KIWIRAIL

NATIONAL RESILIENCE IMPROVEMENTS PROGRAMME BUSINESS CASE

17 August 2023

Tonkin+Taylor

Stantec

Revision Schedule

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1	23 Dec 2022	Draft (Strategic Case)	Stantec	Stantec	Stantec	T+T
2	6 June 2023	Draft Part A and B	Stantec	Stantec	T+T	T+T
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EXECUTIVE SUMMARY

Rail transports people and freight, supporting productivity and business growth, reducing emissions, congestion, and road deaths, and strengthening social and cultural connections between communities. Rail is a key part of a multi-modal transport system for both freight and passengers in New Zealand and is a critical part of New Zealand's supply chain.

Events occur that challenge and disrupt everyday use of facilities and it is no different for KiwiRail's rail network. Over the years, the KiwiRail network has been affected by large storm events, cyclones, coastal retreat processes, earthquakes and fires. In response, the government has developed a strategy that seeks to specifically address this issue the inaugural Rail Network Investment Programme (RNIP) outlining planned investment over the next three to ten years.

This Programme Business Case (PBC) identifies the resilience problems with respect to natural hazards that are exacerbated by climate change and determines a 10-year programme of options in response. The next version of the RNIP will be informed by the preferred programme of this PBC.

Purpose

Transportation resilience is defined as the ability of a transportation system to move people and good around in the face of one or more major obstacles, including extreme weather events or major accidents. In the context of the rail environment, resilience captures three key facets – 'robustness', 'redundancy' and 'response'.

This report investigates the resilience of KiwiRail's 3,700km mainline network covering both the north and south islands to natural hazards, highlighting key problems and risks, assessing potential solutions, with the goal of identifying a programme of works to improve network condition, reliability, and safety.

Preferred programme

The preferred programme aims to enhance the resilience of the KiwiRail network by prioritising interventions that address the most significant risks and hazards while being affordable.

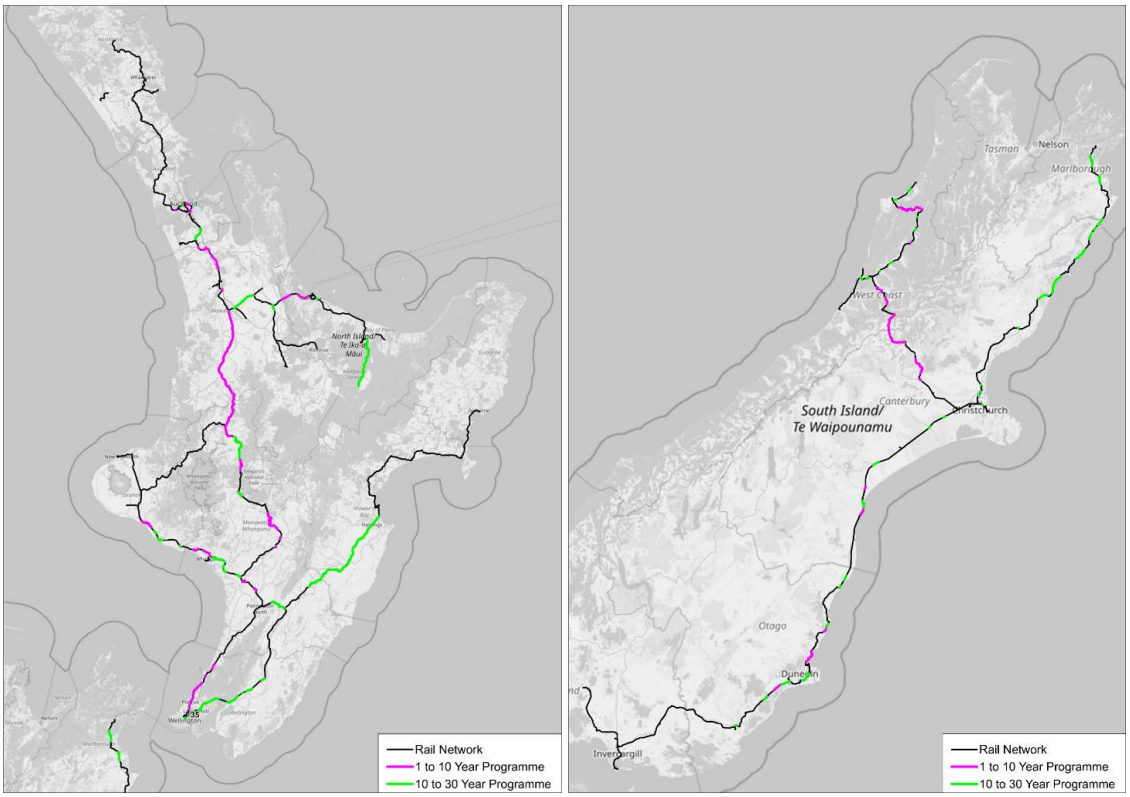
The programme covers a 30-year period and incorporates a range of engineering, operational, and strategic interventions that have been tailored to address issues along the network. Long (between 10-30 years) and short (less than 10 years) term interventions have been identified to improve the network's ability to withstand and recover from a range of natural hazards and climate change-related stressors.

Overall, the preferred programme represents a strategic and integrated approach to enhancing the resilience of the KiwiRail network and supports the long-term sustainability of the rail industry in New Zealand.

The following table provides shows the 30-year programme cost by line.

Line	Interventions	TOTAL
Bluff Line	0	6(2)(i) - Commercial Activities
East Coast Main Trunk	10	
Hokitika Line	0	
Johnsonville Line	0	
Kinleith Branch	1	
Main North Line	22	
Main South Line	23	
Marton - New Plymouth Line	35	
Midland Line	24	
Murupara Line	3	
North Auckland Line	4	
North Island Main Trunk	62	
Ohai Line	0	
Onehunga Branch	0	
Palmerston North - Gisborne Line	8	
Port Chalmers Branch	0	
Rapahoe Branch	3	
Stillwater - Ngakawau Line	15	
Wairarapa Line	22	
Wanganui Branch	0	
TOTAL	**232**	**$1,199,900,000**

The figures below geographically map the preferred programme for the North and South Island's respectively.



The need for investment

To understand the performance and risk of the rail network we had to first understand the outcome expectations for the rail services. In a joint workshop with stakeholders, the following outcome statement was developed for this project:

"Delivering safe and reliable rail movement across New Zealand by improving resilience."

Based on this Outcome Statement, KiwiRail's knowledge of the network and analysis of available data three problems were identified:

Problems

The agreed problem statements were:

1. **Natural hazards (30%):** Existing infrastructure is exposed to natural hazard events that can disrupt services for an extended duration.

   A series of workshops were undertaken to engage stakeholders, and a risk calculator was developed using a combination of likelihood and consequence to ascertain rail resilience risks across the country. The three hazards tested are: flooding, landslips, and coastal erosion.

2. **Asset level of service (50%):** Much of the rail network is old and not built to today's standards, which means it is more vulnerable to damage from natural hazard events.

   Available bridge and culvert data[1] was analysed to determine condition of the rail network. The data showed that as expected asset condition is deteriorating.

3. **Response time (20%):** Difficulty in accessing parts of the network following natural hazard events results in long recovery times, which further increases service delays.

   Spatial analysis of the track showed that approximately 80% is within 500m of a road and should allow for speedy response in the event of a natural disaster[2]. Some of the remote areas of track overlap with sections where there are natural hazards present, or far from population centres where there may be a more ready supply of resources and materials to reinstate the line following a resilience event.

[1] Other asset data was not available.

[2] Assuming that road access remains available during the same weather event.

Together with these problems, three benefits and two Investment Objectives were also identified:

Benefits and Investment Objectives

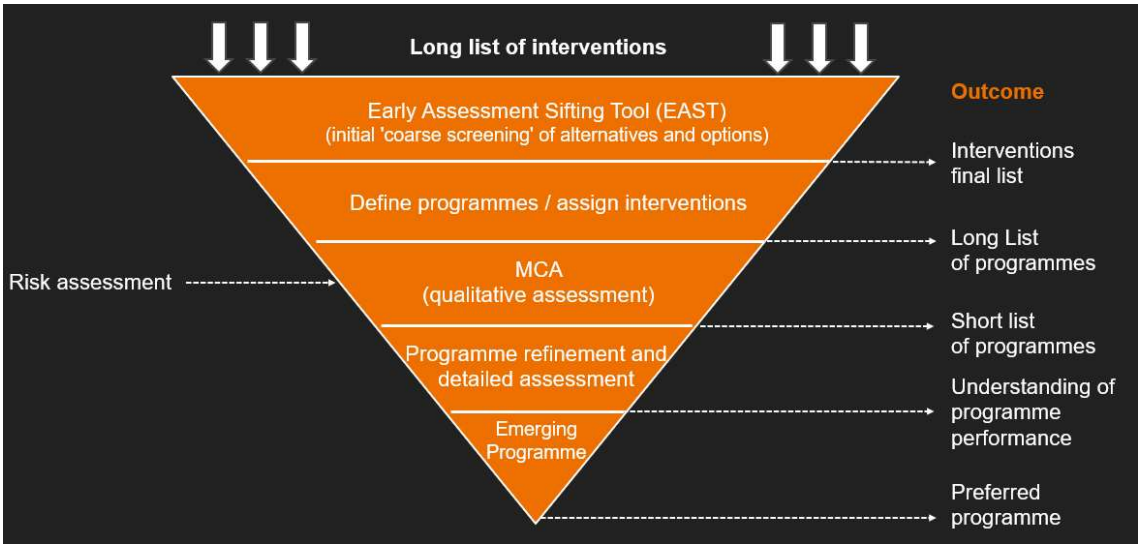
1. Improved reliability of rail services (60%)
2. Economic (25%)
3. Safety (15%)

The project Investment Objectives have been drawn across from the identified problems and benefits. These are:

1. **Resilience exposure:** Address 75% of the extreme resilience risks within the next 10 years and 75% of high resilience risks in the next 30 years.
2. **Access:** Provide reliable access to 50% of high-risk resilience areas in the next 30 years.

Identifying programmes

The following process was used to assess different programme options and identify the preferred programme.



Long list

A ‘long-list’ workshop was then held to identify the entire suite of potential interventions that could be applied to address various problems (categorised by issue type).

Level of service themes were developed by combining the three benefits which essentially reflect the Level of Service (LOS) being provided to customers, forming the three overarching potential strategies for investment:

- **Protect** the current level of service.
- **Improve** the current level of service.
- **Decline** the current level of service.

The Level of service themes were used for option development. To assess the performance of these options a Do Minimum was established:

- The Do Minimum represents the minimum level of expenditure required to maintain a minimum level of service[3].
- The Do Minimum programme includes all existing commitments. It assumes some managed decline over time where this does not pose a risk to the safety of rail operation. It is predominantly a 'reactive'/'just in time' programme, with a focus on safety elements while ensuring the continued operation of the railway network.

A long list of 83 interventions was identified through workshops and categorized into the three LOS themes with “Monitor” being added to round out the categories.

[3] https://www.nzta.govt.nz/planning-and-investment/learning-and-resources/business-case-approach-guidance/supporting-guidance-for-the-business-case-approach/business-case-approach-glossary/#D

Once this was completed, several interventions were flagged for fatal flaws and were not explored past this stage, 70 options went on to be assessed. A simple pass/fail methodology was adopted using the following criteria:

- **Technical** – is each intervention technically able to be undertaken.
- **Consentability** – how easy is it to gain a consent using the intervention and what permits may be required to enable various interventions.
- **Safety in Design** – does the use of this intervention improve safety in design or how easily can safety be implemented.
- **Risk reduction** – will the risk from climate change induced damage be reduced by the implementation of works.

The next part of the process involved assessing the remaining intervention against the "LoS themes". Each intervention was then scored against each key resilience approach using a simple three-point scale (0 to +2). After assigning intervention to problems, it was identified that not all 70 interventions had been utilised.

This in essence was a short listing of the preferred interventions and provided **53 interventions** that were then carried through into the various programmes.

Establishing an emerging programme

"Programmes", which are comprised of several separate interventions, were developed by the project team, and agreed by KiwiRail. A structured approach was adopted for the programme development, which captured:

- Overarching mitigation themes of "Protect", "Improve" and "Decline".
- Line criticality

Additional programmes were then introduced following a review by KiwiRail to capture hybrid programmes and a programme that targets only high-risk areas.

An assessment of the programmes through multi-criteria analysis (MCA) allowed for a better understanding of the relative benefits and costs of each.

MCA

Technical specialists from the project team and KiwiRail collaborated to score the various programmes. Scores were moderated and pulled into a single spreadsheet to show the performance of one option compared to other options, and to ensure that individual scores considered a wide range of different perspectives.

The raw scoring identified that "Do Minimum", "Protect high criticality lines", "Protect all lines", and "Improve high criticality lines" scored notably lower than alternative programmes.

Sensitivity tests were undertaken to understand if programmes rankings would change in response to weighting changes of key criteria. The sensitivity tests focused on the themes of **'equal weighting', 'investment objectives', 'implementability',** and **'technical difficulty'**.

A summary of the scoring, in terms of the relative ranking of programmes, is provided within the table below.

Programme		Baseline	Equal weighting	Investment Objectives	Implementability	Technical difficulty
Do Minimum		10	10	10	10	10
Protect	Protect high criticality lines	9	7	9	6	5
	Protect high and medium criticality line	6	3	6	2	1
	Protect all lines	7	9	7	8	6
Improve	Improve high criticality lines	8	3	8	5	8
	Improve high and medium criticality line	3	3	3	7	7
	Improve all lines	5	8	4	9	9
Hybrid	Protect medium, improve high	4	1	5	1	2
	Protect low, improve medium and high	1	5	1	3	3
Target high risk areas		1	5	1	3	3

The following programmes were consistently within the top three ranking, regardless of the sensitivity test:

- Target high risk areas.
- Protect low, improve medium and high.
- Protect medium, improve high.

- Improve high and medium criticality lines.
- Protect high and medium criticality lines.

The MCA process did not, as a stand-alone tool, conclusively establish a preferred programme. The table below provides the total MCA score for each programme alongside the indicative cost estimate (P50) and potential benefit-to-cost (BRC) ratio.

Programme		MCA: Total Score	MCA: Ranking	Cost Estimate (P50)	BCR Low	BCR High
Do Minimum		-0.16	10	$0	0.0	0.0
Protect	Protect high criticality lines	1.14	9	$280,000,000	2.2	2.9
	Protect high and medium criticality line	1.52	6	$1,324,000,000	2.7	3.5
	Protect all lines	1.32	7	$1,779,000,000	2.1	2.7
Improve	Improve high criticality lines	1.23	8	$1,906,000,000	0.3	0.4
	Improve high and medium criticality line	1.66	3	$6,952,000,000	0.5	0.7
	Improve all lines	1.58	5	$9,102,000,000	0.4	0.5
Hybrid	Protect medium, improve high	1.60	4	$2,950,000,000	1.2	1.6
	Protect low, improve medium and high	1.78	1.5	$7,407,000,000	0.5	0.7
High risk areas	Target high risk areas	1.78	1.5	$7,323,000,000	0.4	0.6

Feedback from stakeholders

An online meeting workshop was held in mid-March 2023 during which KiwiRail reviewed all relevant information and selected the following preferred programme: **Protect the high and medium criticality lines.**

The key reasons were:

- It scored well as part of the MCA.
- At around $1.3bn, the programme is far more likely to be realistically affordable.
- It is likely to present good value for money (a strong BCR).
- Whilst the 'Protect medium, improve high" programme has strong merit, at a cost approximately $3bn it is likely to be unaffordable.

Refining the preferred programme

Preferred programme

Once a preferred programme was selected, a deep dive into the programme was undertaken to establish whether it could be further optimised. This process captured:

- Reviewing the MCA scores for individual interventions to establish whether any interventions had critical flaws, or based on new information, whether a more optimal solution to address a specific issue was available.
- Revisions to intervention type based on a review by KiwiRail. These changes were typically steered by site specific requirements. Specific changes include:
  - The intervention for slopes of trimming and monitoring was changed to trimming and meshing to provide a better level of protection for all the sites with the former intervention applied. With this change came a higher cost as meshing requires construction and materials[4].
  - A further request for the level of protection to be increase for the Oamaru Sea wall. This was changed from minor repairs to a higher level of protection of an adapted design using the materials that are already on site.
- Cost estimates were updated following a second review by the project team and KiwiRail.
- Utilising the 2022 slope data track lengths to fill in gaps and provide a better assessment of treatment length.
- 'Gap assessment' (sense check). The outcome was that interventions that seek to address areas with a risk rating of 1UL were brought through into the 1 to 10 year programme.

[4] These costs were provided by KiwiRail on the 23/3/2023 in a meeting with the Professional Head of Civil.

Costs and economics

A summary of the results for the economic evaluation of the preferred programme is shown as Table 24.

Table 1: Preferred Programme – Economic Assessment

	Benefit (60 Year NPV)	Cost (60 Year NPV)		BCR Range
		Base (P50)	High (P95)	
Preferred Programme	$2.2bn	$623m	$811m	2.7 – 3.5

Sensitivity analysis

The economic assessment was highly sensitive to the factors of Annual Exceedance Probability (AEP), and the duration of an outage due to unforeseen events, for example, a slip blocking the rail line. These will always remain significant uncertainties which means that the final benefits of any programme will be unknown.

Next steps

This PBC provides a clear investment pathway for New Zealand's rail system, which will enable achievement of important objectives and provide significant value for investors.

It is therefore recommended that decision-makers:

- Approve the investment programme as outlined in this business case, and commit to the associated investment requirements and timeframes, subject to the outcome of further business cases and other investigations.
- Approve funding of the first three-year stage of the programme, which includes a series of further business cases and other investigations that will determine the optimal solution for and timing of key elements of the programme, particularly the rail capital components.

PART A – CASE FOR CHANGE

1 Introduction

1.1 Overview

Rail transports people and freight, supporting economic productivity and business growth, reduces emissions, congestion, and road deaths, and strengthens social and cultural connections between communities. Rail is a key part of a multi-modal transport system for both freight and passengers in New Zealand and is a critical part of New Zealand's supply chain.

Resilience is an essential and critical aspect of civil infrastructure and transport networks. Events occur that challenge and disrupt everyday use of facilities and it is no different for KiwiRail's rail network in New Zealand. Over the years, the KiwiRail network has been affected by large storm events, cyclones, coastal retreat processes, earthquakes and fires.

In response to this issue, the Government established a new long-term planning and funding framework under the Land Transport Management Act 2003 and identified strategic investment priorities for a resilient and reliable rail network. Within the new planning and funding framework KiwiRail developed its inaugural Rail Network Investment Programme (RNIP) to access funding from the National Land Transport Fund to deliver of the Governments first priority for rail - *to achieve a resilient and reliable rail network that also improves safety*.

This Programme Business Case (PBC) identifies the resilience problems facing the rail network and determines a 10-year programme of options in response.

What does resilience mean?

Transportation resilience is defined as **the ability of a transportation system to move people around in the face of one or more major obstacles to normal function.** These obstacles can include extreme weather events, major accidents, and equipment or infrastructure failures.

In the context of the rail environment, resilience captures three key facets – 'robustness', 'redundancy' and 'response'. In this definition:

- 'Robustness' reflects the ability of assets to withstand a level of stress without suffering degradation or loss of function.
- 'Redundancy' considers the extent to which assets can satisfy functional requirements in the event of disruption, degradation, or loss of functionality. An example of this would be the use of an alternate route (either locally or regionally) in the case of damage to the primary route.
- 'Response' includes the ability to sense and anticipate hazards, develop a forewarning of disruption threats, and have the ability to resource quickly in the event that a particular hazard occurs. It also relates to how the rail network can perform effectively during unplanned disruptive events and recover functionality quickly.

The focus of this project is the **response to natural hazard events that are exacerbated by climate change**. The risk of earthquakes has however been captured as part of a network risk assessment which has formed part of the evidence base for this business case (refer to Appendix A).

1.2 Project area

New Zealand's national rail network consists of approximately 3,700km of mainline track which is owned and operated by KiwiRail. The project extent covers the entire network.

The network spans almost the full length of the country and is predominantly single track outside of metro areas. It is supported by marshalling yards, loops, and sidings. There is also almost 250km of track in privately-owned and funded sidings that connect customers to the national network.

The North and South Island networks are connected across Cook Strait by KiwiRail's Interislander ferries, which offer roll on/roll off capability for rail freight travelling between the islands.

Figure 1 shows the project area.

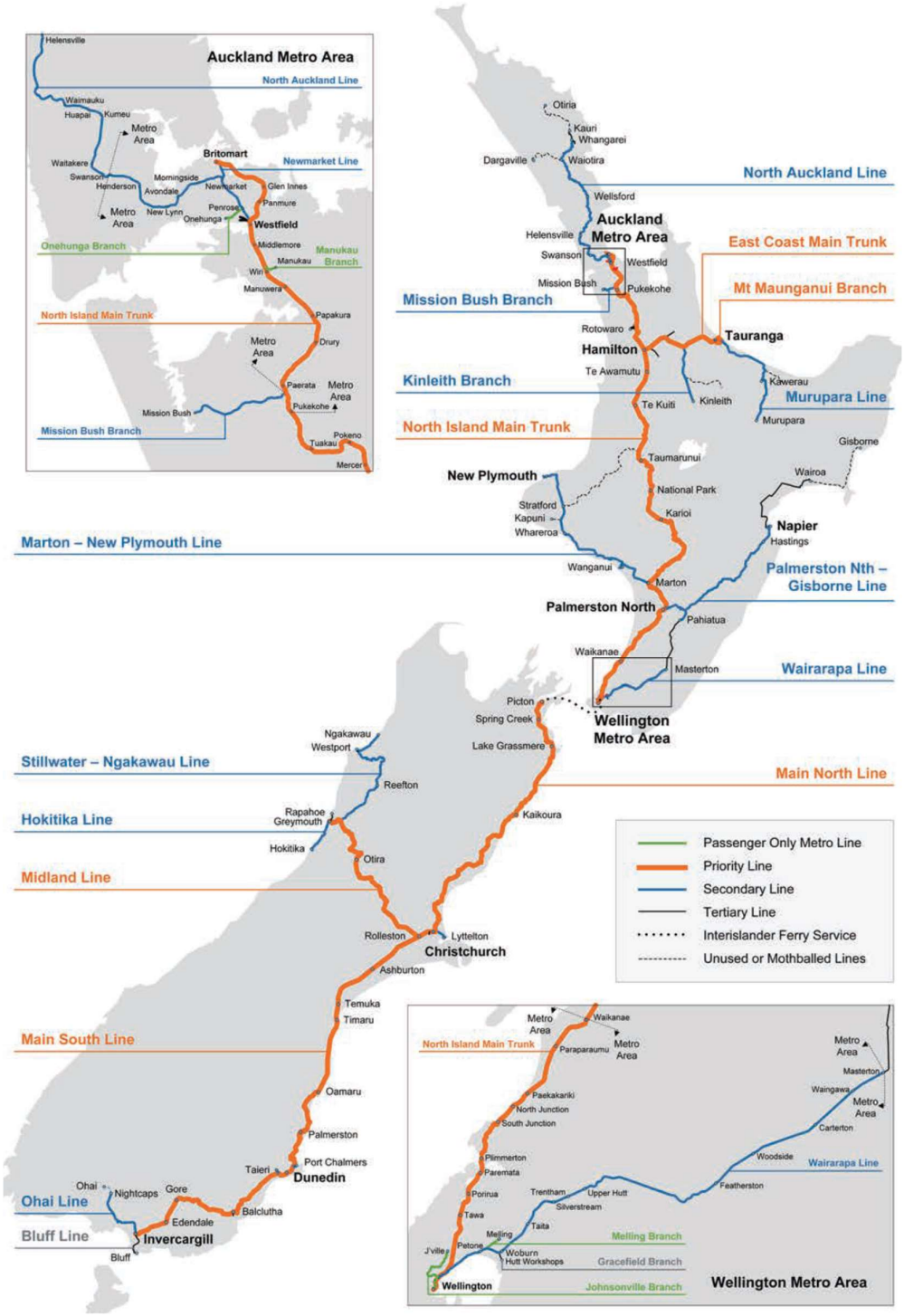


Figure 1: Project area – KiwiRail rail network[5]

[5] Not that the Auckland Urban area extends to Pukekohe.

1.3 Previous investigations

This section covers recent works that have developed resilience considerations in rail on a national level.

1.3.1 The New Zealand Rail Plan (2021)

The New Zealand Rail Plan (NZRP) outlines the Government's vision and priorities for the national rail network until 2030. The NZRP is a non-statutory planning document, and an output of the recommendations of the Future of Rail review by the MoT, KiwiRail, Waka Kotahi, and Treasury, which sought to determine the role of rail in the transport system and implement the investment needed to achieve the NZRP.

The NZRP sets out a long-term vision for: **New Zealand's rail network to provide modern transit systems in our largest cities, and to enable increasing volumes of freight to be moved by rail.**

The NZRP is the first component in a new planning and funding framework. It sets out the Government's intentions for the first decade of investment needed to achieve a reliable, resilient, and safe rail network, and identifies two strategic investment priorities:

- Investing in the national rail network to restore freight rail and provide a platform for future growth.
- Investing in the metropolitan rail networks to support growth and productivity in our largest cities.

The investment priorities informed the development of the 2021 Government Policy Statement on land transport (GPS). Along with the vision, they point towards investment in rail capacity, reliability, resilience, and safety. This aligns with the problems identified in the PBC (refer to Section 3).

1.3.2 Rail Network Investment Programme (2021)

KiwiRail's first Rail Network Investment Programme (RNIP) was approved by the Minister of Transport in June 2021, reflecting a new rail funding framework as outlined in the Land Transport (Rail) Legislation Act 2020. It outlines a 10-year investment programme for the rail network (below rail infrastructure) and was prepared with engagement with Greater Wellington Regional Council (GWRC) and Auckland Transport for the metro areas.

The RNIP sets out planned rail network infrastructure maintenance, management, renewal, and improvement work for the national rail network over the three-year period from 2021-2024, along with forecast potential investment over the 10-year period from 2021-2031. Its focus, in line with the priorities set out in the NZRP, is:

- Investing in the national rail network to restore rail freight and provide a platform for future investments for growth, meaning:
  - A primary focus (and majority of spend) on the continuous programmes of maintenance, management, and renewal.
  - A modest allowance for improvement projects to support resilience and reliability.
- Investing in metropolitan rail to support productivity and growth in New Zealand's largest cities, meaning:
  - A focus on completing the programmes that align with Auckland Transport Alignment Project (ATAP) and the Regional Land Transport Plan (RLTPs).
  - Enhanced regional services (embedding the Hamilton to Auckland and Palmerston North to Wellington services).

1.3.3 National Resilience Programme Business Case (Waka Kotahi, 2020)

Land transport (roads) have previously been assessed for the country through a PBC framework. The following problem statements and investment objectives were identified:

Problem Statements

- Increasing risks from natural hazards in an increasingly transport dependent society is leaving communities and business susceptible to isolation, hardship and economic loss (40%).
- Disjointed and reactive decision-making has led to sub-optimal and inefficient investment choices and is hampering our ability to adapt (40%).
- Failure to account for changing hazard risk is leading to rising costs of unplanned urgent repairs and emergency works (20%).

Investment Objectives

- All communities and businesses are well informed about what the risks of disruption to their transport connections are, and what their choices are.
- The land transport system would be more resilient in the face of a changing hazard profile.

1.3.4 Rail pinch points and hotspots assessment – National Infrastructure Unit

In 2014 a resilience assessment of New Zealand's infrastructure was delivered by the National Infrastructure Unit. Rail was included within this assessment. Pinchpoints and hotspots were identified.

"Pinchpoints" and geographic areas where the presence of multiple elements of infrastructure lead to interdependency vulnerabilities or "Hotspots". The terminology of "Pinchpoints" and "Hotspots" largely derives from activities of local authority emergency management and Lifelines Groups who are the main source of the following lists. It is important to note that the identification of a Pinchpoint or Hotspot does not necessarily imply that there is a weakness or vulnerability but that these areas deserve particular attention in terms of on-going operations and future investments.[6]

Nationally significant pinchpoints were identified (that pertain to rail)

- Rail to West Coast – coal exports
- Auckland to Hamilton & Tauranga – intermodal freight and passenger rail
- North Island Main Trunk – in the vicinity of Marton (Dairy freight) and Palmerston North Freight Hub
- National Train Control Centre

Nationally significant hotspots were identified (that pertain to rail)

Auckland

- Church Street East
- St Marks Road
- Grafton / The Strand / Tamaki Drive

Wellington

- Thorndon
- Paekakariki / Pukerua Bay
- Ngauranga to Petone, including Petone overbridge
- Ngauranga Gorge

Canterbury

- Lyttelton Tunnel and control centre

1.4 Planned, funded and current projects

1.4.1 Transitional Rail

During the period when the Ministry of Transport's *Future of Rail*[7] the Government provided a transitional funding pathway for rail projects through the creation of the Transitional Rail Activity Class in 2018-2021 Government Policy Statement (GPS).

This funded an extensive programme of catch-up renewals ($179.9m) and a programme of capacity and resilience upgrades ($147.4) in Wellington and an extensive programme of catch-up renewals in Auckland ($336.8m).

1.4.2 New Zealand Upgrade Programme

Government funding for rail includes more than one billion dollars through the NZ Upgrade Programme (NZUP)[8]. The programme includes:

- Building a third main line (Wiri to Quay Park) that will ease congestion and support growth on the busiest part of Auckland metro rail network.
- Extending electrification to Pukekohe to provide a faster ride into Auckland.
- Building three new train stations around Drury to support growth areas.
- Overhauling services and amenities on the Wellington, Wairarapa and Palmerston North network and beyond; and most recently. This includes network upgrade component – 6a Wellington Station & 6b Wairarapa all part this project.
- Building a new spur line south of Whangarei to connect Northport.
- Refurbishing the Capital Connection fleet which is an interregional passenger service between Palmerston North and Wellington.

1.4.3 Provincial Growth Fund

KiwiRail has also received $470 million for a range of regional projects through the Government's Provincial Growth Fund. This includes $218 million to save and upgrade the Northland Line, and to start purchasing land along the designated spur route to NorthPort. The Northland Line now has five new bridges and 13 tunnels

[6] Evidence Base: Resilience - National Infrastructure Unit (treasury.govt.nz)
[7] https://www.transport.govt.nz/area-of-interest/infrastructure-and-investment/future-of-rail/
[8] https://www.kiwirail.co.nz/what-we-do/projects/

lowered so that hi-cube shipping containers now run through them. This year work will begin on the line north of Whangarei to Otiria, which is currently mothballed.

Other PGF funded projects include:

- $40 million seed funding to design, designate and purchase land for a new Regional Freight Hub near Palmerston North. This will be major step forward in New Zealand's approach to freight logistics. A purpose-designed facility to link rail and road together like this has not been seen before in New Zealand.
- $6.2 million to reopen the Napier to Wairoa train line to run logging trains to Napier Port.

1.4.4 Other Government Funding

The Government has invested $3.5 billion through Budgets 2019 – 2021, to replace aging locomotives and wagons and to protect and renew the national network. This investment is seeing KiwiRail:

- Complete replacing the North Island main line locomotive fleet, and fully replace the South Island fleet, as well as short haul locomotives and electric shunt engines.
- Assemble 1,500 wagons at Dunedin's iconic Hillside Workshops – creating jobs and raising skills.

The Government's NZ Rail Plan is another crucial development which supports KiwiRail's commercial sustainability by introducing a new model for ongoing network investment and maintenance. It will see tracks, bridges, and other infrastructure funded from the National Land Transport fund, so rail is considered alongside roading investment.

2 Context

2.1 General

New Zealand's rail network is a crucial element to the transport system. The total value of rail to New Zealand's economy is approximately $1.7 - $2.1 billion every year[9]. The network consists primarily of single-track main lines on the North and South Island, with other significant secondary lines connecting to this system such as Midland and Wairarapa Lines.

There are 3,700 km of operational lines / track, and over 1,400 active bridges in the KiwiRail network. In addition, KiwiRail also has signals assets, train control systems, telecommunications assets, traction (includes overhead wire and traction poles), and electrical and active level crossings (approximately 1,200 across the New Zealand)

Figure 2 summarises the extent of KiwiRail's rail assets.

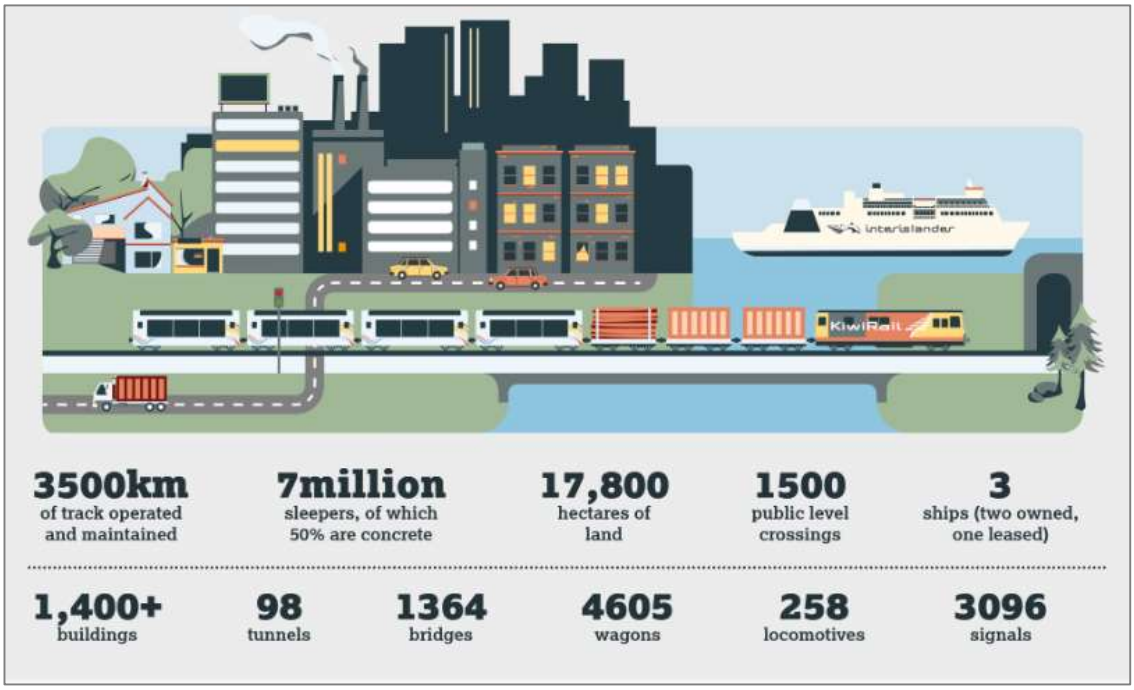


Figure 2: Summary of New Zealand's rail asset statistics[10]

Most of the network was developed over one hundred years ago. Owing in part to gradient requirement of rail, much of the network winds steeply through valleys and gullies, along and through mountains, and beside the ocean and rivers. Impressive engineering achievements are synonymous with New Zealand's rail network with viaducts and tunnels being common. The Raurimu Spiral is of particular significance as an engineering accomplishment in New Zealand.

Rail movements on the North and South Islands are connected via the Interislander Ferry Service between Wellington and Picton, where there is the capability to transfer trains with goods between the rail terminals at either end of the North and South islands. A current project is to increase the capacity of this service to support larger trains. Both new ferries will be capable of carrying 40 IBB wagons[11].

There are also proposals currently under consideration including extending the allowable train length and electrifying additional sections of the network.

2.2 Freight

Rail provides an ability to move a large amount of bulk material to-and-from plants and mills, to ports. Rail moves around 19 million tonnes of freight each year, carries 36% of all freight and transports around 20% of New Zealand's exports and imports. The total revenue from freight in 2021 was $393M (up 6% from 2020)[12].

[9] https://www.kiwirail.co.nz/assets/Uploads/documents/Annual-reports/2021/F.18A-KiwiRail-Holdings-Limited-Annual-Integrated-Report-2021.pdf

[10] https://www.kiwirail.co.nz/what-we-do/assets/

[11] Currently only one rail enabled ferry can carry 32 IH wagons

[12] https://www.kiwirail.co.nz/assets/Uploads/documents/Annual-reports/2021/F.18A-KiwiRail-Holdings-Limited-Annual-Integrated-Report-2021.pdf

The key freight hubs across New Zealand are shown on Figure 3.

Key freight movements (more than a million tonnes in 2017/18) include:

- Bay of Plenty to Auckland (1.4M tonnes),
- Auckland to Bay of Plenty (1.6M tonnes),
- Within Bay of Plenty (2.2M tonnes),
- Waikato to Bay of Plenty (1.7M tonnes),
- West Coast to Canterbury (1.4M tonnes).[14]

In urban areas industrial areas have been commonly constructed beside and nearby railway lines providing convenience and efficiency for moving freight.

Figure 3: Key freight locations on the KiwiRail network[13]

2.3 Suburban Passenger Rail

Overall, rail helps commuters make 35 million low-carbon journeys each year on our network[15].

Commuting by rail is locally available in Auckland and Wellington. In addition to these metro services a wider interregional network links these cities to other parts of the country, for example Hamilton to Auckland, and Palmerston North to Wellington. Commuting via rail is popular and growing (refer to Figure 4) as shown by patronage statistics in Auckland and Wellington leading up to Covid-19 pandemic.

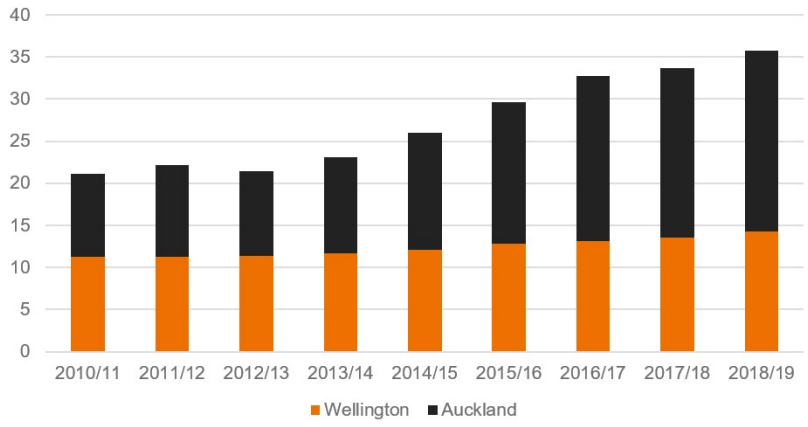


Figure 4: Rail public transport patronage (millions) 2010/11 – 2018/19[16]

[13] https://www.kiwirail.co.nz/assets/Uploads/documents/Annual-reports/2021/F.18A-KiwiRail-Holdings-Limited-Annual-Integrated-Report-2021.pdf
[14] https://www.transport.govt.nz/assets/Uploads/Report/NFDS3-Final-Report-Oct2019-Rev1.pdf
[15] https://www.kiwirail.co.nz/assets/Uploads/documents/Annual-reports/2021/F.18A-KiwiRail-Holdings-Limited-Annual-Integrated-Report-2021.pdf
[16] https://www.transport.govt.nz/statistics-and-insights/public-transport/sheet/boardings-all-modes

Large scale engineering projects are underway to add capacity and redundancy into the network, such as the City Rail Link in Auckland.

2.4 Tourism

Rail is a popular tourist attraction in New Zealand. Three of the major routes operated by KiwiRail used for this purpose are the Northern Explorer (Auckland to Wellington), the Coastal Pacific (Christchurch to Picton), and TranzAlpine (Christchurch to Greymouth). Figure 5 provides a picture of the Northern Explorer on the Hapuawhenua Viaduct, which is a popular tourist route.

Figure 5: Northern Explorer on the Hapuawhenua Viaduct[17]

The trains run daily, and in 2021 (noting the negative impact of the Covid-19 pandemic) carried approximately 680,000 passengers and generated $16M in revenue[18]. Rail tourism was growing prior to the pandemic at approximately 10% per year, bringing in $104 million in the 2017/18 financial year (an increase of 10% on the prior period)[19]. The rail lines often diverge far from roads and tracks, meaning relatively unique views can be obtained via this mode. However, the distance between road and rail can also create a vulnerability when it comes to be ability to respond to rail track issues.

2.5 New Zealand rail resilience history

Resilience events form an infamous part of New Zealand's rail history. The following section briefly provides context by case studying four rail resilient events in New Zealand, highlighting potential impacts, and importance of addressing resilience.

2.5.1 Case Study 1: Kaikoura 2016 Earthquake

A magnitude 7.8 on the Kaikoura Region occurred with ruptures of several faults propagating south-west to north-east through the North Canterbury and Marlborough area. The Main North Line was significantly damaged, with enormous landslips covering the tracks, along with buckled and broken sections. A freight train was trapped in between landslips. State Highway 1 was also closed. With no alternate rail routes connecting North Canterbury to Picton and beyond meant that freight movements were mode shifted via a much longer inland route, and the Coastal Pacific service temporarily stopped.

Train trapped following the earthquake[20]

Work underway fixing the line

[17] https://www.kiwirail.co.nz/what-we-do/great-journeys-of-new-zealand/
[18] https://www.kiwirail.co.nz/assets/Uploads/documents/Annual-reports/2021/F.18A-KiwiRail-Holdings-Limited-Annual-Integrated-Report-2021.pdf
[19] https://www.transport.govt.nz/assets/Uploads/RIA/18.-RIA-New-Planning-and-Funding-Framework-for-Rail-in-New-Zealand_Redacted-Redacted.pdf
[20] https://www.rnz.co.nz/news/national/320771/looted,-quake-stuck-train-moved

10 months after the earthquake, freight rail services resumed in a limited capacity on the Main North Line. As a measure of the scale of the work that has been carried out, about 50,000 cubic metres of ballast (or 90,000 tonnes, enough to fill 20 Olympic-size swimming pools) was used to restore the track.[21]

The earthquake caused 150km of damaged rail[22].

2.5.2 Case Study 2: Wairoa Storms 2012

In 2012 the Napier to Gisborne rail line was mothballed after severe storm causes extensive damage north of Wairoa.[23] The cost of repairing and protecting the line far exceeded its commercial value at the time.

Storm damage to the Wairoa-Gisborne line[24]

Rail line re-opened to cope with an expected 'wall of wood'[25]

In 2018 the Government announced funding to enable the reopening of the mothballed Napier to Wairoa section of line[26]. The line re-opened in 2020 to service the demand for log trains to Napier removing 10,000 truck movements per year from local roads[27].

2.5.3 Case Study 3: The Tangiwai Disaster 1953

While the Tangiwai Disaster occurred nearly 70 years ago it is pertinent to this business case as it highlights another potential impact to customers; death and serious injuries. The disaster occurred when a passenger train travelling between Wellington and Auckland plunged into the Tangiwai River after the rail bridge had been destroyed by a lahar emanating from Mount Ruapehu.

Wreckage of the train in the Tangiwai River[28]

Aerial view of the disaster debris[29]

The disaster resulted in deaths of 151 people. As a result, Mount Ruapehu's crater lake and the river crossing is now monitored using a lahar warning system[30].

[21] https://www.nzta.govt.nz/projects/kaikoura-earthquake-response/making-progress/september-november-2017-milestones-achieved/#rail
[22] https://www.stuff.co.nz/national/107130276/kaikura-road-and-rail-rebuild-up-against-fantastic-feats-of-engineering
[23] https://www.kiwirail.co.nz/what-we-do/projects/napier-to-wairoa/#:~:text=After%20the%20Napier%20%2D%20Gisborne%20Line,of%20the%20Provincial%20Growth%20Fund.
[24] http://www.stuff.co.nz/dominion-post/news/6665475/Uncertain-future-for-damaged-rail-line
[25] https://www.stuff.co.nz/business/85005563/napier-to-wairoa-rail-line-shaking-off-the-mothballs-to-reopen-next-year
[26] https://www.kiwirail.co.nz/our-story/history/
[27] https://www.kiwirail.co.nz/media/napier-to-wairoa-log-trains-now-running-weekdays/
[28] https://www.stuff.co.nz/national/91766007/tangiwai-unveiling-brings-closure-to-taihape-family
[29] https://www.stuff.co.nz/manawatu-standard/news/91903679/daughter-of-tangiwai-disaster-hero-speaks-of-her-fathers-bravery
[30] https://www.civildefence.govt.nz/resources/ruapehu-lahar-residual-risk-assessment/

2.5.4 Case Study 4: 2023 Weather Events

Te Puke Derailment

In late January 2023, after an extraordinary rainfall event that caused flooding across parts of Northland, Auckland, the Coromandel and other regions of the North Island, a train traveling along the East Coast Main Trunk (ECMT) railway line was derailed. The train was travelling from Kawerau to Mount Manganui when it passed over a section of track east of Te Puke where the supporting embankment was compromised due to the flooding, resulting in significant damage to the rail infrastructure and the derailment of at least 10 wagons[31].

The Te Puke to Te Maunga connection of the ECMT was closed for three weeks[32]. The Kawerau to Te Maunga railway line has been classified as a secondary line in the Rail Network Investment Programme[33] and runs a week-day train service allowing containerised exports to travel directly between Kawerau and Port of Tauranga.

This service was developed to cater for exports from Norske Skog, Sequal Lumber (logs forming one of the primary traffic generating items on this line) and Waiu Dairy. However, has capacity for other exporters in the region[34].

Wreckage of the train derailed in Te Puke[35] Aerial View of the train wreckage[36]

There are concerns regarding the impact of this railway closure on the forestry industry which relies on a stable resilient rail network to transport logs to the port[37].

Cyclone Gabrielle

In early February 2023, Cyclone Gabrielle impacted New Zealand causing major damage to the rail network. The impact was felt across a wide geographic area, including:

- A track washout to occur on the North Island Main Trunk Line. This occurred approximately 5km south of Mangaweka, in the Manawatu-Whanganui region and caused temporary cancellations to all services running through the section for several days[38].
- Damaged Auckland's Eastern and Western rail lines. After a rail network inspection, KiwiRail discovered subsidence on both lines[39] which resulted in decreased frequency and in some areas, cancellation with buses replacing regular services.
- Line to Northland - 50 slips fell on the rail line between Swanson and Whangārei. The total duration to fix the slips was over 3 months[40].
- Hawkes Bay - the line between Woodville and Hastings was closed for around 4 weeks. Bridge 217, north of Clive, lost piers and spans.
- Cutting off Napier Port to rail until at least the end of 2023, plus closing the North Auckland Line to freight from Wanganui.
- Numerous washouts and slips of various sizes on the track between Napier and Wairoa.

[31] https://www.taic.org.nz/inquiry/ro-2023-102

[32] https://sunlive.co.nz/news/312168-work-begins-to-remove-derailed-train-near-te-puke.html

[33] RNIP document_210630.indd (kiwirail.co.nz)

[34] https://www.kiwirail.co.nz/media/investment-in-kawerau-hub-welcomed/

[35] https://www.nzherald.co.nz/bay-of-plenty-times/news/te-puke-train-derailment-could-cause-problems-for-logging-industry-if-not-fixed-soon/UQJR6UFAZNELZCFJODJJURSKCA/

[36] https://www.foxweather.com/extreme-weather/watch-drone-video-train-derail-floods-new-zealand

[37] https://www.nzherald.co.nz/bay-of-plenty-times/news/te-puke-train-derailment-could-cause-problems-for-logging-industry-if-not-fixed-soon/UQJR6UFAZNELZCFJODJJURSKCA/

[38] Flooding on tracks forces cancellation of Auckland to Wellington train | Stuff.co.nz

[39] Auckland floods: Train lines damaged on rail network, debris slows harbour ferries, bus depots inundated - NZ Herald

[40] https://www.rnz.co.nz/news/national/485164/some-freight-railway-lines-will-remain-closed-for-months-due-to-cyclone-gabrielle-damage-kiwirail

2.5.5 Case Study 5: Petone Sea Wall

The storm damage[41] to the Petone Seawall in Wellington in 2013 is another example of how an extreme weather even can cause network gridlock. During the 1 week of repairs, those commuting from the Hutt Valley needed to do so using State Highway 2.

2.6 Organisations and stakeholders

There are several partners and key stakeholders with an interest in providing resilient rail network in New Zealand. As part of the PBC a workshop was held in July 2022 with KiwiRail and Waka Kotahi representatives to:

- Present background information.
- Confirm the problem statements and benefits.
- Seek additional evidence for the strategic case.

Table 2: Organisations and stakeholders

<table>
<tr><th>Stakeholder</th><th>Roles and responsibility</th></tr>
<tr><td>KiwiRail</td><td>KiwiRail is responsible for rail operations in New Zealand. This includes the Interislander ferry service, managing property, infrastructure and assets, and Great Journey's of New Zealand – a tourism division of KiwiRail operating long distance passenger services.</td></tr>
<tr><td>Waka Kotahi NZ Transport Agency</td><td>Waka Kotahi's primary purpose is to provide transport solutions for a thriving New Zealand. They achieve this by investing in land transport activities, regulating access and use of the land transport system, and protecting, operating, planning for and improving the state highway network.
Waka Kotahi NZ Transport Agency also has primary regulatory responsibility for rail safety in NZ.</td></tr>
<tr><td>Regional Councils</td><td>• Auckland Transport and Greater Wellington Regional Council
• Passenger rail operations are contracted by these Council's. They coordinate bus, ferry, and passenger rail into a public transport service.</td></tr>
<tr><td>Civil defence</td><td>Lifelines Groups are established in most regions of New Zealand; and most have informal relationships with regional Civil Defence Emergency Management (CDEM) Groups, with some being defined within the structures of CDEM Group Plans.</td></tr>
<tr><td>Freight Operators</td><td>KiwiRail also has/provides services to many individual freight customers. These include[42].
<table>
<tr><th>Section</th><th>Customer</th></tr>
<tr><td>Import/Export</td><td>Fonterra</td></tr>
<tr><td>Import/Export</td><td>Port of Tauranga</td></tr>
<tr><td>Bulk Goods</td><td>Bathurst/BT mining</td></tr>
<tr><td>Domestic goods</td><td>Toll</td></tr>
<tr><td>Domestic goods</td><td>Mainfreight</td></tr>
<tr><td>Import/Export</td><td>CentrePort</td></tr>
<tr><td>Bulk goods</td><td>NZ Steel</td></tr>
<tr><td>Forestry</td><td>Timberlands</td></tr>
<tr><td>Forestry</td><td>OJI Fibre Solutions</td></tr>
</table>
</td></tr>
</table>

[41] https://www.stuff.co.nz/dominion-post/news/wellington/8851796/Round-the-clock-work-to-put-track-back

[42] https://fyi.org.nz/request/16098-most-significant-freight-customers

2.7 The National Planning Context

Investing to improve KiwiRail's resilience will contribute to key national, regional, sector and organisational strategies and commitments. The alignment is explained in Table 3.

Table 3: National strategic alignment

Strategy	Alignment (Resilience)
KiwiRail Statement of Corporate Intent (2022-2024)	This business case aligns directly and contributes to KiwiRail achieving their objective to have a resilient and reliable rail network and above rail assets.
Rail Network Investment Programme	This business case has a strong alignment to the strategic investment priority to restore rail freight and provide a platform for future investments for growth. It does this by ensuring that rail transport is reliable and available, ensuring that it is perceived as an attractive choice.
Government Policy Statement on Land Transport 2021/22-2030/31	This business case has strong alignment to the Improving Freight Connections strategic priority. It does this by the improving the reliability of transporting freight by rail as an alternative to road. It consequently has an indirect alignment to the climate change strategic priority by encouraging mode shift to rail, which has fewer emissions than road-based transport. A Rail Network activity class, which aims to improve freight network resilience and reliability, funds the maintenance, operation and renewal of the National Rail Network. Additional Crown funding has been provided, recognising the wider benefits of rail and to support a reliable and resilient national rail network. Improvements to the metro rail network are funded through the Passenger Transport Infrastructure activity class.
Transport Outcomes Framework (MOT)	This business case strongly aligns with the Resilience and Security outcomes – 'minimises and manages the risks from natural and human-made hazards', 'anticipates and adapts to emerging threats', and 'recovers effectively from disruptive events'.
Climate Change Response (Zero Carbon) Amendment Act (2019)	This business case indirectly aligns with the Act's goal for NZ to reduce net emissions of all greenhouse gases (except biogenic methane) to zero by 2050. It does this by increasing the attractiveness of rail freight movement, which will reduce the amount of diesel required to move freight by means of mode shift from trucks to rail.
Regional Land Transport Plans	This business case in alignment with many of the current Regional Land Transport Plans. The Auckland, Canterbury, and Wellington RLTPs all signal improvements are required in transport network resilience or management of risk of exposure to extreme events. Improving the resilience of the rail network directly aligns with this desired outcome.
Hīkina te Kohupara – Kia mauri ora ai te iwi: Transport Emissions – Pathways to Net Zero by 2050 (MOT)	This business case aligns with theme 3, 'Supporting a more efficient freight system' by investigating ways to reduce carbon emissions arising from diesel fuel used in transporting freight. It does this indirectly by improving the reliability and consequently the attractiveness of rail which helps shift freight from road (more energy intensive) to rail (less energy intensive).
New Zealand Energy Efficiency and Conservation Strategy 2017-2022	This business case aligns with the Strategy's goal for New Zealand to have an energy productive and low emissions economy by reducing carbon emissions arising from diesel fuel used in transporting freight by rail. While still producing emissions, this is a significantly smaller amount of emission than by road.
Climate Change Commission Recommendations (2021)	This business case aligns with the recommendation that transport sector should be the principal area where substantial change should be made to reduce emissions, including reaching actual (not net) zero for the transport sector by 2050. It responds to the following recommendations that were included in the report: shifting freight from road to rail which is only possible if rail is seen as a viable alternative to road transport which this business case helps to achieve.
Emissions Reduction Plan (2022)	The Emissions Reduction Plan (ERM) sets out New Zealand's direction for climate action for the next 15 years. On of the key areas are the infrastructure systems to support improvement to interregional rail services and the decarbonisation of freight. Improving reliability requires a resilient network which keeps the network open, and as such this PBC directly aligns with the objectives of the ERM.
National Adaptation Plan (2022)	The National Adaption Plan is focused on how New Zealand will meet the challenges of climate change. This initial plan is centred around what the Government will do to enable better risk-informed decisions, drive climate-resilient development in the right locations, help communities assess adaptation options (including managed retreat) and embed climate resilience into all of the Government's work. A key area of focus is to support climate-resilient infrastructure – Action 8.5 specifically relates to progressing the RNIP. This PBC feeds directly into that work.
National CDEM plan (2015)	The National Civil Defence Emergency Management Plan 2015 sets out the roles and responsibilities of everyone involved in reducing risks and preparing for, responding to and recovering from emergencies. This includes central and local government, lifeline utilities, emergency services and non-government organisations. This PBC aligns with this strategy as it seeks to enable faster recover post a major weather event.

3 The need for investment

3.1 Outcome statement

A facilitated Investment Logic Map (ILM) workshop was held on 4th August 2022 to confirm the case for change. The workshop was attended by KiwiRail, Waka Kotahi, and the project team. The minutes of the ILM workshop are provided in **Appendix A**.

A draft outcome statement was developed beforehand, which was intended to set the scene around what the business case seeks to achieve. This was presented to stakeholders and revised based on feedback.

The agreed outcome statement is:

"Delivering safe and reliable rail movement across New Zealand by improving resilience."

3.2 Problem statements

The agreed problem statements were:

3. **Natural hazards (30%):** Existing infrastructure is exposed to natural hazard events that can disrupt services for an extended duration.
4. **Asset level of service (50%):** Much of the rail network is old and not built to today's standards, which means it is more vulnerable to damage from natural hazard events.
5. **Response time (20%):** Difficulty in accessing parts of the network following natural hazard events results in long recovery times, which further increases service delays.

"Natural hazard" relates to the risk of disruption to the current network resulting from an increased number of extreme weather events. Over the past few years, the severity and frequency of events is creating resilience issues across the network, events such as slips on the Johnsonville Line in Wellington or flooding on the Auckland network, this is reflected in the 30% weighting for this problem. These unplanned closures impact commuters and the economy, which is especially true for routes with high criticality. Climate change is anticipated to exacerbate this problem over time.

Whilst the focus is natural hazards and the impacts of climate change, the risk assessment that informs the evidence base for this business case has captured the susceptibility of the rail network to other geohazards (e.g. earthquakes)

"Asset level of service" is about ensuring the design and condition of assets will minimise the impact to rail services when a nature hazard event occurs. Much of the rail network was built a long time ago, with varying degree of available information about condition and design (capacity, strength, etc), however, historic processes have endeavoured to ensure the network is safe or closed. 50%.

"Response time" relates to the challenges related to remoteness and lack of access to part of the network which is resulting in the inability to respond timeously to events. In addition, there is limited technical competence which is also leading to a slower response time. The priority of reducing disruption means that recovery is weighted at 20%.

Sections 5, 6 and 7 provide the evidence base behind each of the problems.

3.3 Benefits

The benefit statements for the project are presented below. Draft themes were presented at the first workshop and further developed by the project team after consideration of the problem statements and benefits.

- Improved reliability of rail services (60%)
  - Recognises that addressing the problems will enable a more reliable rail service for freight and passengers. This will help people to plan journeys and may make rail a more attractive mode.
- Economic (25%)
  - Reflects the desire for rail to be economically sustainable and productive. The less the network is disrupted in resilience events, the better it will be able to contribute to the economy.
- Safety (15%)
  - Reflects that reducing resilience will increase risks to public safety, by increasing the exposure of passengers to natural hazards when using train service

3.4 Investment Objectives

The project Investment Objectives have been drawn across from the identified problems and benefits. These are:

1. Address 75% of the extreme resilience risks within the next 10 years and 75% of high resilience risks in the next 30 years.
2. Provide reliable access to 50% of high-risk resilience areas in the next 30 years.

3.5 Investment Logic Map

The agreed ILM is provided as Figure 6.

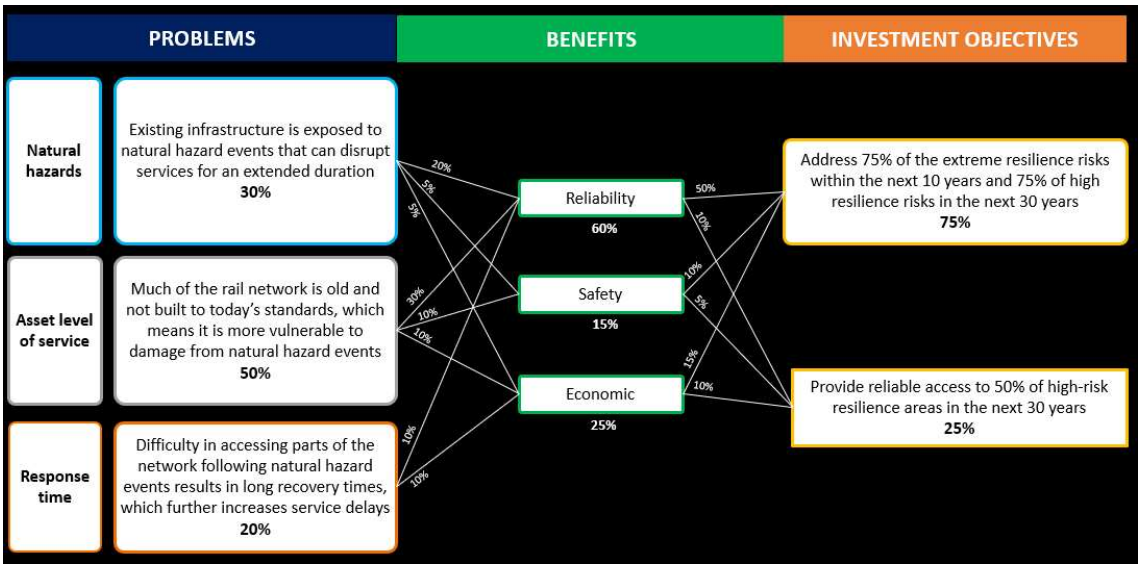


Figure 6: Investment Logic Map

3.6 Opportunities

As well as the benefit of addressing the identified issues, there are also some associated opportunities.

These include:

- **Improved knowledge database - r**esilience is a broad subject and because there is over 3,700 km of rail network in New Zealand a large dataset therefore exists. This business case provides an opportunity to compile, reduce, and simplify the available data for analysis and to inform a programme of options in response (both now, and in future). The process will enable a stock take of datasets enabling easier management, and greater awareness amongst practitioners in future.

  An improved database will also aid to further strengthen New Zealand's overall transport system by understanding pinch points, and scenarios, that may have wider impacts than just the rail network.

- **Beautification / environmental** - where physical works is undertaken to address identified problems there will be an opportunity to use that access to the site to beautify and improve urban design. This may be particularly relevant to urban sections that are viewable from adjacent roads or buildings.

  There is also an opportunity for environmental benefits from activities such as planting (for erosion control - slopes and coastal/river areas) and meeting new NES-F requirements[43] through culvert renewals.

- **Incorporation of new and emerging technology** - there is some discrepancy in the technology present across the KiwiRail network. For example, signaling systems tend to be more modern in urban areas than in some of the less frequented rural areas. Investment into the network may present an opportunity to improve other infrastructure in parallel and provide enduring benefits to users of the rail network.

- **Reduced maintenance** – particularly interventions, such as larger culverts, would reduce future maintenance requirements.

[43] National Environmental Standard for Freshwater 2020.

4 Problem 1 – Exposure of the network

Existing infrastructure is exposed to natural hazard events that can disrupt services for an extended duration.

4.1 Overall vulnerability to natural hazards

To obtain a national picture of resilience risk, a series of workshops were undertaking to ascertain rail resilience risks across the country. The risk calculation was a combination of likelihood and consequence (as shown in Figure 7). Please refer to **Appendix B** for the full explanation of this process and results.

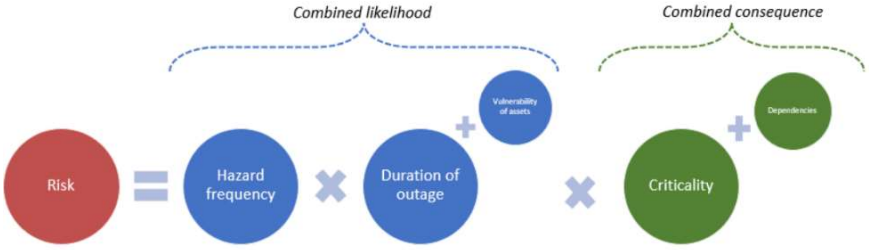


Figure 7: Resilience risk calculation

The overall output of the process was the identification of resilience risks across the country. Note that the Midland Line contains extensive extreme rated risk, while there are also sections of extreme risk near Auckland and Wellington, among others. Overall, 33 current extreme risks were identified.

Future growth and general actively on each rail line was captured as part of the 'criticality' component of the resilience risk calculation. This ensures that the resilience programme then capture the importance (economically) of each rail line.

The economic benefit of each line (refer to the Economics chapter) has also been partly derived from the future income stream from freight services, which captures a forecast growth scenario.

Future vulnerability

Climate change is predicted to impact New Zealand in many ways. In terms of natural hazards, it is predicted that rising sea levels will mean more coastal erosion and flooding. Increased rainfall will result in areas with higher stormwater flows in floods. Infrastructure will be at risk from both high intensity rainfall and flood events, which are likely to happen more often as the climate changes.[44]

An analysis was undertaken to understand how the rail resilience risks could change over time, which took into consideration several climate change factors. The overall results are presented below showing the number of extreme risks will increase from 33 in the present day, to 51 in the long term (50 years).

[44] https://niwa.co.nz/education-and-training/schools/students/climate-change/impacts-for-NZ#:~:text=Sea%2Dlevel%20rise%20is%20caused,infrastructure%20like%20pipes%20and%20roads.

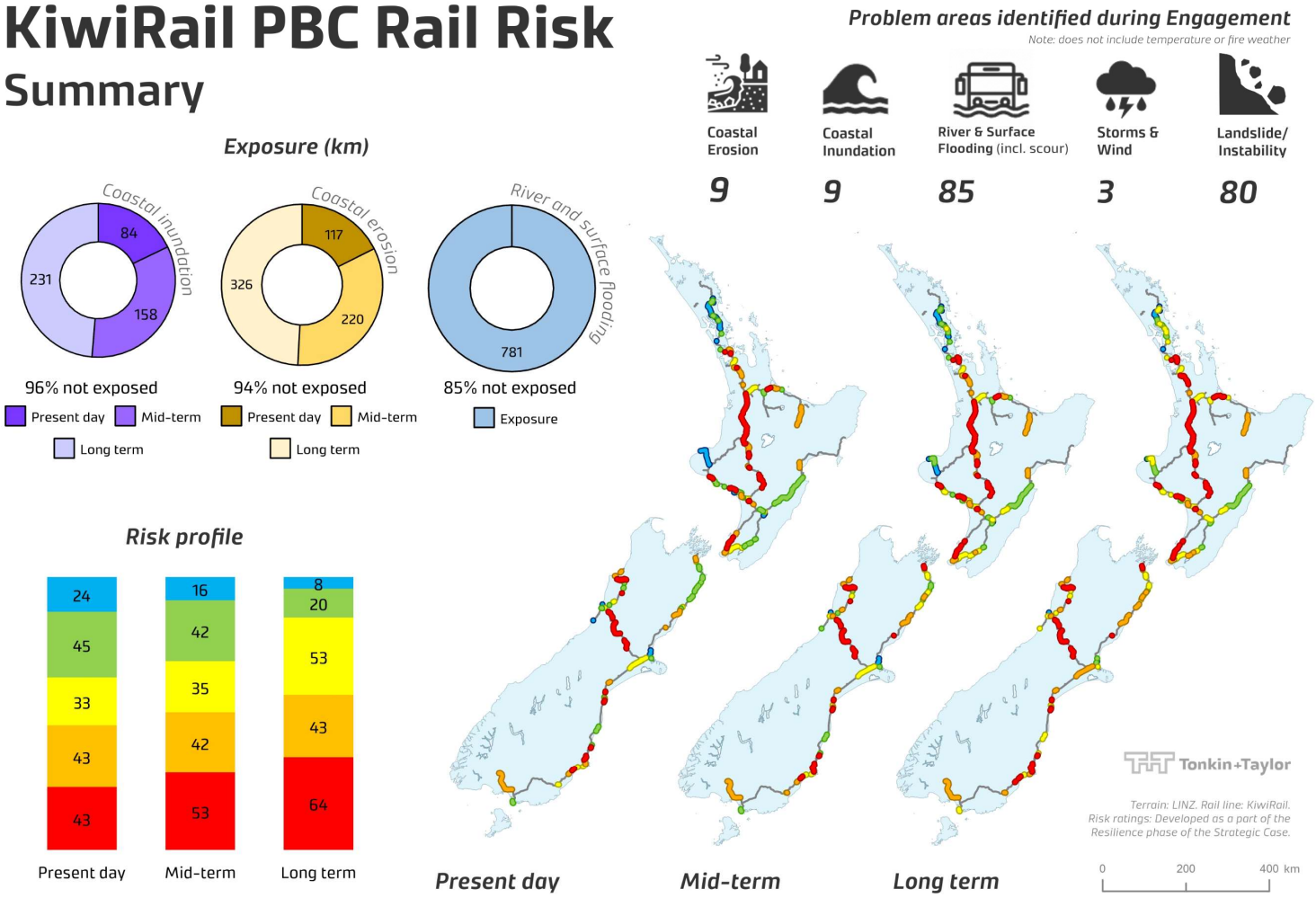


Figure 8: New Zealand rail resilience risks - present day, mid-term, and long-term time periods

4.2 Natural hazard risks

4.2.1 Exposure assessment

An exposure assessment was carried out to understand the current and future exposure of KiwiRail assets to natural hazards, particularly those impacted by climate change.

The acute hazards that were assessed include:

- Coastal inundation
- Coastal erosion
- River and surface flooding

The chronic hazards that were assessed include:

- Increasing temperatures
- Storms and winds
- Increased fire risk

Acute hazards were assessed spatially, and it was concluded that there is a higher proportion of assets exposed to river and surface flooding, compared to coastal hazards. This is expected as there are limited rail corridors located within coastal areas.

Chronic hazards were assessed non-spatially, through a series of workshops and information was elicited from stakeholders.

It was highlighted that strong winds are of particular concern within the Auckland region, along the Orakei basin (North Island Main Trunk 676-680 km) and Parnell. Ex-tropical cyclones are likely to become more frequent in this region, which could lead to increased impacts to this section of track. Additionally, areas along the Canterbury Plains, notably between Templeton and Rakaia (Main South Line 23-70 km) and the Midland Line between Springfield and Arthur's Pass, are likely to see an increased frequency and intensity of wind events. There are wind fences at bridges, particularly in Arthurs Pass, to help mitigate the disruption. However, it is likely that wind fences will have limited usefulness, and that more closures (particularly on the Canterbury Plains) are likely to occur.

In terms of increasing and more variable temperatures, tracks can be subjected to significant safety risks such as heat buckling. The network is predominantly designed as Continuously Welded Rail (CWR) with an operating rail temperature of -6 to +60°C. Above 36°C, the rail is in compression and, when managed correctly, is designed to withstand these thermal forces. However, when maintenance and renewals plans are overdue on CWR, Temporary Speed Restrictions (TSRs) must be in place over at-risk locations throughout the network until remedial work is completed. This process requires a thorough Risk Assessment of the whole network prior to each summer season. This has been previously demonstrated in Auckland where TSRs were issued following network failures due to high temperatures in between 2014 and 2019. With temperatures and the number of hot days (days above 25 degrees) set to increase nationally, temperature-related events may become more common. It is understood there are structures in place (counterweighted overhead lines) that help reduce the impacts of hot temperatures, for example, on hills near Wellington. The use of these structures throughout more of the network may need to be considered.

It was highlighted that the South Island tracks have an increased vulnerability to fire risk due to the heavily vegetated areas close to the rail corridor. During the fire season the risks of fire creation are managed, and it is understood that work is currently underway in this space (particularly for the South Island). However, it was noted that more work to understand the fire risk to other sections of the network is needed, alongside potential mitigation strategies.

Further information on the exposure assessment can be found in the Resilience Summary Results Memo by Tonkin + Taylor in November 2022

4.2.2 Landslides

Landslide risk pertains to the stability of land above and below assets that may give way. In the case of the rail network slope stability relates to vulnerable land along the network and embankments susceptible to the ground slipping due changing weather partners.

Based on the provided data, it was identified that land instability is common across much of the network. There are long stretches of rail with many identified landslide risks, include Central North Island, the Kaikoura Coast, and north of Dunedin. The area north of Dunedin suffers land instability on both SH1 and the MSL rail line due to the underlying geology (wind dispersed losses).

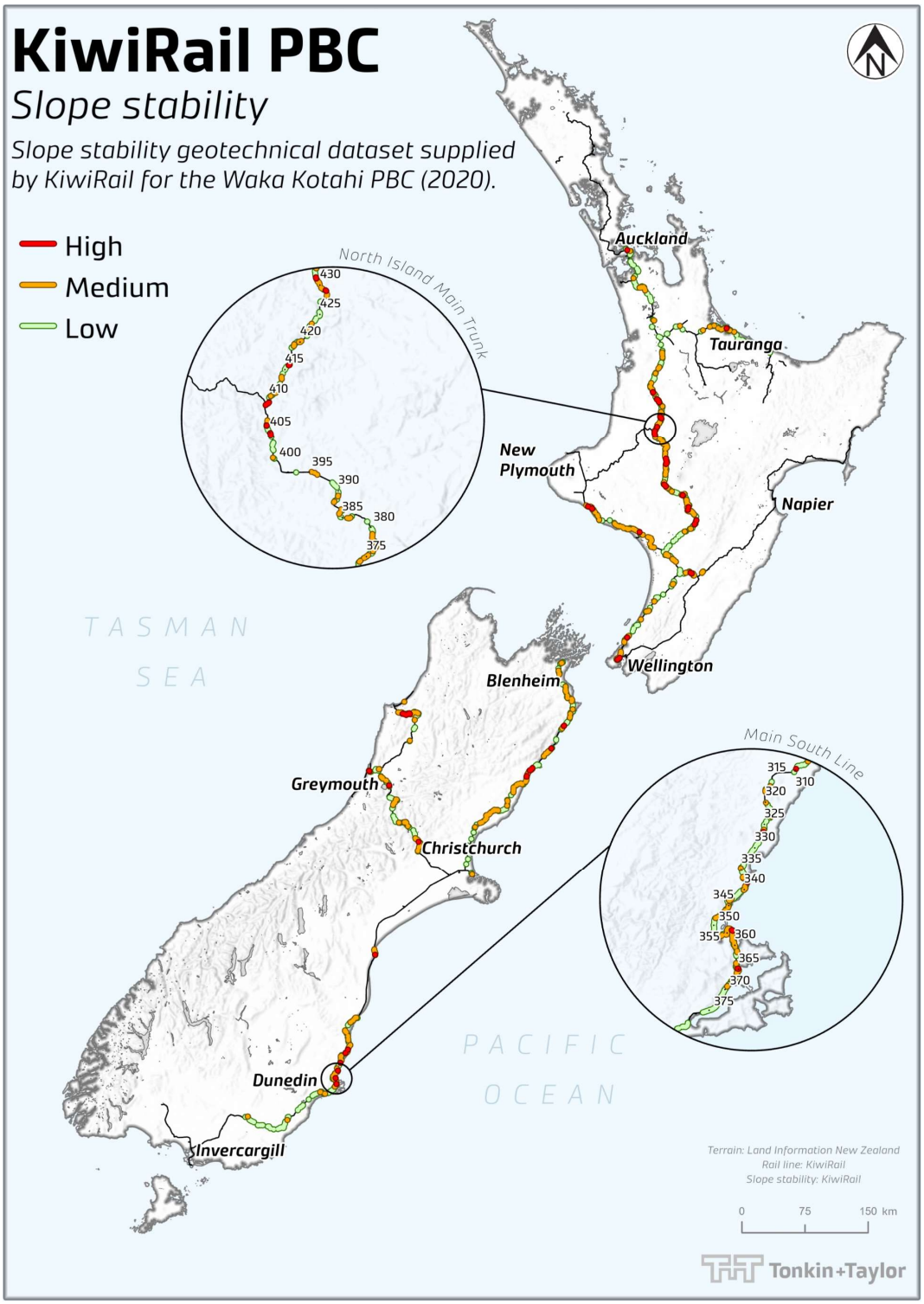


Figure 9: New Zealand rail slope stability

4.2.3 Flooding

Flooding is a common natural hazard in New Zealand. Given the preference for gentler grades much of the rail network follows rivers and flat flood plain areas, susceptible to flooding. Flooding can block the line with water overtopping the track, undermine structures, and washing away or loosening ballast and subgrade. Flooding also causes major scour problems for bridges and culverts across the network, requiring constant monitoring and remedial work.

Auckland and the surrounds contain some of the more extensive areas of exposure risk. These are parts of the network that also commonly have high consequences for closure. The Taieri Plains (south of Dunedin) and Mataura River (near Gore) are the longer stretches of flood risk in the South Island.

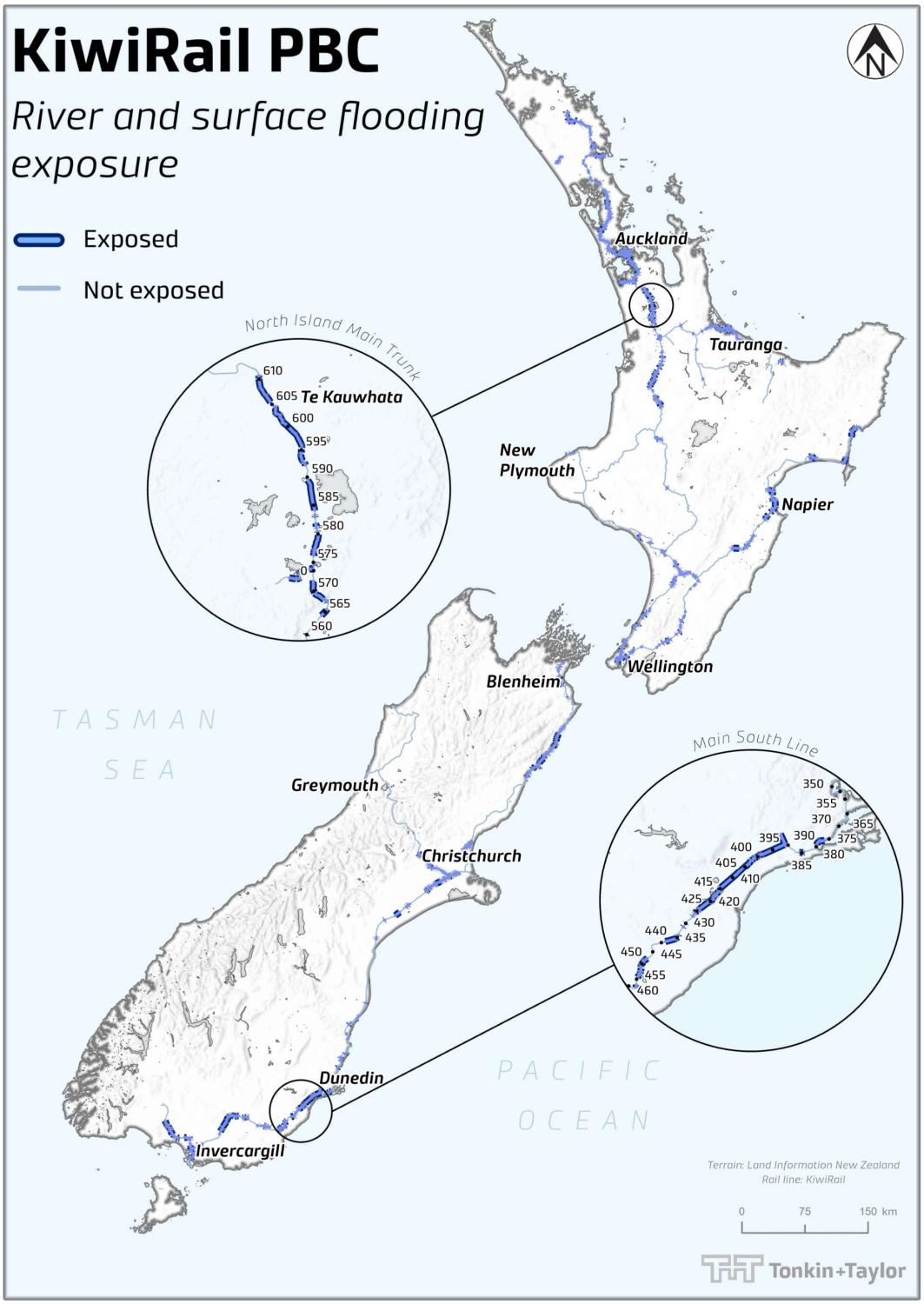


Figure 10: New Zealand rail river and surface flooding exposure

An analysis of work order data shows that flooding related events were most common on the Midland Line (over 80 in the past 10 years) followed by the North Island Main Trunk (over 60 in the past 10 years). The Main South Line between Christchurch and Timaru has been experienced numerous flood events.

4.2.4 Coastal erosion

Rail coastal erosion hazards occur where the rail line is located close to the coast, or when large storm events, erode and undermine the land beneath and adjacent rail lines. Given New Zealand's mountainous interior in some places the coast is one of the few flat areas for a rail line – for example, the Kaikoura Coast.

Coastal erosion exposure locations are located (among others) in Auckland, Wellington, and Tauranga, and several sections of the east coast of the South Island where the rail line is particularly close to the ocean.

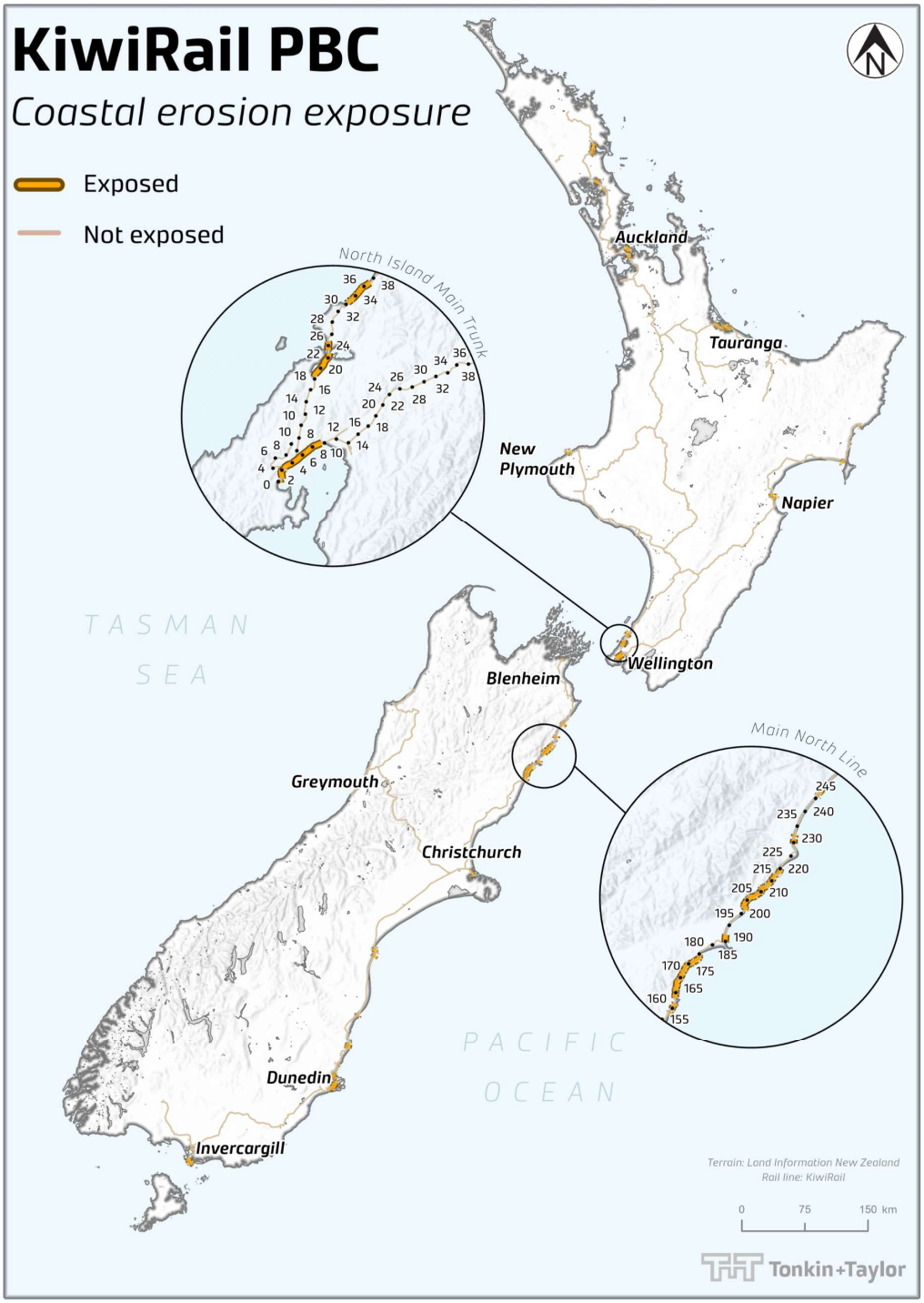


Figure 11: New Zealand Rail – Coastal Erosion Exposure

4.2.5 Coastal inundation

Similar to coastal erosion, risks to the rail line from coastal inundation occur in locations where the network is in close proximity to the coast. Inundation can stretch further inland, particularly in low-lying areas e.g., South Dunedin. Key locations that were identified as exposed include Christchurch, Auckland, Tauranga and Dunedin.

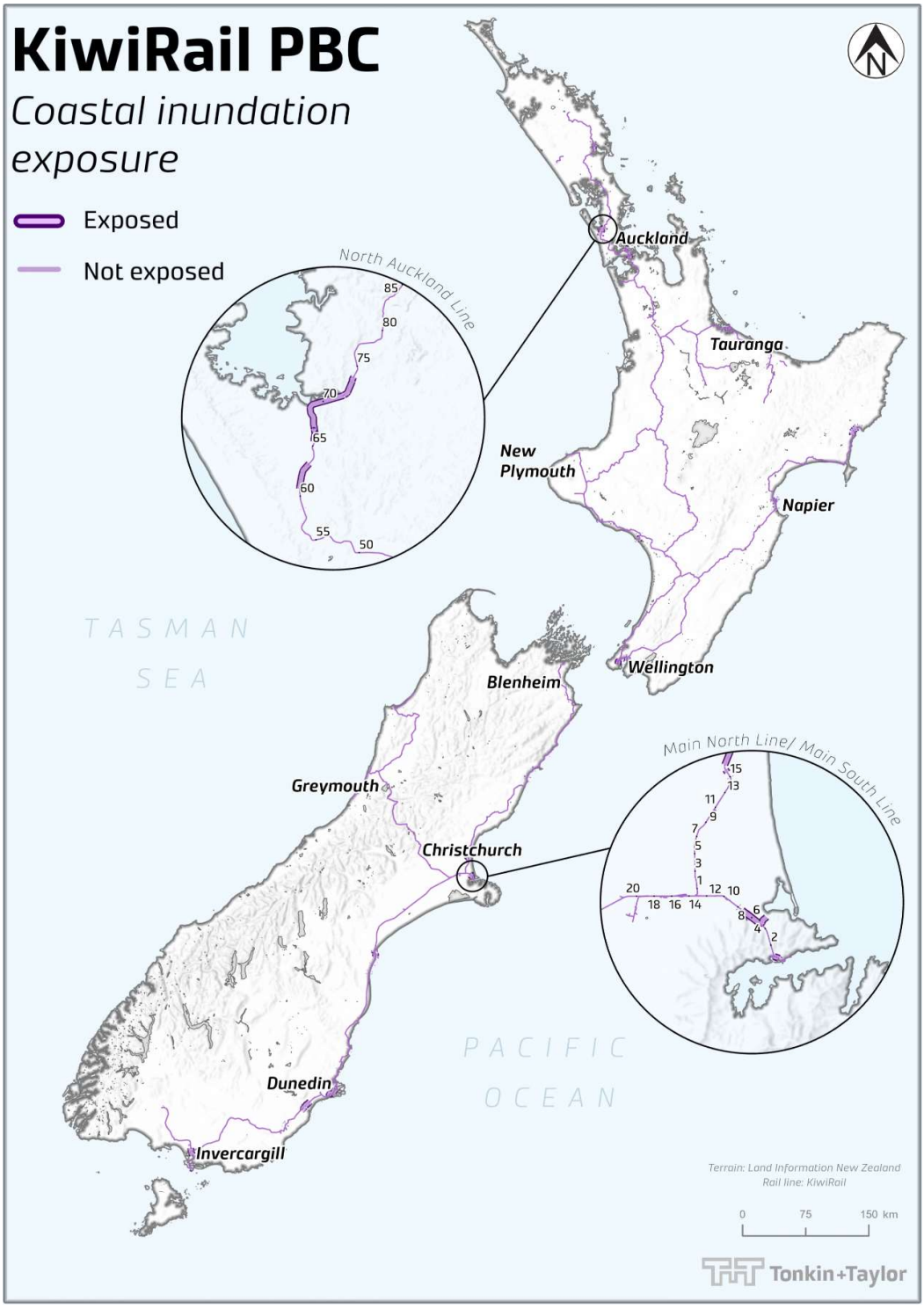


Figure 12: New Zealand Rail – Coastal Inundation Exposure

5 Problem 2 – Vulnerability of assets

The design and condition of existing assets means that the network is more vulnerable to damage leading to more disruptions from natural hazard events.

5.1 Asset design

The New Zealand rail network consists of approximately 3,700km of track with a narrow-gauge of 1,068 mm. This narrow gauge was chosen because of the difficult New Zealand topography. New Zealand's difficult terrain also means that the network consists of many bridges (1,408), tunnels (150) and culverts (12,000) that ran across, around, over, and through swamps, wetlands, mountains, forests, streams and rivers.

Due to adverse terrain, a portion of the network is vulnerable to climate change due to the location of infrastructure, either along the coast (vulnerable to sea level rise), through mountains/slopes (vulnerable to slips), bridges and tunnels (vulnerable to seismic events). The assets themselves can exacerbate the hazard – for example, the culverts were not sized to cater for the scale of recent rain events.

5.2 Asset condition

5.2.1 Structures

Currently, the average bridge structure age in New Zealand is 80 years old, with an average of 500 bridge structures (bridges and footings) currently 100 years old, or older. Older bridges may suffer from corrosion, spalling, welding problems, cracks, and corrugations, defects that can occur over time and result in worn out assets. Many older bridges have significant timber components, which are susceptible to rot and toredo worm, as well as timber becoming less available for repair works. Newer assets are often built to modern standards and can be capable of withstanding greater hazards (for example larger earthquakes) for longer. This means that there is a significant gap in the level of service between new and older (existing) assets.

To better understand the bridge condition on rail assets KiwiRail have undertaken a structural health index assessment. This assessment considers condition, strength, fatigue, foundation, seismic, scour and knowledge gaps. Each factor is given a risk rating which is tallied to provide an overall health index. The index then indicates the level of service for each structure using four zones. Structural health index assessments were undertaken for six periods. **The data used is not mature, so needs to be used with caution.**

The assessment shows that 50% of structures are currently within market tolerated or better zone and is expected to grow to 60% within 6 years. Figure 13 clearly shows structural deterioration over the short analysis period – indicating structure could be reaching remaining useful life.

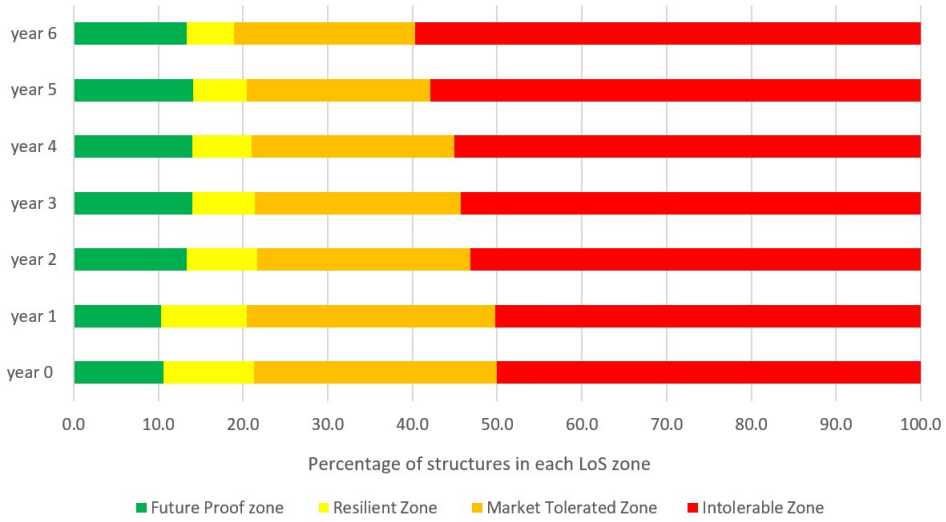


Figure 13: Percentage structural deterioration – structure health index[45]

5.2.2 Culverts

Culverts form an important part of drainage systems which can be strained during times of flood. These structures also require annual maintenance, rehabilitation and renewals. Similar bridges could also suffer from failure once remaining useful life has been reached, or if bridges are not maintained appropriately. Culverts, however, have an

[45] The available data does not indicate a date, condition assessment year or any information which could be used as a time reference.

added complexity - capacity. In 2014 KiwiRail undertook an assessment of the catchment 100-year ARI peak flow against the discharge capacity for culverts along some sections of the North Island rail network, approximately 1000 culverts were identified, with approximately 400 analysed. The results are shown in Table 4.

Table 4: Number of culverts failing 100-year ARI peak flow capacity (2014 analysis of selected tracks)

Track Location	Chainage	Number of culverts failing
ECMT	5.016 to 62.648	87
MNPL	47.861 to 59.967	90
PNGL	1 to 9.995	53
NIMT	343.637 to 372.725	118
NIMT	541.96 to 567.472	33

The analysis showed that on all rail lines (apart from the NIMT) **roughly 80% of culverts along these lines do not have sufficient capacity to adequately cater for a 100-year storm event**.

Culverts along the NIMT line showed the opposite with only 20% of the culverts unable to accommodate a 100-year storm event[46]. Undersized culverts could also generate impacts further upstream, and the knock-on effects could be damage to other transport assets.

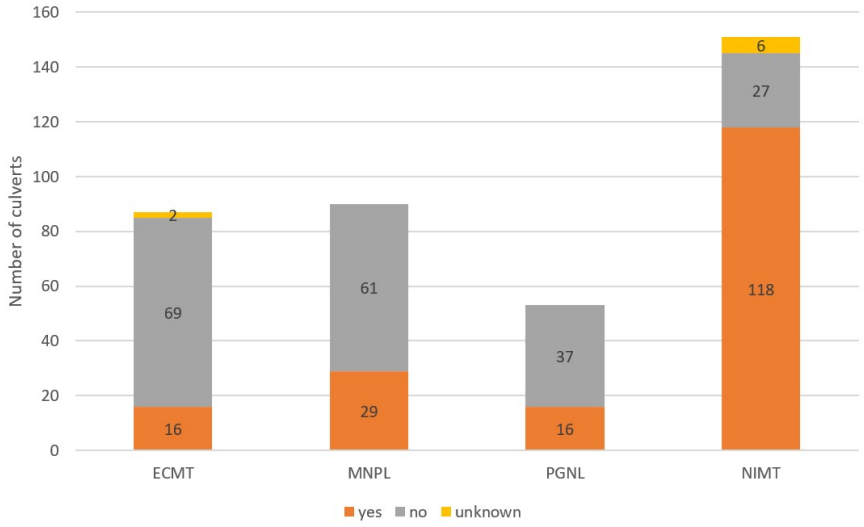


Figure 14: KiwiRail culvert analysis – ability of culverts to hand 100-year ARI storm event

[46] Since this analysis was undertaken, NIWA has released version 4 of the High Intensity Rainfall Design System (HIRDS), which could result in a different number of culverts considered over capacity if the analysis was re-run.

6 Problem 1 & 2 - Consequences

6.1 Higher maintenance costs

The rail network contains many assets, such as signalling hardware, bridges, culverts, and track. Over time, as with any asset, maintenance and ultimately replacement is required (refer to 5.2 for more information). Resources, funding, and time are all important considerations of asset management, and the lack of maintenance increases the risk of assets failing catastrophically and a reduction in expected design life as demonstrated in Figure 15.

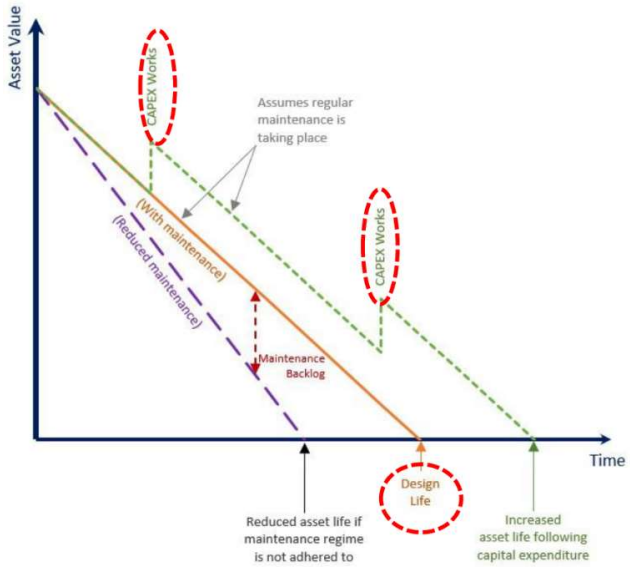


Figure 15: Bridge asset management – value vs time[47]

The graph below shows that land instability and scouring are the two activities consistently requiring maintenance (note bridge maintenance not included). In 2017 there were a high number of maintenance activities undertaken, most of which were related land instability – likely due to the Kaikoura Earthquake[48]. This is consistent with the risk analysis undertaken for the rail network, which shows slope/land stability and flooding as risk areas for resilience.

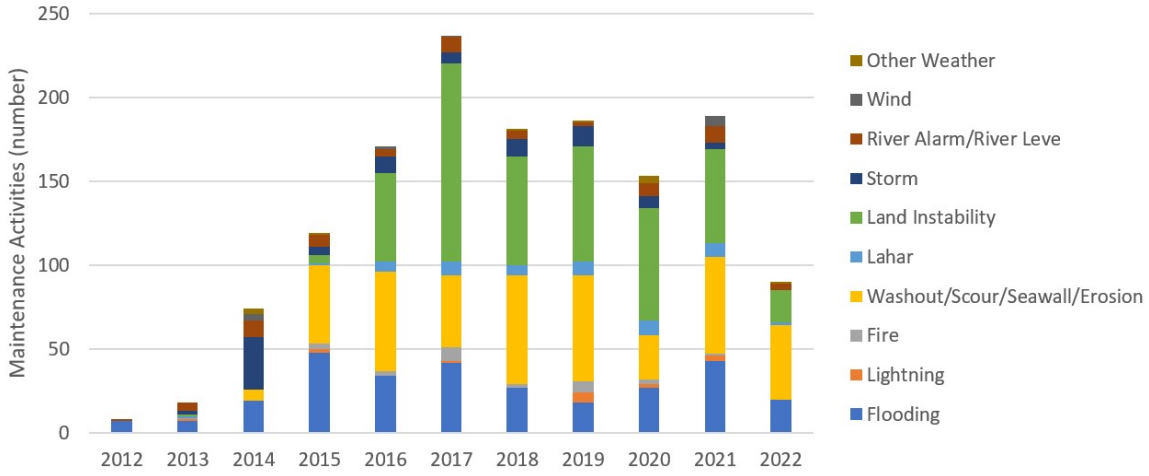


Figure 16: Maintenance costs by year

[47] Source: Liam Coleman Inspection and Policies for Bridge Structures presentation

[48] It should be noted that maxima was not completely rolled out across New Zealand until 2015, affecting the lower return of maintenance figures in 2012-2014.

Figure 17 shows maintenance costs relating to weather events for the network. Scouring (likely related to flooding) and flooding account for almost 50% of the maintenance costs, followed by land instability which has the highest maintenance costs.

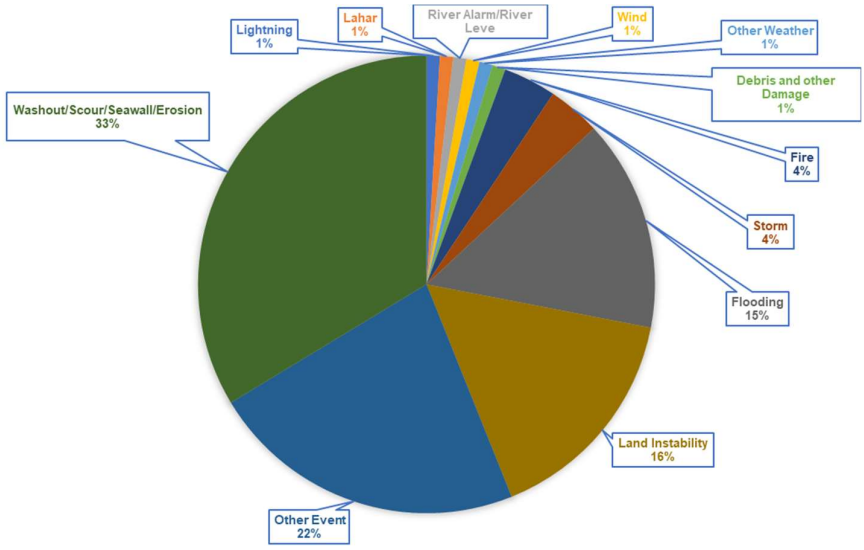
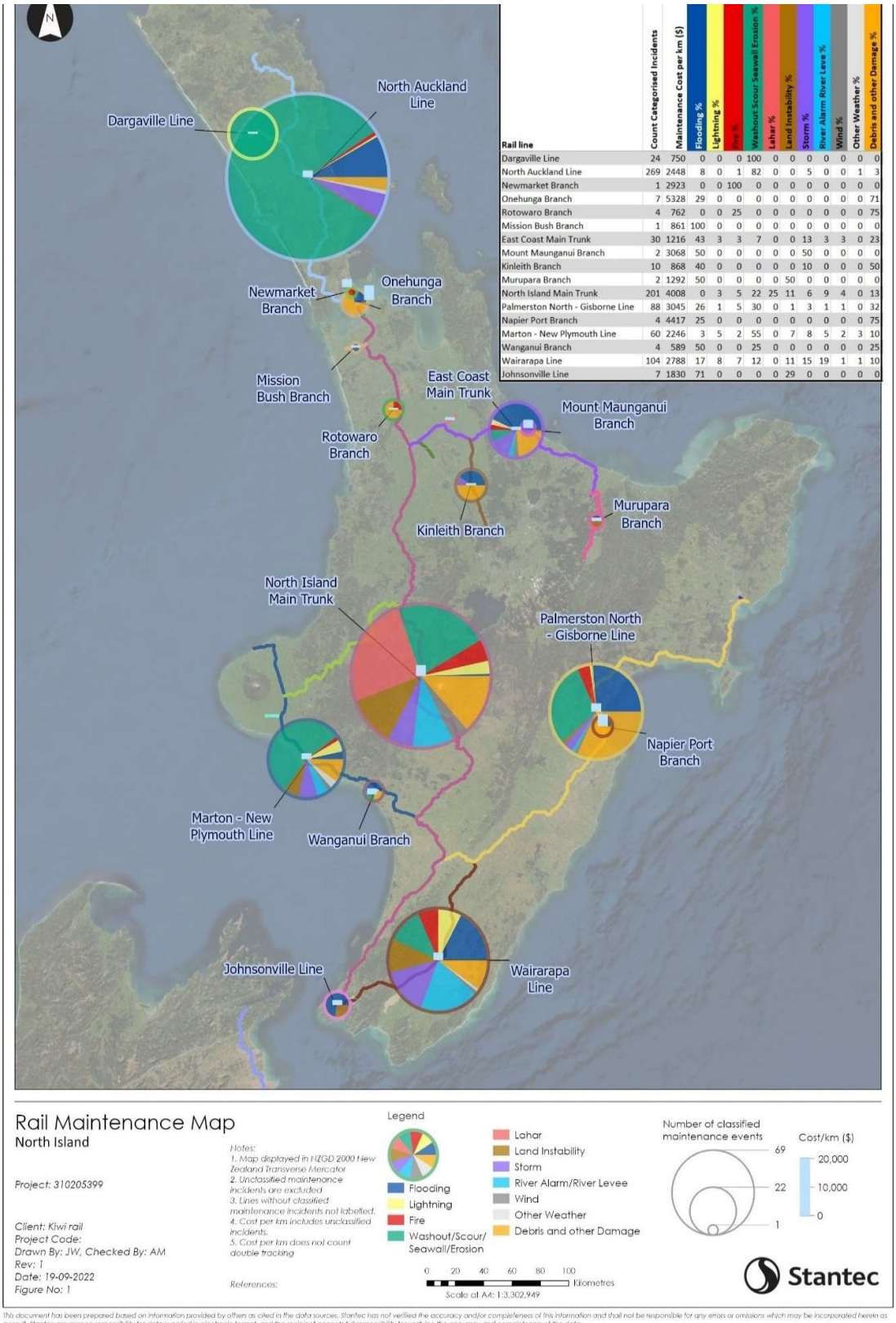


Figure 17: Maintenance costs (percentage)

The New Zealand Rail Plan[49] outlines two strategic priorities for rail, one of which is Investment priorities for a resilient and reliable rail network. By 2052, freight tonnage in New Zealand is expected to increase by more than 40% and a rail network that supports this growth is desirable. However, the national rail network has suffered from under-investment and significant parts of the rail freight network have been facing a state of managed decline. KiwiRail states that over the next decade there will be a need to invest in restoring a resilient and reliable rail network. This will provide a platform for further investment to support growth in rail freight.

An assessment of the number of maintenance incidents per line, and associated cost per kilometre, relating to resilience events (flooding, lightning, fire, washout/scour/seawall erosion, lahar, land instability, storm, river alarm/river levee, wind, other weather, debris and other damage) has been undertaken - refer to Figure 18 and Figure 19. The assessment identifies that some of the lines in the South Island, such as the Midland Line and Main South Line, have had a much higher cost per kilometre rate than in the North Island.

[49] The New Zealand Rail Plan, April 2021



Rail line	Count Categorised Incidents	Maintenance Cost per km ($)	Flooding %	Lightning %	Fire %	Washout Scour Seawall Erosion %	Lahar %	Land Instability %	Storm %	River Alarm River Leve %	Wind %	Other Weather %	Debris and other Damage %
Dargaville Line	24	750	0	0	0	100	0	0	0	0	0	0	0
North Auckland Line	269	2448	8	0	1	82	0	0	5	0	0	1	3
Newmarket Branch	1	2923	0	0	100	0	0	0	0	0	0	0	0
Onehunga Branch	7	5328	29	0	0	0	0	0	0	0	0	0	71
Rotowaro Branch	4	762	0	0	25	0	0	0	0	0	0	0	75
Mission Bush Branch	1	861	100	0	0	0	0	0	0	0	0	0	0
East Coast Main Trunk	30	1216	43	3	3	7	0	0	13	3	3	0	23
Mount Maunganui Branch	2	3068	50	0	0	0	0	0	50	0	0	0	0
Kinleith Branch	10	868	40	0	0	0	0	0	10	0	0	0	50
Murupara Branch	2	1292	50	0	0	0	0	50	0	0	0	0	0
North Island Main Trunk	201	4008	0	3	5	22	25	11	6	9	4	0	13
Palmerston North - Gisborne Line	88	3045	26	1	5	30	0	1	3	1	1	0	32
Napier Port Branch	4	4417	25	0	0	0	0	0	0	0	0	0	75
Marton - New Plymouth Line	60	2246	3	5	2	55	0	7	8	5	2	3	10
Wanganui Branch	4	589	50	0	0	25	0	0	0	0	0	0	25
Wairarapa Line	104	2788	17	8	7	12	0	11	15	19	1	1	10
Johnsonville Line	7	1830	71	0	0	0	0	29	0	0	0	0	0

Figure 18: North Island - resilience incident maintenance costs and number of events (2014 – 2022)

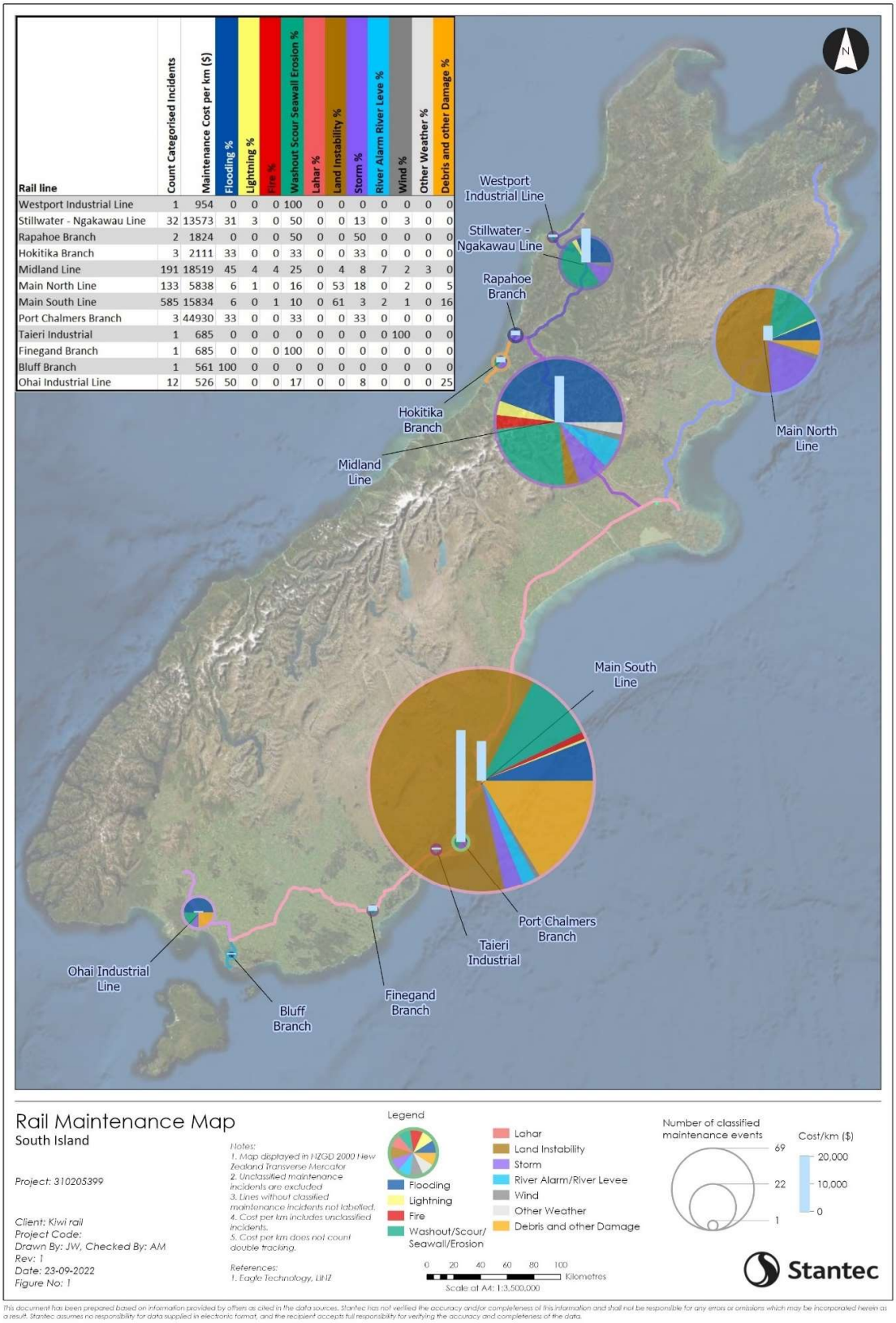


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Figure 19: South Island - resilience incident maintenance costs and number of events (2014 – 2022)

6.2 More reliance on the roading network

When train operations are disrupted, there can be significant impact on the remainder of the transport system. This is evidenced by two key events that occurred in Wellington – the 20 June 2013 storm, when a major washout closed the Hutt Line for several days, and the derailment of a freight train on the evening of 2 July 2019. In both cases, the loss of rail led to major congestion across much of the road network.

Surveys conducted in the wake of the June 2013 storm event highlighted the drastic change in commuter patterns (Figure 20)The associated report noted that there were large changes to commute times, with 57% of respondents leaving for work earlier than usual. Only 9% delayed their travel with the remainder leaving at the normal time. Of those who left earlier than normal, nearly two-thirds of respondents, experienced delays of 30 minutes or more. Some workers chose not to attempt to travel to work resulting in lost productivity.

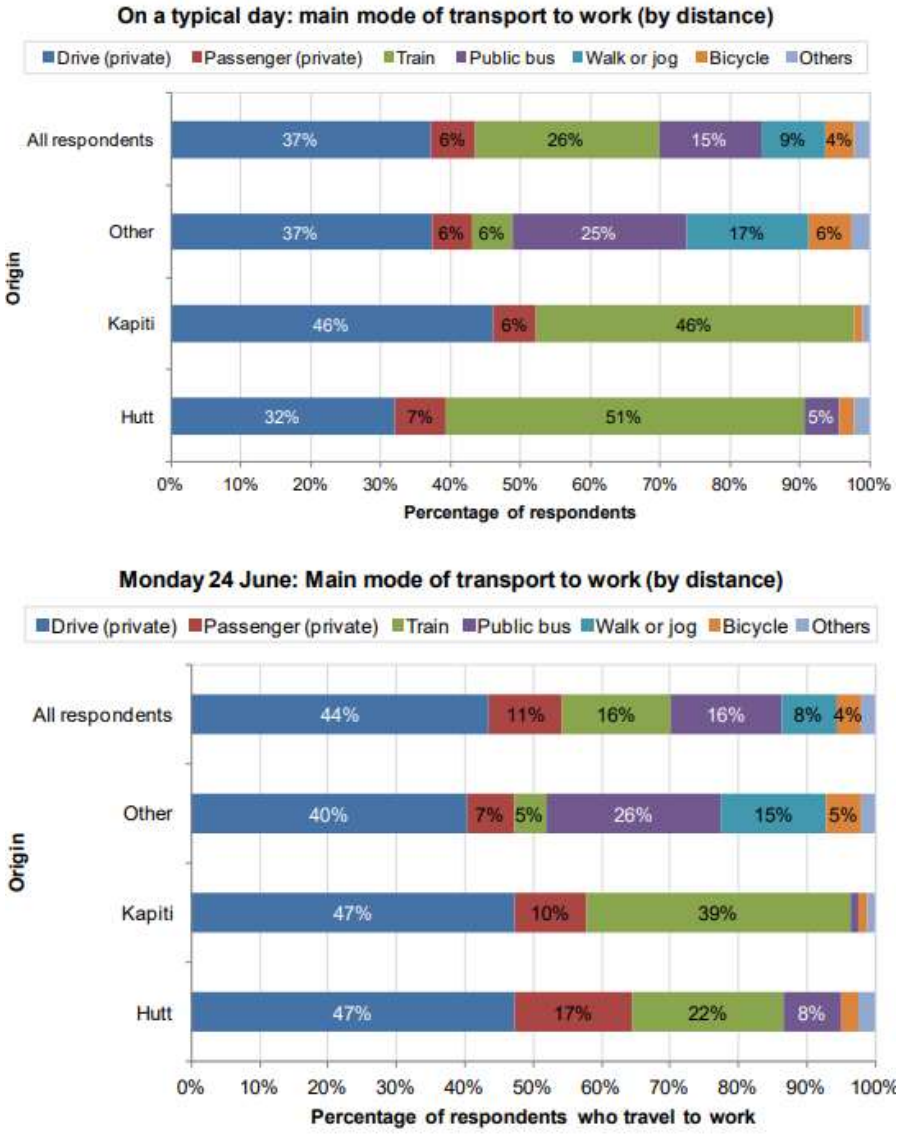


Figure 20: Main mode of transport to work (by distance) - typical day and Monday 24 June

The closure of the Hutt Valley Line put significant pressure on all parts of the roading network, with large traffic volumes clogging the state highways, all major arterial roads, and the Wellington CBD. The MoT subsequently estimated that there was a significant increase in average travel times during the morning peak, by between 14 and 20 minutes in the week that followed. These travel time estimates were used to determine the added cost of

congestion of the four-day outage showing a cost in the order of $2.66M in lost time in the morning peak alone, suggesting that the daily cost of the outage was around $1.33M per day[50].

The impact of the July 2019 freight train derailment is clear when evaluating the traffic volumes on the state highway, presented in Table 5. The effect of train cancelations on traffic volumes is shown by rising above normal at 5am and remaining higher than normal until 11am. The road remained at capacity for a significantly longer period than normal.

Table 5: Traffic volumes on SH2 before, during and after train cancelations

Hour of:	05:00 - 06:00	06:00 - 07:00	07:00 - 08:00	08:00 - 09:00	09:00 - 10:00	10:00 - 11:00	11:00 - 12:00
Average Week before	678	2396	2496	2322	1750	1368	1350
July 3 2019	797	2420	2581	2234	2311	1584	1380
Average Week after	662	2352	2493	2159	1693	1474	1436

The story of the road network being unable to cope with the additional traffic after the freight train derailment is also replicated in the expected travel times. TomTom travel times between the Mungavin Interchange and the intersection of Vivian and Willis Streets via SH1 showed that the median expected travel time was equal to or higher than the normal 95th percentile expected travel time. The 95th percentile expected travel time was significantly higher, nearly reaching two hours at one point compared to the 50 minutes, which is the typical 95th percentile travel time. A comparison of the expected travel times is shown in Figure 21.

Figure 21: Expected travel times from Porirua to Wellington with and without rail services

Both events show the importance of the rail contribution to the effective operation of the transport system. The impact may now be less pronounced due to the increased ability for people to work from home, but it remains substantial as recent rail disruption events show. The remainder of the transport system also needs to pick up the freight task.

It is noted that with the change in attitude to people working from home because of the COVID-19 pandemic the split between employees working from home or switching to person vehicle travel is unclear. The increasing acceptance of working from home could result in a minimised impact to the road network when rail services are disrupted.

6.3 Delays

The data available for Wellington shows an array of reasons delays occur. The data shows that on average delays resulting from natural events such as earthquakes last for over an hour. The data also shows that if a line is disrupted and a bus replacement service is called into action it delays commuters by an average of 30 minutes. These bus replacements could be the result of natural events such as slips or flood, which is common along the

[50] In contrast, the Wellington rail system cost an average of $222,000 per day to operate in 2013, suggesting that the value of the Wellington rail system to the region and country is high.

Wellington line. These delays are typically unplanned and creates the perception that commuting by rail is unreliable which leads to a recession in mode-shift. Figure 22 shows the delays by event type on the Wellington metro rail network between May 2018 and May 2019.

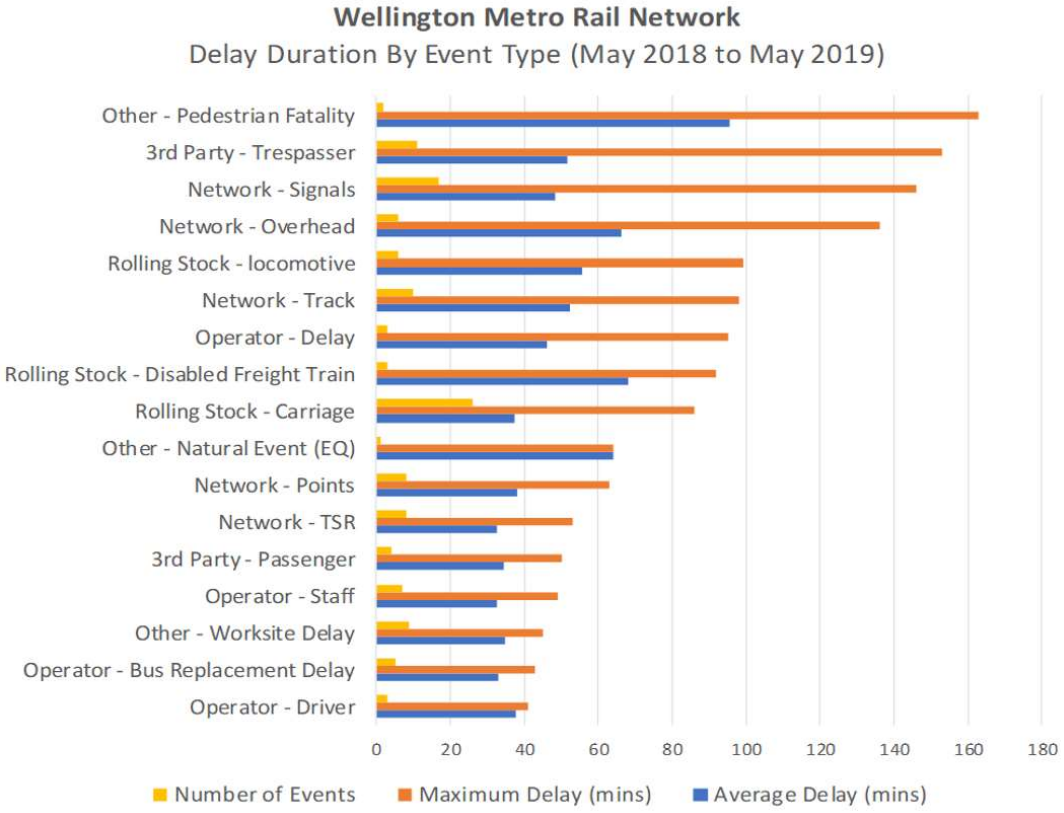


Figure 22: Top monthly delays by event type[51]

6.4 Frequency of line closures

Delay data across the rail network is not available for all lines in New Zealand. However, specific line data is available for the Midland Line in the South Island and the Wellington line in the North Island. Figure 23 provides a graph that shows the disruption of services (hours) on the Midland Line from natural events in 2019.

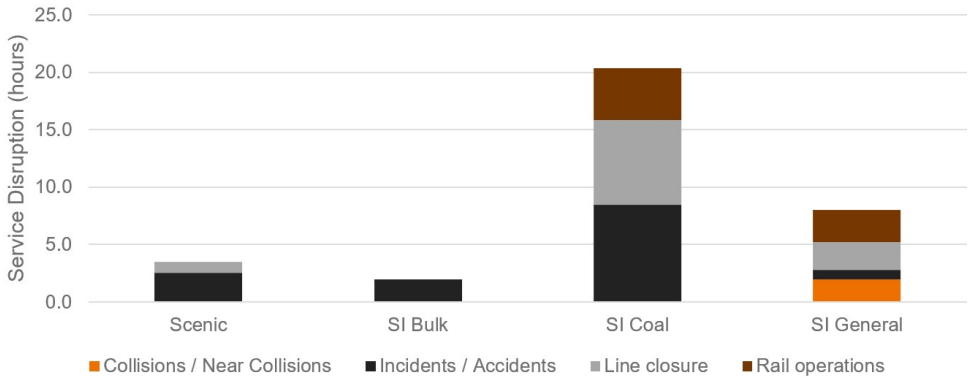


Figure 23: Disruption of services (hours) on the Midland Line from natural events in 2019

[51] Source: Transdev Monthly Reports

The Midland line data indicates that weather events and trackside fire caused 34 hours of delay in 2019[52]. South Island Coal movements were the most effected, with over 20 hours of delay incurred.

6.5 Failure to meet national resilience expectations for rail

In 2014 the National Infrastructure Unit assessed the resilience of the rail network from a national perspective, across three areas of the rail network; suburban (including rolling stock), national (including rolling stock), and the national train control centre. See below:

Table 6: National rail resilience expectations and assessment (National Infrastructure Unit, 2014)

Transport	Resilience Expectations	Assessed Resilience	Desired Movement
Rail			
Suburban (incl rolling stock)			↑
National (incl rolling stock)			↑
National Train Control Centre			↑

National Train Control Centre

The following explanation was provided by the NIU on the ratings.

> *"In rail, the low rating for the National Train Control Centre reflects the fact there is only one for the country. An example of the risk this poses is the case of an electricity outage in Wellington stopping rail services in Auckland, as happened recently. The medium ratings shown in both suburban and national rail is reflective of the lack of investment over recent years, and the "catch up" mode we are currently in"[53].*

To address this issue, KiwiRail invested in the recently opened new Railway Traffic Control Centre, which allows real-time monitoring of nearly all of New Zealand's track and train issues. The new control centre in Upper Hutt watches over every railway track from Invercargill to Whangārei, bar the Auckland commuter network which has its own separate centre[54].

6.6 Negatively impact emissions targets

KiwiRail plays a critical role in New Zealand's transport system and its environmental ambitions. Rail has a natural advantage as an energy-efficient and low-carbon mode of transport, with every tonne of freight moved by rail producing 70% fewer carbon emissions compared with heavy road freight over the same distance. In May 2022 the Ministry for the Environment released the Emissions Reduction Plan in which it sets out emission reduction targets (refer to **Error! Reference source not found.** below) for transport by 2035.

The increased risk of disruption to the network because of natural disaster events will impact the reliability of rail and therefore impact mode shift, as people and freight operators bridge the gap of an unreliable rail service, make the MoT targets harder to achieve. Freight movements may also be negatively impacted by increased frequency of disruptions.

[52] There was a significant downturn in line closures in 2020 and 2021. It is unclear whether this was, at least in part, due to the COVID-19 pandemic and associated lockdown responses. 2019 has therefore been presented as the most recent complete year that was unaffected by COVID-19. Line cancellations over the 2019-2021 period were more stable. With 120 occurring in 2019, 102 in 2020, and 121 in 2021.

[53] Evidence Base: Resilience - National Infrastructure Unit (treasury.govt.nz)

[54] https://www.stuff.co.nz/national/wellington/132076511/kiwirails-new-national-railway-nerve-centre-opens

7 Problem 3 – Response time

Difficulty in accessing parts of the network following natural hazard events results in long recovery times, which further increases service delays.

7.1 Cause

7.1.1 Network remoteness

Throughout New Zealand railway lines and roads are often located adjacent or nearby each other. However, this is not the case everywhere. There are significant sections of rail where there are no state highways or local roads located nearby a rail line, as shown in Figure 24 and Figure 25.

The cause of this is the need for rail to generally connect places located farther apart than road (which by contrast served individual properties). The rail network generally has followed flatter more level ground and has in many places deviated away from towns and cities, and other infrastructure, passing through mountains and higher exposure areas.

Analysis of the rail network along with the road network, the data indicates that just over three quarters of the rail network is within 500m of a road, but that there is nearly 70km of track that is 3km or more away from the nearest road (refer Table 8 below).

Table 7: Distance and proportion of rail network from nearest road

Distance to nearest road	%	Distance (km)
< 500m	77.4%	2966
500m to 1500m	16.2%	621
1500m to 3000m	4.7%	179
3000m to 6000m	1.3%	48
> 6000	0.5%	19

Some of the remote areas of track also overlap with areas where there are natural hazards present, or far from population centres where there may be a more ready supply of resources and materials to reinstate the line following a resilience event. However, the distance measurement is somewhat indicative, as some sections remain accessible by hi-rail (in sections within tunnels and viaducts).

Another issue is that the introduction of hirail vehicles has lead to a dependency on them for access with a lot of historic access agreements and access tracks not as well Protected. This can make movement by rail the only option for access.

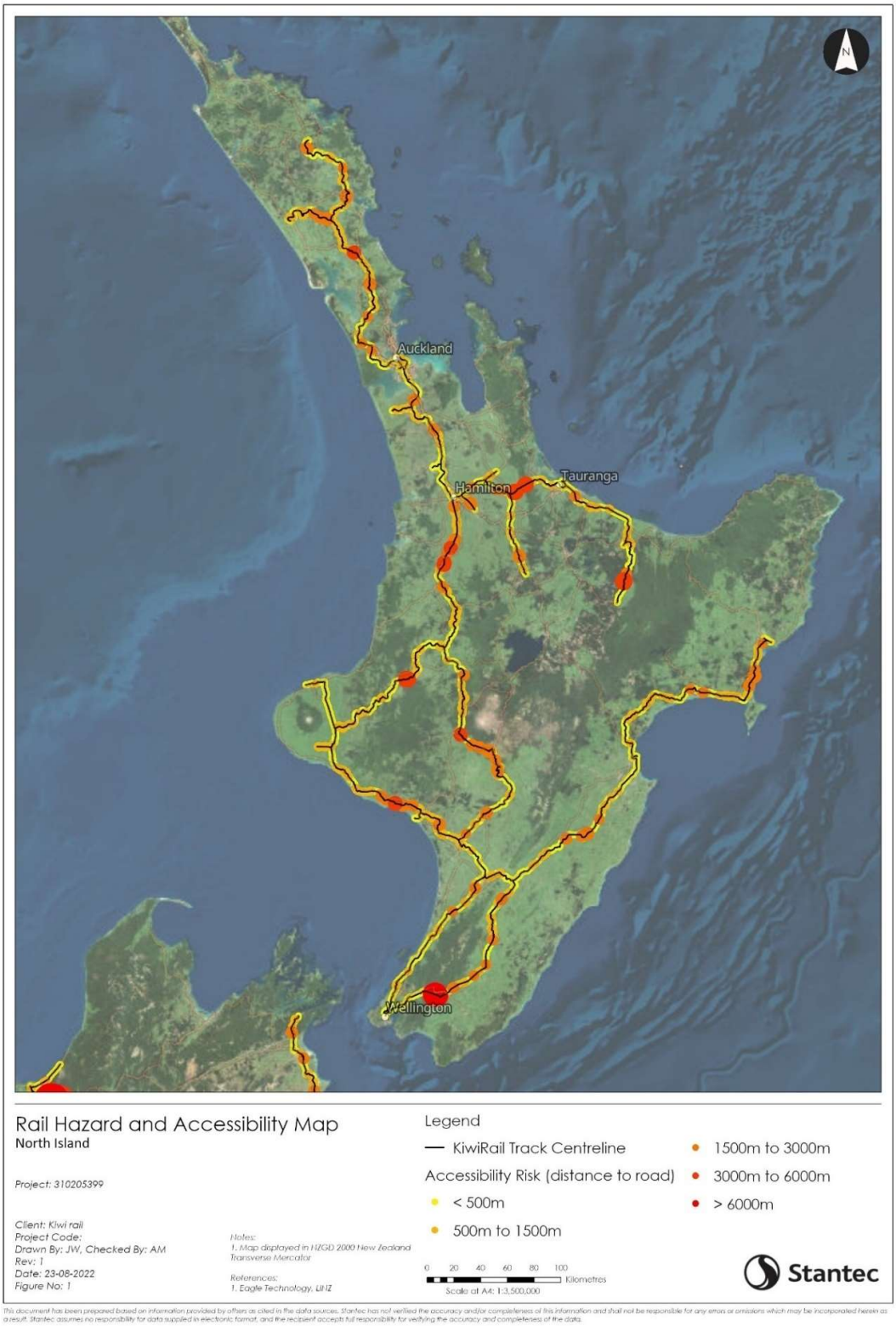


Figure 24: Rail hazard and accessibility map – North Island

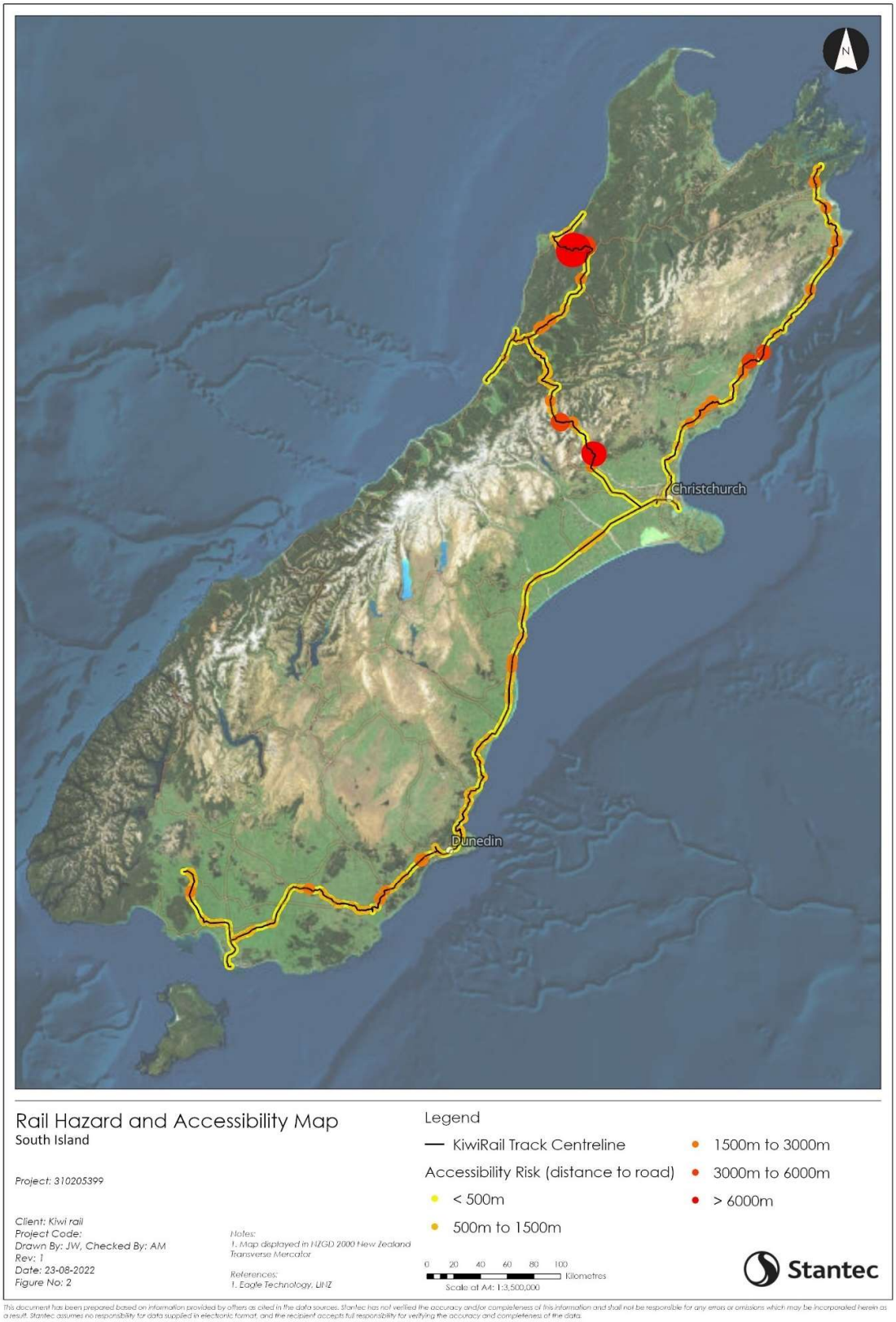


Figure 25: Rail hazard and accessibility map – South Island

7.1.2 Lack of alternate routes and modes

There are very few alternative rail routes in New Zealand. Most cities and towns tend to have one railway line. There are some exceptions to this; the Wairarapa Line, the mothballed Stratford Okahukura Line, the North Auckland Line (Westfield-Newmarket section), and the City Rail Link (under construction). The last two are relatively short lines within Auckland. There are no alternate routes available in the South Island. This means, effectively, there is only one major line (the Wairarapa Line) that provides a long-distance alternate route to the North Island Main Trunk (NIMT)[55].

Most of the rail network is single tracked, with some exceptions in the main centres (Auckland, Wellington, and Christchurch), and between Auckland and Hamilton. Double tracking provides additional flexibility to either protect some movements after a resilience event, or to be able to supply the event site with equipment and materials as required. There are current projects to double track parts of the existing network close to main centres, similar to for example, the Trentham to Upper Hutt section completed in 2021[56].

Rail lines vary in terms of the ability for whatever is being moved to be reassigned onto another mode. For example, buses, bicycles, and private cars can carry passengers to and from their destination in the event a commuter rail service cannot. However, for others, in particular an export coal route, the alternatives are much more limited.

The following is a classification table that is used to feed into the criticality assessment for rail lines. It shows that while there is no rail freight that cannot be moved by any other mode, export coal is limited. The Midland Route is the prime example of an export coal route in New Zealand.

Table 8: Criticality assessment of the ability for rail freight to be transported by other modes

Classification	Score	The section…	Example(s)
None	2	Carries rail freight that could not be conveyed by any other mode (if rail was not available). This is an extremely high test, because there is almost always another possible mode that could be used for moving freight	• None identified
Limited	1	Carries rail freight that would be logistically difficult for another mode to handle, especially without new investment in vehicles and infrastructure	• Export coal route
Good	0	Carries rail freight that could readily be handled by another mode (or be transferred to another port), albeit with some new investment in vehicles (and maybe infrastructure), or the section is currently unused (meaning that another mode is already handling freight in that area)	• The remainder of the network
n/a	0	Is intended to carry passengers only, or the track has been lifted	• Manukau Branch • Melling Branch • Johnsonville Line • Kimihia Branch

In terms of public transport there are some sections of the network that have more redundancy in terms of alternate bus options than others. An assessment of available bus alternatives in the Wellington Metro area indicates the top 6 lines without good bus alternatives as being:

- Thorndon (Distant Junction) to Tawa
- Wellington to Johnsonville
- Porirua to Plimmerton
- Plimmerton Station
- Featherston to Waingawa (including sidings)
- Masterton Station

7.1.3 Size and scale of event

The ability to recover is also related to the size and scale of resilience events. For example, a large, wide scale, event is more likely to require significant equipment and labour to remedy compared to small, localised events. Please refer to Table 9 for discussion on response options and typical corresponding resilience events.

[55] The WRAPA only offers an alternative for a relatively short section of the NIMT, and it will do so when in conjunction with the PNGL.

[56] www.kiwirail.co.nz/our-network/our-regions/wellington/hutt-valley-line/double-tracking-trentham-to-upper-hutt/

7.2 Consequences

7.2.1 Constrained options

Given the remoteness of much of the network, there are limited ways of responding to events.

Table 9 outlines access options when a resilience event occurs in a remote area of the rail network.

Table 9: Resilience event response options

Access mode to remote resilience event site	Advantages	Disadvantages	Resilience event
Rail	Direct access to outage. No reliance on other modes.	• May be limited space to unload – may be limited to double tracked areas. • May be limited ability to move some kinds of equipment or materials, such as large cranes.	• Typically, small to medium sized events. • Potentially events located in the main centres, or the Auckland to Hamilton line, where double track is present.
Temporary road	Once constructed allows for fast movement of many kinds of equipment and materials for reinstatement	• Can be expensive, and time consuming.	• Typically larger, more significant events, such as large slip or washout.
Access by foot	Potentially cheap.	• Minimal equipment and materials can be transported. Option unlikely to be used in lieu of access via rail. • Terrain and distance may be challenging to negotiate.	• Useful for inspection purposes after an event. However, any works would likely require machinery.
Access by air	Immediate.	• Costly, cannot bring in heavy equipment.	• Likely only be economically justifiable during large events. Helicopter inspections are a quick way to assess damage in an event. • Drone could potentially be used.
Access by sea	Potentially large amount of equipment and material could be moved to the event site.	• Accessibility likely constrained by available port facilities. • Expensive. • Much of the rail network is located inland away from the sea.	• Likely only be economically justifiable during large events, near the ocean with accessible ports.
Access by river	Access to inland locations that are not accessible by road.	• Accessibility likely constrained by available access points. • Limitation to how much equipment can be carried.	• Events where road accessibility is poor
Existing road	Cheap, fast, and versatile.	Not all sections of rail have easy access via road and developing new roads can be expensive.	All events

If access cannot be successfully undertaken via rail to a resilience event site, then the options become either limited in terms ability to shift equipment and resources (access by foot or air), or costly (construction of a temporary road).

7.2.2 Alternate routes impact

The consequence of not having many alternate routes was highlighted following the Kaikoura earthquake. There were no 'work around' alternatives to recovery. The recovery therefore consisted of working quickly to reinstate the line, and rely on alternative modes (trucks, air, coast shipping) to temporarily move all the required freight.

Before the earthquake, in 2016, there was 1 million tonnes of freight moved per year (2,740 tonnes on average per day)[57]. Following the earthquake the alternate road route carried twice as many vehicles, and three times as many heavy vehicles. Following the reinstatement of the rail line (prior to State Highway 1 being reinstated), there was a reduction of 2,000 freight vehicles per month from the alternate route (increasing to 4,000 at full capacity).

[57] https://www.stuff.co.nz/national/107130276/kaikura-road-and-rail-rebuild-up-against-fantastic-feats-of-engineering

This shows that the lack of an alternative route had a consequence of reassigning 2,000 to 4,000 extra heavy vehicles on the state highway network per month. There are cost implications for this in terms of safety, carbon emissions, road maintenance, and driver delays.

7.2.3 Alternate modes impact

Previously highlighted were the six lines in the Wellington Metro area with the worst bus alternatives rating. These six lines are revisited here to identify their relative importance. All the lines have the potential to cause either extreme or high reputation damage to Metro – likely due in part to there being limited transport alternatives. Distant Junction to Tawa, Porirua to Plimmerton, and Plimmerton Station are all identified as providing major congestion relief. It follows, therefore, that the temporary closure of these lines also results in a major congestion impact – refer to Table 10.

Table 10: Worst six Wellington Metro lines for bus alternatives, with associated impacts[58]

Rail line	Provides congestion relief	Potential damage to Metro reputation	AM Peak hour boardings indicator (estimated) (range)
Distant Junction to Tawa	Major	Extreme	145-213
Wellington to Johnsonville	Medium	High	35-245
Porirua to Plimmerton	Major	Extreme	198-236
Plimmerton Station	Major	High	198
Featherston to Waingawa (including sidings)	Medium / Minor	High	10-90
Masterton Station	Medium / Minor	High	180

[58] From the Network Criticality Assessment

8 Risk assessment

8.1 Overview

A risk assessment of the rail network was a crucial step in identifying, analysing, and evaluating potential risks and hazards that may affect an organisation's operations, assets, and stakeholders. The purpose of the risk assessment was to understand **the likelihood and impact of risks and establish the vulnerabilities of KiwiRail's network**.

The information was then used to help develop and prioritise measures to prevent or minimize the impact of adverse events. The assets that were considered in this assessment were:

- Rail line[59]: operational and proposed.
- Tunnels: all operational.
- Bridges: rail bridges only, owned by KiwiRail, regular and occasional.
- Signaling: active.

The natural hazards that were used in this assessment were:

- **Flooding**: coastal, river, surface water
- **Erosion**: coastal and river
- **Geohazards**: earthquakes, liquefaction susceptibility, slips.
- **Temperature**: extreme heat, drought, mean annual temperature increases and fire risk
- **Storms and wind**: extreme wind.

The full risk assessment process (method and results) can be found in two memos dated 24 September 2022 and 10 February 2023 titled KiwiRail PBC Resilience Assessment Method Statement (v.2) and Resilience summary Results Memo v3 respectively. These documents are provided in **Appendix B**.

8.2 Assessment methodology

Figure 26 presents the risk framework. This aligns with theISO31000 and KiwiRail's Risk Management approach, while also considering the IPCC's framing of risk from climate change.

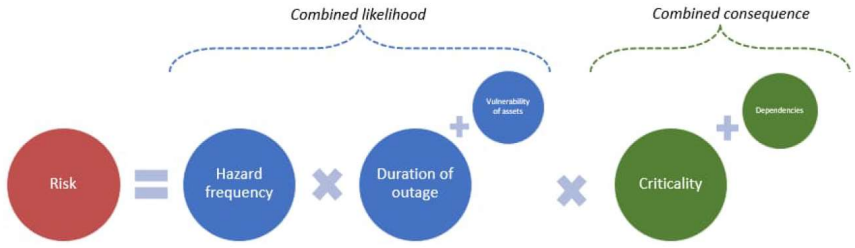


Figure 26: Risk assessment framework

The combined likelihood is calculated by combining hazard frequency (exposure), the duration of outage (indicative of the potential level of damage), and asset vulnerability (which adds further context to potential level of damage). When considering combined consequence, the criticality of each asset is the driving factor, with consideration of areas of dependency. It was agreed with KiwiRail that the duration of outage would be used to define the assets vulnerability due to the lack of availability in vulnerability information across the network.

The criticality rates are presented in Table 11, with the updated risk matrix presented in Table 12.

[59] Assets such as slopes, culverts (river and coastal) were considered as part of the rail line component.

Table 11: Risk assessment – combined consequence rating criteria

Rating	Criticality descriptor
1	Highest quartile
2	Second-highest quartile
3	Third-highest quartile
4	Lowest quartile
5	No regular traffic

Dependency adjustment*	Reason
-1	Double line or extensive loops present, ease of access for recovery.
0	Limited dependence or limited access to area for recovery.
+1	Presence of dependencies and/ or limited access to area for recovery.

* No adjustment to be made below criticality rating 1 or above criticality rating 5

Table 12: Risk assessment – risk matrix

Combined Consequence	Combined Likelihood: UL	L	VL
5	5UL	5L	5VL
4	4UL	4L	4VL
3	3UL	3L	3VL
2	2UL	2L	2VL
1	1UL	1L	1VL

Rating Key
Low
Medium
High
Very High
Extreme

8.3 Establishing the likelihood and consequences

To establish the '**likelihood'** and '**consequence'** of a natural hazard event for each part of KiwiRail's network, six workshops were held across 2022 and 2023 to elicit information from KiwiRail stakeholders (asset engineers, infrastructure and business strategy managers)[60].

The purpose of these workshops was to:

- Identify risks to KiwiRail assets from natural hazards, looking at exposure, duration of outage and ease of access.
- Identify and document whether previous works had occurred at these locations, and what potential measures could be put in place to reduce the risk.

These workshops were targeted at different geographical areas so that a nationwide picture of risk could be developed[61].

After these problem/risk identification workshops were complete, a validation workshop (27 October 2022) was undertaken with the KiwiRail business strategy leads to:

- Validate the identified risks.
- Identify and fill any gaps.
- Prioritise and optioneer.

The outcome was geographically linked problems. These problems by hazard can be further categorised to show themes of risks. For example, this could include undersized culverts for present conditions, that, with climate change will increase in quantum and severity.

[60] Additional engagement was completed in January 2023, to capture risks in the Central North Island, as these were not captured in first six workshops.

[61] Due to the limited availability of KiwiRail staff, additional workshops were carried out to obtain better geographic coverage of risk information. During these workshops problems were identified along the network at varying scales across geographies. It is recognised that not every potential problem area was identified at the most granular scale, however enough spatial coverage was achieved to capture categories of problems/ risks to inform the PBC.

8.4 Risk maps

Figure 27 and Figure 28 provide the line criticality and risk rating maps for the entire KiwiRail network. These maps are also important when it comes to the assessment of the preferred programme against the Investment Objectives, which link directly to the risk assessment.

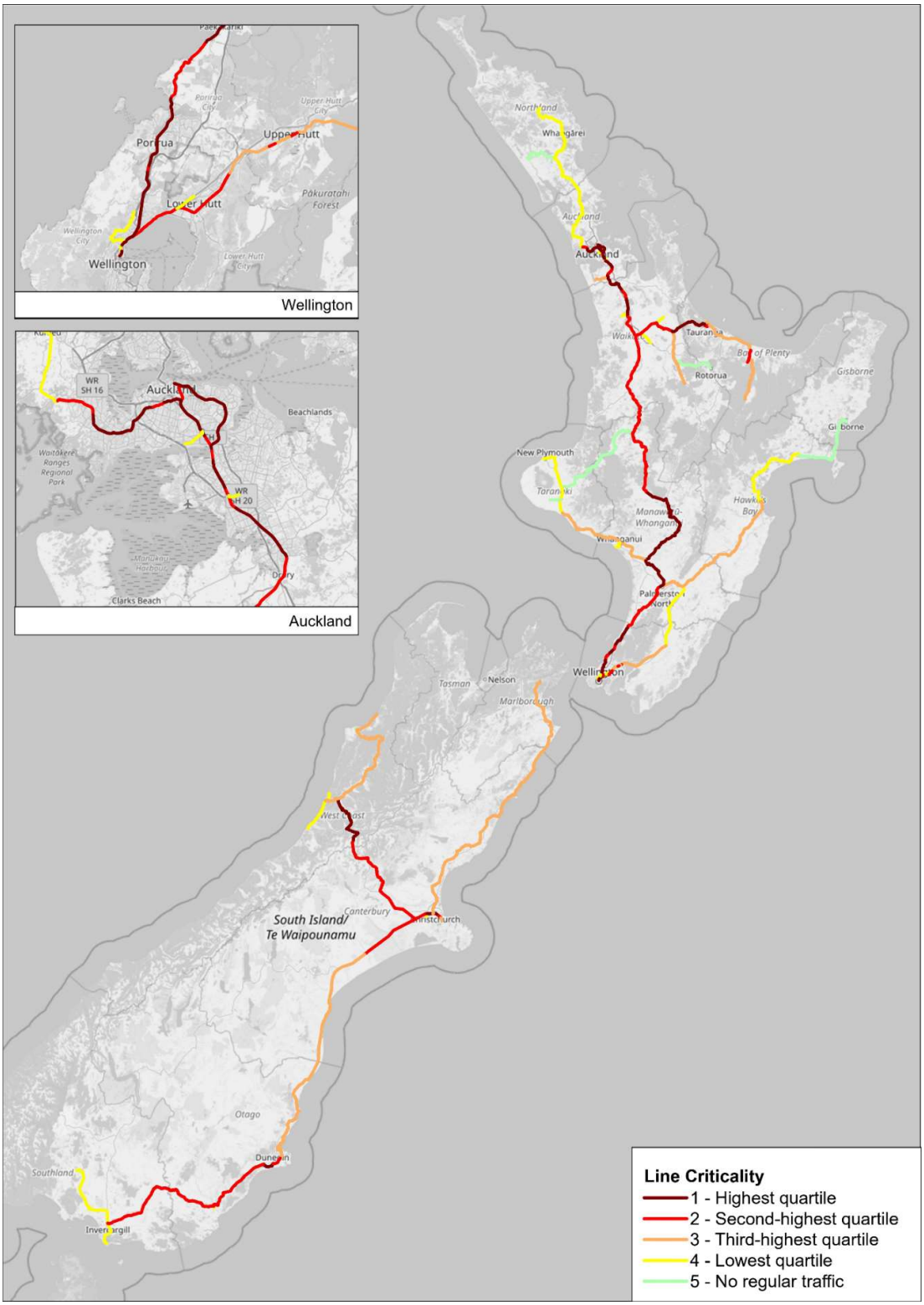


Figure 27: Criticality map

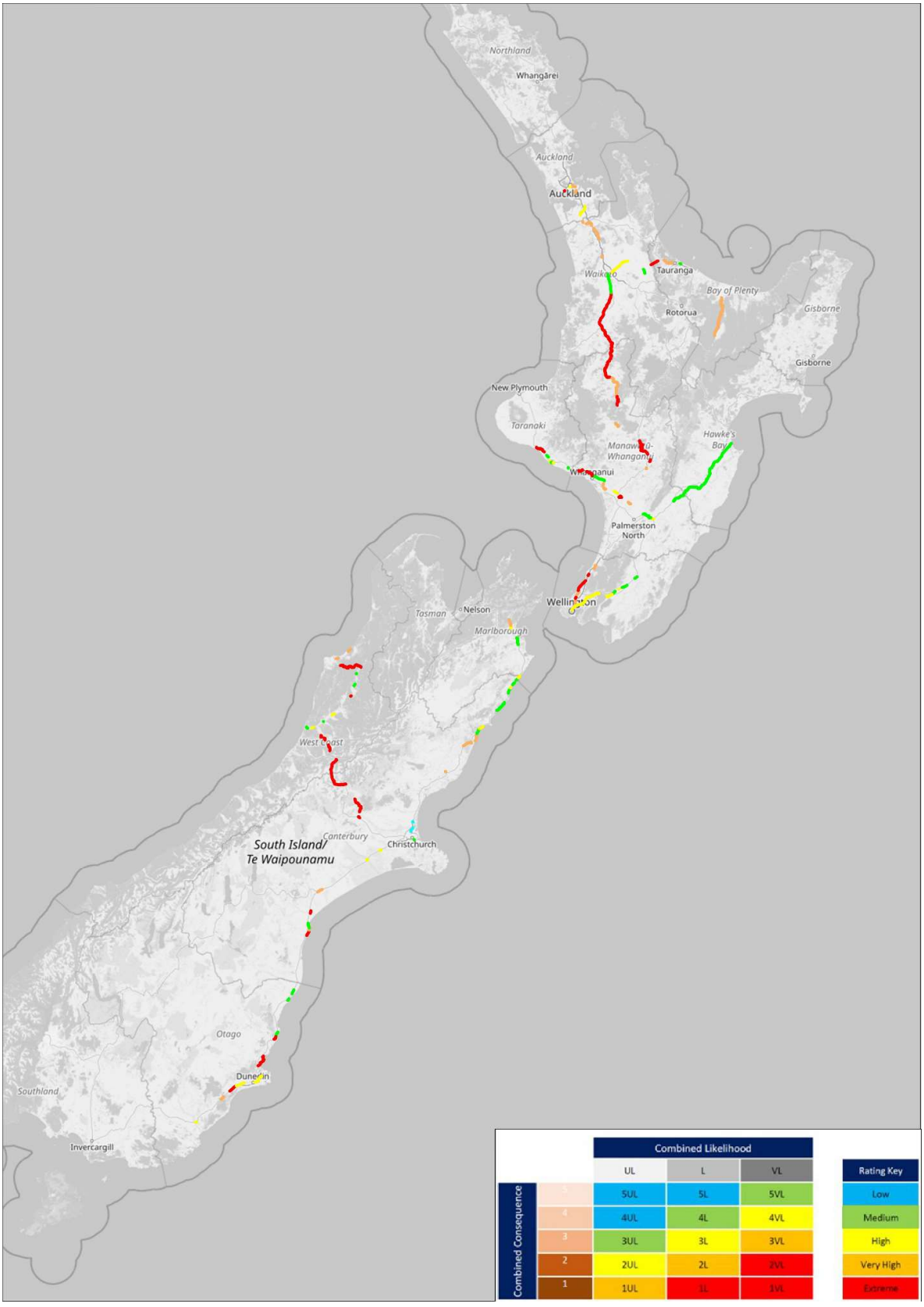


Figure 28: Risk ratings map

8.5 Capturing the uncertainty of major weather events

The start of 2023 highlighted the effect that extreme events can have on New Zealand's transport infrastructure, with repeat extreme weather events affecting the North Island.

Infrastructure has typically been designed for 1 in 100 year events – but the scale of the Auckland weather event in January 2023 was much greater than a 'typical' 1 in 100 year event. The Cyclone Gabrielle event (a few months later) was only just within the margin for a 1 in 100 year event. As such, current systems are not designed in a way to effectively account for exceedance of the given design standard.

The 2023 events have highlighted the importance of considering exceedance events beyond commonly used design events for resilience implementations. These extreme weather events that occur above the events that are currently modelled present two key risks for the network:

- Areas identified as exposed to a given event could experience increased impacts.
    - For example - an area identified to flood to 500mm during the 1% AEP with an allowance for climate change could experience increased flood depths during an exceedance event.
- Areas not identified to flood could experience flooding and wider impacts from extreme weather events.
    - For example - heavy rainfall resulting in flooding of parts of the network that are located way from rivers).

Any areas identified as being exposed to flooding could potentially experience larger impacts than what has been assessed. Management of this can be through ensuring that design standards consider exceedance events.

For the second risk, it is plausible to realise that parts of the network that are not identified as exposed to flooding may flood. This will result both from these larger events, and also where there are gaps in existing flood information in New Zealand. Consideration of this should be made when undertaking redevelopment of lengths of track, and associated assets. For example, locating signalling gear on raised platforms above ground will increase resilience to potential hazards.

When considering this Resilience PBC, interventions have been identified that provide benefit. These interventions should be considered with exceedance in mind, accounting for plausible future events. Beyond this, resilience should be considered on all future upgrades, so far as reasonably practicable.

9 Constraints, dependencies & assumptions

9.1 Constraints

The physical scope of the business case is broad, covering all New Zealand. The constraints, therefore, are too numerous to list specifically. Environmental and social screening typically covers the following technical disciplines (shown below).

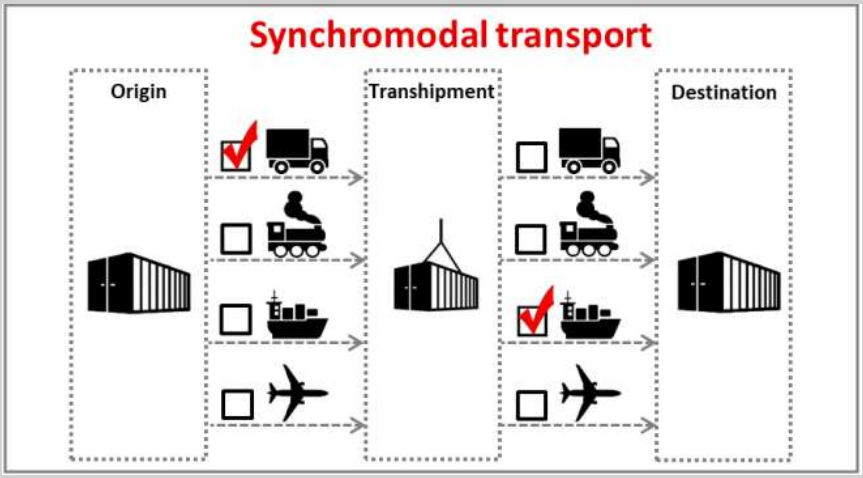
- Air quality and climate
- Biodiversity
- Community and stakeholders
- Consenting and consent compliance
- Cultural and historic heritage
- Noise and vibration
- Resource efficiency
- Stormwater
- Urban design and landscape

As the programmes emerge, leading to a preferred, constraints will become clearer and easier to quantify. Optioneering assessments will likely need to consider the ability for programmes to be delivered within the spectrum of constraints likely to be encountered.

9.2 Inter-dependencies

This section outlines the key inter-dependencies identified that either impact the business case, or the business case potentially could influence.

Table 13: Strategic case inter-dependencies

Inter-dependencies	Notes and management strategies
I1 Transport system network resiliency	The resilience of the rail network is, to a degree, inter-dependent with all other elements of the transport network. For example, if there is a resiliency issue with a port, or section of road, then rail may be required to carry a greater share, and vice versa in a reverse scenario. Research was undertaken by L'Hermitte and Wotherspoon[62] on the interdependency of transport networks when facing resilience events. They outlined the importance of 'synchromodal transport', which means the ability for different modes to be used for different parts of the freight movement process (refer below). 

[62] https://ir.canterbury.ac.nz/bitstream/handle/10092/101412/POSTER%20-%20L-Hermitte_Reseilient%20and%20adaptable%20transport%20across%20modes%20-%20Key%20enablers%20and%20existing%20barriers%20in%20NZ.pdf?sequence=1

9.3 Assumptions

This section outlines the key assumptions that have underpinned the PBC.

Table 14: Strategic Case assumptions

Assumptions	Notes and management strategies
Growth	It is assumed that train movements in New Zealand will (on most routes) continue to grow through demand to shift freight, and passengers.
Wider network elements	It is assumed that other elements that closely relate to the successful network resilience – operational, financial, resources, etc – will be addressed either in parallel or as when required.
Current KiwiRail Projects	It is assumed that current KiwiRail projects will be delivered, and that their outcomes will be congruent with those of this business case. These include, but not limited to: Auckland Rail Metro Programme, Northland rail rejuvenation, Wellington Metro Upgrade Programme (WUMP), NZUP, Regional Rail Hub
Government support during large events	It is assumed that the Government will continue to provide additional emergency support in response to large scale resilience events. For example, akin to the support provided following the Kaikoura Earthquakes. The removal of consenting constraints has also been part of the government's support to recovery works.
Existing services continue	It is assumed that current operations and lines will continue largely unchanged to the current system (current projects accepted).

10 Summary

As demonstrated in Table 14, the available evidence base supports the problem statements, and progressing a programme to address the identified resilience problems and given alignment with the GPS as well as specific rail strategy such as the Rail Plan.

There are clear resilience deficiencies in the rail network caused by the location of the rail network near natural hazards such as unstable slopes, rivers, and coasts. These issues are leading to high maintenance costs, delays, and impacts on other modes such as road. The remoteness of the rail network in some areas also leads to there being limited options when considering recovery options following an event, potentially increasing delays and costs.

Table 15: Case for Change - Summary

Problem / Opportunity	Key Findings
Existing infrastructure is exposed to natural hazard events that can disrupt services for an extended duration	• 320km (8.4%) located within 500m of a known fault line, 6.7km (1.8%) within 50m of the coast. • There are several areas of New Zealand's rail network that are at either high or very high resilience risk • Flooding, and land instability are common resilience risks on the network. • An estimated daily cost of the outage of around $1.33m per day in Wellington when a resilience event closes the line and disrupts train movements. • Midland line data indicates that weather events and trackside fire caused 34 hours of delay in 2019 • South Island coal movements were the most effected on the Midland Line, with over 20 hours of delay incurred. • A 2014 rating of New Zealand's rail network by the National Infrastructure Unit placed rail resilience at below overall expectations.
The design and condition of existing assets means that the network is more vulnerable to damage leading to more disruptions from natural hazard events	• On the ECMT, MNPL and PNGL roughly 80% of culverts do not have sufficient capacity to adequately cater for a 100-year storm event. • The design life of a bridge in New Zealand is 100 years. Currently, the average bridge structure age in New Zealand is 80 years. • Currently 50% of structures are currently within market tolerated or better zone and is expected to grow to 60% within 6 years.
Difficulty in accessing parts of the network following natural hazard events results in long recovery times, which further increases service delays.	• There are limited alternate rail routes in New Zealand. This means when there is a closure for any substantial time then movements must be redirected to another mode. This occurred during the Kaikoura earthquake with freight transported by road/ship. • Some metro rail lines have limited bus alternatives. In Wellington the North Island Main Trunk line weas identified in the criticality assessment as providing major congestion relief (when available) and having an extreme potential damage to metro reputation risk. • Most of the network is single tracked, with the only significant exceptions being in Auckland, Wellington, and Christchurch, and the Auckland to Hamilton line. Single tracked lines constrain options following resilience events.
Opportunities – improve knowledge, beautification, innovation	• There is a clear opportunity to develop and enhance resilience data sets and tools to manage and respond to events and problem areas of the network. • In addressing the identified problems there are opportunities to innovate and beautify where appropriate. • Opportunities to improve the historic situation for upstream land use due to the impacts of undersized culverts.

Further information should be collected regarding the costs and impacts of resilience events, and longer expenditure trends over time. This measure may come through as part of a recommended programme – as part of a Do Minimum.

PART B – ECONOMIC CASE

11 Identifying a preferred programme

11.1 General approach

The process taken for establishing a preferred programme is shown in Figure 29.

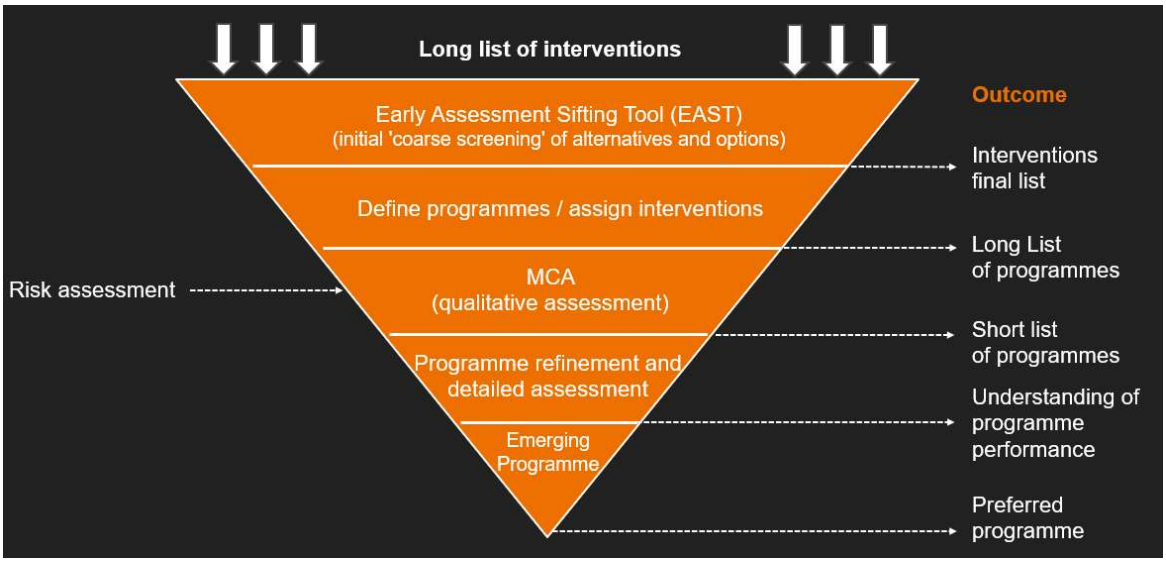


Figure 29: Programme Assessment Process

The key steps are described in detail below:

1. Undertake a **Risk Assessment** of the entire network.
   - Determine the problems that the rail lines are experiencing.
   - Undertake a Risk Assessment for each part of the network. This assessment captured key factors such as hazard frequency, duration of outage the sites, vulnerability of assets, criticality, and dependencies.
   - This process is explained further in the next section of the report.
2. Define the **Do Minimum**.
3. **Identify a long list** of interventions.
   - Targeted solutions that can directly address the various problems identified during the risk assessment.
   - Categorised by intervention type.
4. **Screening** of the long list of interventions.
   - Fatal flaw analysis
   - Assessment against the level of service themes of “improve”, “protect” and “decline” using a 3-point scale.
5. **Define programme themes.**
   - Frame Programmes around the overarching level of service themes of “improve”, “protect” and “decline”, with sub-categories that link to the criticality of various lines.
6. **Assign interventions to programmes.**
   - Use the Investment Objectives, interventions were assigned to each of the identified problem areas. The assessment used previously in the ‘screening’ process informed this.
   - sense check using available evidence (e.g. knowledge of what types of intervention work).
   - Assign more than one intervention if required to reduce the risk level identified in the risk assessment.
   - Assign interventions to a length (proportion) of track.
7. **Assessment of the programmes**.
   - Multi-criteria analysis
   - Indicative cost estimates and economic appraisal of the various programmes
8. **Selection of the preferred programme**
9. Incorporate feedback as appropriate from the KiwiRail project team and decision makers and a wider KiwiRail stakeholder group on the various programmes and emerging preferred programme.

11.2 Approach to MCA

11.2.1 What is Multi Criteria Analysis?

MCA enables a wide range of different aspects to be taken into consideration when evaluating programmes and provides a systematic framework for working through the merits and disadvantages of each option. It is a tool that can help decision making, but it does not make the decision.

Done well, it can provide an open, traceable, and repeatable process. It enables consideration of a range of criteria which are both qualitative and quantitative. These criteria can reflect social, economic, cultural, and environmental characteristics of the project outcomes and effects. It can also enable sensitivity testing to a range of different perspectives to add additional robustness to the option selection process.

11.2.2 Criteria

Table 16 describes each criterion and matters to be considered as part of the evaluation.

The base weightings for each category are:

- Investment Objectives = 50%
- Critical Success Factors = 40%
- Impacts of Te Ao Māori = 10%

The table includes the weightings for each criterion that sit under each category, which were agreed by the KiwiRail project team.

For clarity, the contribution of the 'safety' criteria to the total score would be 8% (40% x 20%).

Table 16: MCA Criteria

Attribute & weighting	Evaluation tools	Weighting
Investment Objectives		
Resilience exposure	• Review of the Resilience Risk maps. • Assessment of how the combination of interventions within the programme support this overall objective. • Captures reduction of outages. • How many interventions within the programme directly address known high-risk resilience risks.	75%
Access (and operations)	• How many interventions within the programme directly address known high-risk accessibility issues.	25%
Critical Success Factors		
Safety	• How safe will the network be after the programme is implemented? • What types of resilience issues (e.g. slips) cause the highest safety risks, and how far does the programme go to address major safety issues?	30%
Technical difficulty	• Ability to construct the intervention without having a big impact on the network (how quickly services can return to normal)	40%
Environmental effects	• Do the works have an adverse effect on the environment? • How well does the program address the effects on ecology, water quality, stormwater, visual effects, archaeology etc.	20%
Consentability	• How many interventions which would bring major consenting challenges? • Can work be done within the current designations?	10%
Impacts on Te Ao Māori		
Impacts on Te Ao Māori	• How does the option impact Te Ao Maori or mana whenua values? • Does the option provide benefit to iwi?	100%

It was agreed that 'cumulative effects of multiple events' would be assessed for the preferred programme only.

11.2.3 Scoring framework

Table 17 provides a framework for how programmes have been scored against the various criteria.

Table 17: Scoring Framework

Magnitude	Definition	Score
Large Positive	Major positive impacts resulting in substantial and long-term improvements or enhancements of the existing environment or presents no difficulties on the basis of the criterion being evaluated.	+3
Moderate Positive	Moderate positive impact, possibly of short-, medium- or long-term duration. Positive outcome may be in terms of new opportunities and outcomes of enhancement or improvement or presents few aspects of difficulties on the basis of the criterion being evaluated.	+2
Slight Positive	Minimal positive impact, possibly only lasting over the short term. May be confined to a limited area, or only presents minor aspects of difficulties on the basis of the criterion being evaluated.	+1
Neutral	Neutral – no discernible or predicted positive or negative impact. The option presents some aspects of difficulties on the basis of the criterion being evaluated.	0
Slight Negative	Minimal negative impact, possibly only lasting over the short term, and definitely able to be managed or mitigated. May be confined to a small area or presents some aspects of reasonable difficulties on the basis of the criterion being evaluated.	-1
Moderate Negative	Moderate negative impact. Impacts may be short, medium or long term and are highly likely to respond to management actions or includes significant difficulties or problems in terms of the criterion being evaluated.	-2
Large Negative	Impacts with serious, long-term and possibly irreversible effect leading to serious damage, degradation or deterioration of the physical, economic, cultural or social environment. Required major rescope of concept, design, location and justification, or requires major commitment to extensive management strategies to mitigate the effect, or results in unacceptable adverse effects that may not be able to be appropriately avoided or mitigated in terms of the criterion being evaluated.	-3

11.2.4 Assessment process

The following approach was taken to scoring the programmes.

- Initial scores undertaken by KiwiRail and project team Specialist Matter Experts (SMEs).
- Collaborative workshop to review the scores.
- Finalisation of the scores.

11.3 Approach to cost estimates

The overall cost estimates for each programme were based on costs for each intervention, based on KiwiRail Civil and Structural teams and T&T inhouse Quantity Surveyor experience with recent costs of construction for typical interventions. The costs:

- Assumed a base date of Quarter 4 2022.
- No allowance for escalation has been made.
- Used typical unit rates, with some estimates adjusted based on any site-specific considerations.
- Followed the Waka Kotahi cost estimation manual (SM014).
- The P50 estimate has been applied a 30% contingency on top of the base estimate.
  - This is typical for a PBC level cost estimate.
- The P95 estimate has assumed a further 30% contingency on top of the P50 estimate.
- Estimates exclude property purchase; service relocation/extension; consents/legal costs; emergency response works or significant enabling costs; and environmental/heritage and cultural requirements.

11.4 Approach to the economics

The economic evaluation provides a high-level assessment of the costs and benefits associated with the preferred programme and aims to inform decision-makers about the economic viability and feasibility of the proposed interventions. The economic evaluation considers both the direct and indirect costs and benefits of the programme, including the initial capital costs of the interventions, ongoing operational and maintenance costs, and the expected benefits in terms of improved safety, reduced service disruptions, and increased network availability and reliability.

The evaluation also considers the broader economic impacts of the programme, such as increased productivity, reduced congestion, and improved access to goods and services.

The economic evaluation was conducted in accordance with best practice standards and will utilise appropriate analytical tools and techniques to ensure that the results are robust and reliable.

Approach to the economics

The general approach to deriving the economic benefit for various programmes was:

- Categorise lines according to criticality (refer to Figure 26).
- For each line, derive its economic benefit based on its overall commercial value – i.e. the value of the commodities which are being transported along the line each year (as defined by KiwiRail).
- Convert this benefit into value of time (VOT). This then provides a proxy for the potential loss of revenue through periods of closure where a line is unavailable.
    - Different lines will have a different VOT based on (a) line criticality; and (b) value of commodities transported.
- Define various resilience events, each of which would have a typical likelihood and duration. This was determined through the risk assessment (refer to the next chapter of the report). For simplicity the categories have been defined as “high”, “medium” and “low” impact events.
- Establish the “Do Nothing” scenario. For this, it has been assumed that each risk eventuates, which then reduces the availability of the rail network for a certain period of time (again established through the risk assessment).
- The “cost” of an event is then calculated by:
    - For each segment of the rail network: Duration of closure x VOT
    - Total cost = the sum for all segments.
        - This essentially provides a minimum commercial value for KiwiRail under restricted conditions.
- Benefits are then accrued through the reduction or removal of closures through various interventions or preventative measures, applied for each programme.
- The monetised benefit is the difference between the “Do Nothing” and various programme (“Do Something”) costs.
- Costs are discounted over 60 years at 4%.

12 Long list

12.1 Long list identification process

During the workshops which informed the risk assessment process, discussion was held around the types of resilience problems that the network is susceptible to. These were broadly categorised as:

- Flooding/track inundation.
- Slips or slope movements.
- Coastal erosion and inundation.
- Wind.
- Heat.
- River scour/Inundation.
- Access requirements.
- Third Party Assets causing risk of flooding or landslips.

A 'long-list' workshop was then held to identify the entire suite of potential interventions that could be applied to address various problems (categorised by issue type).

12.2 Level of Service themes

The three key benefits of investment were identified as being improve reliability, safety and efficiency (economic). Combined, these benefits essentially reflect the Level of Service (LOS) being provided to customers.

For this reason, three overarching potential strategies for investment have been established:

- **Protect** the current level of service.
- **Improve** the current level of service.
- **Decline** the current level of service.

These strategies have been used to help form various programmes of works (described later).

12.3 Do Minimum

The Do Minimum represents the minimum level of expenditure required to maintain a minimum level of service[63].

The Do Minimum programme includes all existing commitments. It assumes some managed decline over time where this does not pose a risk to the safety of rail operation. It is predominantly a 'reactive'/'just in time' programme, with a focus on safety elements while ensuring the continued operation of the railway network.

12.4 Interventions

When considering strategies to improve resilience to natural hazards and climate change impacts, there are numerous interventions that can be implemented. These interventions can range from physical infrastructure improvements, such as raising sea walls or reinforcing structures, to operational changes, such as modifying response protocols or implementing early warning systems.

Workshops were undertaken to discuss the long list of options for the risks or problems identified along the rail corridors. We used the risk assessment outputs to determine the hazards that require addressing. In total, the workshops established 83 different intervention types, which are listed in Table 18.

To prioritize and align our interventions with the Waka Kotahi Resilience Response Framework, the interventions were then categorized into the various LOS themes of "Protect", "Improve", "Decline".

An additional category of "Monitor" has been added for completeness.

[63] https://www.nzta.govt.nz/planning-and-investment/learning-and-resources/business-case-approach-guidance/supporting-guidance-for-the-business-case-approach/business-case-approach-glossary/#D

Table 18: Long list of interventions

No.	Risk type	Intervention	Category
1	Access track location issues	Widening and improving existing tracks where narrow or big machinery is unable to pass without difficulty	Improve
2		Cutting new tracks, either to create better access points from roads or in areas that do not have tracks	Improve
3		• More regular maintenance of tracks • Setup a maintenance schedule • Standardise approach to maintenance	Improve
4		Study to identify key areas for access	Monitor
5		Access to a drone service to establish the location prior to sending machinery, can be used to determine level of machinery required.	Protect
6	Bridge (Flood / Erosion)	Do Nothing	Decline
7		Monitor the bridge piers and abutments	Monitor
8		Planned response	Protect
9		Lift the level to allow capacity increase	Improve
10		Scour protection around piers and abutments, including replacement	Improve
11		Replacement bridge with more resilient structure	Improve
12		Install river training structures – weirs / infrastructure / upstream works	Improve
13		Weirs in the river to push or direct water away from critical infrastructure	Improve
14		Upgrade roading infrastructure to provide an alternative if flooding damages rail	Improve
15		Culvert the (smaller) river/stream crossings to remove piers from the system	Protect
16	Coastal Scour / Inundation	Coastal -Event Response - stockpile rock and monitor	Monitor
17		Coastal Palisade/sea wall/ cast insitu	Improve
18		Coastal Retaining (Iron, Pole or block)	Improve
19		Coastal Rock revetment (Rock or Concrete armour)	Improve
20		Coastal - Lift track or install structures (low bridges/viaducts) to remove inundation potential	Improve
21		Coastal - Realignment away from coastal hazard. Undertake managed retreat inland and reinstating sand dunes and vegetation as retreat occurs to provide resilience	Improve
22		Have consenting in place or wildlife permits to be able to undertake mitigation works	Monitor
23		Coastal TARPS	Monitor
24		Undertake monitoring of coastal retreat (e.g. topographic surveys / flyovers) regularly to determine reaction timeframes.	Monitor
25		Abandonment of the line	Decline
26		Undertake a study of the emerging coastal hazards to identify future requirements	Protect
27		Reinforce the current seawalls using an adapted designs to provide a higher level of protection	Protect
28		Install artificial reefs or surf breaks off shore in areas of coastal erosion to reduce the impact of storm events	Protect
29	Weak Ground Seismic	Earthquake - Map susceptibility of line to the effects of seismic shaking hazard.	Monitor
30		Earthquake - Respond to damage caused by earthquake	Protect
31		Earthquake - Upgrade and improve resilience of assets to earthquake hazard. Including rebuilding/remediating weak embankments.	Improve
32		Earthquake - build in redundancy by adding an alternative route	Improve
33	Flood Inundation - where flood banks are not the rail embankment	Flood Mitigation (Flood banks, non rail) - Accept current condition	Decline
34		Flood Mitigation (flood banks, Non rail) - Repair or Protect existing flood banks to a similar level as existing	Protect
35		Flood Mitigation (flood banks, non-rail) - Upgrade or increase in size of flood banks or Enable flood banks to be adapted in the future to match increasing levels (prep work). Consider sacrificial flood areas – take the water away from the rail network	Improve
36		Flood Mitigation (flood banks, non rail) - New flood banks	Improve

No.	Risk type	Intervention	Category
37		Realign the rail line away from the flood prone areas.	Improve
38		• Work with councils re. river/flood bank and flood protection works. • Agreements in place to allow for repairs or improvements (inc. consents).	Monitor
39	Heat	Heat -TARPS	Monitor
40		Heat – De-stress track programme[64]	Protect
41		Heat - Improve rails ability to withstand deformation, paint the rails to reduce heat absorption in areas that are at high risk. This is not viable outside of critical turnouts such as double slips.	Improve
43	Other	Abandon rail line	Decline
44		Do Nothing	Decline
45		New Track - Duplication to provide redundancy	Improve
46		New Track - Realignment of entire track (not just sections)	Improve
47	Slope Issues Rock/Soil	Slope Works - Re-assessment of slope data • Monitoring using passive or active (track inspection / remote monitoring systems)	Monitor
48		Slope - Response to weather events.	Protect
49		Slope Works - Trimming of slope or vegetation	Protect
50		Slope - Drainage Horizontal/Works/dewatering of slope, improve drainage with cut off drains	Improve
51		Slope Works (Active) (Rock bolting, mesh Netting or pinning, retaining wall, minor embankments)	Improve
52		Slope Works Rock - Blasting rock	Improve
53		Slope Works Rock/Soil - (Passive) Shelter/Barriers/Fences/ Shotcrete/Buttress of the toe to provide erosion protection and stability	Improve
54		Slope Works Rock/Soil - Large cuts to provide improved access or run out distances (earthworks)	Improve
55		Slope - Realignment away from issues. This may be a small length of realignment to provide slope run out	Improve
56		Slope - Tunnel (new) to avoid slope	Improve
57		Slope - Enlarge swale catchments/ catch ditches	Protect
58		Control of overland flow from neighbouring properties – agreements with adjacent landowners	Protect
59	Tunnel - Flooding / Rock Fall	Tunnel Do Nothing	Decline
60		Tunnel Monitoring for condition and rock fall	Monitor
61		Tunnel Planned response or emergency plan (Response to a rock fall or partial collapse within the tunnel)	Protect
62		Tunnel Drainage improvements within the tunnel	Improve
63		Tunnel lining improvements, rock bolting, meshing or shotcrete/Concrete	Improve
64		Tunnel Daylighting	Improve
65	Flood Inundation / Scour - where the rail embankment is subjected to ponding, river scour	River Erosion Protection - Protect, accept and repair after event.	Protect
66		Trackside drainage inc. swale clear-out	Improve
67		Undersize culvert assessment /Replacement/ Debris barriers upstream of culverts to avoid clogging	Improve
68		River Erosion Protection- New Culvert or Bridge Structure	Improve
69		Install upstream water diversion – Weirs, flood banks or river diversions	Improve
70		Install trackside drainage or drainage channels to remove water from the rail line	Protect
71		Track realignment to a higher location away from the flooding	Improve
72		Install bunds or debris barriers to direct flow or engineer catchment area capacity or settlement area	Improve
42		River Erosion Protection - Lift formation and/or armour to above flood levels	Protect

[64] Often lack of ballast, poor geometry are major factors. Note there are in total 18 different factors that affect track stability.

No.	Risk type	Intervention	Category
73	Wind	Wind - TARPS	Monitor
74		Wind - Wind protection structures including planting	Improve
75		Vegetation control using Policy's	Monitor
76	Fire	Monitoring of corridors and areas trains will be running / checking permits for hot works	Monitor
77		Designing out elements that are more prone to burning- remove wooden sleepers, wooden bridge piers, wooden signal poles, severe vegetation clearance around the rail corridor	Improve
78		• Ensure water carts available when needed. • Use ponds or water storage adjacent to high-risk locations such as viaducts.	Improve
79	Third Party Assets causing risk of flooding or landslips, or a combined WK resilience issue.	Forestry or other 3rd party structure blocking the overland flow path, engagement with the locals to improve the situation, Build relationships with third parties	Decline
80		MoU's with Councils on culverts or structures that councils own	Monitor
81		Easements/land acquisition – understand where land boundaries are. Increase land holding around rail to allow for realignment or works to be undertaken	Protect
82	Coastal Scour / Inundation	Agreement of consents to be able to undertake mitigation works	Protect
83	Slope Issues Rock/Soil	Large scale Embankment rebuild and large scale earthworks	Improve

12.5 First pass sifting (fatal flaws)

After establishing the long list, a "first pass sifting" exercise was undertaken.

A simple pass/fail methodology was adopted using the following criteria:

- **Technical** – is each intervention technically able to be undertaken.
- **Consentability** - how easy is it to be granted a consent for the intervention.
- **Safety in Design** – does the use of this intervention improve safety in design or how easily can safety be implemented.
- **Risk reduction** - will the risk from climate change induced damage be reduced by the implementation of works.

During the first sift, we used a seven-point scoring system (+3 to -3) to determine the best outcome for each criterion, providing a level of granularity to the evaluation process. Positive results were carried forward to the next stage, while negative results were discarded. A single score of -3 was deemed a fatal flaw and discarded.

This exercise enabled the project team to summarize the option performance and identify the most effective interventions for each theme. The results of the sift will guide our decision-making process as we move forward with implementing interventions to programmes to enhance the resilience of KiwiRail Network's rail lines.

A total of 77 interventions were carried through after the sifting process (from 83).

Example of the long-list sifting

An example of this is presented below, where we have two coastal protection options.

- The first option to reinforce existing seawalls, it was scored as a positive for technically feasible, positive for consentability and does provide a positive safety by providing greater working area. It will reduce the risk to the site as it will add protection and is allocated a positive score. Overall, it has a total of 5 and is carried forward.
- The second option is to install artificial reefs, technically very difficult, difficult to gain consent, provides no real safety in design. So were all score negatively. Its risk reduction is also negative as it not primarily used for risk reduction but for use as an offset. So overall it was a negative and discounted.

27	Coastal Scour/Inundation	Reinforce the current seawalls using an adapted designs to provide a higher level of protection	Reduce (maintain)	1	1	1	1	2	5
28	Coastal Scour/Inundation	Install artificial reefs or surf breaks off shore in areas of coastal erosion to reduce the impact of storm events	Reduce (maintain)	1	-2	-3	-2	-1	-8

12.6 Second pass sifting (vs. LoS themes)

12.6.1 Step 1 – Assessment vs "LoS Themes"

The next part of the process involved assessing the remaining intervention against the "LoS themes" – i.e. the extent to which the intervention would either **Protect**, **Improve** or **Decline** the current level of service.

Each intervention was then scored against each key resilience approach using a simple three-point scale (0 to +2). A score of +2 means refers to a strong alignment to a particular resilience theme – noting good alignment could be achieved with one or more of the mitigation themes.

Example of the assignment of interventions to problems

A retaining wall was scored a +2 for protect and a +1 for improve. This is because it provides protection and some improvement but does not completely remove the risk in the long term.

In this case to provide the improve you would either realign the track or major earthworks (i.e. avoid or remove the hazard) which score +2 in both protect and improve.

12.6.2 Step 2 – Total intervention score

We then multiplied the score from the "sifting" process with the score with the score from the "mitigation approach" to get a total "core" score. If an intervention had a negative score, it was excluded from further consideration.

Total score (Sifting x Mitigation Approach)	Outcome
0-12	Carried Forward
12-24	Preferred Carried forward
Less than 0	Discounted

Example of scoring

- The first option to widen and improve existing tracks. It passed the first sifting and has been positively scored for protecting and improving. This intervention was carried forward for those mitigation themes.
- The second option to build new access tracks. It passed the first sifting and has been positively scored for Protecting and Improving. This intervention was carried forward for those mitigation themes.

Draft Long list (to be confirmed)	Categories		Technical	Consentability	Safety in Design	Risk Reduction	Score	Do minimum	Protect	Improving	Do minimum	Protecting	Improving	Pass/Fail
Widening and improving existing tracks where narrow or big machinery is unable to pass without difficulty	Reduce (improve)	1	1	1	3	1	6	0	1	1	0	6	6	Carried Forward
Cutting new tracks, either to create better access points from roads or in areas that do not have tracks	Prevent/Remove/Avoid	1	1	-1	2	1	3	0	2	1	0	6	3	Carried Forward

The process reduced the total list of interventions from 77 to 72.

12.7 Assigning interventions to the specific problems

12.7.1 Length of line that the interventions were applied

As this is a PBC, the lengths of track for intervention were directly defined by the risks and problem areas identified by KiwiRail in the workshops. While we did not alter the lengths of the areas, we reviewed each one to determine the actual lengths of susceptibility wherever possible.

Each intervention has been assigned to a length of track that may encompass multiple sites. For instance, there is a coastal erosion site south of Timaru that continues for 5 km and is split into numerous sections, of which 3 km is subject to coastal erosion. Since the hazard is not continuous, we apply the cost of interventions to the total treatment length, i.e., 3 km. This approach allows us to focus our efforts on the specific areas most in need of intervention, as identified by KiwiRail. By reviewing each area and determining the actual lengths of susceptibility, the interventions are targeted and cost-effective.

12.7.2 Application of interventions to specific problems

Taking the sifted long list of interventions and reviewing the problem sites identified in the risk assessment, the project team assigned an intervention to each problem in line with the investment objectives.

The approach taken was:

- Reviewed each problem using the data available. This included known information of the site (slope risk rating etc.), internal knowledge and assets located in the area the problem was identified (e.g. culverts and retaining walls).
- Reviewed the network for overlapping problems and selected the best intervention/s to provide risk reduction to both problems where possible.
- Use the line dependency score to determine if access improvements and protection would be an intervention.
- A risk assessment to determine the level of risk reduction.

The full spreadsheet that provides the assessment of risk can be found in **Appendix C**.

A snapshot is provided below.

OBJECTID	Region	Line Name	Hazard	Asset Type	Describe the hazard impact	Response	Risk Category	North/South	Line Criticality	Length of Polygon (m)	Length of track requiring interventions (m)	Length of track assumptions	Assets requiring replacement	Interventions to improve lines. Increase LoS, reliability and	Interventions to protect lines. Maintain LoS, reliability and access	Interventions to do the minimum required
162	Canterbur	Main South Lin	Coastal inund	Rail line	Inundation of the track with Redruth - often occuring.	Rock wall to support but track still getting sand on it with higher seas. $1m on rockwall but still got issues. Built lower than design height proposed - barriers were geographic rather than budget. Wall is short term solution - track realignment going to be needed. Could go inland 10-15m of current corridor to provide buffer.	<Null>	South Island	3	1821.7	1821.7			Coastal - Realignment away from coastal hazard. Undertake managed retreat inland and reinstating sand dunes and vegetation as retreat occurs to provide resilience	Reinforce the current seawalls using an adapted designs to provide a higher level of protection	Coastal TARPS
163	Canterbur	Main South Lin	Coastal erosi	Rail line	Normanby and Redruth related, interchanging issues. High seas break over track + erosion issues.	Funding available for reactive works. Treated as separate reactive issues. Realignment again?	<Null>	South Island	3	4820.5	4820.5			Coastal - Realignment away from coastal hazard. Undertake managed retreat inland and reinstating sand dunes and vegetation as retreat occurs to	Reinforce the current seawalls using an adapted designs to provide a higher level of protection	Coastal TARPS

12.7.3 Remaining interventions

After assigning intervention to problems, it was identified that not all 70 interventions had been utilised. This was due to:

- Lack of intervention suitability to the problem identified. This includes length of problem to be applied to, cost, high level geographical conditions.
- Lesser level of intervention when compared to other options in the long list that could be used for the identified problem.
- Reduced gain of risk reduction from an intervention when compared to another.
- Intervention did not align well with other interventions being considered for the problem.

This in essence was a short listing of the preferred interventions and provided **53 interventions** that were then carried through into the various programmes (described in the next section).

13 Programmes

"Programmes", which are comprised of several separate interventions, were developed by the project team and agreed by KiwiRail. A structured approach was adopted to programme developed, which captured:

- Overarching mitigation themes of "Protect", "Improve" and "Decline".
- Line criticality (refer to the map provided as Figure 27.

Additional programmes were then introduced following a review by KiwiRail to capture hybrid programmes and a programme that targets only high-risk areas. The agreed programme themes are summarised in Table 19.

Table 19: Draft programmes

Theme		Description
Do Minimum		• Existing commitments • Managed decline • Predominantly 'reactive' / 'just in time' programme
Protect	Protect high criticality lines against natural hazard events	• Maintain level of service, reliability and access in high criticality lines • Managed decline of medium and low criticality lines
	Protect high and medium criticality lines against natural hazard events	• Maintain level of service, reliability and access in high and medium criticality lines • Managed decline of low criticality lines
	Protect all lines against natural hazard events	• Maintain level of service, reliability and access in all lines
Improve	Improving high criticality line performance with increasing natural hazard events	• Increase level of service, reliability and access in high criticality lines • Maintain for medium and low criticality lines
	Improving high and medium criticality line performance with increasing natural hazard events	• Increase level of service, reliability and access in high and medium criticality lines • Maintain for low criticality lines
	Improving all line performance through increasing natural hazard events	• Increase level of service, reliability and access in all lines
Hybrid	Protect medium, improve high	ADDED DURING THE PROGRAMME WORKSHOP
	Protect others, improve medium + high	
High risk areas	Target high risk areas	

Relevant interventions were then assigned to each programme.

14 Programme assessment

14.1 Multi-Criteria Analysis

14.1.1 Baseline scores

Technical specialists from the project team and KiwiRail collaborated to score the various programmes in relation to their specialisation. These specialisation scores were then presented and moderated before being pulled together into a single MCA matrix. The focus of the moderation process was to understand how much (slightly, moderately, significantly) one programme performed better or worse than another, and to ensure that individual scores considered a wide range of different perspectives.

The MCA scores are presented in Table 20[65].

Table 20: MCA scores

Category Weighting		50%	50%	40%	40%	40%	40%	10%			
Sub-Weightings		75%	25%	30%	40%	20%	10%	100%			
Contribution to the total score		38%	13%	12%	16%	8%	4%	10%			
Programme		Investment Objectives		Implementability				Te Ao Maori	Raw score	Weighted Score	
		Resilience exposure	Access (and operations)	Safety	Technical difficulty	Environmental effects	Consentability	Impacts on Te Ao Maori	Total (equal weighted score)	Baseline	Weighted score ranking
Do Minimum		0	0	0	-1	0	0		-0.17	-0.16	10
Protect	Protect high criticality lines	1	1	1	3	1	-1		1.00	1.14	9
	Protect high and medium criticality line	2	1	1	3	1	-1		1.17	1.52	6
	Protect all lines	2	1	1	2	1	-2		0.83	1.32	7
Improve	Improve high criticality lines	1	2	2	2	1	-1		1.17	1.23	8
	Improve high and medium criticality line	3	2	2	0	1	-1		1.17	1.66	3
	Improve all lines	3	2	3	-1	1	-2		1.00	1.58	5
Hybrid	Protect medium, improve high	2	2	2	2	1	-1		1.33	1.60	4
	Protect low, improve medium and high	3	2	2	1	1	-2		1.17	1.78	1.5
High risk areas	Target high risk areas	3	2	2	1	1	-2		1.17	1.78	1.5

Commentary

The rationale behind the scoring, and key points of differentiation is provided below:

- **Resilience exposure** – established by assessing the extent to which individual interventions would reduce the risk of exposure to the effects of climate change. Total scores were formulated, and then the MCA scoring was based on the relative 'benefit' each programme would provide. For this reason, targeting 'high risk' areas scored well and generally programmes with a higher quantity of interventions scored better.
- **Access** – generally the 'improve' programmes scored 1 point higher than the 'protect' programmes.
- **Safety** – where there are a greater number of 'large scale' interventions within the programme, a higher score was given. Hence this is why 'improve all lines' scored a +3. Generally, 'improve' programmes scored 1 point higher than 'protect' programmes.
- **Technical difficulty** - Each programme was scored on the level of complexity that would be required to implement. As protect interventions provide level of resilience less than the improve interventions, the design and implementation requirements are also less, so scored higher. A negative score was provided for 'Do minimum' as works general fall to reactive in nature. This means that designs are costly and require the additional complexity of failure to be addressed.
- **Environmental effects** - established by scoring each type of intervention separately based on broad consideration of environmental risks, such as the effects on ecology, water quality, stormwater and visual effects. The cumulative scores for each programme when then totaled and then compared. Generally, the scale of environmental risk, when considering programmes as a whole, relatively low – with little to differentiate the programmes. Some specific interventions would carry some higher risk (e.g. drainage works).
- **Consentability** – established by scoring each type of intervention separately, with consideration of sub-criteria of 'how easy will the intervention be to consent?' and 'can work be done within the current designations?'.

[65] Note that a -1 score was given for Technical Difficulty for the Do Minimum because if we KiwiRail need to be reactive to events, generally remedial solutions are more difficult to design and build.

Interventions such as 'coastal rock revetment' and 'control of overland flow from neighbouring properties' scored poorly. The MCA scores were based on a comparison of the total scores (sum of all interventions) between the various programmes.

Total scores

The total scores for the MCA have showed that:

- The following programmes ranked highest (weighted score = 1.78):
  - "Target high risk areas".
  - "Protect low, improve medium and high".
- However, several other programmes had a weighted score which was only slightly lower:
  - "Protect high and medium criticality lines" (weighted score = 1.52).
  - "Improve high and medium criticality lines" (weighted score = 1.66).
  - "Improve all lines" (weighted score = 1.58).
  - "Protect medium, improve high" (weighted score = 1.60).
- As a standalone tool, the MCA arguably was only able to exclude the following programmes due to the low comparative score (when compared to the highest-ranking programmes):
  - "Do Minimum".
  - "Protect high criticality lines".
  - "Protect all lines".
  - "Improve high criticality lines".

14.1.2 Sensitivity analysis

Sensitivity analysis was undertaken to understand whether the relative rankings of programmes would significantly alter in response to changes to the weightings of various criteria. The following sensitivity tests were undertaken:

- Equal weighting
  - Equal weightings for all criteria
- Investment Objectives
  - Investment Objective category contributes 60% (from 50%) towards the total score.
  - Implementability category reduced to 30% (from 40%)
- Implementability
  - Implementability category increased to 60% (from 40%)
  - Investment Objectives category reduced to 30% (from 50%)
- Technical Difficulty
  - Technical difficulty criteria contribute 30% towards the total score (from 16%).
  - All other criteria proportioned in line with the baseline weightings.

Table 21 shows how the relative ranking of programmes changed according to the various sensitivity tests.

Table 21: MCA – Sensitivity analysis

Programme		Baseline	Equal weighting	Investment Objectives	Implementability	Technical difficulty
Do Minimum		10	10	10	10	10
Protect	Protect high criticality lines	9	7	9	6	5
	Protect high and medium criticality line	6	3	6	2	1
	Protect all lines	7	9	7	8	6
Improve	Improve high criticality lines	8	3	8	5	8
	Improve high and medium criticality line	3	3	3	7	7
	Improve all lines	5	8	4	9	9
Hybrid	Protect medium, improve high	4	1	5	1	2
	Protect low, improve medium and high	1	5	1	3	3
Target high risk areas		1	5	1	3	3

The following programmes were consistently within the top three ranking, regardless of the sensitivity test:

- Target high risk areas.
- Protect low, improve medium and high.
- Protect medium, improve high.
- Improve high and medium criticality lines.
- Protect high and medium criticality lines.

14.1.3 Summary

The MCA process did not, as a stand-alone tool, conclusively establish a preferred programme. Regardless, other decision-making tools such as economic and costs (affordability) need to also be considered.

14.2 Programmes – economics and cost estimates

Table 22 provides the total MCA score for each programme alongside the indicative cost estimate (P50)[66] and potential benefit-to-cost (BRC) ratio.

Table 22: Programme assessment

Programme		MCA: Total Score	MCA: Ranking	Cost Estimate (P50)	BCR Low	BCR High
Do Minimum		-0.16	10	$0	0.0	0.0
Protect	Protect high criticality lines	1.14	9	$280,000,000	2.2	2.9
	Protect high and medium criticality line	1.52	6	$1,324,000,000	2.7	3.5
	Protect all lines	1.32	7	$1,779,000,000	2.1	2.7
Improve	Improve high criticality lines	1.23	8	$1,906,000,000	0.3	0.4
	Improve high and medium criticality line	1.66	3	$6,952,000,000	0.5	0.7
	Improve all lines	1.58	5	$9,102,000,000	0.4	0.5
Hybrid	Protect medium, improve high	1.60	4	$2,950,000,000	1.2	1.6
	Protect low, improve medium and high	1.78	1.5	$7,407,000,000	0.5	0.7
High risk areas	Target high risk areas	1.78	1.5	$7,323,000,000	0.4	0.6

Table 22 shows that:

- Whilst the "Target high risk areas" and "Protect low, improve medium and high" programmes rank (marginally) better than the alternatives, the BCR is expected to be less than 1.0. This means that the programmes are unlikely to represent good value for money. This is also true for the third highest ranking programme from the MCA – "Improve high and medium criticality lines". These were also the most expensive programmes, and with a cost estimate of around $7bn and considered by KiwiRail to be unaffordable.
  - As such, it was agreed to remove these programmes from further consideration.
- The "improve all lines" programme, with a cost estimate of over $9bn was again considered to be unaffordable and was also removed from further consideration.
- The following programmes had a strong MCA score and are also expected to deliver good value for money:
  - Protect high and medium criticality lines.
  - Protect medium, improve high.

14.3 Selection of the preferred programme

An online meeting was held on the 17 March 2023 where KiwiRail reviewed the following information and selected the following as the preferred programme: **Protect high and medium criticality lines.**

The key reasons were:

- It scored well as part of the MCA.
- At around $1.3bn, the programme is far more likely to be realistically affordable.
- Whilst "Protect Medium, Improve High" scored well, at close to $3bn was considered to be unrealistically affordable to KiwiRail. The BCR range is also far less favourable than the "Protect High and Medium" programme.
- It is likely to present good value for money.

[66] These are capital cost estimates only, and do not account for avoided repair and remediation costs post-treatment (rather this is captured as part of the economic appraisal for the preferred programme).

- Whilst the ‘Protect medium, improve high” programme has strong merit, at a cost approximately $3bn it is likely to be unaffordable.

Several sites have been omitted from the programmes due to their high costs and low level of line criticality. During the selection of the programme process, sites with low criticality were excluded, resulting in the exclusion of major sites from those areas. This decision was based on a combination of factors, including the expenses involved in carrying out the work, affordability considerations, and the level of service required.

When it comes to higher criticality lines, major resilience works were implemented as a whole of line. By deferring or excluding these works, the benefits intended for those lines are not realised within the programme. This is because the associated risks have not been addressed, which creates a potential point of failure.

14.4 Optimisation of the preferred programme

Once a preferred programme was selected, a deep dive into the programme was undertaken to establish whether it could be further optimised. This process captured:

- Reviewing the MCA scores for individual interventions to establish whether any interventions had critical flaws, or based on new information, whether a more optimal solution to address a specific issue was available.
- Revisions to intervention type based on a review by KiwiRail. These changes were typically steered by site specific requirements. Specific changes include:
  - The intervention for slopes of trimming and monitoring was changed to trimming and meshing to provide a better level of protection for all the sites with the former intervention applied. With this change came a higher cost as meshing requires construction and materials[67].
  - A further request for the level of protection to be increase for the Oamaru Sea wall. This was changed from minor repairs to a higher level of protection of an adapted design using the materials that are already on site.
- Cost estimates were updated following a second review by the project team and KiwiRail.
- Utilising the 2022 slope data track lengths to fill in gaps and provide a better assessment of treatment length.
- ‘Gap assessment’ (sense check)
  - This involved considering how the network would function as a whole and whether the staged approach makes sense from a benefits realisation perspective. For example, does the programme address a particular resilience issue in Years 1-10, but a similar issue further up the rail line is not addressed until Years 11-30?
  - Review of whether improvements to the higher criticality lines have been prioritised first.
  - The outcome was that interventions that seek to address areas with a risk rating of 1UL (refer to Table 12) were brought through into the 1-10 year programme.

[67] These costs were provided by KiwiRail on the 23/3/2023 in a meeting with the Professional Head of Civil.

15 Preferred programme

15.1 Overview

The selected preferred programme aims to enhance the resilience of the KiwiRail network by prioritising interventions that address the most significant risks and hazards while being affordable.

The programme incorporates a range of engineering, operational, and strategic interventions that have been tailored to meet the specific needs of the network. The interventions identified in the programme have been designed to improve the network's ability to withstand and recover from a range of natural hazards and climate change-related stressors. The preferred programme also includes a cost review that ensures that the interventions are cost-effective and feasible for implementation. Overall, the preferred programme represents a strategic and integrated approach to enhancing the resilience of the KiwiRail network and supports the long-term sustainability of the rail industry in New Zealand.

The following table provides a breakdown of the indicative programme by line and cost.

Table 23: Preferred programme – cost breakdown

Line	Interventions	TOTAL	Years 1 to 10	Years 11 to 30
Bluff Line	0	9(2)(i) - Commercial Activities		
East Coast Main Trunk	10			
Hokitika Line	0			
Johnsonville Line	0			
Kinleith Branch	1			
Main North Line	20			
Main South Line	21			
Marton - New Plymouth Line	35			
Midland Line	24			
Murupara Line	3			
North Auckland Line	4			
North Island Main Trunk	65			
Ohai Line	0			
Onehunga Branch	0			
Palmerston North - Gisborne Line	8			
Port Chalmers Branch	1			
Rapahoe Branch	3			
Stillwater - Ngakawau Line	15			
Wairarapa Line	22			
Wanganui Branch	0			
TOTAL	**232**	**$1,199,600,000**	**$429,400,000**	**$770,100,000**

Figure 30 and Figure 31 geographically map the preferred programme for the North and South Island's respectively. The distribution of proposed expenditure on various lines reflects the risk rating of that line, which considers a range of factors including hazard frequency, vulnerability of assets and line criticality. For example, the North Auckland Line has Line Criticality of 4 (low).

Programme cost estimate

The total cost for the programme is approximately $1.2bn (2022 base) across a 30-year period.

The Net Present Value (NPV) cost across the 30-year period is $625m.

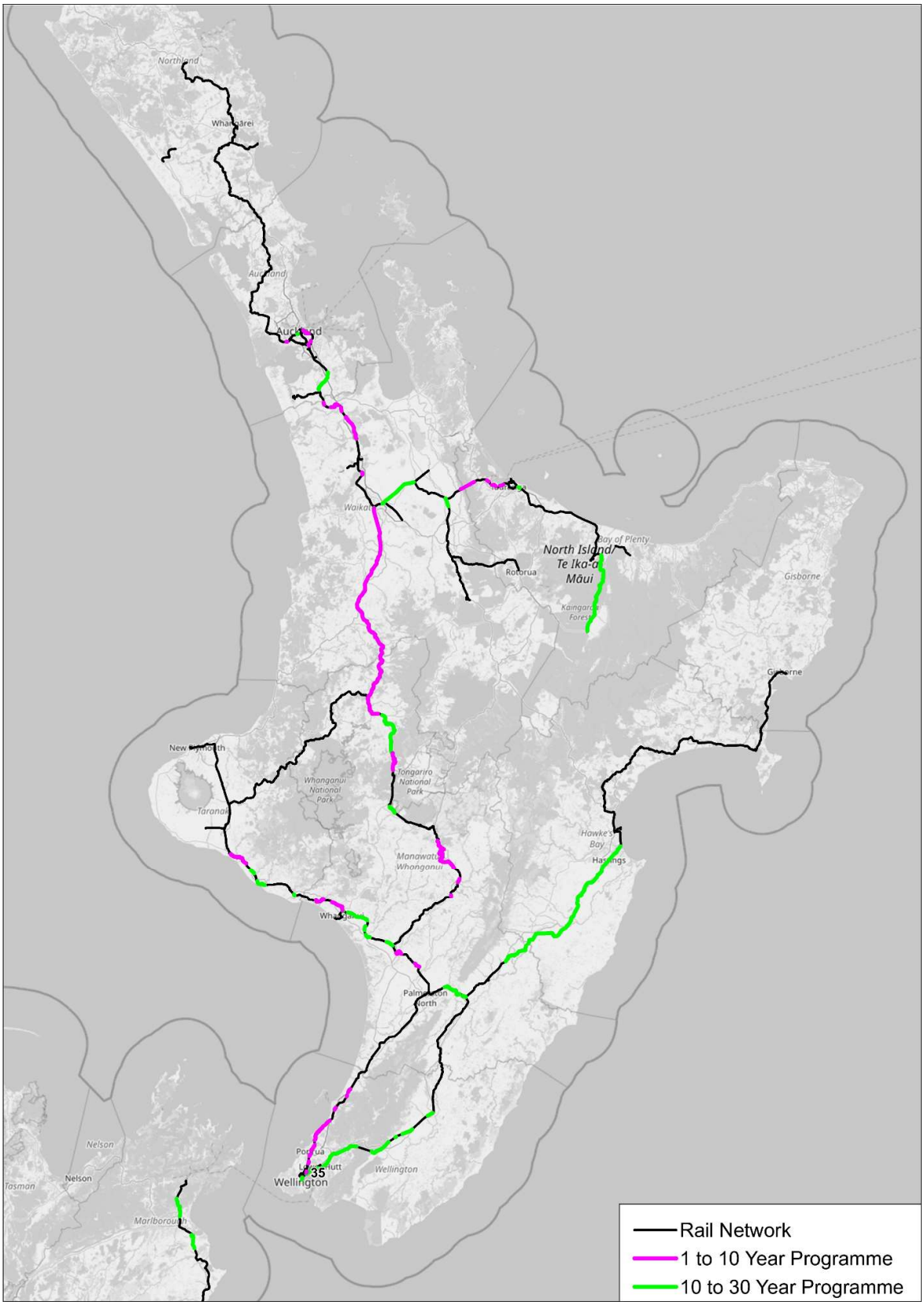


Figure 30: Preferred Programme (North Island)

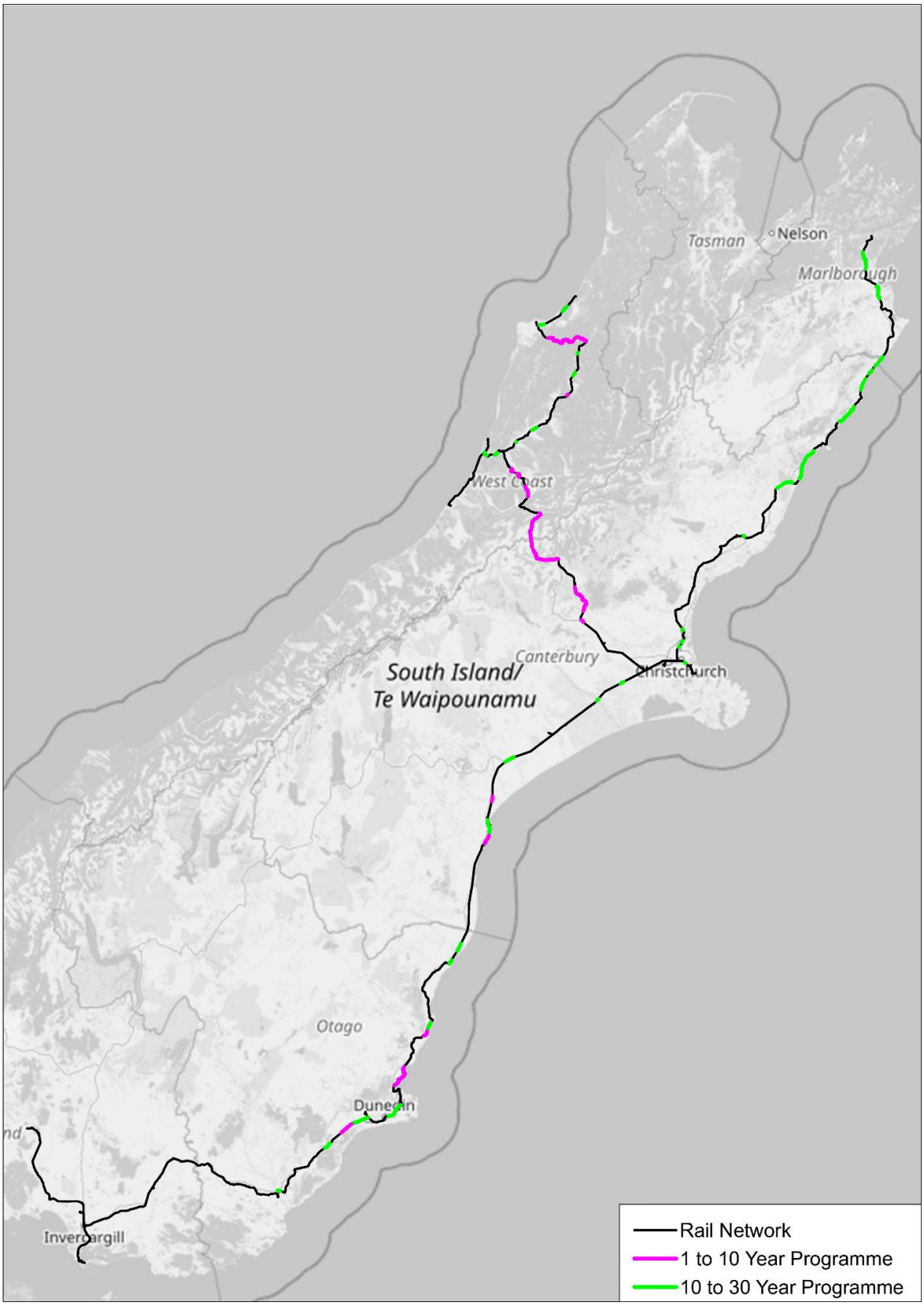


Figure 31: Preferred Programme (South Island)

15.2 Economic assessment

A summary of the results for the economic evaluation of the preferred programme is shown as Table 24.

Table 24: Preferred Programme – Economic Assessment

	Benefit (60 Year NPV)	Cost (60 Year NPV)		BCR Range
		Base (P50)	High (P95)	
Preferred Programme	$2.2bn	$623m	$811m	2.7 – 3.5

Sensitivity analysis

The economic assessment is however highly sensitive to the following key factors:

- Annual Exceedance Probability (AEP)
  - Refers to the likeliness of an event occurring.
  - Base assumptions:
    - Low = 2% chance of an event occurring every 50 years
    - Medium = 5% chance of an event occurring every 5-50 years
    - High = 12.5% chance of an event occurring every 0-5 years
      - E.g. minor slips and flooding.
- Duration of outage
  - Refers to the duration of outage.
  - Base assumptions:
    - Low = 12 hours
      - E.g. clearing a minor slip from the line
    - Medium = 48 hours
    - High = 6 months
      - E.g. a bridge collapsing.

Table 25 provides sensitivity analysis to understand how the expected BCR range would change in response to changes to these two key factors.

Table 25: Preferred Programme – Sensitivity Analysis

Factors		Variable	Benefit (60 Year NPV)	Cost (60 Year NPV)		BCR Range
				Base (P50)	High (P95)	
Annual exceedance probability	High	5%	$1.1bn	$623m	$811m	1.4 – 1.8
		12.5%	$2.2bn			2.7 – 3.5
		20%	$3.3bn			4.1 – 5.3
Duration of outage	High	1 month	$350m			0.5 – 0.6
		6 months	$2.2bn			2.7 – 3.5
		1 year	$4.4bn			5.4 – 7.0

The analysis shows that the economic appraisal is highly sensitive to key assumptions around probability of an event and/or duration of outage. These will always remain significant uncertainties which means that the final benefits of any programme will be unknown.

Notwithstanding, as shown earlier, in a comparative sense the preferred programme is expected to deliver notably higher benefits than any other programme. The analysis also does not capture Wider Economic Benefits, such as impact to community livelihood, which could be a significant benefit.

Figure 32 plots NPV cost of the programme against NPV benefit.

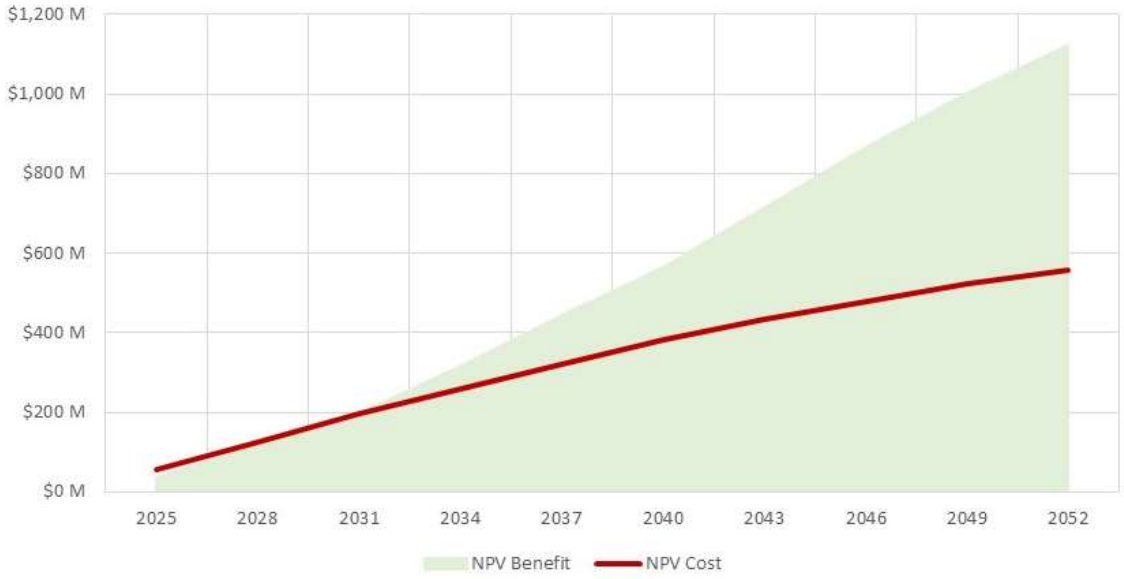


Figure 32: Benefits vs costs over time

15.3 Delivering the investment objectives

The preferred programme is expected to fully achieve the Investment Objectives, as described below.

15.3.1 Investment Objective 1 – Addressing High Risk Areas

The first investment objective is to **"address 75% of the extreme resilience risks within the next 10 years and 75% of high resilience risks in the next 30 years**".

To understand how well the programme achieves this, two maps has been produced which overlays the short-term programme against the extreme (risk ratings 1VL, 1L and 2VL) risk and the full 30-year programme with the identified high risks (risk ratings 1VL, 1L, 2VL, 2UL, 2L, 3VL, 2UL, 3L and 4VL).

These maps are provided as Figure 33 and Figure 34. The maps show that:

- The programme improves resilience at 100% of the extreme risk areas within the next 10 years.
- The programme improves resilience at 100% of the high-risk areas within the next 30 years.

As such, it is considered that the preferred programme will more than satisfy this Investment Objective.

15.3.2 Investment Objective 2 – Improving Access

The second investment objective is **"provide reliable access to 50% of high-risk resilience areas in the next 30 years".** Figure 35 provides a map which overlays the high-risk resilience areas with interventions which would improve access; namely:

- ID 1: widening and improving existing tracks where narrow or big machinery is presently unable to pass without difficulty.
- ID 3: more regular maintenance of tracks / setup a maintenance schedule / monitoring of track quality / standardise approach to maintenance – potential study to identify risk areas / development of standards for access tracks.
- ID 19: coastal rock revetment - rock or concrete armour.
- ID 27: reinforce the current seawalls using an adapted designs to provide a higher level of protection.
- ID 51: slope works (Active) - rock bolting, mesh netting or pinning, retaining wall, minor embankments.
- ID 53: slope works rock/soil (passive) – shelter / barriers / fences / shotcrete / buttress of the toe to provide erosion protection and stability.
- ID 54: slope works rock/soil - large cuts to provide improved access or run out distances (earthworks).
- ID 67: undersize culvert assessment / replacement / debris barriers upstream of culverts to avoid clogging.

In total, the preferred programme includes 232 interventions, of which 113 would see access improvements. It also provides **improved access to 51% of the high-risk resilience areas** over the 30-year period.

As such, the preferred programme fully meets the second Investment Objective.

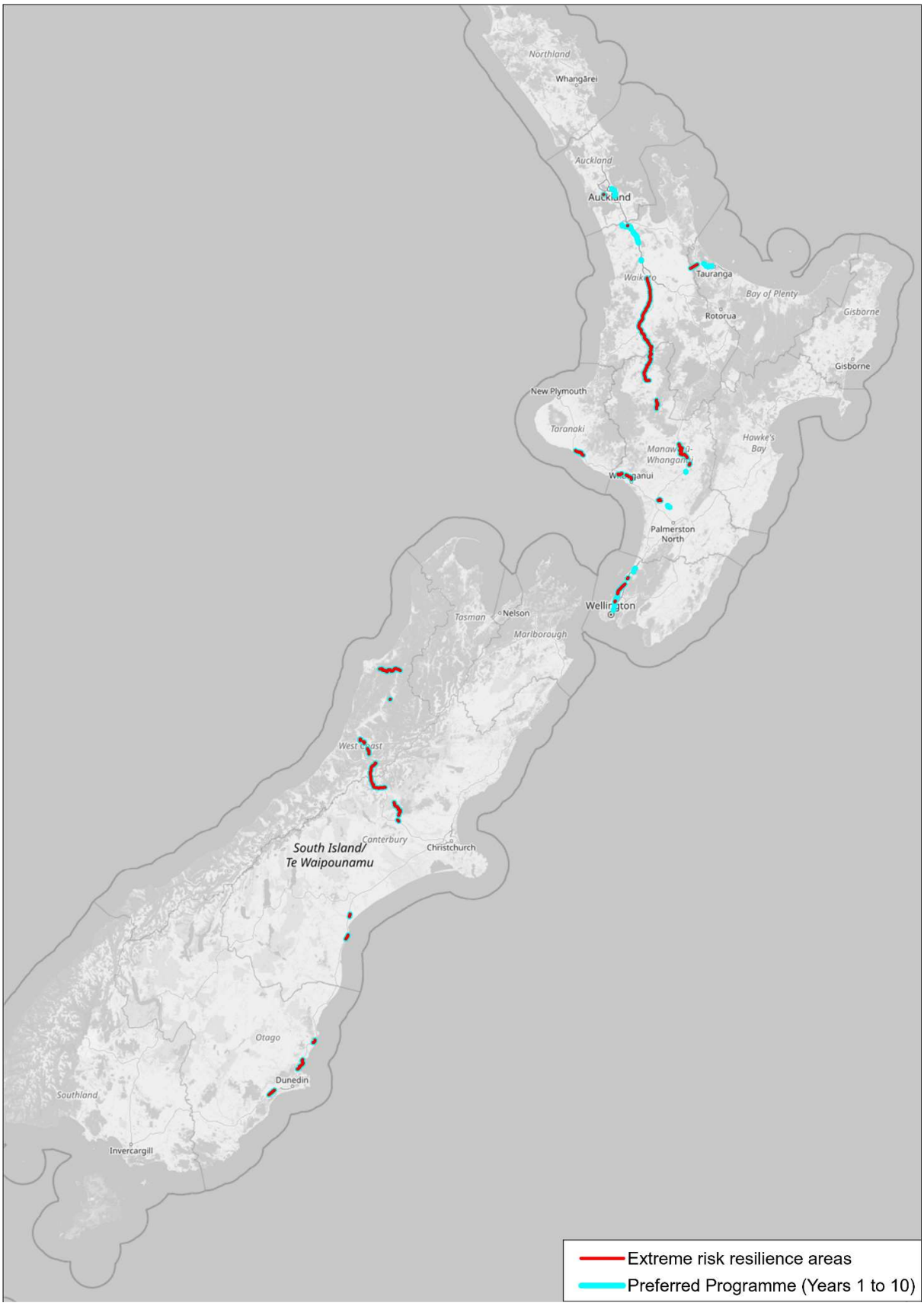


Figure 33: Addressing extreme resilience risks in the short term (1 to 10 years)

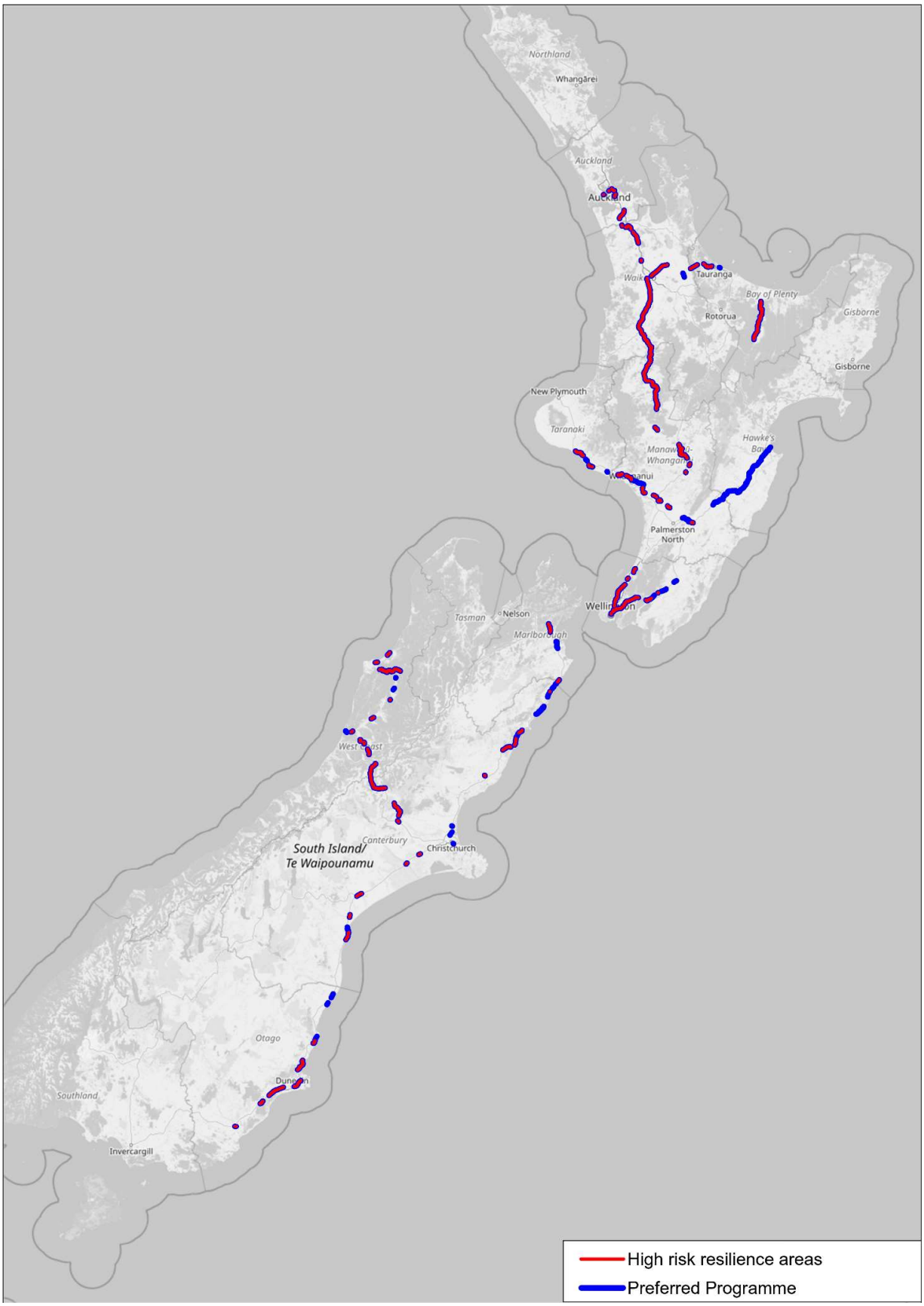


Figure 34: Addressing high resilience risks (1 to 30 years)

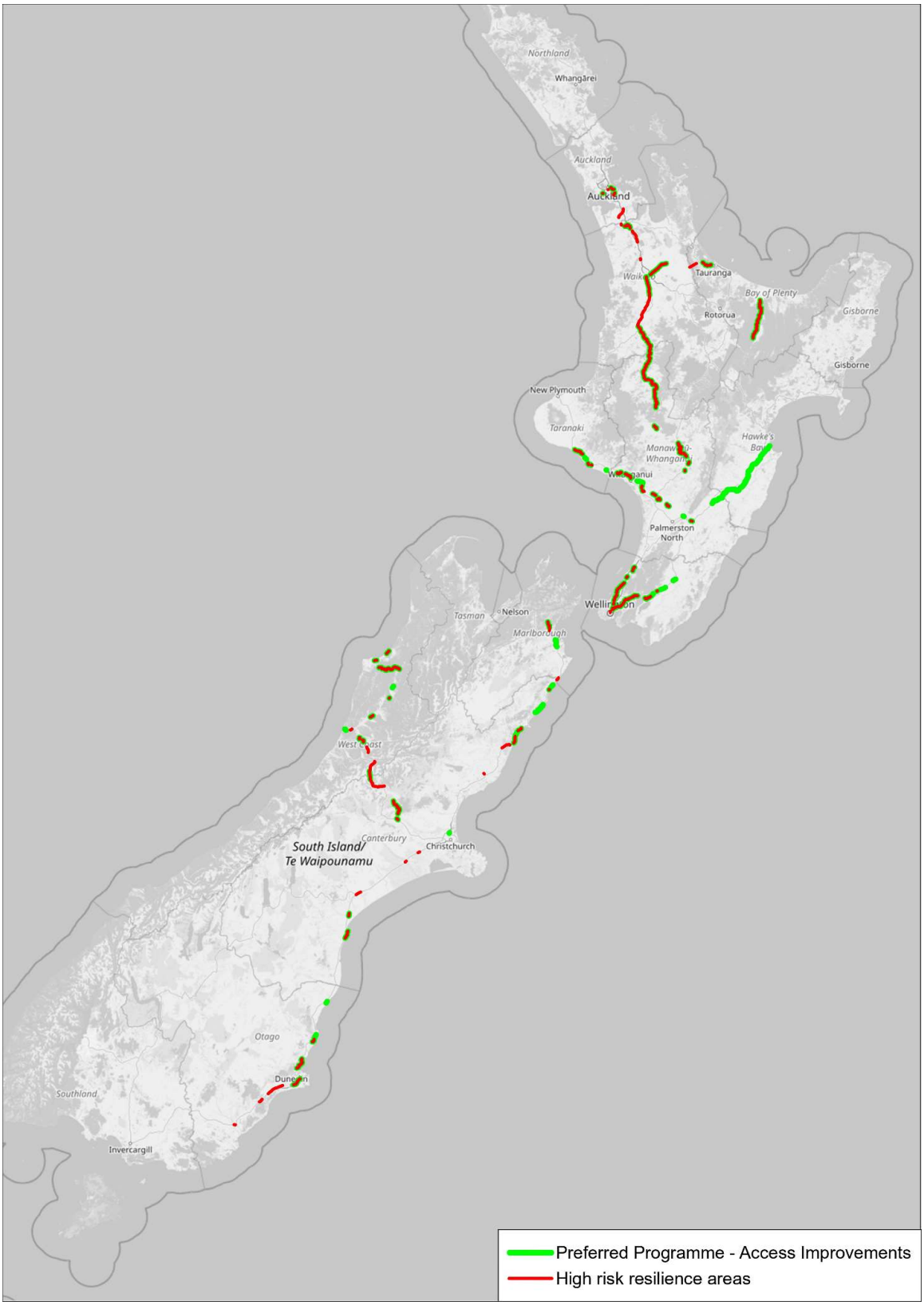


Figure 35: Preferred programme – access improvements

15.3.3 Alignment vs key strategies

A broad assessment of the preferred programme vs the key strategies is provided as Table 26.

Table 26: Assessment vs key strategies

Strategy	Alignment (Resilience)
The New Zealand Rail Plan (2021)	Strong alignment with the Government's priority to restore core rail freight assets, such as track, to improve the reliability and safety of the rail network and support the expected increase in rail freight tonnage.
KiwiRail Statement of Corporate Intent (2022-2024)	This Statement of Corporate Intent focuses on the next three years of phase one – investing in reliable and resilient assets. The preferred programme aligns directly and contributes to this as it directly seeks to mitigate the areas of high resilience risk.
Rail Network Investment Programme	The preferred programme has a strong alignment to the strategic investment priority to restore rail freight and provide a platform for future investments for growth. It does this by ensuring that rail transport is reliable and available, ensuring that it is perceived as an attractive choice.
Government Policy Statement on Land Transport 2021/22-2030/31	The preferred programme has strong alignment to the Improving Freight Connections strategic priority. It does this by the improving the reliability of transporting freight by rail as an alternative to road. It consequently has an indirect alignment to the climate change strategic priority by encouraging mode shift to rail, which has fewer emissions than road-based transport.
Transport Outcomes Framework (MOT)	The preferred programme strongly aligns with the Resilience and Security outcomes – 'minimises and manages the risks from natural and human-made hazards', 'anticipates and adapts to emerging threats', and 'recovers effectively from disruptive events'.
Regional Land Transport Plans	The preferred programme aligns with many of the current Regional Land Transport Plans. The Auckland, Canterbury, and Wellington RLTPs all identify improvements for network resilience or management of risk of exposure to extreme events. These are captured by the preferred programme.
Hīkina te Kohupara – Kia mauri ora ai te iwi: Transport Emissions – Pathways to Net Zero by 2050 (MOT)	The preferred programme aligns with theme No.3, 'Supporting a more efficient freight system' by investigating ways to reduce carbon emissions arising from diesel fuel used in transporting freight. It does this indirectly by improving the reliability and consequently the attractiveness of rail which helps shift freight from road (more energy intensive) to rail (less energy intensive).
Climate Change Commission Recommendations (2021)	The preferred programme helps to achieve a shift in the movement of freight from road to rail which is only possible if rail is seen as a viable alternative to road transport which this business case helps to achieve.

15.4 Cumulative effects of the preferred programme

The MCA process identified the need to consider the additive risk effects and associated cumulative impacts of the programme. The key considerations for cumulative impacts are to:

- Consider how the programme would work as a system as a whole.
- Look at the interactions and interlinkages across hazards and across the network.

The preferred programme is "protect the high and medium criticality lines". This programme has a range of interventions, each of which have been individually assessed as part of the MCA process for the benefits they bring to managing a specific hazard exposure, along with the wider technical aspects of design and associated cost.

Along with the benefits the selected interventions provide to the identified problem, consideration of the cumulative impacts that may arise from the preferred programme is also required. While each individual intervention aims to address a specific problem and enhance resilience, cumulative impacts arise from the identified interventions providing wider both positive and negative impacts during the undertaking of the programme.

Types of cumulative impact

Cumulative impacts can manifest in various ways, including improvements to the seismic performance, providing better access due to enabling work, altering of the natural environment and short-term negative reduction of rail trip duration performance.

Positive impacts are generally encountered during implementation of various interventions, where increasing resilience to other identified hazards or problems should bring up to standard for asset life. For example:

- When undertaking a culvert rebuild, the embankment the rail runs on is excavated to allow access to the level of the culvert. After the culvert is installed, the embankment is built back up to formation level with modern materials to modern standards, resulting in a lower likelihood of failure during a seismic or weather event. The formation will also be bought up to a higher level of acceptable axel loading, which as the freight increases will be required across the network. Access will also be improved for the required machinery, which will provide access to other locations between entry and site location.
- Where a coastal protection intervention is utilised, the interventions primary focus is to reduce toe erosion/overtopping of the embankment and rail. Taking the example of a rock revetment, the intervention

provides a level of buttressing to the toe of the embankment reducing slope failures. This intervention provides free edge protection which will improve the seismic performance of the slope. There are untended positive impacts for this intervention:

- Providing a greater penguin/wildlife habitat
- Protection of ecologically important wetlands
- Protection of other assets that may run in parallel with the rail line.

Consideration of the cumulative impacts of each intervention type has been documented in **Appendix D**.

Cumulative impacts of the programme

The programme has been developed to realise the benefits on higher critically lines earlier (1 to 10 years). This approach has been to provide the lines that KiwiRail deems most important with the earliest funding. This also provides a spokes of a wheel approach to the programme, focus on the high critically lines (hub of the wheel) then moving out to the feeder lines (spokes of the wheel).

A negative aspect to this approach is that there will a higher level of time delays on those high criticality lines for a short duration while the works are being implemented. To reduce the impacts, a works package approach will need to be implemented.

Overall, the programme provides positive cumulative impacts when an engineering solution is utilised. This is primarily because any works to the rail network would incorporate modern standards that typically take a 'whole of network' approach. A minor overset of this positive impact is the times delays during construction. However, once implemented the level of outage will reduce due to the improved resilience of the network.

PART C – DELIVERING AND MONITORING THE PROGRAMME

16 Financial Case

The purpose of this section is to set out the programme financial implications of the preferred programme.

16.1 Programme Cost

The proposed whole of life cost of the programme is $1.2 billion over the expected lifetime of the programme[1].

A breakdown of the cost by period is:

Period	Year 1-3	Year 4 - 9	Years 10 - 30	Years 30+
Investment ($M)	$58m	$177m	$792	$179

The anticipated cash flows for the investment proposal over its intended life span are set out in Figure 36.

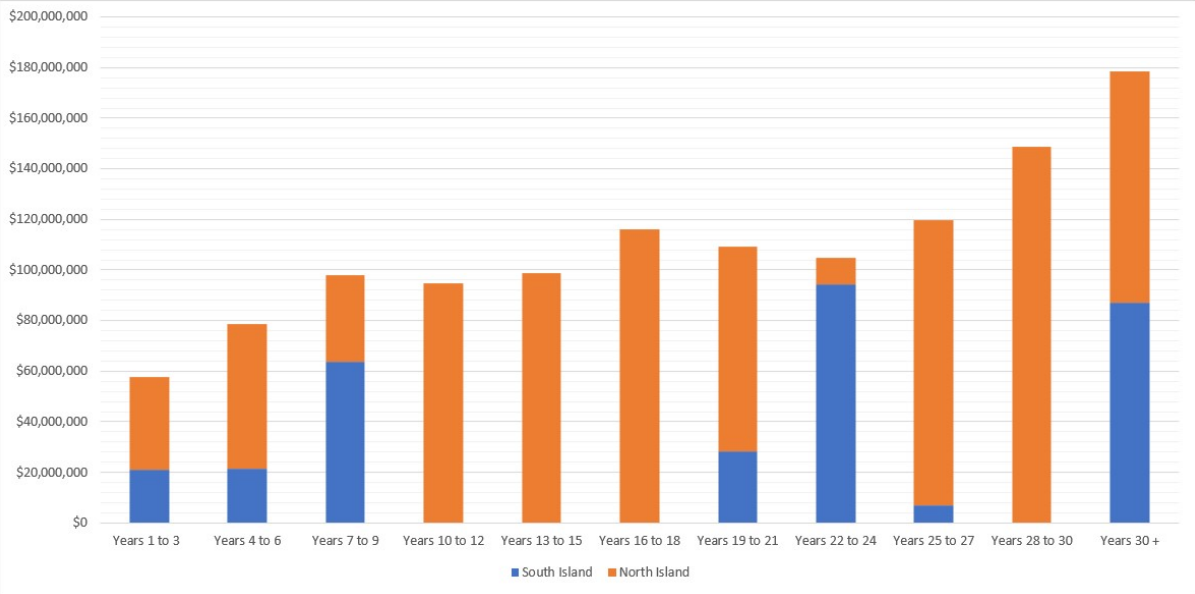


Figure 36: Programme Cost (by expenditure period and Island)

Table 27 provides a breakdown of the programme cash flow by line.

A breakdown of the costs for each intervention are provided within **Appendix B**.

[1] Costs exclude escalation. Costs do not capture potential savings for renewals or maintenance costs.

Table 27: Cash flow by line

Line	Interventions	TOTAL	Years 1 to 3	Years 4 to 6	Years 7 to 9	Years 10 to 12	Years 13 to 15	Years 16 to 18	Years 19 to 21	Years 22 to 24	Years 25 to 27	Years 28 to 30	Years 30 +
Bluff Line	0	9(2)(i) - Commercial Activities											
East Coast Main Trunk	10												
Hokitika Line	0												
Johnsonville Line	0												
Kinleith Branch	1												
Main North Line	22												
Main South Line	23												
Marton - New Plymouth Line	35												
Midland Line	24												
Murupara Line	3												
North Auckland Line	4												
North Island Main Trunk	62												
Ohai Line	0												
Onehunga Branch	0												
Palmerston North - Gisborne Line	8												
Port Chalmers Branch	0												
Rapahoe Branch	3												
Stillwater - Ngakawau Line	15												
Wairarapa Line	22												
Wanganui Branch	0												
TOTAL	**232**	**$1,204,500,000**	**$57,700,000**	**$78,800,000**	**$97,800,000**	**$94,800,000**	**$98,600,000**	**$116,000,000**	**$109,200,000**	**$104,900,000**	**$119,600,000**	**$148,800,000**	**$178,700,000**

Table 28: Total programme cost by intervention type

Intervention	Years 1-9	Years 10-30	Years 30+	Total Cost
Bridge - scour protection	9(2)(i) - Commercial Activities			
Coastal Rock revetment				
Control of overland flow from neighbouring properties				
Flood Mitigation				
Flood Mitigation				
Install river training structures				
Install trackside drainage				
Install upstream water diversion				
Reinforce the current seawalls				
River Erosion Protection				
Slope - Improve drainage with cut off drains				
Slope - Enlarge swale catchments				
Slope Works				
Slope Works				
Slope Works				
Trackside drainage				
Tunnel drainage improvements				
Undersize culvert assessment				
Vegetation control				
Minor improvements*				
Total	**$234,210,000**	**$789,740,000**	**$178,630,000**	**$1,202,560,000**

*Minor improvements = drone service, bridge - planned response, ensure available water carts, install bunds or debris barriers, more regular maintenance, slope - response to weather events, undertake monitoring of coastal retreat, weirs in the river, widening and improving existing tracks.

16.2 Funding risks

Investment sources, investment cashflow and cost increases are the main funding risks for the programme.

The key funding risk elements are:

- Investing organisations (KiwiRail, and central government) have multiple commitments, and the programme will be competing against other priorities for investment.
- Cost increases are probable due to range of factors over the course of the programme, including increased market rates, supply chain disruption, new regulation, changes in risk profile or increased knowledge of asset condition. This risk can be reduced with constant cost baselining, to update the cost forecasts with more accurate reducing the cost far outweigh the budget.

KiwiRail will be responsible for managing the programme in relation to these risks and ensuring that the longer-term objectives remain in focus as the programme adapts to risk changes over time. Intervention and programme costs will be refined in subsequent business cases to provide more cost certainty and ensure the programme remains affordable.

16.3 Funding sources

16.3.1 Rail Network Investment Programme (RNIP)

The RNIP sets out a three-year investment programme and a 10-year investment forecast for the national rail network – the thousands of kilometres of track and associated infrastructure such as signals, tunnels and bridges that provide the network for rail freight and passenger services in New Zealand.

The programme has been developed by KiwiRail, guided by:

- The Government Policy Statement on Land Transport 2021 (GPS), and
- The New Zealand Rail Plan (NZ Rail Plan).

RNIP is divided into two activity classes Rail Network & Public Transport Infrastructure.

RNIP 2 is still being developed and there is the potential for the improvement programme to be adjusted to balance priorities across the whole RNIP programme application. The Resilience programme would start under RNIP 2.0.

Resilience programme

The $1.2B funding required for the resilience programmes is sought/provided from the RNIP.

However, the RNIP programme has several workstreams competing for a limited budget. As such, the RNIP application may need to adjust the resilience improvements programme to balance competing priorities and the different workstreams.

It is worth noting that the RNIP has a renewals programme which may contribute towards resilience for the network. These programmes must consider the projects forming each to avoid spending clashes.

16.3.2 Potential alternative funding sources

Additional or alternative funding sources may become available in the future. This would mostly likely be because of the development of further government policy or changes to existing government policy, and either take the form of a one-off opportunity or become part of regular future funding cycles.

Potential funding sources for the programme are outlined in Table 29.

Table 29: Potential funding sources

Potential funding source	Description
Crown Funding	Crown funding may be available for significant projects. The Crown has previously funded rail projects through the NZUP and Provincial Growth Fund channels, including investment in track, railway stations, rail electrification, rail connections, rail network capacity, and resilience improvements in Auckland, Wellington, and regional areas.
Climate Emergency Response Fund	The Climate Emergency Response Fund (CERF) was established in 2021. It allocates Emissions Trading Scheme proceeds towards initiatives that help meet climate change objectives. The Government allocated $2.9 billion in CERF funding across a four-year forecast period in its 2022 budget, in addition to pre-commitments of $840 million and $25 million for the Decarbonising Industry Fund. $1.3 billion was allocated to the transport sector, $375m of which was allocated specifically to activities, infrastructure and services that reduce reliance on cars and support the uptake of active and shared modes. It is reasonable to expect that the preferred programme will receive funding from this source, given the role of rail within the transport system and climate response.
New Policy and Regulation	New policy and regulatory approaches may be used to both influence transport system use and create new funding streams for this programme. Ensuring a robust pipeline of work will enable KiwiRail to take advantage of emerging funding opportunities as they occur.
National Adaptation Plan (NAP) delivered through the National Resilience Plan	The Government has committed an initial $6 billion towards a National Resilience Plan to support significant medium and long-term infrastructure investments which focus on the resilience of New Zealand's critical infrastructure, including transport, with plans for further funding in future Budgets. The programme will first focus on projects that support recovery and building back better from recent weather events.

Potentially a 'resilience fund' could be drawn from the above funding sources in order to help address new, emerging or urgent resilience risks.

16.3.3 Co-funding opportunities

There are opportunities where the councils (such as in Auckland and Wellington) may contribute a small amount where there is crossover with the main lines to ensure the commuter services continue operating smoothly. Other regional councils could potential contribute given the desire to encourage more rail-based, and less road-based freight movements. This will help achieve the outcomes of the Government's wider Emissions Reduction Plan[1].

Other co-funding opportunities may exist where multiple assets share a corridor that needs protecting/resilience. The Kaikoura shared rockfall assets is an example of this (between Waka Kotahi and KiwiRail).

There are other projects which also can provide a resilience benefit for KiwiRail. One example is the Ngā Ūranga to Pito-One project[1].

The project will provide a safe and attractive route for walking and cycling between Wellington and Lower Hutt, and a new resilient coastal edge protecting the road and rail. The project includes sloping embankments which will act as a coastal defence to protect the shared path, ūranga and the road rail line behind. The embankments known as 'revetments' will be designed with the ability to adapt to sea-level rise and are 16m wide on average.

There is wider opportunity for shared outcomes to be achieved through other transport improvement projects.

16.3.4 Potential funding overlaps

There are potential overlaps between funding requests between various programmes.

One example is the Wellington Rail PBC, where there are five areas of the rail network where interventions are proposed as part of both the Resilience PBC and Wellington Rail PBC. There are also some differences in terms of identified

[1] https://environment.govt.nz/what-government-is-doing/areas-of-work/climate-change/emissions-reduction-plan/

treatment between the two PBCs. This is because the Wellington Rail PBC focuses not only on resilience, but also customer level of service and network capacity. Similar 'overlaps' could also occur for the Auckland Rail PBC, or indeed, wherever in the country future forward works programmes are being developed.

To manage this risk, KiwiRail and the relevant partners would need to discuss any 'overlaps' to confirm:

- The preferred intervention for each 'overlapping' part of the network.
- Relative costs/benefits of identified interventions.
- Respective investment objectives and benefits.
- Timing and funding.

17 Commercial case

The commercial case outlines the proposed procurement arrangements for the preferred option.

17.1 Procurement and project development

KiwiRail will procure projects in accordance with their approved procurement policies, strategies, and plans. These policies, strategies, and plans are not summarised in this PBC2 but a link has been provided. Waka Kotahi have reviewed KiwiRail's procurement procedures and concluded that they are consistent with the Government Procurement Rules (GPR) and the advice provided by the Ministry of Business, Innovation and Employment (as the government Procurement Functional Leader).

While there are no proposed departures from existing procurement policies and plans envisaged in this programme if, for affordability reasons, different funding sources are sought then there is a risk that the procurement requirements of these different funding agencies will need to be met. While these procurement requirements will only be understood at the time and are not outlined in this PBC KiwiRail's procurement principles and considerable in-house procurement expertise will ensure these issues are appropriately addressed.

The projects within the programme range significantly in scale.

As a result, the programme development approach will be varied with KiwiRail agreeing to apply the principles of Waka Kotahi Better Business Case approach[3]:

- Smaller jobs will be managed by KiwiRail (as a part of their day-to-day maintenance, renewal and improvement of the network). All the minor work can be covered under the Activity Management Plan (AMP) process (<$2m).
- If renewals contain a significant component of improvement (i.e. not replacing like with like) then a business case may be required (depending on cost and complexity).
- Large scale interventions will likely need to progress through to a Detailed Business Case (DBC). This recognises that in many instances there are a range of alternatives that need to be explored before determining the most appropriate version of that investment to be made.
- A Single State Business Case (SSBC) Lite can be used for interventions that are within the $2m-$15m range, but only if the intervention is low-risk and low-complexity.
- Relatively simple programmes will be dealt with by means of a SSBC – by site, corridor or theme. In cases where a SSBC identifies a specific and/or difficult intervention that requires additional work, it may refer specific parts of the programme to a DBC. SSBCs will be used where there are economies of scale due to the problems and issues being similar for individual projects.

It is expected that these business cases will be procured through a mix of direct appointment, invited tender, and open tender, depending on the scale of the project. The business cases will determine how each project will be specifically funded and its delivery managed, recognising that KiwiRail does have considerable internal resource who design and deliver projects on the rail network on a day-to-day basis.

Procurement models

Procurement will comply with the KiwiRail Procurement Policy and Procurement Procedure which complies with the Government Rules of Sourcing. An extract of the KiwiRail procurement manual is attached below which sets out the procurement process.

17.2 Market supply and assessment

17.2.1 KiwiRail capacity

KiwiRail has internal capacity to undertake the following tasks:

- Track and track structures installation
- Procurement of rail, sleepers, ballast, track structures, lighting

The following tasks will require outsourcing:

- Earthworks
- Track formation
- Drainage
- Marine works
- Bridge structures, maintenance, and protection.

[2] Procurement procedures can be found here: https://www.kiwirail.co.nz/assets/Procurement-Procedures-Manual_ver8-18-02-2022-Published.pdf

[3] Note: KiwiRail have agreed to follow Waka Kotahi's procedures, but as not bound by them

17.2.2 Construction market supply

KiwiRail consider that much of the programme can be delivered by the existing contractor market, with or without KiwiRail support. There is however limited capacity in specialist fields such as signalling and track design.

For most of this programme KiwiRail is well positioned to procure the required services that fall within the capabilities of the existing contractor market, delivered wholly by or in part in conjunction with KiwiRail.

Auckland's City Rail Link and associated projects, which represent the largest segment of the rail construction capacity in the country, are currently projected for completion in 2024. This date aligns with the timing of the initial three-year programme that targets the highest risk areas.

17.3 Potential for risk sharing

The procurement process sets out a process to select the tendering process based on the scope, constraints, and risks of the package of work. Opportunities for risk sharing forms of procurement will be considered as part of this process.

17.4 Consenting

Following completing a planning assessment of the proposed interventions a consenting strategy will be developed for any DBC that emerges. The purpose of the consenting strategy is to recommend the approach to attaining consents and confirming any designation giving consideration to (amongst other things):

- What planning documents are relevant to the Project;
- The activity status of any activities that will require resource consent consents;
- Whether any aspects of the Project should be enabled by way of designation as opposed to resource consent;
- The range of technical inputs required;
- Likely issues that will need to be addressed through the consenting process and the recommended course of action to address these issues;
- Recommendations on the approach to Notification (Limited or Public nor non) including consideration and identification of potentially affected parties.

One of the key issues to determine is if the works involve designating third party land, or there are significant effects or involves a new discharge as this would also need to include preparation of assessment of alternatives to fulfil the RMA's requirements.

KiwiRail will need to agree to the process that will be followed.

Designations

Interventions undertaken within a designation will be expected to be enabled through an Outline Plan under 176A of the Resource Management Act 1991 (RMA). An Outline Plan must show—

- the height, shape, and bulk of the public work, project, or work; and
- the location on the site of the public work, project, or work; and
- the likely finished contour of the site; and
- the vehicular access, circulation, and the provision for parking; and
- the landscaping proposed; and
- any other matters to avoid, remedy, or mitigate any adverse effects on the environment.

The Outline Plan cannot be refused or altered by the territorial authority but it can ask KiwiRail to make changes to it. If KiwiRail refused to change the Outline Plan, the only recourse the territorial authority has is to the Environment Court.

It is anticipated that most interventions will be undertaken within the rail designation, however it will potentially be necessary to alter the designation where they fall outside of the designation, necessitating lodging of a Notice of Requirement. to the relevant territorial authority to alter the designation. A Notice of Requirement will outline the spatial extent of the new or altered designation and outline the works proposed and may include where and if appropriate designation conditions. The Notice would be supported by an Assessment of Environmental Effects and any relevant technical assessments necessary to assess the work (typically construction related noise and vibration, visual and landscape, ecological and archaeological, and construction traffic).

Resource Consents

Some interventions will trigger the need for regional consents (under regional plans, regional coastal plans and the National Environmental Standards for Freshwater 2020) as they may involve work or discharges that could impact

natural resources such as the coastal marine area (CMA)[4], streams and rivers, wetlands and could result in contaminants being discharged into air or water.

The relevant regional planning documents have a multitude of objectives and policies that include protectionist or avoidance requirements. This has significant implications for the consenting of infrastructure projects that are likely to require non-complying activity regional resource consents.

Potential activities that are high risk, from a consenting perspective, are:

- The removal of vegetation in sensitive locations such as coastal environments e.g mangroves, in wetlands, streams, and rivers.
- Bulk earthworks and discharges of sediment that may impact on wetlands, streams, rivers and the CMA or change the flow of streams and rivers and overland flow paths.
- New stormwater discharges from impervious surfaces into rivers and coastal waters or to land from roads, driveways and parking lots or heavily compacted soils or rocks.
-
- Disturbance of the river or seabed and new structures in the bed such as bridge abutments or rock armoring
- The placement of structures such as culverts in rivers with effects on fish passage.

It is also anticipated that earthworks in some locations will require investigation into the potential for contaminated soils to be disturbed and may require resource consent m pursuant to the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health 2011.

Alternatives Assessment

Under the RMA, an “alternatives assessment” is required when seeking resource consent for projects with the potential to have significant adverse effects and when seeking a Notice of Requirement. The consideration of alternative routes, sites and methods is relevant where new designations are proposed that affect land not owned by KiwiRail and that may have significant adverse effects and of alternative methods for discharge permit or coastal permit applications. Various past court decisions have emphasised that the focus of the alternatives assessment should be on the adequacy of the assessment process rather than the outcome. The selection of an option must be based on a robust, definable, transparent and repeatable process but does not have to be exhaustive, in that not every viable option has to be considered. KiwiRail does not have to have selected the best option but has to be satisfied that the process of assessing the option was adequate.

There are several similarities in the drivers and principles applying to alternatives assessment under the RMA and the business case process that has been followed to date but they are not totally aligned. To reduce the risk, consideration of key RMA directions and iwi and stakeholder engagement should be included along with appropriate alignment of RMA and investment objectives.

At each subsequent stage, a process of identifying and evaluating alternatives by first ensuring that the specific problem is clearly defined and verified through evidence at the outset will need to be undertaken, commensurate with the level of detail at that stage. The site selection, site layout and concept designation steps will involve consideration of impacts on the existing natural and built environment, as well as social and cultural values. To satisfy requirements under the RMA, the criteria should:

- focus on the key resource management issues relevant to the proposal, i.e., environmental, cultural and social issues;
- pay particular attention to relevant part 2 RMA matters; and
- integrate those values that are “protected” by resource management policy statement and plan provisions.

Integral to assessing alternatives is considering any relevant resource management policy statements and plans that have established high regulatory “hurdles”. Identifying any provisions that establish effects management hierarchies that in the first instance seek to avoid certain areas or adverse effects on specific values may be critical for some parts of KiwiRail’s infrastructure.

Engagement with tangata whenua and stakeholders is critical to understanding the available alternatives and their effects and future processes that are location based should include iwi from the start and stakeholders (and sometimes community representatives) at assessment workshops to ensure a full range of ideas is canvassed and that robust discussion and assessment occurs.

[4] means the foreshore, seabed, and coastal water, and the air space above the water—between the outer limits of the territorial sea and the line of mean high water springs, except that where that line crosses a river, the landward boundary at that point shall be whichever is the lesser of— 1 kilometre upstream from the mouth of the river; or the point upstream that is calculated by multiplying the width of the river mouth by 5.

RMA reform

It is noted that at the time of preparing this content the Government has proposed to replace the RMA with three replacement statutes and the Environment Select Committee reported back their changes to two of the three (the Natural and Built Environment and the Spatial Planning Bills) on 27 June 2023.

The new system is expected to include:

- The introduction of regional spatial strategies
- Fewer RMA plans across New Zealand (reduced from 100 to 16) in time
- Retention of the ability to designate and use Outline Plans
- more permitted activities
- Enabling development within environmental limits
- Achieving better environmental outcomes, limits and targets (rather than effects-based management, which has not adequately guarded against cumulative effects like declining water quality and climate emissions)
- Fast track consenting

In addition, the National Policy Statement for Indigenous Biodiversity has been introduced with a new layer of protection, which provides clear and consistent standards for identifying, managing, and protecting our native plants, animals, insects and birds across NZ, This will come into force on 4 August 2023 and will be implemented over several years.

With these changes in place some of the relevant resource management policy statements and plans will be changed but the bulk of the interventions in the 1-10 year programme will potentially be consented under the existing plans. Consultation and Engagement

As KiwiRail is a e State Owned Enterprise and it is expected that projects will be delivered in partnership or with the active engagement of mana whenua. Collaboration with mana whenua at the early stages of a project is important to ensure a partnership approach is taken to honour Te Tiriti o Waitangi - The Treaty of Waitangi. Mana whenua will potentially be asked to provide a Cultural Values Assessment to outline the effects of the project on iwi values. Where any proposal is in the CMA before making the resource consent application to a regional council it is expected that KiwiRail will have:

- Checked to see if any applications have been made for Customary Marine Title under the Marine and Coastal Areas (Takutai Moana) Act 2011
- Identified which iwi groups have applied for Customary Marine Title in the area affected by the resource consent application.
- Notified the iwi groups and 'sought their views' on the application.
- Provided with the consent application any views expressed by the iwi group .

Engagement with other affected parties and the wider public will be undertaken as appropriate to each individual project.

17.5 Property

Property strategies will be developed by each of the subsequent business cases once the extent of any required property requirement is determined. There may be areas where Heritage NZ will become a key partner for isolated projects within the programme.

18 Management Case

The purpose of the management case is to describe the arrangements that will be put in place for the successful delivery of the programme.

18.1 Programme management and governance

18.1.1 RNIP Governance Group

The scope, delivery, and change management is monitored and governed by the RNIP Governance Group. The diagram below outlines the current governance which includes the KiwiRail Board and the Rail Network Investment Programme (RNIP) Governance Board (RGB).

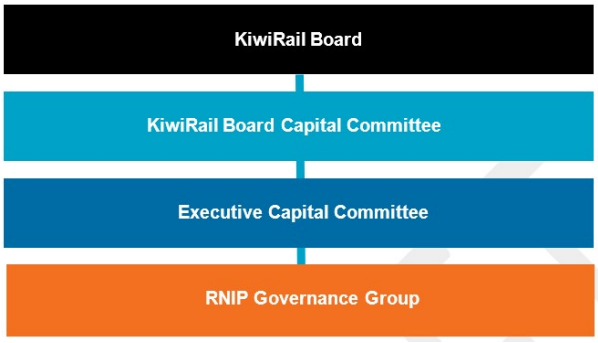


Figure 37: RNIP Governance Structure

The programme governance structure and coverage are dynamic and will evolve over time.

The purpose of the RGB is to maintain programme wide oversight and direction over the investment packages (sub-programmes) to achieve the objectives defined in the RNIP and/or approved business cases. It will provide good stewardship over programme performance, and it will ensure that physical infrastructure assets, KiwiRail people, and safety are at the centre of all considerations by the programme.

The ECC is the governance body responsible for monitoring progress and resolving issues that may compromise delivery and benefit realisation.

The ECC will hold financial delegation (according to the KiwiRail's Financial Delegations) at the direction of the RNIP Governance Board (RGB) and will escalate programme matters and support organisational directives through effective engagement across the business.

Key responsibilities

Key responsibilities of the RGB include:

- Providing direction in relation to programme benefits and objectives, to align the focus of the sub-programmes and projects with the overall business goals and advising on communications regarding overall programme progress.
- Reviewing and providing recommendations for progress reports, forecasts and payment requests.
- Determining whether to approve or recommend change requests within the delegation provided from the Executive Capital Committee.
- Project stage gates recommendations and approvals.
- A forum for escalation of key programme risks and issues, providing recommendation and support for resolution, further escalation, or acceptance.
- Monitoring programme performance against defined and agreed programme, scope and budget and enabling support to be provided to achieve objectives where required.
- Manage dependencies and competing priorities between sub-programmes, projects and BAU activities to provide direction on priorities to the delivery and operations teams, including ensuring any limited resources are managed effectively and efficiently.
- Health, Safety and Environmental monitoring across the programme and providing direction in relation to compliance with legislative requirements, quality systems and standards.
- Provide formal communication from higher level governance groups (ECC and KiwiRail Board)

Change requests

While the work programme can be amended within the triennium, we need to ensure that:

- The overall programme has appropriate governance and change control processes.

- The work programme remains aligned with agreed RNIP Network Measures (KPIs).
- We can demonstrate that we are actively managing our below-rail expenditure consistent with our objectives.
- We can meet our reporting obligations under the RNIP.

The RGB meet to review the recommendations provided and decide whether to approve change requests comprising expenditure of:

- Up to $5m (for changes within an asset class); or
- $2.5m (for changes between asset classes).

For change requests that exceed the levels defined above, the RGB will provide or decline support rather than approval. Where supported, the proposal will proceed to the next level. The RGB may also seek additional information/clarification or provide conditional approval. They may also decide to push the decision up a level at their discretion.

The RGB will also decide whether to approve change requests involving changes to scope or timeline where these are escalated by the Group Managers.

18.1.2 Partners

The success of the programme will require partnering and engagement with Waka Kotahi. The Governance Group will ideally convene and report regularly to ensure that these organisations are kept informed and provide the means for determining the degree of their involvement at the programme level and in individual projects. This involvement could include governance-level involvement of representatives of these organisations, even if just in an advisory or observational capacity. Decisions around programme-level involvement will be made at the earliest opportunity.

No new reporting arrangements are proposed. Information on Waka Kotahi's statutory reporting and monitoring requirements can be found on KiwiRail's website[5].

18.2 Key roles and responsibilities

Key roles and responsibilities, along with decisions on any need for external assistance, will need to be determined for each of the subsequent business cases as required on a case-by-case basis. Typically, each business case will require a project manager and technical lead from KiwiRail. A role that has oversight over the programme of business cases would be prudent.

18.3 Outline programme plan

Individual projects have been identified for treatment via the preferred programme recommendation. The next steps are to further develop these projects though more detailed analysis and planning. Single stage business cases will likely be utilised covering elements in greater detail than a programme business case, such as property, consenting, engagement, design, risk and cost.

Key programme milestones are listed in Table 30.

Table 30: Programme Plan Milestone

Proposed key milestones	Estimated timing
Finalise Resilience PBC	Sept 2023
Low-cost projects identified and included in regional three year programmes July 2024	July 2024 Regional delivery 2024-2026
DBCs / SSBCs for Criticality 1 (very high) risk sections of line (For the 1-3 year works)	Procured 2023/24 Completed late 2024
Detailed design of year 1-3 works	Early 2025
Pre-implementation and Construction of year 1-3 works	Late 2025 – late 2028
DBCs / SSBCs for Criticality 2 (high) risk sections of line (For the 4-10 year works)	Procured 2024/25 Completed late 2025
Detailed design of year 4-10 works	Early 2026
Pre-Implementation and Construction of year 4-10 works	Early 2027 – 2033

The proposed implementation date for each individual intervention is provided within **Appendix B.**

[5] https://www.kiwirail.co.nz/our-network/funding-our-network/rail-network-investment-programme/

18.4 Stakeholder engagement

Four organisations have been identified to be included in engagement within the next phase of this project:

- Waka Kotahi monitor management of the RNIP programme of works and are the regulator of the network.
- Mana whenua and local iwi
- The Ministry of Transport receive and assess recommendations on the funding application.
- Auckland Transport and Greater Wellington Regional Council will be engaged where resilience programme affects operation of the main line.

18.5 Benefits realisation management

Table 31 contains the proposed Benefits Management Plan, which identifies who is responsible for monitoring each benefit and what information sources to use. It is proposed that KiwiRail monitor all benefits. The monitoring of benefits realised could help to demonstrate the value of investment in rail and may help aid future funding applications.

Table 31: Benefit Monitoring

Benefit (Investment Objective)	Responsibilities	Actions to realise benefits
Address 75% of the extreme resilience risks in the next 10 years	KiwiRail	• Update of risk framework (or mapping of high-risk areas) post any major events or new information (e.g. from site inspections) • Monitoring of high-risk areas • Post implementation monitoring following the completion of various interventions. • Update action plan/works programme annually to ensure it remains relevant according to what are the highest risk areas (which may change)
Address 75% of the high resilience risks in the next 30 years	KiwiRail	
Provide reliable access to 50% of high-risk resilience areas in the next 30 years	KiwiRail	• GIS Mapping of risk locations and access points • Matrix of access options per high-risk area

18.6 Risk management

Risk management is undertaken in accordance with the KiwiRail Enterprise risk management policy. Table 32 summarises the programme risks, with mitigation measures and the residual threat/opportunity ratings included.

Threat and opportunity ratings were determined with reference to Waka Kotahi's Risk Management Practice Guide (Minimum Standard Z/44). KiwiRail is the risk owner for all risks related to this programme.

Table 32: High Residual Risks

Main risks	Mitigation strategy	Risk level
Implementation		
Physical works delayed due to parts shortage or the inability to source the required materials	Early development of supply chains for common works. Early engagement with suppliers of specialist materials. Design physical works to utilise local and common materials.	High
Physical works delayed due to the identification of unforeseen contaminated land	Involve contaminated land specialists in projects early to identify and minimise potential contaminated land issues. Likely resulting in removal to a specialist dump site or on-site processing	High
Physical works cause unforeseen ground subsidence resulting in derailments or other disruption	Early involvement of specialist geotechnical engineers in projects to identify and minimise potential issues.	High
Financial		
Investment cashflow is not available when required	Governance group to communicate with investing organisations and central government frequently so they understand cashflow requirements; prioritise the most impactful interventions; adjust intervention delivery timing, as necessary.	High
Additional investment required or investment sources are not available	Governance group to communicate with investing organisations and central government frequently so they understand the investment requirements.	High
Cost increases	Refine cost estimates of interventions as they are further developed through subsequent business cases; communicate changes to investors.	High

Main risks	Mitigation strategy	Risk level
Funding availability – national funding constraints mean that less than 100% of the programme funding is committed.	A review of the programme (timeframe for implementation of various interventions) would be required. Note that the programme targets protection of high-risk areas in the first instance, which means that the programme maximises benefit to within any potential funding constraint (i.e. makes the most out of the money available)	High
Planning		
Consenting delays or prevents outcomes	Involve planners and environmental specialists in projects early to identify and minimise potential consenting issues. Likely resulting by means of discharges to water and contaminated land.	High
Iwi concerns with required projects	Engage with tangata whenua early and work collaboratively to develop solutions.	Medium
Delivery		
Long lead times delay the delivery of outcomes	Educate investors about the long lead times associated with rail projects; commence planning and procurement early.	High
Delays due to interdependencies of programme elements	Communicate with lead organisations to minimise potential knock-on effects; carefully select governance group members to establish a champion of PBC projects within partner organisations.	High
Market capability and capacity delay delivery	Consider the timing of other major projects when timing the delivery of interventions; understand supplier availability by requesting expressions of interest.	Medium
General delay to programme implementation	If the programme is delayed (e.g. due to reprioritisation of various programmes, such as renewals (or otherwise) the risk is that the overall cost to KiwiRail could be more over the long term. I.e. more short-term maintenance or mitigation works. Mitigation is for KiwiRail to confirm priorities through the RNIP 2.0, with consideration of the impacts of 'doing nothing' in the short-term	High
Programme scope		
New major weather event cause major damage to parts of the network not captured by the programme and funding needs to be reallocated.	Monitor programme impacts and determine if emergency / reinstatement works are part of the RNIP programme where funding can be brought forward. Wholly new areas of service loss will require a reassessment of the programme to determine the level of re-prioritisation and reallocation of funds	High

19 Next Steps

This PBC provides a clear investment pathway for New Zealand's rail system, which will enable achievement of important objectives and provide significant value for investors.

It is therefore recommended that decision-makers:

- Approve the investment programme as outlined in this business case, and commit to the associated investment requirements and timeframes, subject to the outcome of further business cases and other investigations.
- Approve funding of the first three-year stage of the programme, which includes a series of further business cases and other investigations that will determine the optimal solution for and timing of key elements of the programme, particularly the rail capital components.