Network Resilience Study Output Report

Avondale-Southdown Project, 2025-26

Prepared by WSP
Workstream: Resilience

KiwiRail

About the Avondale-Southdown rail corridor

The Avondale-Southdown rail corridor will play a key role in transforming both passenger transport in Auckland and freight movement in New Zealand.

Acquired in the 1940s as part of an expansive rail plan for the city, the 13km east-west ribbon of land was intended to be developed for both passengers and freight. Substantial efforts over the last 80 years have ensured the route remains allocated for rail and an option for future.

The 30-year Strategic Rail Programme, launched at the end of 2023 by KiwiRail and Auckland Transport, clearly identified the Avondale-Southdown development as a critical part of Auckland's and New Zealand's future rail network, required in the next 15-20 years. The programme details the upsides of bypassing freight around the city centre (including reducing congestion), the benefits that the wider metro network gains from the addition, and the communities that would become better connected for future.

The potential line's inclusion on the Government's Fast-Track Approvals list in 2024 further reinforced the importance for this rail connection – often called "Auckland rail's missing limb".

Across 2025 and 2026 our Strategic Metro Investments team, with the help of expert agencies and consultancies, is undertaking the most thorough feasibility and scoping study of the rail corridor to date. Their primary objective is to protect the existing rail designation, which is due to lapse in 2029, and to progress initial planning. Additionally, they'll be engaging with key stakeholders and compiling information about the corridor development opportunity.

While not yet funded, the overarching vision is to build the line and deliver the many benefits of improved rail infrastructure - for local communities, for Auckland, and for New Zealand - for generations to come

Find out more on our website: www.kiwirail.co.nz/avondale-to-southdown

About this report

KiwiRail commissioned engineering consulting firm WSP to undertake a dedicated study of network resilience. It was created to understand the operational benefits right across the isthmus that this strategic link could deliver, under both normal and degraded conditions of the Auckland metro rail network. This workstream forms part of KiwiRail's broader programme to protect the existing Avondale-Southdown designation and develop a robust case for future investment.

The study focuses on the corridor's potential to improve network resiliency, capacity, and flexibility, particularly in the context of Auckland's growing metro, freight, and inter regional rail demands.

The report evaluates how A S could enhance service reliability, support higher train frequencies, and provide alternative routing options during planned maintenance or unplanned disruptions. It outlines the methodology applied, key assumptions, and the results of technical assessments, including capacity modelling and scenario testing.

Most importantly, it demonstrates the extent to which AS strengthens Auckland's rail network performance and underpins long term transport objectives.

The results in short: The incorporation of the Avondale-Southdown rail corridor to Auckland's isthmus rail network would unlock up to 32% extra capacity on the inner network – an increase that could otherwise only be achieved via substantial investment in widening those inner network corridors. It would improve network reliability (which will otherwise come under pressure due to sustained periods of demand at or in excess of available capacity), and would transform network performance during disruptions by providing alternative routings and faster recovery options.

Confidential

KiwiRail

Avondale - Southdown Rail Corridor

Resilience Study Output Report

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Avondale - Southdown Rail Corridor

Resilience Study Output Report

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EXECUTIVE SUMMARY

Avondale-Southdown (A-S) is a proposed **13km cross-city** rail link in Auckland between Westfield Junction on the North Island Main Trunk (NIMT) and just east of Avondale station on the North Auckland Line (NAL).

Initial proposals for the A-S corridor date back to the 1940s, and since then, KiwiRail has progressively acquired and held land along the designated route specifically for this future connection. More recently, the corridor was identified as a critical component in the Auckland Rail Programme Business Case (AR-PBC, 2023) - a 30-year investment strategy for Auckland's rail network.

Following on from the AR-PBC, KiwiRail is now progressing further work to support the extension of the corridor's designation lapse date and to lay the groundwork for its eventual delivery. A key element of this work is to develop a more comprehensive understanding of the corridor's potential benefits, which can inform a future investment case.

This study focuses specifically on the resiliency benefits that the A-S corridor offers to the wider Auckland-isthmus rail network; particularly the extent to which it **enhances capacity, reliability, and flexibility** for running additional services, including under degraded operations and during planned maintenance periods. These benefits are broadly grouped under the umbrella term 'Resiliency'.

CONTEXT OF THE NETWORK AND FUTURE GROWTH

The Auckland rail network services three primary markets that serve both regional and national needs:

- **Intra-Auckland metro passenger services**, primarily focused on Auckland's city centre; the backbone of the Rapid Transit Network for New Zealand's largest city which is home to around one third of the national population,
- **Inter-regional commuter and tourism services**, providing vital passenger connectivity to and from Hamilton and Wellington, and
- **Inter-regional/national rail freight**, a critical component of the national freight supply chain, imports, exports, and the national economy.

Together, these markets connect the nation's ports, industries, and major population centres. The **capacity, reliability** and **resiliency** of the Auckland rail network therefore carries significant national importance, with performance directly influencing economic productivity and travel demand across the upper North Island.

Across all three markets, future demand is expected to increase, and this growth is likely to concentrate on the Inner Network - the portion of the system roughly bounded by New Lynn in the west, Panmure in the east and Otahuhu in the south.

METRO DEMAND GROWTH

Recent modelling has indicated that the inner sections of the Eastern and Western lines will reach capacity first. The section between New Lynn ↔ CBD and Panmure ↔ CBD are expected to experience:

- High levels of crowding
- Potential platform passenger "left-behind" events
- Increasing pressure on Southern Line capacity, particularly for trains originating at Pukekohe

Crowding intensifies toward the city centre, indicating that additional train paths and higher reliability will be required to meet long-term metro demand.

FREIGHT DEMAND GROWTH

Forecasting freight growth is inherently uncertain due to global supply chain dynamics, economic conditions, and port activity. However, in Auckland the import/export freight task represents a major growth opportunity for KiwiRail.

The AR-PBC outlined bookend scenarios for Northport freight ranging from:

- **3 tpd** - representing continuation of current patterns
- Up to **15 tpd** - under scenarios where Northport takes on increasing import/export activity

Actual future demand will likely fall between these extremes. However, several recent developments suggest the upper range is increasingly plausible, including:

- Changes in Northport's ownership structure, increasing alignment with Port of Tauranga[1]
- Northport Expansion consents being granted[2]
- Central government support for advancing the Marsden Point Rail Link[3]

Based on operational analysis undertaken for the AR-PBC, growth beyond **5-7 tpd** would likely require freight services to operate during high-density metro periods. This would place significant pressure on the Inner Network, especially at Newmarket Junction.

INTER-REGIONAL PASSENGER DEMAND

Inter-regional travel also has strong potential for growth. The success of Te Huia and the government's commitment to procure new long-distance passenger rolling stock for the Lower North Island indicate emerging demand for a revitalised North Island inter-regional rail network.

Future inter-regional trains will ideally serve both The Strand and Newmarket, enhancing regional mobility and enabling high-quality transfers to the wider Auckland public transport system.

FUTURE NETWORK CAPACITY, PRE-A-S

To meet future demand across all service markets, rail operations will need to continually evolve. For freight, this will require an increase in the number of available freight paths within the timetable, ultimately resulting in freight services operating during metro peak periods. For metro, meeting demand will require both peak and all-day frequency increases. The same is true for inter-regional services, which also require improved access to the wider Auckland rail network.

In **Section 3**, an illustrative pre-A-S service concept was developed to satisfy these demands[4]. Key aspects of the service concept are:

- Providing **8 tph** on the East-West line (E-W) all day and enabling the Onehunga Branch Line to run all day rather than off-peak only (as per the current CRL timetable).
- Introducing a new **4 tph** inner E-W line service to accommodate increasing demand on the Inner-Network
- Providing all-day freight paths on the Northern Freight Line.

[1] *https://www.nrc.govt.nz/news/2025/may/consortium-buyout-of-mmh-strongly-supported-by-shareholders/*

[2] *https://northport.co.nz/node/24236*

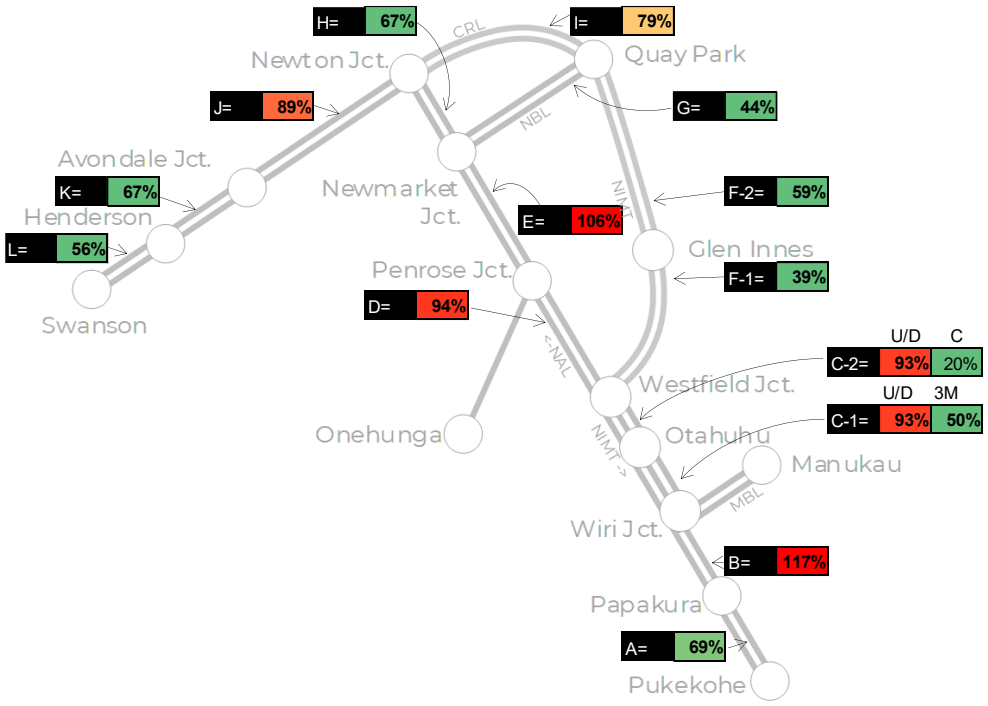
[3] *https://www.beehive.govt.nz/release/northland-new-zealands-economic-powerhouse*

[4] *This builds upon the current post-CRL timetable concept which consists of three main lines; The East-West line (E-W line) that runs from Swanson to Manukau through the CRL, the South City line (S-C line) that runs between Pukekohe and the city centre, and the Onehunga West line (O-W line) that runs from Henderson to Onehunga via Newmarket.*

- Incremental improvements on the South city line (S-C), including increasing Papakura starter services **from 2 to 4 tph** relative to the CRL Day One timetable.
- Re-routing inter-regional services to use the NAL between Westfield and Newmarket junctions to provide better access to the network with a new stop at Newmarket.

A capacity utilisation assessment was then undertaken for this illustrative concept. The approach is based on the **UIC 406 Leaflet** on Capacity, which provides a methodology for measuring rail capacity and recommended utilisation thresholds that represent acceptable levels of service. The framework helps identify the utilisation "sweet spot" for a typical passenger railway, balancing capacity supply and service quality based on international experience on dense European networks.

The results of the analysis are summarised in **the figure below**. Here, a **value of 100%** represents maximum reliable utilisation. A value of **less than 100%** indicates room to grow while a value of **greater than 100%** indicates potential reliability issues and suggests the need to reduce the timetable. In reality the threshold for reliable operations is not precise and depends on particularities of the network, its operation and performance targets. There are also a number of uncertainties at this stage of long-term planning that mean it is more appropriate to consider a range of **between 75% - 100%** utilisation over which there is an increasing risk of capacity becoming constrained.



COMPRESSION ANALYSIS RESULTS, PRE-A-S IMPLEMENTATION, WITH ETCS L2 SIGNALLING

The results show two primary areas of capacity constraint. Firstly, the NIMT between Papakura and Westfield junction shows high utilisation under both current and future signalling systems. This southern corridor capacity constraint is already well understood, but is not impacted by the A-S and is therefore not considered further in the analysis.

The other primary area of capacity constraint is on the **Inner Network** between Westfield, Newmarket and Avondale. Prior to A-S implementation, the inner section of the NAL between Westfield and Newmarket will become particularly congested with a utilisation of **up to 124%** based on current signalling, and **up to 106%** based on the theoretical improvements provided by ETCS L2 implementation. The inner section of the NAL between Avondale and Maungawhau also has high utilisation of **113%** under current signalling and **89%** with ETCS Level 2 based signalling.

This analysis demonstrates that with the current signalling system it will not be possible to operate the envisioned future service concept to acceptable levels of reliability and consequently will not meet anticipated future demands for freight and passenger markets. Even with ETCS L2 implemented and theoretical optimisation of signal placement to improve headways, utilisation still exceeds the **100%** threshold for reliable operation on the **Inner Network**, though by a smaller margin which may be feasible to operate.

IMPROVED NETWORK CAPACITY AND SERVICE EXPANSION

The introduction of the A-S corridor, in addition to enabling new passenger services, addresses the capacity constraints identified above by providing an alternative route for Northern freight. This delivers a two-fold capacity benefit for the **Inner Network**:

1. Freight trains are removed from the corridor, freeing up train paths.
2. The corridor becomes a pure metro operation, which consistent with the UIC 406 Leaflet allows the network to operate with a reduced margin between physical and planned occupancy due to more consistent rolling stock performance and headway characteristics.

In **Section 4.1**, an illustrative post-A-S service concept was developed to assess this capacity benefit. The service concept is largely the same as the pre-A-S concept, but include two new potential service patterns that utilise the A-S,

- An **'Isthmus Loop line'** service which travels between the NIMT (Orakei - Sylvia Park) to the NAL (Maungawhau - Mount Albert) via the A-S corridor on one side of the loop and the CRL on the other, and:
- A **'Crosstown line'** service that travels between Henderson in the west and Glen Innes in the east via the new A-S.

It is also assumed that the current Onehunga branch line services will be removed from the network post-A-S. This assumption reflects two key considerations:

- New A-S passenger services are expected to offer more attractive travel options for most Onehunga catchment users.
- Removing the Onehunga service releases valuable capacity on the **Inner Network**, delivering broader systemwide benefits.

This assumption does not imply that the Onehunga Branch Line itself must be closed and further study is required to determine the optimal long-term operating scenario for the branch.

The figure below summarises the capacity assessment results.

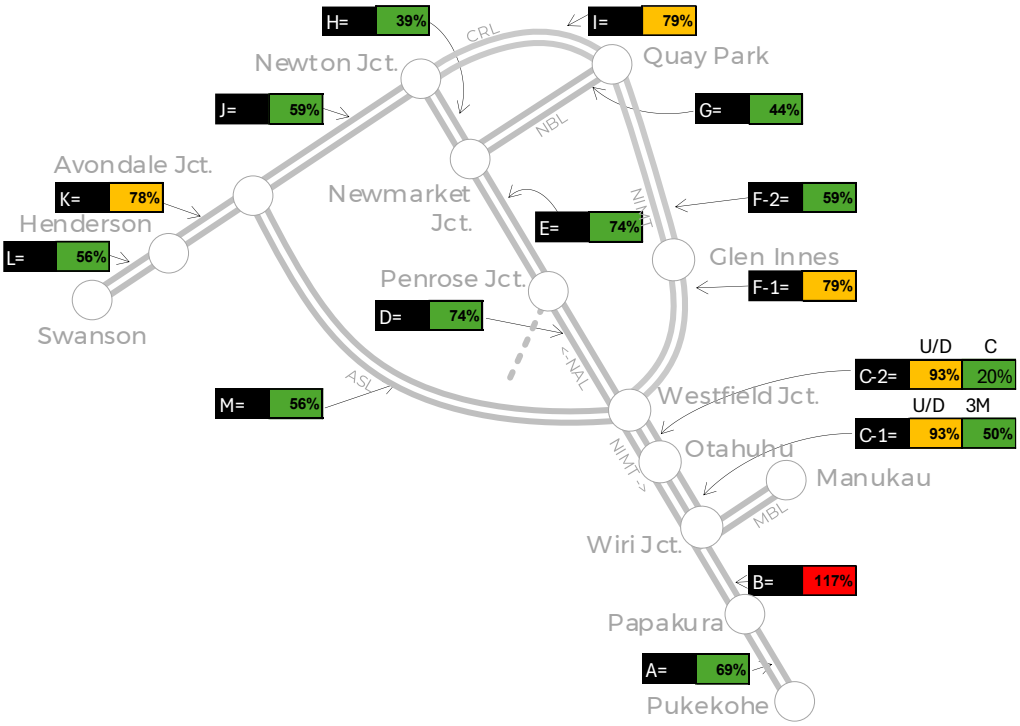


FIGURE 8-2 - COMPRESSION ANALYSIS RESULTS, POST-A-S, UTILISING ETCS L2 SIGNALLING

The analysis shows that with the A-S corridor in place, the **Inner Network** achieves acceptable levels of capacity utilisation across all segments. Under ETCS L2 signalling assumptions:

- Most **Inner Network** segments operate **below 75%** utilisation.
- Two exceptions - the short segment between Westfield and Glen Innes, and the CRL - show **utilisation of 79%**, still well **below the 100%** threshold for reliable operation.
- The previously congested segment between Penrose and Newmarket shows a significant capacity uplift utilisation falls **from 106% to 74%,** representing a **32% improvement**.

The resulting spare capacity can be used to support a range of future improvements, including:

- Additional inter-regional services
- Extra or faster Pukekohe express services
- New routes such as a West-Newmarket service (as explored in the AR-PBC)
- Improved timetable robustness and overall reliability

In summary, A-S materially improves the capacity envelope of the **Inner Network** while enabling a wider range of passenger and freight service enhancements.

IMPROVED NETWORK FLEXIBILITY

Avoiding major disruptions on the scale experienced during the Rail Network Rebuild (RNR), while also accommodating the post-CRL growth in passenger and freight services, will require a step change in maintenance practices. Although this will be achieved through a range of initiatives, a critical requirement is increased access to the network for maintenance activities.

The only feasible way to balance both objectives, higher maintenance access and higher service levels, is through diversification of routing. Providing additional routing options enables trains to bypass maintenance worksites, reducing the need for full line closures or extensive block-of-line interventions. Even with improved maintenance practices – incidents, asset degradation, and operational failures will inevitably still occur. Flexibility in routing is highly valuable for managing such events while minimising customer impact.

Section 6 of this study assessed how the A-S corridor improves network flexibility and resilience under degraded operations. Six representative line blockage scenarios were evaluated, covering both individual network segments and key junctions. The assessment was informed by a workshop involving experienced rail operations specialists, followed by detailed desktop analysis.

The analysis demonstrated a wide range of resilience benefits associated with A-S. These include the expected advantages for the Northern freight line, which gains the ability to bypass several outages that would otherwise prevent operation or significantly reduce capacity. However, the benefits extend well beyond freight. Under various outage scenarios, A-S supports improved outcomes for:

- Auckland Port (POAL) freight services
- Inter-regional passenger services
- All metro lines, to varying degrees depending on the scenario

The scale of benefits varies from minor improvements-such as enabling two additional metro services per hour during peak-to major operational advantages, including scenarios where A-S allows services to be maintained with no customer impact, whereas the same outage would otherwise require full cancellation.

In cases where the service response is the same with or without A-S, the corridor still improves network performance by releasing capacity elsewhere, supporting more reliable service delivery even when A-S is not being used as the diversionary path.

IMPLICATIONS FOR NETWORK RELIABILITY

Providing reliable services is a fundamental requirement for the sustained growth of rail, both in Auckland and nationally. When the rail network is unreliable, the impacts are felt immediately across both passenger and freight services.

For passengers, unreliability results in longer travel times, increased crowding, and missed connections. Cancellations may require passengers to transfer to alternative modes of transport, undermining confidence in rail as a dependable option. For freight customers, delays and disruptions mean that goods may not be delivered on time; or in some cases, may need to be diverted to road transport.

If a consistent and acceptable level of reliability cannot be achieved, both passenger and freight customers will inevitably begin shifting to more permanent alternatives, most often the road network. Once that shift occurs, it is notoriously difficult to win those users back to rail. In other cases, where alternatives are not affordable or accessible, people are left with fewer opportunities and businesses face real economic losses.

Section 5 presents evidence supporting the relationship between network utilisation and reliability. It includes discussion of UIC 406 capacity margins and presents sensitivity simulations that test the effects of increased mixing between freight and passenger services on the CRL Day One network.

The analysis demonstrates that even under CRL Day One conditions, increased mixing of freight and metro services on the **Inner Network** can significantly impact punctuality, with serious consequences for customer satisfaction, operational efficiency, and long-term mode shift objectives.

FINAL CONCLUSIONS

The analysis undertaken for this study provides clear and compelling evidence that the A-S Corridor delivers **substantial and multi-dimensional resiliency, capacity, and operational benefits** to the Auckland metro rail network.

Firstly, A-S provides a **strategic and future-proofed** alternative freight route for Northland-bound services (expected to expand significantly over future decades), and thereby increasing the capacity of the network overall.

Diverting freight from the inner metro spine releases **up to 32% capacity** between Westfield junction, Newmarket and the new Avondale junction. This uplift has material system-wide implications: it supports **higher-frequency metro services**, **improves timetable robustness**, and **reduces the operational conflicts** that currently constrain performance across the inner network.

Secondly, the corridor **unlocks transformative opportunities** for heavy rail passenger operations.

By providing a new north-south alignment through the isthmus, A-S enables the introduction of additional Rapid Transit Network (RTN) services, including a city-centre-focused orbital loop and a Crosstown line linking major suburban centres. These services respond directly to **emerging travel patterns** that have historically been underserved by Auckland's rail system and **supports long-term mode shift**, equitable access, and balanced urban growth.

Finally, the corridor delivers a **step change** in network resiliency. The degraded operations assessment, supported by operator workshops and desktop analysis, confirms that A-S markedly improves Auckland's ability to **withstand, absorb, and recover** from both planned and unplanned disruptions. Benefits extend across all markets, metro, freight, and inter-regional, and range from incremental improvements in delay recovery to major mitigation of severe incident impacts. The corridor creates **substantive new routing options**, **reduces reliance on existing heavily utilised routes**, and **enhances the maintainability** of the network by enabling worksites to be isolated without crippling service delivery.

Taken together, these findings underscore that the A-S Corridor is not merely an enhancement project but a critical piece of strategic rail infrastructure. It materially strengthens the **resiliency, capacity, and long-term adaptability** of Auckland's rail system, capabilities that will be essential to supporting CRL Day One operations and the region's 30-year transport investment strategy.

ABBREVIATIONS

AR-PBC	Auckland Rail Programme Business Case (2023)
A-S	Avondale - Southdown (Rail Corridor)
AT	Auckland Transport
CBD	Central Business District
CRL	City Rail Link
ETCS L#	European Train Control System - Level #
E-W line	East-west line (metro service)
MBL	Manukau Branch Line (track section)
MSM	Auckland Forecasting Centre's **M**acro **S**trategic Demand **M**odel
MVP	Minimum Viable Product
NAL	North Auckland Line
NBL	Newmarket Branch Line (track section)
NIMT	North Island Main Trunk
NZ	New Zealand
OBL	Onehunga Branch Line (track section)
OTP	On Time Performance
O-W line	Onehunga west line (metro service)
POAL	Port of Auckland Limited
RNR	Rail Network Rebuild
S-C line	South city line (metro service)
tpd	Trains per Direction, per Day
tph	Trains per Hour
UIC	Union Internationale des Chemins / International Union of Railways

1 INTRODUCTION

The A-S Corridor is a proposed 13km cross-city rail link in Auckland between the North Auckland Line (NAL) (just east of Avondale station) and the North Island Main Trunk (NIMT) at Westfield Junction in the Southdown area.

Initial proposals for the A-S Corridor date back to the 1940s, and since then, KiwiRail has progressively acquired and held land along the designated route specifically for this future connection. More recently, the corridor was identified as a critical component in the Auckland Rail Programme Business Case (AR-PBC, 2023) - a 30-year investment strategy for Auckland's rail network. Within that framework, the A-S corridor is positioned as a strategic link supporting the national freight supply chain, the spine of Auckland's public transport system, and an emerging inter-regional passenger network.

Following on from the AR-PBC, KiwiRail is now progressing further work to support the extension of the corridor's designation lapse date and to lay the groundwork for its eventual delivery. A key element of this work is to develop a more comprehensive understanding of the corridor's potential benefits, which can inform a future investment case.

This study focuses specifically on the resiliency benefits that the A-S Corridor offers to the wider Auckland-isthmus rail network; particularly the extent to which it enhances capacity, reliability, and flexibility for running additional services, including under degraded operations and during planned maintenance periods.

These benefits are broadly grouped under the umbrella term 'Resiliency', which represents just one of several core benefit streams anticipated from the corridor. Other benefits; such as increased passenger catchment, urban uplift potential, and economic productivity gains - are being explored through other dedicated workstreams within the A-S project.

1.1 REPORT PURPOSE AND STRUCTURE

This report summarises the outcomes of the A-S Resiliency Study, including the methodology and process followed, key inputs and assumptions, and the results of the technical analysis. The structure of this report is aligned with the primary resilience benefits identified through the study and illustrated in **Figure 1-1**.

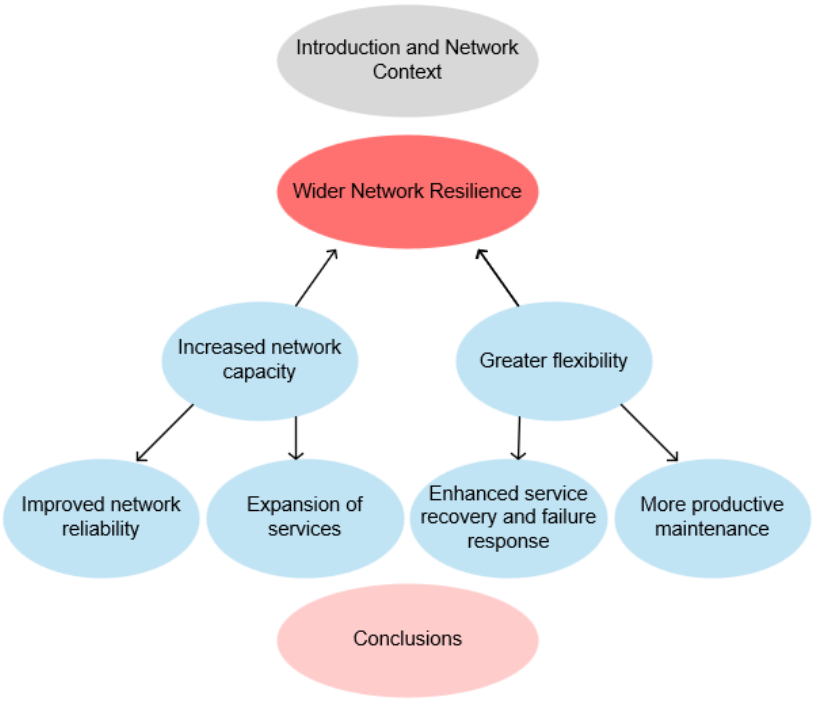


FIGURE 1-1 - RESILIENCE BENEFITS AND REPORT STRUCTURE

1.2 SCOPE, ASSUMPTIONS AND EXCLUSIONS

The following points should be noted in relation to the scope and boundaries of this study:

- This report summarises the outcome of a qualitative and quantitative assessment of **reliability and resiliency benefits** of the A-S only. While the A-S is expected to deliver broader benefits; including environmental, financial, commercial, and social outcomes; these aspects are outside the scope of this particular study.
- This study is intended to support both the development of the overall case for funding and investment in the A-S Programme and KiwiRail's efforts to extend the designation lapse date for the corridor. As such, this report should not be read in isolation, but in conjunction with other planning workstreams and studies related to the A-S Programme.
- This study excludes any assessment of climate change or flood risk resilience. These matters are assumed to be addressed through other parallel assessments.
- The benefits identified have not been monetised as part of this work. This study focuses on technical and operational impacts rather than economic evaluation.
- At the time of writing, several alignment and delivery options for the A-S corridor are still under consideration. This analysis is therefore preliminary in nature, based on a defined set of working assumptions. These are detailed in **Appendix E**.
- This report does not represent an optioneering study; however, some analysis included may inform future work in that area; particularly relating to the configuration of junctions at Westfield and Avondale.
- The study does not prescribe or mandate any specific metro or freight service patterns. Service patterns used in modelling are illustrative only and were developed in agreement with KiwiRail and relevant stakeholders to provide a realistic basis for identifying potential benefits,
- While the report includes an assessment of network capacity, it does not include an assessment of junction capacity. The analysis focuses on network segments between junctions rather than on the detailed performance of individual junctions.

2 NETWORK CONTEXT

This section provides an overview of the current Auckland rail network how it operates, and key constraints to future growth that are relevant to the A-S Corridor.

2.1 THE AUCKLAND RAIL NETWORK

Auckland's rail system comprises of two primary rail corridors: the **North Island Main Trunk (NIMT)** and the **North Auckland Line (NAL)**, supported by several branch lines. The proposed A-S Corridor would provide a new connection between Westfield junction (where the NIMT and NAL converge) and a future junction just east of Avondale Station. The network is illustrated in **Figure 2-1** and described in **Table 2-1**.

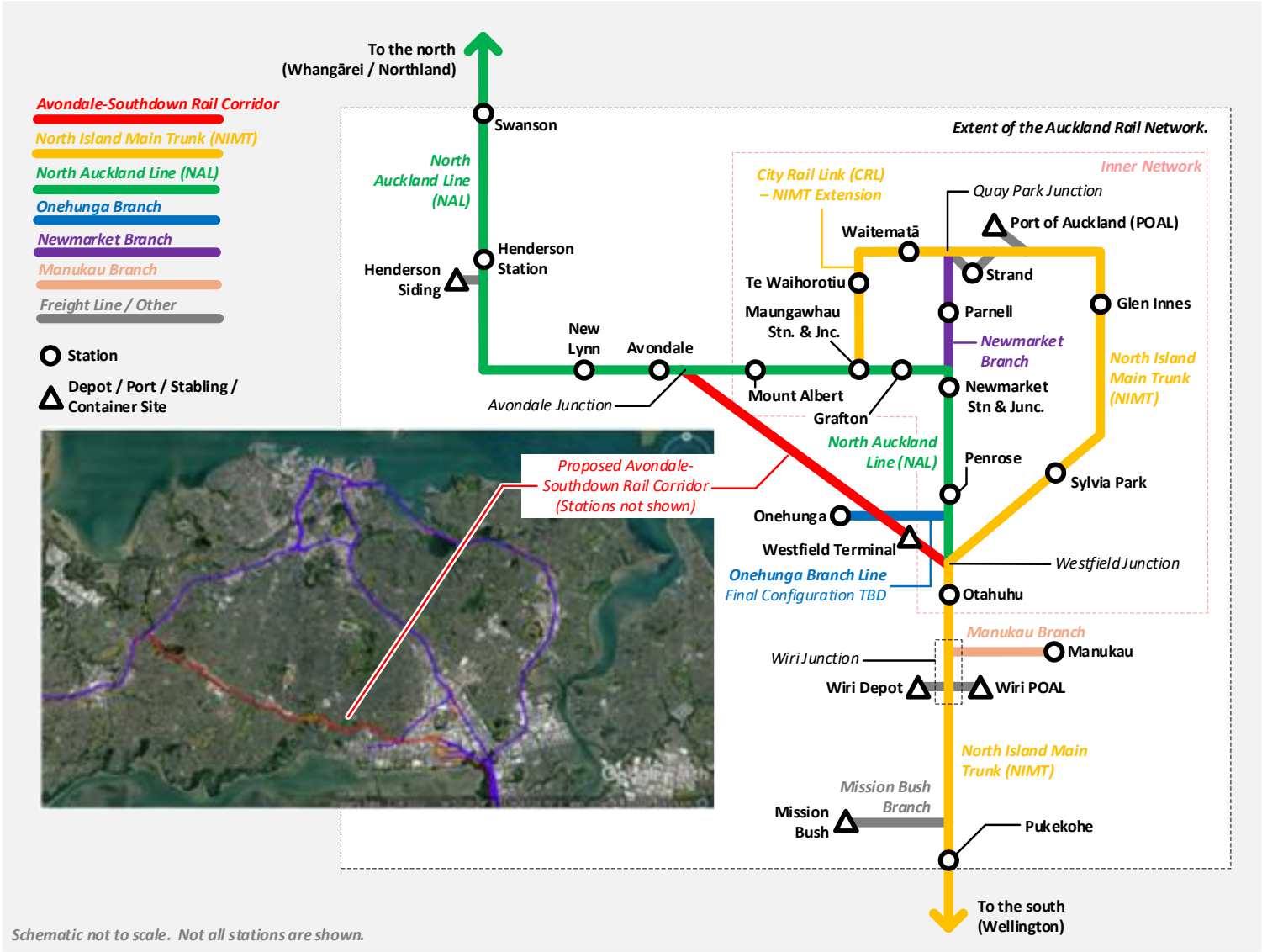


FIGURE 2-1 - CURRENT AUCKLAND RAIL NETWORK SCHEMATIC

Name	Type	Description
North Island Main Trunk (NIMT)	Trunk	Runs from Wellington Station to Waitematā (previously Britomart) Station with the CRL further extending the line to Maungawhau Station. The extent of the Auckland rail network with respect to this route is shown in **Figure 2-1**.
North Auckland Line (NAL)	Trunk	Connects to the NIMT at Westfield Junction in the Southdown area of Auckland and runs via Ellerslie, Newmarket, Grafton, Avondale and Swanson, then northward towards Whangārei and Northland. The extent of the Auckland rail network with respect to this route is shown in **Figure 2-1**.
Newmarket Branch Line (NBL)	Branch	Links the NAL at Newmarket Junction with the NIMT at Strand Junction, enabling operational flexibility and train movements between the corridors.
Onehunga Branch Line (OBL)	Branch	Links the NAL at Penrose to a terminating station at Onehunga via Te Papapa Station.
Manukau Branch Line (MBL)	Branch	Connects the NIMT at Wiri to Manukau Station, supporting high-demand passenger movements within South Auckland.
City Rail Link (CRL)	Trunk (Extension)	Extends the NIMT from Waitematā Station to meet up with the NAL at Maungawhau (previously Mount Eden) Station. The CRL enables services to pass through Waitematā[5] (removing a key constraint on AT metro capacity) as well as providing a versatile loop for AT metro services around the Central Business District (CBD) via Grafton, Parnell and Waitematā.
Mission Bush branch	Branch	Connects to the NIMT at Paerata, serving the Glenbrook Steel Mill.
Manukau Branch Line (MBL)	Branch	Links the NIMT at Wiri to Manukau Station.

TABLE 2-1 - DESCRIPTION OF AUCKLAND RAIL NETWORK LINES

2.2 A MIXED TRAFFIC NETWORK

Auckland's rail network is part of the wider national rail network which supports a broad range of service types, including:

- **Intra-Auckland metro passenger services**, primarily focused on Auckland's city centre; the backbone of the public transport system for New Zealand's largest city, which is home to around one third of the national population,
- **Inter-regional commuter and tourism services,** connecting Auckland with Hamilton and Wellington, and

[5] *Note that freight traffic is not permitted through the CRL.*

- **Inter-regional/national rail freight services**, a critical component of the national freight supply chain, imports, exports, and the national economy.

These services connect the nation's ports, industry, and population centres. Consequently, the service level and capacity of the Auckland rail network is of significant national importance.

While this multipurpose function is strategically advantageous, it also introduces complexity. Mixed-traffic railways, where metro, express passenger and freight services share the same track, are inherently less efficient and reliable than dedicated mode networks due to:

- Different train types operate at different speeds and require different headways.
- Stopping patterns vary widely.
- Freight services often require longer signal sections and extended dwell at terminals.
- Metro services require high frequency and reliability during peak periods.

Internationally, as rail demand grows, most networks increase segregation between service types to improve efficiency, utilisation, and reliability. This typically involves separating:

- all-stop metro from express passenger services
- passenger from freight services

In Auckland, physical segregation is currently limited to the 7 km Wiri-Westfield Third Main, purpose-built to separate freight from metro operations on one of the busiest parts of the network.

Ahead of the CRL opening, the network timetable has been designed to separate passenger and freight services by time wherever possible:

- Freight services are concentrated in off-peak periods.
- Metro services operate at reduced frequencies outside the peaks.

However, on the southern section of the network, where freight demand is substantially higher-full time-based separation is not possible, requiring operational compromises to maintain acceptable levels of reliability.

Time-based separation is functional today but is not sustainable as demand continues to increase across all markets. Growth in metro patronage post-CRL, together with increasing freight volumes driven by national supply chain requirements, will make reliance on this approach increasingly untenable.

As demand grows, Auckland will require increased physical segregation of services. This makes new routes such as the Avondale-Southdown Corridor-an essential long-term investment to:

- Improve operational efficiency
- Increase resilience and redundancy
- Enable higher-frequency metro services
- Support freight growth without constraining passenger capacity

The A-S Corridor therefore represents a critical opportunity to structurally relieve current and future constraints on Auckland's mixed-traffic network

2.2.1 METRO SERVICES

Figure 2-2 illustrates the restructured rail network post CRL along with Rapid Bus lines which form the backbone of Auckland public transport system, referred to as the Rapid Transit Network.

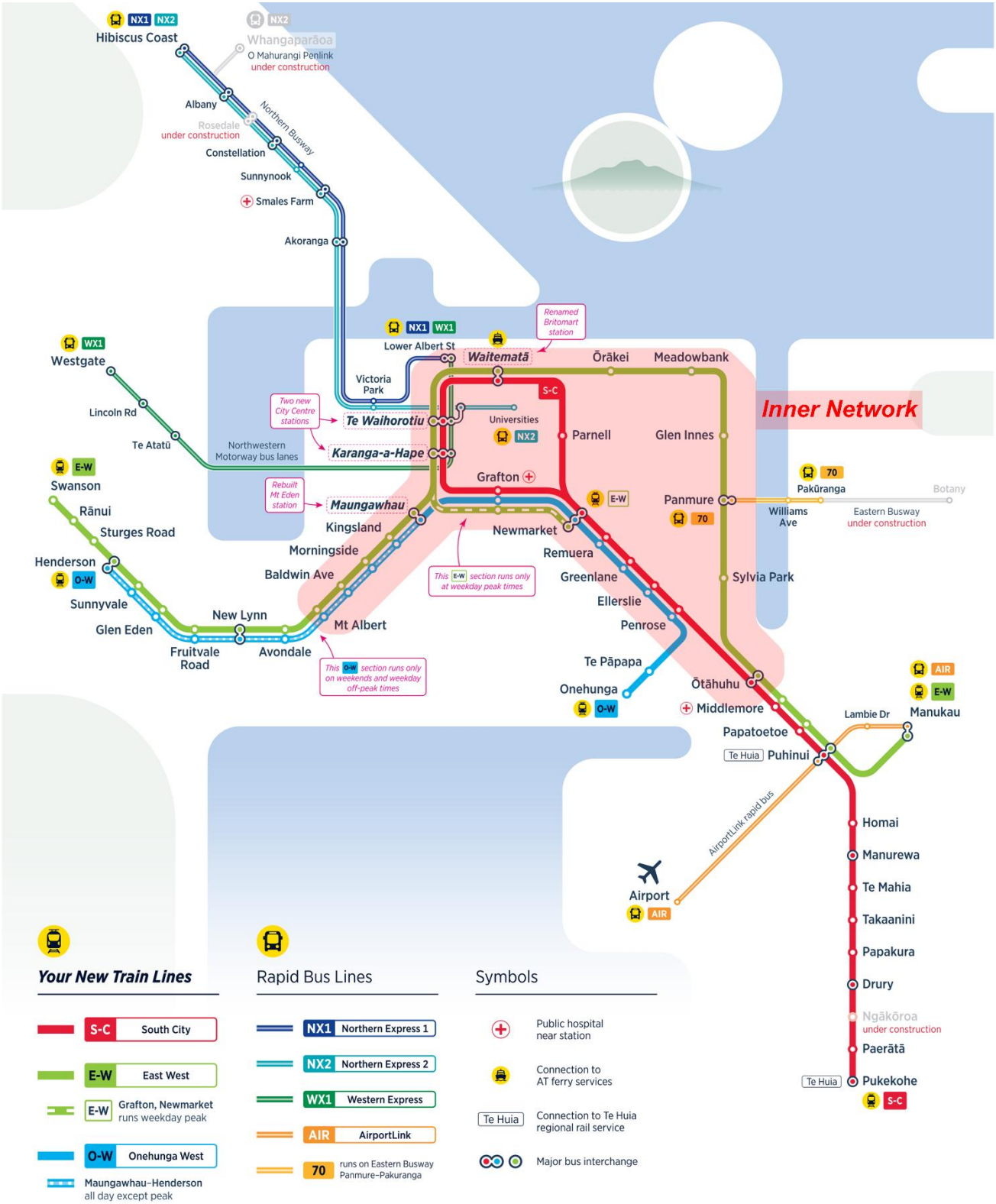


FIGURE 2-2 - AT METRO SERVICES - POST-CRL OPENING

The network (at the time of this report - pre-CRL opening) consists of four main lines (routes) as described below. *Note that these are the metro service designations that are distinct from the designations of track sections as described within* ***Section 2.1****.*

- **Western Line:** Operates between Waitematā and Swanson via Newmarket on the NAL and the NBL.

- **Southern Line:** Operates between Waitematā and Pukekohe via Newmarket on the NIMT, NAL and the NBL.
- **Onehunga Line:** Operates between Newmarket and Onehunga on the NAL and the OBL.
- **Eastern Line:** Operates between Waitematā and Manukau via Glen Innes on the NIMT and MBL.

The completion of the CRL and the new through platforms at Waitematā Station, fundamentally changes the operating model and enables new types of service to be run, and an uplift in train frequencies. The new services[6] that will replace the current services (at the time of this report) are as follows:

- **East-West line (E-W line)** that runs from Swanson to Manukau via the NAL, CRL/NIMT, NIMT and MBL.
- **South City line (S-C line)** that runs from Pukekohe to Waitematā via the NIMT, NAL, looping around the CRL/NIMT via Waitematā and back to Pukekohe.
- **Onehunga West line (O-W line)** that runs from Henderson to Onehunga via the NAL and the OBL.

2.2.1.1 AUCKLAND METRO SERVICE DEMAND CONTEXT

At the time of this report, demand for metro rail services remains significantly below its 2019 pre-Covid pandemic peak by approximately 40%. Recovery has been slowed by two factors:

- **Ongoing disruption** from the Rail Network Rebuild (RNR), including multiple sustained corridor closures since 2023 and continued weekend closures into 2025.
- **Changes in travel behaviour**, particularly increased levels of working from home.

Both the RNR programme and the CRL project are both set to be complete in 2026. Once completed, a return to reliable daily operations, combined with the substantial journey time reductions and higher metro service frequencies delivered through the CRL timetable, is expected to drive renewed growth in rail patronage.

Auckland rail has historically demonstrated strong latent demand when the network is improved. Patronage grew from approximately **3.5 million in 2005** to **over 22 million in 2019**, averaging **10% year-on-year growth**, driven by transformative system upgrades such as the opening of Britomart (now Waitemata Station), network electrification, and improvements to connecting bus services.

Long-term demand projections from the Auckland Macro Strategic Model (MSM) anticipate a similar scale of growth over the next 25 years. MSM outputs indicate that the CRL-enabled timetable will eventually reach capacity, though precise timing is uncertain due to MSM's limited suitability for short-term forecasting or for modelling recovery from external shocks such as Covid-19 and RNR-related disruption.

Current modelling and analysis indicate that the **Inner Network,** conceptually the area between New Lynn (west) and Panmure (east), will experience capacity pressure first. These sections of the Eastern and Western corridors are projected to face:

- high levels of peak-time crowding
- customers potentially being left behind on platforms
- rapid load growth post-CRL

Southern Line services, particularly those originating from Pukekohe, are similarly expected to reach overcrowding thresholds relatively quickly.

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[6] *https://at.govt.nz/projects-initiatives/city-centre-projects-and-initiatives/city-rail-link-auckland-s-new-network-in-2026/how-the-train-network-and-timetables-will-change-for-the-city-rail-link*

To address these constraints, additional peak-time train services will be required. As informed by the AR-PBC, most of the uplift will need to occur:

- between Mount Albert and Glen Innes on the E-W Line, and
- between Otahuhu and the CBD on the S-C Line,

collectively referred to throughout this report as the "***Inner Network***" *(***see Figure 2-2***).*

In addition to peak capacity increases, Auckland Transport's strategic intent includes:

- providing turn-up-and-go frequencies (≤10-minute headways) across the full day,
- aligning metro service standards with those of the broader Rapid Transit Network, and
- potentially expanding the duration of peak service periods.

Delivering these improvements will introduce increasing conflict with freight services, which are currently scheduled predominantly in off-peak periods. As metro frequencies expand across the full operating day, the limits of time-based separation between metro and freight operations will be reached, reinforcing the need for additional track capacity and segregation, such as that enabled by the A-S Corridor.

2.2.2 FREIGHT SERVICES

The Auckland rail network contains several major freight facilities including Westfield yard, sidings connecting to the Port of Auckland Ltd (POAL), and significant intermodal facilities at Southdown and Wiri POAL. Smaller private sidings also exist, for example the Coca-Cola Amatil at Mount Wellington. These facilities are connected by multiple freight services that can be broadly grouped into three primary lines as described in **Table 2-2** below.

Freight Lines	Definition
Southern	All freight services travelling between Pukekohe and Westfield, including services to/from the Mission Bush Branch Line. This includes a mixture of domestic unit and manifest trains as well as import express trains.
Auckland Port	All freight services travelling between POAL, Westfield and Wiri East Sidings. This primarily includes import-export freight to and from the port, but also includes some smaller shunting movements to customers along the route.
Northern	All freight services travelling between Westfield and Swanson (enroute to northern locations such as Whangārei). Current traffic consists primarily of domestic unit trains together with shunting movements along the route to the sidings at Penrose.

TABLE 2-2 - PRIMARY FREIGHT LINES

2.2.2.1 FREIGHT SERVICE DEMAND CONTEXT

Freight operations connecting the international ports of Auckland, Northport and Tauranga represent a significant and growing component of KiwiRail's national freight task. Auckland's import-export market is centred on the movement of containerised freight between ports and inland hubs. These operations typically follow **cyclic service patterns** designed to optimise fleet utilisation and ensure terminal capacity is not exceeded.

For example, MetroPort services between Tauranga and Auckland operate on a defined cycle: trains arriving in Auckland must be unloaded and reloaded within a set window before returning south. A similar cycle applies at Tauranga.

Forecasting the scale and distribution of future import-export freight is challenging due to its dependence on macroeconomic conditions, global supply chains, and port-related investment decisions. The AR-PBC developed scenarios for future Northport demand ranging from **3 tpd** (broadly aligned with current volumes) to **15 tpd** under assumptions of substantial growth in Northport's import-export role.

Recent developments-including changes to Northport's ownership structure (aligning more closely with Port of Tauranga and excluding POAL)[7], the granting of consents for Northport's expansion[8], and central government support for the Marsden Point Rail Link[9], suggest demand may trend toward the upper end of this range.[10]

Because most of this growth is expected to be container-based, freight operations will continue to favour a cyclic pattern rather than strict timetable adherence. To operate efficiently, these services must be distributed relatively evenly across the day to avoid terminal congestion.

During periods of high-frequency metro operation, freight services are effectively excluded from significant portions of the NAL, particularly during the morning and afternoon peak periods. This places a practical cap on freight volumes that can be accommodated in Auckland.

Current analysis indicates a practical throughput limit of approximately **5-7 tpd**[11] on the NAL. Any growth above this level would require freight trains to operate within the high-density metro periods. This would substantially increase pressure on the network, especially within:

- the **Inner Network**, where passenger loadings are highest, and
- the Newmarket flat junction, a critical operational constraint.

If Auckland Transport extends its future peak-period span (which it has previously signalled as an ambition), the effective operating window for freight becomes even narrower. This would have the same effect as increasing freight demand-it would force freight movements into peak periods unless additional track infrastructure is available.

There are also plausible scenarios in which POAL experiences significant growth in container volumes. Under such conditions, the eastern section of the NIMT would become heavily capacity constrained. This may require routing a higher proportion of metro services via the southern part of the NAL to balance network loads.

The AR-PBC reflects the logic described above, assuming that future southern express metro services would operate on the NAL rather than the NIMT to relieve capacity pressure on the eastern corridor.

In both the POAL-growth and Northport-growth scenarios, the **Inner Network** is expected to experience the highest levels of capacity consumption as freight volumes increase.

2.2.3 INTER-REGIONAL SERVICES

KiwiRail currently operates two inter regional passenger services into Auckland:

- The Northern Explorer, a tourism-focused service operating between Auckland Strand and Wellington.
- Te Huia, operating between Auckland Strand and Hamilton.

Both services currently use the NIMT, merging into the same operational corridors as the EW and S-C metro services *(***see Section 2.2.1***)*, and sharing track with Southern and Auckland Port freight *services (***see Section 2.2.2***).*

With the introduction of ETCS Level 1-equipped locomotives, peak Te Huia services are expected to undergo routing changes. These services will need to loop via the NAL before rejoining the NIMT (or vice versa), in order to access compliant signalling sections and maintain operational reliability.

In addition, there is a strategic desire for all inter-regional services, including Te Huia and the Northern Explorer, to be routed along the NAL with a new stop at Newmarket. This would provide substantially improved passenger

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[7] See *https://www.nrc.govt.nz/news/2025/may/consortium-buyout-of-mmh-strongly-supported-by-shareholders/*

[8] See *https://northport.co.nz/node/24236*

[9] See *https://www.beehive.govt.nz/release/northland-new-zealands-economic-powerhouse*

[10] As indicated - growth in NAL freight traffic is contingent upon wider network investments including the Marsden Point Rail Link and potentially other improvements to the existing NAL.

[11] *Based on analysis undertaken as part of the AR-PBC*

access to Auckland's city centre, compared with the existing terminus at the Strand, and better integrate inter-regional travel with the future CRL-enabled metro network.

2.2.3.1 INTER-REGIONAL SERVICE DEMAND CONTEXT

Inter-regional rail travel has emerged as a growth market in New Zealand. Te Huia, which commenced in April 2021, has performed strongly, generally exceeding patronage expectations and supporting subsequent service expansions, including additional weekend services[12]. The early success of the Te Huia service may also serve as the catalyst for the longer-term formation of a wider inter-regional rail network.

Momentum for wider inter-regional rail has also increased at a national level. A 2022 parliamentary inquiry into inter-regional passenger rail recommended scoping work for new services[13] such as:

- Auckland-Tauranga
- Auckland-Wellington

In parallel, KiwiRail's commitment to procuring 18 new battery-electric locomotives to enhance inter-regional operations between Wellington, Masterton, and Palmerston North indicates growing investment and confidence in this mode.

As routing patterns evolve and inter-regional passenger volumes grow, these services will place additional capacity pressure on the **Inner Network**, particularly as they compete for limited timetable slots shared with high-frequency metro and expanding freight movements.

2.3 MAINTAINABILITY, RELIABILITY AND RESILIENCE

As set out in the AR-PBC,[14] investment in the New Zealand rail network has been insufficient over the past several decades; critical physical assets such as track, signalling, and level crossing systems, have become increasingly unreliable.

Failures of network assets result in an unreliable service for rail customers with speed restrictions, cancellations, and poor levels of punctuality becoming more frequent. The degree of historic underinvestment has been highlighted in the extreme by the current RNR programme. The RNR has required *full closures* of large segments of the Auckland rail network over a three-year period to restore the basic foundations of the network to a modern standard.

To avoid such major disruptions in the future and to accommodate the increase in passenger and freight traffic planned post CRL, clearly a step change in maintenance practices is required. This will be achieved through a variety of measures, and critically will require that maintenance activities be given better access to the network. The specific target adopted in the AR-PBC was to provide a 6-hour productive maintenance window each day, a goal which directly conflicts with AT's ambition to extend the coverage of frequent metro services throughout the day.

The only feasible way to achieve both goals simultaneously (to the extent that this is possible) is through diversification of routing - essentially providing alternative routes through the network that allow trains to bypass maintenance worksites. For some activities, this will be achieved through single track running (this is where, over a short section, trains in both directions share one track while the other is undergoing maintenance). For more substantial maintenance activities requiring both tracks to be taken out of service, alternative corridors

[12] *https://www.waikatoregion.govt.nz/community/whats-happening/news/media-releases/final-green-light-given-for-sunday-te-huia-services/*

[13] *Inquiry into the Future of Inter-Regional Passenger Rail, October 27, 2022 - https://www.parliament.nz/en/pb/sc/make-a-submission/document/53SCTI_SCF_INQ_125787/inquiry-into-the-future-of-inter-regional-passenger-rail*

[14] *https://www.kiwirail.co.nz/our-network/our-regions/amp/auckland-rail-program-business-case/*

can be used where available. At present, this is only possible on the NAL between Westfield and Newmarket junctions, or on the NIMT between Westfield junction and Quay Park junction, where one route can be used as an alternative to the other.

Even with a step change in maintenance access, incidents, asset degradation and failures will inevitably occur. The significant increase in traffic planned under the CRL day one timetable (along with its more complex and interconnected structure) is expected to result in further challenges in responding to, and recovering from, such incidents. Flexibility in routing options would create significant advantages for this, but the current network provides limited opportunities for this as mentioned above.

3 NETWORK CAPACITY

Section 3 has established that future demand for rail services in Auckland (across all markets) is likely to concentrate on the **Inner Network** - the portion of the Auckland rail network broadly situated between Mount Albert in the west, Panmure in the east and Otahuhu in the south (**Figure 2-2**).

This section of the report explores the extent to which these demands can be accommodated within the capacity of the current network, and how the introduction of A-S expands the capacity on the **Inner Network** to support this demand and further growth beyond it. To do this, the methodology outlined in the **UIC 406 Leaflet on Capacity** has been applied to a future network service concept pre-A-S and a future network service concept post-A-S.

3.1 ASSESSING CAPACITY

UIC 406 provides a methodology for measuring rail capacity and a set of suggested capacity utilisation thresholds that generally represent an acceptable quality of service. The framework effectively provides a means of determining the utilisation 'sweet spot' for an average railway that best balances supply and quality of transport based on the historic experience of various organisations operating dense passenger rail lines in Europe.

The methodology outlined in UIC 406 is referred to as the *Compression Method*. This method involves firstly computing the minimum possible time it would take to run a sequence of trains through a segment of the network, with trains operating at maximum performance and not needing to slow down due to restrictive signal aspects nor accounting for human performance variations - this is referred to as the *Occupancy Time*.

UIC 406 then provides recommended buffers (referred to as *Additional Time Rates*) that are added to the theoretical Occupancy Time to absorb delays and ensure a reliable level of service. There are different Additional Time Rates that are recommended depending on the type of traffic that is being operated on the section of the network as shown in **Table 3-1** below.

Traffic Type	Suggested Buffer
Dedicated passenger commuter	18%
Dedicated passenger high speed	33%
Mixed traffic	33%

TABLE 3-1 - ADDITIONAL TIME RATES FOR DIFFERENT TRAFFIC TYPES

Finally, the following calculation can be used to compute the utilisation of the network segment under study.

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

The *Capacity Consumption Rate* provides a measure of how "full" the network is; a value of 100% represents maximum reliable utilisation. A value of less than 100% indicates room to grow while a value of greater than 100% indicates potential reliability issues and suggests the need to reduce the timetable. The 100% threshold is not a hard limit but rather represents an acceptable level of performance for an average network. Examples exist of systems operating reliably with margins less than the recommended Additional Time Rates of UIC 406;

however, it is apparent from these examples that a combination of robust operational delivery and long-term planning is required[15] - capabilities that are currently not well developed within the New Zealand context[16].

A key aspect of this framework is that capacity is defined both by the volume and composition of traffic. A mixed traffic operation, consisting of trains with different performance and operational characteristics (freight and passenger trains, or all-stops and limited-stop trains for example) will require a much greater buffer to operate reliably. This is important in the context of the A-S where additional capacity creation on the wider isthmus network will arise not only from freight services being physically diverted off the NAL, but also from simplification of traffic types to dedicated metro in this segment of the network which allows reliable operation with smaller buffer.

3.2 UIC 406 MODEL SETUP

For this study, a simplified application of the Compression Method has been employed based on specifying a single technical headway value per network segment, per train type (e.g. metro all stops, metro limited stop, inter-regional, and freight).

The segmentation used for this analysis is shown schematically in **Figure 3-1** below. Note that in the following analysis, the network south of Westfield Junction is typically omitted as introduction of the A-S does not affect that section of the railway.

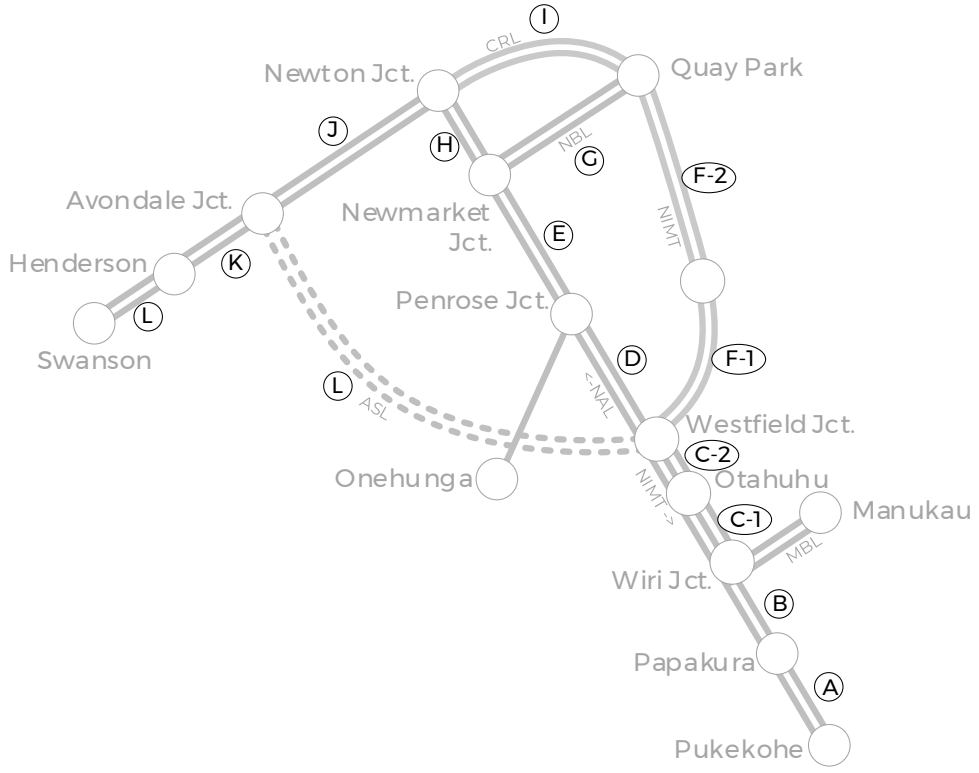


FIGURE 3-1 - NETWORK SEGMENTATION USED FOR THIS STUDY

[15] *This is the case for parts of the Swiss rail network for example. Additional in some cases, a decision to increase capacity at the expense of service quality is also be seen as preferable (e.g. the Paris Tunnel Gare du Nord - Châtelet).*

[16] *The primary purpose of this analysis is to compare the capacity of the network pre and post A-S, therefore the exact value of Additional Time Rate is not particularly important - only that it is applied consistently between scenarios.*

The Auckland rail network's existing ETCS L1 signalling system is planned to be upgraded, with a detailed business case currently underway. This, in combination with the proposed removal of level crossings would allow signals to be respaced and headways to be improved further.

To test the impact of future signalling upgrades on capacity utilisation, this study has considered two headway scenarios:

1. Current signalling system using technical headway data provided by KiwiRail based on OpenTrack simulations.
2. A future enhanced signalling system, nominally based on ETCS L2[17]. This study has made the blanket assumption that such a system could achieve a Technical Headway of **2.1 min** which results in a **2.5 min** Operational Headway in exclusive metro territory[18].

Further details of the simplified methodology and the key inputs of technical headways and freight paths are provided in **Appendix A**.

The approach to assessing capacity via UIC 406 is appropriate for early stages of planning (such as this study) but does have certain notable limitations:

- The assessment does not consider the capacity of junctions though these can represent major bottlenecks - particularly at 'flat' junctions. Where relevant, qualitative commentary has been included on the likely impact of A-S on existing junctions (particularly Newmarket Junction), and the network impact of adding a new junction at Avondale.
- The assessment considers sections of the network in isolation of each other so does not account for interface between sections, imported delays, etc. This would require a more detailed analysis that is not practical at this stage

3.3 ILLUSTRATIVE PRE-A-S SERVICE CONCEPT

The final step towards evaluating the Auckland rail network's capacity prior to implementation of the A-S is to develop a service concept that meets expected future demands. The service concept describes the routing and frequency of future train services; this, in addition to the headway and freight path values (defined in **Appendix A**) provides the basic input required to complete the compression assessment.

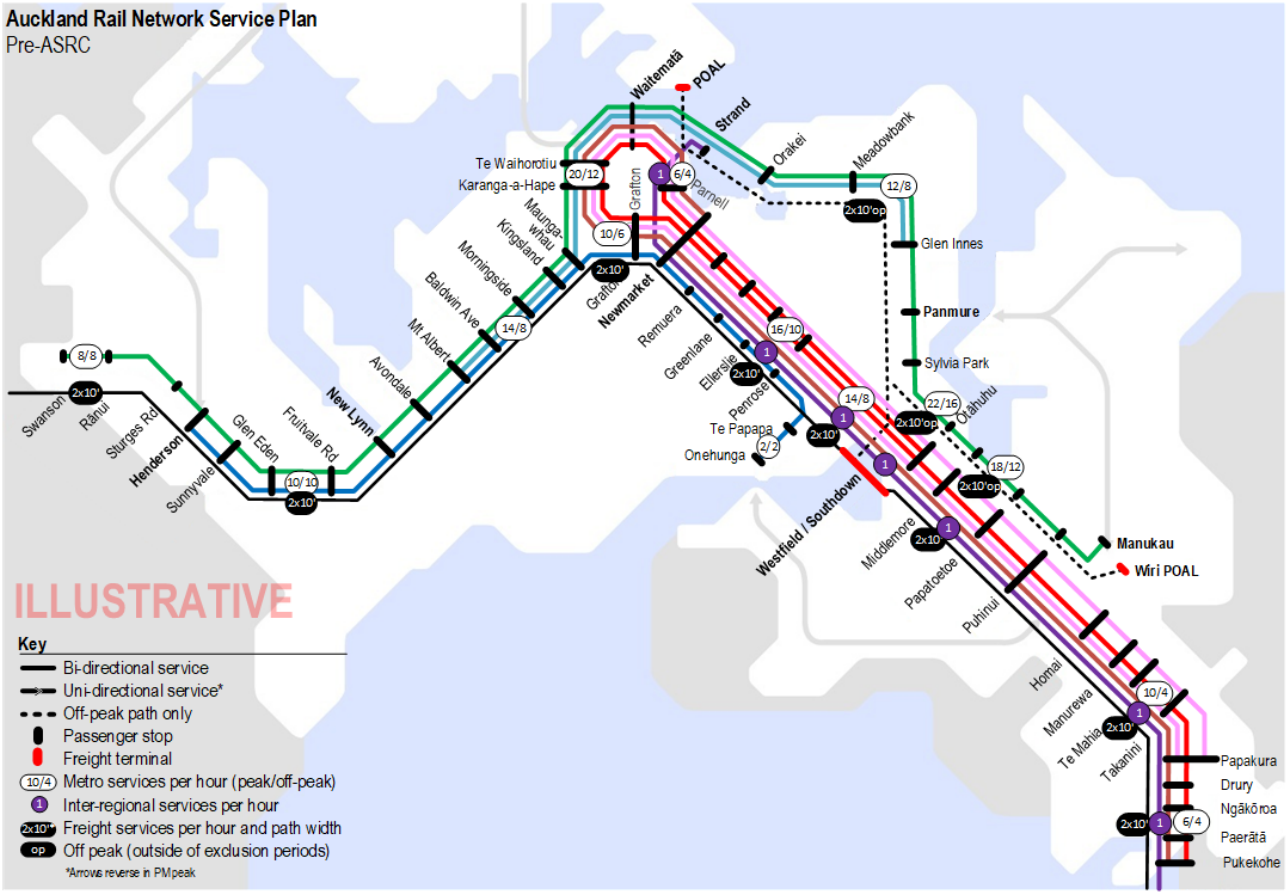
The pre-A-S Service Concept is illustrated in **Figure 3-2**, this concept is broadly based on the illustrative *'Configuration States'*[19] that were developed in the AR-PBC's 30-year plan - specifically **Configuration State**

[17] *The Auckland Signalling Capacity Improvement business case does not pre-suppose ETCS L2 as the preferred long term solution for the network. However ETCS L2 has been assumed in previous long term planning work (the AR-PBC) so has been assumed in this report).*

[18] *Technical headway refers to the minimum headway between trains based on the maximum performance of the rolling stock and signalling system, whereas operational headway includes some margin on top of the technical headway to account for variability in operational conditions, performance, driver behaviour etc.*

[19] *A Configuration State is a pairing of infrastructure, rolling stock and system upgrades, with an operational output - or in this case a service concept representing an improvement to the network timetable. All-day frequent services on the E-W line and all day freight paths on the Northern freight line, were not introduced in the AR-PBC until CS3 which included Avondale - Southdown and additional capacity expansion between Wiri and Westfield. This has been pulled forward in the analysis to test the capacity benefits of the A-S.*

CS0-4, with some minor adjustments[20]. This future service concept does rely on some additional infrastructure and system improvements being implemented - refer to 0 for further detail.



Line	Service Type	Origin	Destination	Runs in		Trains Per Hour	
				Off-Peak	Peak		
South to City (SC), all stops	Metro	Pukekohe	Otahuhu	●	●	4	[1]
South to City (SC), all stops	Metro	Papakura	Papakura		●	2	[1]
South to City (SC), limited stops	Metro	Pukekohe	New market		●	2	
East to West (EW)	Metro	Manukau	Swanson	●	●	8	
East to West (EW), Inner	Metro	Glen Innes	Mt Albert		●	4	
Onehunga to Henderson	Metro	Onehunga	Henderson	●	●	2	
Te Huia / Northern Explorer	Inter Regional	Hamilton / Wellington	Auckland	●	●	1	[2]
Southern	Freight	Pukekohe	Westfield	●	●	2	[3]
Northern	Freight	Westfield	Swanson	●	●	2	[3]
Auckland Port	Freight	Southdown / WPOAL	POAL	●		2	[3]

[1] Looped routing results in doubling train frequencies along segments of the route

[2] Up to 1tph. Services don't run every hour

[3] 2 paths per hour reserved for freight.

FIGURE 3-2 - ILLUSTRATIVE PRE-A-S AUCKLAND NETWORK SERVICE CONCEPT

[20] *S-C line limited stop service is routed between Pukekohe - Newmarket (via a clockwise loop around the CRL) whereas in the AR-PBC they were routed between Pukekohe - Pukekohe (via loops around the CRL in alternating directions similar to the S-C line all-stops service).*

The pre-A-S service concept is based on the following principles:

- As discussed within **Section 2.2.1**, growth in passenger demand is expected to result in high levels of crowding between Panmure and New Lynn on the E-W line. To address this, a new **4 tph** inner E-W line service is introduced that runs between Glen Innes and Mount Albert Stations.
- To meet the all-day frequency targets of the Rapid Transit Network, The E-W line will have ramped up of **8 tph** all day. Additionally, the O-W line will move to an all-day **2 tph** service, an improvement over the currently planned off-peak only service of the post-CRL timetable.
- As discussed in **Section 2.2.2**, as freight traffic between Auckland and Northland grows, it will become increasingly likely that freight trains will need to run through the Auckland network during metro passenger peak periods. As noted previously, due to a variety of constraints, the number of additional freight trains that can *practically be scheduled* around the metro peak periods is actually quite low - within the AR-PBC, this was estimated to be between **5 to 7 tpd**. As such, the service concept provisions for up **2 freight paths per hour, per direction,** on the Northern freight line; however, given the spacing of loops on the NAL north of Auckland, only **one freight train per hour** has been included within the peak capacity calculations.

The combined effect of these changes is a fully mixed traffic NAL corridor with high metro frequencies all day and the removal of freight exclusion periods.

Note that in addition to the improvements to accommodate growth anticipated on the **Inner Network**, incremental improvements to services travelling on the southern corridor have also been incorporated into this service concept, namely:

- Increased train frequencies between Papakura and the city centre. This is a change that is already planned to be implemented shortly after CRL Day One, requiring minor signalling improvements to be completed first.
- Re-routing of southern limited-stop and inter-regional services onto the NAL as opposed to the eastern line. These changes were envisioned as part of the AR-PBC (Configuration State CS0-3) providing, among other things, a new hub at Newmarket for inter-regional passengers to connect into the local Auckland network.[21]

3.4 NETWORK CAPACITY PRIOR TO A-S IMPLEMENTATION

Results of the compression analysis carried out according to the methodology, inputs and assumptions described above, are presented in **Figure 3-3** and **Figure 3-4** below. Two sets of results are presented for existing signalling and ETCS L2 scenarios described in **Section 3.2**. Colouring in the diagram represents the level of capacity utilisation with a value of 75% or less shown as green, 76% to 99% is shown as amber, and a value of 100% shown as red. Further discussion on this point is provided in **Section 5.1**.

[21] *The decision to route limited stops and inter-regional services on the NAL has an impact on the absolute values of capacity utilisation, but it turns out to have minimal impact on the delta between the with and without A-S scenarios. As will be shown in the next section, the theoretical capacity benefit of A-S is between 18-23%. Performing the same analysis on an alternative service concept where limited stop and inter regional services are routed on the eastern line as opposed to the southern line, yields a capacity benefit of between 18-21%. In other words, the capacity benefit of A-S is largely unaffected by this decision.*

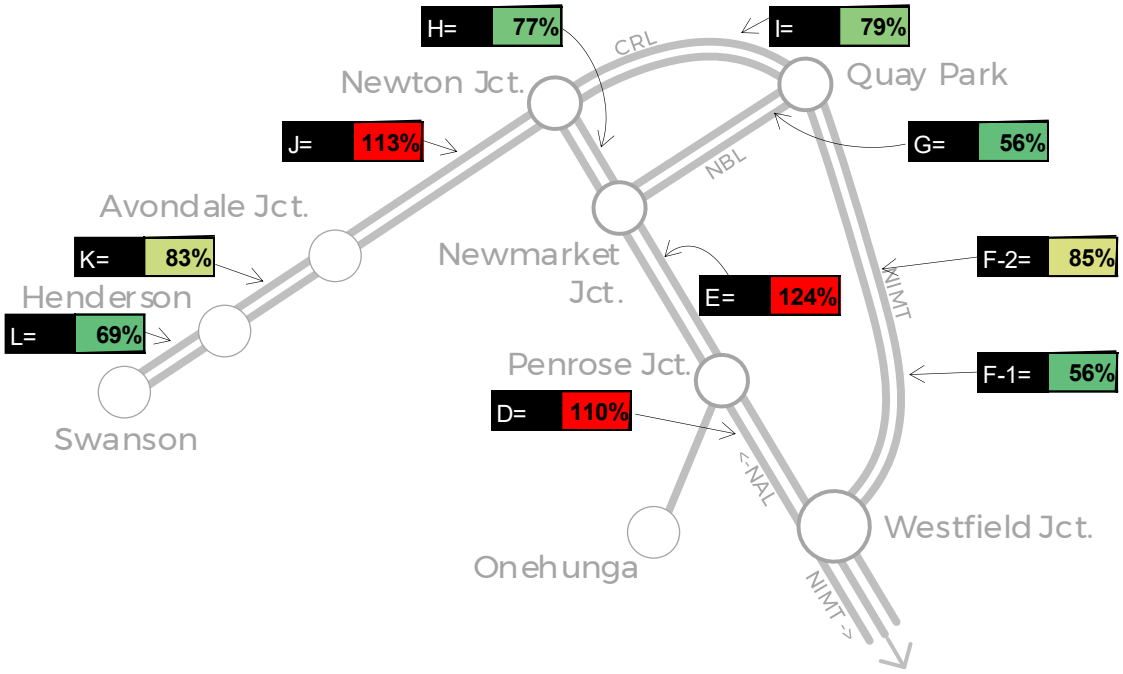


FIGURE 3-3 - COMPRESSION ANALYSIS RESULTS, PRE-A-S IMPLEMENTATION, WITH EXISTING SIGNALLING

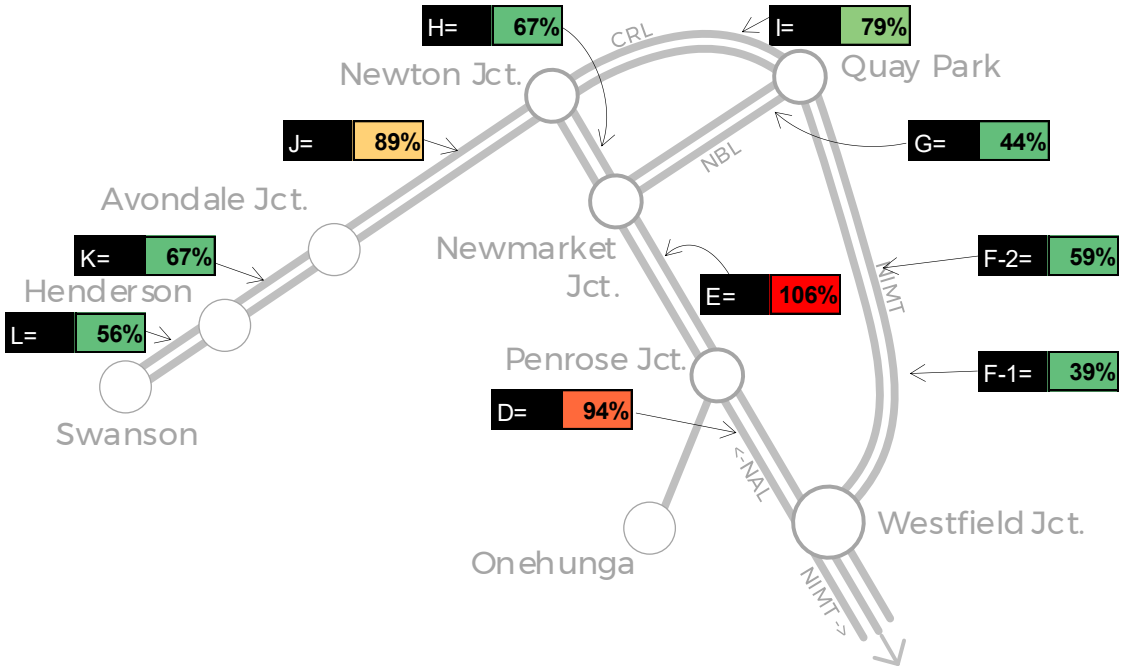


FIGURE 3-4 - COMPRESSION ANALYSIS RESULTS, PRE-A-S IMPLEMENTATION, WITH ETCS L2 SIGNALLING

Firstly, as noted in **Section 3.2**, the southern corridor south of Westfield, has been excluded from the analysis diagrams. This corridor does show significant capacity constraints under the current infrastructure-configuration, but this is not impacted by the inclusion of A-S and so will not be discussed further in this report.

The primary area of capacity constraint is on the **Inner Network** between Westfield, Newmarket and Avondale. Prior to A-S implementation, the inner section of the NAL between Westfield and Newmarket (**Segments D & E**) will become particularly congested with a utilisation of **up to 124%** based on current signalling, and **up to 106%** based on the theoretical improvements provided by ETCS L2 implementation. The inner section of the

NAL between Avondale and Maungawhau (**Segment J**) also has high utilisation of **113%** under current signalling and **89%** with ETCS L2.

This analysis demonstrates that under the current signalling system it will not be possible to operate the envisioned future service concept to acceptable levels of reliability, and consequently will not meet anticipated future demands for freight and passenger markets.

Signalling enhancements provided by an optimised ETCS L2 system achieve closer to acceptable utilisation except for the inner section of the NAL between Westfield and Newmarket which will be **oversubscribed at 106%.** While these sections of the network could (in theory) still be operated reliably when considered in isolation (being close to the **100%** threshold for reliable operation); it is likely that operating traffic at this density would place significant constraints on the network timetable. This tends to require adding buffer to the timetable in advance of junctions to ensure that trains pass through it in the correct sequence, increasing travel time for passengers.

While not explicitly analysed, the volume of conflicting movements through the flat junction at Newmarket under this service concept is also likely to become a significant source of delay in the network.

In summary, based on these results and practical experience of network timetabling, it is likely that the pre-A-S service concept is not operationally viable, even with an optimised ETCS L2 signalling system.

Under both existing and enhanced signalling scenarios, what is clear from this analysis is that there would be no room for further service improvements beyond the illustrative service concept under this configuration of the network; including (for example) any frequency increases on the S-C line or other service enhancements to bring the CRL up to its full potential of 24 tph.

3.5 THEORETICAL CAPACITY ENHANCEMENT DUE TO A-S

In addition to providing a new corridor for passenger services, the A-S also provides an alternative route for the Northern freight line. This has a two-fold impact on the capacity calculation for the sections of the NAL between Westfield, Newmarket and Avondale (**Segments D, E, H & J**):

- It removes one freight train per hour, and
- It changes the traffic composition from mixed traffic to pure metro, allowing for a reduction in additional time margin from **33% to 18%.**[22]

Without considering any other changes to the earlier service concept (**Figure 3-2**), the theoretical impact of this on capacity is presented in **Figure 3-5** - the values are expressed as an increase in capacity, which is simply the inverse of a reduction in capacity utilisation.

The results show an increase in capacity of **between 18 and 23%**, with approximately the same level of improvement under existing signalling and ETCS L2.[23]

[22] *Technically some of these segments will still see mixed traffic, being shared by metro and inter regional services. However, inter-regional trains are expected to 'coast' at the same average speed as metro trains in this area, effectively taking up the same capacity per service. Therefore these segments can be considered pure metro for all intents and purposes.*

[23] *Part of the reason for this is that the freight path requirement has been held constant under both signalling scenarios. For the Northern freight line, the study has adopted a 10 min freight path, which is applied under both the existing and enhanced signalling scenarios. This assumption is consistent with analysis undertaken in the AR-PBC. In reality freight may be able to operate within a tighter path under ETCS L2 which would then reduce the level of capacity released by the A-S - further analysis would be required to assess this.*

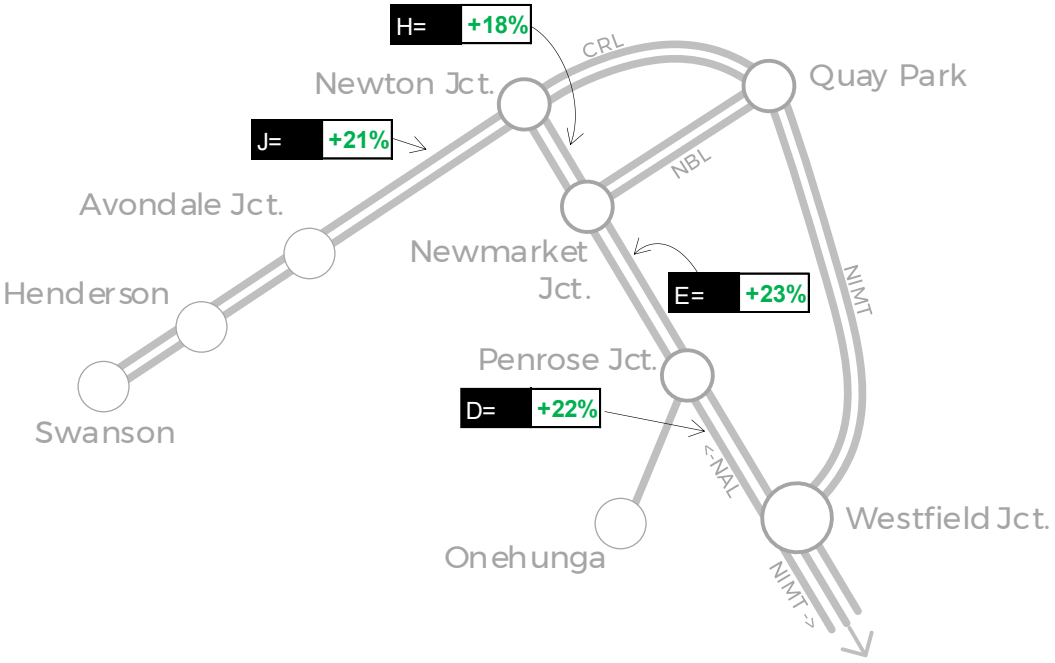


FIGURE 3-5 - A-S CAPACITY BENEFIT TO THE INNER NETWORK, UTILISING EXISTING SIGNALLING

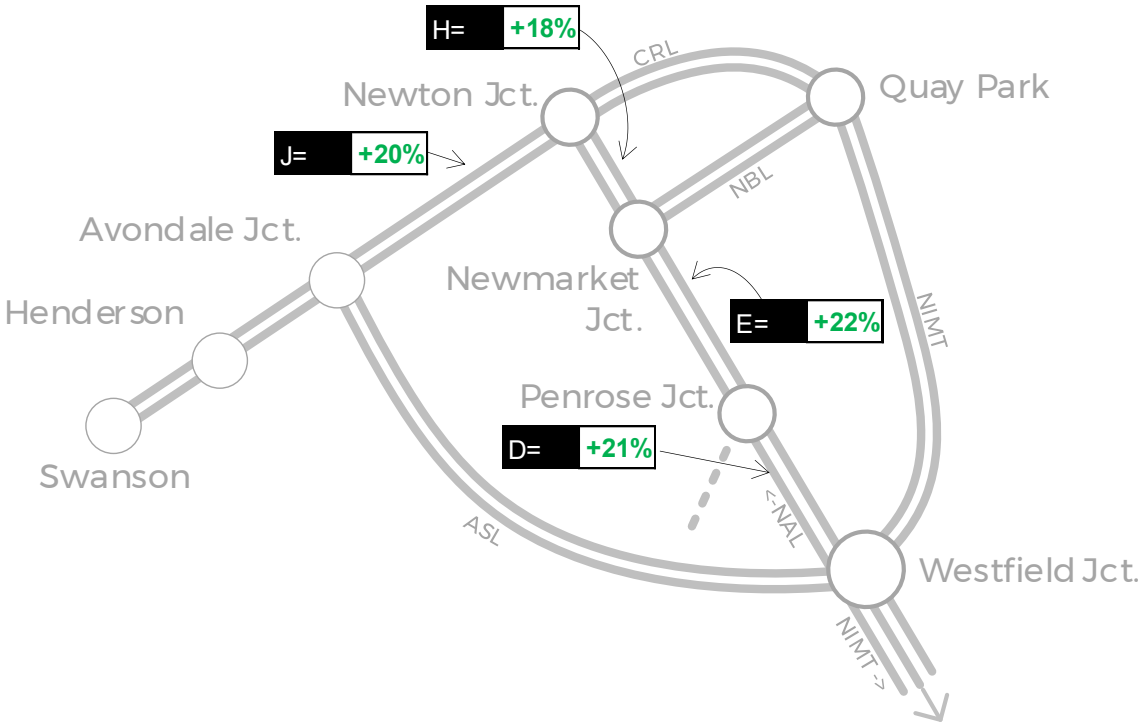


FIGURE 3-6 - A-S CAPACITY BENEFIT TO THE INNER NETWORK, UTILISING ETCS L2 SIGNALLING

This additional capacity released on the **Inner Network** by the A-S can be utilised to:

a) expand and improve the rail passenger service offering,

b) improve the overall reliability of the current service offering, or,

c) a balanced combination of both.

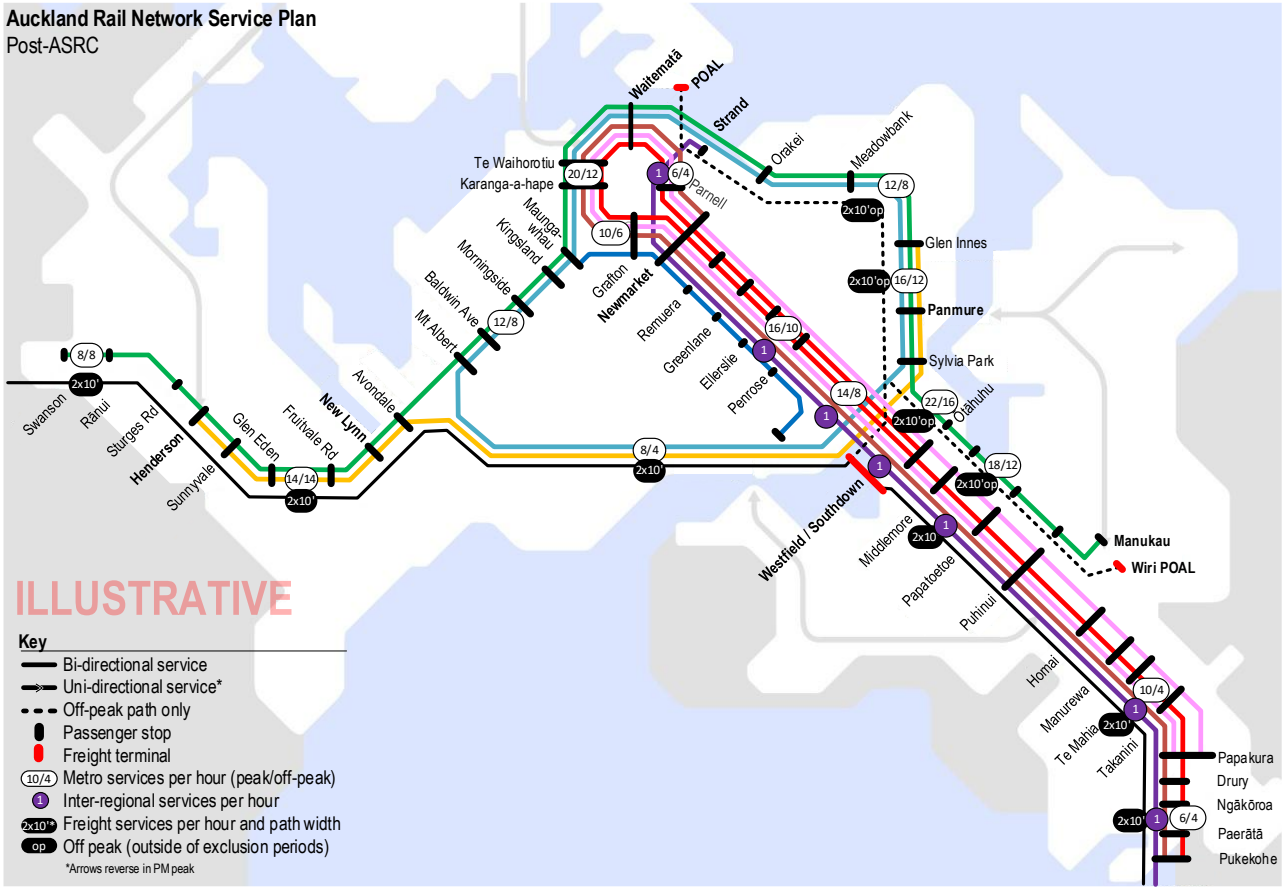
Sections 4 and 5 will explore these potential benefits in more detail.

4 EXPANSION OF SERVICES

In **Section 3** the analysis showed how the A-S expands the capacity on the **Inner Network**. In this section the study explores how this capacity could be used to expand and improve the rail service offering, including how the corridor might be utilised for new passenger lines.

4.1 AN ILLUSTRATIVE POST-A-S SERVICE CONCEPT

An illustrative post-A-S service concept is presented in **Figure 4-1 below**. Note that at the time of this report the number and location of stations along the A-S had not yet been confirmed and will be determined as part of the continual development of the project.



Line	Service Type	Origin	Destination	Runs in Off-Peak	Runs in Peak	Trains Per Hour	
South to City (SC), all stops	Metro	Pukekohe	Otahuhu	●	●	4	[1]
South to City (SC), all stops	Metro	Papakura	Papakura		●	2	[1]
South to City (SC), limited stops	Metro	Pukekohe	Newmarket		●	2	
East to West (EW)	Metro	Manukau	Swanson	●	●	8	
A-S Isthmus Loop Line	Metro	Mt Albert	Mt Albert		●	4	
A-S Crosstown Line	Metro	Henderson	Glen Innes	●	●	4	
Te Huia / Northern Explorer	Inter Regional	Hamilton / Wellington	Auckland	●	●	1	[2]
Southern	Freight	Pukekohe	Westfield	●	●	2	[3]
Northern	Freight	Westfield	Swanson	●	●	2	[3]
Auckland Port	Freight	Southdown / WPOAL	POAL	●		2	[3]

[1] Looped routing results in doubling train frequencies along segments of the route

[2] Up to 1tph. Services don't run every hour

[3] 2 paths per hour reserved for freight.

FIGURE 4-1 ILLUSTRATIVE POST-A-S AUCKLAND NETWORK SERVICE CONCEPT

For the purpose of this study, two potential service patterns have been adopted in the post-A-S service concept (**Figure 4-1**), to further illustrate the potential benefits of the corridor:

- An **'Isthmus Loop line'** service which travels between the NIMT (Orakei - Sylvia Park) to the NAL (Maungawhau - Mount Albert) via the A-S corridor on one side of the loop and the CRL on the other, and
- A **'Crosstown line'** service that travels between Henderson in the west and Glen Innes in the east via the new A-S.

The 'Isthmus Loop line' services replace the inner-E-W line service in the pre-A-S service concept, expanding it to serve new stations along the new A-S as well as Panmure and Sylvia Park. Note that to support this service concept, it is assumed that the new junction at Avondale includes an east-facing connection, although this is not part of the minimum viable product design concept for the project - refer to **Section 7** for further discussion.

It is also assumed for the purpose of this study that the existing Onehunga services will be removed from the network, given that the new passenger services running on the A-S will likely provide more desirable alternatives for the majority of passengers. Further discussion on this is provided in **Section 4.1.1**.

Aside from these changes, the S-C line and E-W line have been kept as per the pre-A-S service concept.

4.1.1 ONEHUNGA SERVICE CHANGES

The Onehunga branch line provides a direct rail service to the Onehunga area. At one time this service connected Onehunga directly to the city centre. Due to the reconfiguration of Waitematā platforms this is no longer possible and the service currently terminates at Newmarket, but with plans to extend the route to Maungawhau and Henderson post-CRL.

Whilst the direct rail service has benefits to the Onehunga community, there are a number of constraints that limit its utility and create problems for the operation of the wider network. Firstly, the corridor is only wide enough for a single track, which practically limits the service to a half hourly frequency. Platforms on the line are only long enough to support the shortest length train (three-car) which means that whilst the service consumes track-capacity on the busiest sections of the E-W line and S-C line, it provides very limited additional passenger carrying capacity. Traversing these busy sections of the network also contributes to the high-capacity utilisation figures presented in previous sections which can lead to reliability issues, constrains expansion of more productive services, and limits the flexibility of the network timetable.

With the introduction of the A-S, new rail lines serving the Onehunga catchment area will be created. In the illustrative post-A-S service concept, both the 'Crosstown' and 'Inner-Loop' services would likely provide a more desirable alternative to the existing Onehunga branch line service with routes directly into the city centre, as well as to the eastern and western areas of the city. These lines would also operate at much higher frequencies and capacity; at 8 tph (six cars in length), this would represent an eight-fold increase in capacity over the existing Onehunga branch line service.

It is worth noting that achieving an equivalent level of service uplift on the existing Onehunga branch line would require substantial investment including double tracking the corridor, removing existing level crossings, plus adding and extending platforms.

In summary, introduction of the A-S provides an opportunity to review how the Onehunga area is serviced by rail in the future, including potentially removing or modifying the existing service to free up valuable capacity on the inner-network. This is not to say that the Onehunga branch line itself would need to be closed as it could still be utilised as a shuttle service to Parnell or some other routing concept.

A wider study is required to further investigate this - but, for simplicity it has been assumed that the Onehunga branch line service is removed in this study.

4.2 NETWORK CAPACITY POST A-S

Results of the compression analysis carried out on the post-A-S service concept (according to the methodology described in **Sections 3.1 and 3.2**) is presented in Figure 4-2 overleaf. This includes a comparison to the pre-A-S results presented in **Section 3.4**, under existing signalling and ETCS L2 scenarios.

The analysis shows that the introduction of A-S results in an acceptable level of capacity utilisation on all segments of the **Inner Network** with the exception of the short segment between Westfield and Glen Innes (**Segment F-1**). This section receives a significant increase in train volumes due to the combined effect of the new Crosstown and Isthmus Loop line services which is the reason for the higher utilisation. This segment has a capacity utilisation of **113%** under the existing signalling scenario but reduces to an acceptable **79%** under the ETCS L2 scenario.

The results for the ETCS L2 scenario show potential for service expansion in the **Inner Network** with most sections **below 75%**. Comparing the pre-A-S and post-A-S networks, the following can be observed:

- **Segments D and E** are both **74%** utilised, compared with **94%** (D) and **106%** (E) pre-A-S. Note that the level of capacity released by the A-S is further improved upon by removing the Onehunga branch line service as discussed in **Section 4.1.1**[24].
- **Segment F-1** increases in utilisation from **39%** pre-A-S to **79%** post-A-S. This is due to the combined effect of the overlapping Isthmus Loop line and Crosstown services which add an additional **8 tph** to this segment. While utilisation has increased compared to the pre-A-S service concept, the **79%** value is still well below the **100%** threshold for reliable operation with room for further expansion.
- **Segments H and J** reduce in utilisation from **67%** (H) and **89%** (J) to **39%** (H) and **59%** (J), again this is due to the removal of the Onehunga branch line services combined with the effect of re-routing freight on to the A-S.
- **Segment K** increases slightly from **67%** pre-A-S to **78%** post-A-S; this is due to the addition of the **4 tph** Crosstown service that replaces the previous **2 tph** Onehunga service (noting that the **78%** value is well below the **100%** threshold for reliable operation).

In addition to these network segments, the post-A-S service concept would relieve substantial pressure on Newmarket junction, by removing freight movements and the additional Onehunga services, reducing potential for delays and increasing flexibility for timetabling.

As previously discussed, the capacity utilisation of the southern corridor is not impacted by the A-S and these constraints require a separate set of investments to address.[25]

For clarity – the reader will notice that the delta values in Figure 4-2 are different to those shown previously in **Section 3.5**. The difference between the two is that the results in **Section 3.5** show the capacity benefits of A- considering only the extent to which it allows freight traffic to be separated from the **inner network**, whereas the figures in Figure 4-2 below include the additional benefit of removing the existing OBL services.

[24] *The analysis in **Section 3.5** gives an indication of the capacity improvement generated simply by routing freight onto the A-S corridor, and excluding the removal of the OBL services.*

[25] *As noted in **Section 1.2**, the capacity analysis does not consider the utilisation of junctions. Westfield junction will be operating a higher levels of utilisation post-A-S, which may have an impact on services on the southern corridor. However, this will depend on the exact configuration of the junction.*

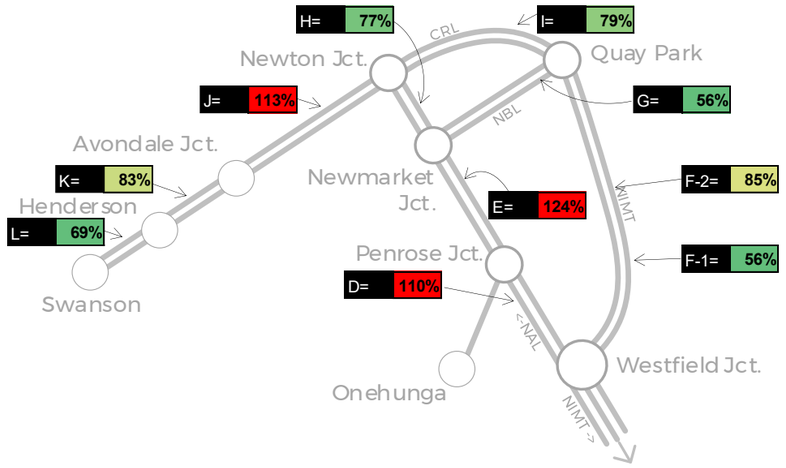
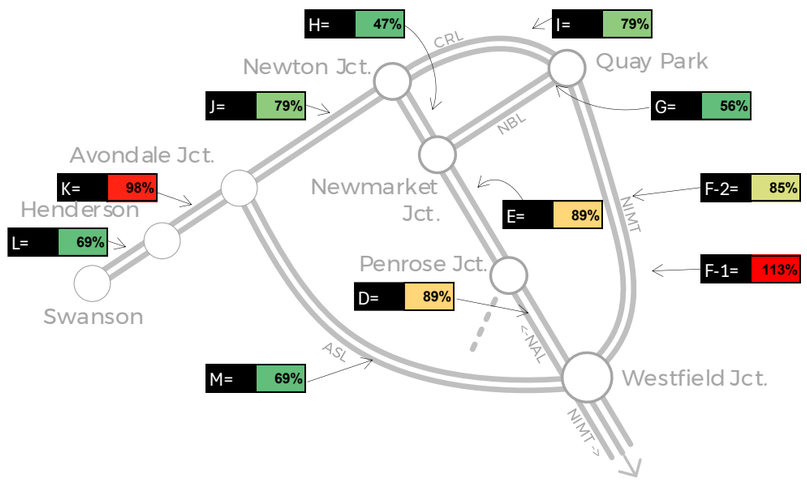
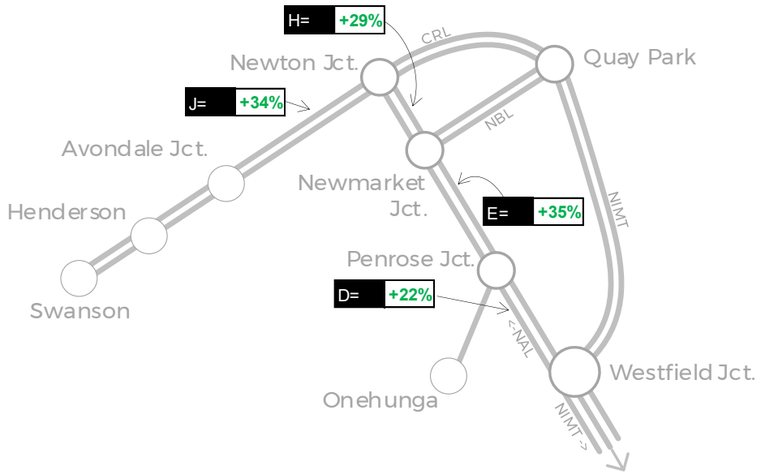
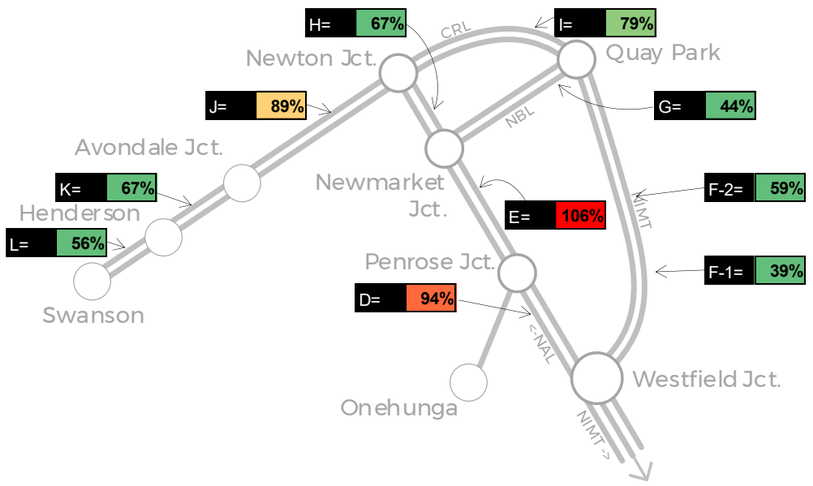
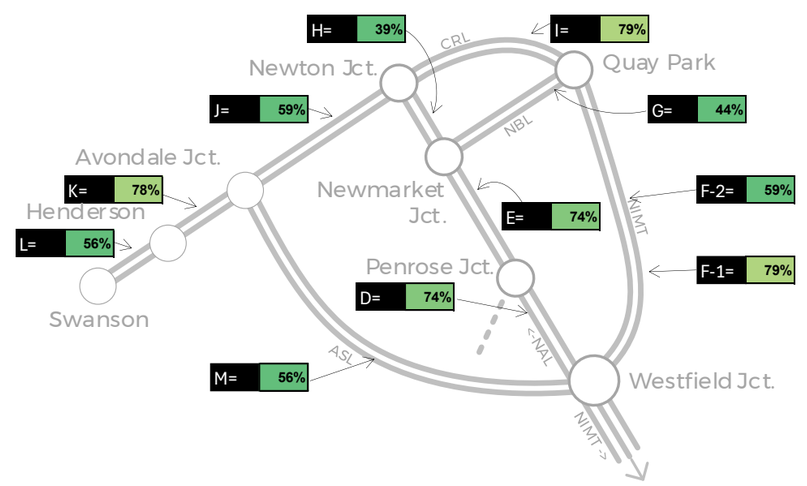
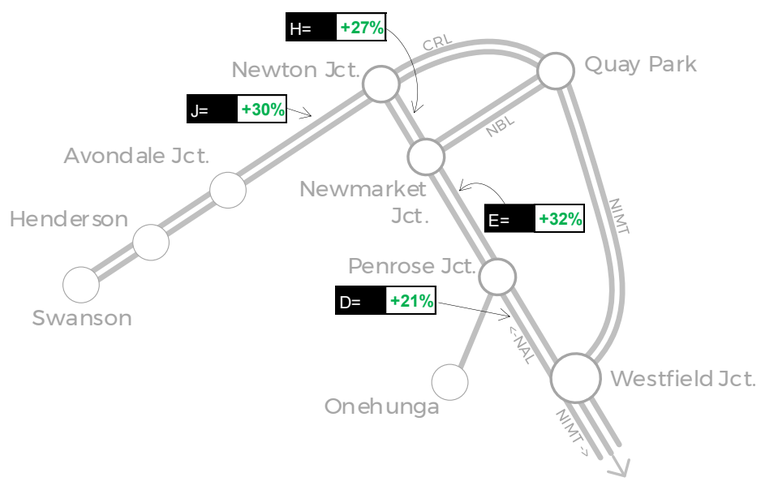
	Pre-A-S	Post-A-S	Delta
Existing Signalling			
ETCS L2 Scenario			

FIGURE 4-2 COMPRESSION ANALYSIS RESULTS

4.3 BENEFITS OF THE POST-A-S SERVICE CONCEPT AND BEYOND

The post-A-S service concept has a number of major benefits to passengers:

Most obviously, it introduces two new passenger lines to the network along with new stations that expand the overall catchment of the Rapid Transit Network and the access it provides to the CBD. With the assumed routing of the Isthmus Loop and Crosstown lines, the A-S provides opportunities to serve traditional commuter flows in Auckland that focus on the CBD, as well other travel purposes, which are becoming increasingly important to the continued growth of public transport in the city.

The Isthmus Loop service concept expands upon the pre-A-S inner E-W line service and by doing so, addresses one its major weaknesses that it doesn't service the major interchange station of Panmure. The Isthmus Loop service effectively serves dual purposes - firstly as a city-centre focused service for the communities along the A-S, and secondly as a capacity boost along the existing inner sections of the E-W line. This service will now be better matched to demand along the eastern corridor with the line being extended through Panmure and Sylvia Park.

Even after incorporating these additional services into the network, the analysis presented in **Section** demonstrates that substantial capacity remains available to accommodate further service expansion. To recap, under the ETCS L2 scenario, nearly all segments of the **Inner Network** initially operate at less than **75%** utilisation (noting that the assumed removal of the existing Onehunga branch line services that positively contribute to this as well).

Further expansion of services could include:

- Additional inter-regional services. The 2051 service aspirations of the AR-PBC was to provide up to 2 train paths per hour for inter-regional services, which could accommodate a wider variety of different service patterns south of Auckland.
- Extra or faster express services from Pukekohe. The spare capacity could be utilised to add an additional two limited stop services from the far southern parts of the network. This was one of the ultimate service objectives documented in the AR-PBC. Alternatively, the spare capacity could be used to provide further runtime savings for the existing two limited stop trains, making them even more attractive to customers.
- Provision of a new West-Newmarket service. The AR-PBC also envisioned a future train line running between Mount Albert and Remuera in 2051. The purpose of such a service is to retain a direct connection between west Auckland and Newmarket, which is currently a major origin-destination flow that will not be directly serviced in the CRL Day One timetable.

It may not be possible to incorporate all these service improvements simultaneously, but the A-S creates the opportunity to explore each of them. None of these service enhancements would restrict the ability to provide two train paths per hour, all day on the Northern freight line. Thus, the post-A-S network has potential to accommodate significant growth in rail freight to Northland as well as passenger services on the Inner Network.

This illustrates A-S's ability to support long-term mode shift, equitable access to the network for all markets, and balanced urban growth in Auckland.

4.3.1 SOUTH TO CITY GROWTH

Interestingly, the 2051 service concept of the AR-PBC requires the exact same number of S-C line trains on the **Inner Network** as the post-A-S concept described in **Section 3.3**.

Both service concepts require 14 tph between Westfield and Newmarket consisting of 8 all-day (all-stops) services, 4 peak only (all-stops) services, and 2 limited stops services. What this implies is that the post-A-S

service concept provides sufficient passenger carrying capacity on the S-C line until at least 2051 on the **Inner Network**.

To clarify, demand for S-C line services is forecast to grow substantially over the next 25 years; however, the growth largely occurs south of Otahuhu - this will be addressed by introducing longer trains (up to 9-car lengths for express services) and by gradually shifting the current terminal at Otahuhu further south. This concept is illustrated in **Figure 4-3**. As shown, on CRL day one, the loop structure of the S-C line results in 8 tph between Otahuhu and Newmarket. By moving the terminal down to Papakura and eventually to Pukekohe, the 8 tph section is extended south, which accommodates much of the additional demand, without actually increasing train volumes on the **Inner Network**.

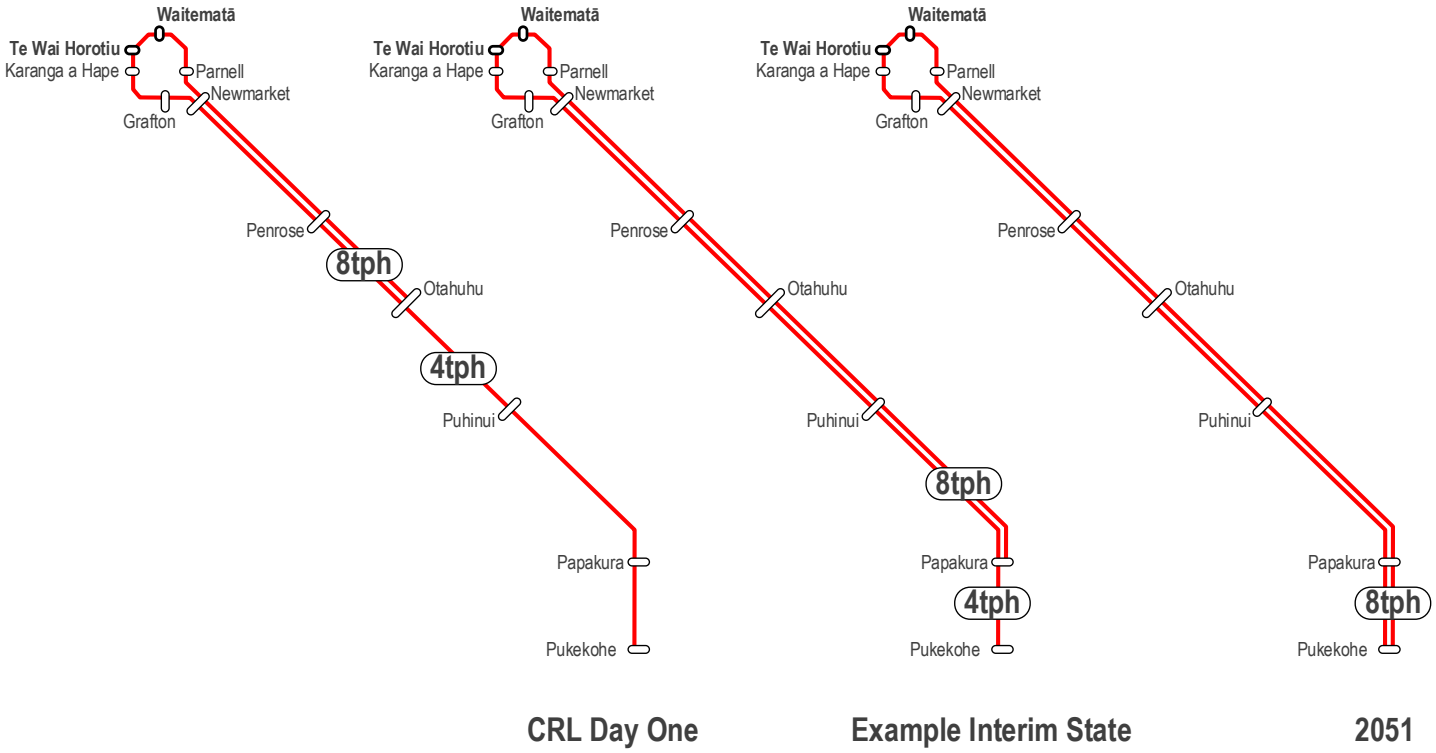


FIGURE 4-3 - EXPANSION OF THE S-C LINE

4.3.2 SUMMARY

To summarise - the A-S provides new heavy rail passenger lines and allows the Northland freight line to grow substantially whist also expanding capacity on the **Inner Network** to add and enhance services on existing passenger lines. Achieving all of these objectives simultaneously without the A-S is not possible even with a theoretical, enhanced ETCS L2 signalling system, as demonstrated by the analysis in **Section 3.4**.

The only way of achieving a comparable level of capacity uplift without the A-S would be to add an additional two tracks to the existing NAL corridor between Westfield, Newmarket and Avondale[26]. This would be considerably more complex and costly and would not provide the extra benefit of the additional passenger lines. In effect, as well as the new capacity created by the A-S itself, it also creates new capacity on the rest of the **Inner Network** without requiring any new investment in those corridors.

[26] *See discussion in the Auckland Rail Programme Business Case, Options Report Part 1, Section 5 - Long List to Short List.*

5 NETWORK RELIABILITY

In **Section 4** the analysis showed how a post-A-S network provides new heavy rail passenger lines and allows the Northland freight line to grow substantially whilst also expanding capacity on the existing **Inner Network**.

The analysis also indicates that, although demand for South-City line services is projected to grow significantly, the post-A-S service concept provides sufficient capacity to accommodate this growth within the **Inner Network**. Additional service expansion would only be necessary south of Otahuhu.

This means that post-A-S, future planners would have the luxury of choosing between increasing services to utilise the expanded capacity, reserving this capacity to provide a highly reliable service, or coming to some optimal combination of the two.

This section discusses how capacity utilisation is conceptually related to reliability, and how poor reliability impacts customers of the rail network.

5.1 RELATIONSHIP BETWEEN CAPACITY UTILISATION AND RELIABILITY

The capacity of a rail system is associated with a required quality of service, ultimately dictated by the needs and experience of the end user (passenger and freight customers). A given railway will be able to support a certain level of traffic volumes but at a particular point, the quality of service will start to degrade and eventually fall below service quality targets. Typically, these targets are in the form of punctuality (% of services arriving on time) and reliability (% of services running) - the concept is illustrated in **Figure 5-1**.

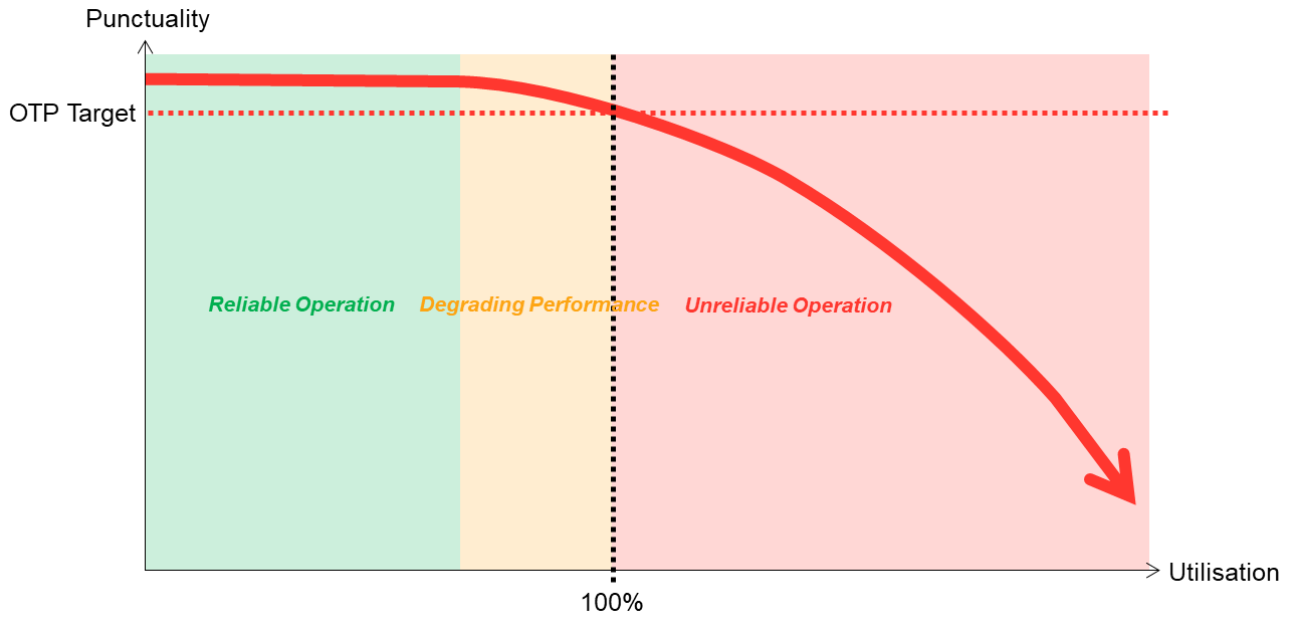


FIGURE 5-1: RELATIONSHIP BETWEEN UTILISATION AND PUNCTUALITY

With respect to the above relationship, it is important to note that an increase in utilisation does not necessarily equate to an increase in train volumes. As previously established, utilisation also increases when train services with different performance and operational characteristics run together in mixed operation. For example, a uniform all-stops operation with trains running every 5 min might have the exact same utilisation as a mixed traffic operation including all-stops passenger services running every 10 min, and two freight trains per hour.

The UIC 406 compression methodology and associated additional time buffers can be used as a proxy to assess reliability. As previously stated in **Section 3.2**, a utilisation value greater than **100%** will tend to perform unreliably whilst a value of less than **100%** tends to indicate room for growth. In reality, the threshold for reliable operations is not so precise. This study has adopted a range between **75% - 100%** over which performance degradation may begin to occur. The rationale for showing a range is as follows:

- As illustrated in Figure 5-1, as capacity utilisation increases, service quality reduces, but generally there is a threshold above which some reduction in quality is acceptable. A **100%** utilisation value in theory represents the point at which this threshold is exceeded, but there would have been some service degradation prior to this point.
- The additional time rates of the UIC 406 leaflet are based on the experience of typical European railway operations. We don't currently have a clear understanding of how applicable these buffers are to the Auckland network but given the lower level of maturity of the network, there is a risk of lower performance.
- The analysis in the report has focused on peak period operation, for which UIC 406 provides specific rates. The leaflet also provides rates applicable to utilisation over a full day, which are much higher. This is because peak operation is usually limited to a defined time period and is not sustainable for a longer durations. The **75-100%** range serves also to indicate where a certain level of train volumes would bot be sustainable for an extended time period.
- Finally, in the context of long-term planning, the analysis may be underestimating the number of train movements required to run the envisioned services, due to lack of detailed timetable information - for example, we have not included empty train moves in the analysis.

The specific relationship between reliability and utilisation can be derived for a particular railway by undertaking simulations. In the context of the future pre and post-A-S service concepts developed as part of this study, this would be a complex and involved exercise given the substantial number of changes to the services and infrastructure, coupled with the fact that almost all infrastructure elements are only at a concept design stage or earlier. In lieu of this, we have undertaken a simple sensitivity simulation test which considers the impact of mixed traffic on the NAL, under the CRL Day One timetable, which is presented in **Section 5.2** below.

5.2 SIMULATION TEST ON THE CRL TIMETABLE

To further test the relationship between utilisation and reliability in the context of the Auckland rail network, a simple sensitivity simulation was performed using the CRL Day One timetable OpenTrack model.

As noted, a major contributor to the high utilisation of the **Inner Network** (pre-A-S) is the mixing of freight and metro services during peak periods. To assess the impact of mixed operation on the **Inner Network**, a simple test was performed by scheduling Northern freight-line trains to run in the up and down directions through the AM and PM peaks.[27] The impact of this on reliability was an approximate **1.8% and 3.4% reduction** in On Time Performance (OTP) during AM and PM peak periods respectively, and **1.5% over the full day** as shown in **Table 5-1** below. While this may not sound significant, it should be put into context that AT's current OTP target is 95% so a **1.5 to 3.4%** reduction in performance can easily be the difference between "pass" and "fail" on a given day of operation.

[27] *Other simulation settings also include ETCS L1 disabled on freight, release speed as per the current system, and base TSRs enabled. These settings are not particularly important, so much as that they are held constant between the two scenarios.*

Test Scenario	Scheduling NAL up/down								
	Test A - Base TT			Test A - with NAL Freight					
Seed	AM	PM	Full Day	AM	PM	Full Day			
1				93.3%	92.3%	96.1%			
2	100.0%	97.3%	98.8%	97.3%	97.3%	97.4%			
3				95.3%	87.4%	94.9%			
4	96.7%	94.0%	96.9%	96.0%	92.9%	96.9%			
5	97.3%	96.7%	97.9%	95.3%	95.1%	96.8%			
6	97.3%	94.0%	97.3%	94.7%	92.3%	96.4%			
7	94.7%	96.2%	97.3%	94.7%	94.0%	96.5%			
8	97.3%	94.5%	97.3%	96.7%	85.2%	94.1%			
9	96.7%	94.5%	97.1%	94.7%	94.0%	96.6%	Delta		
10	97.3%	98.4%	98.8%				AM	PM	Full Day
AVG	**97.2%**	**95.7%**	**97.7%**	**95.3%**	**92.3%**	**96.2%**	**-1.8%**	**-3.4%**	**-1.5%**

KEY
<80
>95
Deadlocks

TABLE 5-1 - SUMMARY OF OTP RESULTS FOR SCHEDULING NAL FREIGHTS DURING AM AND PM PEAKS

Furthermore, the effect of this mixing would likely be greatly amplified under the pre-A-S service concept where significantly more trains are run on the **Inner Network**.

6 NETWORK RESILIENCE

In **Sections 3, 4 and 5** this study showed how the A-S not only introduces new passenger lines and provides a more efficient route for traffic on the northern freight line but also introduces additional capacity on the wider isthmus network to enable further growth in passenger services, and improve reliability under normal operation.

The Auckland rail network is comprised principally of two main trunk lines with several branches that effectively form dead-ends. There are only a small number of loops meaning that there are few (if any) alternative routings possible when lines or sections of lines are closed. Even after re-opening, recovery can be slow due if rolling stock is out of position. This contrasts to roading networks which generally have significantly greater numbers of alternatives, lessening impacts and speeding up recoveries.

The A-S, linking the NAL and NIMT, creates a second loop on the Auckland isthmus that will open up significant new network optionality, expected to create both alternative routing during disruptions and faster recovery (e.g. ability for operators to relocate trains more quickly). This beneficial network effect could not be achieved if the A-S was a mode other than rail.

To understand the transformative effect this would have on the wider rail network, this analysis now considers how the A-S contributes to the resiliency of the network under degraded operation - including times when sections of the network are closed for planned maintenance or alternatively due to an unplanned incident (examples of which might include a defective train needing to be taken out of service, a switch or signal failure, an intrusion into the rail guideway, flooding of the rail corridor, etc.)

To do this, the extent to which the Auckland rail network could continue operation during certain line closure scenarios was evaluated, comparing the network with and without the A-S in place. Note that for simplicity the many potential causes of a closure were not defined or discussed, only that there was some issue that prevented trains from utilising particular sections of the Auckland rail network.

6.1 GENERAL CONCEPTS AND METHODOLOGY

The general service concepts discussed within this aspect of the study assumed that during both planned and unplanned disruptive events, metro services would be isolated such that those services not directly affected by the closure continue to operate as far as possible (albeit at a reduced frequency), with shuttles (where practical) to try and serve stations no longer served by a cancelled line.

During *unplanned* closure events on a particular line, services on *other lines* may still be indirectly affected as a result of trains and drivers being out of position, requiring dynamic service adjustments or service cancellations as rolling stock and drivers are reassigned or sent to stabling locations.

Dedicated rail replacement bus services take time to arrange and deploy during *unplanned* events (circa 1 hour), which is exacerbated during the peak hours where busses are utilised for school services; therefore, in the interim, passengers may need to resort to regular metro bus services to complete their journeys wherever a rail service is no longer available. In either case, de-training a six-car metro train (carrying hundreds of people) onto buses at short notice cannot be achieved without substantial disruption and delays to both rail and bus passengers. It is therefore desirable to keep passengers within the rail network minimising the need for them to interchange in order to complete their journeys during disruptive events.

In terms of freight, any severe disruption would lead to freight services being held north of Swanson if heading to the Southdown Container Terminal from Northland or held in the depot / siding / facility until the route becomes available again. The shuttle freight services from POAL and customer sidings to Wiri and Westfield may also be compromised depending on the location of the disruption, resulting in freight services being held in the port or depot locations until the route becomes available again. The nature of shuttle services means that lost time can only be made up by reducing turn-around times either by short loading trains or cancelling freight services. In

both cases, this is freight capacity that is permanently lost, with knock-on impacts to the owners of goods as well as the overall efficiency of port operations.

The exact response to an unplanned event will be dynamic and subject to the specific situation, context and operational procedures that are invoked to deal with it; for that reason, this study does not discuss specifics in terms of what has caused the postulated closure scenarios.

In the following sections, a number of hypothetical scenarios of possible network disruptions has been set out to assess the impact of the A-S has to mitigate disruption, including potential options for alternative routings and recovery.

The information in the following sections summarise the findings of the assessment; the detailed assessment and methodology for these closure scenarios is documented within **Appendix D**.

6.2 BLOCK 1: CLOSURE BETWEEN AVONDALE AND MAUNGAWHAU

"**Block 1**" is a postulated closure scenario of **the NAL between Avondale Station and Maungawhau Station**.

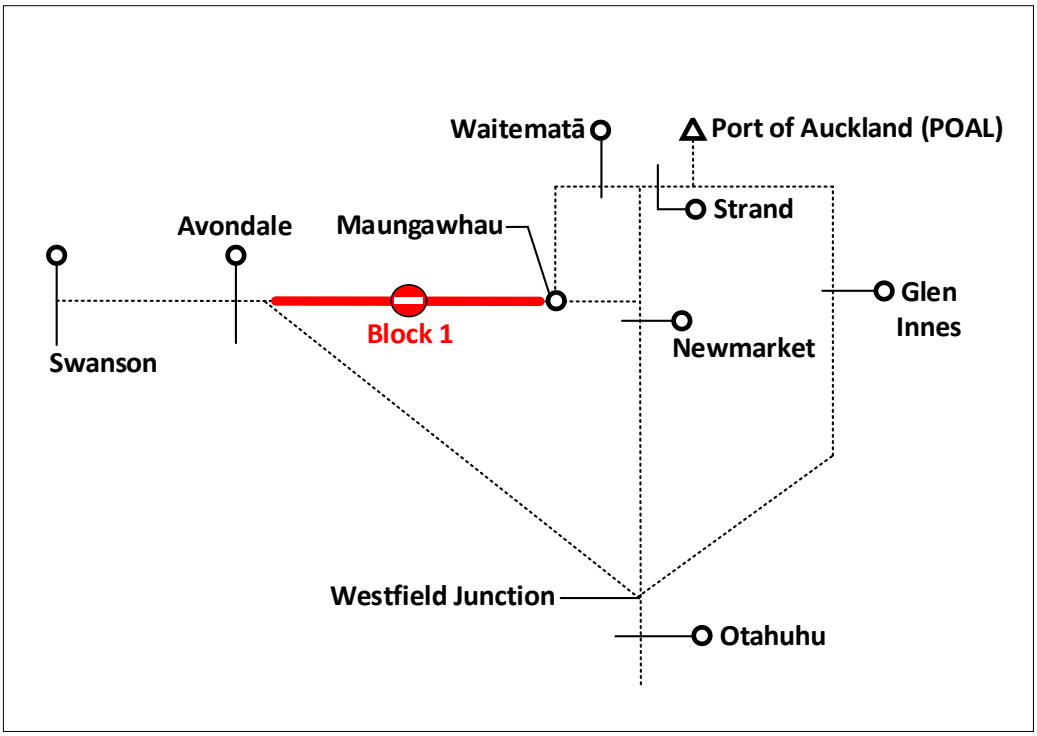


FIGURE 6-1: BLOCK 1 CLOSURE SCENARIO

The key resiliency benefits delivered by the A-S under this closure scenario are summarised below. For the detailed assessment of this closure scenario, including the alternative service concepts on which these assessments are based upon, refer to Appendix D1.

Impact on freight services:

- Without A-S there is no alternative route for freight traffic from the north to the freight terminal at Southdown; therefore, the Northern freight line would cease operation for the duration of the closure. In a planned maintenance scenario, it may be possible to still move freight through the network but would require maintenance crews to temporarily clear the line, significantly impacting productivity.

✓ A major benefit of A-S under this scenario is that it allows freight services on the Northern freight line to be maintained without disruption; this would be the case under both planned and unplanned maintenance scenarios.

Impact on inter-regional services:

- In this closure scenario there is no foreseeable impact on inter-regional services.

Impact on metro services:

- The primary impact of this blockage on metro services is to the western leg of the E-W line. During the closure no rail services can be provided between Mount Albert and Kingsland (inclusive), and direct rail connectivity from the west to the CBD is no longer possible. Passengers that normally board services west of New Lynn to travel into the city or further east/south will need to transfer to a bus replacement service at New Lynn or take an alternative bus route (the inverse would be true for passengers travelling west). During this scenario, the A-S corridor provides significant benefits to the wider metro network that aren't as immediately obvious:

✓ The A-S allows a direct rail service to be maintained between the outer western catchment and the CBD with a temporary Western Line service running from Swanson to Waitemata via the A-S and the NIMT-East. Based on a journey time assessment, this rail service is estimated to be at least as good as (if not better than) available bus replacement options.

> ***Journey Time Analysis:*** *Henderson to Waitematā:* ***60 min*** *via direct rail service on A-S vs.* ***57 - 77 min*** *by bus - refer to* ***Appendix D1*** *for further details.*[28]

Rail travel times tend to be less variable than bus travel times, particularly during peak periods; this in combination with a single seat journey, means that the direct rail service will likely be preferred by most passengers, perhaps also benefiting some customers east of Avondale.

✓ The A-S also benefits customers on the eastern line. During the blockage a temporary Eastern Line service terminating at Newmarket can be operated with a maximum frequency of 4 tph - a significant reduction over normal operation in both peak and off-peak periods. With A-S in place, the re-routed Western Line service boosts train frequencies at all stations from Sylvia Park to the city centre by an additional 4 tph to 8 tph total, minimising the impact of the blockage during peak, and resulting in no impact during off-peaks.

✓ For passengers in the Onehunga area - the A-S allows a direct 4 tph rail service to the city centre and to the eastern and western areas of the city to be maintained. This is a substantial improvement over the 2 tph Onehunga to Maungawhau service that would otherwise be required.

[28] The comparative results between direct rail post A-S and bus replacement pre A-S are similar when assuming transfer at New Lynn as opposed to Henderson.

6.3 BLOCK 2: CLOSURE BETWEEN NEWMARKET AND WESTFIELD JUNCTION

"**Block 2**" was a postulated closure scenario of **the NAL between Newmarket Station and Westfield Junction**.

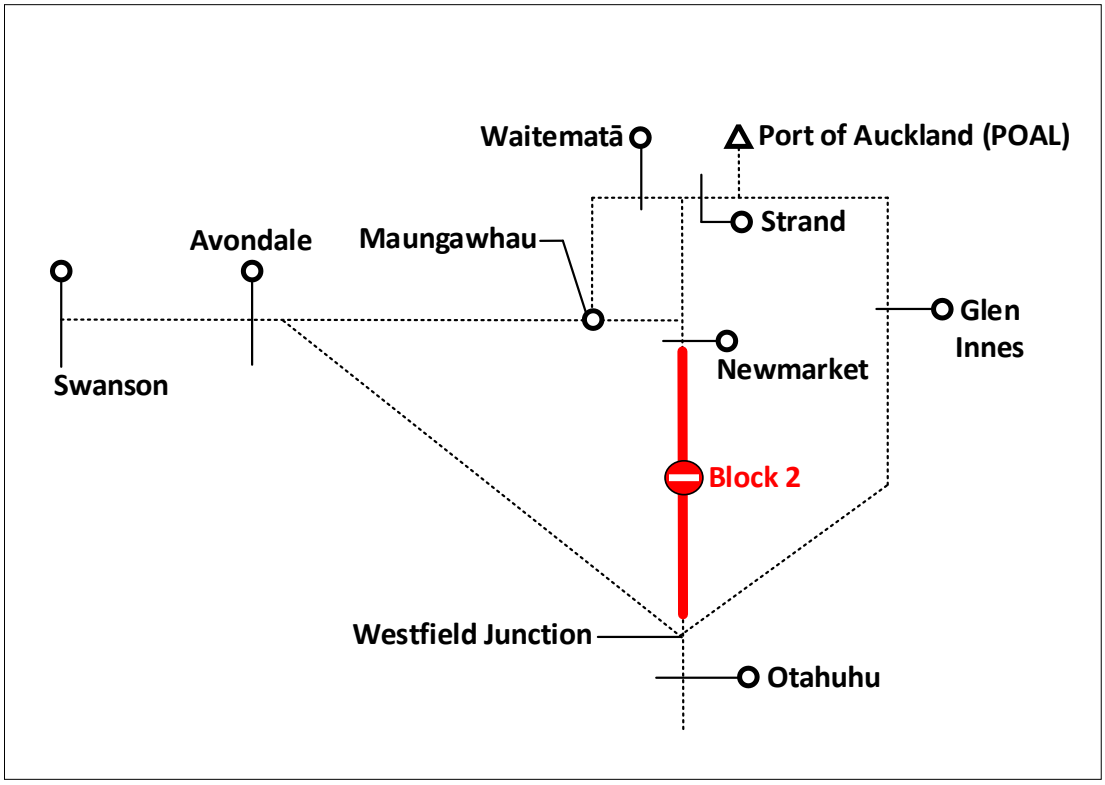


FIGURE 6-2: BLOCK 2 CLOSURE SCENARIO

The key resiliency benefits delivered by the A-S under this closure scenario are summarised below. For the detailed assessment of this closure scenario, including the alternative service concepts on which these assessments are based upon, refer to Appendix D2.

Impact on freight services:

- Without A-S, the blockage requires traffic on both freight lines to be routed along the NIMT-E between Quay Park and Westfield junctions. For Northern freight, this results in highly unfavourable routing through Quay Park Junction - the Southern-Eastern chord of the junction is effectively single tracked, includes the Strand platform, and has slow 25km/h turnouts on either end. This would restrict Northern freight to off-peak periods only. During off-peak periods, both freight lines would then need to compete for the same freight paths in the network timetable, so ultimately the capacity of freight from both Northland and the Ports of Auckland are heavily impacted by this outage.

✓ As with Block 1, a major benefit of A-S under Block 2 is that it allows freight services on the Northern freight line to be maintained without disruption. But these benefits also extend to the Auckland Port freight line under this scenario.

✓ With A-S in place, all aforementioned conflicts are resolved with both lines running on separate corridors. This results in no reduction in capacity compared with normal operation - a significant benefit to freight operation.

Impact on inter-regional services:

- Te Huia and Northern Explorer services are largely un-impacted by this outage, only needing to be re-routed onto the alternative corridor of the NIMT. However the routing of Northern freight through Quay Park junction and the Strand station, may cause operational challenges during off-peak periods, potentially resulting in delays or cancellations to inter regional services.

Impact on metro services:

- During the closure no rail services are provided between Penrose and Remuera (inclusive), however the S-C line can continue to run via the NIMT. This is a commonly used contingency plan in current operations.

✓ The A-S provides significant benefits to the customers on the eastern and western area of the network, during off-peak periods. Without A-S, E-W line service frequencies need to be reduced to 4 tph during off peak periods due to high track utilisation on the eastern corridor where the East-West and South to City metro lines, and the Northern and Auckland Port freight lines converge together. With Northern freight separated onto the A-S, a full 8tph off-peak service can be maintained for the entire E-W line.

✓ Passengers in the Onehunga area also benefit from the A-S in this scenario. Without A-S, the existing Onehunga branch line service is most likely to be completely cancelled. With A-S in place, either of the Isthmus Loop line or the Crosstown line can be retained, giving passengers in the Onehunga area a direct rail service to the CBD and to the eastern and inner western areas of the city.

6.4 BLOCK 3: CLOSURE BETWEEN PORT OF AUCKLAND/STRAND AND WESTFIELD JUNCTION

"**Block 3**" was a postulated closure scenario of **the NIMT between Port of Auckland / Strand and Westfield Junction**.

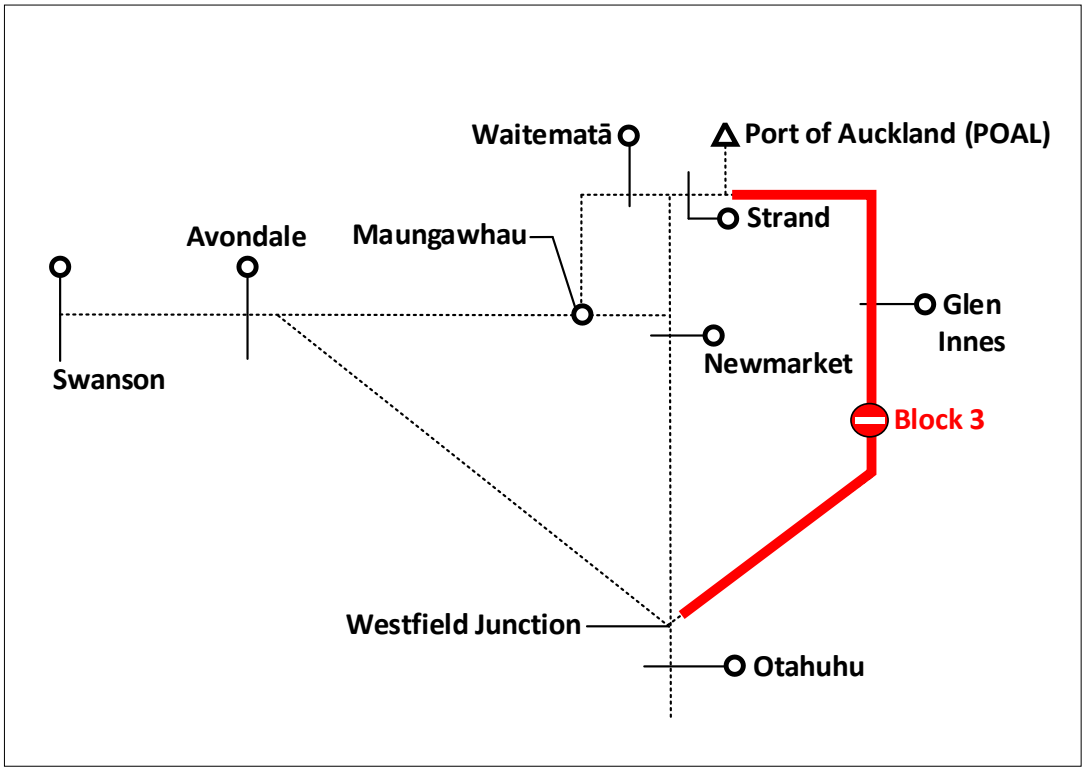


FIGURE 6-3: BLOCK 3 CLOSURE SCENARIO

The key resiliency benefits delivered by the A-S under this closure scenario are summarised below. For the detailed assessment of this closure scenario, including the alternative service concepts on which these assessments are based upon, refer to Appendix D3.

Impact on freight services:

- Similar to Block 2, Block 3 forces the Northern and Auckland Port freight lines to share a single corridor between Newmarket and Westfield, causing both lines to run at reduced capacity as they complete for slots within the network timetable.

✓ The introduction of A-S allows each service to run on a separate corridor, resulting in no capacity reduction.

Impact on inter-regional services:

- In this closure scenario there is no foreseeable impact on inter-regional services.

Impact on metro services:

- The eastern leg of the E-W line would not be available under this outage; however, Manukau can still be served by re-routing the S-C line.

- Train services on the eastern corridor will need to be cancelled due to the blockage, which leaves the S-C line to operate more or less unimpeded. As discussed in **Section 3.4**, even under normal operation, the section of the network between Westfield and Newmarket junction will see very high capacity utilisation, making it infeasible to operate the proposed service concept in practice. To address this capacity constraint without A-S, the **peak overlay services starting at Papakura** will need to be reduced from 4 tph to at least 2 tph along this section of the corridor.

✓ In contrast, with A-S in place, no reduction of the peak overlay services will be required.

> ***Capacity analysis:*** *Due to the high density of metro traffic, mixed with inter-regional and freight services, segment E between Penrose and Newmarket junction will be operating at* ***106%*** *utilisation, even assuming an optimised ETCS L2 signalling system. Introduction of the A-S expands the capacity of the network by re-routing Northern freight and providing an alternative service to Onehunga, resulting in a greatly reduced utilisation of* ***74%***

✓ To accommodate the cancellation of services on the eastern line, the western leg of the E-W line and inner-E-W line would be rerouted to loop around the city via the CRL and NBL. Without A-S, this results in very high (though still technically acceptable) utilisation between Newmarket and Westfield of **94%**. With A-S in place and freight re-routed away from the **Inner Network**, this section is reduced to **69%** utilisation. This suggests that the A-S would support a much more reliable service for western line passengers.

6.5 BLOCK 4: CLOSURE BETWEEN SWANSON AND AVONDALE

"**Block 4**" was a postulated closure scenario of **the NAL between Swanson and Avondale**.

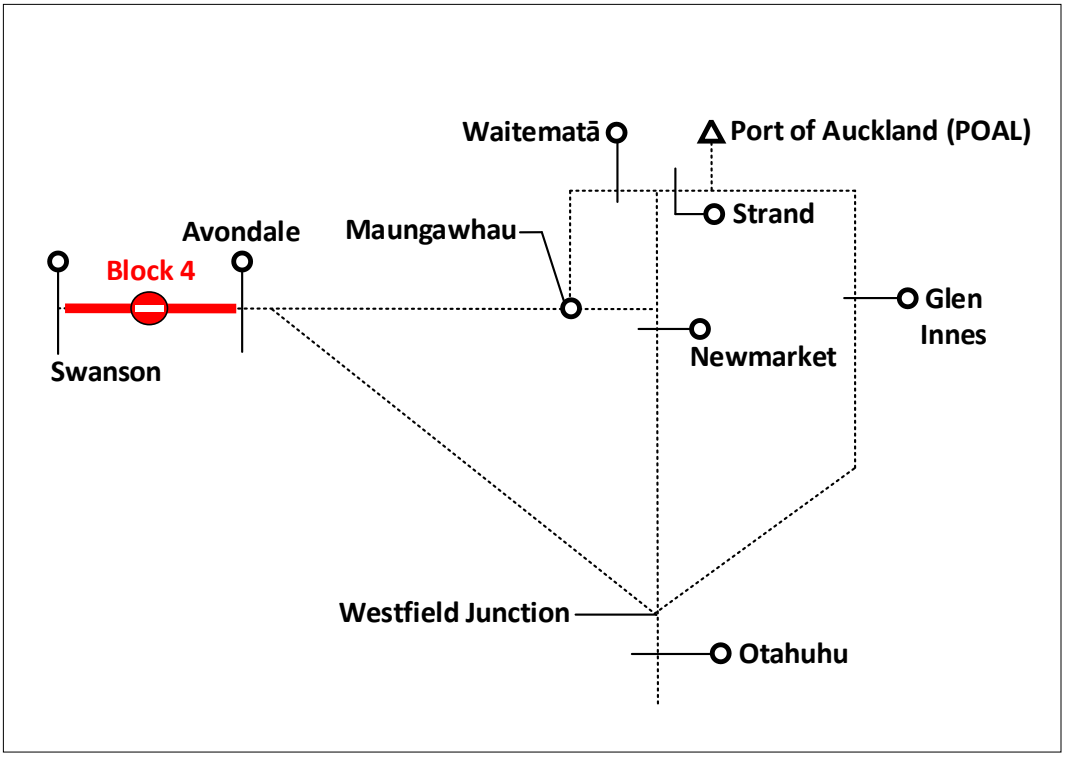


FIGURE 6-4: BLOCK 4 CLOSURE SCENARIO

The key resiliency benefits delivered by the A-S under this closure scenario are summarised below. For the detailed assessment of this closure scenario, including the alternative service concepts on which these assessments are based upon, refer to Appendix D4.

Impact on freight services:

- The Northern freight line would cease operation for the duration of the closure. In a planned maintenance scenario, it may be possible to still move freight through the network but would require maintenance crews to temporarily clear the line, significantly impacting productivity. In an unplanned scenario, freight trains would need to be held at Westfield or north of Swanson until the blockage is cleared.

Impact on inter-regional services:

- In this closure scenario there is no foreseeable impact on inter-regional services.

Impact on metro services:

- The impact of A-S in this scenario is to the eastern leg of the EW line, which would need to terminate prior to Avondale. Without A-S, all E-W line services, as well as the current Onehunga service, would terminate at Mount Albert. With three platforms available, this would require a reduction in peak frequencies from 12tph down to at least 10tph.

✓ The A-S provides a slight benefit here - by providing an alternative service for the Onehunga area, capacity is freed up Mount Albert to run a full peak service.

6.6 BLOCK 5: CLOSURE AT NEWMARKET JUNCTION

"**Block 5**" is a postulated closure scenario of **Newmarket Junction** where all movement through the junction is prevented.

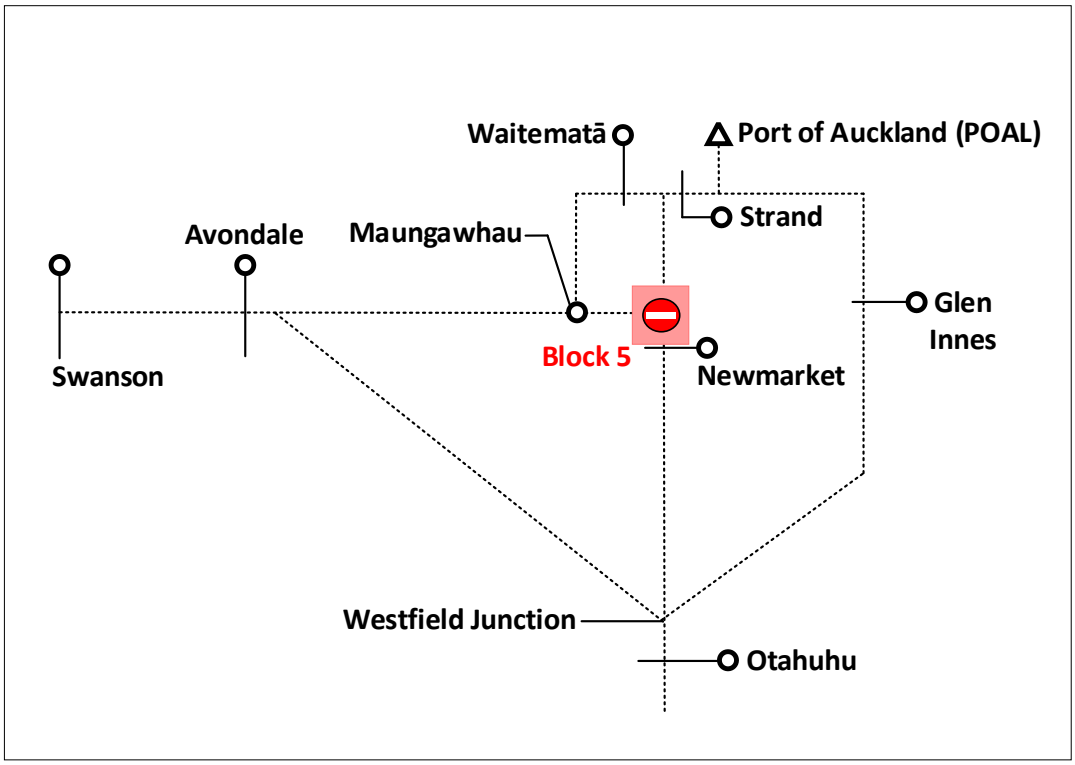


FIGURE 6-5: BLOCK 5 CLOSURE SCENARIO

The key resiliency benefits delivered by the A-S under this closure scenario are summarised below. For the detailed assessment of this closure scenario, including the alternative service concepts on which these assessments are based upon, refer to Appendix D5.

Impact on freight services:

- Without A-S the Northern freight line must cease operation since all possible routes pass through Newmarket Junction.

✓ The primary benefit of the A-S in this scenario is to freight services; with A-S in place, Northern freight is completely unimpacted by this scenario.

Impact on inter-regional services:

- Inter-regional services would need to be re-routed onto the NIMT; this is not expected to significantly impact the service capacity or timing.

Impact on metro services:

- Block 5 has a very similar operational response to Block 2 (closure of the NAL between Westfield and Newmarket) with the following exceptions:
  - The S-C line is terminated at Grafton as opposed to Newmarket,

- Parnell is served by a shuttle service which runs through the CRL between Grafton and Parnell, as opposed to between Newmarket and Waitematā via the NBL, and
- There is no possibility to run traffic on the Northern freight line, whereas in Block 2 this was still possible via the NIMT-East.

- Grafton is not ideally configured for terminating services; with only 2 platforms, and crossovers that are approximately 180m from the end of the platform. In contrast Newmarket has 3 platforms and a more compact layout. As such, the analysis of Block 5 is largely based on the analysis of Block 2 but reflecting a reduced service frequency on the S-C line due to the limitations at Grafton.

6.7 BLOCK 6: CLOSURE AT WESTFIELD JUNCTION

Westfield Junction is a critical and complex junction in the Southdown area. "**Block 6**" is a postulated closure scenario of **for Westfield Junction** where all movement through the junction is prevented.

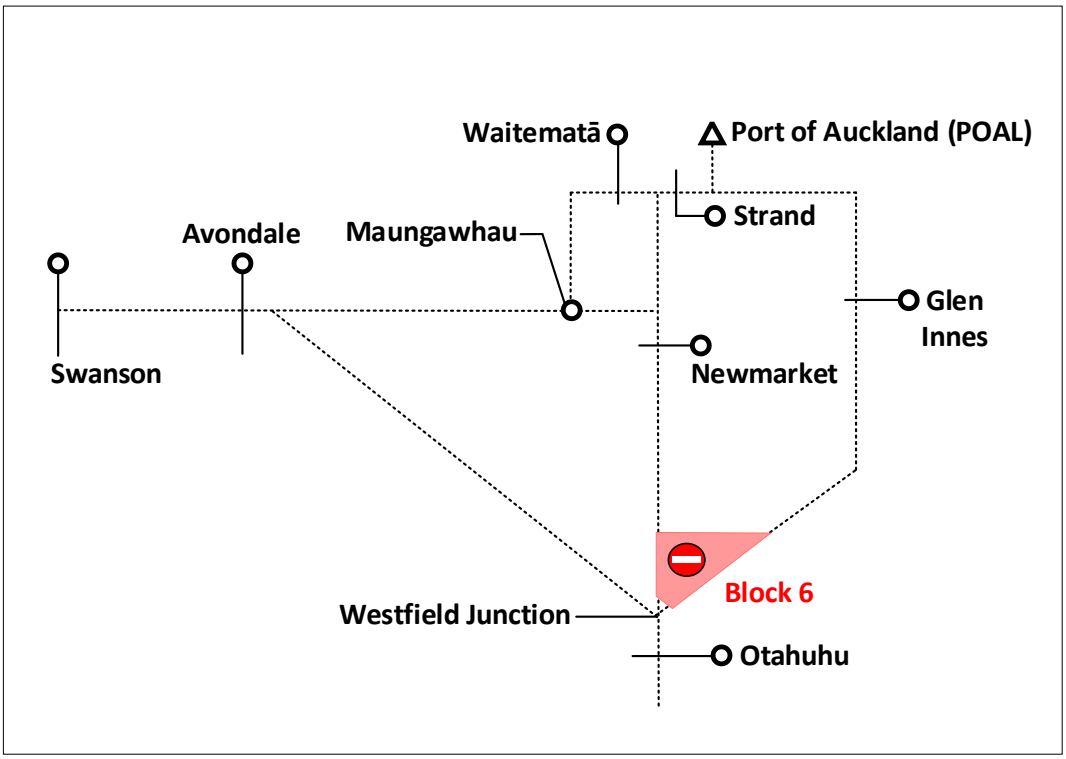


FIGURE 6-6: BLOCK 6 CLOSURE SCENARIO

The key resiliency benefits delivered by the A-S under this closure scenario are summarised below. For the detailed assessment of this closure scenario, including the alternative service concepts on which these assessments are based upon, refer to Appendix D6.

Impact on freight services:

- As with Block 5, without A-S the Northern freight line would normally need to cease operation since all possible routes pass through Westfield Junction. This also applied to the Auckland Port freight line under this scenario.

✓ With A-S in place, Northern freight is completely unimpacted by this scenario.

✓ Auckland Port freight could also continue operation via the A-S corridor and the NAL if an east-facing connection is provided at Avondale Junction (refer to **Section 8** for further discussion on this point).

Impact on inter-regional services:

- Services to/from the Strand would not be able to continue.

✓ Inter-regional services could continue operation via the A-S corridor and the NAL if an east-facing connection is provided at Avondale Junction (refer to **Section 8** for further discussion on this point).

Impact on metro services:

- Under both with and without A-S scenarios, the S-C line needs to be truncated north of Westfield junction. The assumed routing has trains starting and ending at Newmarket with a loop around the CRL. Up to 8 tph is expected to be possible.

- Under both with and without A-S scenarios, the east leg of the E-W line needs to be truncated east of Westfield junction. The assumed routing is between Swanson and Sylvia Park. Note that this would require additional crossovers to be provided at Sylvia Park to support the turnback - based on this assumption, up to 8 tph is expected to be possible.

- Without A-S, the O-W line services run as normal. With A-S, the Onehunga community is served via the Crosstown line that normally runs between Henderson and Glen Innes; however, for this service concept to work, turnback functionality will be required on the A-S at the station immediately west of Westfield junction.

6.8 SUMMARY OF A-S RESILIENCY BENEFITS

The analysis above demonstrates the wide range of benefits of the A-S under degraded modes of operation, including planned and unplanned outages; this includes the somewhat obvious benefits for the Northern freight line, which is able to bypass a number of blockages that would prevent it from running or greatly reduce its capacity under the current network configuration. The analysis also includes benefits which apply to other services, including the Auckland Port freight line, inter-regional services and all metro lines to different extents under different outage scenarios.

Additionally, even when the operational response is the same with or without the A-S, the new corridor in many cases is expected to support more reliable service delivery via the capacity that it releases on the rest of the network.

Assessing the operational resiliency benefits of an infrastructure improvement is complex because the range of scenarios that can be encountered in actual operations is almost limitless. To this point, it is important to note that the analysis outlined in this section was carried out within a limited scope, based upon a workshop exercise involving experienced rail operations staff, and subsequent desktop analysis. It is very likely that there are many other scenarios that has not been covered as part of this study and for which A-S may also have benefits.

7 ADDITIONAL BENEFITS OF BIDIRECTIONAL JUNCTIONS

The analysis set out in **Section 7** is based on a 'minimum viable product' concept for the A-S in which the junctions connecting it to the rest of the Auckland rail network are single direction only (i.e. west-facing connection to the NAL at Avondale Junction, and east-facing connection to the NIMT-E at Westfield Junction). This minimum viable product concept thus excludes bi-directional junctions, namely an east-facing connection at Avondale and a south-facing connection at Westfield.

For the purpose of this analysis, the study does not make any particular assumptions regarding the configuration of the junctions (i.e. whether they are flat or grade separated etc.).

The analysis that follows contributes to understanding the additional benefits that would arise from the inclusion of an east-facing connection at Avondale and/or a south-facing connection at Westfield. The purpose of this approach is to ensure that any enhancements beyond the minimum necessary to achieve objectives are substantiated by a thorough understanding of both the additional benefits provided and the corresponding increase in costs[29].

The following use cases have been identified for consideration by the A-S Programme; each use case would require either an east-facing, or south-facing connection, or both.

- Enabling of an Isthmus Loop line service (as discussed within **Section 4.1**).
- Enabling a staged delivery of the A-S.
- Enabling a direct route from the west to Otahuhu via the A-S.
- Enabling A-S services to terminate / turnback at Mount Albert.
- Providing an alternative route between the CBD and the south via the A-S.

These aspects are elaborated upon in the following sections.

7.1 ISTHMUS LOOP LINE SERVICE

Requires A-S east-facing connection at Avondale	Requires A-S south-facing connection at Westfield
Yes	No

Implementation of an east-facing connection to the NAL would enable the operation of an inner-loop type metro service during normal and/or degraded operations (**Figure 7-1**) - an example service concept is detailed in **Section 4.1.**

As discussed in **Section 4.3**, the benefit of the east-facing connection in enabling this loop line is that it serves dual purposes as both a city-centre focused service for the communities along the A-S, and as a capacity boost along the existing inner sections of the E-W line. On the Eastern Corridor the Isthmus Loop line is also better

[29] Note: Costs, including any additional costs beyond the minimum viable concept, are being assessed in another workstream.

matched to demand than the previous Inner E-W service as it now serves the key interchange station at Panmure as well as Sylvia Park, whereas the Inner E-W line terminates at Glen Innes.

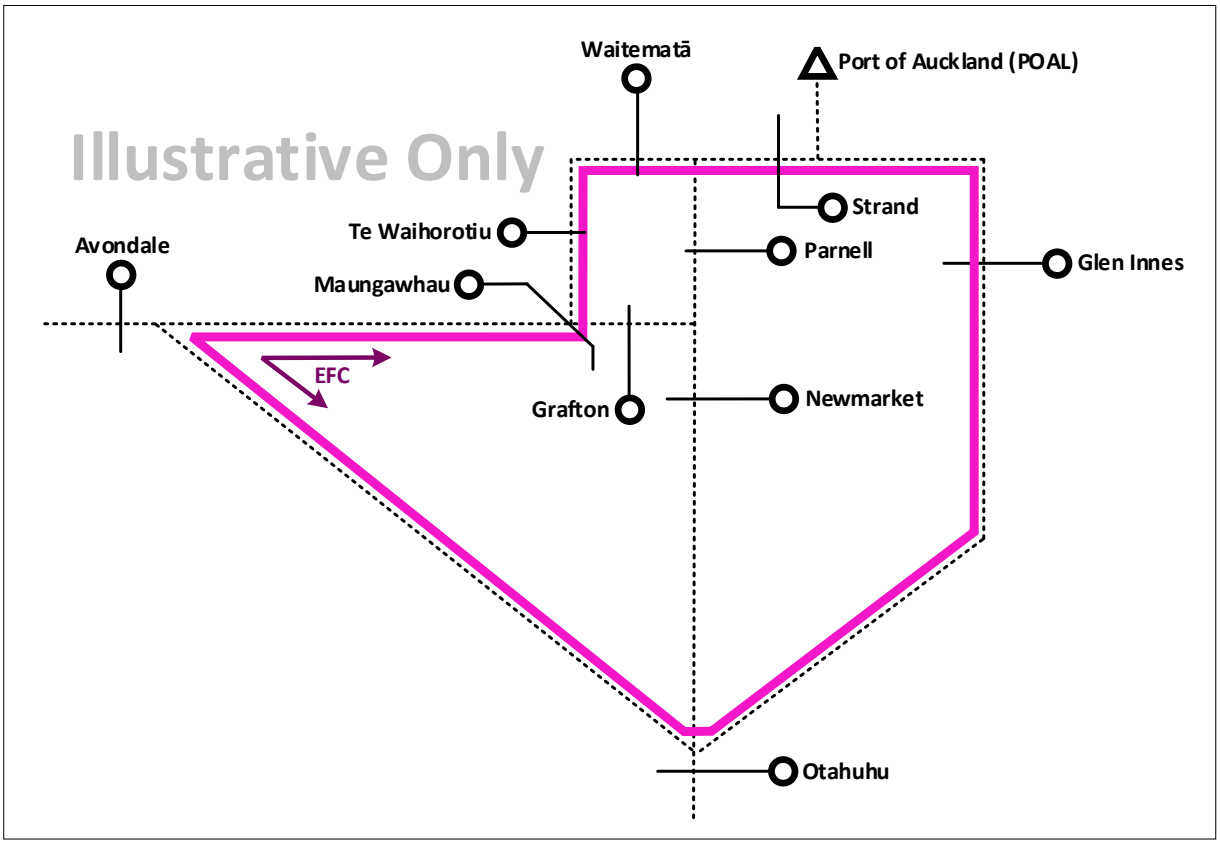


FIGURE 7-1: ISTHMUS LOOP LINE SERVICE ENABLED BY AN EAST-FACING CONNECTION AT AVONDALE

Note that an east-facing connection at Avondale was assumed throughout Section 4 in the development of a post-A-S service concept; however, the minimum viable concept for Avondale Junction currently excludes it.

7.2 STAGED A-S IMPLEMENTATION

Requires A-S east-facing connection at Avondale	Requires A-S south-facing connection at Westfield
Yes	No

Large scale projects and programmes typically benefit from staged construction and implementation of the infrastructure from a risk mitigation and budgetary perspective - in particular mitigating the risks associated with “big-bang” type introductions.

Implementation of an east-facing connection to the NAL would enable A-S to be developed in phases from the northern end such that passenger services can be delivered earlier as sections of the infrastructure are completed; for example, initial services could be provided from the CBD to the Mount Roskill area (thus releasing benefit) whilst more complex stages of the project are still being delivered (**Figure 7-2**).

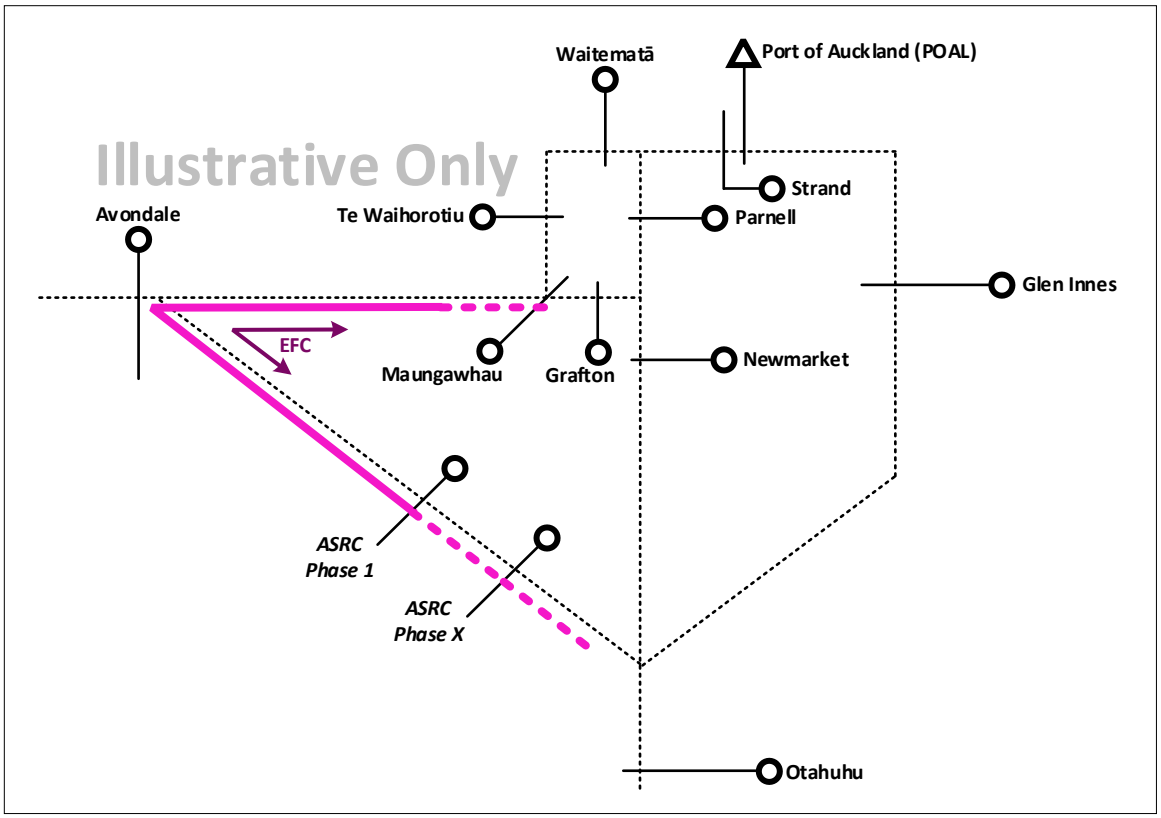


FIGURE 7-2: CONSTRUCTION STAGING ENABLED BY AN EAST-FACING CONNECTION AT AVONDALE

A phased delivery would require suitable turnback capabilities be provided on A-S at the temporary terminal. This adds capital cost and becomes to some extent redundant as the line is further extended. However, the intermediate turnback stations would continue to provide resiliency benefits including enabling different service routings during closures, storing disabled trains, recovering from delays etc. For example, during closures of the NAL west of Avondale, metro passenger services from the CBD would be able to continue beyond Mount Albert to the terminating station on the A-S.

Note that there were no details on any potential A-S phasing at the time of this. For the purpose of this analysis, it is assumed that should a phased approach be taken, A-S would be introduced from north to south, since the northern end of the route carries the least amount of construction complexity. An alternative staging from the south could also be considered. Such an approach would not require a bi-directional junction at Avondale or Westfield and could accelerate urban developments in the Onehunga and Mount Smart area.

It is recommended that the phasing of the works (and the requisite enabling capabilities) are considered by the A-S Programme as part of the concept stages.

7.3 DIRECT ROUTING FROM WEST TO SOUTH (VIA A-S)

Requires A-S east-facing connection at Avondale	Requires A-S south-facing connection at Westfield
No	**Yes**

A south-facing connection at the eastern end of the A-S (i.e. at Westfield Junction) would allow direct routing of trains from the west to Otahuhu southwards; there are two main benefits of this:

- Provision of a diverse route to/from the south from/to Henderson Sidings (**Figure 7-3**).
- Enabling of a passenger service from the west that can terminate at Otahuhu **(Figure 7-4**).

The south-facing connection would provide a direct secondary route (without needing to shunt on the NIMT) for trains in the south that need to be stabled in Henderson; and similarly any trains stabled in Henderson can be dispatched southwards during a planned or unplanned closure of the NAL or NIMT between Avondale Junction and Westfield Junction. This would be mostly applicable for non-revenue movements - for example: to support a more efficient service ramp-up and ramp-down, or to send a defective unit to Wiri for inspection.

During normal operation, the link also provides alternative access to / from Wiri to/from the west (avoiding any potential congestion on the NAL).

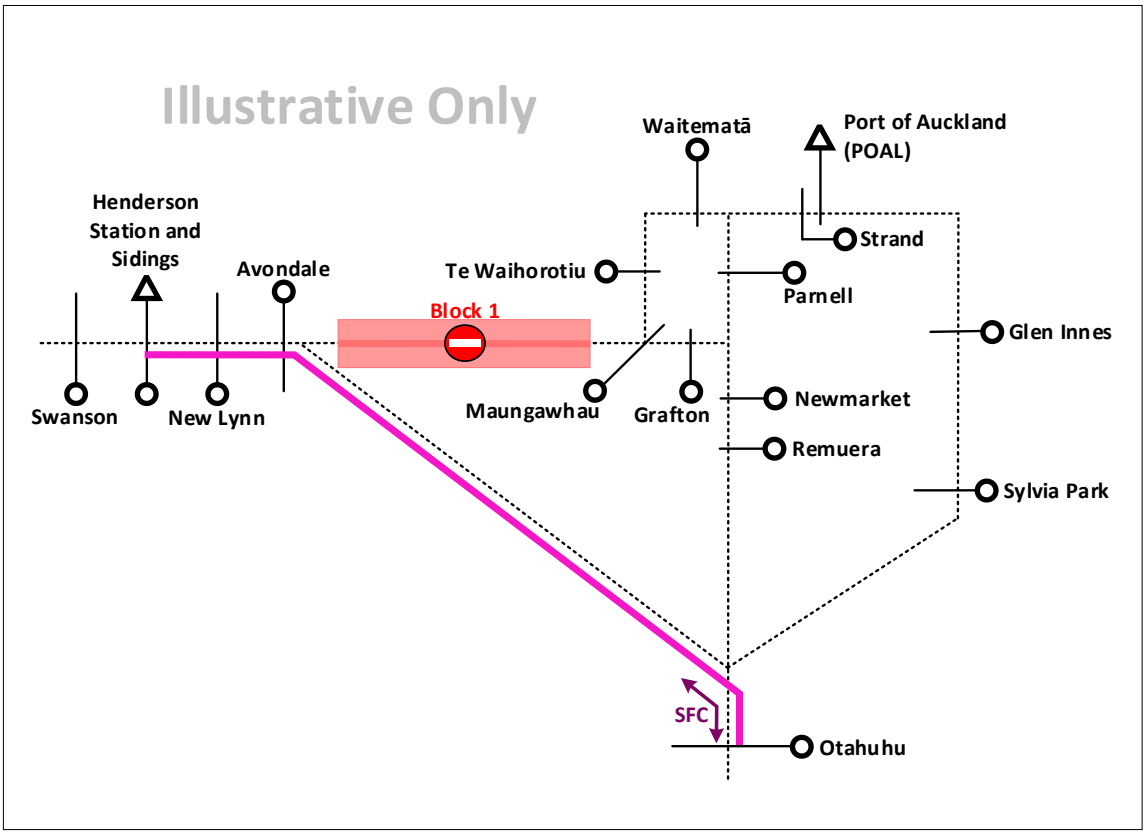


FIGURE 7-3: DIRECT ROUTING OPTION FROM THE SOUTH TO HENDERSON SIDINGS

A south-facing connection could also enable a service to be operated from the west to Otahuhu, which would provide a better onward connection on to the S-C line during disruption; this could be a service that is employed during closures along the NAL, but also along the eastern section of the NIMT where the Crosstown line service would require a station to terminate at. Otahuhu would be a suitable place to terminate, otherwise trains would need to turn-back somewhere along the A-S or continue to Sylvia Park (if available) where passengers needing to transfer to the S-C line would then need to back-track by bus.

Such a service could also be used in normal operation as part of the base service concept. Indeed in the AR-PBC this was considered as an alternative to the assumed routing of the ARSC between Henderson and Glen Innes. A benefit of routing to Otahuhu is that it enables passenger transfers from the ARSC to the S-C line.

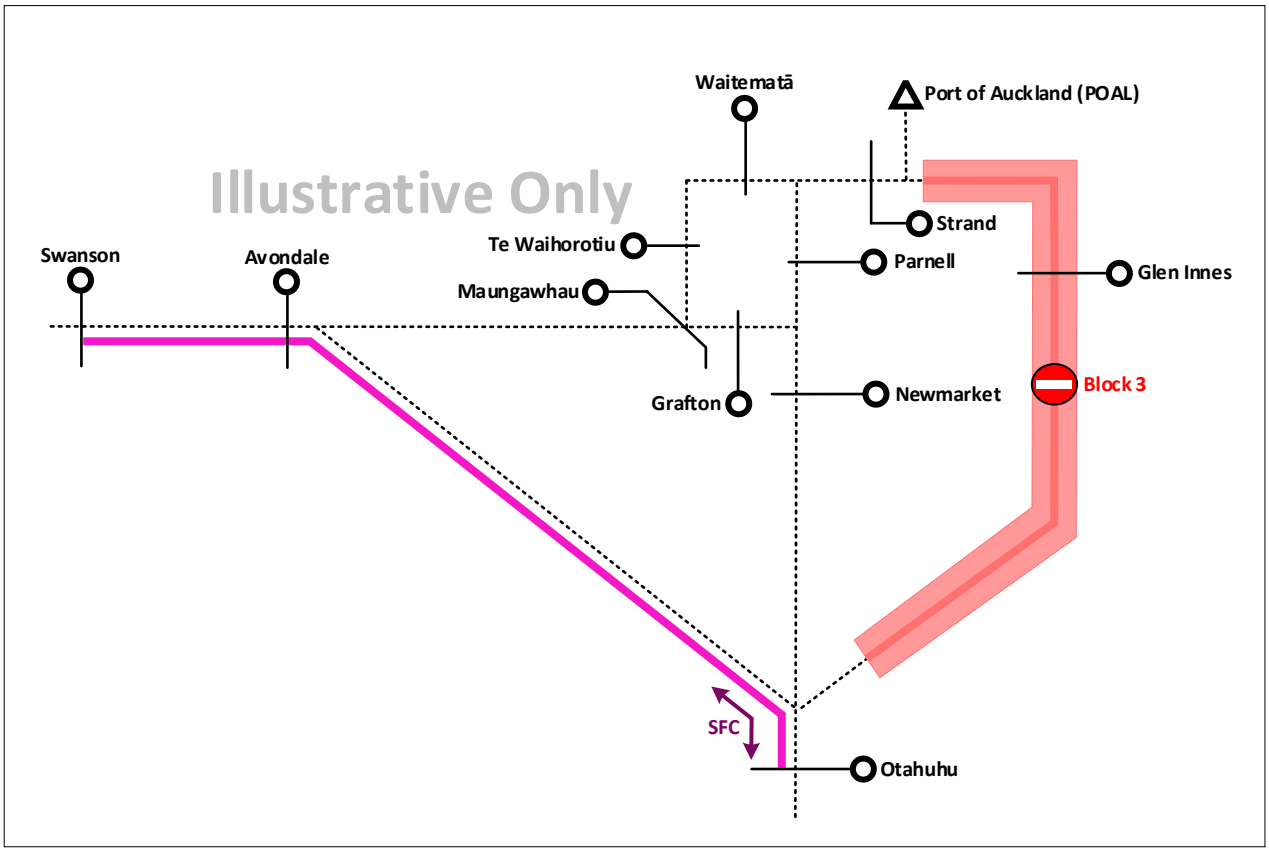


FIGURE 7-4: EXAMPLE TRUNCATED CROSSTOWN LINE SERVICE BETWEEN THE WEST AND OTAHUHU (DURING A CLOSURE ON THE NIMT).

A further potential benefit of a south facing connection is in service ramp-up / ramp-down and empty train positioning as it would allow empty trains to be routed directly between A-S and the Wiri EMU depot.

7.4 TERMINATION OF A-S SERVICES AT MOUNT ALBERT

Requires A-S east-facing connection at Avondale	Requires A-S south-facing connection at Westfield
Yes	No

An east-facing connection at Avondale Junction would provide the capability to route Crosstown line services to Mount Albert in order to terminate / turnback, in the event of a blockage of the NAL west of Avondale (with Avondale station also unavailable to terminate trains) (**Figure 7-5**).

This would also allow metro train passengers to transit to / from the Crosstown line onto truncated E-W Line services to continue their journeys to/from the city.

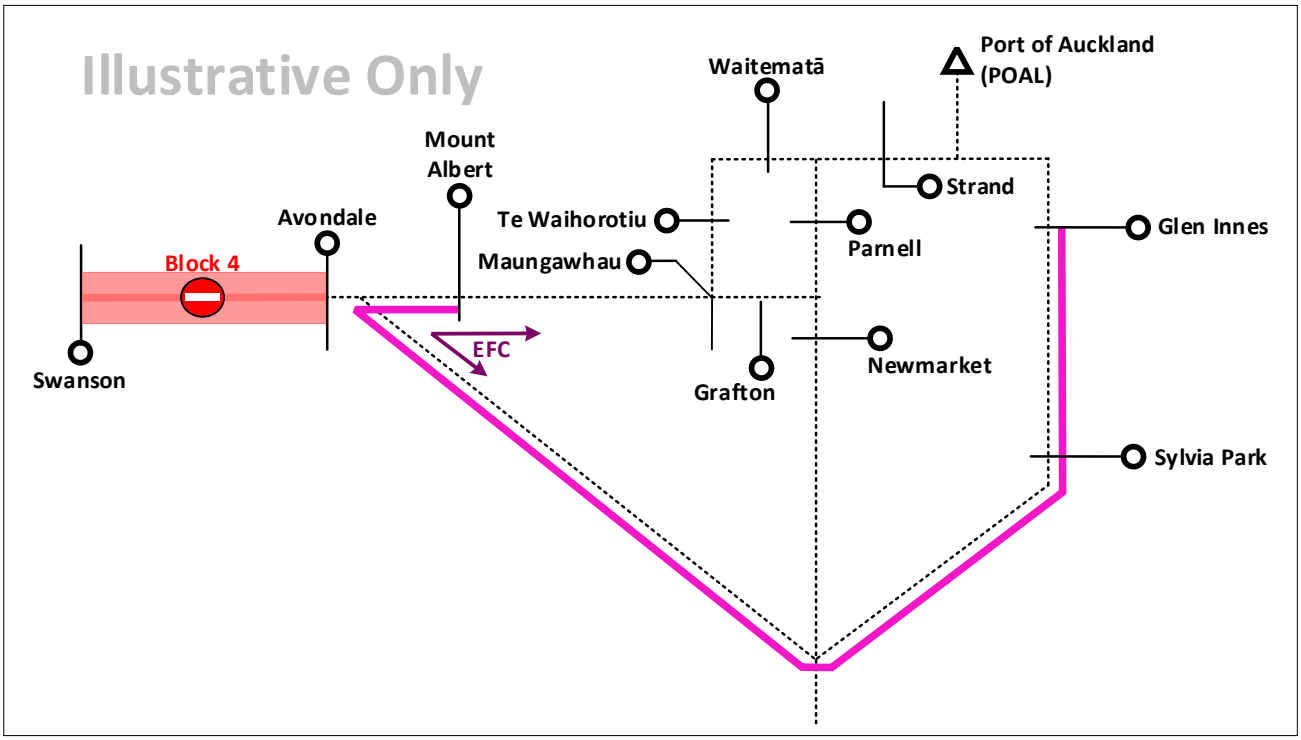


FIGURE 7-5: ROUTING OF CROSSTOWN LINE TO MOUNT ALBERT DURING NAL CLOSURE (ENABLED BY AN EAST-FACING CONNECTION AT AVONDALE)

7.5 ALTERNATIVE ROUTING BETWEEN THE CITY CENTRE AND SOUTH

Requires A-S east-facing connection at Avondale	Requires A-S south-facing connection at Westfield
Yes	Yes

A combination of an east-facing connection at Avondale Junction and a south-facing connection at Westfield Junction would allow an alternative routing of trains from the CBD southward. The benefits of this are as follows:

S-C line services can be routed such that they do not have to be all channelled along one corridor during closures of the NAL between Westfield Junction and Newmarket. Instead, services can be looped around the east-NIMT line, through the CRL, along the NAL then down the A-S (refer to **Figure 7-6**). Other service routings may also be possible but the general principle is that having A-S supports alternative routings that don't place undue pressure on any one particular line. This would help prevent further resilience issues during degraded operation and potentially allow the supply of capacity to be better distributed over the network during normal operations.

It would also prevent the need to terminate S-C line services at Newmarket, as was assumed in the analysis of Block 2 (**Section 6.3**) and Block 6 (**Section 6.7**). This resulted in reduced frequencies due to Newmarket's capacity to terminate up to 12 tph only. A looping service would likely allow for a high frequency of service to maintained.

A further benefit of this routing option (Via the NAL and A-S) is for inter-regional trains. Te Huia services will soon need to be routed in a loop, either up the NIMT and down the NAL of visa versa, due to only having a single locomotive once ETCS L1 fitment is complete. This train configuration, along with the configuration of the Strand and Quay Park Junction, does not support services running into and out of Auckland along the same route. Under Block 2, shown below, the required looping operation could be maintained if the east-facing and south-facing connections are provided.

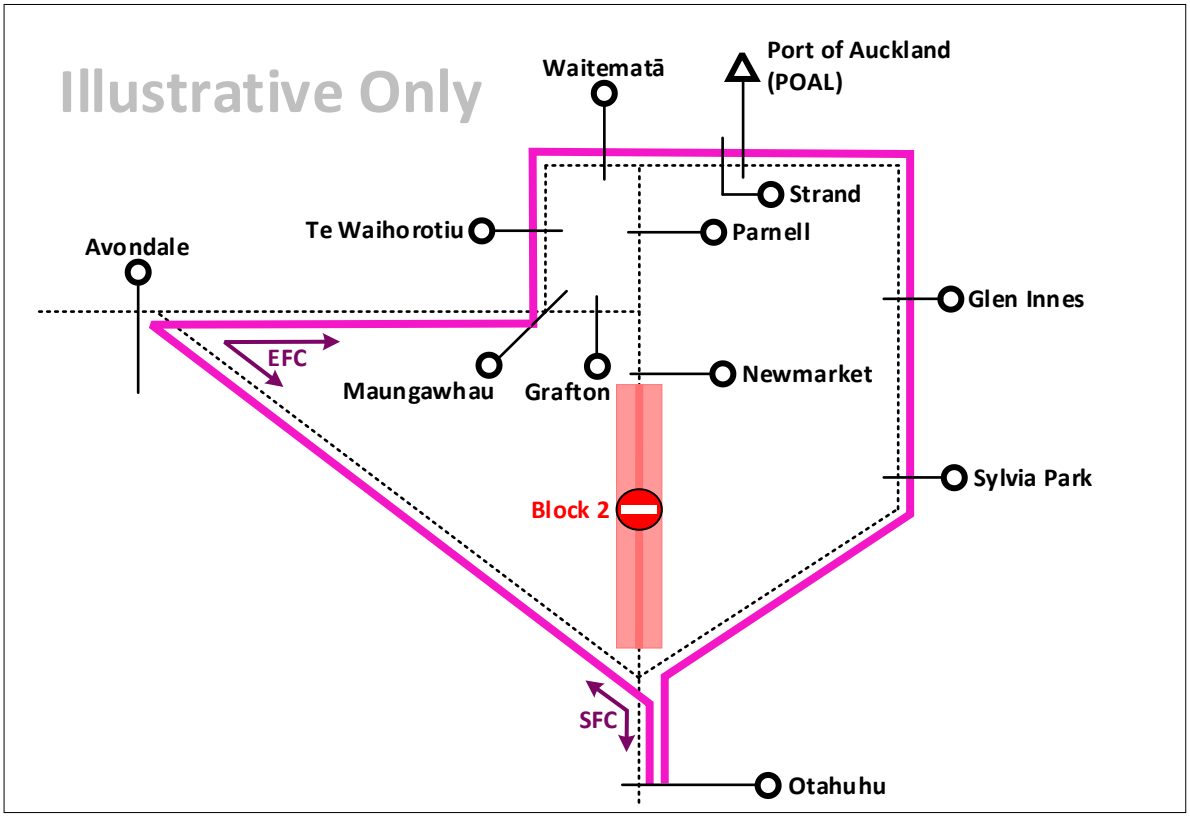


FIGURE 7-6: POTENTIAL ALTERNATIVE ROUTING OF THE SOUTH CITY LINE DURING CLOSURE OF THE NAL.

The various routings shown in **Figure 7-7** below may be beneficial for Inter-regional services.

- Under Block 2, both the S-C line and E-W line will be routed along the corridor segment between Westfield and Quay Park on the NIMT which will tend to result in high levels of utilisation. Routing inter-regional services along an alternative corridor would alleviate this congestion.

- Similarly under Block 3, an alternative routing for inter-regional services would avoid congestion on the segment between Westfield and Newmarket on the NAL.

- Under Block 5, the alternative routing again avoids congestion on the NIMT. Note that this assumes future electrified inter-regional trains could travel through the CRL.

- Under Block 6, the alternative routing could be utilised by Auckland Port freight which would otherwise have no available route to Southdown. Using the A-S would allow these services to access Southdown directly without traversing the junction. The route may also be used by inter-regional services, as well as revenue and non-revenue metro services under this block provided that the outage at Westfield still allows access to the A-S.

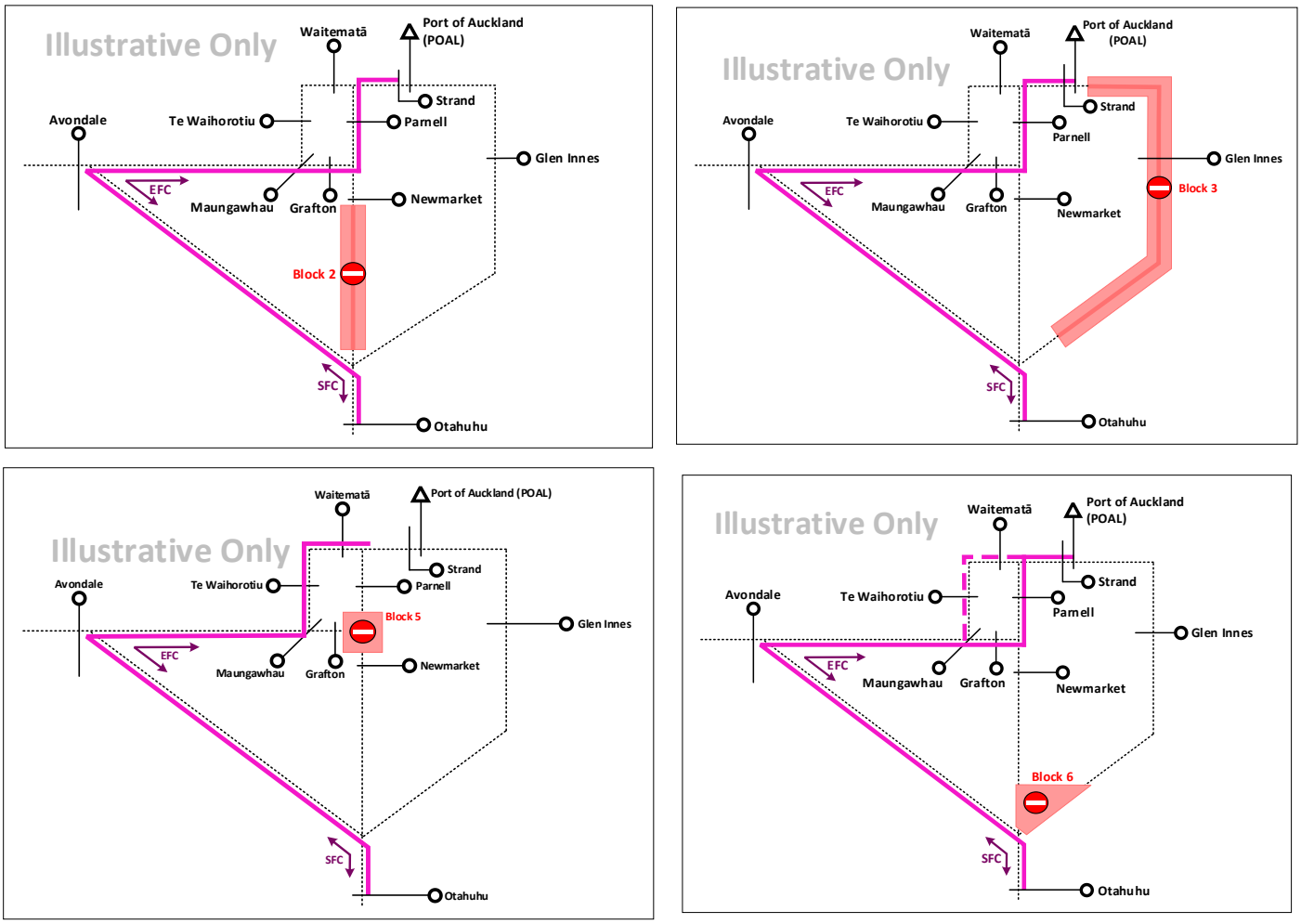


FIGURE 7-7: ALTERNATIVE ROUTING OPTIONS FROM THE CBD TO THE SOUTH (VIA A-S) DURING LINE CLOSURE EVENTS

7.6 SUMMARY OF BENEFITS

During the analysis various use cases for an east-facing connection and/or a south-facing connection were discussed; these aspects have been summarised for consideration by the A-S programme.

This study does not make any specific conclusions with respect to whether these bidirectional junction connections for metro / inter-regional services ought to be provided; but several potential benefits have been identified.

It is therefore recommended (based on the discussions held during the workshops) that the A-S programme carefully considers the capabilities of Avondale Junction and Westfield Junction with respect to normal and degraded Auckland rail network operation.

It should be noted that whilst accommodation of additional routing capabilities does provide additional operational flexibility and service options, this would need to be balanced against aspects such as envisaged frequency of use, cost, feasibility, reliability and maintainability of the junctions themselves, etc.

8 OVERALL OUTCOMES AND CONCLUSIONS

The analysis undertaken for this study provides clear and compelling evidence that the A-S Corridor delivers **substantial and multi-dimensional resiliency, capacity, and operational benefits** to the Auckland metro rail network.

Firstly, A-S provides a **strategic and future-proofed** alternative freight route for Northland-bound services (expected to expand significantly over future decades), and thereby increasing the capacity of the network overall.

Diverting freight from the inner metro spine releases **up to 32% capacity** between Westfield junction, Newmarket and the new Avondale junction. This uplift has material system-wide implications: it supports **higher-frequency metro services**, **improves timetable robustness**, and **reduces the operational conflicts** that currently constrain performance across the inner network.

Secondly, the corridor **unlocks transformative opportunities** for heavy rail passenger operations.

By providing a new north-south alignment through the isthmus, A-S enables the introduction of additional Rapid Transit Network (RTN) services, including a city-centre-focused orbital loop and a Crosstown line linking major suburban centres. These services respond directly to **emerging travel patterns** that have historically been underserved by Auckland's rail system and **supports long-term mode shift**, equitable access, and balanced urban growth.

Finally, the corridor delivers a **step change** in network resiliency. The degraded operations assessment, supported by operator workshops and desktop analysis, confirms that A-S markedly improves Auckland's ability to **withstand, absorb, and recover** from both planned and unplanned disruptions. Benefits extend across all markets, metro, freight, and inter-regional, and range from incremental improvements in delay recovery to major mitigation of severe incident impacts. The corridor creates **substantive new routing options**, **reduces reliance on existing heavily utilised routes**, and **enhances the maintainability** of the network by enabling worksites to be isolated without crippling service delivery.

Taken together, these findings underscore that the A-S Corridor is not merely an enhancement project but a critical piece of strategic rail infrastructure. It materially strengthens the **resiliency, capacity, and long-term adaptability** of Auckland's rail system, capabilities that will be essential to supporting CRL Day One operations and the region's 30-year transport investment strategy.

8.1 RECOMMENDATIONS AND OPPORTUNITIES FOR FURTHER STUDIES

Throughout this report, we have touched upon a number of areas that would benefit from further analysis; these included the following aspects:

- While this report does not make any specific conclusions with respect to whether or not an east-facing connection or south-facing connection for metro / inter-regional services ought to be provided, several potential benefits of an east-facing connection and south-facing connection have been identified by this analysis (**Section 87**). It is therefore recommended (based on the discussions held during the workshops) that the A-S programme carefully considers the capabilities of Avondale Junction and Westfield Junction with respect to normal and degraded network operation. It should be noted that whilst accommodation of additional routing capabilities does provide additional operational flexibility and service options, this would need to be balanced against aspects such as envisaged frequency of use, cost, feasibility, reliability and maintainability of the junctions themselves, etc.

- It was also discussed during the workshops that a closure of the eastern line would provide difficulties for the Crosstown line (Avondale to Glen Innes) services without anywhere to turnback at the end of the A-S (Westfield). Options to terminate at Otahuhu were also discussed during the workshop, but this would depend on a south-facing connection at Westfield. Therefore, it is recommended to consider the provisions / locations of turnbacks during the design development considering the closure scenarios discussed as part of this analysis.
- Outcomes depend on appropriate traction power sectionalisation that enables appropriate isolation of sections and potential faults, and does not prevent the required rerouting of services during closure scenarios. The traction power design needs to be informed by the operational need and contingency service concepts.
- As discussed within **Section 4.1.1** a wider study is required to further investigate the merits of retaining / removing the Onehunga branch line following the implementation of A-S.

APPENDICES

APPENDIX A

Benchmarking of Capacity Utilisation

APPENDIX B Simplified UIC 406 Methodology

APPENDIX C Infrastructure Analysis for Future Service Concepts

APPENDIX D Network Resilience Assessment

APPENDIX E Baseline Assumptions, Constraints and Exclusions

APPENDIX A. BENCHMARKING OF CAPACITY UTILISATION

WSP has previously undertaken a study for KiwiRail to assess the applicability of the UIC 406 recommended occupancy time rates to the New Zealand network. This included a research and benchmarking exercise to develop a better understanding of how capacity is measured in railway systems internationally, and what levels of capacity utilisation are typically adopted.

Various research activities were undertaken including:

- A review of applicable literature including academic articles, textbooks, and industry standards and guidelines.
- Eliciting opinions from independent academic experts.
- Advice from WSP global experts in rail modelling, simulation and operations who have brought international examples of peak occupancy time rates for planning purposes, based on their experience in rail advisory services and rail operations planning in various countries. The selected WSP experts have held roles as consultants and railway operators and can make the link between theory and practice.
- Additional information collected from WSP Practice Area Networks related to railway operations, where several other experts within WSP provided information on their experience with applying capacity consumption rules.

An overall summary of the results of the benchmarking is provided in the table below.

Country	Corridor	Traffic Lines	Capacity Consumption Rates For Planning
United Kingdom	Network Rail (General rule)	Mixed (Passenger and Freight)	100%
	Birmingham New Street	Passenger Only (Long Distance, Regional and Metro)	106%
	London Charing Cross	Passenger Only (Metro)	113%
	(High Speed 2) HS2	Mixed (Passenger and Freight)	80-100%
	Elizabeth Line (Great Western Main Line Segment)	Mixed (Passenger and Freight)	100-108%
	Castlefield Corridor	Mixed (Passenger and Freight)	101%
Slovakia	National Standard	Mixed (Passenger and Freight)	100%
Sweden	National Standard	Mixed (Passenger and Freight)	Very high (>=106%): very high sensitivity to disturbances / low average speed Medium-high (<=105% and >=81%): difficulty in utilising available capacity / issues during maintenance

			Low (<=60%): stable operation / potential for additional services
	Stockholm Metro Tunnel	Passenger Only (Metro)	100%
Colombia	Bogota Metro	Passenger Only (Metro)	100%

BENCHMARKING OF RAILWAY CAPACITY

The data above generally supports the UIC 406 framework. Most jurisdictions studies were found to operate at or below, the suggested UIC rates in planning and operation.

The UIC 406 buffers are not hard limits, and there are examples of systems operating above them; however, it was apparent from the analysis that a combination of robust operational delivery and long-term planning is required to sustain this. In some cases, a decision to increase capacity at the expense of service quality may also be seen as preferable.

APPENDIX B. SIMPLIFIED UIC 406 METHODOLOGY

As described in Section 3.1;

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

According to UIC 406.

In this study, a simplified application of the compression method is used, which is appropriate for longer term planning. Typically, Occupancy Time is determined by taking a defined timetable of trains (with different speed profiles, stopping patterns, dwell times etc.) and compressing them to their minimum technical headway based on the signalling design. In this study we instead define a single technical headway value for each train type (e.g. metro all stops, metro limited stop, inter-regional, freight) for each network segment. The Occupancy Time can then be calculated as:

$$Occupancy\ Time_i = \sum_{t \in T} h_t^i \cdot v_t^i$$

Where h_t^i ·is the technical headway for train type t over network segment i, and v_t^i is the number of trains of type t travelling over network segment i.

The analysis has considered two different signalling system scenarios. The ETCS L2 scenario is consistent with the AR-PBC programme, which assumes ETCS Level 2 will be implemented on the Auckland rail network prior to A-S, with signal blocks optimised to achieve tighter technical headways. An ultimate technical headway of 2 mins has been assumed, noting that this would likely require level crossings works to be completed first.

Acknowledging that ETCS Level 2 upgrades are not funded and there are some uncertainties regarding the solution that will ultimately be adopted in Auckland, an Existing Signalling scenario has also been considered. Signal headways for passenger services under this scenario, have been taken from a simulation analysis undertaken by KiwiRail in early 2025. The model assumes that headways in both up and down directions are identical, whereas KiwiRail's analysis considered both directions separately. Where up and down headways differ, the worst-case headway has been used.

The technical headways and freight paths adopted in the modelling are provided in the table overleaf.

Existing signalling system scenario

	A		B		C-1				C-2			D		E	F-1	F-2	G	H	I	J	K	L	M
Service	PUK-PAP		PAP-WIR		WIR-OTU				OTU-WSF			WSF-PNR		PNR-NMJ	WSF-GNI	GNI-QPJ	NMJ-QPJ	NMJ-NTJ	QPJ-NTJ (CRL)	NTJ-AVJ	AVJ-HND	HND-SWN	WSJ-ASJ
	E	W	E	W	E	C	W	3rd	E	C	W	M	3rd										
Technical Headway (THW) / Freight Path (FP)																							
THW_EMU-local [TWH]	3.6		3.3		3.0				3.0	3.0		3.0		3.0	3.6	3.6	3.2	3.0	2.0	3.3	3.3	3.3	3.3
THW_EMU-express [TWH]	8.0		8.2		6.5				6.5			4.2		4.2	7.2	7.2	7.2						
THW_IR [TWH]	3.6		3.6		6.8				6.8			3.1		3.1	3.1	3.1	3.1						
THW_Freight [FP]	12.5		12.5		10.0			15.0	10.0			10.0		10.0	10.0	10.0		10.0		10.0	10.0	10.0	10.0

ETSCS L2 scenario

	A		B		C-1				C-2			D		E	F-1	F-2	G	H	I	J	K	L	M
Service	PUK-PAP		PAP-WIR		WIR-OTU				OTU-WSF			WSF-PNR		PNR-NMJ	WSF-GNI	GNI-QPJ	NMJ-QPJ	NMJ-NTJ	QPJ-NTJ (CRL)	NTJ-AVJ	AVJ-HND	HND-SWN	WSJ-ASJ
	E	W	E	W	E	C	W	3rd	E	C	W	M	3rd										
Technical Headway (THW) / Freight Path (FP)																							
THW_EMU-local [TWH]	2.5		2.5		2.5				2.5	2.5		2.5		2.5	2.5	2.5	2.5	2.5	2.0	2.5	2.5	2.5	2.5
THW_EMU-express [TWH]	8.0		8.2		6.5				6.5			4.2		4.2	7.2	7.2	7.2						
THW_IR [TWH]	2.5		2.5		2.5				2.5			2.5		2.5	2.5	2.5	2.5						
THW_Freight [FP]	12.5		12.5		10.0			15.0	10.0			10.0		10.0	10.0	10.0		10.0		10.0	10.0	10.0	10.0

References:

CRL Modelling Report

AR PBC

KiwiRail Spreadsheet - 20250320

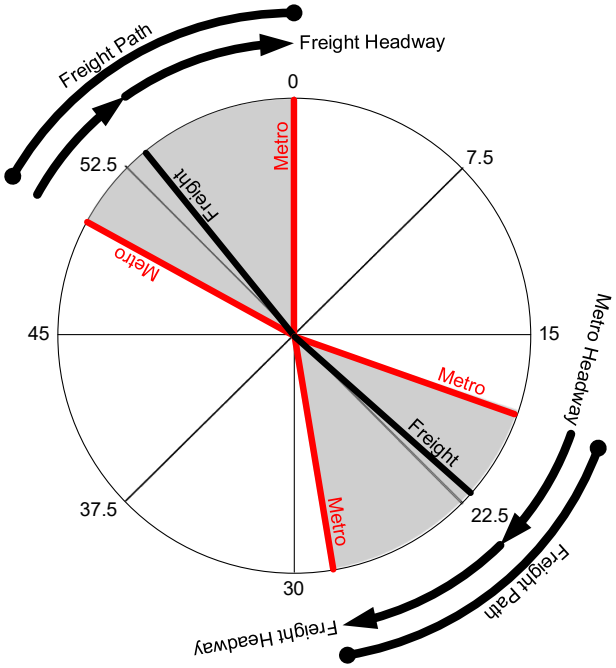
ETCS L2 assumed

No data, assumed

References:

Nominal optimised ETCS L2 tech. headway 2.5

Freight paths are treated slightly differently in the calculation. A freight path is treated as a gap between two metro services. Technically this contains two headways as shown in **the figure below**; a headway between the freight train and the metro train ahead of it, and a headway between the metro train behind the freight train. The freight path is therefore converted to a headway by subtracting a metro headway from it. Also reflected in **the figure below** is the assumption that two freight paths per hour are provisioned in the timetable, however for the purpose of the analysis, only 1 path is assumed to be utilised during a representative peak hour.



FREIGHT PATH HEADWAYS

The following freight path values have been used in the analysis:

Freight Line	Path Size	Note
POAL (Auckland Port to Westfield and Wiri)	10min	Feasible given shorter 650m train lengths expected in operation
NAL (Westfield to North of Auckland)	10min	Would restrict freight train lengths to 650m max
NIMT (Westfield to South of Auckland)	12.5min	Allows for up to 900m train lengths.

FREIGHT PATH VALUES

The following limitations should be noted with respect to this analysis:

- This analysis looks at peak period capacity only.
- This analysis does not consider the capacity of junctions, only track sections between junctions. Newmarket junction in particular is expected to be a key constraint.
- Does not consider limitations due to the structure of the timetable - i.e. the need to interline / merge services together.

APPENDIX C. INFRASTRUCTURE ANALYSIS FOR FUTURE SERVICE CONCEPTS

Both the pre and post-A-S service concepts described in Section 3.3 and 4.1 respectively, will require other infrastructure investments across the Auckland rail network to be enabled. The table below provides an assessment of the infrastructure requirements for both the pre and post-A-S service concepts.

The assessment is based partially on analysis carried out as part of the AR-PBC which set out an inter-dependent programme of service and infrastructure improvements over 30 years, as well as concept timetable analysis undertaken as part of this study.

Infrastructure Improvement	Needed:		Rationale
	Pre-A-S	Post-A-S	
Third platform at Swanson	●	●	Required to allow NAL freight to pass through Swanson when the **8 tph** all-day service will mean that the other two platforms are often both occupied.
Level crossing removals / safety mitigations implemented along the NAL	●	●	Required to allow: A full bi-directional **8 tph** service on the Western line in peaks, The **2 tph** Onehunga service to operate during the peaks as well as the off-peaks, and Introduction of the new inner-E-W line service under the Pre-A-S concept or the Isthmus Loop service under the Post-A-S concept.
ETCS Level 2 signalling	●	●	Required to accommodate the tighter headways that will be introduced under both service concepts. For the purpose of this assessment, we have assumed ETCS L2 will be rolled out across the entire network and signals will be optimised to provide an operational headway of 2.5min.
A-S including new junction at Avondale		●	Self-explanatory. See note below regarding junction configuration.
Grade separation of Westfield Junction	●	●	Required to accommodate: A significant increase in volume through the junction including new east-west movements An increase in off-peak services on the E-W line (to **8 tph**) while maintaining access for freight between Port of Auckland and the Southdown freight hub.
Additional turnback platform(s) at Glen Innes	● 1 platform	● 1 platform	One platform required to terminate the **4 tph** inner-E-W line service pre-A-S, and One platform required to terminate the **4 tph** 'crosstown' service post-A-S.

Infrastructure Improvement	Needed:		Rationale
	Pre-A-S	Post-A-S	
Additional turnback platform(s) at Mount Albert	● 1 platform	● 2 platforms[30]	One platform required to terminate the **4 tph** inner-E-W line service pre-A-S, and Two platforms required to terminate the **4 tph** 'crosstown' service post-A-S.

KEY INFRASTRUCTURE ASSUMPTIONS RELATING TO THE COMPRESSION ANALYSIS

In addition to these investments it should be noted that:

- Any service frequency or capacity improvements beyond the current CRL Day One service concept will require additional rolling stock and associated stabling and depot facilities and may also trigger additional power and maintenance of way upgrades.
- The service concept for Avondale-Southdown would require an east-facing connection at the new Avondale junction (refer to **Section 87**).
- Neither service concept (pre or post-A-S) makes any assumptions regarding upgrades of the Auckland rail network south of Westfield junction including four tracking which was a major component of the AR-PBC; the intent of this is simply to isolate the benefits of the A-S from other infrastructure elements.
- With the introduction of A-S, there is an opportunity to remove the Onehunga branch line. This has been assumed in the analysis of the post-A-S concept, and further described in **Section 4.1.1**.

The analysis shows that (except for the new A-S) the post-A-S service concept would only require one additional turnback platform, which could be at Mount Albert (as assumed in the post A-S concept timetable) or another location. All other infrastructure and system improvements will already need to be in place to support growth objectives prior to the A-S being introduced. On the other hand, by providing a significant service and connectivity uplift to the Onehunga community, the A-S can be seen as avoiding the significant costs that would be involved in upgrading the existing Onehunga branch line.

[30] *Two turnback platforms will be required to support the loop line. The purpose of these platforms is to provide a hold point along the loop to allow trains to recover from delay. Because the service is intended to be a bi-directional, one platform is required per direction. The two platforms could be located at different stations - for example one at Mount Albert and one at Glen Innes. For the purpose of this study and the development of the post-A-S concept timetable, both platforms are assumed to be located at Mount Albert but it is acknowledged that this is probably ideal due to a number of site constraints. Further work is required to confirm a preferred location.*

APPENDIX D. NETWORK RESILIENCE ASSESSMENT

This appendix documents the network resilience assessment referred to within **Section 7** of this report. The following closure scenarios were assessed:

- **Block 1** - A closure of the NAL between Avondale and Maungawhau Station (**Appendix D1**).
- **Block 2** - A closure of the NAL between Newmarket and Westfield Junction (**Appendix D2**).
- **Block 3** - A closure of the NIMT between the Port of Auckland / Strand and Westfield junction (**Appendix D3**).
- **Block 4** - A closure of the NAL between Swanson and Avondale (**Appendix D4**).
- **Block 5** - A closure of Newmarket Junction (**Appendix D5**).
- **Block 6** - A closure of Westfield Junction (**Appendix D6**).

The assessment looked at each closure scenario and the effects that it would have on the following passenger and freight services both without and with the A-S corridor in place:

- **Freight services: ***
    - Northern freight services
    - Services to Port of Auckland
- **Inter-regional services:**
    - Te Huia and Northern Explorer
- **Auckland metro services:**
    - S-C line
    - E-W line
    - Onehunga-West line / A-S services **

** Note: The Southern freight line was not assessed as it is not impacted by any of the blockage scenarios considered.*

*** Note: Onehunga-West line and A-S services have been evaluated as part of the same line item. As discussed in **Section 5.1.1**, the Onehunga branch line services are assumed to be removed from the network post-A-S, but would effectively be replaced by the new 'Isthmus Loop' and 'Crosstown' line services.*

Each closure scenario listed above was discussed within a workshop with subject matter experts from KiwiRail and Auckland Transport. The outputs of the workshop were illustrative service concepts that could be realistically deployed during each respective scenario to minimise the amount of disruption caused (again, this was done without and with A-S).

The *exact* response to an unplanned event will be dynamic and subject to the specific situation, context and operational procedures that are invoked to deal with it; for that reason, this study does not discuss specifics in terms of what has caused the postulated closure scenarios, only that there was some issue that prevented trains from utilising particular sections of the Auckland rail network.

Assessing the operational resiliency benefits of an infrastructure improvement is complex because the range of scenarios that can be encountered in actual operations is almost limitless. To this point, it is important to note that the analysis was carried out within a limited scope with specific high level closure scenarios, based upon a workshop exercise involving experienced rail operations staff, and subsequent desktop analysis. It is very likely that there are many other scenarios that has not been covered as part of this study and for which A-S may also have benefits.

The service concepts without and with A-S were then compared; for each of the services listed above, a high-level impact classification was assigned (as defined in the table below) along with a narrative within **Appendices D1 to D6**.

	No impact to services.
	Degraded - service maintained with reduced frequency and/or modified route, via direct rail service.
B	Degraded - service maintained with reduced frequency and/or modified route, via bus replacement. *Note: Bus replacements will be required under all blockage scenarios to provide an alternative service for stations directly within the blockage. The classification 'B' is used to indicate where bus replacement services are also required for passengers using stations outside of the blockage.*
	Operations ceased - services no longer able to continue.
↑ ↓	Used to denote that a service is improved (or made worse) by the introduction of A-S (even though its overall impact classification may not change).
*	Used to highlight that an assumption or caveat applies to the impact classification, which will be described in the associated notes.

SERVICE IMPACT CLASSIFICATION

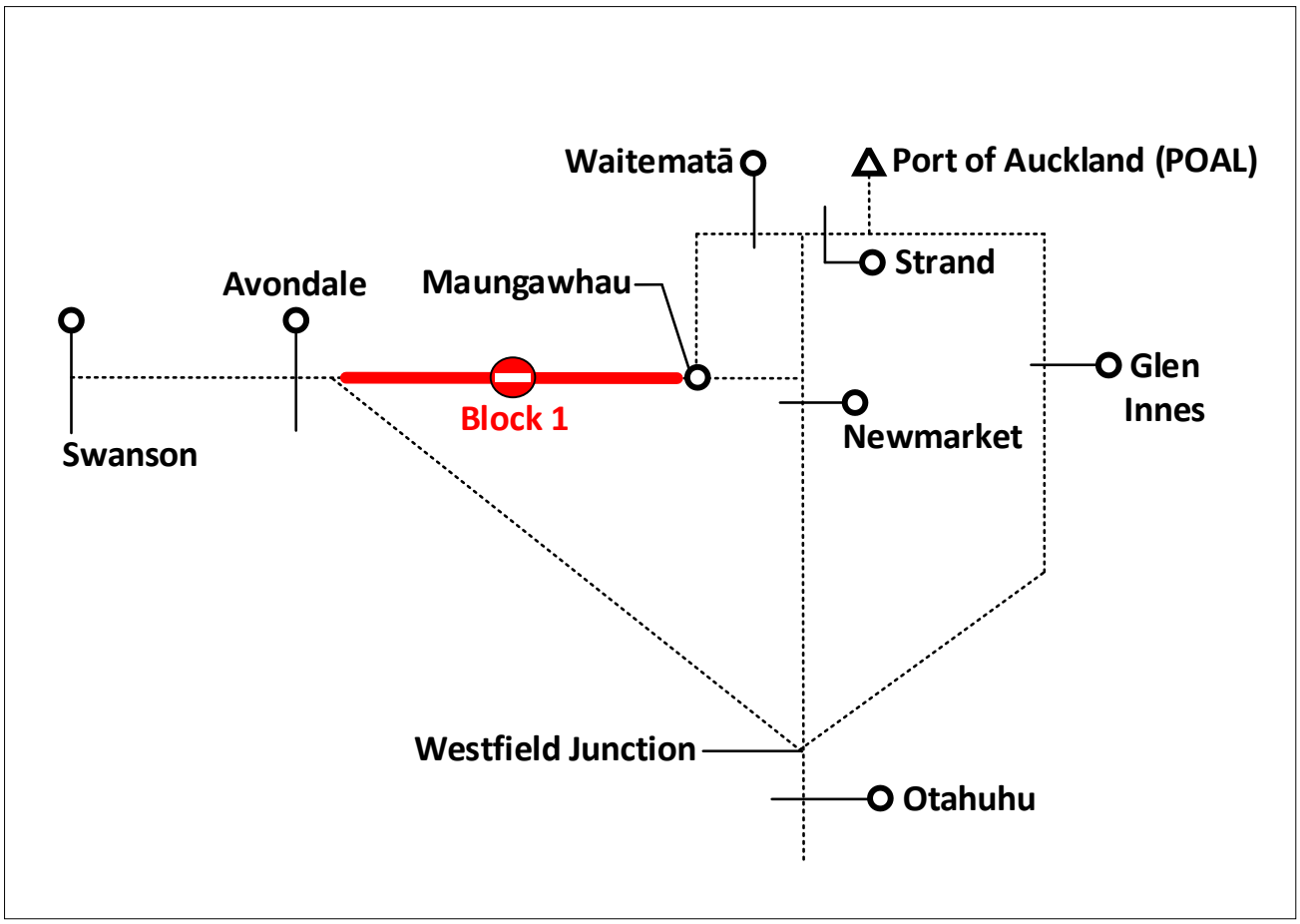
During the workshop key constraints of the current **Inner Network** were noted; these are aspects that would not be addressed by the A-S scheme, but may impact the degraded mode service concepts that were developed. These aspects are noted below for reference in **Table D-2**.

Restriction / Constraint	Impact during a Degraded Mode Scenario
Access to/from Parnell from/to the Strand is constrained to two tracks adjacent to Platforms 1 and 2. Platform 1 is utilised to terminate the Te Huia and Northern Explorer Services, and Platform 2 is often used to stable trains.	The worst case is that one or both roads are unavailable to reroute trains through the Strand.
A closure of the NAL between Westfield and Newmarket would result in compromised access to the customer freight sidings at Penrose.	Restrictions or inability for freight services to access the customer freight sidings at Penrose.
A closure of the NIMT between Westfield and the Strand would result in compromised access to the Coca-Cola customer sidings at Sylvia Park.	Restrictions or inability for freight services to access the Coca-Cola customer sidings at Silvia Park.
CRL tunnels can only be utilised by AT Metro Trains.	Freight and inter-regional services cannot be re-routed via the CRL.

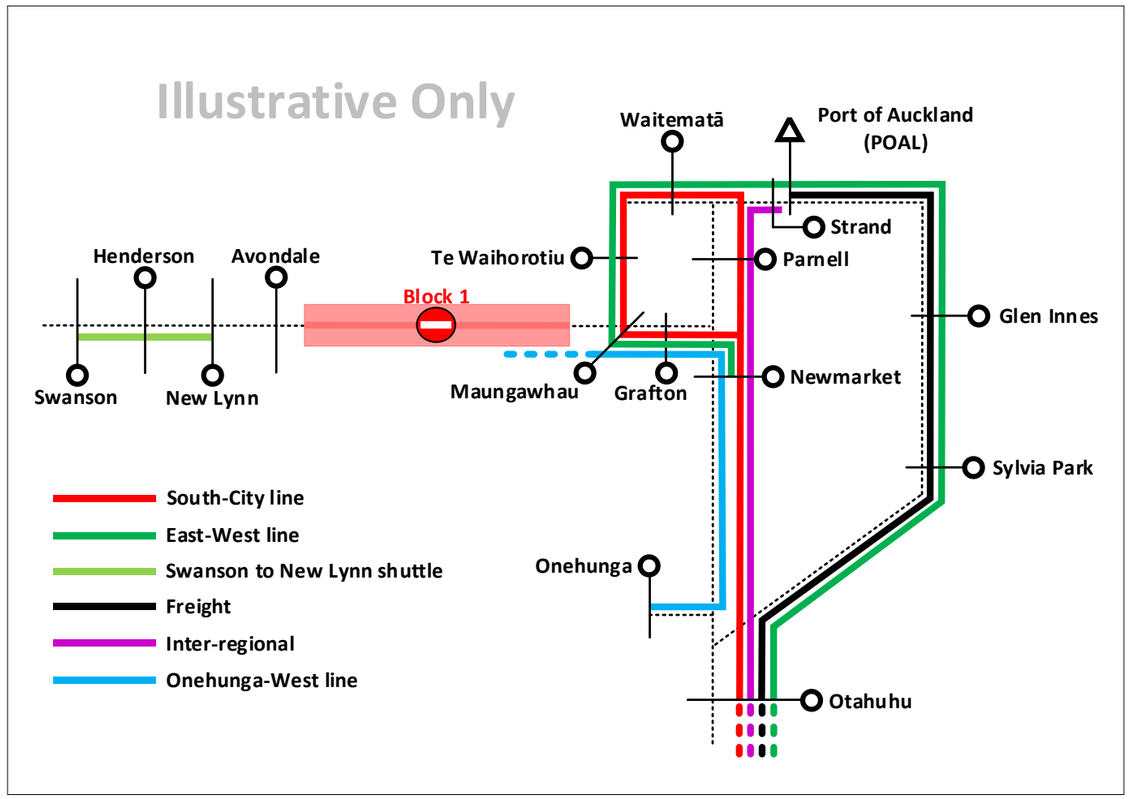
PERTINENT RESTRICTIONS ACROSS THE INNER AUCKLAND RAIL NETWORK RELATED TO THIS RESILIENCE ASSESSMENT

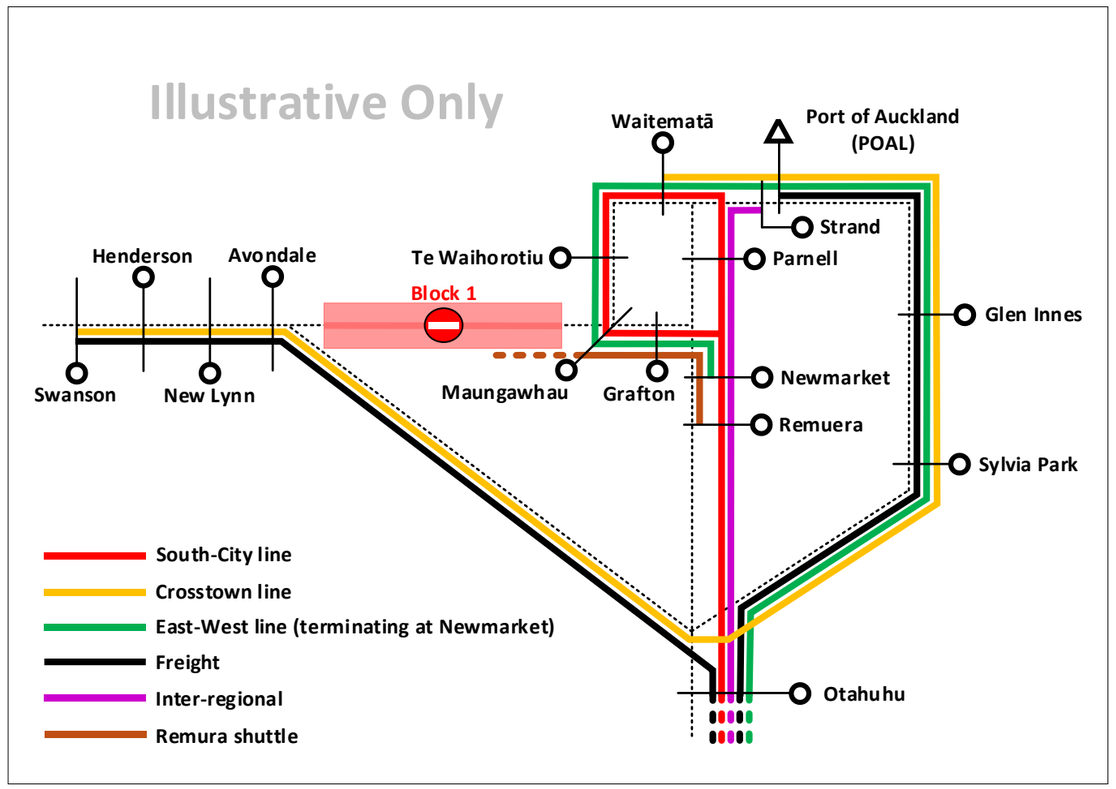
APPENDIX D1: NETWORK RESILIENCE ASSESSMENT - CLOSURE BETWEEN AVONDALE AND MAUNGAWHAU (“BLOCK 1”)

“**Block 1**” is a postulated closure scenario of the **NAL between Avondale Station and Maungawhau Station**.



BLOCK 1 CLOSURE SCENARIO





Line	Service Type	Origin	Destination	Runs in		Trains Per Hour
				Off-Peak	Peak	
South to City (SC), all stops	Metro	Pukekohe	Otahuhu	●	●	4
South to City (SC), all stops	Metro	Papakura	Papakura		●	2
South to City (SC), limited stops	Metro	Pukekohe	New market		●	2
East to West (EW), East Leg	Metro	Manukau	New market	●	●	4
East to West (EW), West Leg	Metro	New Lynn	Sw anson	●	●	4
Onehunga to Henderson	Metro	Maungaw hau	Henderson	●	●	2
Te Huia / Northern Explorer	Inter Regional	Hamilton / Wellington	Auckland	●	●	1
Southern	Freight	Pukekohe	Westfield	●	●	2
Northern	Freight	Westfield	Sw anson	●	●	2
Auckland Port	Freight	Southdow n / WPOAL	POAL	●		2

Line	Service Type	Origin	Destination	Runs in		Trains Per Hour
				Off-Peak	Peak	
South to City (SC), all stops	Metro	Pukekohe	Otahuhu	●	●	4
South to City (SC), all stops	Metro	Papakura	Papakura		●	2
South to City (SC), limited stops	Metro	Pukekohe	Newmarket		●	2
East to West (EW), East Leg	Metro	Manukau	Newmarket	●	●	4
East to West (EW), West Leg	Metro	Waitemata	Swanson	●	●	4
A-S Loop Line	Metro	Mt Albert	Mt Albert			
A-S Crosstown Line	Metro	Henderson	Glen Innes			
Te Huia / Northern Explorer	Inter Regional	Hamilton / Wellington	Auckland	●	●	1
Southern	Freight	Pukekohe	Westfield	●	●	2
Northern	Freight	Westfield	Swanson	●	●	2
Auckland Port	Freight	Southdown / WPOAL	POAL	●		2

BLOCK 1 SCENARIO - ILLUSTRATIVE SERVICE CONCEPTS WITHOUT AND WITH A-S

The table below provides a description of the operational and customer impacts of the **Block 1** scenario without A-S and with A-S based on the above service concepts.

Line	Impact without A-S		Impact with A-S	
Freight Services				
Northern		With no alternative route, the Northern freight line would cease operation for the duration of the closure. In a planned maintenance scenario, it may be possible to still move freight through the network but would require maintenance crews to temporarily clear the line, significantly impacting productivity. In an unplanned scenario, freight trains would need to be held at Westfield or north of Swanson until the blockage is cleared.	↑	A major benefit of A-S under this scenario is that it allows freight services on the Northern freight line to be maintained without disruption; this would be the case under both planned and unplanned maintenance scenarios.
Auckland Port		No impact.		No impact.
Inter-Regional Services				
Te Huia / Northern Explorer		No impact.		No impact.
Metro Services				
S-C line		The S-C line is not expected to be impacted in this scenario. Re-routing of the eastern leg of the E-W line places some additional pressure on the segment between Newmarket and Maungawhau, but given its reduced frequency this should be easily accommodated.		No impact.
E-W line (west leg)	*B*	The primary impact of this blockage on metro services is to the western leg of the E-W line. During the closure no rail services can be provided between Mount Albert and Kingsland (inclusive), and direct rail connectivity from the west to the CBD is no longer possible. Passengers that normally board services west of New Lynn to travel into the city or further east/south will need to transfer to a bus replacement service at New Lynn, or take an alternative bus route (the inverse would be true for passengers travelling west). Based on a high-level analysis of the concept timetables developed in **Section 4** and bus travel times, we estimate typical travel times for outer western line passengers would be as follows: Henderson to CBD by bus: **57 - 77min** * * Further details of the assumptions relating to this journey time range is provided below. A rail shuttle service could be established between Swanson and New Lynn (which has the required trackwork to turn back trains) but at a reduced frequency of **4 tph.**	↑	A benefit of A-S under this blockage scenario is that it allows a direct rail service to be maintained between the outer western catchment and the CBD. Based on the concept timetable developed in **Section 4** it is estimated that typical travel times for the outer western line passengers are as follows: Henderson to Waitematā: **60 min**[31] by train (vs. **57 - 77 min** by bus) Whilst the alternative routing of the east leg is a significant diversion over normal routing, the travel time is estimated to be at least as good as (if not better than) available bus replacement options. Importantly, as discussed previously, rail travel times tend to be less variable than bus travel times, particularly during peak periods. This in combination with a single seat journey, means that the direct rail service will likely be preferred by most passengers, and may even benefit some customers east of Avondale. Overall, the service is still reduced in frequency and capacity but is significantly improved over the 'without A-S' scenario for many passengers along the western catchment.

[31] *This travel time is a high-level estimate based on a concept timetable developed with runtimes from OpenTrack including dwell times and margin to coordinate services in overlap areas. Calculated as follows: 16.6mins (Henderson to Avondale Junction), 21.9mins (Avondale Junction - Westfield Junction), 8.6mins (Westfield Junction - Glen Innes), 12.8mins (Glen Innes - Waitematā):- Total = 59.9mins (rounded up to 60 mins).*

Line	Impact without A-S		Impact with A-S	

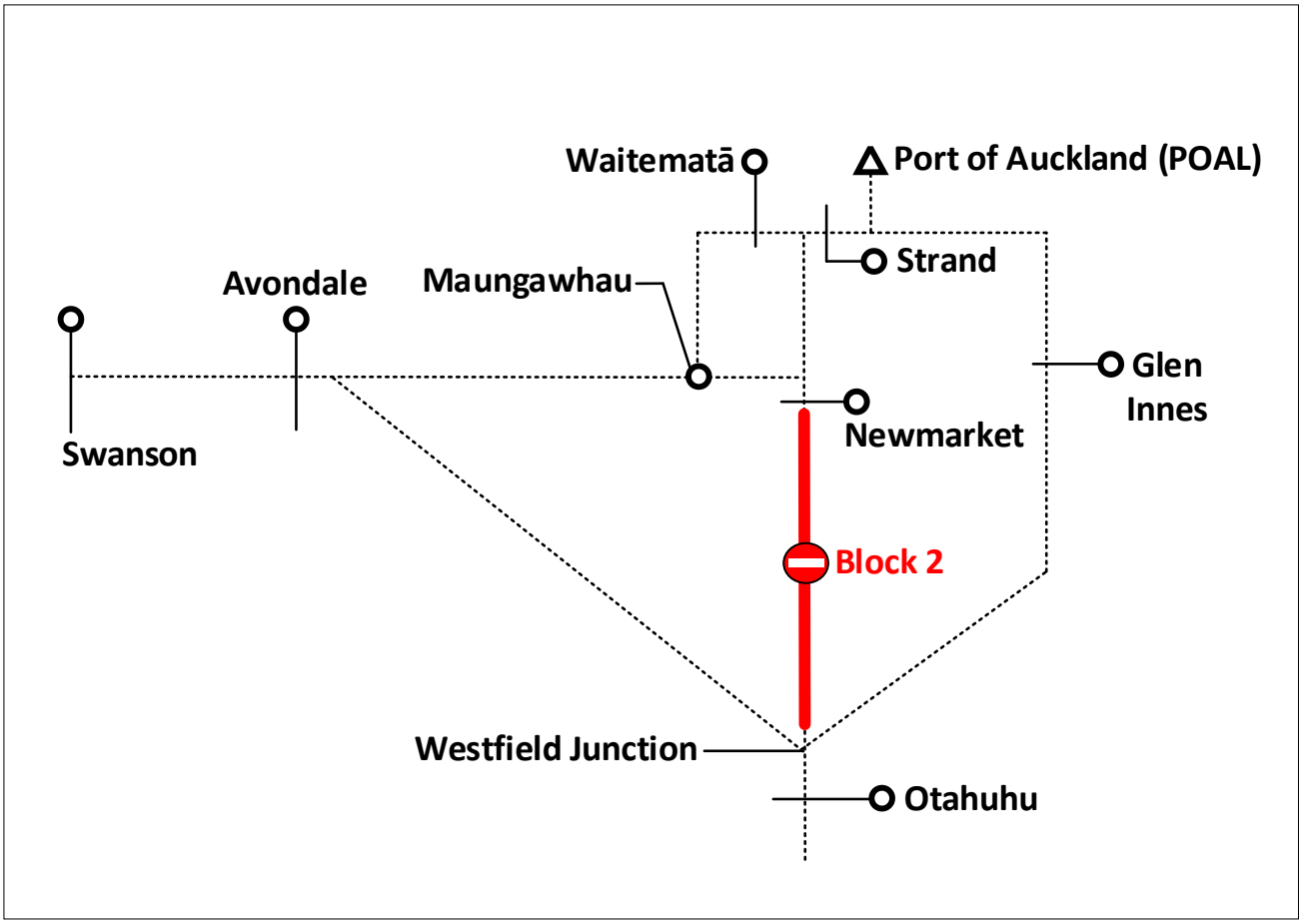
	The bus journey times referenced above were derived from an analysis of publicly available data via the AT Journey Planner website, as well as data provided by AT on recent bus replacement service travel times. A key observation from this analysis is that bus journey times vary significantly by time of day due to the impact of road congestion, and by route. In comparison, rail travel times are relatively stable throughout the day. It was also noted that in many cases more than one bus to bus transfer was required to complete the journey.
	
	Generally the bus replacement journey times were much slower than using alternative bus routes (as suggested by the AT Journey Planner
	
	The following inputs and assumptions have been made with respect to the travel time analysis:
	• *Data was collected from the AT Journey Planner[32] website for journeys on Monday 06 October 2025 with no assumed road / bus disruption or special bus timetables.*
	• *Travel times consider a typical AM commuter trip, based on the following:*
	  ○ *7:00am departure, which resulted in between 07:07 and 08:07 listed.*
	  ○ *Origin set to Henderson Station, under the assumption that the first leg of the trip is taken by rail.*
	  ○ *Destination set to Waitemata Station.*
	• *Walking time included in the trip time. A maximum 10 min walking time (per leg) was applied in the search tool. It was noted that changing the maximum walking time affects the bus service options presented by the tool.*
	• *Bus replacement timings were provided by AT for the Western Line for closures on Tuesday 01 to Thursday 03 July 2025, and Tuesday 08 July 2025.*
	• *No additional penalties have been applied to transfer between rail and bus or bus and rail.*			

E-W line (east leg)		To maintain operation of the eastern leg of the E-W line, an alternative western terminus is required. This is likely to result in a Newmarket to Manukau (via CRL) service, utilising the centre platform at Newmarket. A reduced service frequency of **4 tph** is expected due to only having a single platform available at Newmarket for turnback. The feasibility of implementing this routing change in an unplanned outage scenario (as well as establishing a shuttle service with appropriate bus bridging on the western leg of the E-W line) is probably limited due to the complexities involved in traffic management and availability of buses.	↑	The A-S corridor also benefits the eastern leg of the E-W line. Though the routing and frequency of service is the same as for the 'without A-S' scenario, the alternative routing of the west leg, boosts train frequencies at all stations from Sylvia Park to the city centre to **8 tph** - no reduction over normal operation. We still classify the service as degraded given that stations between Manukau and Otahuhu will see a reduction from **8 tph** to **4 tph**. However, based on typical patterns of demand, we wouldn't expect this to result in overcrowding (generally high levels of crowding occur starting at Panmure station for an inbound trip).
O-W line / A-S services		**O-W line** Service can be maintained to Onehunga under this scenario but would only operate as far as Maungawhau due to the closure.	↑	**A-S services** Both the Isthmus Loop line and Crosstown line services are cancelled under this blockage scenario, but the Crosstown line is effectively replaced by the modified east leg of the E-W line. This means that passengers in the Onehunga area still have a direct rail service to the city centre and to the eastern and western areas of the city, which is a substantial improvement over the 'without A-S' Onehunga Line service of **2 tph**.

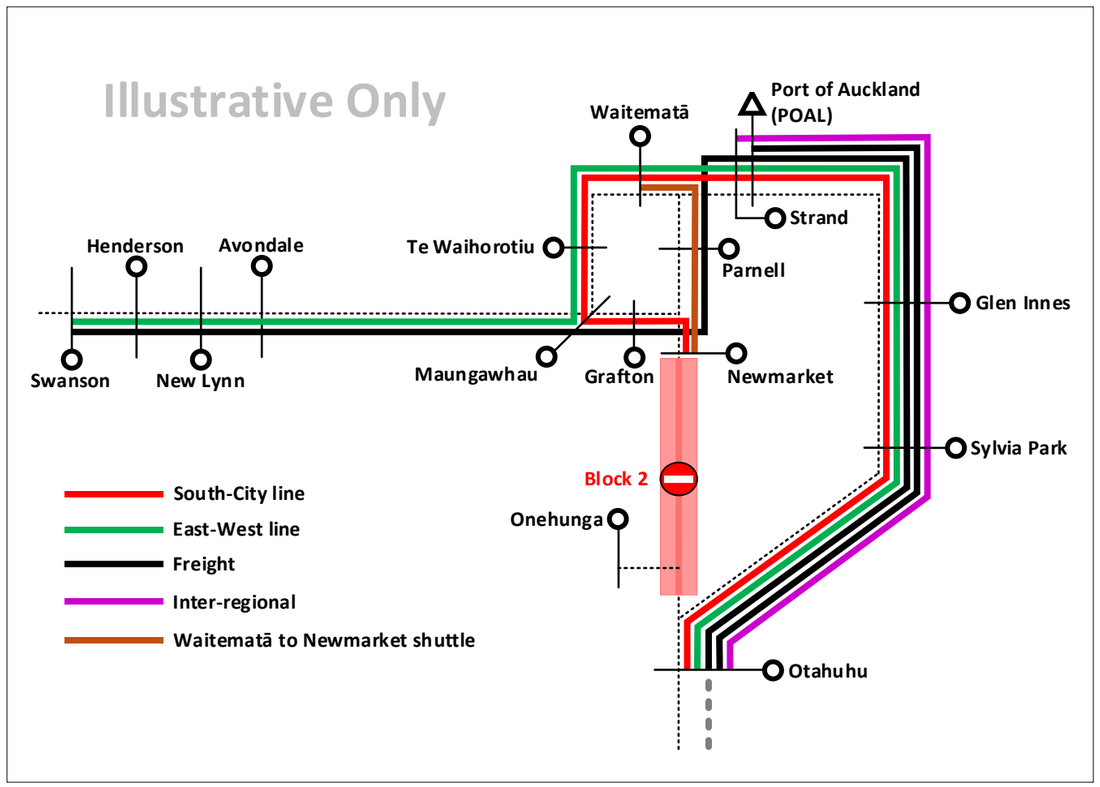
[32] *https://at.govt.nz/bus-train-ferry/journey-planner*

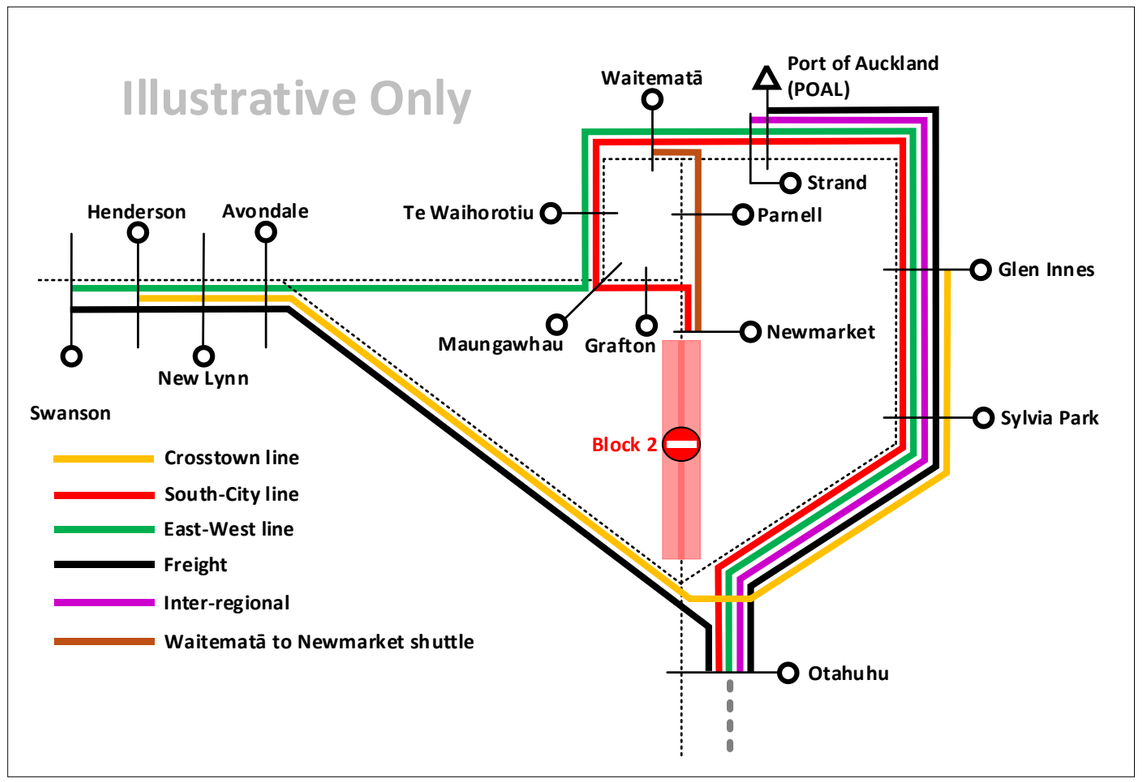
APPENDIX D2 - NETWORK RESILIENCE ASSESSMENT - CLOSURE BETWEEN NEWMARKET AND WESTFIELD JUNCTION (“BLOCK 2”)

“**Block 2**” was a postulated closure scenario of **the NAL between Newmarket Station and Westfield Junction**.



BLOCK 2 CLOSURE SCENARIO

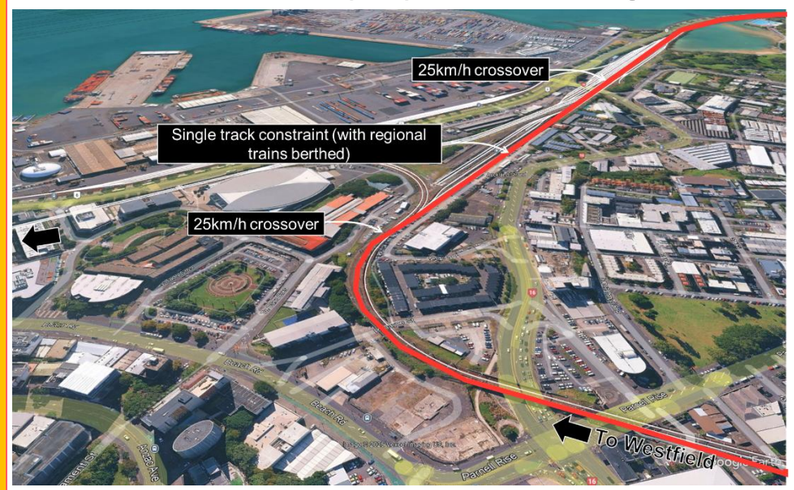




Line	Service Type	Origin	Origin	Runs in OP	Runs in P	Trains Per Hour
South to City (SC), all stops	Metro	New market	Pukekohe	●	●	4
South to City (SC), all stops	Metro	New market	Waitemata		●	4
South to City (SC), limited stops	Metro	Pukekohe	New market		●	
South to City (SC), Parnell Shuttle	Metro	New market	Waitemata	●	●	4
East to West (EW)	Metro	Manukau	Sw anson	●	●	8
East to West (EW), inner	Metro	Mt Albert	Glen Innes		●	2
Onehunga to Henderson	Metro	Te Papapa	Henderson	●	●	
Te Huia / Northern Explorer	Inter Regional	Hamilton / Wellington	Auckland	●	●	1
Southern	Freight	Pukekohe	Westfield	●	●	2
Northern	Freight	Westfield	Sw anson	●		2
Auckland Port	Freight	Southdow n / WPOAL	POAL	●		2

Line	Service Type	Origin	Origin	Runs in OP	Runs in P	Trains Per Hour
South to City (SC), all stops	Metro	Newmarket	Pukekohe	●	●	4
South to City (SC), all stops	Metro	Newmarket	Pukekohe		●	4
South to City (SC), limited stops	Metro	Pukekohe	Newmarket		●	
South to City (SC), Parnell Shuttle	Metro	Newmarket	Waitemata	●	●	4
East to West (EW)	Metro	Manukau	Swanson	●	●	8
A-S Loop Line	Metro	Mt Albert	Mt Albert		●	2
A-S Crosstown Line	Metro	Henderson	Glen Innes	●		2
Te Huia / Northern Explorer	Inter Regional	Hamilton / Wellington	Auckland	●	●	1
Southern	Freight	Pukekohe	Westfield	●	●	2
Northern	Freight	Westfield	Swanson	●	●	2
Auckland Port	Freight	Southdown / WPOAL	POAL	●		2

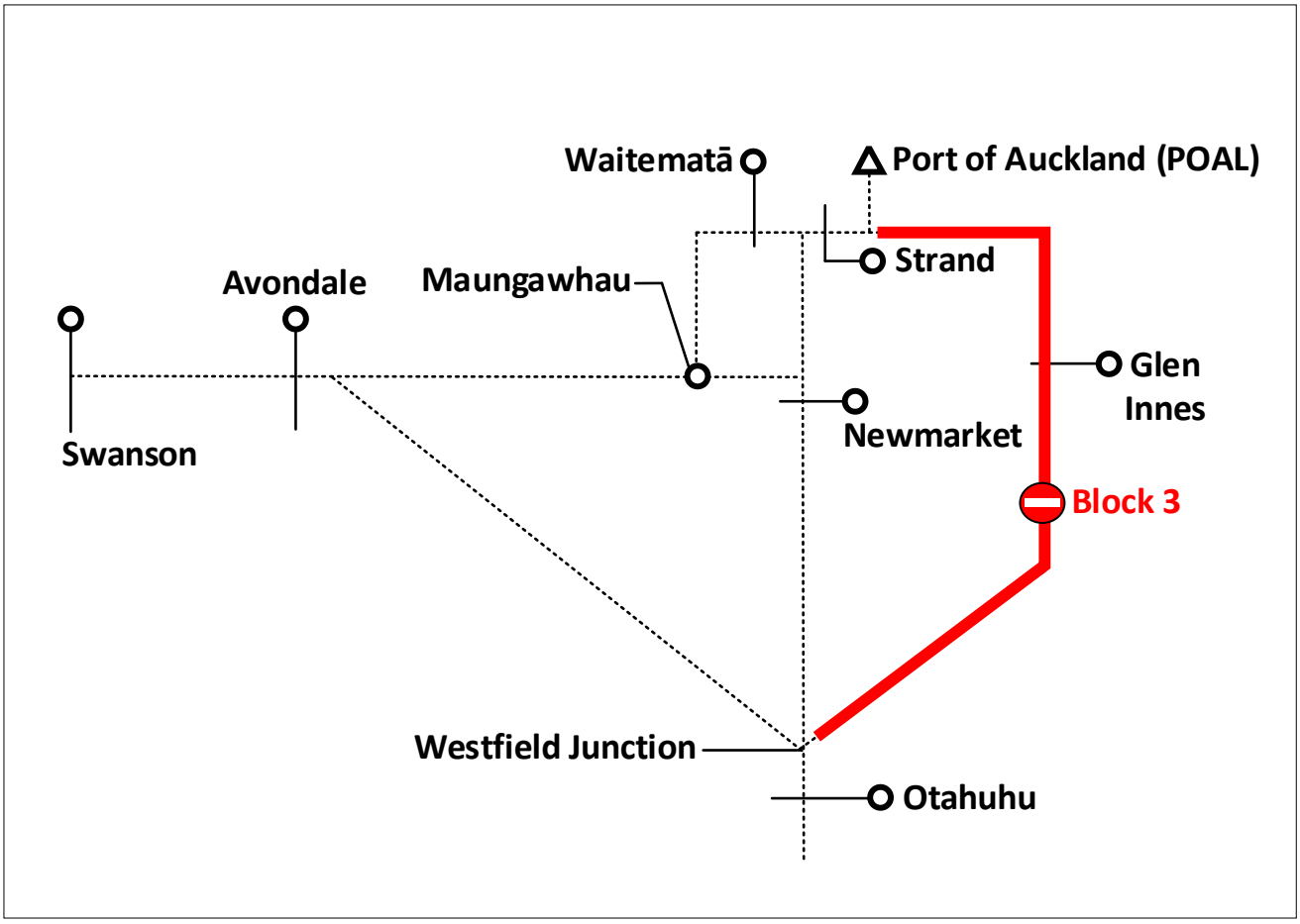
BLOCK 1 SCENARIO - ILLUSTRATIVE SERVICE CONCEPTS WITHOUT AND WITH A-S

Line	Impact without A-S		Impact with A-S	
Freight Services				
Northern		Northern freight must be diverted from its normal route down the NAL to maintain operation. This is possible via the Newmarket branch line and NIMT east. Use of this routing during peak periods is expected to have a significant impact on capacity at Quay Park Junction. This is due to the track configuration of the junction which has the Strand platforms on the Southern-Eastern chord and slow 25km/h turnouts on either end (as illustrated below). This will result in very long occupation times for freight trains passing through the junction in this direction. **As such, it is expected that the Northern freight line would mostly liken need to be restricted to off-peak periods in this blockage scenario.**  The alternative routing also results in an overlap with the Auckland-Port freight line, which would likely reduce the capacity of both lines during off-peak periods given that they would need to share the same freight paths in the network timetable.	↑	As with Block 1, a major benefit of A-S under Block 2 is that it allows freight services on the Northern freight line to be maintained without disruption. To recap - in the 'without A-S' scenario, traffic on this line will need to be excluded from metro peak periods and reduced in volume during off-peak periods due to its competing for slots with the Auckland Port line. This would be the case under both planned and unplanned maintenance scenarios. This then results in benefits to other services as described below.
Auckland Port		As per above, the routing of the Auckland Port freight line is unimpacted by the closure, but re-routing of the Northern freight line would reduce its overall capacity.	↑	The overlapping freight lines on the NIMT east also required a reduction in capacity of the Auckland Port freight line in off-peak periods. Again, this is avoided when Northern freight can be routed on A-S.
Inter-Regional Services				
Te Huia / Northern Explorer		Inter-regional services will need to be re-routed onto the NIMT (a deviation from the routing assumed in the pre-A-S service concept). This is not expected to significantly impact the service capacity or timing, however operational issues may arise from the alternative routing of the Northern freight line.	↑	Inter-regional services will need to be re-routed onto the NIMT under this blockage scenario (a deviation from the routing assumed in the pre-A-S service concept). This is identical to the 'without A-S' scenario, however the operational issues that may arise from routing Northern freight through Quay Park junction is avoided with A-S in place, which would be expected to improve service reliability.

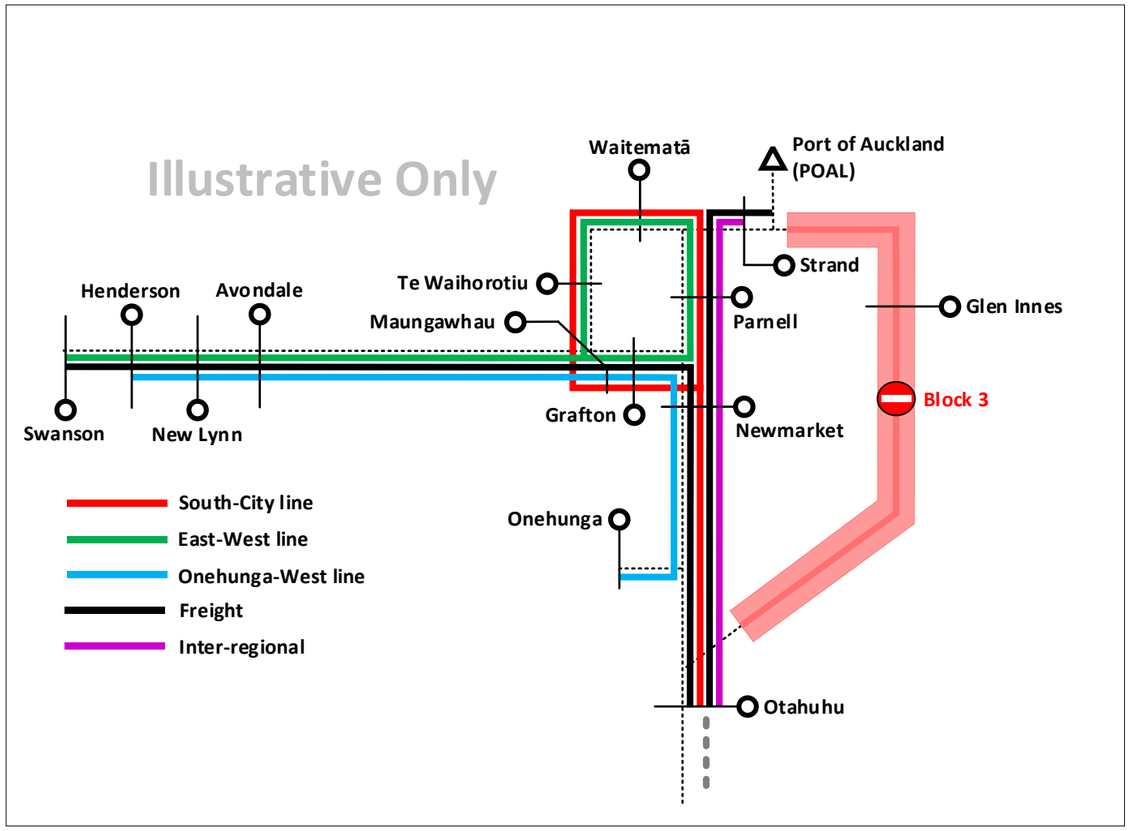
Metro Services				
S-C line		During the closure no rail services are provided between Penrose and Remuera (inclusive), however the S-C line can continue to run via the NIMT. This is a commonly used contingency plan in current operations. The most likely routing of the service would have it terminating at Newmarket. Given the modified routing, all three Newmarket platforms are available, which supports a high frequency service - we have assumed **8 tph** during the peak, which would be reduced to **4 tph** in the off-peak to accommodate freight. A looping service concept was also considered for the S-C line where it would continue around on the Newmarket Branch Line after exiting the CRL and then back towards Otahuhu on the NIMT to terminate as per normal operation. However, due to the restrictions described above at Quay Park, this is not feasible. As the selected routing does not provide any service to Parnell, a short shuttle service of **4 tph** has been included between Newmarket and Waitematā. Finally, due to high utilisation of the eastern corridor (**segments F-1 and F-2**), limited stops services will need to be cancelled under this blockage scenario.		The S-C line has the same modifications as in the 'without A-S' scenario. In both cases, a frequency of **8 tph** peak and **4 tph** off-peak is operated on the base all-stops service, a **4 tph** all-day shuttle is provided between Newmarket and Waitematā to cover Parnell and, the limited stops services are cancelled due to capacity constraints on the eastern corridor.
E-W line (west leg)		The routing of the E-W line is unimpacted in this outage scenario. During peak periods, based on the assumption that Northern and Auckland Port freight is excluded, a service frequency of **8 tph** can be maintained on the main E-W line, however the peak only inner-E-W line service will need to be reduced from **4 tph** to **2 tph** to achieve acceptable utilisation on the eastern corridor (**segment F-2** would be at **103% with 4 tph** and **93% with 2 tph**) During off-peaks it is likely that the main E-W line service will need to be reduced to **4 tph** to accommodate the overlapping of the re-routed S-C line as well the Northern and Auckland Port freight lines (with **8 tph** on the E-W line during off peaks, a capacity utilisation of **94%** is calculated for **segments F-1 and F-2**, which is likely not sustainable for a long duration).	↑	The E-W line is almost unaffected under this blockage scenario with A-S in place. Whereas in the 'without A-S' scenario, the E-W line needed to be reduced to **4 tph** in off peak periods (due to the overlapping of E-W line and S-C lines, and the Northern and Auckland Port freight lines), this is no longer required with Northern freight being routed on to the A-S.
E-W line (east leg)			↑	The only slight degradation is that the Isthmus Loop line (which replaces and extends the inner E-W line in the post-A-S service concept) will still need to be reduced from **4 tph** to **2 tph**. *Note that this assumes availability of the Avondale east-facing connection - refer to **Section 7** for further detail.*
O-W line / A-S services		**O-W line:** Not available under this blockage scenario	↑	**A-S Services:** With A-S in place, the Isthmus Loop line is retained under this blockage scenario, giving passengers in the Onehunga area a direct rail service to the CBD and to the eastern and inner western areas of the city. The A-S services are still degraded due to the high-capacity utilisation of the southern corridor; different options could be considered, but it has been assumed for the purpose of this assessment that: The Crosstown line service is cancelled in the peaks and reduced to **2 tph** in the off-peak The Isthmus Loop line is cancelled in the off-peak and reduced to **2 tph** in the peak. This approach results in acceptable levels of utilisation in both peak and off-peak periods.

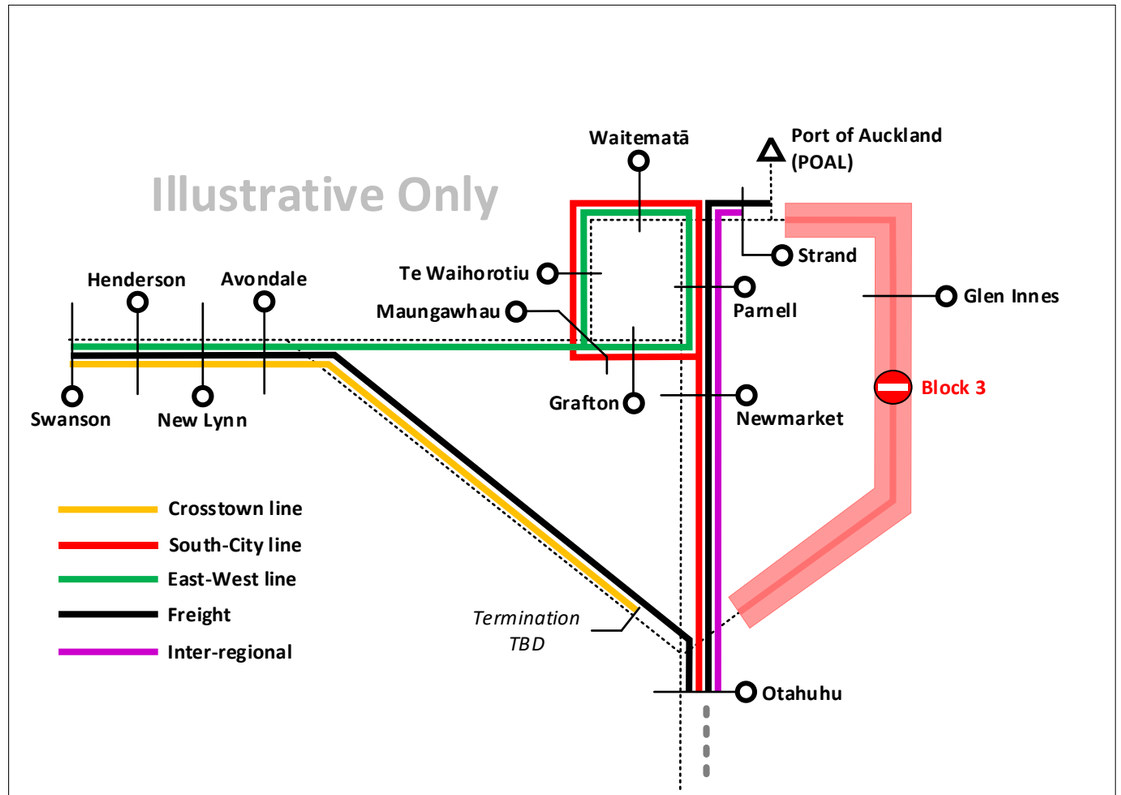
APPENDIX D3 - NETWORK RESILIENCE ASSESSMENT - CLOSURE BETWEEN PORT OF AUCKLAND/STRAND AND WESTFIELD JUNCTION (“BLOCK 3”)

“**Block 3**” was a postulated closure scenario of **the NIMT between Port of Auckland / Strand and Westfield Junction**.



BLOCK 3 CLOSURE SCENARIO





Line	Service Type	Origin	Origin	Runs in OP	Runs in P	Trains Per Hour
South to City (SC), all stops	Metro	Pukekohe	Manukau	●	●	4
South to City (SC), all stops	Metro	Papakura	Papakura		●	1
South to City (SC), limited stops	Metro	Pukekohe	New market		●	2
East to West (EW)	Metro	Sw anson	Sw anson	●	●	4
East to West (EW), inner	Metro	Mt Albert	Mt Albert		●	2
Onehunga to Henderson	Metro	Te Papapa	Henderson	●	●	2
Te Huia / Northern Explorer	Inter Regional	Hamilton / Wellington	Auckland	●	●	1
Southern	Freight	Pukekohe	Westfield	●	●	2
Northern	Freight	Westfield	Sw anson	●	●	2
Auckland Port	Freight	Southdow n / WPOAL	POAL	●		2

Line	Service Type	Origin	Origin	Runs in OP	Runs in P	Trains Per Hour
South to City (SC), all stops	Metro	Pukekohe	Manukau	●	●	4
South to City (SC), all stops	Metro	Papakura	Papakura		●	2
South to City (SC), limited stops	Metro	Pukekohe	Newmarket		●	2
East to West (EW)	Metro	Swanson	Swanson	●	●	4
A-S Loop Line	Metro	Mt Albert	Mt Albert		●	2
A-S Crosstown Line	Metro	Henderson	TBD	●	●	4
Te Huia / Northern Explorer	Inter Regional	Hamilton / Wellington	Auckland	●	●	1
Southern	Freight	Pukekohe	Westfield	●	●	2
Northern	Freight	Westfield	Swanson	●	●	2
Auckland Port	Freight	Southdown / WPOAL	POAL	●		2

BLOCK 3 SCENARIO - ILLUSTRATIVE SERVICE CONCEPTS WITHOUT AND WITH A-S

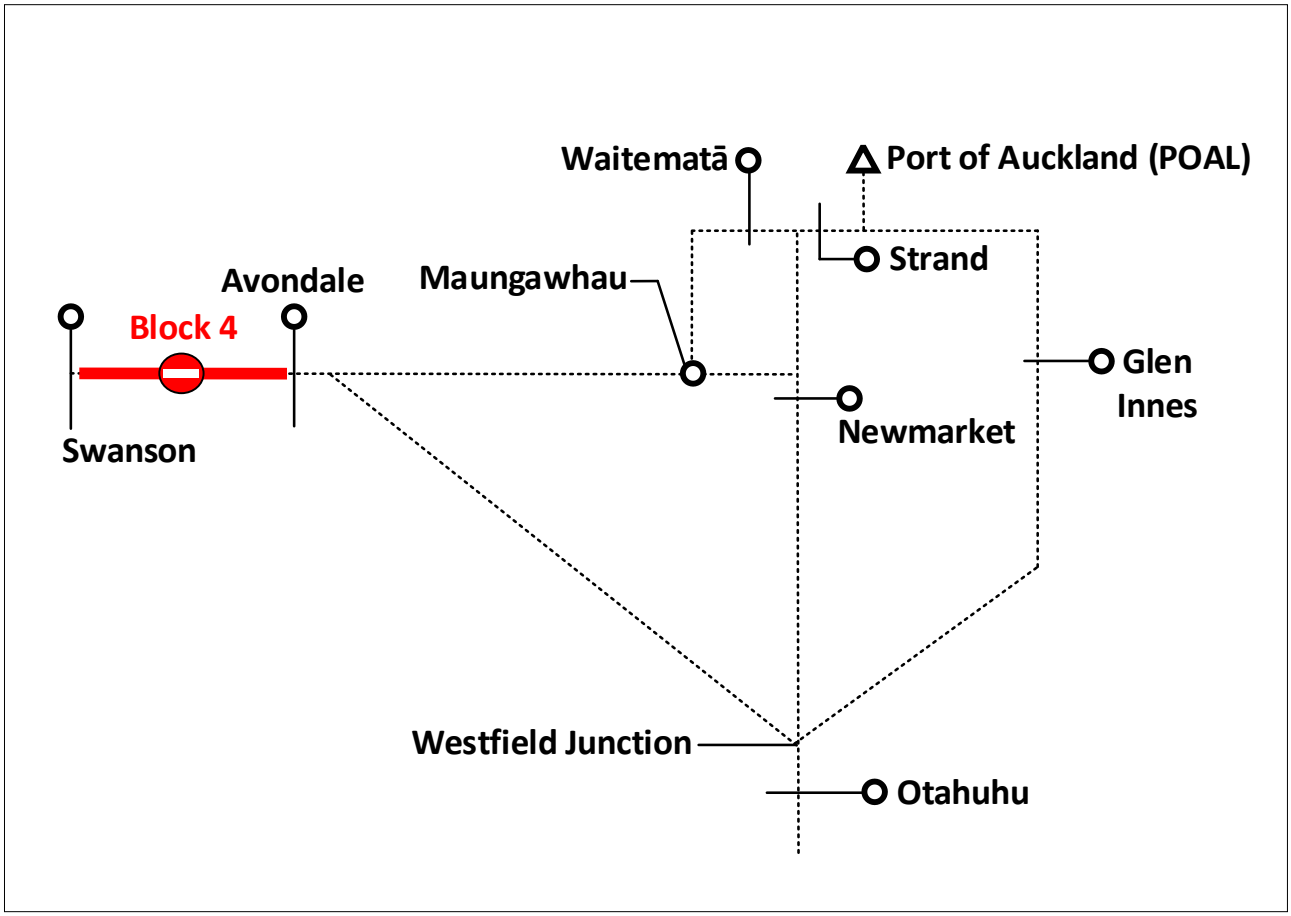
Line	Impact without A-S		Impact <u>with</u> A-S	
Freight Services				
Northern		Northern freight is routed along the NAL as per normal operation under this scenario; however, with respect to capacity: As discussed in **Section 3.4**, running Northern freight during peak periods along with the other envisioned metro service enhancements, will result in very high capacity utilisation on inner section of the southern corridor between Westfield and Newmarket junctions (segment D = **94%, E = 106%**). In reality a compromise would be required to either exclude Northern freight from metro peak periods, or reduce metro peak frequencies to accommodate freight. In this analysis we have assumed the later - see further discussion with respect to the S-C line below. During off peak periods, traffic along the re-routed Auckland Port freight line will compete with traffic on the Northern freight line for slots in the network timetable in the overlapping section between Westfield and Newmarket. This will mean that the capacity of both lines will be reduced. In summary - the capacity of the Northern Freight line is reduced in this blockage scenario due to competition for slots with the Auckland Port line in off-peak periods.	↑	With A-S in place, the Northern freight line can operate completely unimpeded under this blockage scenario. To recap - without A-S, the Northern and Auckland Port freight lines share the corridor between Newmarket and Westfield during off-peak periods, causing both lines to run a reduced capacity.
Auckland Port		As per above, re-routing of the Auckland Port freight line results in a reduction in overall capacity as it competes for slots in the network timetable in the overlapping section between Westfield and Newmarket.	↑	As per commentary above - the Auckland Port freight line operates without impact under this scenario.
Inter-Regional Services				
Te Huia / Northern Explorer		No impact.		No impact.
Metro Services				
S-C line		The S-C line is largely un-impacted in this scenario, however as noted above, even under normal operation the section of the network between Westfield and Newmarket junction will see very high capacity utilisation, making it infeasible to operate the propose service concept in practice. To address this, the **peak overlay services starting at Papakura** have been reduced from **2 tph** down to **1 tph**[33]. The resulting utilisation for segment E between Penrose and Newmarket is still high at **94%** which may result in reliability issues in operation. The other change made to the S-C line, which is not visible in the figure above, is that its route is adjusted to terminate at Manukau rather than Otahuhu. This allows the S-C line to pick up coverage of Manukau while the east leg of the E-W line is not operating.	↑	The S-C line is fully un-impacted in this scenario. In contrast to the 'without A-S' scenario, no reduction of the **peak overlay services starting at Papakura** is required because the utilisation of the Inner Network is already at a reasonable level per the previous analysis. As with the 'without A-S' scenario - the S-C line is adjusted to terminate at Manukau rather than Otahuhu, to pick up coverage of Manukau while the eastern leg of the E-W line is not operating.
E-W line (west leg)		The western leg of the E-W line is rerouted to loop around the city via the CRL and Newmarket branch line, similar to the looping structure of the S-C line. The inner-E-W line service which normally runs between Mount Albert and Glen Innes, is similarly re-routed loop around the CBD. A capacity analysis of this concept indicates that service frequencies of **8 tph** west of Mount Albert and **12 tph** east of Mount Albert are feasible, as per normal operation. However, the segment between Newmarket and Newton junctions (**segment H**), still sees high utilisation of **94%** which could result in further reliability issues in operation.	↑	As with the 'without A-S' scenario, the western leg of the E-W line and inner-E-W line are rerouted to loop around the city via the CRL and NBL. The capacity of all network segments remains at reasonable levels (**segment H = 69% vs 94%** under the 'without A-S' scenario), which suggests an improvement in reliability due to the A-S.

[33] Note that due to the overlapping route structure, a 2 tph service results in 4 tph between Papakura and Newmarket, and 1 tph service results in 2 tph between Papakura and Newmarket.

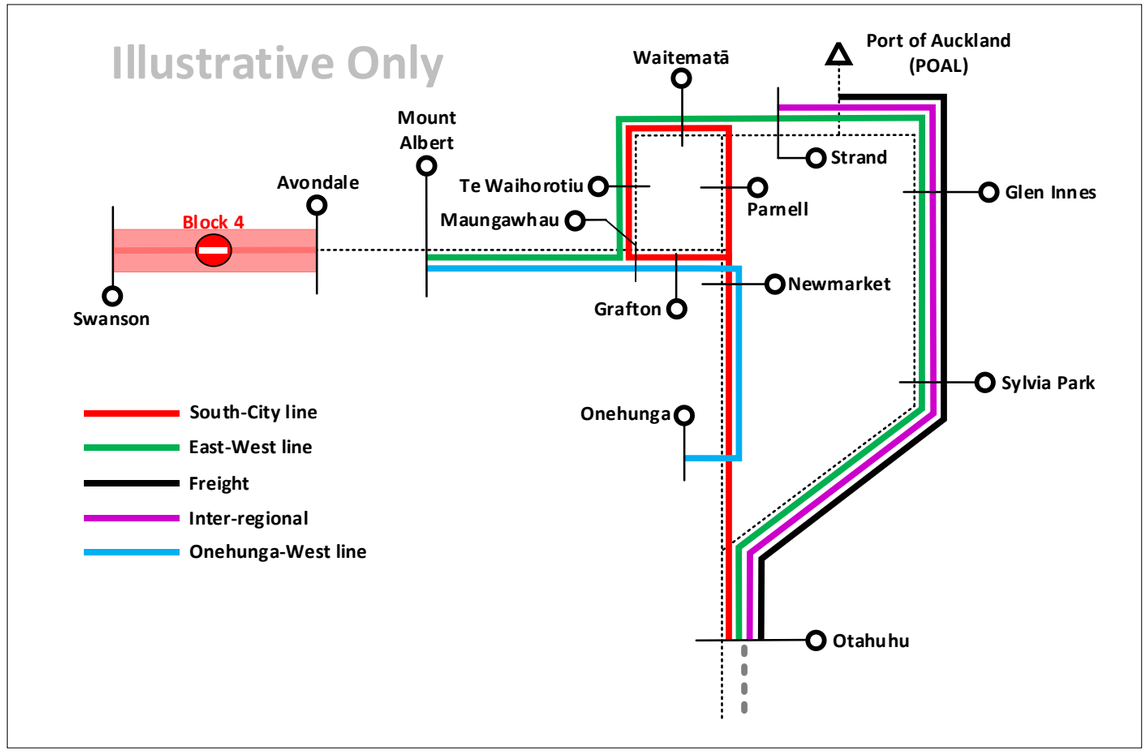
Line	Impact without A-S		Impact with A-S	
E-W line (east Leg)		Not available under this outage. Note that Manukau can still be served by re-routing the S-C line as described above.		As per the 'without A-S' scenario, the east leg of the E-W line is not available under this outage. Note that Manukau can still be served via re-routing of the S-C line as described above.
O-W line / A-S services		**O-W line:** Onehunga services can run as per normal operation noting that segments of the route are at very levels of utilisation (**segments E and H** are at **94%**) which could lead to reliability issues as noted above.		**A-S services:** The Onehunga community is served under this scenario via the Crosstown line that normally runs between Henderson and Glen Innes. The benefit of this service when compared to the O-W line service in the 'without A-S' scenario is that it provides a greatly increased frequency and capacity, with **4 tph** and 6-car trains compared to a **2 tph** and 3-car trains. In terms of routing, under both scenarios, a transfer would be required to access the city centre; at Newmarket, Grafton or Maungawhau under the 'without A-S scenario' and at Avondale under the 'with A-S' scenario. The 'without A-S' routing is more direct and thus preferred from a travel time perspective. From a reliability perspective, as previously noted, the 'without A-S' scenario sees high utilisation over the Onehunga - Henderson route, suggesting potential reliability issues which do not exist in the 'with A-S' scenario. Finally it should be noted that in order for this service concept to work, turnback functionality will be required on the A-S at the station immediately west of Westfield junction.

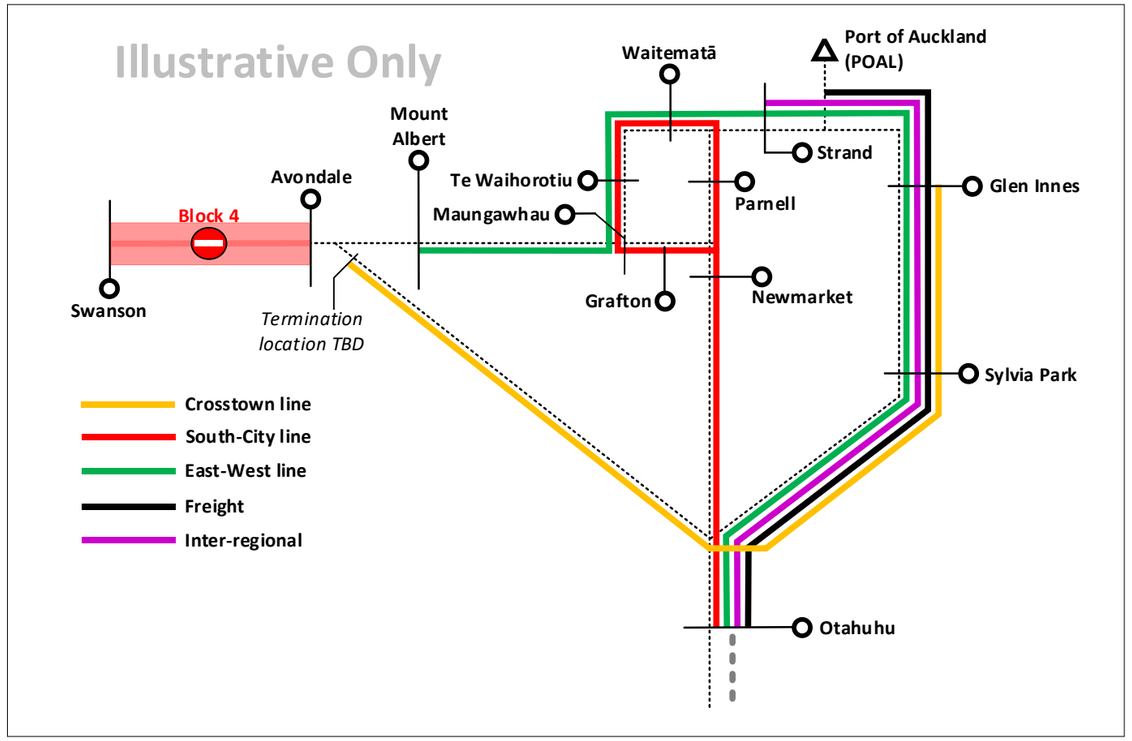
APPENDIX D4 - NETWORK RESILIENCE ASSESSMENT - CLOSURE BETWEEN SWANSON AND AVONDALE (“BLOCK 4”)

“**Block 4**” was a postulated closure scenario of **the NAL between Swanson and Avondale**.



BLOCK 4 CLOSURE SCENARIO





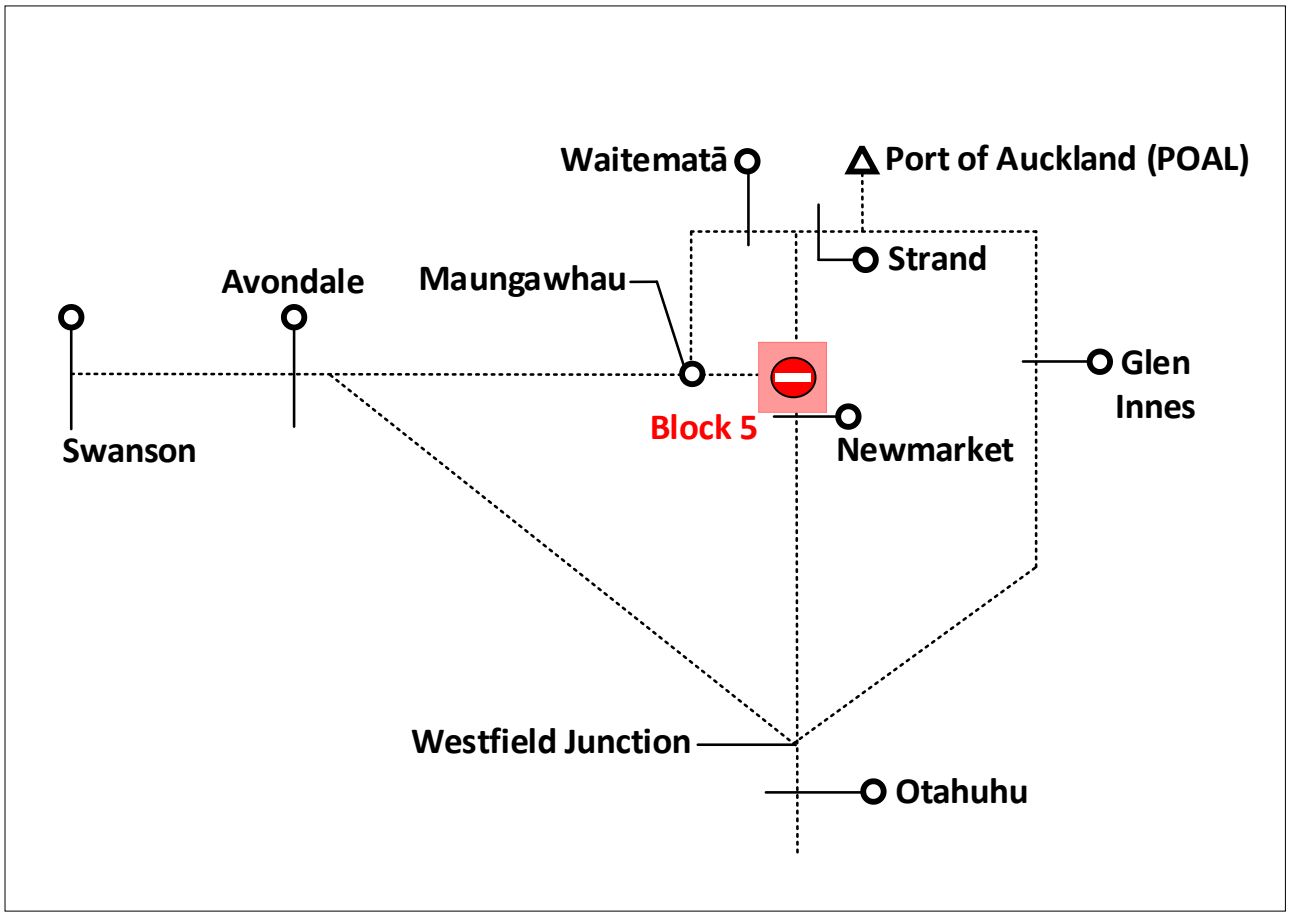
Line	Impact without A-S	Impact with A-S
Freight Services		
Northern	In both scenarios, the Northern freight line would cease operation for the duration of the closure. In a planned maintenance scenario, it may be possible to still move freight through the network but would require maintenance crews to temporarily clear the line, significantly impacting productivity. In an unplanned scenario, freight trains would need to be held at Westfield or north of Swanson until the blockage is cleared.	
Auckland Port	Unaffected in both scenarios	
Inter-Regional Services		
Te Huia / Northern Explorer	Unaffected in both scenarios	
Metro Services		
S-C line	Unaffected in both scenarios	

Line	Impact without A-S		Impact with A-S	
E-W line (west leg)		The major impact of this scenario is to the eastern leg of the E-W line, which would need to terminate prior to Avondale. Under the 'without A-S' scenario, all E-W line services (including the all-day service and the peak only inner service) as well as the Onehunga service, would terminate at Mount Albert. With three platforms available, this will require a reduction in train frequencies on the inner-E-W line service from **4 tph** to **2 tph**[34].	↑	Under the 'with A-S' scenario, the exact same operation is assumed for the E-W and inner E-W lines, but because the Onehunga service is removed post-A-S, there is no requirement to terminate this service at Mount Albert and therefore the full inner-E-W line service of **4 tph** can be operated. The Onehunga community continues to be served a truncated version of the Crosstown line. In summary - the A-S provides a slight advantage in this blockage scenario. By providing an alternative service for the Onehunga area, capacity is freed up on the inner western line to run addition peak services.
E-W line (east leg)			↑	Finally, as with Block 3, note that in order for this service concept to work, turnback functionality will be required on the A-S at the station immediately east of Westfield junction.
O-W line / A-S services		As described above, under both scenarios a rail service is maintained to the Onehunga area, with modifications to routing.		

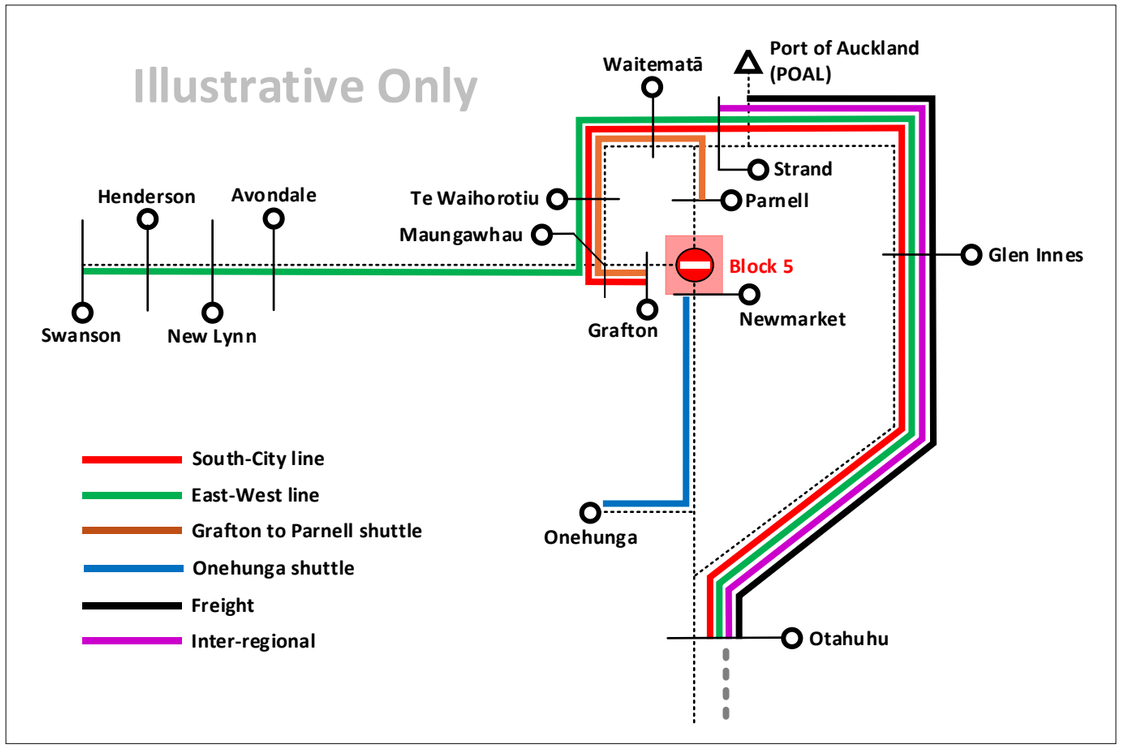
[34] *The rule of thumb analysis applied here is that a two-platform terminal station can support up to 8 tph (as per the current Swanson and Manukau terminals), and a 3rd centre platform turnback can support up to an additional 4 tph (as per the current terminal at Newmarket for the Sylvia Park - Newmarket service). Thus a 3-platform terminal station can support up to 12 tph. For the without A-S scenario, this would require the inner EW-service to be reduced from 4 tph to 2 tph to yield: 8 tph E-W + 2 tph inner-E-W + 2 tph Onehunga branch line = 14 tph total.*

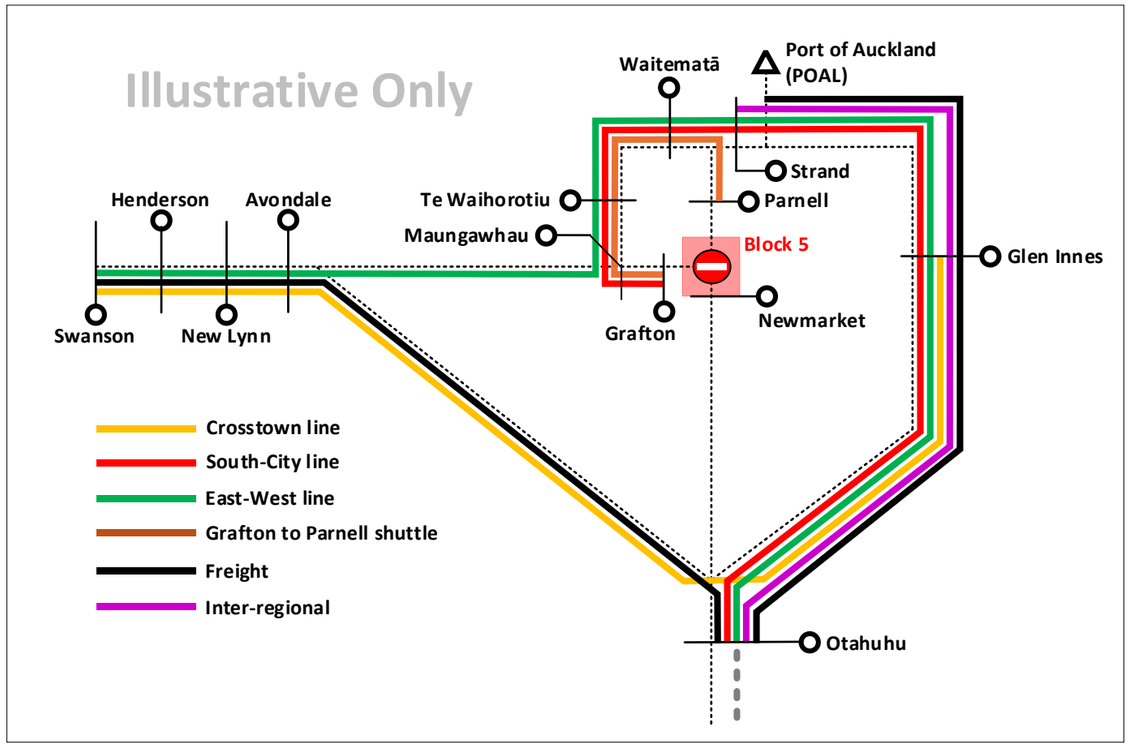
APPENDIX D5 - NETWORK RESILIENCE ASSESSMENT - CLOSURE AT NEWMARKET JUNCTION (“BLOCK 5”)

“**Block 5**” is a postulated closure scenario of **Newmarket Junction** where all movement through the junction is prevented.



BLOCK 5 CLOSURE SCENARIO





BLOCK 5 SCENARIO - ILLUSTRATIVE SERVICE CONCEPTS WITHOUT AND WITH A-S

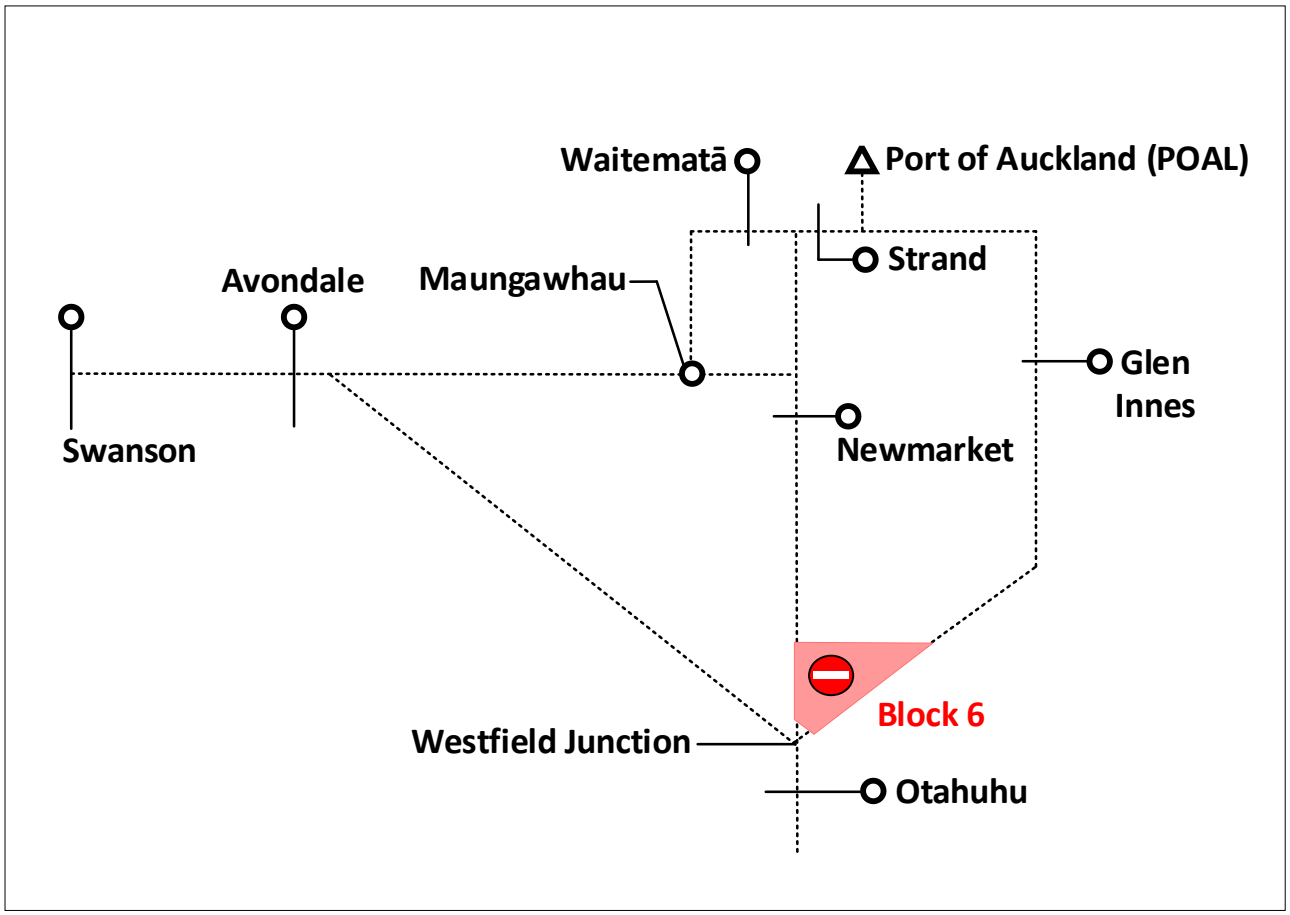
Line	Impact without A-S		Impact with A-S	
Freight Services				
Northern		Without A-S the Northern freight line must cease operation since all possible routes pass through Newmarket Junction.	↑	With A-S in place, Northern freight is completely unimpacted by this scenario.
Auckland Port		Unimpacted. Note that POAL freight is restricted to running during off-peak periods only in this analysis.		Same as without A-S scenario.
Inter-Regional Services				
Te Huia / Northern Explorer		Inter-regional services will need to be re-routed onto the NIMT (a deviation from the routing assumed in the pre-A-S service concept). This is not expected to significantly impact the service capacity or timing.		Same as without A-S scenario.

Metro Services				
S-C line		During the closure, no rail services are provided between Penrose and Newmarket (inclusive), however the S-C line can continue to run via the NIMT; this is a commonly used contingency plan in current operations. The most likely routing of the service would have it terminating at Grafton. Terminating at Newmarket is not possible under this scenario as it requires movement through Newmarket junction. As the selected routing does not provide any service to Parnell, a short shuttle service has been included between Grafton and Parnell via the CRL. As discussed above, given the limitations of Grafton for terminating services, service frequencies would likely be restricted to the following on the S-C line: • Pukekohe starters, all day service: **4 tph** • Papakura starters, peak only service: **2 tph** • Pukekohe starters, peak only, limited stop service: Cancelled • Temporary Grafton to Parnell shuttle service: **2 tph** • Total trains terminating at Grafton: **8 tph** The analysis above would apply equally to both scenarios.		
E-W line (west leg)		The routing of the E-W line is unimpacted in this outage scenario. During peak periods, both the main E-W line and inner-E-W line services can be maintained at normal service levels (**8 tph** and **4 tph** respectively).[35] During off-peaks it is likely that the main E-W line service will need to be reduced to **4 tph** to accommodate the overlapping of the re-routed S-C line as well the Auckland Port freight line.		The same analysis applies equally under both scenarios, with the inner-E-W line service being replaced by the Isthmus Loop line service in the A-S scenario.
E-W line (east leg)				
O-W line / A-S service		**O-W line:** Without A-S, the O-W line routing is modified to terminate at Newmarket. In theory this is possible under Block 5 because arriving and departing Newmarket from the south doesn't require passage through the junction. At Newmarket passengers would transfer to bus to complete their journey.	↑	**A-S services:** With A-S in place, the Isthmus Loop line is retained under this blockage scenario, giving passengers in the Onehunga area a direct rail service to the CBD and to the eastern and inner western areas of the city. The A-S services are still degraded due to the high-capacity utilisation of the southern corridor; different options could be considered, but it has been assumed for the purpose of this assessment that: The Crosstown line service is cancelled in the peaks and reduced to **2 tph** in the off-peak The Isthmus Loop line is cancelled in the off-peak and reduced to **2 tph** in the peak. This approach results in acceptable levels of utilisation in both peak and off-peak periods.

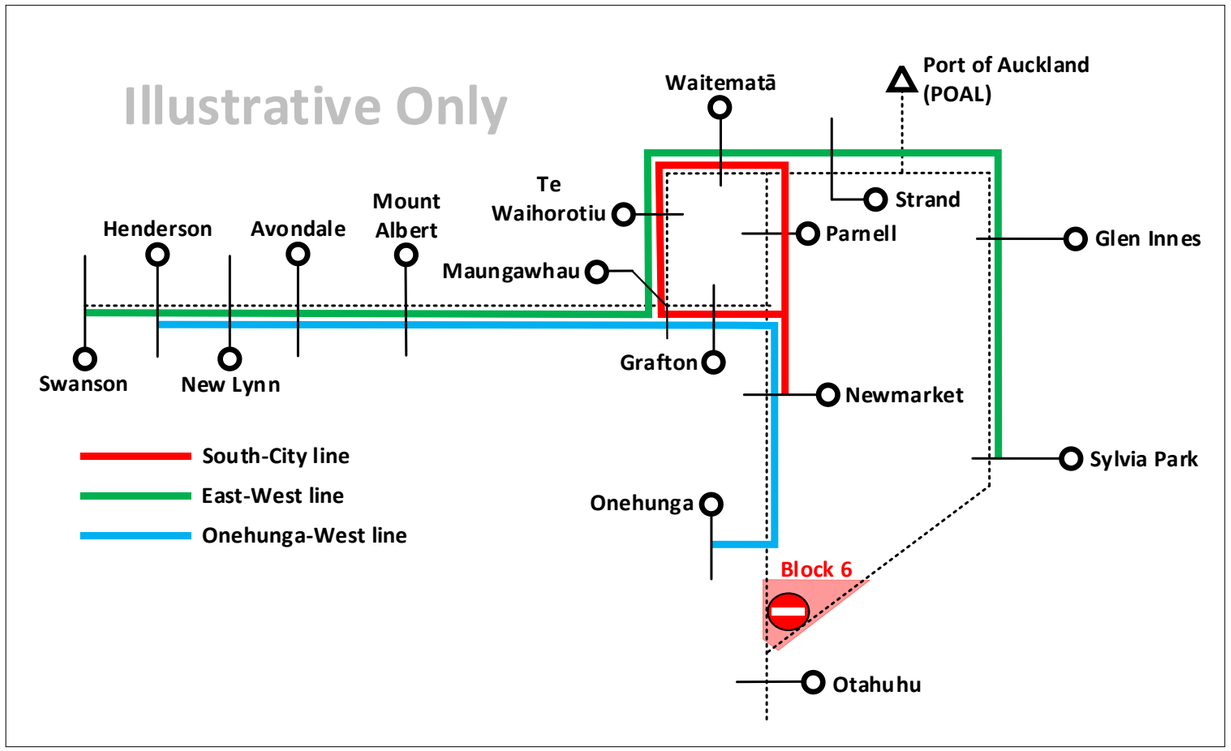
[35] *This is based on the following analysis. Under Block 2, the E-W line is maintained at 8 tph but the inner-E-W line is reduced to 2 tph to achieve acceptable utilisation on segments F-1 and F-2. In this analysis the S-C line operates with 4 tph all-stops services from Pukekohe and 4 tph all-stops services from Papakura. In Block 5, the number of services from Papakura is reduced to 2 tph due to terminal capacity restrictions at Grafton. This reduction in 2 tph therefore allows the inner-E-W line service to be increased back from 2 tph to 4 tph and achieve the same capacity utilisation on segments F-1 and F-2.*

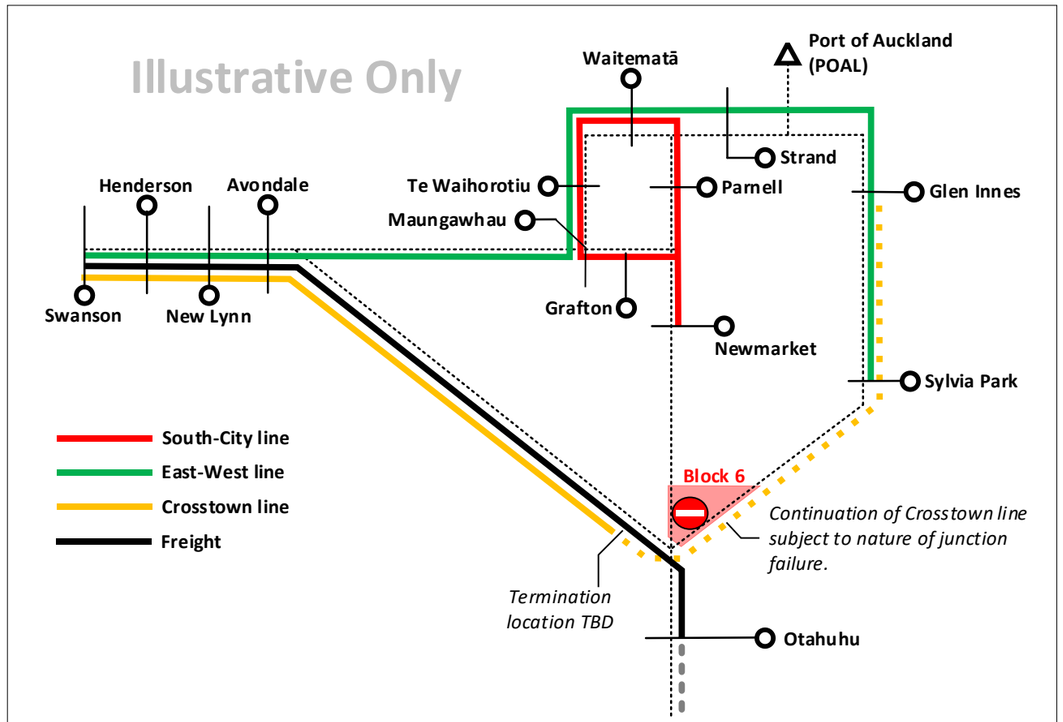
APPENDIX D6 - NETWORK RESILIENCE ASSESSMENT - CLOSURE AT WESTFIELD JUNCTION (“BLOCK 6”)

Westfield Junction is a critical and complex junction in the Southdown area. “**Block 6**” is a postulated closure scenario where all movement through the **Westfield Junction** is prevented.



BLOCK 6 CLOSURE SCENARIO





BLOCK 6 SCENARIO - ILLUSTRATIVE SERVICE CONCEPTS WITHOUT AND WITH A-S

Line	Impact without A-S		Impact with A-S	
Freight Services				
Northern		Without A-S the Northern freight line must cease operation since all possible routes pass through Westfield Junction.	↑	With A-S in place, Northern freight is completely unimpacted by this scenario.
Auckland Port		Without A-S the Auckland Port freight line must cease operation since all possible routes pass through Westfield Junction.	*	With A-S in place, the Auckland Port freight line would still need to cease operation. ** Opportunities exist to continue operation via the A-S corridor and the NAL if an east-facing connection is provided at Avondale Junction. Refer to **Section 7** for further discussion on this point.*
Inter-Regional Services				
Te Huia / Northern Explorer		Services to/from the Strand would not be able to continue.	*	Services to/from the Strand would not be able to continue. ** Opportunities exist to continue operation via the A-S corridor and the NAL if an east-facing connection is provided at Avondale Junction. Refer to **Section 7** for further discussion on this point.*

Line	Impact without A-S		Impact with A-S	
Metro Services				
S-C line		Under both with and without A-S scenarios, the S-C line needs to be truncated north of Westfield junction. The assumed routing has trains starting and ending at Newmarket with a loop around the CRL. Up to **8 tph** is expected to be possible.		
E-W line (west leg)		Under both with and without A-S scenarios, the east leg of the E-W line needs to be truncated east of Westfield junction. The assumed routing is between Swanson and Sylvia Park. Note that this would require additional crossovers to be provided at Sylvia Park to support the turnback. Based on this assumption, up to **8 tph** is expected to be possible.		
E-W line (east leg)				
O-W line / A-S services		**O-W line:** Without A-S, the O-W line services run as normal.	*	**A-S services:** With A-S, the Onehunga community is served via the Crosstown line that normally runs between Henderson and Glen Innes. Note that for this service concept to work, turnback functionality will be required on the A-S at the station immediately west of Westfield junction. *(*) Note: While the 'with A-S' has been classified as 'degraded', the service provided may still be preferable to that of the 'without A-S' scenario, given that it provides higher capacity and frequencies.*

APPENDIX E. BASELINE ASSUMPTIONS, CONSTRAINTS AND EXCLUSIONS

The following table records the pertinent assumptions, constraints and exclusions relevant to this A-S resiliency study. Where an update is required to any of these items, or if any assumption is proven to be incorrect, the impact on the analyses and their outcomes will need to be assessed.

Ref.	Type	Assumption / Constraint / Exclusion	Rationale
001	**Assumption**	The A-S Resilience Study considers a **future timetable that has:** * 8tph on the East/West line all day in both directions. * Reinstatement of Papakura starters. * 2 freight paths per hour on the NAL all day in both directions. * 2tph on the Onehunga line all day in both directions (pre-A-S).	This is the expected level of service on Avondale - Southdown opening day. 8tph on the East / West line is consistent with the AR-PBC.
002	**Assumption**	The A-S Resilience Study considers a future timetable that routes inter-regional and limited stop metro services down the NAL (inner Southern Line) via Newmarket.	Consistent with AR-PBC.
003	**Assumption**	It is assumed for the purpose of this study that the future timetable will provide 2 freight paths per hour on the Northern freight line; however, given the spacing of loops on the NAL north of Auckland, only one freight train per hour has been included within the peak capacity calculations.	Based on capacity constraints of existing NAL, north of Auckland.
004	**Assumption**	Signalling headways used for this study have been assumed as per ***Appendix B of the A-S Resiliency Study - Output Report***.	Headways utilised are consistent with previous KiwiRail simulations and the AR-PBC.
006	**Assumption**	It is assumed for the purpose of this study that **six** stations will be constructed along the A-S route.	Based on figures provided during fortnightly catch up meeting with KiwiRail.
008	**Assumption**	It is assumed for the purpose of this study that traction power sectionalisation of the Auckland Rail Network post-A-S will permit isolations that support the alternative train routing strategies during line closures (or localised traction power failures) discussed as part of the A-S resilience study.	Whilst a physical route to reroute trains may be available by a particular track/junction layout, the availability of the route would depend on the availability of traction power along the proposed route.

Ref.	Type	Assumption / Constraint / Exclusion	Rationale
009	**Exclusion**	Single line running scenarios have not been considered as part of the A-S resilience study.	For the purpose of this study, this was deemed not to provide too much value to the analysis.
011	**Assumption**	It is assumed for the purpose of this study that the A-S design will truncate the Onehunga Line at Te Papapa and will therefore not interface with the A-S.	With the introduction of the A-S, new rail lines serving the Onehunga catchment area will be created. In the illustrative post-A-S service concept, both the 'Crosstown' and 'Inner-Loop' services would likely provide a more desirable alternative to the existing Onehunga branch line service with routes directly into the city centre, as well as to the eastern and western areas of the city.
012	**Assumption**	It is assumed for the purpose of this study that the Onehunga branch line service will be removed.	
013	**Assumption**	It is assumed for the purpose of the capacity and resiliency aspects of the study that the Avondale Junction be a bi-directional junction. Note that the benefits of a bidirectional junction at Avondale are discussed within ***Section 7 of the A-S Resiliency Study - Output Report.***	As discussed/developed within KiwiRail and AT workshops.
017	**Assumption**	Infrastructure assumptions for the pre and post-A-S service concepts are as per ***Appendix C of the A-S Resiliency Study - Output Report.***	Based on concept timetable analysis undertaken as part of this study.
019	**Exclusion**	Climate resilience assessment excluded from this study.	Not the main focus of this analysis. Understood that the A-S alignment has already been designed to try and avoid flood plains.
020	**Assumption**	Pre and post-A-S service concepts assumed are documented within ***Sections 3 and 4 of the A-S Resiliency Study - Output Report***.	As discussed/developed within KiwiRail and AT workshops.
021	**Constraint**	The current A-S scheme excludes a south facing connection at Westfield Junction that can be utilised for metro and inter-regional services to/from the A-S to/from the NIMT.	As discussed/developed within KiwiRail and AT workshops.
022	**Constraint**	The current A-S scheme excludes a north facing connection at Westfield Junction that can be utilised for metro and inter-regional services to/from the A-S to/from the NIMT.	As discussed/developed within KiwiRail and AT workshops.

END OF REPORT