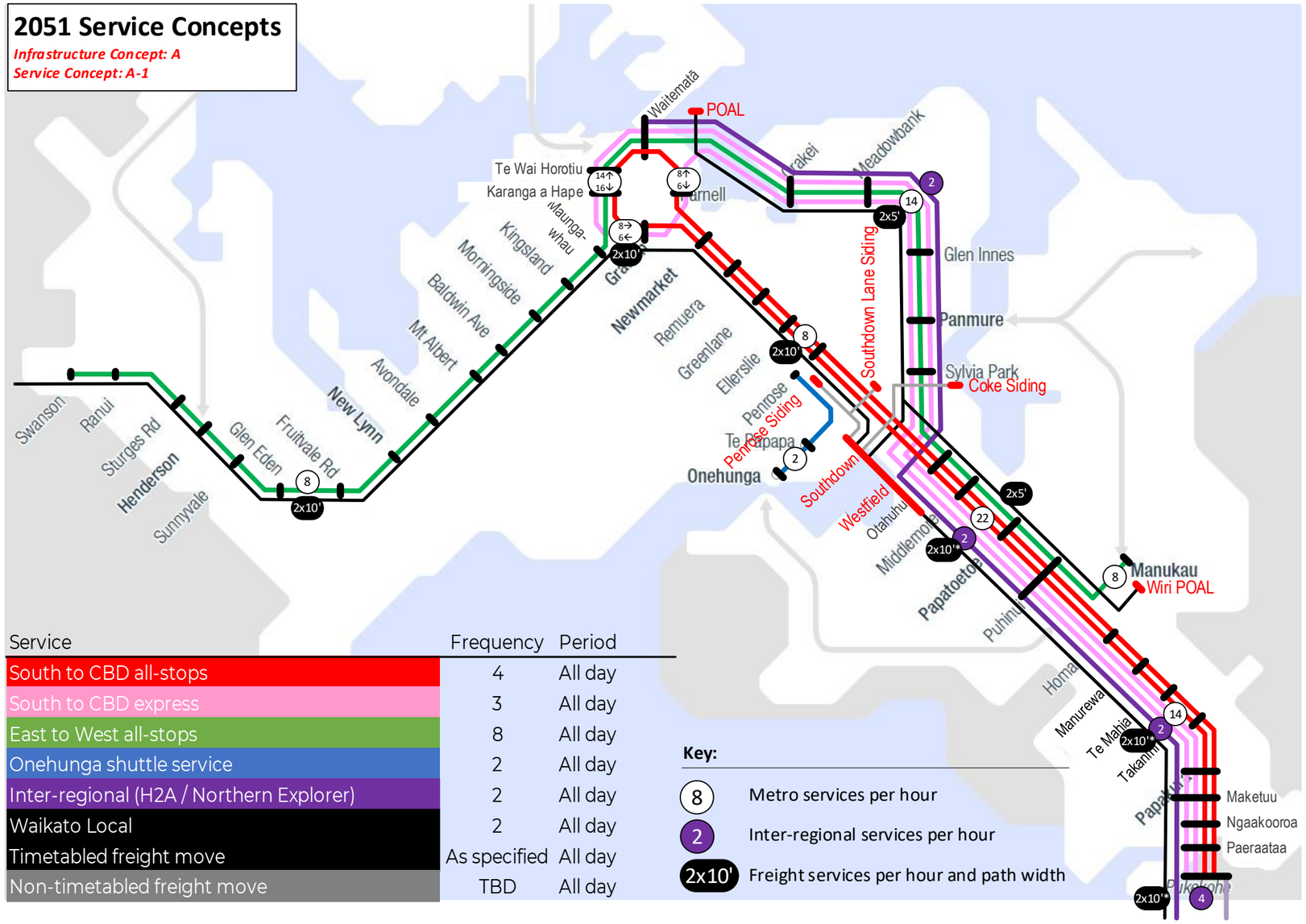
Figure 6-3: Clockface representation of the network timetable

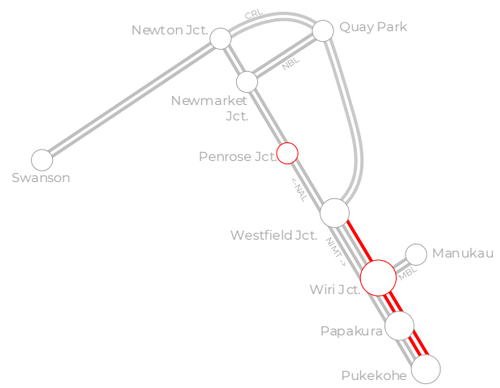
The development of timetables allowed for a greater understanding of various aspects of the three short listed options to inform their assessment under the MCA framework, including:

- Assessment of whether grade separation of junctions is required to eliminate crossing conflicts
- Quantification of junction buffer required to synchronise movements through junctions (and how much buffer can be saved from eliminating conflicts), providing a more accurate assessment of travel time benefits of each option
- Validation of what headway patterns can be achieved
- Refinement of infrastructure requirements at key junctions / terminals
- Assessment of the quality of freight paths and the impacts these have on the passenger timetable
- Refinement of routing concepts

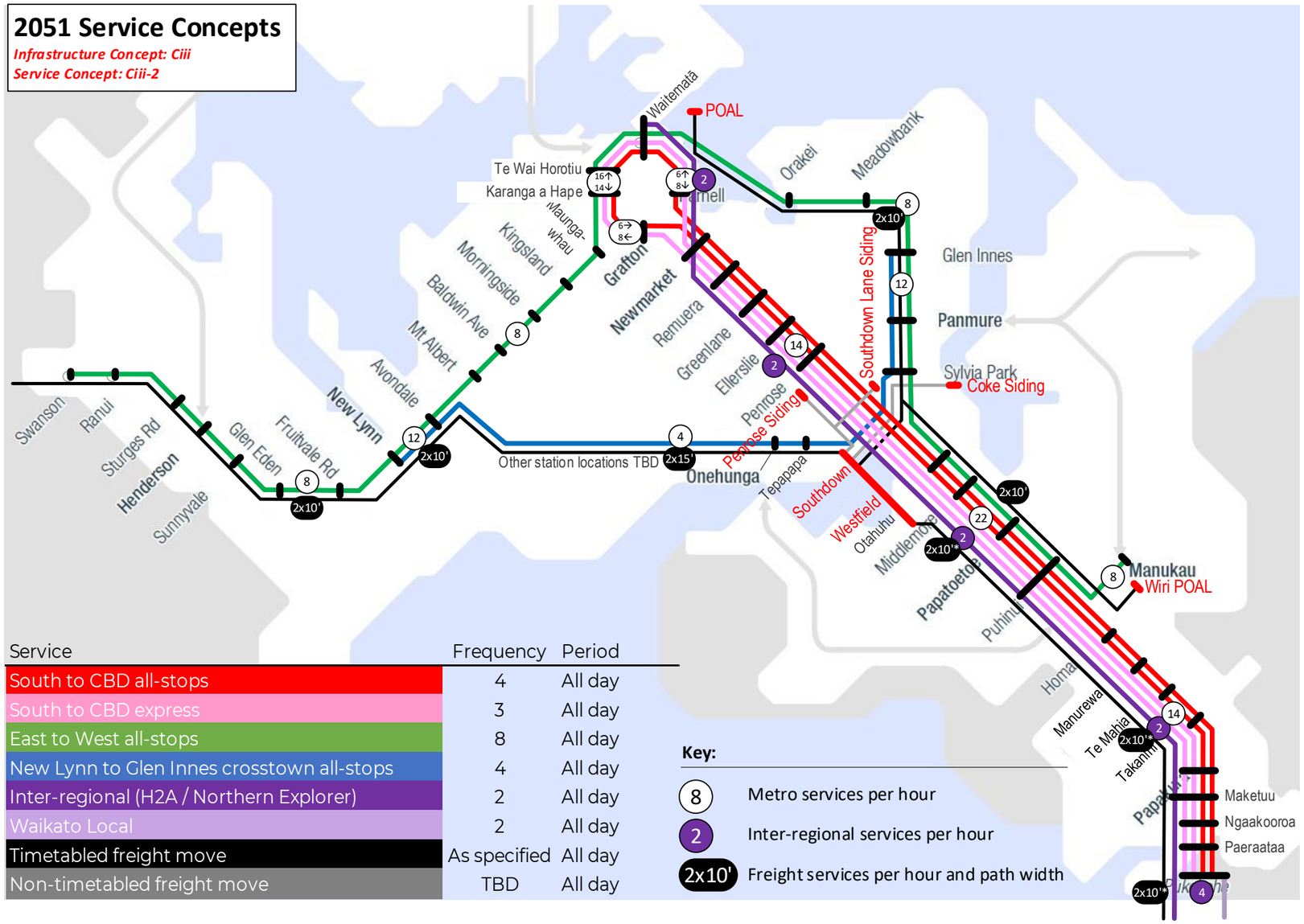
Table 6-1: Service concept key features across the short list

Options	Key Features
Option Ai	Routing of Express and H2A • Via NIMT E due to lack of available capacity on NAL S • Express and H2A trains need to alternate directions around the CBD in order to protect freight path from Newton to Newmarket i.e. 2 of 6 trains access the CRL via a clockwise move through Parnell and Grafton. • On further inspection, this routing is assessed to be very likely infeasible without additional infrastructure intervention at Westfield and Quay Park • See Section 6.3.2.1 for further detail Port shunt path • Only 5min paths can provided on NIMT E, due to presence of express trains • See Section 6.3.2.1 for further detail Metro headways • 10min NAL freight path, and the Wiri to Westfield 4-track configuration, triggers uneven headways of 5/10min splits, on all lines • See Section 6.3.2.1 and Section 6.3.2.3 for further detail Macro Infrastructure Summary



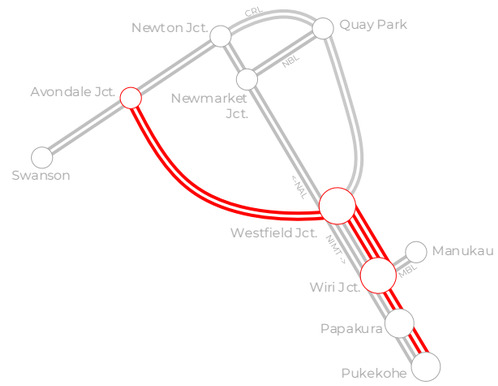


Options	Key Features
Option Ciii	Routing of Express and H2A • Separation of freight onto Avondale - Southdown allows express and H2A services to be routed on the faster NAL-S route • H2A serves Newmarket enroute to Waitemata • See Section 6.3.2.1 for further detail Port shunt path • 10min can be provided along entire route Metro headways • 10min NAL freight path triggers uneven on East-west line, however… • Based on early timetable concept development, even headway can be protected on southern line due to the 6-tracking configuration between Wiri and Westfield. See Section 6.3.2.3 for further detail • Avondale-Southdown service is even headway if 4tph, else uneven. See Section 0 for further detail

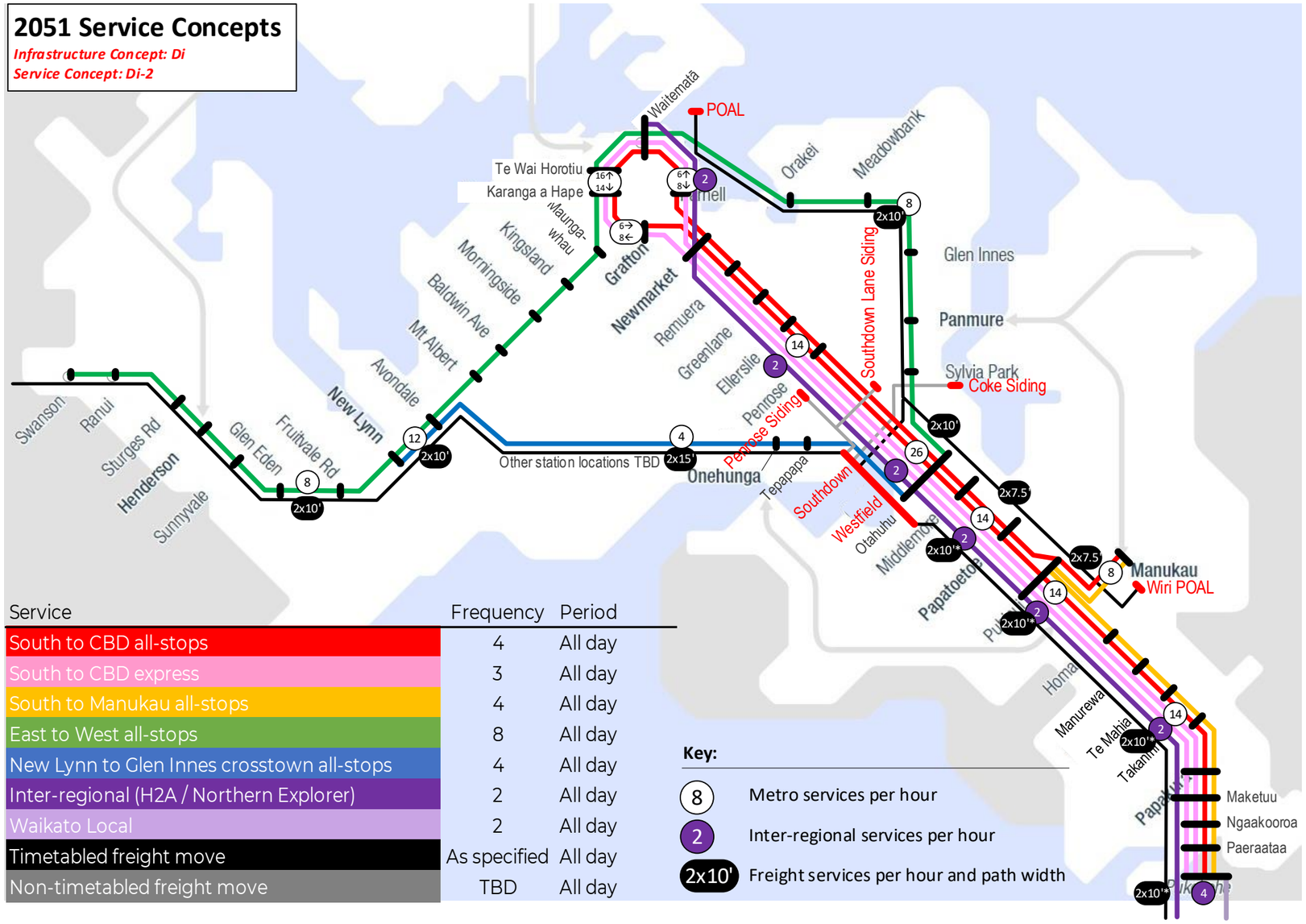


Service	Frequency	Period
South to CBD all-stops	4	All day
South to CBD express	3	All day
East to West all-stops	8	All day
New Lynn to Glen Innes crosstown all-stops	4	All day
Inter-regional (H2A / Northern Explorer)	2	All day
Waikato Local	2	All day
Timetabled freight move	As specified	All day
Non-timetabled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

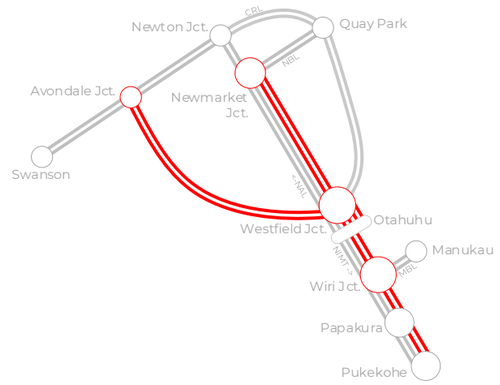
Infrastructure Summary



Options	Key Features
Option Di	Routing of Express and H2A • Separation of freight onto Avondale - Southdown allows express and H2A services to be routed on the faster NAL-S route. 4 tracking on NAL-S allows skipping additional stations. • H2A serves Newmarket en route to Britomart. • See Section 6.3.2.1 for further detail Port shunt path • 10min can be provided along NIMT-E but only 7.5' between Wiri and Westfield (unless south line forced to uneven headway).. See Section 6.3.2.3 for further detail Metro headways • 10min NAL freight path triggers uneven on East-west line, however... • Based on early timetable concept development, even headway can be protected on southern line • Avondale-Southdown service is even headway if 4tph, else uneven.



Infrastructure Summary



6.3.2.1 CAPACITY OF THE INNER SOUTHERN CORRIDOR

The timetable analysis of Ai indicated that it would be impossible to provide all day freight paths on the NAL while running all day express services on the southern line, due to a lack of capacity on the inner southern corridor (between Westfield and Newmarket). This led to the decision to route express services on the eastern corridor, which was assumed to have more capacity given the tighter headway requirement for POAL freight.

However, on further analysis, significant issues were found at junctions under this routing concept. With routing of 6 metro express services + 2 Inter Regional services on the NIMT, Quay Park junction becomes a significant challenge from a timetabling perspective as there are a total of five crossing conflicts between pink, red, and green services, all of which need to be separated in time, while maintaining the appropriate structure to merge within the CRL and scheduling similar crossing and merging conflicts at Newmarket.

The analysis concluded that a timetable based on the Ai infrastructure concept would likely be infeasible without compromising on the following service objectives;

- Running all day express services,
- Running all day freight paths

Another conclusion of the timetable analysis on Ai, irrespective of the issue above, was that an even headway operation would not be possible on the Southern Line since the service pattern would need to accommodate a 10min path on the two tracked inner southern corridor, and this would need to operate a 5/10min headway split.

Both of these issues were found to be resolved with the inclusion of the Avondale – Southdown corridor in the timetable analysis of option Ciii, thus the benefit of Avondale – Southdown was able to more precisely defined as:

1. Allowing for all-day freight access on the NAL, providing improved capacity (required to support growth scenarios on this corridor e.g. closure of Auckland Port), and optimal timetabling.
2. Allowing for all day express services on the southern line, providing car competitive journey times and meeting the 45min journey time target for more stations
3. Allowing for an all-day even headway operation on the southern line

All these benefits then have flow on impacts to the improvement of rail attractiveness and potential to impact emissions reduction.

Option Di has similar benefits to Ciii however the configuration of Wiri to Westfield imposes additional constraints as discussed below.

6.3.2.2 EXPRESS BENFIITS OF CIII VS DI

The initial concept for express and local services was to share the eastern pair of mains between Pukekohe and Papakura, split to the western mains north of Papakura, and then merge back with local services, as well as inter regional services, north of Otahuhu/Westfield. This is shown visually in Figure 6-4

Local services on the eastern mains operate on an even 7.5' headway, so in order for the metro express services merge with this pattern the express service must save a multiple of 7.5min by skipping stations (or something close to this).

Based on simulations ; the potential travel time savings of skipping stops for options Ciii and Di are are 0:08:02 for Ciii and 0:10:49 for Di. This implies that the Ciii option is feasible, but there may actually be no benefit to the express under Di unless a further 4min travel time can be achieved from curve easing etc. which under further analysis of the speed profile, is very unlikely to be possible.

To achieve any travel time benefit therefore, Di needs to take a difference concept of operations between Pukekohe to Papakura – with local and express services separated completely all the way to the Pukekohe terminal or potentially further south to turn back in dedicated platforms, adding to the infrastructure cost and complexity of the option. However, even under this scenario – the total potential runtime saving over Ciii is less than 3 minutes according to the raw simulation results.

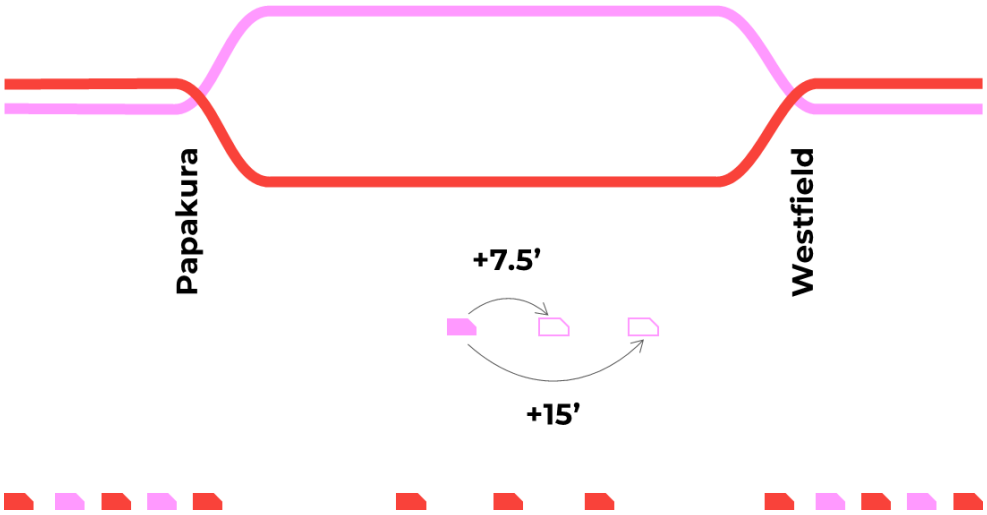


Figure 6-4: Skip stop timetable concept

6.3.2.3 WIRI TO WESTFIELD OPERATION AND BENEFITS OF 6-TRACKING

The Wiri to Westfield segment of the network became a central theme in discussions and assessment in this phase of optioneering. This relatively short 7km stretch of rail corridor sees the highest volumes of traffic in the entire New Zealand rail network, contains the largest freight yard and industrial rail hub in Auckland, an inland port, four busy stations including two major hubs / shoulder stations in Otahuhu and Puhinui and a station accessing the hospital, two complex 'flat' junctions, and the main EMU depot. With the current network bottleneck of the Britomart stub end terminate removed by the CRL, Wiri to Westfield will very likely become the next bottleneck. This section outlines key observations obtained from the timetable analysis of the three options for this segment of the network.

6.3.2.3.1 JUNCTION BUFFERS

The timetabling analysis allowed for the estimate of buffers that need to be incorporated into the timetable to coordinate movements through junctions. In option Ai there are four 'flat' junctions on the network; Wiri, Westfield, Newmarket and Quay Park, while in Options Ciii the junctions at Wiri and Westfield are effectively eliminated as a constraint in the timetable by separating traffic across an additional pair of mains. Table 6-2 below quantifies the junction buffers required in concept Ai vs. Ciii, which points to a significant travel time saving that can be achieved by the 6-tracking project for all services on the Eastern and Western lines. For example, a potential 7.5 min

travel time reduction is expected to be possible on the Eastern Line. It is important to note that this analysis is not based on a detailed timetable confirmed through simulation - this would be required at future business cases – and the results should be treated as indicative. However the overall amount of buffer in Ai is considered to be a reasonable estimate, and consistent with the latest CRL Day one timetable. Further, the total amount of buffer that can be removed via the 6-maining project is also considered a reasonable estimate, though the assignment of buffer between the service groups could vary quite significantly depending on further timetable optimization and testing.

Timetable analysis was ultimately not completed for the Di option due to complexities with the Wiri to Westfield segment that will be described in the following section. Based on the assumed infrastructure it appears that although the red and the green lines are physically separated between Westfield and Wiri, similar or even potentially more restrictive constraints will be imposed at the junctions under this option. It was therefore considered likely that the Di timetable would have similar level of junction buffer to the Ai timetable.

Table 6-2: Junction buffer analysis for options Ai and Ciii

LINE	DIR	TOTAL BUFFER AI / DI	TOTAL BUFFER CIII	DELTA
Red (Southern Line)	Up	5.5	2.5	3min
Red (Southern Line)	Down	6.0	3.5	2.5min
Green (Western Line)	Up	2.5	2.5	0min
Green (Western Line)	Down	0.0	0.0	0min
Green (Eastern Line)	Up	7.5	0.0	7.5min
Green (Eastern Line)	Down	4.5	0.0	4.5min
Pink (Southern Express)	Up	-2.75	-7.5	4.75min
Pink (Southern Express)	Down	-3.25	-6.0	2.75min

6.3.2.3.2 DI JUNCTION COMPLEXITY

Detailed analysis of the Di option revealed that whereas the provisional short list assessment had assumed no infrastructure requirements at Puhinui, in fact significant track configuration modifications would be required to support the turnback operation envisioned for the South to Manukau service. As shown in Figure 6-5, the section of track between Wiri junction and Puhinui would have 16 metro services per direction, plus a minimum of two 7.5 minute freight paths for the port trains to Wiri, on the eastern mains alone. It was realized that without 6 mains over this segment of track (similar to the assumption at the Otahuhu end) and a 7th track at the station to accommodate the turnback movement, it would not be possible to accommodate all train moves under this concept with the requisite level of reliability.

An alternative option of a direct connection between the Manukau Branch Line and the NIMT from the south was ruled out for two main reasons.

1. it would reduce the number of direct train trips to Puhinui by 4tph over the day, which was considered to be a poor compromise given the importance of this connection to the Airport and buses to South Auckland
2. The physical construction of the wye junction was expected to impinge upon the Wiri terminal and be significantly complicated by the presence of the southern motorway.

Figure 6-5: High train volumes between Puhinui and Wiri on the eastern mains

6.3.2.3.3 FREIGHT PATHS

A further output of the timetable analysis was the assessment of freight path widths provided by each option. Table 6-3 below focuses on Port movements as applicable to the Wiri to Westfield section. The minimum path width requirement at this stage of analysis was taken to be 7.5min between metro trains, though note that this does not apply to crossing conflicts through junctions where tighter headway gaps can be accepted.

The primary conclusions of this analysis were:

- Ai does not meet the freight path requirement between Wiri and Westfield even with an uneven headway on both the East-west and Southern lines. Accommodating the required POAL traffic under this option would require compromises to both the RTN aspiration of metro (on either the East-West line or Southern Line) and the all-day access aspiration of freight for port movements.
- Ciii meets requirements with a 10min provided for port movements.

- Di would require additional infrastructure to meet the required path requirements (6-tracking between Puhinui and Wiri) but even then significant expected operational complexity may create reliability issues for freight access between Wiri and POAL

Table 6-3: Freight path assesment between Wiri and Westfield

OPTION	PATH	PATH ASSESMENT
Ai	POAL – WIRI	7.5' on the Eastern Line with a 5' path between Wiri and Westfield. A 5' path between W2W presents significant reliability risk under RTN frequency
	POAL – Southdown	7.5'. Grade separated through Westfield
Ciii	POAL – WIRI	10' throughout with a 7' gap through Wiri junction (it would be possible to achieve a larger gap through Wiri with additional buffer on the green line if required).
	POAL – Southdown	10' throughout. Grade separated through Westfield
Di	POAL – WIRI	An acceptable solution could not be found to accommodate freight paths and metro paths between Puhinui and Wiri due to the complexity noted in Section 0 above. Additional infrastructure (6-tracking between Puhinui and Wiri) should resolve this issue but significant expected operational complexity may create reliability issues for freight..
	POAL – Southdown	Same as Ciii. 10' throughout. Grade separated through Westfield

6.3.2.3.4 UNEVEN HEADWAYS

Analysis also determined that the structure of the timetable required to accommodate the South to Manukau service under Option Di would necessarily result in an uneven headway on the Southern Line Thus all options except for Ciii would have an uneven headway on all lines, while Ciii would only have an uneven headways on the East-west line.

6.3.2.4 AVONDALE-SOUTHDOWN PASSENGER SERVICE

In the development of the service concepts, decisions were needed about the configuration of the Avondale – Southdown crosstown metro service, particularly with respect to where it should terminate at each end. On the eastern end of the line, two main options were identified:

1) Terminate at Otahuhu, to enable connectivity to the southern line
2) Terminate at Glen Innes[14] to enable connectivity to centers along the Eastern Line

[14] The clear preference for a terminal on the Eastern Line is Panmure (given high demand at this station and connectivity to the Eastern Busway), but Glen Innes was selected on the basis that this routing would still

Both options have significant pros and cons and it was not immediately clear which to prefer over the other. It was therefore pragmatically decided to include one routing in each of the two options containing the A-S corridor, Ciii containing the Glen Innes terminal and Di containing the Otahuhu terminal. Both options are further assessed in the MCA section.

On the western end, it was agreed to terminate at New Lynn given that this station has the highest ridership on the Western Line and is a transit hub connecting to bus services in West Auckland. Given that New Lynn is in a trench and it would be costly to add the required platforms to facilitate a turnback operation at this location, it was assumed that a rear platform turnback could be provided west of the station.

A further opportunity flagged to be explored in later business case phases, was the idea that the Avondale – Southdown metro services could continue north towards the Unitech campus at Mt Albert rather than merging with the Western Line, potentially with a transfer station constructed at Mt Albert. Connections would still need to be provided to the NAL to accommodate freight to Northland.

6.3.2.5 PASSENGER TIMETABLE COMPLEXITY

A potential issue raised with the Di service concept in early workshops was the complexity introduced to the passenger timetable introduced by terminating the east west line at Otahuhu rather than extending it through to Manukau. A high-level analysis was undertaken that indicating for many key journeys this would be the case. This is summarised in Table 6-4 below. While this does not provide an exhaustive analysis of all journeys, it is illustrative of the general disbenefits of the Di timetable concept compared to Ciii from a passenger perspective, leading to a less attractive rail service offering with lower potential to attract mode shift.

Table 6-4: Complxity analysis of timetable concepts

EXAMPLE JOURNEY	CIII (SIMILAR TO AI)	DI
Aotea to Pukekohe	Direct: 8tph Pukekohe via Newmarket 6tph Pukekohe via Newmarket, Limited Stops	Direct: 4tph Pukekohe via Newmarket 6tph Pukekohe via Newmarket, Limited Stops
Aotea to Manukau	Direct: 8tph Manukau via Panmure (Note: similar indirect options also available)	Direct: 4tph Manukau via Newmarket Indirect: Take a Pukekohe bound service to Puhinui (4tph red + 6tph pink) Transfer to a Manukau bound service (4tph red + 4tph yellow)

allow Panmure to be served, while avoiding the more complex track upgrades that would required at Panmure station which is in a trench, compared to Glen Innes which is less constrained.

Panmure to Mankau	Direct: 8tph Manukau via Panmure	Indirect: Take any Otahuhu bound service to Puhinui (8tph green) Transfer to a Manukau bound service (4tph red) - OR - Transfer to a Pukekohe bound service (4tph red + 6tph pink) to Puhinui Transfer to a Manukau bound service (4tph red + 4tph yellow)
Pukekohe to Manukau	Indirect: Take an Aotea bound service to Puhinui (8tph red + 6tph pink) Transfer to a Manukau bound service (8tph green)	Direct: 4tph Manukau via Puhinui (yellow) Indirect: Take an Aotea bound service to Puhinui (4tph red + 6tph pink) Transfer to a Manukau bound service (4tph red)

6.3.3 *PASSENGER DEMAND ANALYSIS*

Service concepts for each of the three short listed options along with their estimated travel times based on OpenTrack simulations and the timetable assessment described in Section 6.3.2, where modelled in MSM to assess demand performance. Key outputs and observations from this analysis are presented below.

6.3.3.1 OVERALL PATRONAGE AND MODE SHIFT

A summary of overall demand is presented in Table 6-5 below.

Table 6-5: Overall summary of demand modelling on the short list

Scenario Description	Annual weekday boardings	Delta %	Total 2-hr Demand			Delta %		
			AM	IP	PM	AM	IP	PM
DM			47,594	19,566	39,680			
Ai	59.4M	9%	55,964	23,799	46,982	18%	22%	18%
Ciii	63.9M	18%	59,281	25,292	49,902	25%	29%	26%
Di	64.9M	20%	58,714	24,960	49,257	23%	28%	24%

This analysis appears to show Di as the overall best performer in increasing the attractiveness of passenger rail with a 20% uplift in annual weekday boardings over the do minimum. However this number is misleading because it counts each transfer as a boarding which inflates the number for Di option since, as described in Section 6.3.2.5, this option requires transfers for a higher number of

trips than Ciii. **When comparing the 2-hour demand data, it can be seen that the Ciii option outperforms Di** with an uplift in demand of approximately 25% in peak periods, and close to 30% in the inter peak.

The data also shows a significant improvement in demand between Ai and Ciii/Di. This is largely due to travel time improvements and the addition of Avondale – Southdown. It is important to note that, as modelled, all options provide sufficient capacity to accommodate demands. However, based on the subsequent detailed timetable analysis described above, it is very likely that the modelled Ai service concept would not be feasible without compromises, and therefore the demands estimated for this option are likely over estimated. Furthermore modelling of Di assumed the same reduction in junction buffers as Ciii but the subsequent timetable analysis presented in Section 0 indicated that this would not likely be achievable, therefore the demand for Di is also likely overstated.

A summary of PT mode share and model split is presented in Table 6 6.

Table 6-6: PT mode share and mode split statistics

	DM	Ai	Ciii	Di
% of Person Trips by Mode - AM 2hr				
Car	66.3%	65.8%	65.7%	65.6%
Public Transport	14.6%	15.1%	15.2%	15.2%
Active	19.1%	19.2%	19.2%	19.2%
% Proportion PT Modal Split				
Bus	58.4%	55.4%	54.5%	54.4%
Heavy Rail	17.1%	21.3%	22.6%	22.9%
Light Rail	22.9%	21.7%	21.4%	21.2%
Ferry	1.7%	1.6%	1.6%	1.6%

This shows that even with this scale of demand uplift predicted for the options (18-30%), overall PT mode share is expected to improve by around 1% increase, leading to a total PT share of around 15% by 2051. This suggests that a wider programme of investments and policies will be needed to generate the levels of mode shift required to support emission reduction targets. However, it is critical that the future rail network be able to accommodate this mode shift under such a setting. This topic is explored as a scenario in the Part 2 Options Development Report

6.3.3.2 DI VS CIII AND THE SOUTH TO MANUKAU SERVICE AND

From a demand perspective, modelling shows a clear preference for the 6-track W2W configuration of Ciii:

The Manukau turnback service required in Di to serve stations south of Puhinui with 8tph, has very low utilization, indicating that there is little justification for this service. This also results in over utilization of the red line services starting at Pukekohe, with standing occurring at around Homai inbound to the CBD, failing the 15min standing requirement. This is illustrated in Figure 6-6 and Figure 6-7 comparing the line load profiles of each option. Under Di, the all-stops CBD bound trains (red) are at 117% seating capacity at Homai while the Manukau trains are only at 25%.

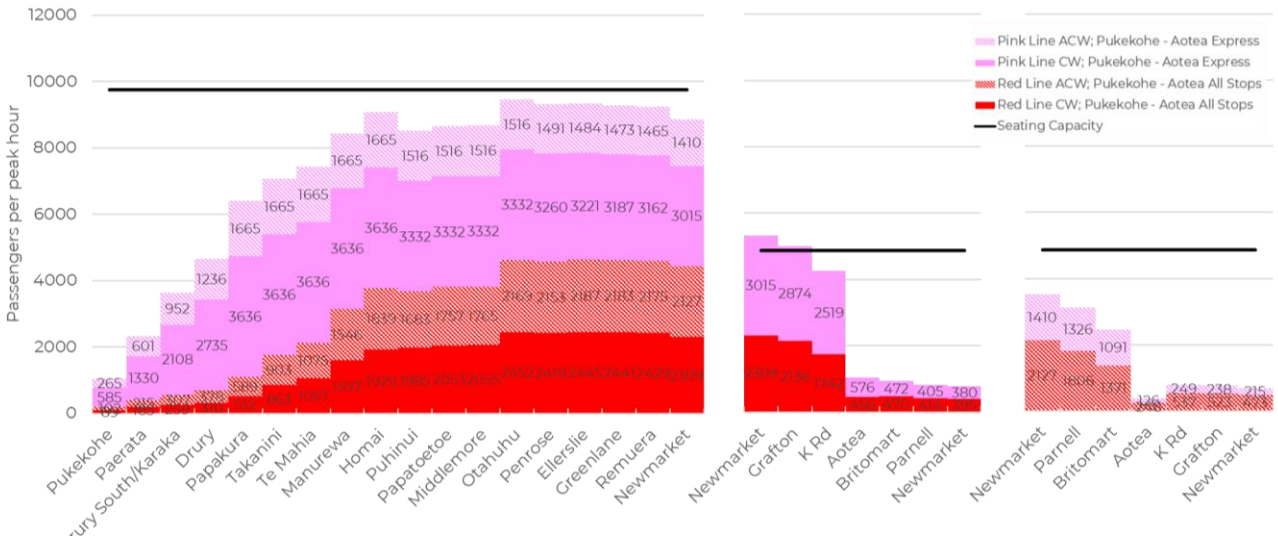


Figure 6-6: Ciii southern line line load profile

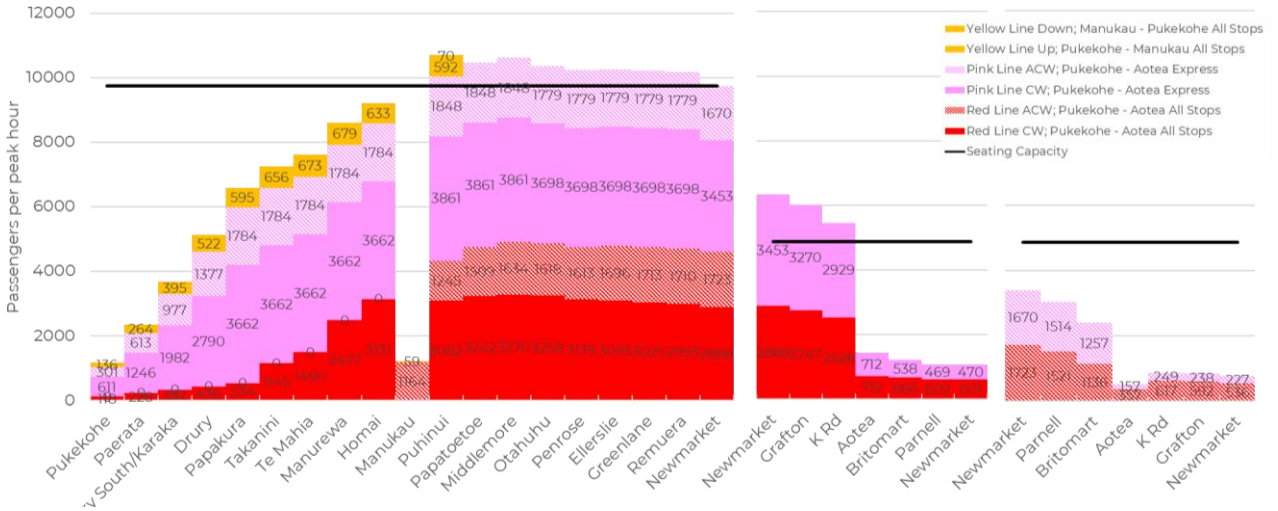


Figure 6-7: Di southern line line load profile

With respect to the general service structures of the Ciii and Di options, Table 6-5 shows that the overall AM peak demand for Ciii is approximately 2% higher than Di even though Di has faster express services from the south (which should generate more demand)[15]. It is therefore assumed that the majority of the demand dropped between Ciii and Di is due to the restructuring of the green and red lines.

This is also reflected in an ~8% reduction in total boardings over the stations no longer served by the green line as shown in Figure 6-8; from (5,448 to 5,023)

[15] The two different routings of A-S are also very similar between to two options from a demand perspective

Ciii

	CBD	CBD Fringe	East	South	West	Total
Puhinui	700	178	52	372	27	**1330**
Manukau	1427	94	274	217	182	**2194**
Papatoetoe	647	154	100	287	48	**1236**
Middlemore	362	74	60	160	31	**688**
						5448

Di

	CBD	CBD Fringe	East	South	West	Total
Puhinui	869	143	32	300	51	**1396**
Manukau	1217	251	42	388	77	**1977**
Papatoetoe	567	128	32	255	32	**1014**
Middlemore	354	69	27	161	25	**637**
						5023

Figure 6-8: Demand comparison between Ciii and Di for W2W stations

6.3.3.3 AVONDALE SOUTHDOWN ROUTING OPTIONS

MSM outputs allowed for a comparison of the two routings tested for the A-S crosstown service; terminating at Glen Innes in Ciii and Otahuhu in Di. Modelling showed minor difference in ridership between the two routings, with the GI route having slightly more boardings in the peak AM period: Glen Innes: 4,921 vs. Otahuhu 4,583 (2-hr boardings)

Among both options, Otahuhu had the highest patronage, with 1760 boardings up and 1342 alighting's down. Panmure had the second highest patronage with 1,141 boardings up, and 848 alighting's down, however, the Glen Innes routing captures 2 additional stations compared with the Otahuhu routing, which likely explains the overall difference.

Though the service concepts for both Ciii and Di only call for 4 trains per hour on Avondale – Southdown, the service was modelled at 8tph to get a unconstrained picture of the potential demand for this corridor. The results show that a 4tph service would be more than sufficient to meet demand as illustrated in Figure 6-9 below for the Ciii option (horizontal lines represent seating capacity). It should be noted that the value of the Avondale – Southdown corridor is likely not to be typical peak commuter trips, but rather improving the overall flexibility and connectivity of the network for off peak and non-commuter trips.

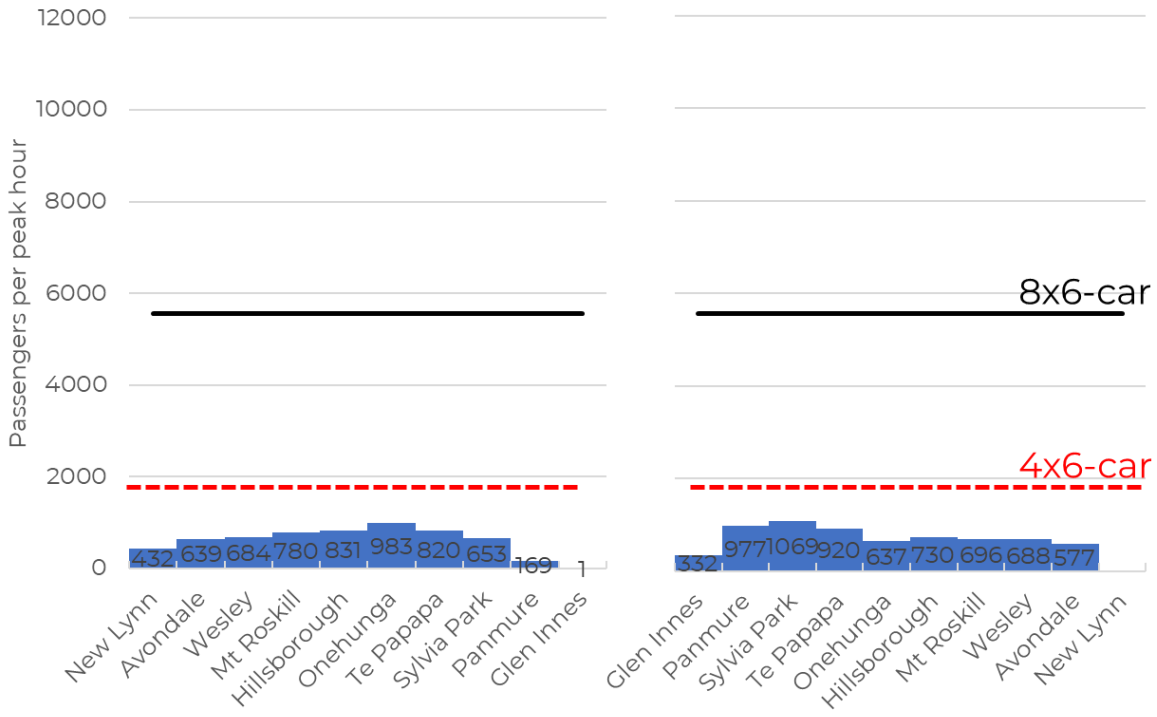


Figure 6-9: Avondale - Southdown ridership

6.3.3.4 DEMAND FOR EXPRESS SERVICES

Modelling shows a demand uplift associated with the ~3min runtime improvement between Di and Ciii of around 6% in the peak.

This results needs to be traded off against the significant cost of 4-tracking of the NAL that is required to achieve this (as will be discussed in subsequent sections), and tempered by the fact that this 3min travel time improvement would only be achievable under an operating concept that allowed trains to turn back on the western mains which would like drive additional infrastructure requirement at Pukekohe or further south (as discussed in Section 6.3.2.2). Thus the improvement to rail attractiveness is likely to be out of proportion to the critical success factor of capital cost.

Furthermore, as indicated in Section 0, timetable analysis indicates that option Ciii is able to eliminate between 3.5-7.5min of timetable buffer compared to Di and Ai, by removing conflicts at Wiri and Westfield. So Ciii may ultimately generate more demand than Di despite Di's potential runtime advantage for express services.

Modelling also showed that for both options Ciii and Di, the 15min standing target is not met for express services, with standing occurring between Papakura and the CBD (around 35min journey time). Ciii has total capacity to support all demand without standing – standing is a result of a preference for the express service from southern stations. In reality, passengers will have a choice between less crowding and faster travel times.

6.3.4 INFRASTRUCTURE ASSESMENT

Conceptual design was carried out in critical areas of the network to assess the feasibility / achievability of the options. This analysis focused around the Wiri to Westfield section in particular and the implications of a 6-track corridor.

The main conclusions from the analysis were:

- Under all options, the Wiri and Westfield ends of the corridor segment were likely to require significant land take with little differentiation between Ciii and Di in particular. It was assessed that 6-7 tracks would likely be required between Wiri and Puhinui and 7-8 tracks (including yard roads) between Otahuhu and Westfield) in both options.
- The delta in property requirements between Ciii and the other two options for the remainder of the corridor between these segments, was not deemed to be significant (with the exception of Middlemore) given that principals established in the PBC to provide sufficient corridor width to enable efficient maintenance access, meant some land take would likely be required under all options.
- At Middlemore, while the solution is likely to be complex, it was not deemed to be infeasible with an initial indication that expanding to the west rather than the east would be the preferred approach. The potential for additional land to contribute to a combined development with the Hospital including noise & vibration mitigation (ie. layout additional carparks as buffer between rail and hospital facilities) and improved station access including to planned Kainga Ora development was also raised as an opportunity, which would support the investment objectives of contributing to a denser urban form.

6.3.5 COSTING

Indicative cost estimates for the three short listed options were further refined for the short list assessment. The incremental costs of each differentiating option element with respect to Ai, along with the total of each option is presented in Table 6-7.

Table 6-7: Incremental cost analysis on short list (numbers in $M)

OPTION	Ai		Ciii		Di	
Range	llower	upper	llower	upper	llower	upper
4T Westfield Jcn - New Market (2T)					3,030	4,770
6T Otahuhu - Westfield Jcn (2T)					580	900
6T Wiri Jcn - Westfield Jcn (2T)			2,520	3,950		
4T Swanson - Avondale (2T)						
2T Avondale - Southdown			4,150	6,220	4,150	6,220
Differentiating items	-	-	6,670	10,200	7,760	11,900
Total Option Cost	**17,500**	**24,800**	**24,500**	**35,600**	**25,600**	**37,300**

6.3.6 PRELIMINARY PHASING

A preliminary phasing was developed as part of the Short List assessment, primarily for the purpose of calculating cashflow and benefits over the 30-year period as an input to the economic assessment.

Initial phasing was developed in line with the overall philosophy presented in Figure 6-10.

Decade 1 focuses on improving the overall resiliency of the network and making best use of existing assets through implementation of more advanced signalling and traffic management systems, and improvements in maintenance practices, plant and equipment, while also starting work on civil elements including level crossing removals and corridor sanitation, in preparation for track capacity expansion in the second decade.

- Decade 2: Builds upon the resiliency established in the first decade and increases capacity of the system through platform extensions to support longer train sets and the addition of 3rd and 4th mains between Pukekohe and Westfield to accommodate the significant growth in passenger and freight demand.
- Decade 3: Introduces additional major infrastructure elements to further enhance service quality and reliability and accelerate mode shift. Avondale-Southdown opens up high-capacity freight access to Northport, and improvement the catchment and connectivity to the metro network, while 6-maining of Wiri to Westfield see major service quality improvements for all network users and increases the quality of access to the Port for freight.

Figure 6-10: Phasing philsophy

Phasing of the 30-year plan is further developed in the Options Report Part 2.

6.3.7 INDICATIVE ECCONOMIC ANALYSIS

To complete the process of selection, an Indicative Benefit Cost Ratio approach was set up in advance of the MCA workshop to help differentiate between options with similar MCA scores. This indicative approach, being focused on differentiation, did not include all the non-differentiating elements of cost (e.g., opex) and was based on non-optimised programmes and simplified Do-Minimum models (incl. costs). **The indicative benefits and costs information provided in Table 6-8 below are not to be taken as an indication of the Benefit Cost Ratio to be expected from the Preferred Programme, but simply understood as a selection support tool.** Further discussion on this is provided in the Economic Case Section 2.4.4.

Table 6-8: Short list BCR

	Option Ai		Option Ciii		Option Di	
Benefits (PV, 2021$)						
Metro passenger benefits						
PT user benefits	$2,118		$2,650		$2,586	
Fare revenue	$565		$680		$676	
Road user benefits	$544		$671		$678	
Crash cost reductions	$32		$39		$39	
CO2 emission reductions	$19		$21		$22	
Air quality emission reductions	$3		$4		$4	
Health benefits (walking)	$148		$196		$183	
Second round impacts	$820		$902		$895	
Total (excl. WEBs)	**$4,249**		**$5,163**		**$5,083**	
WEBs	$1,230		$1,353		$1,342	
Total (incl. WEBs)	**$5,479**		**$6,516**		**$6,425**	
Freight benefits						
CO2 emission reductions	$77		$77		$77	
Fuel cost reductions	$827		$827		$827	
Net maintenance cost savings	$1,448		$1,448		$1,448	
Congestion avoided - urban and rur	$1,784		$1,784		$1,784	
Crash cost reductions	$156		$156		$156	
Air quality emission reductions	$565		$565		$565	
Total	**$4,857**		**$4,857**		**$4,857**	
Total benefits (excl. WEBs)	**$9,106**		**$10,020**		**$9,940**	
Total benefits (incl. WEBs)	**$10,336**		**$11,373**		**$11,282**	
Costs						
Capital cost estimates	Lower	Upper	Lower	Upper	Lower	Upper
Total (undiscounted, 2023$)	$17,472	$24,823	$24,537	$35,578	$25,622	$37,283
Economic costs (PV, 2021$)	**$9,800**	**$13,930**	**$13,480**	**$19,550**	**$13,880**	**$20,190**
Indicative BCR						
	Lower	Upper	Lower	Upper	Lower	Upper
IBCR	0.74	1.05	0.58	0.84	0.56	0.81
(used for differentiation purposes only)						

6.4 OUTPUT AND OUTCOMES

The three shortlist options were assessed via a workshop held on 13th October 2022 with technical specialists and stakeholders from Auckland Transport, KiwiRail and WSP.

A final Multi-Criteria Analysis (MCA) was undertaken to compare all shortlist options against each other based on the same framework used throughout the optioneering process. As with previous phases, detailed scoring of the conditional outputs was undertaken separately for each geographical area, with the same division of the network.

Prior to the workshop, specialists from Auckland Transport, KiwiRail and WSP were briefed on what each of the shortlist options were, a summary of the analysis that had been undertaken on them (as described in the previous section) and provided with a prepopulated MCA including

commentary and preliminary scoring. During the workshop, these scores and commentary were discussed and challenged by all stakeholders. This scoring excluded the Te Ao Māori impacts, however subsequent huis were conducted in October and November to get input into the programme selection.

In this section, summarized MCA scoring is provided alongside commentary on major differentiating factors in a single table. This information is presented in Section 6.4.1, while Section 6.4.2 outlines the logic by which the final preferred 2051 end state was selected based on the body of evidence presented.

6.4.1 MCA SUMMARY

Table 6-9 provides a summary of the scoring of the MCA, with **the full Short List MCA provided in Appendix I**. Each line item in Table 6-9 corresponds to one or more rows of the MCA. Where aggregating scores over multiple criteria, the average is taken. The key insights from the MCA workshop and follow up analysis were as outlined below.

Table 6-9: Shortlist MCA Summary

OPTIONS	AI	CIII	DI	DIFFERENTIATING COMENTARY
Investment Objectives				
IO 1: Continually increase the use of rail in Auckland (all markets) over the next 30 years, by increasing its attractiveness (eg reliability, frequency, capacity and travel times)	2	3	2	Option Ciii was preferred from a passenger attractiveness perspective as having even headways across all lines (not the case for Options Ai and Di which require uneven headways on the Southern Line), all day express services on the Southern line (which is not possible in Option Ai), and a more convenient service structure than Di. Both options Ciii and Di were estimated to generate an additional 1% mode shift to public transport and 8% increase in rail mode share as compared to Option Ai. From a freight perspective, both options Ciii and Di have additional flexibility for timetabling freight services, especially for NAL that is constrained to off peak periods in Ai, and POAL which does not protect for sufficient path widths between Wiri and Westfield. From a network reliability perspective, differentiation centred around Wiri to Westfield. Ai did not achieve the 75% capacity utilisation target with a value of 83% with expected reliability issues due to interlining of the south and east-west lines. Option Di was seen as having a critical constraint around Wiri junction that would compromise the network reliability. By contrast Ciii was seen as achieving a high level of reliability in this area.
IO 2: Reduce Auckland's net transport emissions by increasing rail's share of Auckland's transport task over the next 30 years	2	2	2	Options were not significantly differentiated by their CO2 emissions reduction potential with all options deemed to generate similar levels of reduction. It should be noted that the performance of options was expected to differ significantly under scenarios outside of base demand e.g. a Port Move scenario or an strong policy setting to drive PT mode shift. Under such scenarios Option Ai would be expected perform significantly worse than Cii and Di. • Total AKL road CO2 (2051): 1.5m T • Reduction in AKL road CO2 (2051): 6,700 T (-0.4%) under Ai and 8,000 T (-0.5%) under Ciii and Di Freight-related CO2 avoided (2051): 16,600 tonnes
IO 3: The Auckland rail network supports and enables a denser urban form within the metro	1	2	2	Options Ciii and Di were scored higher on the basis of a modest improvement over Ai as a result of an overall increase in accessibility from improved all day service, and from the A-S corridor with the % of jobs accessible within 30min increasing from 4.4% in Ai to 5.9% in Ciii and 5.4% in Di, and the % of jobs accessible within 60min increasing from 7.0% in Ai to 9.4% in Ciii and 9.9% in Di.

station catchments within the next 30 years				
Critical Success Factors				
Potential achievability/deliverability	Not scored			The deliverability criteria is highly dependent on phasing which will be addressed in Options Report Part 2 –. This criteria was not scored in the workshop however much of the workshop discussions centred around the achievability/feasibility of the Wiri to Westfield option. On this point, it was generally agreed that the differences between Ciii and Di were not as significant as first anticipated with Ciii presenting an opportunity for integrated development around Middlemore (see Section 6.3.4). Furthermore, the complexity of the Puhinui to Wiri segment implied by Di was deemed to be highly challenging and potentially infeasible (see Section 6.3.2.3.2). Thus the options were not significantly differentiated overall with a slight preference to Ai over Ciii and Di.
Potential affordability	Not scored			Potential affordability was assessed as being primarily correlated with the capital costs at this stage of analysis (presented in the Critical Success Factors section), given specific funding envelops were not known. From an OPEX perspective, again all three options are relatively similar as services are scaled to the same set of demands from a metro perspective (all options were assessed to have roughly the same revenue fleet requirements and thus operational costs would be similar) and would accommodate similar volumes of freight and inter regional services (under base demand scenarios). Fundability is further discussed in the Part 2 report, being an important factor in assessing how quickly investments are phased over time.
Supplier capacity and capability	-3	-3	-3	Though options vary substantially by capital costs, all options contain significant construction costs over the first decade (50% between 2025-2035), being required in parallel with other major projects. Thus this criterion was not considered differentiating.
Scheduling/programming	-3	-3	-3	Scored analogously to the Supplier capacity and capability
Opportunities and impacts				
Environmental effects	-2	-3	-3	Primarily differentiated by the inclusion of the Avondale – Southdown corridor. The creation of a new corridor, whilst designated already, will have temporary (construction) and permanent (operational) effects on the environment. Options Di and Ciii will have differing environmental impacts due to differences in the total length of widened corridor, however this was not deemed differentiating.

Social and cultural impacts	-1	-2	-2	Similarly, options were primarily differentiated by inclusion of Avondale – Southdown, resulting in the construction and operation of a railway within an established residential area including operation of heavy freight trains. It was noted that residential land around Onehunga can be developed to medium intensity, which may increase the size of the population exposed to adverse effects. It was also noted that under the assumed alignment, the railway would have an impact upon built heritage and natural heritage e.g. lava caves in Onehunga, and an existing school. Commentary included the suggestion that the new corridor will need to be grade separated (elevated/trenched) to reduce severance effects. The 6-tracking alignment in Option Ciii was also noted as having potential for community severance to be exacerbated, if residential land is required for the widened corridor, with existing residents displaced from the community. However this difference didn't lead to an overall difference in scoring between Ciii and Di.
Climate Change mitigation	1	2	2	All options delivered similar VKT reduction, however the lack of meaningful separation of freight and metro services under this option, does not support mode shift to rail freight and was therefore scored lower than options Ciii and Di.
Climate change adaptation	-1	-1	-1	Not deemed to be differentiating. All options include new infrastructure in areas exposed to sea level rise (Westfield) which presents a risk, but also an opportunity for mitigation as part of the project.
Cumulative impacts	-1	-2	-2	Options were again primary differentiated based on the inclusion of Avondale – Southdown corridor, for similar reasons to those provided above.
Impacts on Te Ao Māori	Not scored			This scoring excluded the Te Ao Māori impacts, however project partners participated in huis with Iwi through mana whenua representatives in October and November to get input into the programme selection. Shared initial thinking on options with agreement to check back in later in the process. Key considerations from this engagement were environmental impacts and the need for mitigations, the potential benefits to create jobs from an increase in freight operations and construction, and the ability of the investments to support trips outside of the typical commuter peaks.
Property impacts	-2	-3	-3	All options were deemed to have a significant impact on property within Ciii and Di receiving a lower score due to the following features: - Ciii includes widening of existing rail corridor to six tracks between Westfield and Wiri impacting residential, commercial, and recreational land, and existing infrastructure such as bridges. - Di includes widening of the existing rail corridor to four tracks between Westfield to Newmarket resulting in impacts upon adjacent properties along the whole length of alignment. In some locations

				the rail corridor is directly adjacent to the State Highway network, which expansion into may, or may not be feasible. The additional negative impacts of Ciii and Di over Ai were considered to be relatively similar in scale, resulting in the same score for each. For both Ciii and Di, the Avondale – Southdown corridor was not considered to be a major differentiator over Ai given that the majority of Avondale-Southdown corridor is owned by KiwiRail (though it was acknowledged that designation boundaries may need to be widened to accommodate two tracks in some locations).
Impacts on road safety	1	1	1	All options include removal of level crossings and only result in a small vkt reduction. Therefore a similar scale of benefit to road safety is expected across all options.
Conditional Output Assessment				
Metro Passenger	*1*	*2*	*1*	Overall scoring based on the assessments below.
Provide peak period capacity for base demand (metro passenger)	1.5	2	1	Peak capacity was primarily differentiated by the Wiri to Westfield configuration. Option Di was scored lowest due to the utilization issues with the South to Manukau service (see Section 6.3.2.3.2 for discussion). Options Ciii was scored higher than Ai given that the 6-track configuration provides substantial room for further growth.
Maximum length of standing (target <15mins)	1	1.25	0.5	For similar reasons Di was score low due to the issues with the South to Manukau service. Ciii was scored higher than Ai given that the expected buffer reduction (see Section 6.3.2.3.1) improved travel times and therefore reduced standing times.
Enable incremental journey time improvements	1	2.5	1.5	All options were expected to provide improved travel times on the southern line, with Di provided slightly greater benefits due to the Westfield to Newmarket 4-tracking. However, the greatest benefits were judged to arise from 6-tracking in Option Ciii due to expected buffer reduction (see Section 6.3.2.3.1) which would benefit a greater number of passengers. This resulted in Ciii having the highest score.
Point-to-point journey time comparable to off-peak car trip	1	2.5	1.5	A similar logic was applied per above.

Journey time to central area should not be more than 45mins	0.25	0.75	0.75	A similar logic was applied as per above. For this metric the only stations not meeting the target are those on the outer southern corridor. Di provides the best express benefits for those stations but this was not deemed differentiating between the options.
Comply with 2018 RPTP RTN aspirations for service: 10 min (or better) minimum frequency between 6am and midnight	1	1.25	1	All options were assessed to provide an RTN compliant service frequencies of 8tph minimum. However as per Section 6.3.2.3.4 options Ai and Diii require uneven headways (5/10min split) on all lines while the 6-track configuration of Ciii allows for an even headway on the Southern line. Thus Ciii scored slightly higher.
Freight	*1*	*2*	*1*	Overall scoring based on the assessments below.
Provide peak period capacity for base demand (freight; # slots)	0.75	1.75	1.5	The options were differentiated as follows: • For POAL freight, Ai scored lowest given the significant constraints on freight paths imposed by the 4-track configuration of W2W along with all day RTN frequencies. Option Ciii scored higher than Di based on the fact that while Di theoretically provides sufficient capacity for the port shunt between Wiri and Westfield, this would require precise timetabling particularly between Wiri and Puhinui – presenting reliability issues. • For NAL Ai scored a 0 as having no improvement over current day, while both Ciii and Di scored highly with the inclusion of A-S. The options were not differentiated by the NIMT freight line given that all options provide a 4-track southern corridor.
Provide optimal timetabling with freight destinations (i.e., ports, ferries, logistic industries etc.)	1	2.25	2	A similar logic was applied per above. resulting in the same relative scoring
Enable transition to 1500m freight from south of Auckland to Southdown	0.75	0.75	0.75	Not differentiating as required under all options.
Inter-regional	*1*	*1*	*1*	Overall scoring based on the assessments below.

Provide peak period capacity for base services (interregional passenger; # slots)	0.5	0.5	0.5	With all options containing the four tracking, peak capacity is expected to be provided for all options.
Enable incremental journey time improvements	0.5	0.75	0.75	With Avondale – Southdown, both options Ciii and Di allow for inter-regional services to be re-routed via the inner southern corridor, thereby providing an incremental benefit in runtime over Ai reflected in the lower scoring for this option.
Reliability	*1*	*2*	*2*	
Enable 6hrs of productive maintenance per night (on avg)	2	2.25	2.25	The options were differentiated on the ability to route freight between Avondale and Southdown under Ciii and Di, which reduces risk of maintenance down time waiting for trains on NAL between Newmarket and Avondale (9 km)
Enable 30-minute evening service with one main closed (for maintenance)	0.5	0.75	1	Option Di was scored higher than Ai and Ciii for the inner southern segment of the network, given that the four track railway between Westfield and Newmarket would provide additional flexibility for running services while maintenance was carried out in this area. On the other hand, Option Ciii scored higher than Ai and Di for the outer southern segment (to Westfield) as the 6-tracking configuration would provide access for a nightly freight timetable and 24/7 passenger operation (close to RTN frequency) without conflicting with maintenance access requirements in this area. This led to the overall scoring giving a slight preference to Di over Ciii over Ai.
Peak network capacity utilisation (target <75%)	1	1.75	1.25	Options were again primarily differentiated on the Avondale – Southdown and Wiri to Westfield segments with greater utilisation provided by these infrastructure elements in relation to Ai.
Project-specific Critical Success Factors				
Capital cost	$17-25B	$25-35B	$26-37B	See further discussion on final selection in Section 6.4.2
Total score	**13.8**	**27**	**20.3**	
BCR	1	0.84	0.8	

6.4.2 SELECTION

Based on the assessment presented above on the full set of MCA criteria, the following overall assessments were made of the options.

6.4.2.1 SEPERATION OF MODES ON THE INNER NETWORK

The analysis concluded that the ability of Option Ai to satisfactorily achieve the strategic objectives of the PBC, was compromised due to a lack of meaningful separation between freight and metro services over the inner network, with freight and high-density passenger services sharing a two-track railway from Westfield to Swanson including the restrictive flat junction at Newmarket.

This lack of separation restricts the option's ability to provide all day freight access to the NAL which in turn limits the potential for demand growth in freight and associated emissions reduction. It also precludes the operation of all day express services and results in an uneven headway pattern on the Southern Line, limiting the potential to attract and accommodate passenger mode shift and vkt reduction with modelled demand 7-8% less than Option Ciii. (IO1 and IO2)

These compromises are resolved in Ciii and Di via the Avondale to Southdown corridor, which also better supports dese urban form via the addition of a crosstown metro corridor, linking areas of strategic growth within Auckland, creating connectivity to Light Rail and improving access to opportunities. (IO3)

Within the Wiri to Westfield segment, freight traffic between POAL and Wiri share a pair of tracks with the interlined Eastern and Southern all stops services, equating to at least 16 trains per hour.

6.4.2.2 EXPRESS BENEFITS OF FOUR TRACKS TO NEWMARKET

The previous round of optioneering had carried forward four tracking of the NAL via Option Di, to provide the greatest possible runtime benefit from the southern parts of the network, to get as close to the 45min target as possible and provide competitive travel to off-peak car journeys, thereby increasing the attractiveness of passenger rail and its ability to contribute to emissions reduction (IO1 and IO2).

However, it was ultimately identified that the incremental runtime benefit would be relatively small (up to 3min with a risk that additional investments in the southern corridor would be required to even achieve this) compared to options Ai and Ciii. Considering the high cost of this investment (between $3.0 – 4.8B), and the fact that there are no notable additional benefits, it was deemed that there would likely be no justification for this infrastructure as an isolated element of Di.

6.4.2.3 WIRI TO WESTFIELD – THE NEW NETWORK BOTTLENECK

This single 7km segment of track, while small in physical size, is of huge significance to the network, not only in the context of Auckland but in the context of the national railway system, given its high traffic volumes and strategically important depots and stations.

Analysis suggested the four track configuration of Option Ai would have significant capacity constraints, with the junctions of Wiri and Westfield in particular requiring onerous restrictions from a timetable perspective and precise operation to achieve desired levels of reliability. This is coupled with the inability of the option to provide adequate freight paths for port traffic.

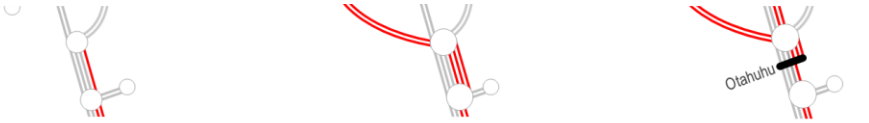
The solution represented in Di to restructure metro services was shown to have considerable flaws under scrutiny. The Pukekohe to Manukau service created a high utilisation area in the network requiring complex infrastructure to resolve, with a risk of being fundamentally infeasible. And the utilisation of this service was much lower than expected – resulting in significant crowding on the alternative route to the CBD, undermining the basic aim of this option to relieve capacity.

The 6-tracking solution of Ciii on the other hand, not only resolved the issues of the alternative schemes, but resulted in significant additional travel time benefits arising from the ability to completely separate the Southern and East-west lines from each other; and improved maintenance access benefits.

The 6-tracking option was clearly preferred from an operational and service perspective and its ability to support the investment objectives of increased rail attractiveness for passenger and freight markets and from a network reliability perspective (IO1)

Concerns were raised as to the feasibility and cost of this option given the land take requirements associated with it. However, given the principal established to provide a wider corridor for maintenance access improvements, it was demonstrated that the delta in number of impacted properties between the three options would not be as significant as first expected, which is reflected in the cost of 0.58 – 0.9B, relatively small in the overall scheme of the programme.

A summary of the overall comparisons on of options for W2W are presented in Figure 6-11.



	Ai	Ciii	Di
Service Benefits	High utilization of mixed traffic eastern mains leads to reliability issues and timetable constraints	Simplifies operation and improves utilization, leading to higher reliability and significant travel times benefits	Turnback's improve utilization but complexity in operation leads to similar service outcomes to Ai
Maintenance Benefits	Maintenance mode operation is degraded from	Greater ability to run quality timetables during maintenance Greater flexibility for maintenance windows	Similar to Ai
Costs	1.6B – 2.6B	4.1 – 6.6B	2.2B – 3.5B
Property Impacts	Property impacts expected along the W2W corridor for 4-tracking	Similar to Ai and Di at the Otahuhu and Puhinui ends, with additional property take in between including Middlemore.	Similar to Ai with risk of additional take around Otahuhu and Puhinui
Infrastructure Complexity	Risk of complexity around junctions	6 tracking simplifies operation and reduces conflicts – risk of complexity reduced	Significant risk of additional complexity at Puhinui and Otahuhu ends to facilitate turnbacks

Cost/impact Benefit

Figure 6-11: Wiri to Westfield options comparison

6.4.2.4 CONCLUSION

As presented in Figure 6-12, the issues of inadequate separation of modes within the inner network and poor performance of the 4-tracki Wiri to Westfield configuration led to a much lower overall MCA score for Option Ai compared to other options, reflecting poor performance against a number of investment objective and conditional output assessment criteria. This scoring also reflected the fact that Ai was not resilient against various freight scenarios including any future

with growth at Northport (which as discussed in Section 4.4.5.1, is more likely than the zero-growth assumed under the base demand scenario). Therefore, despite Ai's higher economic performance, this option was discounted as lacking the ambition required to achieve the overall investment objectives of the PBC. Therefore, Ai also came with the risk of not being fit for purpose It was also acknowledged that the selection either Ciii or Di would entail the selection of Ai as an early phasing of the investment programme, thus providing flexibility to scale and flex the programme to adapt to future scenarios such as a port move, or strong emissions reduction policy interventions as will be discussed further in the Part 2 Report.

Then comparing options Di and Ciii, there is a clear preference for Ciii on the basis that it has the highest overall MCA scoring, lower cost, and higher BCR. However, if factoring out the four-tracking element between Westfield and Newmarket, which was deemed to provide little benefit for its substantial cost and therefore not justified as an isolated element of the option, the two options would only be differentiated by the Wiri to Westfield segment of the network, for which the 6-tracking configuration was strongly preferred for the reasons described above.

Thus at the conclusion of the MCA analysis and selection process described above, it was agreed that Option Ciii was to be selected as the Initial Preferred 2051 End State.

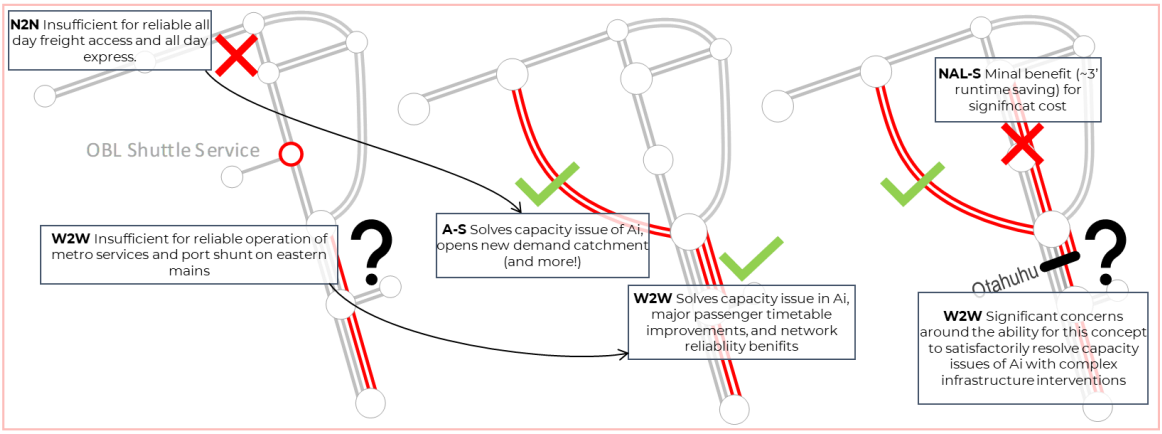
	Ai	Ciii	Di
Key Differentiators			
MCA overall score	13.8	27	20.3
Est. capital cost	$17bn - $25bn	$25bn - $35bn	$26bn - $37bn
Indicative BCR.	0.76 – 1.0	0.58 - 0.84	0.55 - 0.80

Figure 6-12: Final option summary

6.4.2.5 SENSITIVITY ANALYSIS

To test the robustness of the MCA scoring sensitivity testing was performed by varying the weightings applied to the various MCA criteria. The analysis, summarized below, demonstrates that selection of Ciii was a robust decision, being unchanged across the various scenarios considered.

- Weighting of Passenger outcomes vs Freight outcomes:
  Increasing the relative weight of the Freight conditional outcome MCA scores to balance the weight of the Passenger conditional outcome MCA scores increases the differentiation between Ciii and Di and reinforces the conclusion that Ciii is preferable to Di.
- Weighting of Markets outcomes vs Reliability outcomes:

Increasing the relative weight of the reliability outcomes to outweigh the outcome MCA scores of the three markets decreases marginally the differentiation between Ciii and Di but does not change the conclusion that Ciii is preferable to Di.

- Weighting of Investment Objectives vs Conditional Outputs:
  Increasing the relative weight of IOs to match the total weight of COs of the three markets decreases the differentiation between Ciii and Di further, but still does not change the conclusion that Ciii is preferable to Di.

APPENDIX A – IDEAS GENERATION TO LONG LIST GENERATION OF OPTIONS

APPENDIX B - SERVICE CONCEPT LONG LIST THEMATIC OPTIONEERING

APPENDIX C – LONG LIST DEVELOPMENT AND REFINEMENT

APPENDIX D – LONG LIST MCA SUMMARY

APPENDIX E – LONG LIST MCA

		Do Minimum		Option 1 - All Stops		Option 2 - Peak, Limited Stops		Option 3 - Inner / Outer		Option 4 - Express + All-Day Frequent + All-Day Freight		Option 5 - Express + All-Day Frequent + All-Day Freight + Avondale - Southdown	
		Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
#	Investment objectives												
	Continually increase the use of rail in Auckland (all markets) over the next 30 years, by increasing its attractiveness (eg reliability, frequency, capacity and travel times)												
1	Extent to which the option increases rail's attractiveness for metro passengers (ie service offering characteristics)	0		0	**Doesn't conform to RTN** definition of frequent service **Not providing competitive travel times** with car, particular south of Puhinui. **Low off-peak** frequencies/ This option mostly adds capacity as it moved to 9 car. But does not change other attractiveness features.	1	**Doesn't conform to RTN** definition of frequent service. Utilizes 3rd and 4th mains to run **faster metro services on the South**. **Provides faster service to the West** without need for additional trackage.	2	**Consistent with RTN** – at least 10min headways all day. Utilizes 3rd and 4th mains to run f**aster metro services on the South**, and attempts to run faster service on the East and West lines without need for additional trackage. More frequency all day compared to option 2. Note it removed OBL, but low catchment.	3	**Better than RTN** – 7.5min headways all day. New South-west line provides higher frequency for local trips within southern and western zones, a **more direct cross-town** service, and a release valve for the CRL. Cross town, 7.5min headway, express peak overlays, good inter-regional (allowance 2/hr all day).	3	**Better than RTN** – 7.5min headways all day Four tracking of the southern line from Pukekohe to Newmarket **allows peak express services** to be provided saving close to 10min in journey time. Avondale-southdown add additional coverage
2	Extent to which the option increases metro passenger rail patronage	0		1	Low off-peak frequencies allow for off-peak freight paths without comprise to symmetric passenger timetable. Allows an increase in patronage because it has more capacity.	1	Travel time improvements are relatively small and may not result in significant demand uplift. Travel time improvements on Western Line rely upon uneven headways (alternating 5 and 10min) which may reduce perceived service quality and result in uneven loads	2	All day express service in recognition of significant demand growth in outer regions of network. Travel time improvements rely upon uneven headways (alternating 5 and 10min) which may reduce perceived service quality and result in uneven loads Significant additional capacity to induce and cater for addiitonal demand.	3	See above. Significant additional capacity to induce and cater for addiitonal demand.	3	Pukekohe to Newmarket allows peak express services to be provided saving close to 10min in journey time. Avondale Southdown Significant additional capacity to induce and cater for addiitonal demand.
3	Extent to which the option increases metro passenger rail mode share	0		1	Linked to rail patronage for long list scoring.	1	Linked to rail patronage for long list scoring.	2	Maxes out capacity of the CRL in 2051. No headroom for growth. Linked to rail patronage for long list scoring.	3	Linked to rail patronage for long list scoring.	3	Linked to rail patronage for long list scoring
4	Extent to which the option increases the share of freight moved by rail	0		2	Wiri – Westfield close to capacity (92% utilized). Limited potential for further growth. Extra freight tracks dedicated to freight/interregional (no metro passenger).	1	Lower utilization of Wiri-Westfield and CRL provides headroom for capacity growth Low off-peak frequencies allow for off-peak freight paths without comprise to symmetric passenger timetable (except on the Western Line).	1	Off peak freight will be very challenging to incorporate without additional track on the NAL between Otahuhu and Newmarket, and without some element of grade separation at Westfield and Wiri.	3	Additional tracks allow for accommodation of all-day freight paths	3	6-tracking Wiri-Westfield allows for segregation of South and East-west services. Mixed metro and freight still required on the Western Line (west of Mt Albert) and Avondale - Southdown.

		Do Minimum		Option 1 - All Stops		Option 2 - Peak, Limited Stops		Option 3 - Inner / Outer		Option 4 - Express + All-Day Frequent + All-Day Freight		Option 5 - Express + All-Day Frequent + All-Day Freight + Avondale - Southdown	
		Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
							Freight sharing with express (south) and north and port only has off peak paths.		Freight sharing with express (south) and north and port only has off peak paths.				
5	Extent to which the option improves rail network reliability	0		1	Complete separation of Freight/Interregional from Metro services allows for more efficient and flexible freight operation, potential for faster interregional service, and overall improved network resilience. Wiri – Westfield close to capacity (92% utilized) - so make it difficult to recover from incidents.	2	Travel time improvements on Western Line rely upon uneven headways (alternating 5 and 10min) which may reduce perceived service quality and result in uneven loads. Better than Opt 1 because lower utilisation for wire/Westfield section	2	Separation of South and East-west lines between Wiri and Westfield improves service reliability and reduces need for timetable buffer. Tidal express is efficient from an operational perspective. Diversity of trip types may lead to an unreliable service Better than Opt 1 because lower utilisation for wire/Westfield section	2	Additional tracks allow for accommodation of all-day freight paths without compromise to symmetric passenger timetable and ability to run express services that are not constrained by all-stops services, with faster and more reliable journey times. Better than Opt 1 because lower utilisation for wire/Westfield section	3	This requires paths be provided in the passenger timetable, resulting in uneven headways (however this also provides an opportunity to run skip stop services). Potential reliability issues with H2A trains running through the CRL at close to capacity, with long dwell times. Extra lines provide resilience.
6	Extent to which the option reduces on road vkt	0		1	Linked to patronage/mode share	1	Linked to patronage/mode share	2	Linked to patronage/mode share	3	Linked to patronage/mode share	3	Linked to patronage/mode share
	Reduce Auckland's net transport emissions by increasing rail's share of Auckland's transport task over the next 30 years												
7	Extent to which the option reduces Auckland's net CO2 emissions from transport	0		1	Linked to vkt	1	Linked to vkt	2	Linked to vkt	3	Linked to vkt	3	Linked to vkt
	The Auckland rail network supports and enables a denser urban form within the metro station catchments within the next 30 years												
8	Extent to which the option increases employment accessibility by public transport (within 30 and 45 minutes travel)	0		0	No real TT saving for any areas over DM so accessibility improvements limited to what is enabled by capacity.	1	Utilizes 3rd and 4th mains to run faster metro services on the South. Provides faster service to the West	2	Better headways	3	Better headways compared to Opt 3	3	Avondale-Southdown allows for some separation of freight and metro traffic and opens up a new catchment and connection opportunities for the metro network. As with previous concept South-west line also provides a more direct cross-town service, and a release valve for CRL
	Critical Success Factors												

		Do Minimum		Option 1 - All Stops		Option 2 - Peak, Limited Stops		Option 3 - Inner / Outer		Option 4 - Express + All-Day Frequent + All-Day Freight		Option 5 - Express + All-Day Frequent + All-Day Freight + Avondale - Southdown	
		Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
9	Potential Achievability/Deliverability (Programme Business Case only)	0		-1	No comment on phasing at this stage - timing of construction may increase difficulty - Level Crossing removal requires significant land purchase and risk of delay during consultation / challenge to closure / grade separation - Depots and Stabling will require land purchase and risk of large land area in urban setting - Additional track infrastructure and platforms may not be able to efficiently phase. - Land purchase for fourth main may constrain potential corridor width (e.g. can't provide access track)	-1	No comment on phasing at this stage - timing of construction may increase difficulty - Level Crossing removal requires significant land purchase and risk of delay during consultation / challenge to closure / grade separation - Depots and Stabling will require land purchase and risk of large land area in urban setting - Additional track infrastructure and platforms may not be able to efficiently phase. - Land purchase for fourth main may constrain potential corridor width (e.g. can't provide access track)	-2	No comment on phasing at this stage - timing of construction may increase difficulty - Level Crossing removal requires significant land purchase and risk of delay during consultation / challenge to closure / grade separation - Depots and Stabling will require land purchase and risk of large land area in urban setting - especially for stabling close to city centre - Additional track infrastructure and platforms may not be able to efficiently phase. - Land purchase for fourth main may constrain potential corridor width (e.g. can't provide access track) - Westfield Grade Separation technically challenging, Wiri Grade Separation potentially not practically feasible	-3	No comment on phasing at this stage - timing may increase difficulty - Level Crossing removal requires significant land purchase and risk of delay during consultation / challenge to closure / grade separation - Depots and Stabling will require land purchase and risk of large land area in urban setting - Significant additional track infrastructure compared to other options and do minimum will require significant resource and planning. Land purchase for fourth main may constrain potential corridor width (e.g. can't provide access track). - Very significant infrastructure / Potentially unfeasible pinch points ie New Lynn Trench, CRL Connections to NAL, Newmarket, Purewa Tunnel, Penrose Junction. - Westfield Grade Separation technically challenging, Wiri Grade Separation potentially not practically feasible.	-3	No comment on phasing at this stage - timing may increase difficulty - Level Crossing removal requires significant land purchase and risk of delay during consultation / challenge to closure / grade separation - Depots and Stabling will require land purchase and risk of large land area in urban setting - Significant additional track infrastructure compared to other options and do minimum, will require significant resource and planning. Land purchase for fourth main may constrain potential corridor width (e.g. can't provide access track). - Very significant infrastructure / Potentially unfeasible pinch points ie New Lynn Trench, CRL Connections to NAL, Newmarket, Purewa Tunnel, Penrose Junction. - Westfield Grade Separation technically challenging, Wiri Grade Separation potentially not practically feasible - Avondale - Southdown in area not used to rail noise and construction. Current alignment through Onehunga and over Waterview tunnel
10	Potential affordability (Programme Business Case only)	0		-1	Aligned with capital cost (row 82)	-1	Aligned with capital cost (row 82)	-1	Aligned with capital cost (row 82)	-3	Aligned with capital cost (row 82)	-2	Aligned with capital cost (row 82)
11	Supplier capacity and capability	0		0	Not relevant for this stage of PBC	0	Not relevant for this stage of PBC	0	Not relevant for this stage of PBC	0	Not relevant for this stage of PBC	0	Not relevant for this stage of PBC
12	Scheduling/programming	0		0	Not relevant for this stage of PBC	0	Not relevant for this stage of PBC	0	Not relevant for this stage of PBC	0	Not relevant for this stage of PBC	0	Not relevant for this stage of PBC
	Opportunities and impacts (insert N/A if not relevant)												

		Do Minimum		Option 1 - All Stops		Option 2 - Peak, Limited Stops		Option 3 - Inner / Outer		Option 4 - Express + All-Day Frequent + All-Day Freight		Option 5 - Express + All-Day Frequent + All-Day Freight + Avondale - Southdown	
		Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
13	Environmental effects	0		-1	All network in brownfield, new tracks will be adjacent to existing	-1	All network in brownfield, new tracks will be adjacent to existing	-1	All network in brownfield, new tracks will be adjacent to existing	-1	All network in brownfield, new tracks will be adjacent to existing	-2	All network in brownfield apart from new corridor on existing designation. Potential noise issues and section between Avondale and SH20 is going through a park at north end (top of waterview tunnel)
14	Social and cultural impacts												
15	Climate Change mitigation (mandatory)	0		2	Complete separation of Freight/Interregional from Metro services allows for more efficient and flexible freight operation, potential for faster interregional service. However option is not competitive for car for passenger mode shift between Puhinui and Pukekohe	1	3rd and 4th mains to run faster metro services, however Travel time improvements are relatively small and may not result in significant demand uplift. Doesn't allow for peak freight from western and Akl port shunt.	1	Utilizes 3rd and 4th mains to run faster metro services on the South. All day express service support growth in outer regions of network. Doesn't allow for peak freight from western and Akl port shunt.	3	Higher frequency and express services enabled for local trips and cross town services. Opportunity for all freight to travel at peak time due to all day freight paths. More infrastructure will create high embodied/construction carbon but option creates higher mode shift in long term which offsets this.	3	Avondale-Southdown allows for some separation of freight and metro traffic, creating opportunity for all freight to travel at peak time . Opens up a new catchment and connection opportunities for the metro network. Option enabled larger mode shift with additional infrastructure and by interregional services going through CRL. More infrastructure will create high embodied/construction carbon but option creates higher mode shift in long term which offsets this.
16	Climate change adaptation	0		-1	infrastructure built in area exposed to sea level rise (4 tracks Otahuhu-Westfield)	-1	infrastructure built in area exposed to sea level rise (4 tracks Otahuhu-Westfield plus 2 more in freight yard)	-1	infrastructure built in area exposed to sea level rise (4 tracks Otahuhu-Westfield)	-2	infrastructure built in area exposed to sea level rise (4 tracks Otahuhu-Westfield plus 2 more in freight yard). Extra track on NIMT E in exposed area also.	-2	Significant infrastructure built in area exposed to sea level rise (4 tracks Otahuhu-Westfield plus 2 more in freight yard plus new Avondale-Southdown line).
17	Cumulative impacts	0		0		0		0		0		0	
18	Impacts on Te Ao Māori (Mandatory)	0		0		0		0		0		0	
19	Property impacts *(ie number or scale of impact, not cost)*	0	Limited impact on property	-1	Land take: Four-track railway from Pukekohe to Otahuhu	-2	Land take: Four-track railway from Pukekohe to Wiri and 6 tracks Wiri to Otahuhu Upgrades to support 9-car trains	-1	Land take: Four-track railway from Pukekohe to Otahuhu and Quay Park Stabling	-3	Land take: Six-track railway from Wiri to Otahuhu Four-track railway from Pukekohe to Wiri Four-track railway from Otahuhu to New Lynn or Henderson Four-track railway Otahuhu to Britomart	-3	Land take: 4-track railway from Pukekohe to Newmarket; 6 between Wiri and Westfield Two-track Avondale-Southdown (2-track NAL south and NIMT east are sufficient for this concept)

		Do Minimum		Option 1 - All Stops		Option 2 - Peak, Limited Stops		Option 3 - Inner / Outer		Option 4 - Express + All-Day Frequent + All-Day Freight		Option 5 - Express + All-Day Frequent + All-Day Freight + Avondale - Southdown	
		Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
20	**Impacts on road safety** Extent to which the option reduces exposure to road based safety risks	0	No funding in place for removing level crossings in do-minimum	2	All Level crossings will be removed	2	All Level crossings will be removed	2	All Level crossings will be removed	3	All Level crossings will be removed All-day frequent service may encourage additional off peak demand, better potential reduciton in vkt	3	All Level crossings will be removed Addition of A-S should encourage additional reduciton in vkt, lowerin safety exposure
	Conditional output assessment												
	All markets												
21	Option enables 6hrs of productive maintenance per night (on avg)	0	Significant issues with access to network- especially Westfield - Pukekohe	2	Westfield - Pukekohe enables two mains closed for maintenance with two operating a service North Westfield has one track closed with one track operations a service	2	Westfield - Pukekohe enables two mains closed for maintenance with two operating a service North Westfield has one track closed with one track operations a service	2	Westfield - Pukekohe enables two mains closed for maintenance with two operating a service North Westfield has one track closed with one track operations a service	3	All railway enables two mains closed for maintenance with two operating a service	2	Westfield - Pukekohe enables two mains closed for maintenance with two operating a service Westfield - Newmarlet via NAL enables two mains closed for maintenance with two operating a service North Westfield via NIMT has one track closed with one track operating a service. Newmarket - Swanson has one track closed with one track operating a service. Avondale - Southdown adds maintenance burden to network but adds new routes for freight to route around work zones, and for MTMV/Maintenance vehicle deployment
22	Option enables 30 minute evening service with one main closed (for maintenance)	0	Not available in current state	2	All options can support this with appropriate special trackwork, but more feasible on 4-track railway, therefore Option 4 preferred as it provides 4-tracks over most of the network	2	All options can support this with appropriate special trackwork, but more feasible on 4-track railway, therefore Option 4 preferred as it provides 4-tracks over most of the network	2	All options can support this with appropriate special trackwork, but more feasible on 4-track railway, therefore Option 4 preferred as it provides 4-tracks over most of the network	3	All options can support this with appropriate special trackwork, but more feasible on 4-track railway, therefore Option 4 preferred as it provides 4-tracks over most of the network	2	All options can support this with appropriate special trackwork, but more feasible on 4-track railway, therefore Option 4 preferred as it provides 4-tracks over most of the network
23	Peak network capacity utilisation (target <75%)	0	By 2051, network will be significantly over capacity and constraining demand	1	Wiri – Westfield close to capacity (92% utilized) if only 4-tracked. Would require 6-tracks to achieve acceptable utilisation (~60%). Limited potential for further growth CRL 63% utilised	2	Meets Rqmts except CRL (79% utilised). >75% may be acceptable for CRL Lower utilization of Wiri-Westfield and CRL provides headroom for capacity growth	1	Meets Rqmts CRL 75% UP direction and 100% Down direction utilised in am peak (vice versa in PM peak) NAL south has 16tph, mixed 8tph local / 8tph express which will strain capacity. W2W is ok as some express service is	3	Exceeds Rqmts - enables additional local journeys on western and southern lines CRL 79% utilised	2	Potential reliability issues with H2A trains running through the CRL at close to capacity, with long dwell times. Enables additional local journeys on southern line CRL 75% UP direction and 83% Down direction utilised

		Do Minimum		Option 1 - All Stops		Option 2 - Peak, Limited Stops		Option 3 - Inner / Outer		Option 4 - Express + All-Day Frequent + All-Day Freight		Option 5 - Express + All-Day Frequent + All-Day Freight + Avondale - Southdown	
		Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
									shifted to western mains				
	Metro passenger - Western												
24	Option provides peak period capacity for base demand (metro passenger)	0	Western line would be significantly over capacity in 2051	1	Sufficient capacity to service demand No journey time saving compared to do minimum	2	Sufficient capacity to service demand 3 min saving for express may encourage some additional demand	3	Sufficient capacity to service demand 6min saving for express services may encourage additional demand	3	Sufficient capacity to service demand 7min saving for express services may encourage additional demand All-day frequent service may encourage additional off peak demand	3	Sufficient capacity to service demand 3 min saving for express may encourage some additional demand Avondale - Southdown opens potential additional journey from west to Airport (change to Light Rail at Onehunga) and to south Potential to add new stations for new catchment
25	Maximum length of standing (target <15mins)	0	Significant standing expected	3	Service designed to seating capacity. No standing	3	Service designed to seating capacity. No standing	3	Service designed to seating capacity. No standing	3	Service designed to seating capacity. No standing	3	Service designed to seating capacity. No standing
26	Incremental journey time improvements	0	Not provided	0	No potential for incremental journey times	1	Potential for incremental journey time improvements but depends on phasing	1	Greater potential for incremental journey time improvements but depends on phasing	1	Greater potential for incremental journey time improvements but depends on phasing	1	Potential for incremental journey time improvements but depends on phasing
27	P2P journey times at least as fast as peak period car (85%ile) travel	0	Opening day runtimes conform to P2P runtime targets	0	No journey time saving compared to do minimum.	1	3 min saving for express compared to do minimum. However do-min already meets P2P targets	1	6 min saving for express compared to do minimum. However do-min already meets P2P targets Results in uneven all-stops headways, increasing wait times	2	7 min saving for express compared to do minimum. However do-min already meets P2P targets	1	3 min saving for express compared to do minimum. However do-min already meets P2P targets Results in uneven all-stops headways, increasing wait times
	Metro passenger - Eastern												
28	Option provides peak period capacity for base demand (metro passenger)	0	Eastern line would be significantly over capacity in 2051	1	Sufficient capacity to service demand No journey time saving compared to do minimum	1	Sufficient capacity to service demand.	1	Sufficient capacity to service demand.	1	Sufficient capacity to service demand.	1	Sufficient capacity to service demand.
29	Maximum length of standing (target <15mins)	0	Significant standing expected	3	Service designed to seating capacity. No standing	3	Service designed to seating capacity. No standing	3	Service designed to seating capacity. No standing	3	Service designed to seating capacity. No standing	3	Service designed to seating capacity. No standing
30	Incremental journey time improvements	0	Not provided	0	No potential for incremental journey times	0	No potential for incremental journey times	1	Potential for incremental journey time improvements but depends on phasing	1	Potential for incremental journey time improvements but depends on phasing	1	Potential for incremental journey time improvements but depends on phasing

		Do Minimum		Option 1 - All Stops		Option 2 - Peak, Limited Stops		Option 3 - Inner / Outer		Option 4 - Express + All-Day Frequent + All-Day Freight		Option 5 - Express + All-Day Frequent + All-Day Freight + Avondale - Southdown	
		Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
31	P2P journey times at least as fast as peak period car (85%ile) travel	0	Opening day runtimes conform to P2P runtime targets. Puhinui - Aotea: 40min car vs. ~25min train	0	No journey time saving compared to do minimum. Conforms to P2P requirements. Doesn't conform to RTN frequency requirement	1	No journey time saving compared to do minimum. Conforms to P2P requirements. Doesn't conform to RTN frequency requirement	1	Otahuhu express service saves ~3min over do-min. However Puhuhunui and Manukau trips now require a transfer. Other stations on eastern line have no change Conforms to P2P targets	2	Panmure and Puhinui get express service saves ~3/5min over do-min. Other stations on eastern line have no change Conforms to P2P targets Better than RTN – 7.5min headways all day	2	Skip stop service at high demand stations ~3min over do-min. Other stations on eastern line have no change Conforms to P2P targets Better than RTN – 7.5min headways all day
	Metro passenger - Inner Southern												
32	Option provides peak period capacity for base demand (metro passenger)	0	Southern line would be significantly over capacity in 2051	1	Sufficient capacity to service demand No journey time saving compared to do minimum	2	Sufficient capacity to service demand	2	Sufficient capacity to service demand	3	Sufficient capacity to service demand East-south service may encourage increased ridership	3	Sufficient capacity to service demand A-S may encourage increased ridership[
33	Maximum length of standing (target <15mins)	0	Significant standing expected	3	Service designed to seating capacity. No standing	3	Service designed to seating capacity. No standing	3	Service designed to seating capacity. No standing	3	Service designed to seating capacity. No standing	3	Service designed to seating capacity. No standing
34	Incremental journey time improvements	0	Not provided	0	No potential for incremental journey times	0	No potential for incremental journey times	0	No potential for incremental journey times	0	No potential for incremental journey times	0	No potential for incremental journey times
35	P2P journey times at least as fast as peak period car (85%ile) travel	0	Opening day runtimes should conform to P2P runtime targets.	0	No journey time saving compared to do minimum. Conforms to P2P requirements. Doesn't conform to RTN frequency requirement	0	No journey time saving compared to do minimum. Conforms to P2P requirements. Doesn't conform to RTN frequency requirement	0	No journey time saving compared to do minimum. Conforms to P2P requirements. Doesn't conform to RTN frequency requirement	1	No journey time saving compared to do minimum, but higher frequencies reduce wait time. Conforms to P2P requirements. Conform to RTN frequency requirement	0	No journey time saving compared to do minimum. Conforms to P2P requirements. Conform to RTN frequency requirement
	Metro passenger - Outer Southern (Sub-urban)												
36	Option provides peak period capacity for base demand (metro passenger)	0	Southern line would be significantly over capacity in 2051	1	Sufficient capacity to service demand No journey time saving compared to do minimum	2	Sufficient capacity to service demand 4.5 min saving for express may encourage some additional demand	2	Sufficient capacity to service demand 4.5 min saving for express may encourage some additional demand	3	Sufficient capacity to service demand 7 min saving for express may encourage some additional demand East-south service may encourage increased ridership	3	Sufficient capacity to service demand 9 min saving for express may encourage some additional demand A-S may encourage increased ridership
37	Maximum length of standing (target <15mins)	0	Significant standing expected	3	Service designed to seating capacity. No standing	3	Service designed to seating capacity. No standing	3	Service designed to seating capacity. No standing	3	Service designed to seating capacity. No standing	3	Service designed to seating capacity. No standing
38	Incremental journey time improvements	0	Not provided	0	No potential for incremental journey times	1	Potential for incremental journey times	1	Potential for incremental journey times	1	Greater potential for incremental journey times	1	Greater potential for incremental journey times
39	P2P journey times at least as fast as peak period car (85%ile) travel	0	Opening day runtimes do not comply with P2P runtime targets. Not competitive to car journeys	0	No improvement over do min i.e. no express service means that service is not comparable to peak period car Doesn't conform to	2	4.5 min saving for express compared to do minimum Doesn't conform to RTN frequency requirement	2	4.5 min saving for express compared to do minimum Conforms to RTN frequency requirement	3	7 min saving for express compared to do minimum Conforms to RTN frequency requirement	3	9 min saving for express compared to do minimum Conforms to RTN frequency requirement

		Do Minimum		Option 1 - All Stops		Option 2 - Peak, Limited Stops		Option 3 - Inner / Outer		Option 4 - Express + All-Day Frequent + All-Day Freight		Option 5 - Express + All-Day Frequent + All-Day Freight + Avondale - Southdown	
		Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
					RTN frequency requirement								
	Freight												
	NIMT line												
40	Option provides optimal timetabling with freight destinations (ie ports, ferries, logistic industries etc.)	0	Freight timetable will be significantly constrained and inflexible	3	Complete separation of Freight/Interregional from Metro services allows for more efficient and flexible freight operation 5th and 6th main between Wiri and Westfield allows for more efficient freight operation.	2	3rd and 4th main allows for more efficient freight operation (Shared with interregional and limited stops metro)	1	3rd and 4th main allows for more efficient freight operation (Shared with interregional and express metro)	2	5th and 6th main between wire and Westfield allows for more efficient freight operation. Express services share tracks with freight and IR	2	5th and 6th main between wire and Westfield allows for more efficient freight operation Express services share tracks with freight and IR
41	Option provides peak period capacity for base demand (freight; # slots)	0	Capacity will significantly constrain freight demand	1	Sufficient slots to service demand - assumes 1500m freight. 2tph all day	1	Sufficient slots to service demand - assumes 1500m freight. 2tph all day	1	Sufficient slots to service demand - assumes 1500m freight. 2tph all day	1	Sufficient slots to service demand - assumes 1500m freight. 2tph all day	1	Sufficient slots to service demand - assumes 1500m freight. 2tph all day
	NAL (Southdown to Whangarei)												
42	Option provides optimal timetabling with freight destinations (ie ports, ferries, logistic industries etc.)	0	Freight timetable will be significantly constrained and inflexible	0	Travels outside of peak (same as today).	0	Travels outside of peak (same as today)	0	Travels outside of peak (same as today) May additional track on the NAL between Otahuhu and Newmarket	2	Opportunity to travel in peak, and more flexibility in timetable to accommodate delays	2	Some constraints imposed by metro service but A-S allows the busiest section of the NAL to be bypassed, thus providing greater flexibility / robustness for freight
43	Option provides peak period capacity for base demand (freight; # slots)	0	Capacity may constrain freight demand	1	Sufficient slots to service demand	1	Sufficient slots to service demand	1	Sufficient slots to service demand	1	Sufficient slots to service demand	1	Sufficient slots to service demand
	Port shunt (POAL to Wiri terminal)												
44	Option provides optimal timetabling with freight destinations (ie ports, ferries, logistic industries etc.)	0	Freight timetable may be constrained, however shorter trains and short trips allow freight to slot smaller headway gaps	0	Travels outside of peak (same as today)	0	Travels outside of peak (same as today)	0	Travels outside of peak (same as today)	3	Opportunity to travel in peak, and more flexibility in timetable to accommodate delays	1	Opportunity to travel ion peak
45	Option provides peak period capacity for base demand (freight; # slots)	0	Capacity may constrain freight demand	1	Sufficient slots to service demand	1	Sufficient slots to service demand	1	Sufficient slots to service demand	1	Sufficient slots to service demand	1	Sufficient slots to service demand
	Crosstown shunt (POAL to Southdown)												
46	Option provides optimal timetabling with freight destinations (ie ports, ferries, logistic industries etc.)	0	Freight timetable may be constrained, however shorter trains and short trips allow freight to slot smaller headway gaps	0	Travels outside of peak (same as today)	0	Travels outside of peak (same as today)	0	Travels outside of peak (same as today)	3	Opportunity to travel in peak, and more flexibility in timetable to accommodate delays	1	Opportunity to travel ion peak
47	Option provides peak period capacity for base demand (freight; # slots)	0	Capacity may constrain freight demand	1	Sufficient slots to service demand	1	Sufficient slots to service demand	1	Sufficient slots to service demand	1	Sufficient slots to service demand	1	Sufficient slots to service demand
	Inter-regional												

		Do Minimum		Option 1 - All Stops		Option 2 - Peak, Limited Stops		Option 3 - Inner / Outer		Option 4 - Express + All-Day Frequent + All-Day Freight		Option 5 - Express + All-Day Frequent + All-Day Freight + Avondale - Southdown	
		Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
48	Incremental journey time improvements	0		1	Potential for faster interregional service as segregated from metro passenger Terminates at Britomart giving access to city centre	1	Express service enabled option 2 and 3 similar time Terminates at Britomart giving access to city centre	1	Express service enabled option 2 and 3 similar time Terminates at Britomart giving access to city centre	2	Express service enabled slightly faster than option 2 and 3 Terminates at Britomart giving access to city centre	3	Option goes through the CRL - risk of dwell time delay Achieves best travel times of all options
49	Option provides peak period capacity for base demand (interregional passenger; # slots)	0		1	Sufficient capacity to service demand	1	Sufficient capacity to service demand	1	Sufficient capacity to service demand	1	Sufficient capacity to service demand	1	Sufficient capacity to service demand May stimulate additional demand due to additional stops in CRL
	Project-specific critical success factors												
50	Capital cost (not to be scored - scores to be removed, once RO costs added)	0		-1	Four-track railway from Pukekohe to Otahuhu Upgrades to support 9-car trains Level crossing removal,	-1	Four-track railway from Pukekohe to Wiri and 6 tracks Wiri to Otahuhu Upgrades to support 9-car trains Level crossing removal,	-1	Four-track railway from Pukekohe to Otahuhu Upgrades to support 9-car trains Level crossing removal, Tidal south peak express requires mid-day stabling near the CBD	-3	Four-track railway from Pukekohe to Wiri Six-track railway from Wiri to Otahuhu Four-track railway from Otahuhu to New Lynn or Henderson Four-track railway Otahuhu to Britomart Grade separation of Westfield for specific moves (and potentially Wiri)	-2	4-track railway from Pukekohe to Wiri 6 track railway between Wiri and Westfield Four-track railway from Westfeild - Newmarket Two-track railway from Avondale-Southdown (NB. 2-track NAL south and NIMT east are sufficient for this concept) Potential grade separation of Westfield for POAL crosstown-shunt
51	Impacts on operating costs (not to be scored, commentary only)							0			Additional Operators required for all day service		Additional Operators required for all day service
52	Comments/notes from discussion	0		0		0		0		0		0	
53	Decision	0		0		0		0		0		0	

APPENDIX F – CRITICAL DIFFERENTIATING ISSUES ANALYSIS

F1 Critical Issues Analysis

To refine the initial list of provisional concepts prior to a full MCA analysis, an analysis was undertaken based critical differentiating issues. **A first principles' approach is adopted by asking the question *'what are the major problems (deficiencies, constraints) that need to be addressed to achieve the future desired benefits of the rail network.*** Identifying these problems and filtering on those with the most potential to differentiate between options, a number potential infrastructure / service solutions are enumerated and analysed with the aim to either rule out options with fatal flaws or establish an order of priority of some options over others. The general process is shown in Figure 0-1 below:

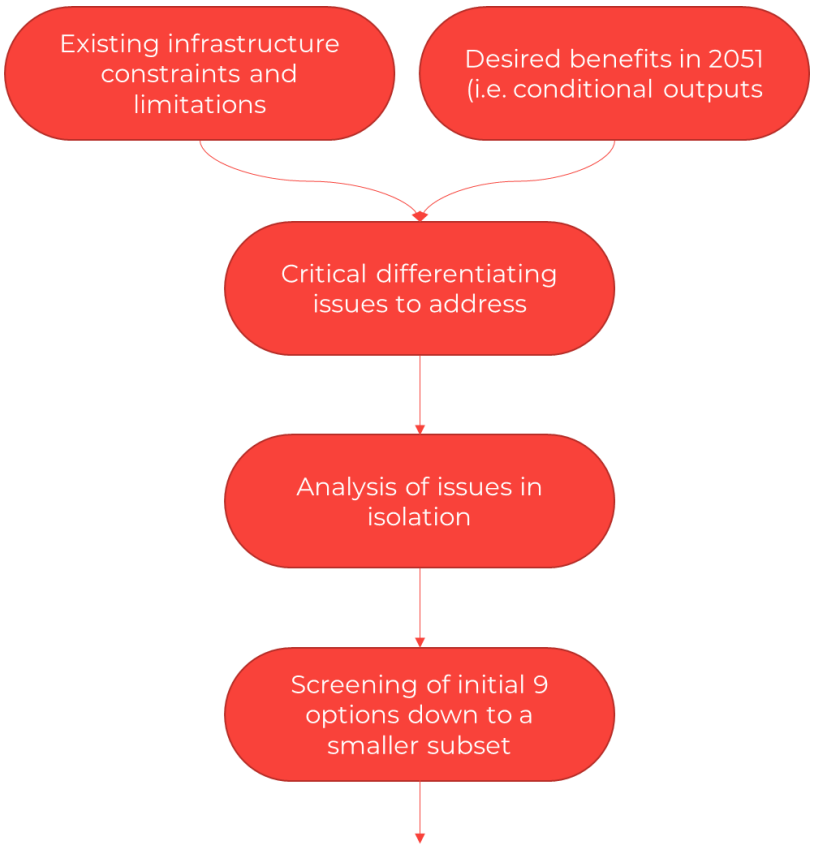


Figure 0-1: Sieving process to narrow down the nine provisional options

F2 Critical differentiating issues

Table 0-1 presents a list of critical issues to be addressed on the network by 2051. This list is a synthesis of the desired benefits which are concretely defined as Conditional Outputs in the Market Study and know constraints of the network which have been identified at a broad level in the Strategic Case and more specifically in memo [1] *Base Network Capacity and Capability*. The most differentiating issues, labeled A through F, are analyzed in following subsections.

Table 0-1: Critical issues for the AMRN in 2051

Ref	Critical Issue	Infrastructure Impact
	Capacity restrictions due to level crossings	Less differentiating
	Platforms only long enough for 6-car trains, whereas 2051 requires 9-car trains	Less differentiating
	Insufficient fleet to meet demand	Less differentiating
	Insufficient stabling to meet demand	Less differentiating
	Signalling system does not support desired levels of capacity (24tph theoretical), and reliability	Less differentiating
A	Insufficient capacity in the southern part of the network to support demands of freight, metro, and inter regional services	More differentiating
B	Inadequate / unreliable freight access from Westfield / Southdown to Northland	More differentiating
C	45min or better journey times to the city centre are not provided from the southern part of the network	More differentiating
D	High utilization of the segment of the network between Wiri to Westfield is likely to result in reliability issues AND restricts access to WPOAL for freight	More differentiating
E	Insufficient capacity on the OBL to run a service of adequate capacity and frequency AND relatedly, lack of a meaningful, frequent crosstown service (especially providing access to Newmarket from the West)	More differentiating
F	Insufficient maintenance access to sustain highly reliable services while maintaining the required level of service	More differentiating
	Presence and location of multiple flat junctions on the network results in an inefficient timetable	Less differentiating

F3 CRITICAL ISSUE A: Insufficient capacity on the south

It is relatively straightforward to demonstrate that four tracking will be required on the southern line to accommodate demand by 2051:

- Base modelling from MSM indicates peak metro service demand will require 13x9-car trains on the southern line (see Attachment B – AM Peak Load Points, Puhunui load point)
- Significant freight demand uplift from the south requires two paths per hour accommodating 1500m train lengths; a 12.5 – 15 minute slot between all-stops metro trains (see memo [5] *Definition of freight paths on the AMRN* for further detail).

- Inter-regional is expected to operate two trains per hour during peak periods between Pukekohe and the CBD.

Based on the max capacity of a single track being 24 tph (i.e. 2.5 min headways) under ETCS L2, a capacity utilization target of 75%, and taking the aggressive assumptions that all metro and inter regional trains require a 1x2.5min slot, and that freight require 5x2.5 minute slots, it can be seen that this demand already exceeds the capacity of a two-track railway:

$$13 + 2 + 2 \times 5 = 25tph > (75\% \times 24 = 18tph)$$

This calculation does not account for the mixing of fast (e.g. inter-regional and metro express) and slow (e.g. all-stops metro) service, which consumes more capacity.

There is potential to consider reducing the number of tracks to three between Pukekohe and Papakura. This should be investigated further as an optimization in later phases of planning and design. Therefore, only one solution is considered acceptable for this issue as shown in Figure 0-2.

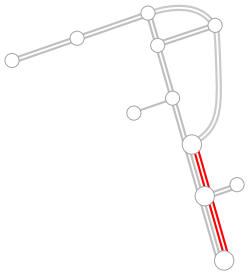


Figure 0-2: Critical issue A - potential solutions

Conclusion: There is insufficient capacity to meet projected demand in 2051 on the southern part of the network. The only viable solution to this capacity problem is to four track the corridor between Pukekohe and Westfield Junction.

F4 Critical Issue B: Inadequate freight access to the north

The Northland freight line runs along the NAL from Westfield Junction to Swanson within the AMRN. The biggest barrier to accommodating this line in the passenger timetable is the small segment of the NAL between Newton and Newmarket junction (N2N) where freight trains have to merge and diverge between red, green, and blue line services, and negotiate the high volume, flat junction at Newmarket. With this in mind, three main solutions have been identified (with a number of variants, discussed later):

1 **Do nothing:** No new track added to the NAL. The critical N2N segment, is managed via timetabling. Coordinating the freight path through this segment places a constraint on the metro timetable, making it less efficient (i.e. introducing buffer) which ultimately leads to slower journey times for customers. The precise nature of the timetable also possess a reliability risk which can however, be mitigated via an enhanced signalling and traffic management system. The mixing of freight and passenger services at RTN frequencies on a two-track railway, also results in an uneven passenger service alternating between 5 and 10min headways.

2 **Avondale Southdown (A-S):** Provides a bypass for freight, critically to avoid the busy N2N section, as well as traffic and steep grades on the NAL on the south. This solution set also provides an opportunity to open a new corridor for passenger services, and increased PT network connectivity. The issue of uneven headways exists in this option but can be eliminated with additional infrastructure intervention (see variants below)

3 **Newton to Newmarket (N2N) Bypass:** A freight only tunnel that bypasses N2N with tie-in locations on the NAL to be determined. This option was originally to four track the entire NAL (see Options Ciii and Dii in the provisional short list) however it is evident that the critical N2N area is heavily constrained by surrounding property, running through a dense area of the city and near/under major elevated motorway structures. Adding 3rd and 4th tracks between N2N would therefore likely require an off-corridor solution which would potentially be significantly shorter than A-S, and therefore cheaper.

Under these high-level options, there are a number of variants to be considered, which center around two separate issues / considerations 1) the ability to run a homogenous metro service (meaning a service with even headways), and 2) the decision on whether to run a passenger service on A-S or treat it as a freight only by-pass. The variants are as follows:

1 Do nothing

N/A

2 Avondale Southdown (A-S):

(a) **Freight only by-pass:** Single track corridor, potentially with a centre siding to support 2 paths per hour.
(b) **Freight by-pass plus new metro service:** Double track corridor to allow an "RTN compliant" service.
(c) **Freight only by-pass, with even metro headways:** Adds four tracks from the A-S junction between Mt Albert and Avondale, to Swanson, thus providing separation between metro and freight on the western line and enabling a homogenous metro timetable. The success of this option in eliminating uneven headways is contingent upon the feasibility of expanding the existing corridor. The major constraints of New Lynn and Henderson possibly call for off-corridor solutions which would make this option clearly unaffordable relative the minor benefit it is attempting to achieve.
(d) **Freight by-pass plus metro service, with even headways:** A combination of b) and c). It is important to note that if AT insists on running an 8tph service on A-S, then this option is basically equivalent to b) as it will force an uneven headway pattern due to metro and freight sharing a 2-track A-S corridor. This option only really works if the service on A-S is limited to 4 tph, which is probably congruent with the expected demand on this corridor. As with option c above, the constraints of New Lynn and Henderson pose a major challenge for this option.
(e) **4 tracking A-S:** A modification to option 2d), adding four tracks to the A-S corridor, in order to provide separation of freight and metro along this corridor, thus allowing a homogenous headway and an 8tph service simultaneously. The current KR land designation clearly will not accommodate four tracks and therefore the cost of aching this would be completely out of scale to the potential benefit.

3 Newton to Newmarket (N2N):

(a) **Freight only by-pass:** A single track diversion accommodating freight only. The exact tie in points for the diversion are still to be determined.
(b) **Passenger service on N2N bypass:** This option, which requires a two track diversion, would skip the key locations of Mt Eden, Newmarket and likely Kingsland, while not picking up any substantial new catchment. It would therefore by of extremely limited additional benefit over option a, so has been ruled out
(c) **Freight only by-pass N2N with even headways:** A modification to option 3a), adding four tracks over the rest of the NAL outside of N2N, to provide separation between metro and freight and enabling a homogenous metro timetable. This option is effectively equivalent to option 2d) but is clearly worse due to the significant additional

corridor expansion required and loss of the A-S corridor as a new passenger catchment, thus failing on cost and benefit in comparison.

Based on discussion with KiwiRail and AT, it was agreed that the base assumption for short list should be to treat A-S as a mixed freight and passenger corridor, with opportunities to revert to a freight only by-pass looked at as a sensitivity in the next phase of the PBC. The rationale for this decision is that it allows the costs and benefits of the new passenger service to be assessed in the short list evaluation, which can then be easily removed to test the alternative scenario later. The A-S freight only options have therefore been taken off the table for this round of optioneering. The final set of seven solutions is illustrated in Figure 0-3.

Conclusion: The issue of unreliable and insufficient freight access on the NAL centres around the Newton to Newmarket (N2N) segment of the corridor where freight trains have to merge and diverge between multiple metro services, and negotiate the high volume, flat junction at Newmarket.

The three main options to address this bottleneck are 1) to accommodate freight on a two track railway via timetabling and precise operation 2) activate Avondale-Southdown as a mixed passenger and freight corridor to bypass N2N, and 3) build a shorter (and cheaper) freight only bypass of N2N, likely a single track tunnel.

In all three of these options, the mixing of freight and passenger services on a two-track railway still occurs at some locations along the NAL, which forces an uneven headway metro (5/10min alternating). To avoid this further problem, additional track can be added to fully separate freight and passenger service on the NAL however the major constraints of New Lynn and Henderson make this a costly solution for relatively minor benefit.

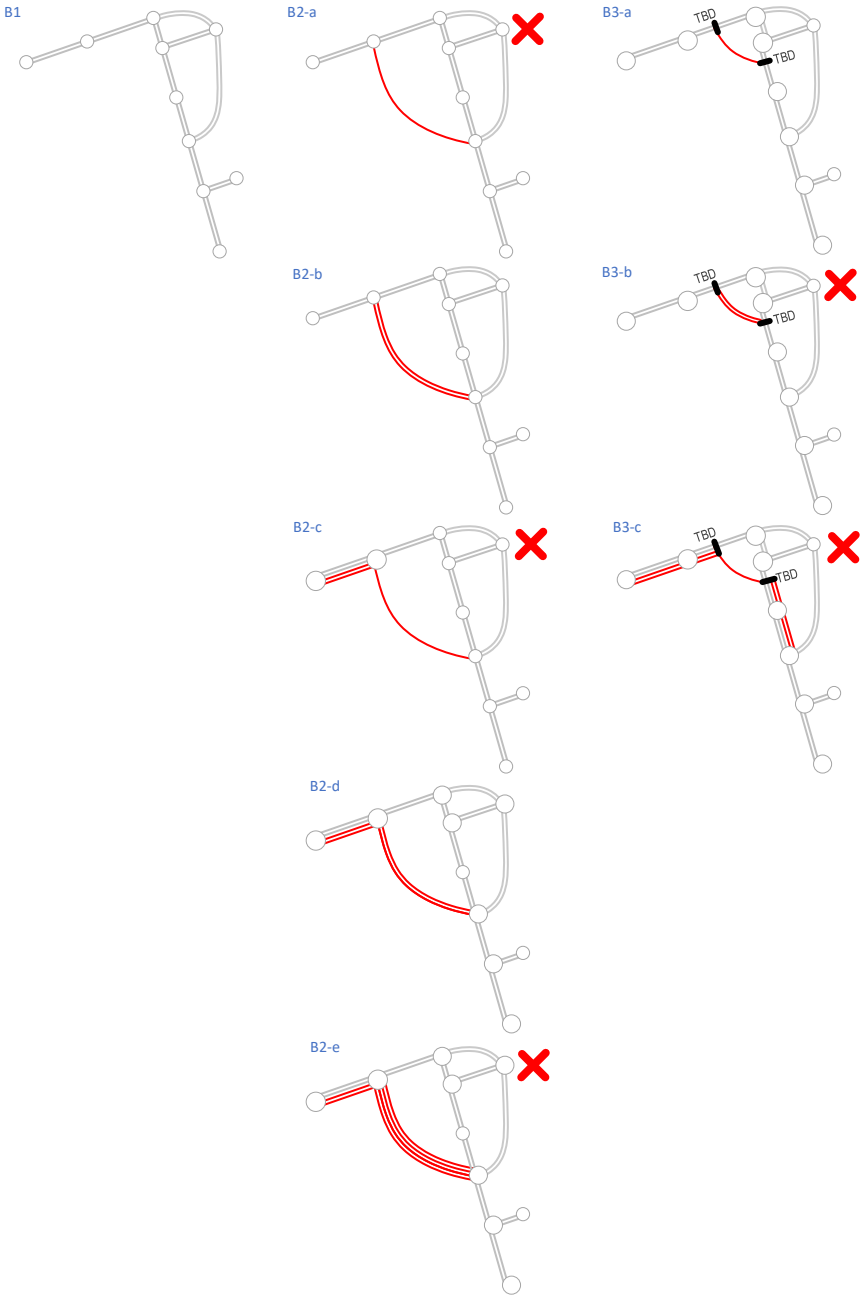


Figure 0-3: Critical issue B - potential solutions

F5 impact of uneven headways

To quantify the issue of uneven headways, further analysis was undertaken to assess whether this regime would pose a capacity risk in trains and on stations.

From a train perspective, under an alternating 5/10min headway, theoretically every second train would be 25% more loaded than if headways were even as illustrated in Figure 0-4 which shows the accumulating passengers at a station between train arrivals. This analysis assumes uniform arrival rate of passengers, and no capacity restrictions at the station or in the train.

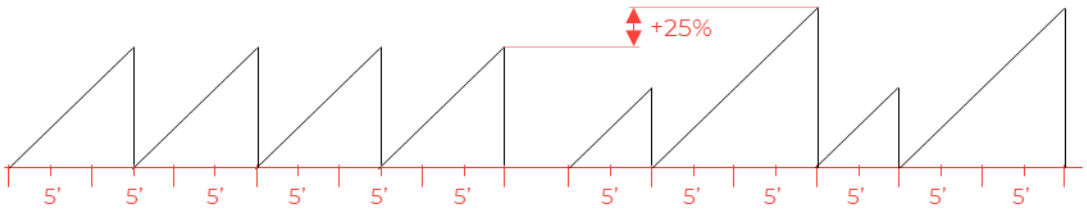


Figure 0-4: Comparison of train loads under even vs. uneven headway

As illustrated in Figure 0-5, on the western line a 25% increase in demand per train would cause standing as far out as Avondale, which is 19min from the CBD according to CRL Day 1 timetable. This marginally fails the 15min standing requirement, but train loading is still well within standing capacity. Note also that travel times on the Western Line are expected to improve by 2051 based on various enhancements. The addition of a 4tph x 6-car crosstown service may mitigate this issue by filling the gaps between CRL bound trains.

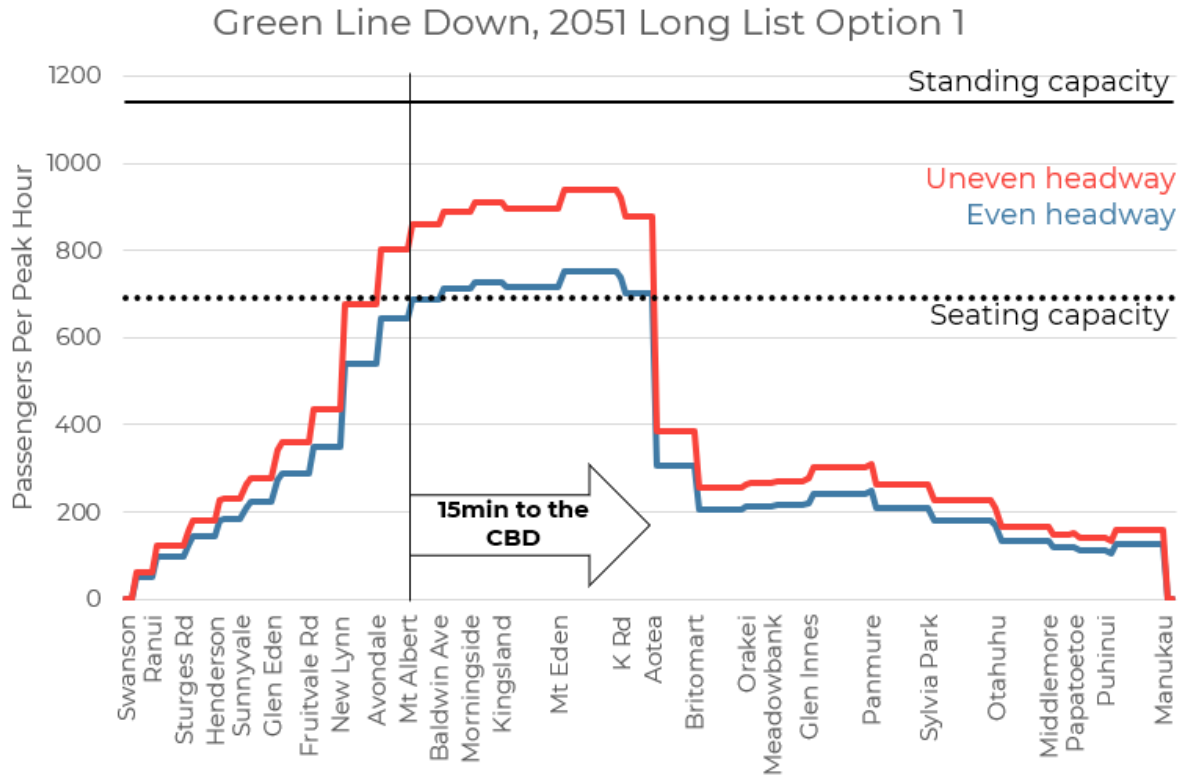


Figure 0-5: Load profile on the Western Line under even and uneven headways

The above example is for the Western Line but similar issues would arise on the Eastern Line and potentially on the Southern Line. However, it is likely to be less critical for these lines as a) the Eastern Line is much shorter and therefore the likelihood of standing for more than 15min is low, and b) on the Southern line there is a higher frequency of service in the peak periods (all-stops + express + crosstown + H2A trains), which would make this issue less pronounced.

Further investigation is required as to the potential impacts of uneven headways on station crowding but from initial review of CRL pedestrian modelling inputs, passenger volume assumptions used in design appear very conservative and therefore this is not expected to cause a significant issue.

F6 Critical Issue C: 45min from the south not achieved

Based on previous analysis (Memo [10] *Southern Line Travel Time Benefits*) it was identified that a 45 min runtime from Pukekohe to the CBD is not likely to be achievable without track speed improvements, however a 45min runtime from Paeraataa (the next station north) could be achievable with a more efficient timetable/operation (eliminating up to 13min of runtime) and an express service (eliminating a further 10min of runtime).[16]

To achieve the 10min express saving in practice, express trains will need to have the ability to pass all-stops metro trains from Papakura to the CBD, and therefore will require four tracks along this entire segment. There are two potential routes the express service can take, one on the NAL and one on the NIMT East which leads to the following potential options:

1 **Four tracks to Westfield only:** This option clearly will not achieve the 45min target but is included for comparison if AT are willing to compromise on this Conditional Output based on cost considerations.
2 **Four tracks on NIMT E:** Provides for an express service on the western line.
3 **Four tracks on NAL S:** Provides for an express service on the inner southern line.
4 **Four tracks on both NAL S and NIMT E:** While possible, the argument against this option is that it is in excess to requirement – quad tracking of one of the corridors will give sufficient capacity to run the levels of express required in 2051, and therefore quad tracking the other would add no real value, for the significant cost increase. Therefore, this option has been discounted (though not precluded from being considered again in the future).

There are of course multiple reasons other than express benefits, to implement the options described above. However, focusing just on the problem at hand, the argument on which option to prefer should ultimately come down to which provides the best travel time balanced against its expected cost (both monetary and environmental/social). On this basis it is relatively straightforward to argue that Option 3; to four track the NAL S should be preferred as it has both the best runtime, due primarily to it providing the shortest route to the CBD, and by the same token, has a lower expected cost as well as less significant constraints as summarized in Table 0-2 below.

Table 0-2: Comparison of infra costs and constraints between NALS and NIMT E 4-tracking

Option	Estimated Cost	Considerations
2. NIMT East four tracking	5,750M NZD (based on an average cost/km)	It is likely to be higher when we take into account the specific challenges on the line, but for optioneering it should be sufficient for relative comparison
3. NAL South four tracking	3,000M NZD (based on an average cost/km)	N/A

Simulations have been run to quantify the benefits of the express service options. As shown in Table 0-3 below, the NAL S route generally has faster runtimes to the CBD depending on whether

[16] The 10min express saving is based on a stopping pattern which calls at all stations from Pukekohe to Papakura, then skips all stations to Newmarket via the NAL with the exception of Puhunui for transfer to the airport link and Manukau.

the train is routed in a clockwise direction (via Grafton) or a counterclockwise direction (via Parnell)[17]. It is also worth noting that the majority of passengers (around 80%) are expected to board and alight at Aotea station.

Table 0-3: Travel time comparison between express services on NAL-S vs NIMT-E

Travel time from Puhunui to...	Via NAL S		Via NIMT E	Delta (NAL S compared to NIMT E)
	Clockwise	Counter-clockwise	Counter-clockwise	
Waitematā (Britomart)	0:22:59	0:19:11	0:18:53	0 - 4min slower
Te Wai Horotiu (Aotea)	0:20:27	0:21:33	0:21:16	0 - 1min faster
Karanga a Hape (K'Road)	0:18:08	0:24:02	0:23:45	0 - 6min faster
Grafton	0:14:51	0:27:33	0:27:15	0 - 12min faster
Newmarket[18]	0:12:05	0:12:05	0:27:15	15min faster

The only potential counter argument in favor of the NIMT East (again with a specific focus on the 45min journey time target) is that the NIMT E option provides a key connection at Panmure to the Eastern Busway. While we cannot quantify the benefits of this transfer at this time (i.e. volume of passengers that would make this transfer), there are 3 ameliorating factors to consider in favor of the NAL South

1 Access to Panmure results in added journey time for the NIMT E option
2 The benefit of taking an express from Panmure to the CBD vs. an all stops train is minimal given its close proximity to the CBD
3 The NAL S route provides a direct connection to Newmarket which is potentially a bigger benefit than serving Panmure.

Taking Option 2 (and Option 4) off the table in this context, does not mean four tracking the eastern line will no longer be considered for any purpose, nor even that express services using the eastern line will no longer be considered (because if four tacking is justified by others reasons then it would only be logical to utilize these additional tracks for an express service). Furthermore, a decision to not four track the Eastern Line in this PBC does in no way preclude this from being implemented in the future.

The four options are summarized in Figure 0-6 below.

[17] As described in memo [4] *Adoption of A8i reduced as a basis for service planning*, the key to maximising network capacity on the AMRN network, post CRL, is to loop the red line in alternating directions around the CRL; clockwise via Grafton and counter clockwise via Parnell.

[18] Note that the NIMT E route will likely not actually have access to a platform face at Newmarket unless upgrades are made to Newmarket station to add a new platform either on the northern or eastern legs of the junction.

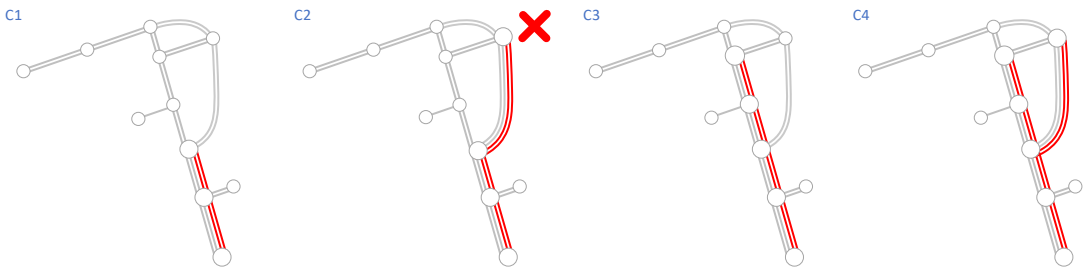


Figure 0-6: Critical issue C - potential solutions

Conclusion: The 45min journey time to the CBD target is not achievable under any option (without track speed upgrades) but express services on the NIMT E or NAL S can get close to this target if four tracking is implemented along these corridors. However, four tracking the NAL S will result in a better travel time to the CBD and is expected to be less costly, therefore this solution should be given preference over the NIMT E.

F7 Critical Issue D: Wiri to Westfield high utilisation

Utilization of the Wiri to Westfield (W2W) corridor is expected to be the most significant issue for the AMRN post construction of CRL. This is because it not only has the highest volume of metro services, due to the inter-lining of the red and green lines but is also the busiest area of the network for freight, with MetroPort and domestic freight from the south, movements between POAL and Wiri, the Northland freight line, and a number of smaller mainline shunting moves, all converging in this small area.

The problem of W2W can be broken into two components. Firstly, metro train volumes required in this area in 2051 cannot be accommodated on a single pair of tracks, while maintaining the 75% capacity utilization target. MSM indicates that 8x9-car tph is required at minimum on the green line, and 13x9-car tph on the southern line, for a total of 21tph. The theorical limit of ETCS Level 2 is 24tph, or 18tph at 75% utilization. This demonstrates the need for 4 tracking W2W, and also suggests the need for metro services (ideally metro express services) to share the western mains with freight in this area in order to reduce utilization on the eastern mains.[19]

On top of this, the second critical component is access for the Port Shunt from the Eastern Line to WPOAL. Early analysis has indicated that it will be practically impossible to grade separate a movement at Wiri Junction to take a freight train from the west side (fast tracks) of the corridor to WPOAL and scheduling this movement across a flat junction would not be feasible given the high volume of conflicting metro traffic. Therefore, the likely best operation will be to keep the port shunt on the east side of the corridor between Wiri to Westfield. KiwiRail have indicated that Port Shunt train may feasibly slot a 5min gap between all-stops metro trains, however this is potentially on the limit of what could be reliably operated in practice (potentially feasible if port shunt trains are ATO enabled along with metro trains).

With this established, 4 potential options have emerged to address this issue in the network

1 **4-tracks Wiri to Westfield:** This concept relies on the port shunt slotting a 5-min gap between the all-stops red and green trains. If the 5min path requirement for the port shunt is correct, then this option can in theory work, but there is a definite reliability risk. Simulation analysis is required to assess this if bought forward to the short list.

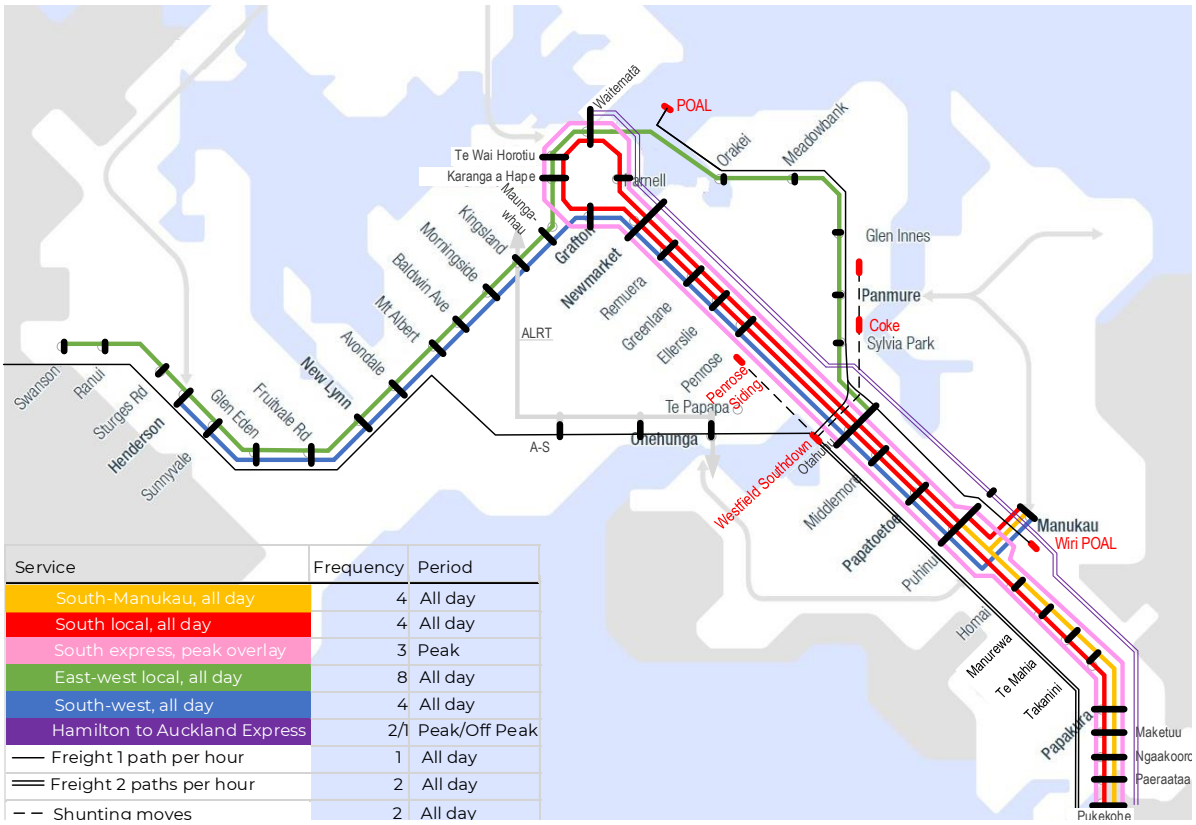
[19] Higher utilization that 75% could also be considered as part of the solution to this problem. This would require implementation of ATO at a minimum.

2 **4 tracks Wiri to Otahuhu and 6 tracks Otahuhu to Westfield:** This infrastructure supports a service where the green line is terminated at Otahuhu, reducing train volumes on the eastern mains between W2W and thereby providing a larger gap for the port shunt. The side benefit of eliminating 2 junctions and a long segment of corridor where the green and red lines conflict is also quite significant in the context of the overall network. However, achieving the reduction in train volumes while maintaining a frequent service to Manukau requires some further service changes including a new south to Manukau service, which will also drive significant upgrade requirements at Puhinui station. This is further discussed below.

3 **6 tracks Wiri to Westfield:** This solves both aspects of the W2W utilization problem, without the service 'compromises' of Option 2 (see discussion below) or the complexity of Option 3. The significant issue with this option however is its engineering feasibility given the tight corroder constraints, and potential cost implications.

(a) **5 tracks Wiri to Westfield:** A potential optimization of the 6-track option would be to provide 5 tracks between W2W with the 5th track dedicated to the port shunt. The concept relies upon a single-track operation for the port shunt in this area and should only be considered if the timetable restrictions imposed by this configuration are a substantial improvement upon lower cost options.

At this point it appears that all four options need to be kept on the table, as summarised in Figure 0-8. It is important to note that Option 2 involves a fairly significant re-structuring of the network service pattern, which will need to be assessed in some detail. This involves the introduction of a Pukekohe to Manukau service which accesses the MBL via a switch back move at Puhinui and the termination of the East-west line at Otahuhu which removes the previous direct connection between Manukau and Sylvia Park / Panmure. Refer to the example service plan shown in Figure 0-7 below.



Service	Frequency	Period
South-Manukau, all day	4	All day
South local, all day	4	All day
South express, peak overlay	3	Peak
East-west local, all day	8	All day
South-west, all day	4	All day
Hamilton to Auckland Express	2/1	Peak/Off Peak
Freight 1 path per hour	1	All day
Freight 2 paths per hour	2	All day
Shunting moves	2	All day

Figure 0-7: Example Service Plan incorporating the Otahuhu and Puhunui turnbacks

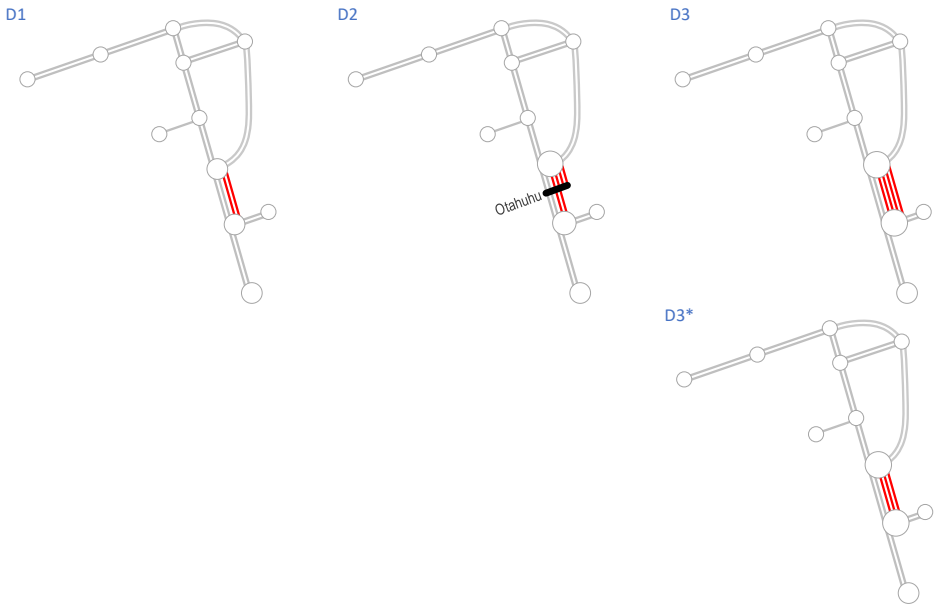


Figure 0-8: Critical issue D - potential solutions

Conclusion: The Wiri to Westfield segment of the network will be a critical capacity bottleneck in 2051 due to a high volume of passenger services, and the requirement to provide access to the WPOAL for the port shunt move, along the eastern side of the corridor (typically designated for passenger services).

Solutions have been identified as 1) four tracking W2W which requires the port shunt slot a potentially insufficient 5 min headway gap, 2) building turn-backs at Otahuhu and Puhinui to reduce metro train volumes between W2W, thus providing a wider headway gap for the port shunt, 3) building 5 tracks to provide a dedicated mainline for the port shunt, and 4) 6 tracking W2W to de-interline the red and green lines while also providing a wider headway gap for the port shunt.

At this time, no options can be obviously taken of the table.

F8 Freight access on NIMT East

At this point it is worth discussing a side topic relevant to this issue. It may be argued that four-tracking the eastern line is required to improve freight access to the port to accommodate growth under some demand scenarios. However, there are a few reasons to suggest that this is not likely required. Firstly, as mentioned the port shunt can slot a smaller headway gap due to its shorter length, more predictable network entry time, and better performance. Secondly, especially in scenarios where express is routed via the NAL, the volume of passenger services on the eastern line is relatively low, which means the port shunt can likely have access to 7.5min or even 10min slots. The combination of these two facts means that accommodating 2 sufficiently sized paths in the passenger timetable per hour, on a two track railway should be relatively straightforward. This then provides significant headroom for future freight growth (currently only 3 of the 48 paths per day is projected to be used in 2051). This issue for the Port Shunt is therefore not on the Eastern Line itself, but rather in the critical W2W area.

Conclusion: From a freight access perspective, a two track railway on the NIMT-E has sufficient capacity to provide reliable access to the port and crosstown shunt moves, due to the ability of these shorter trains to slot a tighter headway gap of 5min.

F9 Critical Issue E: Onehunga capacity and poor crosstown connection

The OBL is a single-track branch line which only supports a 2 x 3-car tph service due it's infrastructure limitations. In 2051, this service will take up valuable capacity on other parts of the network, and will not conform to RTN standards. There are three potential options for dealing with the OBL in the future.

1 **Do nothing:** The OBL continues to exist as is, and the Onehunga service continues to operate 2 x 3-car trains per hour.
2 **OBL Shuttle Service:** The OBL continues to exist as is, but upgrades are undertaken at Penrose station to allow for a shuttle service between Penrose and Onehunga with a cross platform connection to the southern line.
3 **Upgrade the OBL to support 'RTN' service levels:** Based on previous workshops and stakeholder engagement, a 4tph service would be acceptable, according to AT (though I don't understand the logic of what routes get 8 and which can have 4)
4 **Remove the OBL:** And replace with an alternative service.

It is difficult to make a strong argument for upgrading the OBL since it is a service with very low ridership today and is projected to see minimal growth.[20] At the same time, significant infrastructure work would be required to improve capacity to acceptable levels and thus the benefit to cost ratio would likely be very low. The presence of the Onehunga service also consumes capacity on the network which could be used to operate a potentially much more valuable crosstown service with longer trains and high frequencies. And finally, given the planned Auckland Light Rail passes through Onehunga Town Centre and will provide a much high-quality transit service than HR can currently provide, the case for upgrading the line is even less compelling.

On the other hand, closure of a line should be accompanied by the introduction of an alternative transit solution of similar or better quality which is outside the scope of the PBC.

Option 2 is a happy median between all options, as it avoids closure of the line and costly upgrades, while also eliminating the negative impacts of the service to the rest of the network. Improvements to the OBL or removal of the OBL can then be treated independently from the rest of the network, potentially triggered by the introduction of ALRT. It is therefore recommended to take forward Option 2 with other options to be treated as sensitivities in future phases of the study.

The three options are summarized in Figure 0-9 below.

[20] The elasticity of the OBL demand to service improvements have not yet been tested however significant demand uplift is not expected.

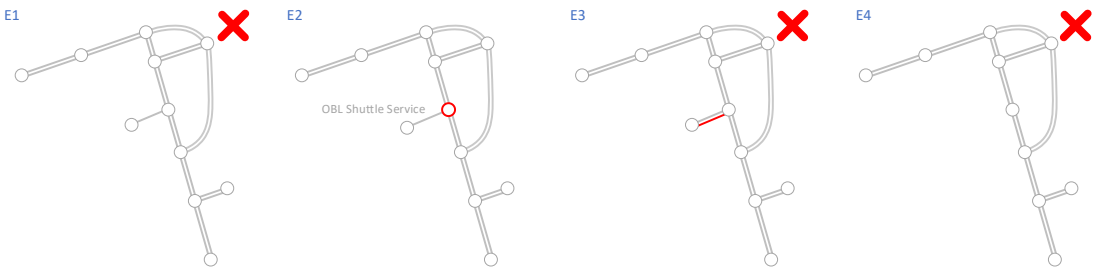


Figure 0-9: Critical issue E – potential solutions

Conclusion: The solution proposed for the OBL is to upgrade Penrose station to allow for a shuttle service between Penrose and Onehunga with a cross platform connection to the southern line. This allows service to continue at 2x3-car tph, without consuming valuable capacity on the main line. The decision to upgrade or remove the OBL should be made at a later date as part of a wider PT network plan.

F10 Critical Issue F: Insufficient maintenance access

The final issue to address is the current state of insufficient maintenance access on the network. In simple terms, improved access is required for maintenance of AMRN to maintain a state of good repair and reliability, while maintaining freight and passenger services at reasonable level of service as often as possible. Addressing this issue will involve a wide range of considerations including providing a greater frequency of walking and vehicle access points, moving to a more proactive maintenance regime generally, new plant / equipment, and critically a work method that allows maintenance to be carried on one main while the other is live, or on two mains while the other two are live (for four track). In the extreme, it has been suggested that four-tracking the entire network would be a viable solution to this problem. Another type of solution that has been discussed previously is to provide diversity of routing such as is provided with the NAL S and NIMT E today. Based on this, three options have been identified:

1 **Do nothing:** No new track, but significant improvement to track access, plan/equipment, planning practices, and developing a work method for 'one line down one line up'.
2 **Four tracking (almost) everywhere:** To allow a pair tracks to be taken out of service for maintenance, while the adjacent pair is used to continue train operations, on all major corridors of the network.
3 **Diverse routing inner, double track outer:** This option has a two track A-S corridor plus four tracking from A-S to New Lynn on the West and from Westfield to Pukekohe on the south. The idea is that a work zone in the centre of the network can be operated around via diverse routes, while a work zone in the outer area of the network can be operated around via an additional pair of mains.
4 **Four tracking everywhere plus A-S:** Like Option 2 but with a four-track A-S corridor.

Based on the likely significant cost of options 2 and 4, and minimal incremental benefit over other options, it is suggested that these options specifically be ruled out. Again, note that this does not mean these infrastructure configurations will no longer be considered for any purpose, and are not precluded from being implemented in the future. The options are illustrated below:

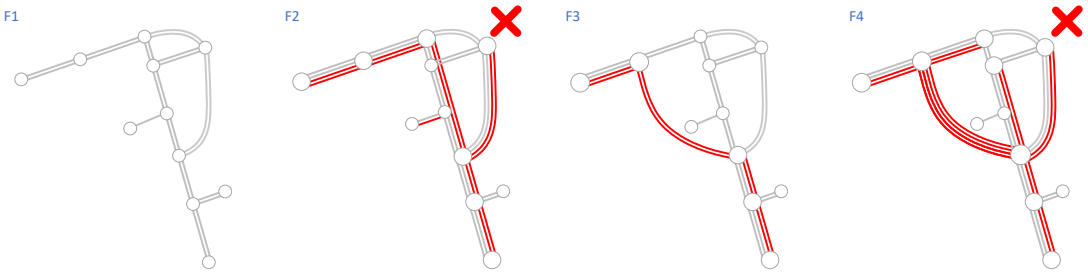
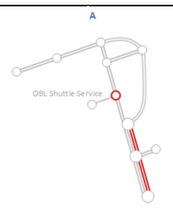
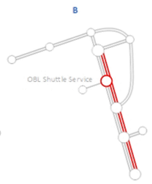
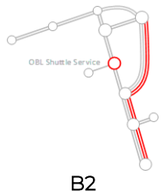
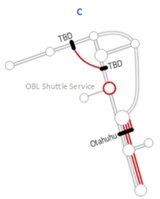
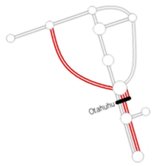
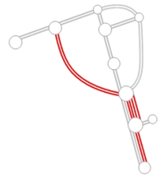
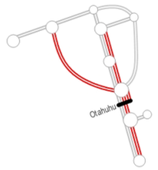
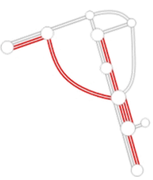
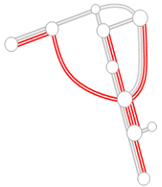


Figure 0-10: Critical issue F – potential solutions

Conclusion: Improving maintenance access on the network while protecting passenger and freight operations to an acceptable level of service and availability, will require a number of improvements in plant, systems, work practices, planning, and infrastructure. From an infrastructure perspective the two main strategies identified are to provide four track corridors (in order to close two tracks for maintenance while continuing operation on the adjacent pair) or provide diversity of routing (where one corridor can be closed for maintenance while continuing operation on an alternative corridor). The solutions proposing to four track most of the network are considered too costly, whereas a combination of both strategies may be feasible.

APPENDIX G – PROVISIONAL SHORT LIST MCA

			A (REFERENCE OPTION)		B1		B2		C1		C2		C3		D1		D2		D3	
																				
#	Investment objectives		Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
	Continually increase the use of rail in Auckland (all markets) over the next 30 years, by increasing its attractiveness (e.g. reliability, frequency, capacity and travel times)																			
	Extent to which the option increases metro passenger rail patronage **(Notes - same conclusions used for attractiveness, pax mode share, road vkt, CO2 emissions, road safety)**	0			2	Approx 6-7% uplift due to express services over Option A	2	Approx 6-7% uplift due to express services over Option A Travel time improvements (relative to B1) not quite as high owing to longer distance (+4km to Aotea)	1	Manukau Branch Line change - likely net negative impact. Increased reliability and associated time saving from separation through Otahuhu-Westfield Likely modest increase in patronage ~3% over Option A	2	Manukau Branch Line change - likely net negative impact. Increased reliability and associated time saving from separation through Otahuhu-Westfield New corridor of A-S provides new catchment and connectivity Likely increase in patronage ~4% over Option A. Better than C1 with addition of A-S	2	New corridor of A-S provides new catchment, plus retntion of Manukau to City service Likely increase in patronage ~5% over Option A. Slightly better than C2 given Manukau retained. Highest reliability through W2W. (2+)	3	All the benefits for metro passengers of B, plus A-S benefits Likely increase in patronage ~9% over Option A	3	All the benefits for metro passengers of B, plus A-S benefits, plus retntion of Manukau to City service Likely increase in patronage ~10% over Option A Slightly better than D1 given Manukau retained. Highest reliability through W2W. (3+)	3	All the benefits for metro passengers of B, plus A-S benefits, plus retntion of Manukau to City service Likely increase in patronage ~10% over Option A Slightly better than D1 given Manukau retained. Highest reliability through W2W. (3+)
	Extent to which the option increases the share of freight moved by rail	0		0	No improvement over A	0	No significant improvement over A. Marginal freight benefits from separation on NIMT E, but doesn't address bottlenecks at Westfield like C/D options	2	Addresses most freight/passenger conflicts - not as flexible due to more mixed use on high use section on NAL S	3	Addresses most freight/passenger conflicts	3	Removes all conflicts, marginally better with W2W 6-track (3+). Complete separation through W2W provides the best reliability	3	Addresses most freight/passenger conflicts	3	Removes all conflicts, marginally better with W2W 6-track (3+). Complete separation through W2W provides the best reliability	3	Removes all conflicts, marginally better with W2W 6-track (3+). Complete separation through W2W provides the best reliability for freight

		A (REFERENCE OPTION)		B1		B2		C1		C2		C3		D1		D2		D3	
		Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
													for freight movements				for freight movements		movements Marginal improvement over D2 for freight on NIMT E
	Extent to which the option improves rail network reliability			1	Impovements through the NAL S, providiny more relaibility options	1	Impovements through the NAL S, providiny more relaibility options	1	Removal of critical conflicts Solves N2N, but retains mixed use on NAL S.	2	Removal of critical conflicts, but still retains more complexity than 6 tracking W2W	3	Provides very high reliability through conflict removal	2	Removal of critical conflicts, but still retains more complexity than 6 tracking W2W	3	Provides very high reliability through conflict removal	3	Provides very high reliability through conflict removal
	The Auckland rail network supports and enables a denser urban form within the metro station catchments within the next 30 years																		
	Extent to which the option increases employment accessibility by public transport (within 30 and 45 minutes travel)			2	Express services extend accessibility by ~10mins	2	Express services extend accessibility by ~10mins Not quite as good as B1 given longer (slightly) travel times via NIMT E	1	Benefits in accessibility for Southern Line through reliability improvement	2	Crosstown service on A-S links South/East to West much better, increasing E-W accessibility Manukau change will have winners and losers (needs further analysis to confirm net effect)	2	Crosstown service on A-S links South/East to West much better, increasing E-W accessibility	3	Express services extend accessibility by ~10mins Crosstown service on A-S links South/East to West much better, increasing E-W accessibility	3	Express services extend accessibility by ~10mins Crosstown service on A-S links South/East to West much better, increasing E-W accessibility	3	Express services extend accessibility by ~10mins Crosstown service on A-S links South/East to West much better, increasing E-W accessibility
	Critical Success Factors																		
5	Potential Achievability/Deliverability (Programme Business Case only)	0		-1	Some challenges widening inner south	-2	NIMT E challenges (causeway, tunnel) and Glen Innes to Mt Wellington	-3	Tunnel complexity and feasibility remains uncertain	-1	Complexity of A-S	-2	6track W2W	-1	Complexity of A-S	-3	New Lynn, Henderson, 6track W2W	-3	New Lynn, Henderson, 6track W2W, NIMT E challenges (causeway, tunnel) and Glen Innes to Mt Wellington
	Opportunities and impacts (insert N/A if not relevant)																		

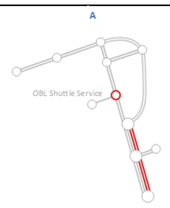
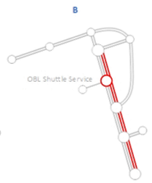
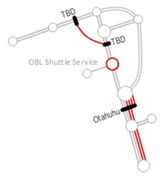
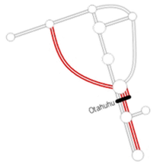
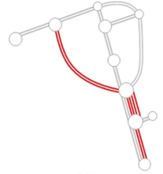
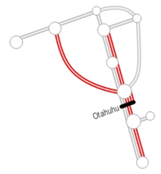
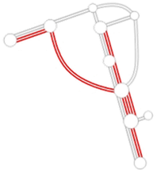
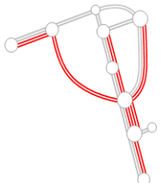
		A (REFERENCE OPTION)		B1		B2		C1		C2		C3		D1		D2		D3	
		Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
6	Environmental effects	0		0	Not too dissimilar to A. Widened tracks adjacent to existing.	-2	NIMT E widening through Hobson Bay and Orakei Basin has sig nifciant environmental concerns	-1	All network in brownfield, new tracks will be adjacent to existing. Further feasibility analysis required on N2N.	-2	All network in brownfield apart from new corridor on existing designation. Potential noise issues and section between Avondale and SH20 is going through a park at north end (top of waterview tunnel)	-2	All network in brownfield apart from new corridor on existing designation. Potential noise issues and section between Avondale and SH20 is going through a park at north end (top of waterview tunnel)	-2	All network in brownfield apart from new corridor on existing designation. Potential noise issues and section between Avondale and SH20 is going through a park at north end (top of waterview tunnel)	-2	All network in brownfield apart from new corridor on existing designation. Potential noise issues and section between Avondale and SH20 is going through a park at north end (top of waterview tunnel)	-3	All network in brownfield apart from new corridor on existing designation. Potential noise issues and section between Avondale and SH20 is going through a park at north end (top of waterview tunnel) NIMT E widening through Hobson Bay and Orakei Basin has sig nifciant environmental concerns
7	Social and cultural impacts	0	TO BE TESTED	1	Improved accessibility (journey time), but avoids any negative impacts by staying in the existing corridor	1	Improved accessibility (journey time), but avoids any negative impacts by staying in the existing corridor	-1	Proximity to Mt Eden cone, potential portal impacts uncertain	1	New catchment offsets potential negative impacts around Onehunga	1	New catchment offsets potential negative impacts around Onehunga	1	New catchment offsets potential negative impacts around Onehunga	1	New catchment offsets potential negative impacts around Onehunga	1	New catchment offsets potential negative impacts around Onehunga
8	Climate Change mitigation (mandatory)	0		3	Higher frequency and express services enabled for local trips and cross town services. Opportunity for all freight to travel at peak time due to all day freight paths. More infrastructure will create high embodied/const ruction carbon but option creates higher mode shift in	3	Higher frequency and express services enabled for local trips and cross town services. Opportunity for all freight to travel at peak time due to all day freight paths. More infrastructure will create high embodied/const ruction carbon but option creates higher mode shift in	1	Exclusion of express services comapred to B2, D series	2	Exclusion of express services comapred to B2, D series Opportunity for A-S to bring more positive impacts for passenger and freight to incentivise mode shift and climate outcomes	2	Exclusion of express services comapred to B2, D series Opportunity for A-S to bring more positive impacts for passenger and freight to incentivise mode shift and climate outcomes	3	Higher frequency and express services enabled for local trips and cross town services. Opportunity for all freight to travel at peak time due to all day freight paths. More infrastructure will create high embodied/const ruction carbon but option creates higher mode shift in	3	Higher frequency and express services enabled for local trips and cross town services. Opportunity for all freight to travel at peak time due to all day freight paths. More infrastructure will create high embodied/const ruction carbon but option creates higher mode shift in	3	Higher frequency and express services enabled for local trips and cross town services. Opportunity for all freight to travel at peak time due to all day freight paths. More infrastructure will create high embodied/const ruction carbon but option creates higher mode shift in

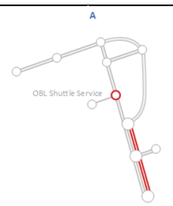
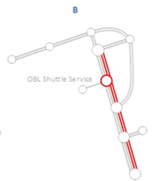
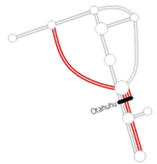
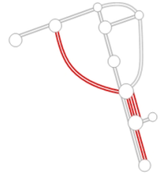
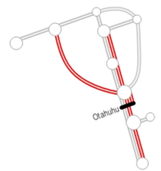
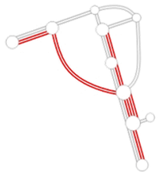
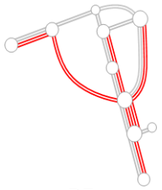
		A (REFERENCE OPTION)		B1		B2		C1		C2		C3		D1		D2		D3	
		Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
					long term which offsets this. IR benefit from travel time savings provides disproportionate benefits		long term which offsets this. IR benefit from travel time savings provides disproportionate benefits								long term which offsets this. IR benefit from travel time savings provides disproportionate benefits		long term which offsets this. IR benefit from travel time savings provides disproportionate benefits		long term which offsets this. IR benefit from travel time savings provides disproportionate benefits
9	Climate change adaptation	0		0	Not too dissimilar to A	1	Potential to improve climate resilience on NIMT E as part of the widening upgrade	0	Not too dissimilar to A	1	Climate resilience through adddition of A-S	1	Climate resilience through adddition of A-S	1	Climate resilience through adddition of A-S	1	Climate resilience through adddition of A-S	2	Climate resilience through adddition of A-S Potential to improve climate resilience on NIMT E as part of the widening upgrade
11	Impacts on Te Ao Māori (Mandatory)	0	TBC Currently more or less mirrors Social/Cultural	1	Improved accessibility (journey time), but avoids any negative impacts by staying in the existing corridor	0	Improved accessibility (journey time), but avoids any negative impacts by staying in the existing corridor Potential negative effects through Hobson Bay, Orakei Basin	-1	Proximity to Mt Eden cone, potential portal impacts uncertain	1	Improved accessibility (journey time), greater catchment and network access, but muted by potential negative cultural impacts for Māori around Onehunga	1	Improved accessibility (journey time), greater catchment and network access, but muted by potential negative cultural impacts for Māori around Onehunga	1	Improved accessibility (journey time), greater catchment and network access, but muted by potential negative cultural impacts for Māori around Onehunga	1	Improved accessibility (journey time), greater catchment and network access, but muted by potential negative cultural impacts for Māori around Onehunga	0	Improved accessibility (journey time), greater catchment and network access, but muted by potential negative cultural impacts for Māori around Onehunga. Potential negative effects through Hobson Bay, Orakei Basin

		A (REFERENCE OPTION)		B1		B2		C1		C2		C3		D1		D2		D3	
		Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
12	Property impacts *(i.e. number or scale of impact, not cost)*	0		-2	Widening the inner south (8.5km) will have considerable property imapcts along route	-2	NIMT E widening will have considerable property effects between Glen Innes and Westfield (7km of 14km total)	-2	Tunnel reduces the property impacts (relative to A-S), but portal strcutures could be significant	-2	A-S designation exists, but still considerable property impacts along the 12km route	-3	A-S designation exists, but still considerable property impacts along the 12km route W2W adds a further 8km of property impacts	-3	A-S designation exists, but still considerable property impacts along the 12km route Widening the inner south (8.5km) will have considerable property imapcts along route	-3	A-S designation exists, but still considerable property impacts along the 12km route Widening the inner south (8.5km) will have considerable property imapcts along route W2W adds a further 8km of property impacts Western Line widening adds a further 16km with soignificnat pinchpoints at New Lynn and Henderson (---3)	-3	A-S designation exists, but still considerable property impacts along the 12km route Widening the inner south (8.5km) will have considerable property imapcts along route W2W adds a further 8km of property impacts Western Line widening adds a further 16km with soignificnat pinchpoints at New Lynn and Henderson NIMT E widening will have considerable property effects between Glen Innes and Westfield (----3)
	Conditional output assessment																		
	All markets																		
3	Peak network capacity utilisation (target <75%)	0		0	No meaningful difference to A	0	No meaningful difference to A	1	Improvement on A, needs further analysis to confirm, not expected to be dramatic differenation	1	Improvement on A, needs further analysis to confirm, not expected to be dramatic differenation	1	Improvement on A, needs further analysis to confirm, not expected to be dramatic differenation	1	Improvement on A, needs further analysis to confirm, not expected to be dramatic differenation	1	Improvement on A, needs further analysis to confirm, not expected to be dramatic differenation	1	Improvement on A, needs further analysis to confirm, not expected to be dramatic differenation. Extent of widening may mean poor utilisation level (ie too low)

		A (REFERENCE OPTION)		B1		B2		C1		C2		C3		D1		D2		D3	
		Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
	Western Line																		
	Metro passenger - Western																		
4	Incremental journey time improvements	0		0	No meaningful difference to A	0	No meaningful difference to A	0	No meaningful difference to A	1	Reliability improvements through greater separation of freight services	1	Reliability improvements through greater separation of freight services	1	Reliability improvements through greater separation of freight services	2	Reliability improvements through greater separation of freight services Delivery of clock face timetable (even headways)	2	Reliability improvements through greater separation of freight services Delivery of clock face timetable (even headways)
	Freight - NAL (Southdown to Whangarei)																		
5	Option provides optimal timetabling with freight destinations (i.e. ports, ferries, logistic industries etc.) *4 trains per day in 2051*	0		0	No difference to A	0	No difference to A	1	Bypass congested N2N section	3	A-S provides greatest bypass on NAL, and extent of removal of mixed section on NAL	3	A-S provides greatest bypass on NAL, and removal of mixed section on NAL	3	A-S provides greatest bypass on NAL, and removal of mixed section on NAL	3	A-S provides separation on NAL to Swanson (3+)	3	A-S provides separation on NAL to Swanson (3+)
	Maintenance																		
6	Option enables 6hrs of productive maintenance per night (on avg) *Western Line*	0		0	No difference to A	0	No difference to A	0	No difference to A New tunnel to maintain, but freight only - low utilisation. Slab track (CRL standard) makes maintenance of tunnel easier.	1	A-S reduces traffic on inner west Plus diversity for routing - ability to maintain operations	1	A-S reduces traffic on inner west Plus diversity for routing - ability to maintain operations	1	A-S reduces traffic on inner west Plus diversity for routing - ability to maintain operations	2	A-S reduces traffic on inner west - but still an issue inner West Plus diversity for routing - ability to maintain operations 4-tracking west of Avondale provides more flexibility for maintenance	2	A-S reduces traffic on inner west - but still an issue inner West Plus diversity for routing - ability to maintain operations 4-tracking west of Avondale provides more flexibility for maintenance
	Eastern Line																		
	Metro passenger - Eastern																		
###	Incremental journey time improvements	0		0	No difference to A	1	Will depend on Express stopping pattern, assuming Panmure only, there will be benefits for	-1	Change to Manukau service degrades this for some trips Impact on passengers to/from Puhinui	-1	Change to Manukau service degrades this for some trips Impact on passengers to/from Puhinui	0	No difference to A	-1	Change to Manukau service degrades this for some trips Impact on passengers to/from Puhinui	0	No difference to A	0	No difference to A (assumes Express trains use NAL S)

		A		B1		B2		C1		C2		C3		D1		D2		D3	
		Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
							metro passengers Panmure - City (remove 3 station stops)												
###	Point-to-point journey times at least as fast as peak period car (85%ile) travel	0		0	No difference to A	0	No difference to A Panmure to city already faster than car	-1	Change to Manukau service degrades this for some trips Impact on passengers to/from Puhinui	-1	Change to Manukau service degrades this for some trips Impact on passengers to/from Puhinui	0	No difference to A	-1	Change to Manukau service degrades this for some trips Impact on passengers to/from Puhinui	0	No difference to A	0	No difference to A
	Freight - Port shunt (POAL to Wiri terminal)																		
9	Option provides optimal timetabling with freight destinations (i.e. ports, ferries, logistic industries etc.)	0		0	No difference to A	1	Separation of freight/all stops metro services provides more flexibility and reliability for freight movements	2	Provides considerable improvement (reliability of freight path through the bottleneck)	2	Provides considerable improvement (reliability of freight path through the bottleneck)	3	Provides greatest removal of conflicts between freight and metro services	2	Provides considerable improvement (reliability of freight path through the bottleneck)	3	Provides greatest removal of conflicts between freight and metro services	3	Provides greatest removal of conflicts between freight and metro services
	Freight - Crosstown shunt (POAL to Southdown)																		
	Maintenance																		
0	Option enables 6hrs of productive maintenance per night (on avg) *Eastern*	0		1	NIMT E maintenance benefit by widening NAL S	1	4-tracking (NIMT E) provides more optionality for maintenance	0	No difference to A	0	No difference to A	0	No difference to A	1	NIMT E maintenance benefit by widening NAL S	1	NIMT E maintenance benefit by widening NAL S	2	NIMT E widening delivers best maintenance benefits for this line. Potential to consider partial widening for maintenance/operational benefits (ie NOT causeway)
	Inner Southern (North of Wiri)																		
	Metro passenger - Inner Southern																		

		A		B1		B2		C1		C2		C3		D1		D2		D3	
																			
		Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
###	Incremental journey time improvements	0		0	Considerable benefits for passengers from Newmarket to South (though not expected to be many people)	0	No meaningful difference to A	1	Some reliability related improvements from removing conflicts around Westfield	1	Reliability improvements through greater separation of freight services on the Inner South (north of Penrose)	2	Reliability improvements through greater separation of freight services De-interlining between W2W	1	Reliability improvements through greater separation of freight services on the Inner South (north of Penrose)	2	Reliability improvements through greater separation of freight services De-interlining between W2W	2	Reliability improvements through greater separation of freight services De-interlining between W2W
	Freight - NIMT line																		
2	Option provides optimal timetabling with freight destinations (i.e. ports, ferries, logistic industries etc.)	0		0	No meaningful difference to A	0	No meaningful difference to A	1	Bypasses congested N2N section Port Shunt benefit in the Eastern Line	2	A-S provides greatest bypass on NAL	3	A-S provides greatest bypass on NAL Complete separation through W2W via 6-tracking	2	A-S provides greatest bypass on NAL	3	A-S provides greatest bypass on NAL Complete separation through W2W via 6-tracking	3	A-S provides greatest bypass on NAL Complete separation through W2W via 6-tracking and separate tracks through to POAL (via NIMT E)
	Maintenance																		
3	Option enables 6hrs of productive maintenance per night (on avg)*Inner Southern*	0		1	4-tracking (NAL S) provides more optionality for maintenance in the Inner South	1	NAL S maintenance benefit by widening NIMT E	0	No meaningful difference to ANew tunnel to maintain, but freight only (low utilisation makes maintenance easier).	0	A-S provides some diversity for routing, but Eastern line already provides this for the Inner South, so the marginal gain is negiligble in practice.	1	A-S provides some diversity for routing, but Eastern line already provides this for the Inner South, so the marginal gain is negiligble in practice.Extent of 6-tracking provides considerable maintenance optionality benefits for this section.	1	4-tracking provides more optionality for maintenance in the Inner South	2	4-tracking provides more optionality for maintenance in the Inner South.A-S benefit is negligible.Extent of 6-tracking provides considerable maintenance optionality benefits for this section	2	4-tracking provides more optionality for maintenance in the Inner South.A-S benefit is negligible.Extent of 6-tracking provides considerable maintenance optionality benefits for this section
	Outer Southern (South of Wiri)																		
	Metro passenger - Outer Southern (Sub-urban)																		

		 A (REFERENCE OPTION)		 B1		 B2		 C1		 C2		 C3		 D1		 D2		 D3	
		Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
###	Incremental journey time improvements	0		2	Approximately 10 mins of benefit through Express section on the Inner South	2	Approximately 10 mins of benefit through Express section on the Inner South	1	Approximately 5-10 mins saving as a result of the reliability related improvements through W2W	1	Approximately 5-10 mins saving as a result of the reliability related improvements through W2W	1	Approximately 5-10 mins saving as a result of the reliability related improvements through W2W	3	Combination of both; potentially up to ~20 mins saved for outer south passengers	3	Combination of both; potentially up to ~20 mins saved for outer south passengers Complete separation through W2W provides flexibility to ensure travel tiome savings (3+)	3	Combination of both; potentially up to ~20 mins saved for outer south passengers Complete separation through W2W provides flexibility to ensure travel tiome savings (3+)
	Freight - NIMT line																		
	Inter-regional																		
5	Incremental journey time improvements			2	Assumes IR trains reroute to Inner Southern, Approximately 10 mins of benefit through Express section on the Inner South. Access to Newmarket for IR trains (highlighted as being desirable)	2	Assumes IR trains use NIMT E, Approximately 10 mins of benefit through Express section on the NIMT E. Similar to B1 from travel time perspective. Lack of Newmarket connection (compared to B1) a slight negative	1	Approximately 5-10 mins saving as a result of the reliability related improvements through W2W	1	Approximately 5-10 mins saving as a result of the reliability related improvements through W2W	1	Approximately 5-10 mins saving as a result of the reliability related improvements through W2W	3	Assumes IR trains reroute to Inner Southern, Combination of both; potentially up to ~20 mins saved for IR passengers	3	Assumes IR trains reroute to Inner Southern, Combination of both; potentially up to ~20 mins saved for IR passengers	3	Assumes IR trains reroute to Inner Southern, Combination of both; potentially up to ~20 mins saved for IR passengers
	Maintenance																		
	Project-specific critical success factors																		
26	Capital cost (Relative to Ref Options A)		Indic. Cost for Option A: $13.6b		Additional indic. cost over Option A: $3b		Additional indic. cost over Option A: $5.8b		Additional indic. cost over Option A: $1.7b		Additional indic. cost over Option A: $4.7b		Additional indic. cost over Option A: $6.7b		Additional indic. cost over Option A: $7.8b		Additional indic. cost over Option A: $15.1b		Additional indic. cost over Option A: $20.8b
	Capital Cost (Total)		13.6		16.6		19.4		15.2		18.3		20.3		21.4		28.7		34.4

APPENDIX H – SERVICE CONCEPT OPTIONEERING – INITIAL PREFERRED PROGRAMME

APPENDIX I - SHORT LIST MCA

	Do Minimum		Option Ai - Minimum investment to meet base demand		Option Ciii - improves passenger journey times and allows for separating freight and passenger services at critical bottlenecks		Option Di - Provides benefits of Ciii + further reliability and service enhancements for all markets	
	Score	Comments	Score	Comments	Score	Comments	Score	Comments
Investment objectives								
Continually increase the use of rail in Auckland (all markets) over the next 30 years, by increasing its attractiveness (eg reliability, frequency, capacity and travel times)								

Extent to which the option increases rail's attractiveness for metro passengers (ie service offering characteristics)	0	DM provides services (Peak//Off-peak):
		West: 8tph // 4tph
		East: 10tph (inc 2 Exp) // 4tph
		Inner South (inc OBL 2tph): 14tph // 10tph
		Outer South: 10tph (inc 2 Exp) // 4tph
		Puke: 6tph (inc 2 Exp) // 4tph
		
		Capacity is exceeded in the peaks, which makes rail an unattractive mode in these times (experience, standing long distances, over crowding).
		Off-peak frequency of 4tph is below desirable levels of service and will fail to attract people to rail to make non-commuting journeys outside the Inner Southern section.
			1	**Add even/uneven headway to the line frequencies**
				
				Ai provides services (Peak//Off-peak):
				West: 8tph // 8tph
				East: 14tph (inc 6 Exp) // 8tph
				Inner South: 8tph // 8tph
				Outer South: 14tph (inc 6 Exp) // 8tph
				Puke: 14tph (inc 6 Exp) // 8tph
				
				Delivers RTN frequency everywhere, all day, with trains running at 7.5min (avg) headway. In practice this is mostly a 5/10 headway to accommodate freight paths. This meets the turn up and go aspiration of an RTN.
				Limitation of Express services to offpeak will reduce the attractiveness of rail for Outer Southern customer catchments.
					3	Ciii provides services (Peak//Off-peak):
						West: 8tph // 8tph
						East: 8tph // 8tph
						Inner South: 14tph (inc 6 Exp) // 14tph (inc 6 Exp)
						Outer South: 14tph (inc 6 Exp) // 14tph (inc 6 Exp)
						Puke: 14tph (inc 6 Exp) // 14tph (inc 6 Exp)
						Plus A-S (New Lynn to TBD): 4tph
						
						Delivers RTN frequency everywhere, all day, with trains running at 7.5min (avg) headway. In practice this is mostly a 5/10 headway to accommodate freight paths. This meets the turn up and go aspiration of an RTN.
						Providing Express services all day will improve the attractiveness of rail for Outer Southern customer catchments.
						Major stations (ie where Express services stop) have very high level of service, increasing viability of rail (and PT) as a viable choice, when connecting with bus services at these interchange locations (eg Otahuhu, Puhinui etc). This increases network attractiveness.
						Inclusion of A-S metro service opens new catchment and can link to ALR for airport precinct access.
						
						Ciii delivers an even headway on the Southern LIne services.
							2	Di provides services (Peak//Off-peak):
								West: 8tph // 8tph
								East: 8tph // 8tph
								Inner South: 14tph (inc 6 Exp) // 14tph (inc 6 Exp)
								Outer South: 14tph (inc 6 Exp) // 14tph (inc 6 Exp) - note 4tph to Manukau
								Puke: 14tph (inc 6 Exp) // 14tph (inc 6 Exp) - note 4tph to Manukau
								Plus A-S (New Lynn to TBD): 4tph
								
								Delivers RTN frequency everywhere, all day, with trains running at 7.5min (avg) headway. In practice this is mostly a 5/10 headway to accommodate freight paths. This meets the turn up and go aspiration of an RTN.
								Providing Express services all day will improve the attractiveness of rail for Outer Southern customer catchments.
								Major stations (ie where Express services stop) have very high level of service, increasing viability of rail (and PT) as a viable choice, when connecting with bus services at these interchange locations (eg Otahuhu, Puhinui etc). This increases network attractiveness.
								Inclusion of A-S metro service opens new catchment and can link to ALR for airport precinct access.
								Compromised service frequency, compared to Ciii, between Otahuhu - Puhinui due to turnback at Puhinui for Manukau-South service (and lack of 6 tracks).
								
								Manukau-South direct service is a new concept, but at 4tph doesn't deliver frequency aspiration. Split pattern for Manukau services only 4tph (4tph to CBD, 4tph to South) doesn't really deliver RTN aspiration. This change will introduce additional transfers for some Southern and Eastern line customers.
								Network more complicated to understand due to Manukau service splits, plus each is only 4tph; an 8tph service with interchange at Puhinui to go South is preferable (as delivered in Ciii) as its simpler to understand and higher frequency.

Extent to which the option increases metro passenger rail patronage *Note: Based on boardings as the metric (see comment in Di)*	0	Annual rail patronage (2051): 55m	2	Annual rail patronage (2051): 72m Additional rail patronage (2051): 16.7m (+30.3%)	3	Annual rail patronage (2051): 77m Additional rail patronage (2051): 22.2m (+40.3%)	3	Annual rail patronage (2051): 78m Additional rail patronage (2051): 23.4m (+42.6%) Additional boardings over Ciii could be due to more forcing of transfers as a result of Manukau service splits
Extent to which the option increases metro passenger rail mode share	0	PT mode share (2051): 14.6% Rail mode share (2051): 3.2%	2	PT mode share (2051): 15.1% (+3%) Rail mode share (2051): 4.1% (+27%)	3	PT mode share (2051): 15.2% (+4%) Rail mode share (2051): 4.4% (+35%)	3	PT mode share (2051): 15.2% (+4%) Rail mode share (2051): 4.4% (+36%)

						Within confines of MSM, the uplift in mode share is considerable.		Within confines of MSM, the uplift in mode share is considerable.
Extent to which the option increases the share of freight moved by rail	0	Rail freight tonne-km (2051): 2b Add national rail mode share	1	Rail freight tonne-km (2051): 4.8b (+140%) Constrained Northland frieght to off-peak only	2	Rail freight tonne-km (2051): 4.8b (+140%) Has additional flexibility for timetabling freight services, especially North in the peak. More flexibility for POAL movements also.	2	Rail freight tonne-km (2051): 4.8b (+140%) As per Cii
Extent to which the option improves rail network reliability	0	The level of maintenance and renewals allowed for will mean compromised reliability across the network. High peak demand will exceed capacity, which makes travel less reliable in the inner parts of the network in particular. Junctions are a major source of reliability issues, where conflicting movements require considerable buffer to be included in the timetable. They are the constraint to reliability and the ability to recover from incidents. Network utilisation is a useful proxy for reliability as it indicates the ability to recover from incidents/delays etc. Utilisation by section is approximately: West: 66% East: % Inner Southern: Outer Southern: Approx. 100%	1	Higher level of maintenance and renewal ensure higher levels of punctuality and reliability across the network, plus improvements to signalling system. Junctions remain the main source of reliability issues in Ai, particularly Newmarket/Newton, Westfield, Wiri. This is exacerbated by the additional services that are introduced. However, enhanced signalling means that most of the increase in services can be accommodated (i.e. enhanced capacity to utilise). Utilisation by section is approximately: West: 50% East: 58% Inner Southern: 75% (at the 'acceptable' limit), with freight confined to off-peak, Express metro peak-only Outer Southern: 83% on the critical W2W section, acceptable south of Wiri. Reliability issues primarily on the Southern line due to high levels of utilisation north of Wiri, but interlining means issues will propagate through the network. Overall, an improved state compared to the Do Min, but service provisions mean limited ability to accommodate further growth.	3	Higher level of maintenance and renewal ensure higher levels of punctuality and reliability across the network, plus improvements to signalling system. Ciii effectively separates the conflicting movements out from constraining junctions, mitigating this issue to a large extent. Utilisation by section is approximately: West: 50% west of Avondale, 33% east of Avondale East: 50% Inner Southern: 66% Outer Southern: 50% - 66% (across the pairs of mains between W2W). High levels of reliability can be achieved, with considerable room to accommodate growth. De-interlining through the junctions means issues will not propagate through the network.	2	Higher level of maintenance and renewal ensure higher levels of punctuality and reliability across the network, plus improvements to signalling system. Di effectively separates the conflicting movements out from constraining junctions at Newmarket/Newton and Westfield. Service pattern changes used to address Wiri constraints. Utilisation by section is approximately: West: 50% west of Avondale, 33% east of Avondale East: 50% Inner Southern: 66% Outer Southern: 50%, with 83% between Wiri and Puhinui. Higher than 'acceptable' through this critical section of the network. High levels of reliability can be achieved, but a critical constraint around Wiri leaves little room to recover from issues. Service pattern reduces the flow on network effects if reliability-related issues occur in this location.
Extent to which the option reduces on road vkt	0	Total AKL road vkt (2051): 15.8b km	2	Total AKL road vkt (2051): 15.7b km Reduction in AKL road vkt (2051): 75m km (-0.5%) Freight-related vkt avoided (2051): 271m km MSM vkt impact appears muted. Potential that car trips still occurring as part of PT trips (eg KnR, PnR). Limitation of modelling approach. Explore ex-post sensitivity for vkt impact (ie additional patronage x avg rail trip distance). Not significant differentiator between options. Considerable reduction in truck-km for freight.	2	Total AKL road vkt (2051): 15.7b km Reduction in AKL road vkt (2051): 91m km (-0.6%) Freight-related vkt avoided (2051): 271m km	2	Total AKL road vkt (2051): 15.7b km Reduction in AKL road vkt (2051): 91m km (-0.6%) Freight-related vkt avoided (2051): 271m km

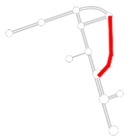
				Note this is network wide, not just within AKL.				
Reduce Auckland's net transport emissions by increasing rail's share of Auckland's transport task over the next 30 years								
Extent to which the option reduces Auckland's net CO2 emissions from transport	0	Total AKL road CO2 (2051): 1.5m TMSM incorporates future fleet conversion to EV, which erodes the magnitude of CO2 emitted from road vkt. This will reduce the CO2 savings in the options for AKL road CO2.Issue still with minor vkt impact. Explore with AFC.	2	Total AKL road CO2 (2051): 1.5m TReduction in AKL road CO2 (2051): 6,700 T (-0.4%)Freight-related CO2 avoided (2051): 16,600 tonnes CO2 directly linked to vkt impact within MSM. Positive net carbon impact from freight mode shift.	2	Total AKL road CO2 (2051): 1.5m TReduction in AKL road CO2 (2051): 8,000 T (-0.5%)Freight-related CO2 avoided (2051): 16,600 tonnes	2	Total AKL road CO2 (2051): 1.5m TReduction in AKL road CO2 (2051): 8,000 T (-0.5%)Freight-related CO2 avoided (2051): 16,600 tonnes
The Auckland rail network supports and enables a denser urban form within the metro station catchments within the next 30 years								
Extent to which the option increases employment accessibility by public transport (within 30 and 45 minutes travel)	0	#Jobs accessible within 30min PT (2051): 56,600 #Jobs accessible within 45min PT (2051): 185,300	1	#Jobs accessible within 30min PT (2051): 59,100 (+4.4%) #Jobs accessible within 45min PT (2051): 198,200 (+7%)	2	#Jobs accessible within 30min PT (2051): 59,900 (+5.9%) #Jobs accessible within 45min PT (2051): 202,700 (+9.4%) Modest improvement over Ai as a result of overall increase in accessibility from improved all day service, and some from A-S.	2	#Jobs accessible within 30min PT (2051): 59,700 (+5.4%) #Jobs accessible within 45min PT (2051): 203,500 (+9.9%) Modest improvement over Ai as a result of overall increase in accessibility from improved all day service, and some from A-S.
Critical Success Factors								
Potential Achievability/Deliverability (Programme Business Case only)	0		0		0		0	
Supplier capacity and capability	0		-3	$17.7B of construction over three decades (50% 2025-2035) in parallel with other major projects, means large competition driving prices up	-3	$26.5B of construction over three decades (50% 2025-2035) in parallel with other major projects, means large competition driving prices up	-3	$27.9B of construction over three decades (50% 2025-2035) in parallel with other major projects, means large competition driving prices up
Scheduling/programming	0		-3	Aligned with "Supplier capacity and capability"	-3	Aligned with "Supplier capacity and capability"	-3	Aligned with "Supplier capacity and capability"
Opportunities and impacts (insert N/A if not relevant)								
Environmental effects	0	No change to existing network – as such no additional environmental effects created.	-2	It may not be possible to provide additional tracks within the existing corridor, and as such a wider railway corridor will need to be formed. Any widening of the corridor will likely generated adverse environmental effects upon the receiving environment. Temporary construction related effects will be experienced along the whole length of the corridor, including noise and vibration, erosion and sediment discharge, dust, reduction in vegetation. The primary operational environmental effect will be increased noise from trains operating over additional tracks, potentially closer to remaining properties. There are a number of streams and potentially wetlands impacted through the greenfield areas of Pukekohe - Papakura	-3	Effects generated will be similar to Option A, however additional environmental effects will be generated due to the construction and operation of the Avondale to Southdown Line. The creation of a new corridor, whilst designated already, will have temporary (construction) and permanent (operational) effects on the environment. Construction of the new line will require extensive civil works, resulting in noise and vibration, erosion and sediment discharge, dust, reduction in vegetation. As the works will relate to the construction of a new alignment, the effects are greater than if it was the widening of an existing corridor. For operational effects, increased noise would be experienced by surrounding properties due to the operation of trains along the alignment. As the alignment is likely to be used for freight movements, trains may operate at night. The visual character of existing residential areas will be changed (around Onehunga), with the provision of railway infrastructure. There could be some large effects on the	-3	This option includes elements of Option Ciii but also results in the widening of the existing railway corridor between Westfield Junction and Newmarket. The likely environmental effects identified in Options A and Ciii will apply to this option. The key difference is the length of corridor impacted. There could be some large effects on the lava caves in Onehunga, as well as the CMA and SEA There could be other effects along the route also (streams, vegetation, earthworks etc) to be assessed at a later date.

						lava caves in Onehunga, as well as the CMA and SEA		
Social and cultural impacts	0	Transport network will not address pax and freight demand. Minimal disturbance to adjacent owners and communities. Immediate community along route less affected. Social impacts along the route largely neutral. But could be negative if wider future city effects considered as congestion and lack of access to education/employment etc and consequences of reduced freight movement is experienced city wide.	-1	All options will require changes to Westfield Junction to provide grade-separation. NZTA East West designation provides for this. Westfield is adjacent to the Coastal Marine Environment (CMA) as well as areas identified as Significant Ecological Areas (SEAs). As such any works to upgrade will likely generate adverse effects · The Designation for East-West Link (Waka Kotahi) has a condition that requires any design to accommodate the future upgrade of Westfield Junction · It is understood that the rail network will be grade-separated, with work undertaken for all options · Cultural effects relating to mana whenua have not been considered Expansion of existing corridor to 4 tracks, limited effects generated. Potential for slight increase in severance issues along corridor. Northern portion Industrial/Southern part largely Residential. Noise mitigation effects.	-2	All options will require changes to Westfield Junction to provide grade-separation. NZTA East West designation provides for this. Westfield is adjacent to the Coastal Marine Environment (CMA) as well as areas identified as Significant Ecological Areas (SEAs). As such any works to upgrade will likely generate adverse effects · The Designation for East-West Link (Waka Kotahi) has a condition that requires any design to accommodate the future upgrade of Westfield Junction · It is understood that the rail network will be grade-separated, with work undertaken for all options · Cultural effects relating to mana whenua have not been considered Similar issues to Option A, but also impacts associated with Avondale-Southdown Line inclusion. Provision of new corridor will need to be grade separately (elevated/trench) to reduce severance effects. Rail corridor will be based around existing designation, resulting in the construction and operation of a railway within an established residential area. Residential land around Onehunga can be developed for medium-intensity development, resulting in an increase in population that may be exposed to adverse effects. Based on current alignment, railway would have impact upon built heritage and natural heritage e.g. lava caves. Alignment adjacent to existing school.	-2	All options will require changes to Westfield Junction to provide grade-separation. NZTA East West designation provides for this. Westfield is adjacent to the Coastal Marine Environment (CMA) as well as areas identified as Significant Ecological Areas (SEAs). As such any works to upgrade will likely generate adverse effects · The Designation for East-West Link (Waka Kotahi) has a condition that requires any design to accommodate the future upgrade of Westfield Junction · It is understood that the rail network will be grade-separated, with work undertaken for all options · Cultural effects relating to mana whenua have not been considered Same issues as Option Ciii in relation to Avondale-Southdown. Existing rail corridor to be widened to 4 tracks between Pukekohe and Newmarket, however 6 tracks to be provided between Otahuhu and Westfield. Six track alignment between Otahuhu and Westfield may be accommodated within existing railway corridor, utilising part of existing sidings. Provision of additional two tracks between Westfield and Newmarket will generate adverse social effects, due to the need to widen the existing railway corridor. Potential for community severance to be exacerbated. If residential land is required for the widened corridor, existing residents will be displaced from the community. Avondale Southdown portion has some complexity - any new corridor is required to be grade separated (elevated/trench?). Significant land take Westfield to Newmarket, compounding issues at major intersections and stations- Greenlane/Ellerslie/Market Rd/ Middlemore. Additional community relocation/displacement Penrose/Nmkt
Climate Change mitigation (mandatory)	0	Preferred programme should test demand against TERP targets (64 per cent reduction in transport emissions by 2030, relative to 2016. VKT in region must reduce by 50% by 2030). Preferred programme and subsequent SSBCs should complete further analysis into mode-shift and VKT reduction. This can be completed using the PEET (project emissions estimation tool) in early stages of business cases.	1	Offers similar VKT reduction to other options. Does not provide separation of freight, therefore does not support mode shift to rail freight. Does not improve inter-regional rail.	2	Offers similar VKT reduction to other options. However, option also provides separation of freight due to new Avondale-Southdown line. This supports improved inter-regional rail and opens up new corridors for further freight mode shift.	2	Same as option Ciii
Climate change adaptation	0	Preferred programme will need to complete further analysis into climate risks. SSBC's in Southdown/Westfield area will need adaptation to sea level rise included in investment objectives.	-1	New infrastructure added to area exposed to sea level rise (Westfield)	-1	New infrastructure added to area exposed to sea level rise (Westfield)	-1	New infrastructure added to area exposed to sea level rise (Westfield)

Cumulative impacts	0	no cumulative impact existing situation	-1	Expansion of corridor width could displace existing land uses and activities adjacent to the railway. Potential for noise and vibration effects to increase and be moved closer to receivers. Visual character of existing corridor will be altered, changing outlook for adjacent properties. Westfield SEA issues/Annes Creek.	-2	Construction and operation of new railway corridor in an existing urban environment. Would likely need to either provide wider corridor to help reduce adverse effects along with other mitigation measures. Despite new railway being grade separated, potential for community severance to be created by placement of infrastructure in environment. Potential of more intense residential development to be located directly adjacent to existing designated corridor. Construction of Avondale-Southdown would result in the loss of informal open space for the local community (despite the land not being officially recognised for that purpose). Consideration is required of effects upon natural environment, as part of existing designation is located within an Significant Ecological Area (near Avondale). Mitigation: greater corridor width and/or seek AUP OP acoustic controls?	-2	Effects of Avondale-Southdown are the same as per Option Ciii. Increase of railways tracks between Westfield and Newmarket will bring railway corridor closer to existing uses/activities. This may result in an increase in noise and vibration effects from railway operations. Otahuhu Stn expansion may be less problematic due to adjacent Ind activity.
Impacts on Te Ao Māori (Mandatory) expected to be scored during next hui	0		0		0		0	
Property impacts *(ie number or scale of impact, not cost)*	0	Minimum land purchase	-2	In south largely residential and FUZ land, some greenfield, some railway sections are 40m wide acting to limit land purchase requirements, more significant residential land takes north of Papakura.	-3	Widening of existing rail corridor, beyond that already shown in Option A, to six track corridor between Westfield and Wiri would impact residential, commercial and recreational land. Existing infrastructure, such as bridges, would need to be re-built/ widened. This is the majority of the impact on the assessment for this option. Majority of Avondale-Southdown corridor owned by KiwiRail, however, potential that designation boundaries may need to be widened to accommodate two tracks in some locations. Effects on THAB zoned land.	-3	Westfield to Newmarket will require expansion of railway outside of existing corridor, resulting in impacts upon adjacent properties along the whole length of alignment. In some locations the rail corridor is directly adjacent to the State Highway network, which expansion into may, or may not be feasible. This is the majority of the impact on the assessment for this option. PLus commentary re Avondale-Southdown for Di.
Impacts on road safety Extent to which the option reduces exposure to road based safety risks	0	Based on modelled VKT and DSI rate DSIs estimate (2051): 599	1	Reflects low reduction in road VKT DSIs estimate (2051): 596 (-0.5%) Additional DSIs avoided from freight mode shift: 12	1	Reflects low reduction in road VKT DSIs estimate (2051): 595 (-0.6%) Additional DSIs avoided from freight mode shift: 12	1	Reflects low reduction in road VKT DSIs estimate (2051): 595 (-0.6%) Additional DSIs avoided from freight mode shift: 12
Conditional output assessment		NOTE. Conditional Outputs are considered in four geographic sections and scores are then averaged as shown below.						
Metro Passenger								
Provide peak period capacity for base demand (metro passenger)	0	Refer CO detail sheet for commentary	1.5	Refer CO detail sheet for commentary	2	Refer CO detail sheet for commentary	1	Refer CO detail sheet for commentary
Maximum length of standing (target <15mins)	0		1		1.25		0.5	
Enable incremental journey time improvements	0		1		2.5		1.5	
Point-to-point journey time comparable to off-peak car trip	0		1		2.5		1.5	
Journey time to central area should not be more than 45mins	0		0.25		0.75		0.75	
Comply with 2018 RPTP RTN aspirations for service: 10 min (or better) minimum frequency between 6am and midnight	0		1		1.25		1	
Freight								
Provide peak period capacity for base demand (freight; # slots)	0	Refer CO detail sheet for commentary	0.75	Refer CO detail sheet for commentary	1.75	Refer CO detail sheet for commentary	1.5	Refer CO detail sheet for commentary

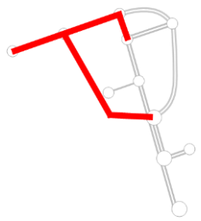
Provide optimal timetabling with freight destinations (i.e., ports, ferries, logistic industries etc.)	0		1		2.25		2	
Enable transition to 1500m freight from south of Auckland to Southdown	0		0.75		0.75		0.75	
Inter-regional								
Provide peak period capacity for base services (interregional passenger; # slots)	0	Refer CO detail sheet for commentary	0.5	Refer CO detail sheet for commentary	0.5	Refer CO detail sheet for commentary	0.5	Refer CO detail sheet for commentary
Enable incremental journey time improvements	0		0.5		0.75		0.75	
Reliability								
Enable 6hrs of productive maintenance per night (on avg)	0	Refer CO detail sheet for commentary	2	Refer CO detail sheet for commentary	2.25	Refer CO detail sheet for commentary	2.25	Refer CO detail sheet for commentary
Enable 30-minute evening service with one main closed (for maintenance)	0		0.5		0.75		1	
Peak network capacity utilisation (target <75%)	0		1		1.75		1.25	
Project-specific critical success factors								
Capital cost (not to be scored - scores to be removed, once RO costs added)	0	Limited new infrastructure needed Replacement rolling stock or major upgrade of first batch of existing rolling stock (late 2040's) Infrastructure renewals Capital cost (rolling stock and infrastructure renewals only): **$1,400M**	0	Four-track railway from Pukekohe to Otahuhu Grade separation of Westfield Junction New rolling stock and depots to provide increased service Upgrades to support 9-car trains Level crossing removal. Capital cost (excl rolling stock and infrastructure renewals): **$19,700M**	0	Four-track railway from Pukekohe to Wiri and **6 tracks Wiri to Otahuhu .** Grade separation of Westfield Junction **New two-track railway Avondale-Southdown** New rolling stock and depots to provide increased service Upgrades to support 9-car trains Level crossing removal. Capital cost (excl rolling stock and infrastructure renewals): **$28,700M**	0	Four-track railway from Pukekohe to Wiri and **6 tracks Westfield Junction-Otahuhu** **Four-track railway Westfield Jcn-Newmarket** Grade separation of Westfield Jcn **New two-track railway Avondale-Southdown** New rolling stock and depots to provide increased service Upgrades to support 9-car trains Level crossing removal. Capital cost (excl rolling stock and infrastructure renewals): **$30,100M**

APPENDIX J – SHORT LIST MCA CONDITIONAL OUTPUT DETAIL

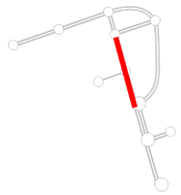
	Do Minimum		Option A - Minimum investment to meet base demand		Option Ciii - improves passenger journey times and allows for separating freight and passenger services at critical bottlenecks		Option Di - Provides benefits of Ciii + further reliability and service enhancements for all markets	
	Score	Comments	Score	Comments	Score	Comments	Score	Comments
Conditional output assessment (Detailed)								
East (Westfield - Quay Park via NIMT East)								
DESCRIPTION (SERVICES \ INFRASTRUCTURE)								
Includes: - Eastern line metro services - Port and crosstown shunt paths Does not include: - H2A services (covered under South (Pukekohe - Westfield)				Two track railway between Westfield and Quay Park via NIMT East		Two track railway between Westfield and Quay Park via NIMT East		Two track railway between Westfield and Quay Park via NIMT East
Metro Passenger								
Provide peak period capacity for base demand (metro passenger)	0	Not accommodated. Demand constrained by ~18% over the entire network	1	Meets peak capacity	1	Meets peak capacity	1	Meets peak capacity
Maximum length of standing (target <15mins)	0	Significant standing is expected. Based on MSM outputs assuming unconstrained demand; standing first occurs at Sylvia park (23min from CBD) and standing capacity is exceeded at Panmure	1	Standing expected starting at Glen Innes. This will be longer than 15min due to significant timetable buffer required to sync junctions potentially up to 18'40". Due to uneven headways every second trains gets 33% more load on avg. which results in longer standing times starting at Panmure. Adding additional trains (+2 tph) to the east-west line not feasible as it would result in 92% utilization Wiri to Westfield	2	Some standing occurs on eastern line starting at around GI. Due to less buffer than Ai - duration of standing expected to be 13'55" (i.e. < 15min). As with Ai - uneven headways causes some trains to have 33% more load on avg. This results in some trains with standing starting at Panmure - 16'32" (i.e. slightly above the 15' target) To mitigate this, 2 additional tph could be added to the east-west line in peak; this appears feasible based on high level timetable sensitivity at an acceptable utilization.	1	Similar timetable buffer will be required to Ai, therefore degree of standing expected to be the same.
Enable incremental journey time improvements	0	Travel time unlikely to improve significantly, and potentially degrades over time as trains become excessively loaded (per point above). Currently planned post CRL travel times for context: - Manukau to Aotea 42min - Panmure to Aotea 21min	1	Travel time improvements can be expected via rolling stock, signalling and TMS upgrades.	3	Est. 7.5min runtime improvements are expected with the elimination of conflicts at Westfield and Wiri, in addition to rolling stock, signalling, and TMS upgrades	1	Travel time improvements can be expected via rolling stock, signalling and TMS upgrades.

Point-to-point journey time comparable to off-peak car trip		Panmure to Aotea. - Car 16-26' - Rail: 21' Manukau to Aotea. - Car: 18-28' - Rail: 42'	0	Panmure to Aotea. - Car 16-26' - Rail: ~ 21' (including ~5' buffer) Manukau to Aotea. - Car: 18-28' - Rail: ~=42' (including ~7' buffer)	3	Per assessment above, significant runtime improvement over Ai due to elimination of junction conflicts. Makes more trips competitive with cars Panmure to Aotea. - Car 16-26' - Rail: ~17' Manukau to Aotea. - Car: 18-28' - Rail: ~34'	0	Similar degree of buffer to Ai - leads to similar performance vs car trips
Journey time to central area should not be more than 45mins		Per data above - Manukau to Aotea is 42' post CRL timetable, with risk that travel time degrades over time due to excessive train loading	0	All options meet this	0	All options meet this	0	All options meet this
Comply with 2018 RPTP RTN aspirations for service: 10 min (or better) minimum frequency between 6am and midnight	0	Not met. 8tph provided in peak direction only, during peak period. Only 4tph provided in off-peak	1	All options meet this, noting that a uneven headway of 5/10' is required to accommodate freight paths	1	All options meet this, noting that a uneven headway of 5/10' is required to accommodate freight paths	1	All options meet this, noting that a uneven headway of 5/10' is required to accommodate freight paths
Freight								
Provide peak period capacity for base demand (freight; # slots)	0	Only accommodated in off peak with a ~10' path	0	Sufficient path provided on Eastern Line (10'), but in the W2W segment can only meet 7.5' path if: - NAL freight limited to off peak - Uneven metro headways on all lines - 6-mains to Otahuhu still needed in order to maintain 1500m depart/arrival roads	2	Exceeds 7.5' requirement - providing 10' paths to port shunts.	1	Sufficient path provided on Eastern Line (10'). Theoretically provides sufficient capacity for port shunt between Wiri and Westfield, but requires precise timetabling. Segment between Wiri and Puhinui in particular will likely require port shunt to slot tight headway gap (between 16tph)
Provide optimal timetabling with freight destinations (i.e., ports, ferries, logistic industries etc.)	0	Only accommodated in off peak with a ~10' path	2	Provides 2 paths per hour all day	3	Provides 2 paths per hour all day, plus resiliency slots	3	Provides 2 paths per hour all day, plus resiliency slots
Enable transition to 1500m freight from south of Auckland to Southdown	0	N/A on Eastern line as port shunt trains limited to 450m - 550m	0	N/A on Eastern line as port shunt trains limited to 450m - 550m	0	N/A on Eastern line as port shunt trains limited to 450m - 550m	0	N/A on Eastern line as port shunt trains limited to 450m - 550m
Inter-regional								
Provide peak period capacity for base services (interregional passenger; # slots)	0	N/A	0	N/A	0	N/A	0	N/A
Enable incremental journey time improvements	0	N/A	0	N/A	0	N/A	0	N/A
Reliability								

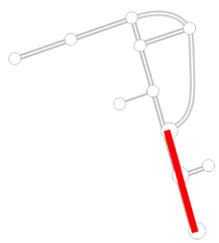
Enable 6hrs of productive maintenance per night (on avg)	0	**Access Strategy:** Planned cyclic maintenance enabled but no investment in sectioning etc results in reduced efficiency **Access Locations:** Six on tracking pads delivered by CRL day one over the entire network **Plant & Equipment:** No new heavy plant allowed for (replacement of existing) **Infrastructure:** Additional crossovers to enable 1/2 hourly service provided by RNIGM	2	**Access Strategy:** Planned cyclic maintenance enabled. Two track railway between Westfield and Quay Park. ½ hourly passenger service enabled from 22:00 with ability of freight to be routed via NAL provides six hours productive maintenance per night. Increased requirement for block of line to enable renewals compared to a four-track section. Reduced overall maintenance access required due to less infrastructure than a four-track section. **Access Locations:** Six on tracking pads delivered by CRL day one and additional six allowed for in each decade (18 total) over the entire network. **Plant & Equipment:** Transition to machine-based maintenance enabled with allowance for replacement of major and minor plant in future decades. **Infrastructure:** Level Crossing at Glen Eden removed eliminating critical failure point. **Data:** Remote monitoring enabled with investment in asset management maturity to enable predictive maintenance.	2	Similar to Ai	2	Similar to Ai
Enable 30-minute evening service with one main closed (for maintenance)	0	Two track railway between Westfield and Quay Park. ½ hourly passenger service enabled from 22:00 for CRL day one by AMTP and RNGIM projects.. Ability for freight to be routed via NAL	0	Two track railway between Westfield and Quay Park. ½ hourly passenger service enabled from 22:00. Ability for freight to be routed via NAL	0	Similar to Ai	0	Similar to Ai
Peak network capacity utilisation (target <75%)	0		1	IF express and IR services routed on eastern line, then utilisation target not met (83%). However this appears to not be feasible. If NAL freight is restricted to off peak only, and express services are limited to peak only, then express services are routed on southern line and utilisation on eastern line will be acceptable (58%) providing significant spare capacity to absorb delay and accommodate growth.	1	Acceptable utilization of 50% providing significant spare capacity to absorb delay and accommodate growth and/or changing service patterns.	1	Similar to Ciii
West (Newmarket - Swanson)								
DESCRIPTION (SERVICES \ INFRASTRUCTURE)								

Includes: - Western line metro services - NAL freight paths - Avondale-southdown metro services Does not include: - Southern line metro services, which overlap between Newton and Newmarket junctions (covered under South | Westfield - Newmarket section)	0			Two track railway between Newmarket and Swanson		Two track railway between Newmarket and Swanson Two (new) tracks between Avondale and Southdown		Two track railway between Newmarket and Swanson Two (new) tracks between Avondale and Southdown
Metro Passenger								
Provide peak period capacity for base demand (metro passenger)	0	Not accommodated. Demand constrained by ~18% over the entire network	1	Meets peak capacity	1	Meets peak capacity Oversuply of capacity for A-S; 4tph @6-car sufficient. Minimal difference between A-S options in Ciii and Di	1	Meets peak capacity Oversuply of capacity for A-S; 4tph @6-car sufficient. Minimal difference between A-S options in Ciii and Di
Maximum length of standing (target <15mins)	0	Significant standing is expected. Based on MSM outputs assuming unconstrained demand; standing first occurs at Fruitvale (22min from CBD) and standing capacity is exceeded at New Lynn	1	Avg. standing expected starting at Baldwin Ave. 11'15" from Aotea.However, due to uneven headways every second trains gets 33% more load, which results in longer standing times starting at New Lynn 19'13" min to Aotea for these trains. Will look for opportunities to reduce degree of uneven headways through S&TC + TMS upgrades	1	Similar to AiNo standing expected on A-S	1	Similar to AiNo standing expected on A-S
Enable incremental journey time improvements	0	Travel time unlikely to improve significantly, and potentially degrades over time as trains become excessively loaded (per point above). Currently planned post CRL travel times for context: - Swanson to Aotea 41min - New Lynn to Aotea 23min	1	Travel time improvements can be expected via rolling stock, signalling and TMS upgrades. - Swanson to Aotea 36min (~5' potential saving) - New Lynn to Aotea 19min (~4' potential saving) However some of this potential saving may not be realised in order to facilitate precise operation through N2N with NAL freight	2	Similar travel time benefit to Ai. Additional benefits can be expected by removal of freight from N2N via A-S bypass, however buffer may need to be added to coordinate movements through A-S junction A-S will improve journey times for some crosstown trips e.g. New Lynn to Sylvia Park	2	Similar to Ciii A-S will improve journey times for some crosstown trips e.g. New Lynn to Sylvia Park (with transfer at Otahuhu)
Point-to-point journey time comparable to off-peak car trip		New Lynn to Aotea. - Car 16-28' - Rail: 23' Swanson to Aotea. - Car: 22-35' - Rail: 41'	2	Rail expected to be relatively competitive to car in all options on south . New Lynn to Aotea. - Car 16-28' - Rail: 19'' Swanson to Aotea. - Car: 22-35' - Rail: 36'	2	Similar to Ai	2	Similar to Ai
Journey time to central area should not be more than 45mins		Per data above - Swanson to Aotea is 41' post CRL timetable, with risk that travel time degrades over time due to excessive train loading	0	All options meet this	0	All options meet this. N/A for A-S	0	All options meet this. N/A for A-S
Comply with 2018 RPTP RTN aspirations for service: 10 min (or better) minimum frequency between 6am and midnight	0	Not met. 8tph provided in peak direction only, during peak period. Only 4tph provided in off-peak	1	All options meet this, noting that a uneven headway of 5/10' is required to accommodate freight paths	1	All options meet this, noting that a uneven headway of 5/10' is required to accommodate freight paths A-S only provides 4tph (not compliant wit RTN aspiration)	1	All options meet this, noting that a uneven headway of 5/10' is required to accommodate freight paths A-S only provides 4tph (not compliant wit RTN aspiration)
Freight								

Provide peak period capacity for base demand (freight; # slots)	0	Only accommodated in off peak, however provides 15' paths	0	NAL freight is restricted to off-peak only i.e. no improvement over DM. Due to increased metro traffic over DM, increase reliability risk for freight, however capacity utilization is low and the risk can be managed via improved signalling and TMS.	2	Freight access is provided all day.	2	Same as Ciii
Provide optimal timetabling with freight destinations (i.e., ports, ferries, logistic industries etc.)	0	Only accommodated in off peak, however provides 15' paths	0	No different than today in terms of flexibility i.e. limited to off peak, but access is more restricted during off peaks per note above	3	Provides 2 paths per hour **all day**, plus resiliency slots. Significant improvement over DM	3	Same as Ciii
Enable transition to 1500m freight from south of Auckland to Southdown	0	N/A on Western line as NAL trains limited to < 750m	0	N/A on Western line as NAL trains limited to < 750m	0	N/A on Western line as NAL trains limited to < 750m	0	N/A on Western line as NAL trains limited to < 750m
Inter-regional								
Provide peak period capacity for base services (interregional passenger; # slots)	0	N/A	0	N/A	0	N/A	0	N/A
Enable incremental journey time improvements	0	N/A	0	N/A	0	N/A	0	N/A
Reliability								
Enable 6hrs of productive maintenance per night (on avg)	0		1	**Access Strategy:** Planned cyclic maintenance enabled. Two track railway between Newmarket and Swanson provides six hours productive maintenance per night. **Available access sections smaller than for a four track railway**Increased requirement for block of line to enable renewals compared to a four-track section. Reduced overall maintenance access required due to less infrastructure than a four-track section.**Access Locations:** Six on tracking pads delivered by CRL day one and additional six allowed for in each decade (18 total) over the entire network. **Plant & Equipment:** Transition to machine-based maintenance enabled with allowance for replacement of major and minor plant in future decades. **Infrastructure:** Level Crossings removed eliminating critical failure point. **Data:** Remote monitoring enabled with investment in asset management maturity to enable predictive maintenance.	2	**Access Strategy:** Planned cyclic maintenance enabled. Two track railway between Newmarket and Swanson and additional two tracks between Avondale and Southdown provides six hours productive maintenance per night. **Available access sections smaller than for a four track railwayAbility to route freight between Avondale and Southdown reduces risk of down time waiting for trains on NAL between Newmarket and Avondale (9 km)** Increased requirement for block of line to enable renewals compared to a four-track section. Reduced overall maintenance access required due to less infrastructure than a four-track section.**Access Locations:** Similar to Ai **Plant & Equipment:** Similar to Ai **Infrastructure:** Similar to Ai **Data:** Similar to Ai	2	Similar to Ciii
Enable 30-minute evening service with one main closed (for maintenance)	0	Two track railway between Newmarket and Swanson. ½ hourly passenger service enabled from 22:00 (in sections of line) for CRL day one by AMTP and RNGIM projects. Nightly freight timetable enabled	0	Two track railway between Newmarket and Swanson. ½ hourly passenger service enabled from 22:00 (in sections of line). Nightly freight timetable enabled	0	Similar to Ai	0	Similar to Ai

Peak network capacity utilisation (target <75%)	0	Current signalling system estimated to be capable of up to 12tph. Peak utilization therefore 8/12=66% i.e. acceptable	1	Signalling improvements will lead to a significant increase in max capacity, and therefore reduce utilization; 50%	2	As with Ai, signalling improvements lead to a significant increase in max capacity. Removing NAL freight further reduced capacity utilization east of Avondale to 33%	2	Same as Ciii
Southern (Newmarket - Westfield)								
DESCRIPTION (SERVICES \ INFRASTRUCTURE)								
Includes: - Southern line metro services, for stations north of Westfield (including Grafton) - Freight shunting to Penrose and Southdown Lane sidings Does not include: - NAL freight path (covered under Western Line section)	0			Two track railway between Westfield and Newmarket via NAL		Two track railway between Westfield and Newmarket via NAL		Four track railway between Westfield and Newmarket via NAL
Metro Passenger								
Provide peak period capacity for base demand (metro passenger)	0	Not accommodated. Demand constrained by ~18% over the entire network	2	Sufficient capacity provided, and service structure results in even loading of trains.	3	Sufficient capacity provided, and service structure results in even loading of trains. Lower capacity utilisation due to W2W should result in ability to scale services to provide more capacity in the future	1	Sufficient capacity provided, however service structure results in uneven loading of trains, which will lead to capacity being maxed out quicker than for other options. Specifically, Manukau-Aotea red services have lower utilization than Pukekohe-Aotea red services: 62% seating vs. 117% seating (73% standing). This is even more pronounced with the Pukekohe to Manukau service - see next section.
Maximum length of standing (target <15mins)	0	Significant standing is expected. Based on MSM outputs assuming unconstrained demand; standing first occurs at Drury South (23min from CBD) and standing capacity is exceeded at Papakura	1	Ai has total capacity to support all demand without standing – however >15min standing does occur on express services, with standing occurring between Papakura and the CBD (around 35min journey time). This standing is the result of a preference for the express service from southern stations and in reality, passengers will have a choice between less crowding and faster travel times.	1	Ciii has total capacity to support all demand without standing – however >15min standing does occur on express services, with standing occurring between Papakura and the CBD (around 35min journey time). This standing is the result of a preference for the express service from southern stations and in reality, passengers will have a choice between less crowding and faster travel times.	0	With Manukau added to the southern line catchment, Di does not provide sufficient total capacity to meet all demand without standing so there will always be some degree of standing in this option, even on the all-stops service. This occurs on express services (similar to Ai and Ciii) but also on the red services starting from Pukekohe, starting at **Homai – failing the 15min standing target**
Enable incremental journey time improvements	0	Travel time unlikely to improve significantly, and potentially degrades over time as trains become excessively loaded (per point above). Currently planned post CRL travel times for context: - Penrose to Aotea 26min - Penrose to Newmarket 11min	1	Travel time improvements can be expected via rolling stock, signalling and TMS upgrades. - Penrose to Aotea 18min (8min saving) - Penrose to Newmarket 9min (3min saving) NB: these savings indicate that additional buffer is included in the post CRL timetable - to be investigated in refinement phase.	2	Similar analysis to Ai, with some additional runtime improvements expected between Westfield and Newmarket with the elimination of conflicts at Westfield and Wiri (in the order of 0.25-1.25min),	1	Similar analysis to Ai Note that 4-tracking the NAL-S results in a theoretical improvement of 3' for express services from the south but this will be captured under the South (Pukekohe - Westfield) section, as stations between Westfield and Newmarket don't benefit from this

Point-to-point journey time comparable to off-peak car trip		Based on express services in current post CRL timetable: Penrose to Newmarket. - Car 9-16' - Rail: 11' Penrose to Aotea. - Car: 10-18' - Rail: 26'	1	Rail expected to be relatively competitive to car in all options on south. Penrose to Newmarket. - Car 9-16' - Rail: ~9' Penrose to Aotea. - Car: 10-18' - Rail: 18'	2	Similar analysis to Ai, with some additional runtime improvements expected between Westfield and Newmarket with the elimination of conflicts at Westfield and Wiri (in the order of 0.25-1.25min),	1	Similar analysis to Ai
Journey time to central area should not be more than 45mins		Post CRL timetable achieves 45' from Westfield	0	All options meet this	0	All options meet this	0	All options meet this
Comply with 2018 RPTP RTN aspirations for service: 10 min (or better) minimum frequency between 6am and midnight	0	Provided all day	0	Ai meets this requirement, however an uneven headway of 5/10' is required to accommodate NAL freight paths	0	Meets requirement with even headways	0	Meets requirement with even headways
Freight								
Provide peak period capacity for base demand (freight; # slots)	0	Shunting moves will be restricted to off peaks with a 10' headway provided between Otahuhu and Penrose. Shunting from Southdown to Southdown Lane siding may need to be done during evenings or nights.	0	With respect freight access to Penrose siding and Southdown lane siding: access is similar to the DM. Infrastructure solutions needed be assessed in refinement phase Note: NAL freight not captured here	0	Similar to Ai	0	Similar to Ai Note; 4-mains do not provide a significant benefit over 2 mains for Penrose siding access, if express trains are operated all day
Provide optimal timetabling with freight destinations (i.e., ports, ferries, logistic industries etc.)	0	Similar assessment to above	0	Similar assessment to above	0	Similar assessment to above	0	Similar assessment to above
Enable transition to 1500m freight from south of Auckland to Southdown	0	N/A	0	N/A	0	N/A	0	N/A
Inter-regional								
Provide peak period capacity for base services (interregional passenger; # slots)	0	N/A	0	N/A	0	N/A	0	N/A
Enable incremental journey time improvements	0	N/A	0	N/A	0	N/A	0	N/A
Reliability								

Enable 6hrs of productive maintenance per night (on avg)	0		2	**Access Strategy:** Planned cyclic maintenance enabled. Two track railway between Westfield and Newmarket provides six hours productive maintenance per night. **Ability to route freight between Newmarket and Westfield via NIMT E reduces risk of down time waiting for trains on NAL** Increased requirement for block of line to enable renewals compared to a four-track section. Reduced overall maintenance access required due to less infrastructure than a four-track section.**Access Locations:** Six on tracking pads delivered by CRL day one and additional six allowed for in each decade (18 total) over the entire network. **Plant & Equipment:** Transition to machine-based maintenance enabled with allowance for replacement of major and minor plant in future decades. **Infrastructure:** Level Crossings removed eliminating critical failure point. **Data:** Remote monitoring enabled with investment in asset management maturity to enable predictive maintenance.	2	**Access Strategy:** Planned cyclic maintenance enabled. Two track railway between Westfield and Newmarket provides six hours productive maintenance per night. **Ability to route freight between Avondale and Southdown reduces risk of down time waiting for trains on NAL** Increased requirement for block of line to enable renewals compared to a four-track section. Reduced overall maintenance access required due to less infrastructure than a four-track section.**Access Locations:** Similar to Ai **Plant & Equipment:** Similar to Ai **Infrastructure:** Similar to Ai **Data:** Similar to Ai	2	**Access Strategy:** Planned cyclic maintenance enabled. Four track railway between Westfield and Newmarket provides six hours productive maintenance per night. **Ability to route freight between Avondale and Southdown reduces risk of down time waiting for trains on NAL** Increased requirement for block of line to enable renewals compared to a four-track section. Reduced overall maintenance access required due to less infrastructure than a four-track section.**Access Locations:** Similar to Ai **Plant & Equipment:** Similar to Ai **Infrastructure:** Similar to Ai **Data:** Similar to Ai
Enable 30-minute evening service with one main closed (for maintenance)	0	Two track railway between Westfield and Newmarket. ½ hourly passenger service enabled from 22:00 for CRL day one by AMTP and RNGIM Projects. Nightly freight timetable enabled and utilises other sections of network	0	Two track railway between Westfield and Newmarket. ½ hourly passenger service enabled from 22:00. Nightly freight timetable enabled and utilises other sections of network	0	Similar to Ai	2	Four track railway between Westfield and Newmarket. Better than ½ hourly passenger service enabled from 22:00. (non-clockface driven by Westfield - Pukekohe section) Nightly freight timetable enabled and utilises other sections of network
Peak network capacity utilisation (target <75%)	0		1	Segment is at 75% utilization - i.e. achieves target but no room for additional growth within planning capacity. This causes an issue for freight access to Penrose and Southdown Lane as described above.	1	Removal of freight from NAL south improves capacity utilization (66%), allowing H2A trains to use the southern line. This issues for freight access to Penrose and Southdown Lane as described above	1	Similar to Ciii
Southern (Westfield - Pukekohe)								
DESCRIPTION (SERVICES \ INFRASTRUCTURE)								
Includes: - Southern line metro services, for stations south of Westfield - NIMT freight - Overall analysis of Wiri to Westfield Does not include: - OBL or Avondale-Southdown services (covered under OBL/A-S section) - Port and crosstown shunt (covered under East section)	0			Four track railway between Westfield and Pukekohe with express, interregional and freight on western side and all stops passenger on eastern side		Six track rail between Westfield and Wiri then Four track railway between Wiri and Pukekohe		Six track rail between Westfield and Otahuhu then Four track railway between Otahuhu and Pukekohe
Metro Passenger								

Provide peak period capacity for base demand (metro passenger)	0	Not accommodated. Demand constrained by ~18% over the entire network	2	Sufficient capacity provided, and service structure results in even loading of trains.	3	Sufficient capacity provided, and service structure results in even loading of trains. Lower capacity utilisation due to W2W should result in ability to scale services to provide more capacity in the future	1	Sufficient capacity provided, however service structure results in uneven loading of trains, which will lead to capacity being maxed out quicker than for other options. Specifically, Pukekohe-Manukau services have low utilization <=24% seating capacity, while Pukekohe-Aotea services are at 117% seating (73% standing).
Maximum length of standing (target <15mins)	0	Significant standing is expected. Based on MSM outputs assuming unconstrained demand; standing first occurs at Drury South (23min from CBD) and standing capacity is exceeded at Papakura	1	Ai has total capacity to support all demand without standing – however >15min standing does occur on express services, with standing between Papakura and the CBD (around 35min journey time). This standing is the result of a preference for the express service from southern stations and in reality, passengers will have a choice between less crowding and faster travel times.	1	Similar to Ai, however standing times expected to be less due to overall faster travel times resulting from 6-track W2W	0	With Manukau added to the southern line catchment, Di does not provide sufficient total capacity to meet all demand without standing so there will always be some degree of standing in this option, even on the all-stops service. This occurs on express services (similar to Ai and Ciii) but also on the red services starting from Pukekohe, starting at Homai (32'28" from Aotea) – failing the 15min standing target
Enable incremental journey time improvements	0	Travel time unlikely to improve significantly, and potentially degrades over time as trains become excessively loaded (per point above). Currently planned post CRL travel times for context: - Pukekohe to Aotea 65min - Papakura to Aotea 46min - Puhinui to Aotea 33min	1	Progressive 4-tracking of NIMT results in significant runtime improvement for express services (est. between 7-8min), and general travel time improvements can be expected via rolling stock, signalling and TMS upgrades for all services. - Pukekohe to Aotea 53min (12min saving) - Papakura to Aotea 35min (11min saving) - Puhinui to Aotea 25min (8min saving)	3	Same benefits as Ai for express services. Further runtime improvements are expected with 6-tracking of Wiri to Westfield which eliminates junction conflicts at Wiri and Westfield; allowing timetable buffer to be removed (est. 2.5-3min).	2	Similar to Ai except that an additional 3min saving is expected for express services. - Pukekohe to Aotea 50min (15min saving) - Papakura to Aotea 32min (14min saving) - Puhinui to Aotea 22min (11min saving)
Point-to-point journey time comparable to off-peak car trip		Based on express services in current post CRL timetable: Puhinui to Aotea: - Car 22-35' - Rail: 33' Papakura to Aotea: - Car 28-40' - Rail: 46' Pukekohe to Aotea. - Car: 40-55' - Rail: 65'	1	Rail expected to be relatively competitive to car in all options on south. Note that below runtimes are based on express services. Puhinui to Aotea: - Car 22-35' - Rail: 25' Papakura to Aotea: - Car 28-40' - Rail: 35' Pukekohe to Aotea. - Car: 40-55' - Rail: 53'	3	Similar analysis as Ai for express. However, all-stops services are generally faster in this option due to W2W 6-tracking eliminating junction conflicts - making this option better for local trips; and thus potentially more car competitive than Di, even though Di has faster express travel times EXPRESS SERVICE AVAILBILITY ALL DAY	3	Similar analysis to Ai but with additional (~3min) runtime benefit for express services. Note that below runtimes are based on express services. Puhinui to Aotea: - Car 22-35' - Rail: 22' Papakura to Aotea: - Car 28-40' - Rail: 32' Pukekohe to Aotea. - Car: 40-55' - Rail: 50'
Journey time to central area should not be more than 45mins		Post CRL timetable achieves 45' from Takanini	1	Express services provide a 53' runtime from Pukekohe to Aotea, 45' runtime from Drury West to Aotea, or from Pukekohe to Newmarket. Note that express services will not be possible in off-peak periods under this option.	3	Same as Ai expect express CAN be operated all day	3	Express services provide a 50' runtime from Pukekohe 45' runtimes are achieved from Paerata to Aotea. Express services CAN be operated all day

Comply with 2018 RPTP RTN aspirations for service: 10 min (or better) minimum frequency between 6am and midnight	0	Not met south of Puhinui station (only 4tph provided off peak)	2	Ai meets this requirement, however an uneven headway of 5/10' is required to accommodate freight paths.	3	Meets requirement with even headways on the southern line	2	Meets requirement however uneven headways are likely required south of Wiri due to merging of Pukekohe-Manukau services with Manukau to Aotea services (these two services overlap between Wiri and Puhinui, therefore forcing an offset pattern). 2x 4tph service (all stop services in this section), as opposed to 8tph.
Freight								
Provide peak period capacity for base demand (freight; # slots)	0	Only accommodated in off peak, however provides 15' paths	3	Based on timetable analysis, all options are expected to provide 2 10' paths per hour on fast tracks + 2 10' resiliency slots;	3	Per Ai	3	Per Ai
Provide optimal timetabling with freight destinations (i.e., ports, ferries, logistic industries etc.)	0	Only accommodated in off peak, however provides 15' paths	2	2 slots per hour over the entire day provide sufficient flexibility and serves southern line freight customers	3	2 slots per hour over the entire day provide sufficient flexibility and serves southern line freight customers	2	2 slots per hour over the entire day provide sufficient flexibility and serves southern line freight customers
Enable transition to 1500m freight from south of Auckland to Southdown	0	N/A on Western line as NAL trains limited to < 750m	3	All options to accommodate this	3	All options to accommodate this	3	All options to accommodate this
Inter-regional								
Provide peak period capacity for base services (interregional passenger; # slots)	0	Post CRL timetable provides 2 paths per hour in peak for H2A - however significant risk that this would result in degraded OTP performance if every slot is actually utilised.	2	Sufficient paths provided (2 per hour)	2	Sufficient paths provided (2 per hour)	2	Sufficient paths provided (2 per hour)
Enable incremental journey time improvements	0	No journey time improvements possible, and risk of degraded journey times with excessive train loading	2	Routing on NAL provides better journey times and access to Newmarket as well as Auckland central stations (Britomart or Strand). Buffer required to coordinate movements at Wiri and Westfield will add some runtime to this service over option Ciii	3	Routing on NAL provides better journey times and access to Newmarket as well as Auckland central stations (Britomart or Strand)	3	Routing on NAL provides better journey times and access to Newmarket as well as Auckland central stations (Britomart or Strand). Additional travel time benefit due to 4-tracks (~3min)
Reliability								
Enable 6hrs of productive maintenance per night (on avg)	0		3	**Access Strategy:** Planned cyclic maintenance enabled. Four track railway between Westfield and Pukekohe provides six hours productive maintenance per night. **Four track railway reduces risk of down time waiting for trains compared to two tracks railwayAccess Locations:** Six on tracking pads delivered by CRL day one and additional six allowed for in each decade (18 total) over the entire network. **Plant & Equipment:** Transition to machine-based maintenance enabled with allowance for replacement of major and minor plant in future decades. **Infrastructure:** Level Crossings removed eliminating critical failure point. **Data:** Remote monitoring enabled with investment in asset management maturity to enable predictive maintenance.	3	**Access Strategy:** Planned cyclic maintenance enabled. **Six track rail between Westfield and Wiri** then Four track railway between Wiri and Pukekohe provides six hours productive maintenance per night. **Four/six track railway reduces risk of down time waiting for trains compared to two tracks railwayAccess Locations:** Similar to Ai **Plant & Equipment:** Similar to Ai **Infrastructure:** Similar to Ai **Data:** Similar to Ai	3	**Access Strategy:** Planned cyclic maintenance enabled. **Six track rail between Westfield and Otahuhu** then Four track railway between Otahuhu and Pukekohe provides six hours productive maintenance per night. **Four/six track railway reduces risk of down time waiting for trains compared to two tracks railwayAccess Locations:** Similar to Ai **Plant & Equipment:** Similar to Ai **Infrastructure:** Similar to Ai **Data:** Similar to Ai

Enable 30-minute evening service with one main closed (for maintenance)	0		2	Four track railway between Westfield and Pukekohe. **Better than ½ hourly passenger service enabled from 22:00 (non-clockface)** 3rd and 4th main provide access for nightly freight timetable and enable 24/7 passenger operation (**less than RTN frequency**)	3	Six track rail between Westfield and Wiri then Four track railway between Wiri and Pukekohe. **Better than ½ hourly passenger service enabled from 22:00 (clockface)** Dedicated track for freight between Otahuhu and Wiri provides access for nightly freight timetable and enable 24/7 passenger operation (**close to RTN frequency**)	2	Similar to Ai
Peak network capacity utilisation (target <75%)	0	Wiri to Westfield: up and down mains operate at around 100% capacity in peak: - Signalling system capable of 20tph between Westfield and Otahuhu and 16tph between Wiri and Otahuhu. - Train volumes are 22tph and 18tph between these sections respectively, during peak period - Utilization is then 110%-112% - and this doesn't capture empty movements, and the TeHuia service.	1	4 mains provides a significant improvement to utilization Wiri to Westfield; however east mains are still at 83% capacity (and potentially higher given that this doesn't include empty moves), failing the 75% target, Option also places significant constraints on Westfield and Wiri junctions to accommodate the port shunt. South of Wiri; both east and west lines have acceptable utilization.	3	Significant improvement in capacity and reliability; east mains at 50%, centre mains between 33%-66% and west mains at 58%	1	Eastern mains have acceptable utilization in theory - 50%, however section between Puhinui and Wiri has 83% and significant complexity with turnbacks to/from MBL.