Business Case for Investment in State Highway Maintenance and Operations 2018-21

New Zealand Transport Agency

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More information

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If you have further queries, call our contact centre on 0800 699 000 or write to us:

NZ Transport Agency
Private Bag 6995
Wellington 6141

This document is available from the NZ Transport Agency on request.

Approval

Prepared by	Reviewed by	Endorsed by	Endorsed by
	Project manager	Project sponsor	Investment reviewer
Just Add Lime	Samuel Grave	David Darwin	Mark Yaxley
Date: 31 July 2017	Date:	Date:	Date:

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Executive summary

Globally the transport system is on the cusp of a revolution. Customers and businesses want access to easier, more personalised and reliable transport services. Our transport system needs to connect people, businesses, services from across New Zealand to support economic prosperity and social wellbeing.

As the backbone to New Zealand's land transport system, the state highway network has a critical role in enabling access to our cities and regions, and enabling people and goods to move within their communities and to markets. Maintaining and operating the state highway network to the right customer levels of service is critical to the functionality of the transport system.

The state highway network makes up 12 percent of New Zealand's roading network and carries 55 percent of all vehicle journeys and 70 percent of all freight journeys. This amounts to 243 million person kilometres each year travelling on the state highway network.

As the custodian of the state highway network, the Transport Agency has a critical role to invest, maintain, operate, and improve the state highway network. The Transport Agency needs to do this is a way that optimises the whole land transport system for the benefit of all New Zealanders.

This detailed business case sets out the case for investment in maintenance, renewal and operational activities proposed on the state highway network as part of the 2018-21 National Land Transport Programme. It presents a more detailed case for investment in maintenance, renewals and operational activities than that presented in the overarching investment proposal for total investment in state highways as set out in the 2018-21 State Highway Investment Proposal (SHIP). As such it should be read together with the State Highway Investment Proposal.

The One Network Road Classification (ONRC) framework is used throughout this business case because it provides a national standard for road activity management to help ensure consistency and equity across New Zealand's Road Controlling Authorities. As such it makes a useful frame for this business case as well as providing a performance management framework.

This business case is organised around an adaptation of ONRC customer level of service. A detailed maintenance and operations programme for each service categorisation is provided. The categorisations and what they set out to achieve are:

- **Access and resilience** – customers and citizens can reach their destination reliably, today, tomorrow and the day after.
- **Travel time reliability** – customers and citizens are able to make timely and informed decisions about their journeys as expected.
- **Safety** – customers and citizens can travel safely on the land transport network.
- **Amenity** – customers and citizens have comfortable and pleasant journeys on our network.

Underpinning this business case is the detailed corridor management plans (CMPs) that have been developed. The CMPS include identification of any levels of service gaps for individual corridors and describe this in a pressure, state, response format. The same format has been applied for this business case where each customer level of service category contains a summary of the pressures, state, and proposed response.

Developing the maintenance and operations business case in this way means the Transport Agency can prioritise and target the most significant gaps on the state highway network, as well as propose future investment to close gaps not yet being addressed.

During the 2015-18 NLTP we deliberately reduced the costs of maintaining the state highway network: for example by ensuring that we only intervene at the right time with the right treatment we have tensioned our reseals and pavement rehabilitation programme significantly, as well as continuously chasing efficiency gains across all activities. Our recent levels of maintenance and renewal activities, whilst low, have been sufficient to maintain the network in a constant good condition in most aspects.

The funding request for the maintenance programme for the 2018-21 NLTP is larger than that of the 2015-18 period for the following reasons:

- An increasing proportion of the state highway network is reaching the end of its service life, requiring a much larger reseals and pavement renewals programme compared to the previous one
- Significant increase in activities and operations due a large number of capital projects and safety improvements delivered in the past decade (many more assets need to be maintained and operated at a higher cost due to the increased complexity of the network)
- Increased demand (including growth in heavy vehicles, commuters and tourists)

The increase in scope and complexity of activities to maintain and operate the state highway network is significant. For example, with the opening of Waterview tunnels there is a $13 million increase per year to maintenance and operation expenditure (over 2% of our total funding request). Consequently, this means that an increase in the investment is necessary to continue providing appropriate ONRC customer levels of service on the state highway network. As such this business case outlines the rationale for an investment of $1.79 billion over 2018-21 (excluding provision for emergency works).

Within the core programme the Transport Agency will continue to drive tension in the programme and on ourselves to deliver value for money. Within the total bid the Transport Agency have assumed two percent year on year cost savings will be achieved through value for money initiatives; this adds up to $80m of savings over 3 years.

Part A – Context to the proposal

Introduction

The transport system is on the cusp of a revolution – customers and businesses want access to faster, easier and personalised transport services. New Zealand's transport system supports economic prosperity and social wellbeing by connecting people, services, and business. As the backbone to New Zealand's land transport system, the state highway network has a critical role in providing access to cities and regions and enabling people and goods to move within their communities and markets.

The state highway network makes up 12 percent of New Zealand's roading network, it carries 55 percent of all vehicle journeys and 70 percent of all freight journeys. This amounts to 243 million person kilometres each year. As the custodian of the state highway network, the Transport Agency's role is to invest to maintain, operate, and improve the state highway network in a way that optimises the whole land transport system for the benefit of all New Zealanders.

This detailed business case sets out the case for investment in maintenance, renewal and operational activities proposed on the state highway network as part of the 2018-21 National Land Transport Programme. It presents a more detailed case for investment in maintenance, renewals and operational activities than that presented in the overarching investment proposal for total investment in state highways as set out in the 2018-21 *State Highway Investment Proposal*. As such it should be read together with the *State Highway Investment Proposal*.

One Network Road Classification

This detailed business case sets out the rationale for investment in the maintenance and operations of the state highway network. The business case is organised around an adaptation of the One Network Road Classification (ONRC) customer level of service. As such there is a detailed maintenance and operations programme for each service categorisation. The categorisations and what they set out to achieve are:

- **Access and resilience** – customers and citizens can reach their destination reliably, today, tomorrow and the day after.
- **Travel time reliability** – customers and citizens are able to make timely and informed decisions about their journeys on our network.
- **Safety** – customers and citizens can travel safely on the land transport network.
- **Amenity** – customers and citizens have comfortable and pleasant journeys on our network.

Government direction

The *Government Policy Statement on Land Transport* (the GPS) outlines the government's strategy to guide land transport investment over the next 10 years. It also provides guidance to decision-makers about where the government will focus resources. The Land Transport Management Act 2003, sets out the scope, and requirements for the government policy statement.

The policy statement influences decisions on how money from the National Land Transport Fund (NLTF) will be invested across activity classes. It guides the NZ Transport Agency and local government on the type of activities that should be included in Regional Land Transport Plans (RLTPs) and the National Land Transport Programme (NLTP).

Draft Government Policy Statement 2018

In developing the 2018–28 Government policy statement for land transport investment, the Ministry of Transport released a draft for consultation in February 2017. The draft strategic priorities are:

- **Economic growth and productivity** by focusing on high quality transport connections, increasing capacity, areas of high urban growth, regional economic development and tourism.
- **Road safety investment**, taking direction from the Safer Journeys strategy 2010 and the associated safer journeys action plans.
- **Value for money** in transport, delivering the right infrastructure and services to the right level at the best cost.

Supporting the strategic priorities are six national land transport objectives intended to deliver a land transport system that:

- addresses current and future demand for access to economic and social opportunities
- is resilient
- is a safe system, increasingly free of death and serious injury
- delivers the right infrastructure and services to the right level at the best cost
- provides appropriate transport choices
- increasingly mitigates the effects of land transport on the environment.

The Transport Agency gives effect to the direction outlined in the GPS through its strategy and strategic responses.

NZ Transport Agency's strategy[1]

The Transport Agency gives effect to the Land Transport Management Act 2013, the GPS on Land Transport, and wider government policy, and contributes to the desired transport system outcomes through its organisational strategy.

The Transport Agency's value statement is our unique offering to our customers and New Zealand. We contribute great journeys to keep New Zealand moving. Our focus is to give effect to the government's policy direction by providing one integrated land transport system that enables people to get the most out of life and support business.

We, with our partners, invest, maintain, operate, and improve the national transport system for today and tomorrow. The relationship between us and our partners is fundamental to providing an integrated, safe and connected transport system that enables customers and goods to move.

The Transport Agency's three strategic responses provide the direction we will take to deliver value to New Zealand. They are the three changes we will need to make in the next five years to deliver what is expected of us and ensure customers and citizens benefit from the rapid changes happening to transport. Our three strategic responses are:

- one connected transport system
- people centred services
- partnerships for prosperity.

[1] http://nzta.govt.nz/resources/nz-transport-agency-statement-of-intent-soi-2017-21

Our strategic responses are underpinned by eight focus areas that provide direction for our efforts and resources to ensure we deliver measurable outcomes for our customers and citizens.

The GPS and strategy provide the high-level direction for the maintenance and operations programme, while the One Network Road Classification customer levels of service are used to prioritise gaps on the state highway network and deliver the right effort to address those gaps. The system is described below.

One Network Road Classification

The Road Efficiency Group (REG) was formed in 2012 as a collaborative project between local government and Transport Agency to implement the One Network Road Classification[2] framework. The classification considers the needs of all road users, be they motorists, cyclists or pedestrians. It will give road users more consistencyand certainty about what standard and services to expect on the national road network, including the most appropriate safety features. It will also help New Zealand to plan, invest in, maintain and operate the road network in a more strategic, consistent and affordable way using a robust, impartial, nationally consistent tool. As the classification is implemented customers will see an increase in the quality of some roads, and a decrease in others that have been over-specified in the past.

The One Network Road Classification divides New Zealand's roads into six categories based on how busy they are, whether they connect to important destinations, or are the only route available.

The six road categories are based on 10 criteria on the function of the road as a link and place maker. To be included in a particular category, a road must meet the agreed criteria and thresholds, including at least one of either – typical daily traffic (AADT), heavy commercial vehicles (HCV), or bus (urban peak) as appropriate.

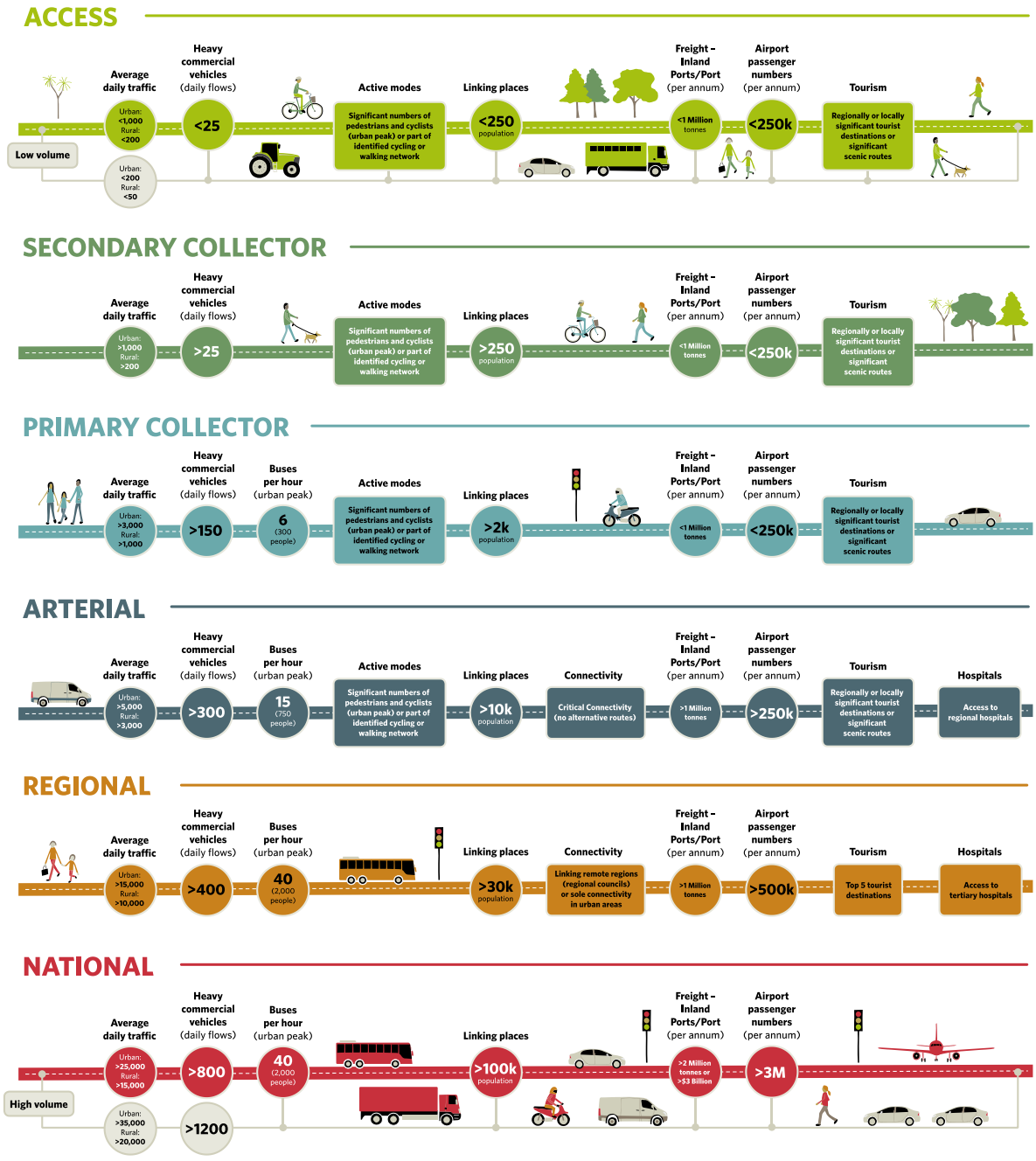
For each road category, there are customer levels of service (customer LOS) which set out what customer can expect on that road. For example, for a national Strategic road, customers can expect a greater level of access and resilience, travel time reliability, safety and amenity compared to an access road. To accompany the customer LOS there are three other types of performance measures including:

1. **Customer outcomes** – are intended to demonstrate how we are performing from the view of our customers. They quantify our progress against what is meaningful to our customers
2. **Technical output** – are intended to allow us to quantify the impact of the works undertaken on the state highway network and support the customer outcomes. These measures are expressed in technical terms intended for our internal personnel and associated contractors / consultants
3. **Cost efficiency** –allow us to ensure that we are delivering our targeted customer outcomes and technical outputs in an efficient manner

These performance measures form a core element of our proposed performance measurement for this business case.

[2] https://www.nzta.govt.nz/roads-and-rail/road-efficiency-group/onrc/

The One Network Road Classification



When reviewing our asset management activities with a view to develop a customer outcomes story, we found that it was sensible to link activities to the following outcomes:

- **access and resilience** – customers and citizens want to reach their destinations reliably – today, tomorrow and the day after
- **travel time reliability** – customers and citizens are able to make timely and informed decisions about their journeys on our network
- **safety** – customers and citizens can travel safely on the land transport system
- **amenity** – customers and citizens have comfortable and pleasant journeys on our network

The table below sets out an adaptation of the customer level of service and the range of maintenance and operations activities that relate to each. Whilst maintenance activities have

been attributed to a key customer outcome in practice maintenance activities give effect to a range of outcomes which is also shown.

Customer level of service and maintenance and operations activities

	Service aspects	Access and resilience	Travel time and reliability	Safety	Amenity
Access & Resilience	Routine road repairs, resurfacing and pavement renewal	✓✓✓		✓✓	
	Bridge and structures maintenance and renewal	✓✓✓		✓	
	Scour management	✓✓✓		✓	
	Winter operations to clear ice and snow	✓✓✓	✓✓	✓✓	
	Drainage	✓✓✓		✓✓	✓
	Rockfall prevention	✓✓✓		✓	
	Seismic retrofit of structures	✓✓✓			
	Facilities management	✓✓✓		✓✓✓	✓

	Service aspects	Access and resilience	Travel time and reliability	Safety	Amenity
Travel Time Reliability	Provide travel information	✓✓✓	✓✓✓	✓✓	
	Event and incident management and response	✓✓✓	✓✓✓	✓✓	
	Network optimisation through TOCs	✓✓✓	✓✓✓	✓	

	Service aspects	Access and resilience	Travel time and reliability	Safety	Amenity
Safety	Skid resistant road surfacing	✓		✓✓✓	
	Delineation and hazard warnings		✓	✓✓✓	
	Vegetation control to maintain sightlines		✓	✓✓✓	✓
	Operating and maintaining tunnel ventilation and fire safety systems			✓✓✓	
	Lighting			✓✓✓	✓
	Cycle path maintenance			✓✓✓	✓✓

	Service aspects	Access and resilience	Travel time and reliability	Safety	Amenity
Amenity	Road roughness treatment				✓✓✓
	Litter, graffiti, rest area maintenance & amenity planting management				✓✓✓
	Pest plant, bio-diversity management, maintenance of water quality devices				✓✓✓

The service categories are used to organise the maintenance and renewal programme and this business case.

Maintenance and operations intervention triggers

The Transport Agency undertakes maintenance and renewals to ensure the effectiveness and efficiency of our operations and the value for money of the services we provide to our customers. We do this by right sizing our routine maintenance activities to meet our customer level of service targets. However, where we need to intervene we do so based on 4 key triggers:

- Service failure – either through excessive deterioration or failure of the asset.
- The Transport Agency determines that it is cheaper to undertake the activity now than in the future (using a net present value whole of life analysis) e.g. a low-cost intervention now may prevent the asset deteriorating to a point whereby a complex and costly intervention is required later.
- There is an opportunity to combine projects providing cost savings, benefits to customers and minimising disruption and travel time delay costs to road users.
- A cost saving opportunity arises by undertaking the works now e.g. replacing an old asset may allow a more efficient replacement to be installed, reducing operational costs such as electricity.

Assumptions underpinning our core programme

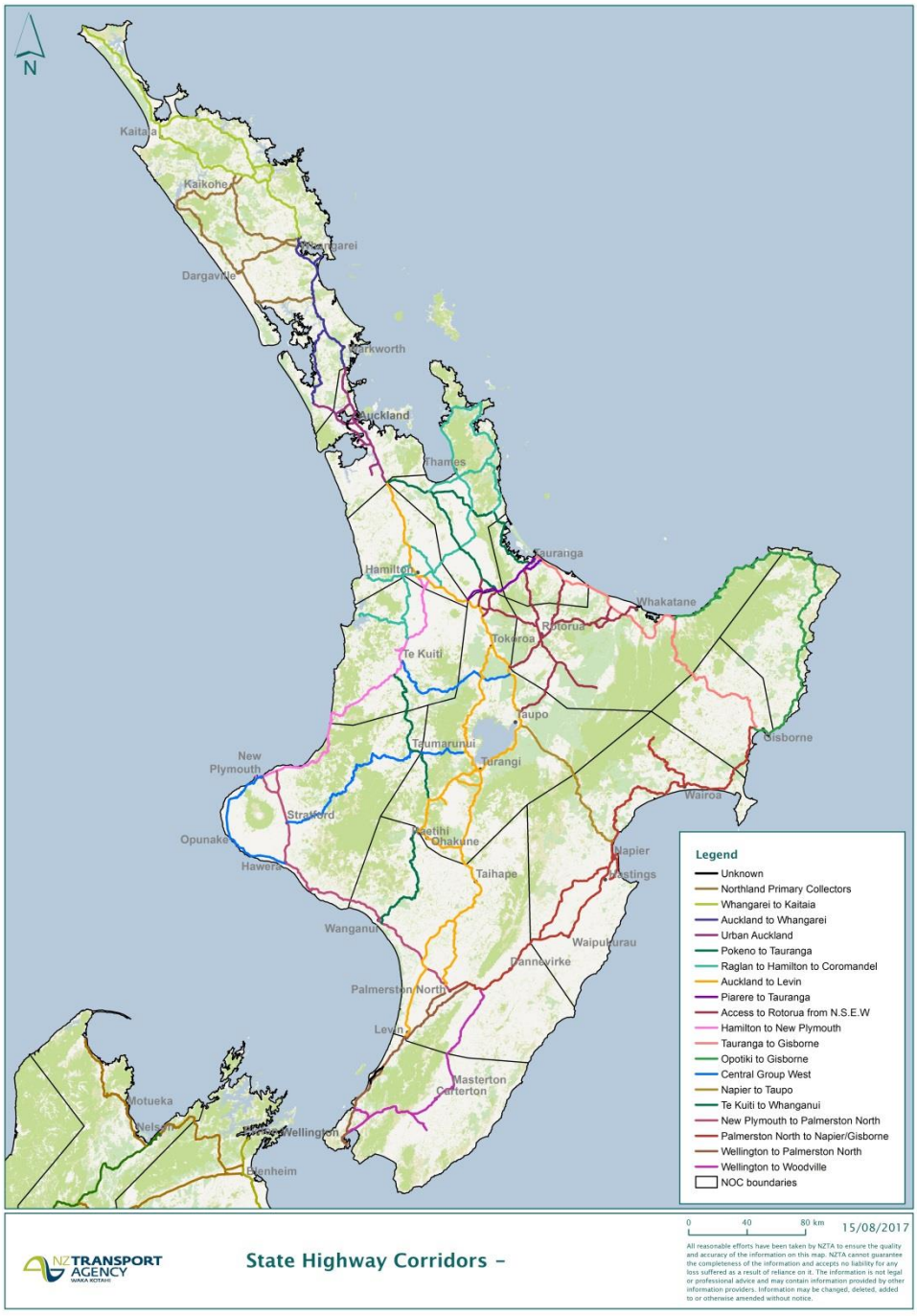
The following assumptions were made for the purpose of developing this business case and recommending the core programme:

- There will be no significant changes in the land transport strategic priorities and objectives set out in the Government Policy Statement.
- All costs are quoted as at June 2016 with an allowance for inflation included in future year costs. This allowance is consistent with the NLTP.
- There will be no increase in network length or configuration due to capital projects, with the exception of identified projects
- There will be no significant change in traffic mix i.e. assumed no increase in percentage of heavy vehicles (HPMV).
  Traffic volumes used in pavement modelling are based on current traffic volume growth projections of 2 percent per annum for rural areas and 3 percent per annum for urban areas. This is consistent with the draft Long Term Strategic View. (*Note: Technical papers hold more detailed modelling assumptions for the pavement renewal modelling*).

Corridor management plans

To assess the customer levels of service across the state highway network, the Transport Agency undertook a national programme of developing 30 corridor management plans (CMPs) for the first time. The 30 corridors are based around key journeys and other local connections as shown on the maps below. Presented below are the North Island and South Island state highway corridor networks for the corridor management plans.

North Island state highway corridor networks for the Corridor Management Plans



South Island state highway corridor networks for the Corridor Management Plans

The corridor management plans are an important tool for asset management as they provide a snapshot of current network performance, how the corridor fits within the transport system and the level of service gaps relative to the One Network Road Classification customer levels of service. As we get better at developing corridor management plans, we expect the process and outputs to improve over time.

The corridor management plans take a more holistic view of asset management. All the transport assets within a corridor are considered and how they collectively provide the levels of service expected by customers. This is a departure from considering asset classes and activities in isolation, and aligns planning more with customer journeys.

A simple four-point assessment has been used to assess the gaps on each corridor:

exceeds: the levels of service provided by the section of corridor for the activity under consideration exceeds what is required for a highway of that classification

good: the section of corridor generally meets the levels of service requirements for the activity and ONRC

average: The section of corridor meets some but not all of the levels of service requirements for the activity and ONRC classification

poor: The section of corridor generally fails the levels of service requirements for the activity and ONRC classification, or there is a significant gap in the levels of service for some aspects of the activity.

Developing the corridor management plans help provide a view of the level of maintenance, operations, and improvement investment that may be required to address the identified gaps.

In conjunction with the Long Term Strategic View (LTSV), corridor management plans provide a basis for engagement with key stakeholders and partners to shape the future of each corridor. The plans do this by developing the customer story and case for investment in maintenance, operations, and improvements to achieve the appropriate One Network Road Classification customer levels of service for the road classification. This is within the context of providing value for money and developing a baseline from which we can build on in the future.

Over time all roads should offer a customer level of service that is consistent with their classification and be fit for purpose. With the knowledge of current levels of service experienced by customers, the Transport Agency can better target investment to meet future intended service levels.

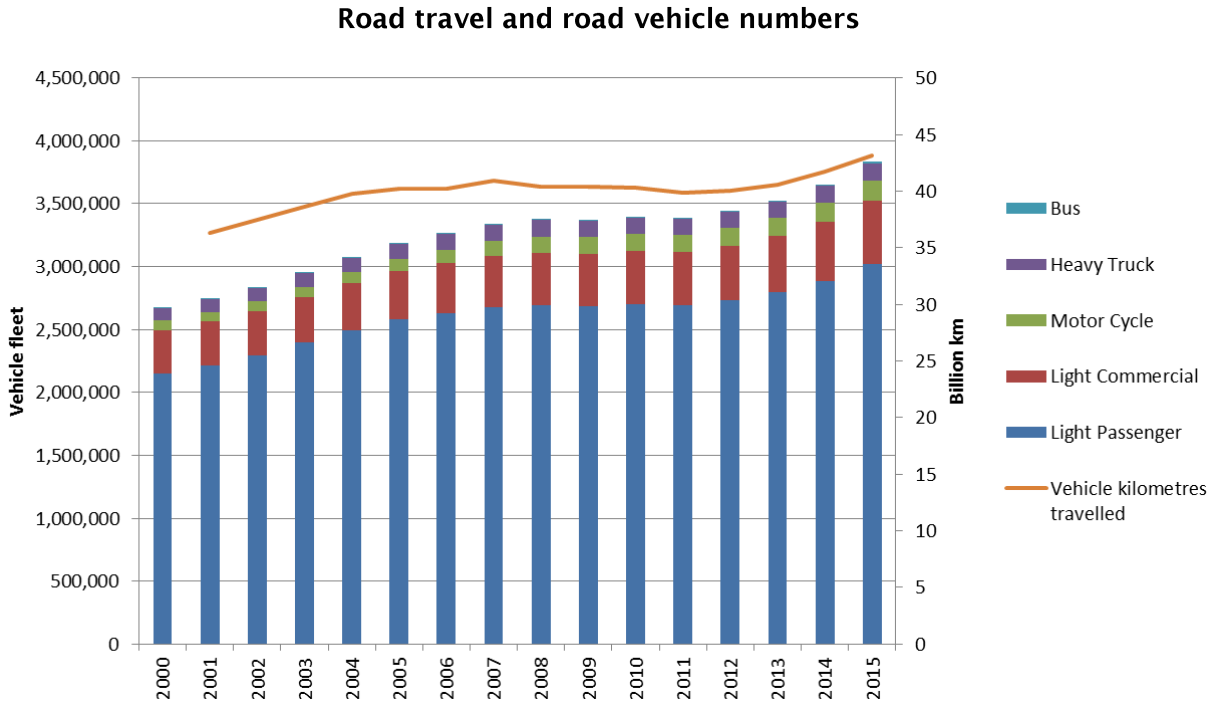
Part B – Network pressures on maintenance and operations

Transport networks require ongoing investment in maintenance and operations to continue being effective, efficient, safe, reliable and resilient. This part of the business case outlines some of the network pressures which are impacting customer service levels and drive our response to shape our core programme. Further information on the sectors view of drivers for changed can be found in the NZ Transport Agency's Long Term Strategic View.[3]

Network pressures

Network usage

Nationwide, over the last 15 years' vehicle numbers have risen by over 40 percent and total vehicle kilometres have increased by around 18 percent[4], as shown below.



Increasing traffic volumes and heavier vehicles in particular, place increased pressure on the durability of the State Highway pavement. The legislative change allowing high productivity motor vehicles to use the network has also contributed to increased pavement wear in some areas, resulting in shorter asset lives and thus accelerated replacement with associated additional cost.

[3] https://nzta.govt.nz/planning-and-investment/long-term-strategic-view/
[4] http://www.transport.govt.nz/ourwork/tmif/transport-volume/

High productivity motor vehicle network

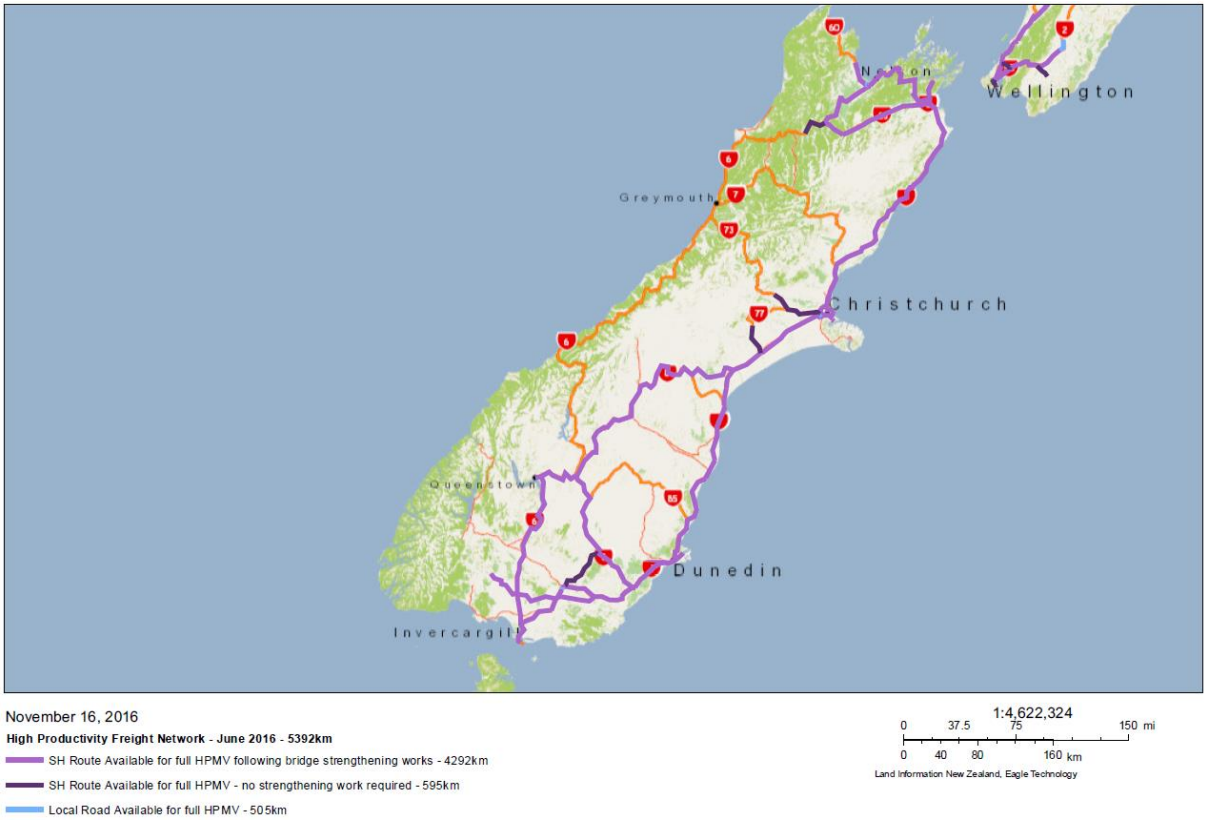
High productivity motor vehicles emerged following an amendment to the Land Transport Rule: Vehicle Dimensions and Mass in 2010. A key freight efficiency project is aiming to open up road and highway access for high productivity motor vehicles[5] (HPMV). This allows trucks heavier than 44 tonnes to use defined routes where demand and uptake is high, promoting freight efficiency with potential economic benefits for producers, customers and communities.

In addition to HPMV routes the Government has also introduced 50MAX permits. These permits allow even greater payloads to be carried but on dedicated trucks which have additional axels to reduce the overall wear and tear on pavements and structures to that of a comparable 44 tonne truck.

Both HPMV and 50MAX opens up 90 percent of roads to higher payloads which can significantly improve efficiency by moving more freight with fewer truck trips, but is only permitted if it can be done safely and on suitable routes. The Transport Agency has provided access to 5,392km of high-productivity freight network (as at June 2016), with a further 505km local roads available for full high-productivity motor vehicles. The maps below show these current state highways and local roads available for HPMV access.

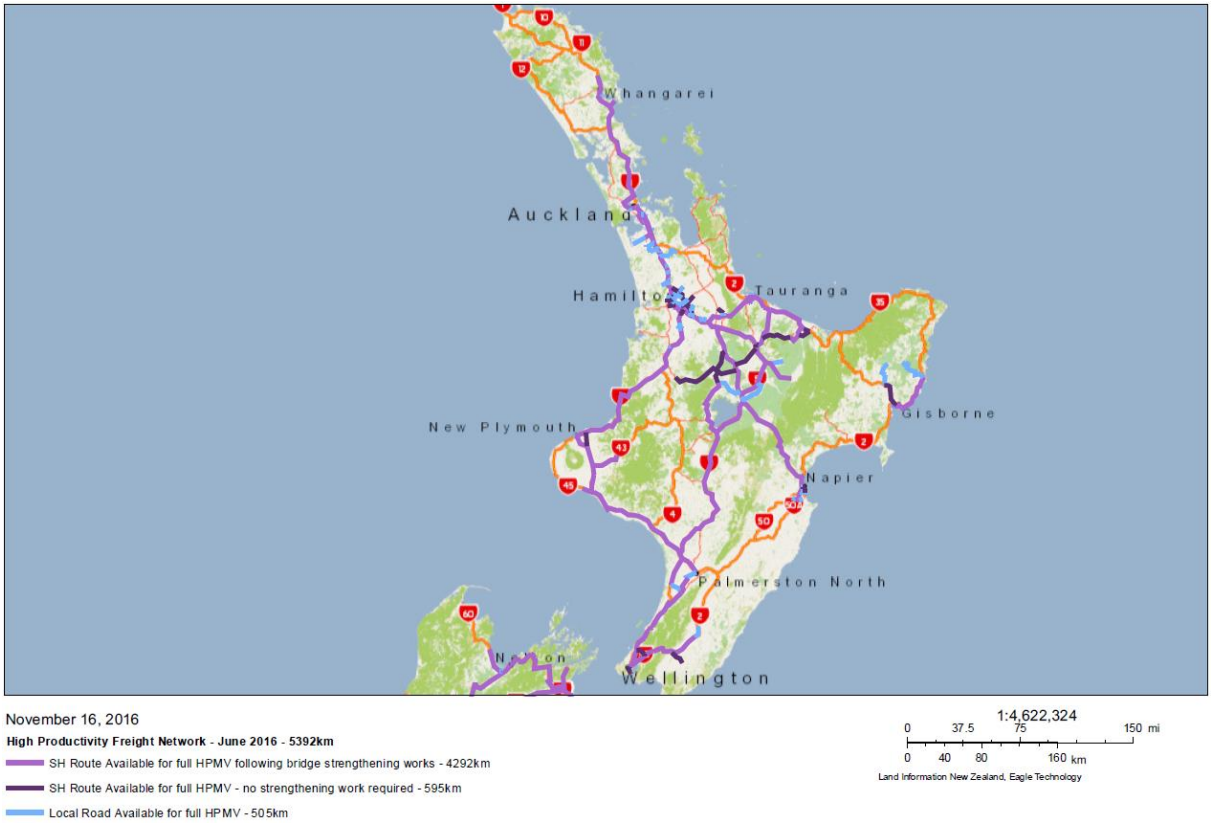
The uptake of high productivity motor vehicles is also encouraging industry to invest in newer, more efficient trucks that in general also have more advanced safety features including anti-lock braking systems and electronic stability control.

High productivity freight network (June 2016)



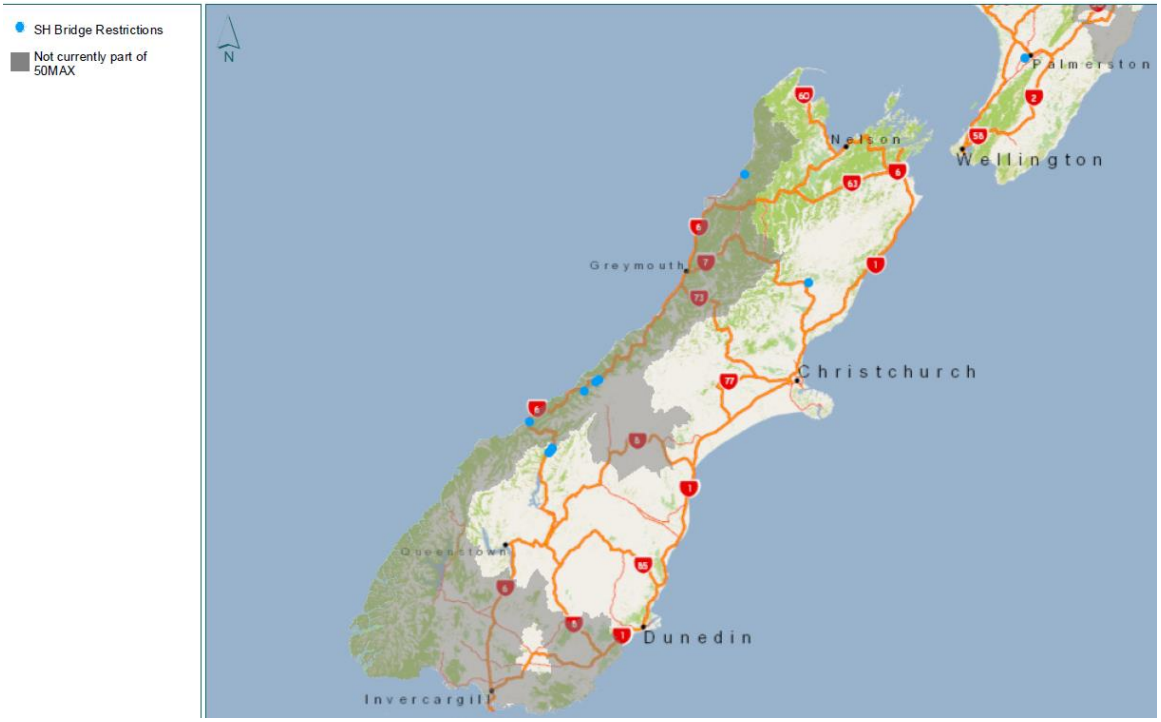
[5] http://www.nzta.govt.nz/commercial-driving/high-productivity/

High productivity freight network (June 2016)

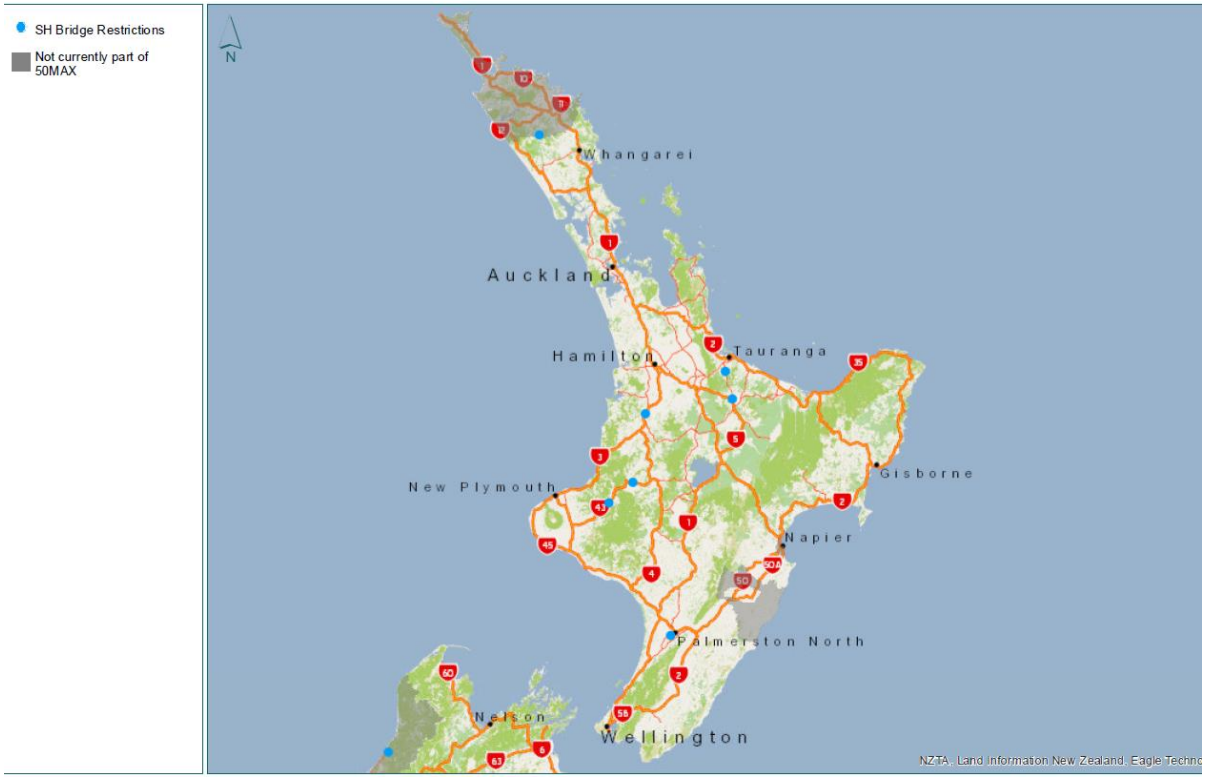


On the state highway network, we have 16 bridges with restrictions in place for 50MAX vehicles. The majority of these have alternative access arrangements in place to enable 50MAX vehicle access as necessary. The maps below show the location of the 16 bridge restrictions, together with those areas of the country not currently part of 50MAX.

State highway bridge restrictions



State highway bridge restrictions



Intermodal and integrated transport

Integrated transport views all transport as a single system and works to optimise options across all formats.

Intermodal freight transport involves the movement of freight in a container or vehicle, using multiple modes of transportation (e.g. rail, ship and truck), without any handling of the freight between modes. The benefits of intermodal freight transport include improved productivity and reduced numbers of trucks on the State Highway, leading to safety benefits, reduced CO2 emissions and a reduced deterioration of highways.

The Transport Agency is working with alternative transportation providers to deliver productivity initiatives, such as guidelines for intermodal hubs, vehicle innovation.

Intermodal passenger transport, also called mixed-mode commuting, involves using two or more modes of transportation in a journey. Mixed-mode commuting often relies on one type of rapid transit, such as regional rail, to which low-speed options (i.e. bus or bicycle) are added at the beginning or end of the journey. Other options include park-and-ride; however, so far this is only available in major metropolitan areas in New Zealand.

We will continue to work with local RCAs and public transport providers to enable intermodal transportation to increase the options available into our major cities and tourist destinations. This in turn will assist in reducing the peak traffic volumes on the State Highways around our main centres.

Electric vehicles

On 5 May 2016, the Government announced its electric vehicle uptake package, a cross-government programme of work that aims to accelerate the uptake of electric vehicles[6] in New Zealand to reach 64,000 vehicles by the end of 2021, reducing our greenhouse gas emissions.

As part of this programme, the Transport Agency has focused on enabling and supporting public charging infrastructure for electric vehicles by leading the development of nationwide guidance, to ensure safe, consistent access to, and usability of, the network and defining a vision for a nationwide public charging infrastructure network and identifying sites on state highways that could be suitable for charging infrastructure.

The Transport Agency will continue to work with the Ministry of Transport and wider sector to ensure that our activities are complementary to the future uptake of electric vehicles.

Autonomous vehicles

Vehicle automation can range from full autonomy, where no human intervention is required, to vehicles where human intervention may be required under certain conditions. Autonomous vehicles (AV) are also known as driverless or driver free vehicles.

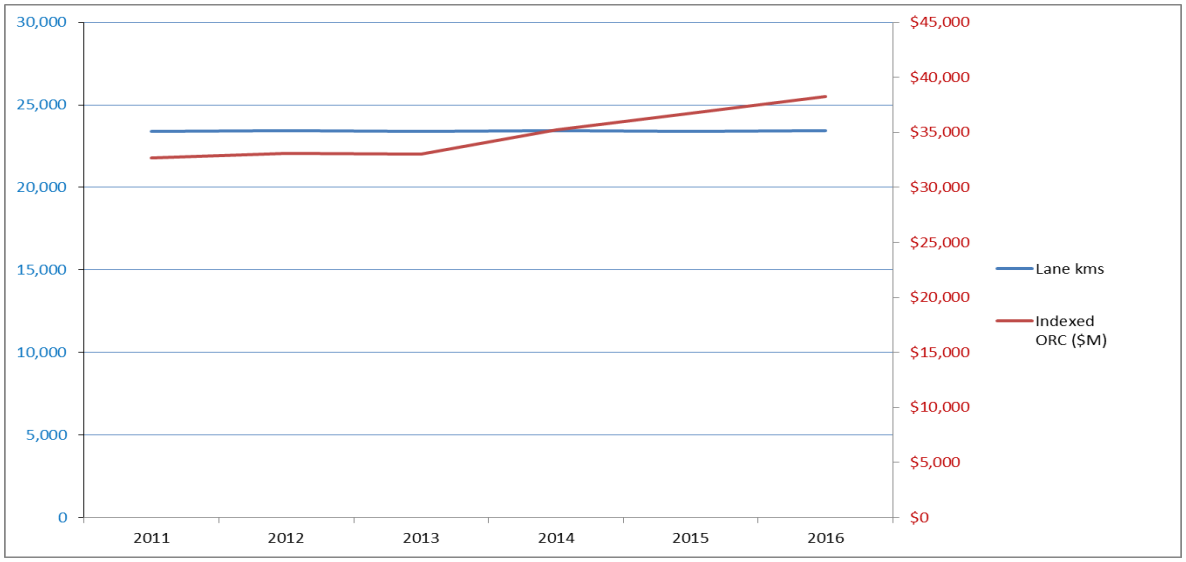
Fully autonomous vehicles may not require any major changes to New Zealand infrastructure for them to operate. Rather, they are likely to operate on our existing roads, using their own on-board sensors to control the vehicle's movement. However, we will continue to work with our partners and stakeholders to understand the changes that need to be made to the existing infrastructure network to ensure that AVs can operate safely and efficiently.

The Ministry of Transport has a work programme to clarify the current legal situation that applies to the deployment of autonomous vehicles in New Zealand. The Transport Agency is working with and supporting the Ministry on this programme.

Network growth

Over the last five years the State Highway network has been extended and improved. The graph below shows that whilst network growth has extended total lane kilometres to approximately 23,754km (from around 23,376km in 2011) the value of the network has increased from $32.7bn in 2011 to $38.2b in 2016.

State highway network growth by lane km and value



[6] http://www.transport.govt.nz/ourwork/climatechange/electric-vehicles/

Service level change

The Transport Agency has also increased levels of service in some areas of maintenance and operations, for example:

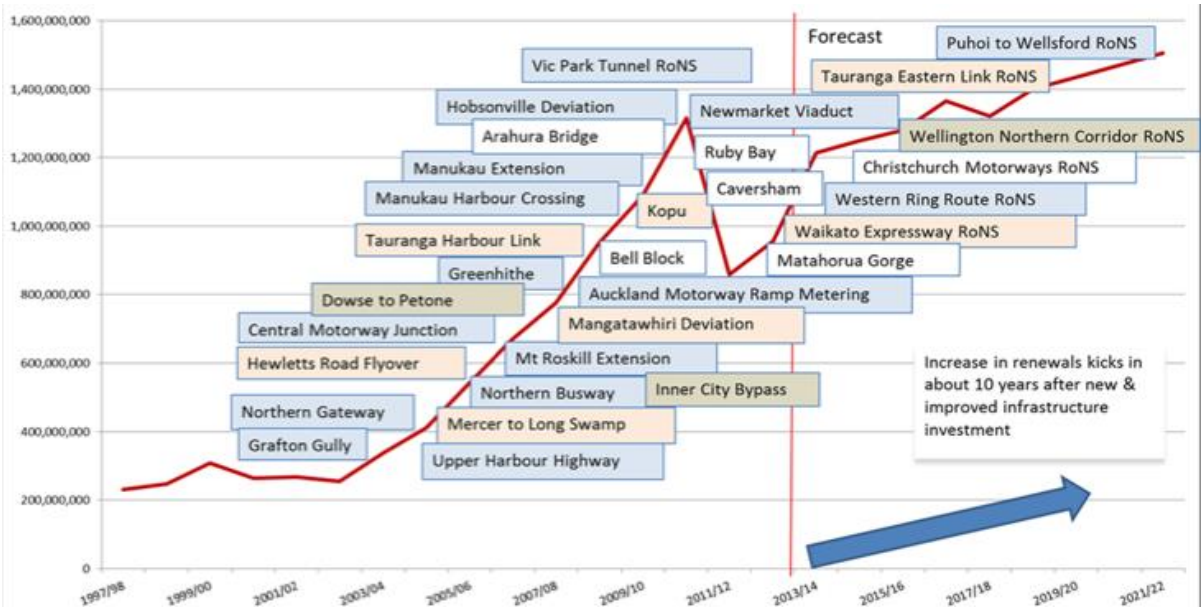
- improved traffic management through the three TOCs in Auckland, Wellington and Christchurch
- improved safety systems in our longer tunnels
- increased use of quieter road surfaces in our urban areas to provide mitigation for noise
- increased maintenance to sustain higher service levels provided by new infrastructure such as safety barriers and audio tactile profiles (rumble strips) on the network in response to our continued focus on safer journeys.

As we approach the end of the 2015-18 NLTP period we are entering a period where, through increased capital investment in the early turn of the millennium, we now have an increased number of assets approaching over 10 years old as shown in chart below. This means we can expect an increased requirement for renewals.

Further, as the complexity and size of the network increases so does the maintenance and operations investment required. For example, with the opening of Waterview tunnels there is a $13 million increase per year to maintenance and operation expenditure. All of which increases the overall maintenance and operations investment required to provide base customer levels of service.

Over time, we expect the investment necessary to sustain appropriate safety levels of service on the state highway network will increase. As roads and roadsides become safer and more forgiving to human error, the cost of operating and maintaining these safety features will also increase. For example median and roadside barriers reduce DSIs by 70-80 percent with annual maintenance costs of between $7,500-9,000 a kilometre.

Timeline of major capital improvements



Ongoing resilience impacts

In recent years there have been a number of other issues which affect the maintenance and operations work we do, impacting our duty of care for our customers, and testing our ability to satisfactorily deliver the desired customer levels of service.

Natural hazards present an ongoing challenge, due to their unpredictable nature. These events happen nationwide and their impact can range from minor local disruptions through to major long term route closures with significant additional unplanned works required to establish alternative access as seen after the Kaikoura earthquake.

The Transport Agency has established a resilience project[7] to strengthen the resilience of the state highway network – increasing network availability, reducing response times, and improving the overall experience for users of our highways. The intent is for the state highway network to be able to withstand disruptions, absorb disturbances, perform effectively in a crisis, adapt to changing conditions (including climate change) and recover quickly from disturbances.

The Kaikoura earthquake in 2016 and the ongoing challenges of providing a resilient journey through the Manawatu Gorge are reminders of the state highway network's vulnerability to natural hazards. Resilience planning encompasses the full gambit of responses – from preventative works, right through to preparedness promotion to customers, alternative route planning and post event response planning. For example, the Transport Agency does a number of preventative resilience activities such as:

- seismic strengthening of high priority bridges on the state highway network which were demonstrably safer through the recent earthquakes experienced
- preventative rock fall through prone areas and the avalanche programme on SH94 to Milford Sound
- scour protection near bridges to better protect the asset
- drainage improvement to increase pavement life and improve road safety
- using thermal imagery from weather stations to proactively apply de-icing agents on the network where necessary.

It is not possible to remove all risks that the state highway network is exposed to, it is important to understand the location and magnitude of the risks and plan for the most effective response to minimise the consequences of these types of disruptions to the network.

The following four sections contain the detailed maintenance and operations analysis programme for each of the four service aspects. These sections have been built up from the corridor management plans developed for the state highway network, and moderated nationally to ensure the maintenance and operations programme gives effect to the GPS and strategic context, while achieving value for money.

[7] https://www.nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/resilience/

Part C – Access and resilience

Introduction

Our customers and citizens want to reach their destinations reliably – today, tomorrow and the day after. Reliable access and a resilient network are the fundamental basis to a well-functioning state highway network and New Zealand's economy.

Continued reliable, cost effective customer access along state highways is predominantly provided by pavement, drainage and bridge maintenance and renewals.

Objectives for investment in access and resilience

Our investment in access and resilience is intended to enable:

People and goods to move from A to B in a sustainable manner: *roads are maintained and renewed in a way that minimises the investment required to consistently meet road users level of service, now and in the future*

a resilient network: *where the availability and restoration of each road when there is a weather or emergency event is appropriate, and appropriate alternative routes or management is in place during such events and that customers are informed.*

The key levels of service that we deliver to our customers under access and resilience are:

- Reliable access for all our customers including freight customers, tourists and commuters.
- In the event of loss of access, due to a natural event or incident, appropriate alternative routes are available (or alternative modes are made available)
- Our highest classification routes remain open throughout the average winter and during severe weather events or can recover quickly from extreme events.

Maintenance activities

Our proposed programme of works to deliver an accessible and resilient network for our customers is made up of core service aspects as outlined below.

Proposed programme of works

	Service aspects	Access and resilience	Travel time and reliability	Safety	Amenity
Access & Resilience	Routine resurfacing and pavement rehabilitation	✓✓✓		✓✓	
	Bridge and structures maintenance	✓✓✓		✓	
	Scour management	✓✓✓		✓	
	Winter operations and maintenance for snow and ice	✓✓✓	✓✓	✓✓	
	Drainage	✓✓✓		✓✓	✓
	Rockfall prevention	✓✓✓		✓	
	Seismic retrofit of structures	✓✓✓			
	Facilities management	✓✓✓		✓✓✓	✓

Maintenance, operations and renewals activities, whilst primarily focussed on maintaining customer access to the network, are also undertaken to ensure the safety of road users is not compromised.

The most significant activity under this category is the maintenance and renewal of pavements and surfaces followed by structural and bridge maintenance. However, we also invest in other activities to strengthen the resilience of the state highway network. These include:

- Operational routine maintenance and managing road incidents.
- Winter services activities and managing access and clearance of weather related incidents.
- Clearing small slips from the carriageway.
- Maintaining other traffic services (e.g. landslip / lahar warning).
- Removal of specific dangerous trees.

Current state

Access and resilience

Our customers and citizens want to reach their destinations reliably – today, tomorrow and the day after. Reliable access and a resilient network are the fundamental base to a well-functioning state highway network and transport system.

The state highway network generally provides a good level of day-to-day access to the transport system. Having good access to the transport system is critical to New Zealand's economy as it enables commuters to move, tourists to reach destinations and, importantly, products to reach factories and ports.

Reliable access can be curtailed by natural events such as intemperate weather and incidents such as crashes. While there are alternative routes to many of our state highways, they may be longer, unsuitable for HPMVs, and cause delays which affect time bound freight.

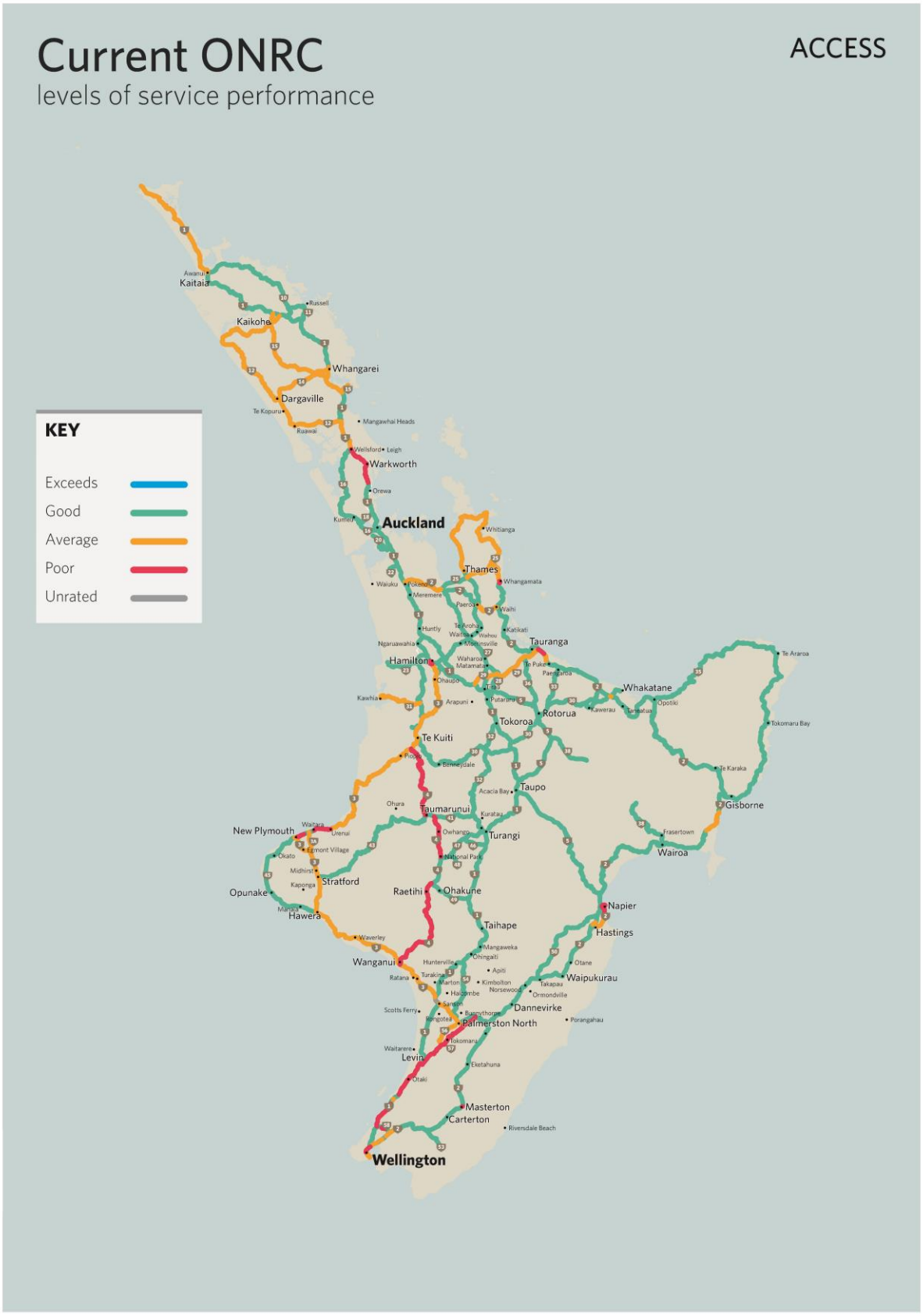
To inform the development of our investment proposal we have compared actual levels of service to the ONRC for each road classification, which enables the Transport Agency to prioritise.

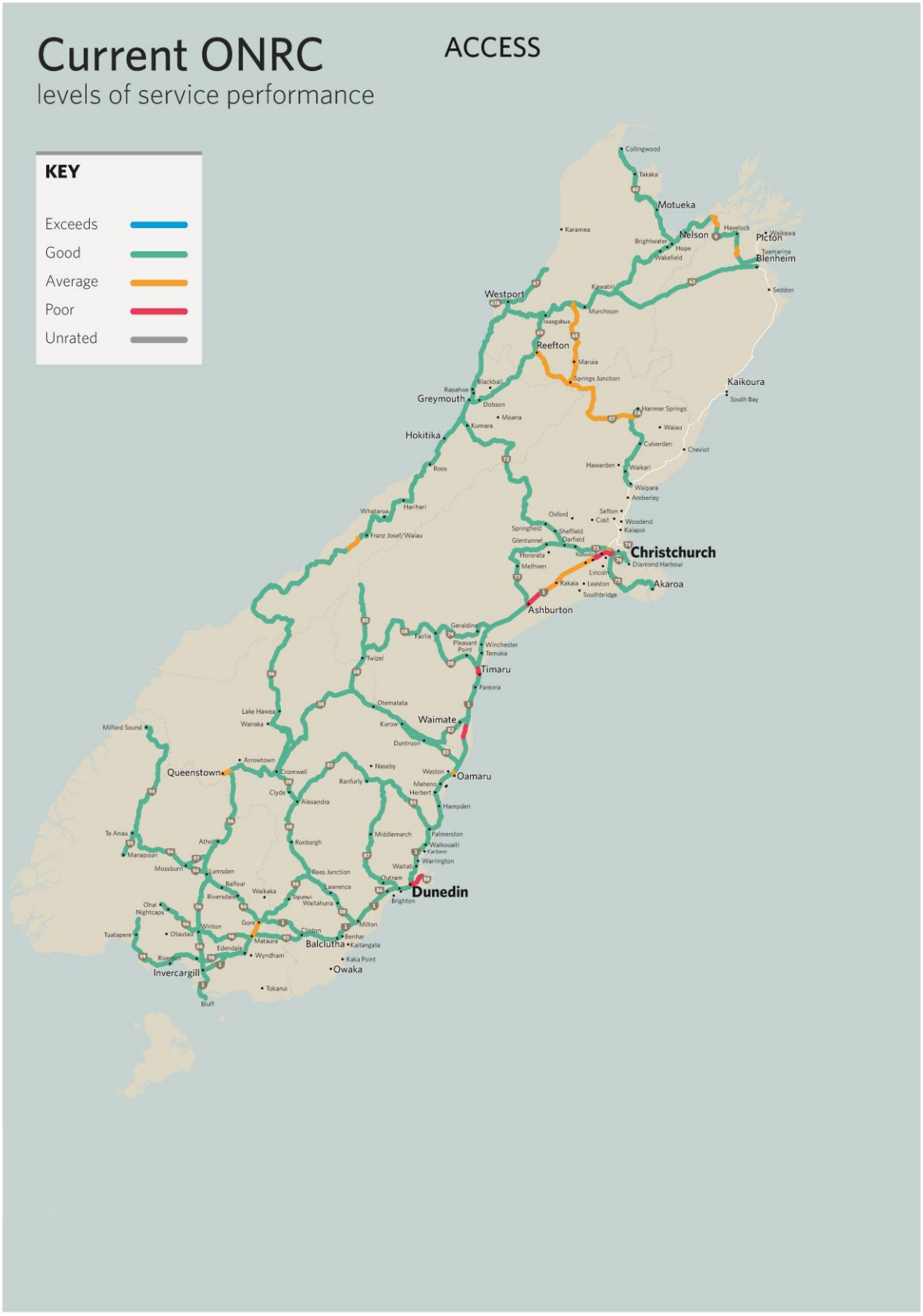
The maps overleaf show the current access and resilience levels of service across the state highway network compared against the ONRC classification and levels of service aspirations for access and resilience.

Overall more than 50 percent of the network has good or better levels of access. Access and resilience customer level of service gaps predominantly occur on regional routes that have lower ONCR classifications such as SH3 north of New Plymouth, the Manawatu Gorge on SH2 and SH2 between Napier and Gisborne, and parts of SH73 and 94. Additionally, regions such as Northland and the West Coast often experience poor levels of access and resilience due to a lack of viable alternative routes.

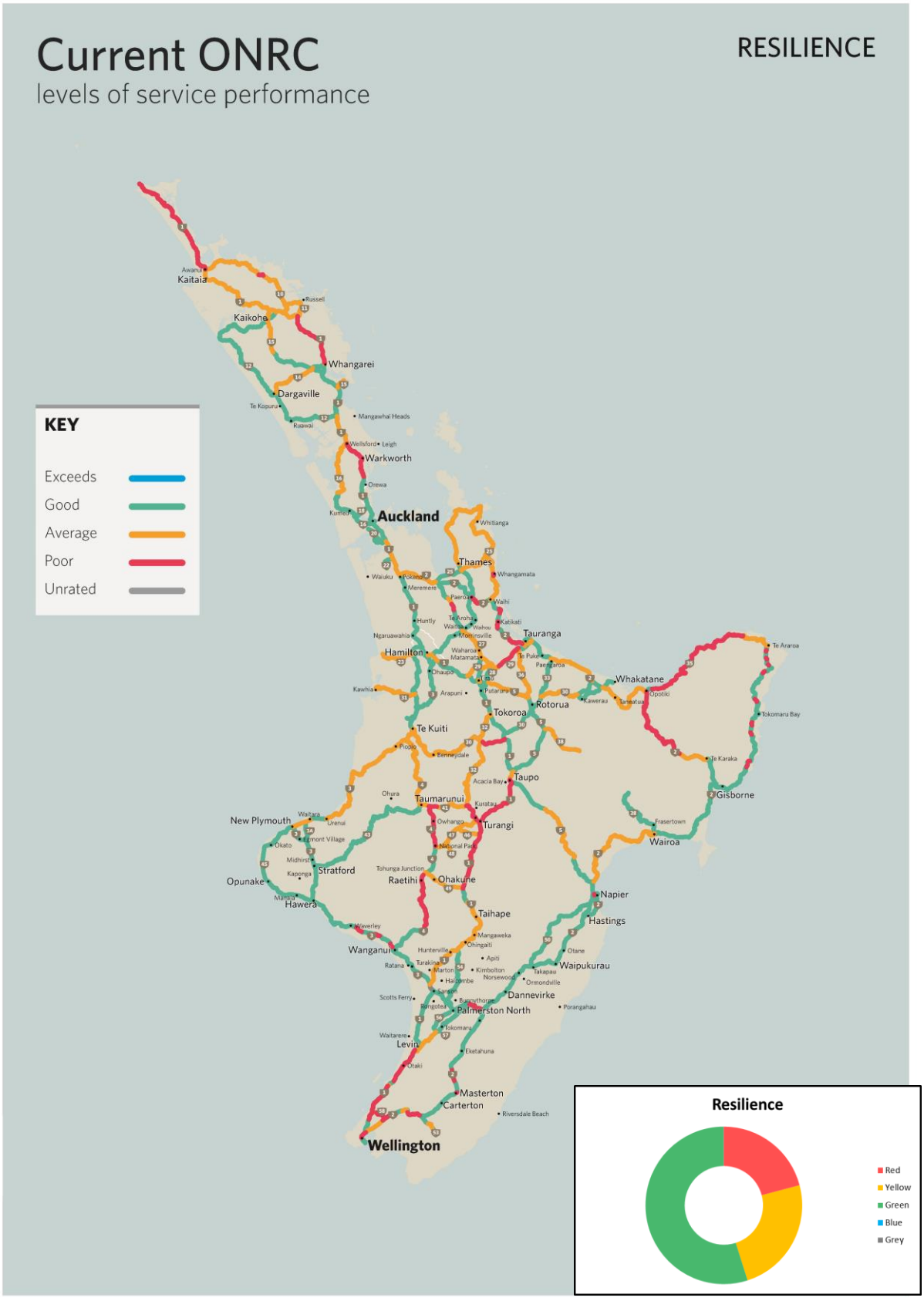
Further, there are resilience gaps at the top of the north island, on the East Cape and through the South Island due to a lack of alternative routes and risk of slips. In the South Island, earthquake risk has also been identified as a particular factor for resilience given recent experiences, earthquake risk is also relevant to the rest of the country.

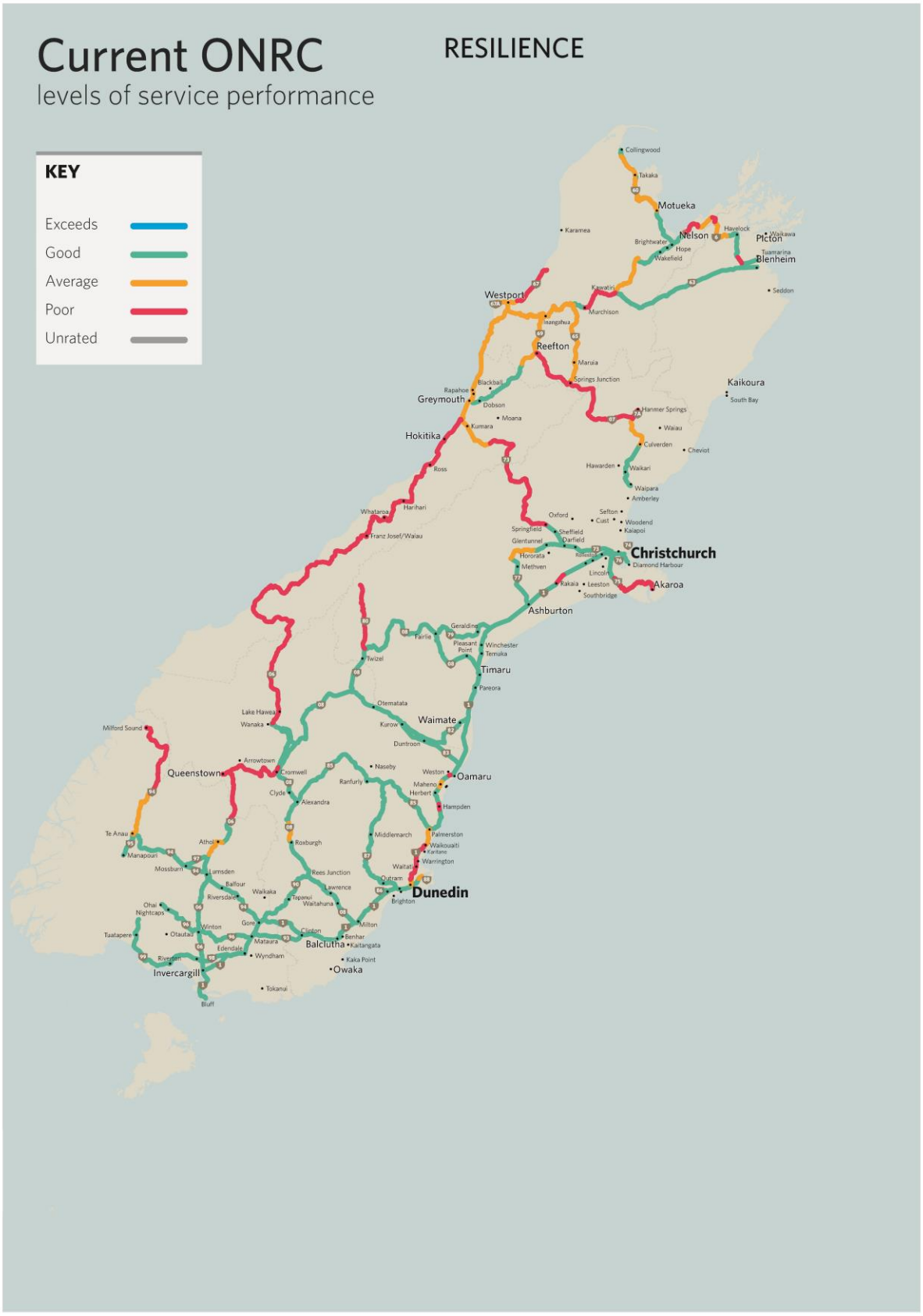
Current ONRC performance – Access




Current ONRC
levels of service performance
ACCESS
KEY
Exceeds
Good
Average
Poor
Unrated
Collingwood
Takaka
Motueka
Karamea
Brightwater
Nelson
Havelock
Wakawa
Picton
Hope
Wakefield
Tuamarina
Blenheim
Seddon
Kawatiri
Westport
Murchison
Inangahua
Reefton
Maruia
Springs Junction
Kaikoura
South Bay
Blackball
Rapahoe
Greymouth
Dobson
Moana
Hanmer Springs
Waiau
Kumara
Hokitika
Culverden
Cheviot
Ross
Hawarden
Waikari
Waipara
Amberley
Harihari
Whataroa
Oxford
Sefton
Cust
Woodend
Kaiapoi
Springfield
Sheffield
Darfield
Franz Josef/Waiau
Glentunnel
Christchurch
Hororata
Rolleston
Diamond Harbour
Methven
Lincoln
Akaroa
Rakaia
Leeston
Southbridge
Ashburton
Geraldine
Fairlie
Pleasant Point
Winchester
Temuka
Twizel
Timaru
Pareora
Otematata
Lake Hawea
Wanaka
Kurow
Waimate
Milford Sound
Duntroon
Arrowtown
Queenstown
Cromwell
Naseby
Weston
Oamaru
Ranfurly
Maheno
Clyde
Alexandra
Herbert
Hampden
Te Anau
Middlemarch
Palmerston
Roxburgh
Waikouaiti
Athol
Fortrose
Manapouri
Warrington
Waitati
Mossburn
Lumsden
Outram
Rees Junction
Balfour
Dunedin
Riversdale
Waikaka
Lawrence
Tapanui
Waitahuna
Brighton
Ohai
Nightcaps
Gore
Winton
Clinton
Milton
Tuatapere
Otautau
Benhar
Mataura
Balclutha
Kaitangata
Edendale
Wyndham
Kaka Point
Riverton
Invercargill
Owaka
Tokanui
Bluff

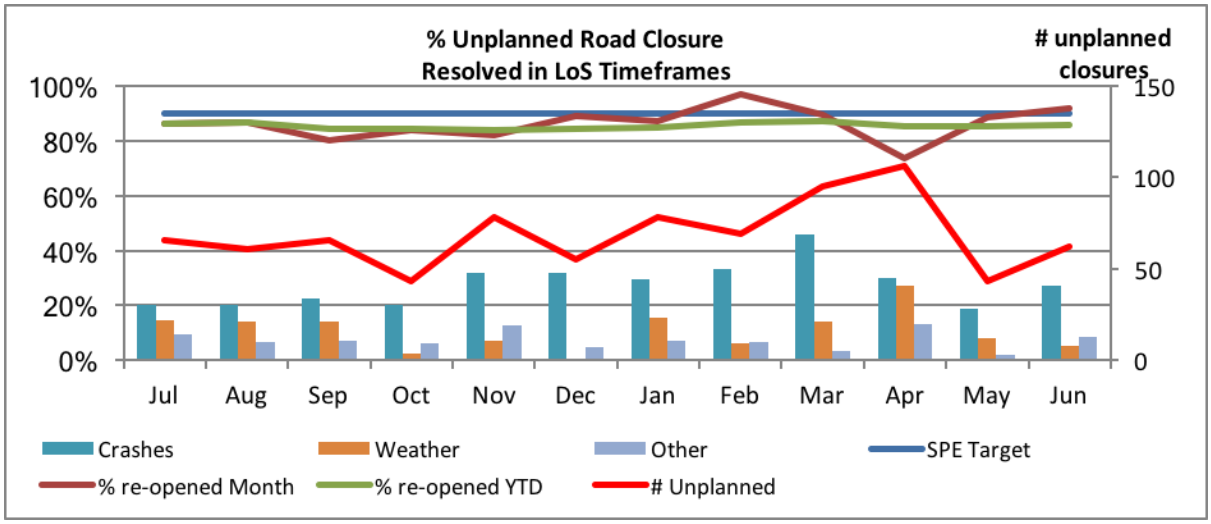
Current ONRC performance – Resilience




Current ONRC
levels of service performance
RESILIENCE
KEY
Exceeds
Good
Average
Poor
Unrated
Collingwood
Takaka
Motueka
Karamea
Nelson
Havelock
Waikawa
Picton
Brightwater
Hope
Wakefield
Tuamarina
Blenheim
Seddon
Westport
Kawatiri
Murchison
Inangahua
Reefton
Maruia
Springs Junction
Kaikoura
South Bay
Rapahoe
Blackball
Greymouth
Dobson
Moana
Kumara
Hanmer Springs
Waiau
Hokitika
Culverden
Cheviot
Ross
Hawarden
Waikari
Waipara
Amberley
Harihari
Whataroa
Franz Josef/Waiau
Oxford
Sefton
Cust
Woodend
Kaiapoi
Springfield
Sheffield
Darfield
Glentunnel
Christchurch
Hororata
Rolleston
Diamond Harbour
Methven
Lincoln
Akaroa
Kakaia
Leeston
Southbridge
Ashburton
Geraldine
Fairlie
Pleasant Point
Winchester
Temuka
Twizel
Timaru
Pareora
Otematata
Lake Hawea
Wanaka
Kurow
Waimate
Milford Sound
Duntroon
Arrowtown
Queenstown
Cromwell
Naseby
Weston
Oamaru
Ranfurly
Maheno
Clyde
Alexandra
Herbert
Hampden
Te Anau
Middlemarch
Palmerston
Roxburgh
Waikouaiti
Karitane
Athol
Manapouri
Warrington
Waitati
Mossburn
Lumsden
Rees Junction
Outram
Dunedin
Balfour
Lawrence
Waikaka
Riversdale
Tapanui
Waitahuna
Brighton
Ohai
Nightcaps
Gore
Winton
Clinton
Milton
Tuatapere
Otautau
Benhar
Mataura
Balclutha
Kaitangata
Edendale
Wyndham
Kaka Point
Riverton
Owaka
Invercargill
Tokanui
Bluff

The number of unplanned road closures and the number of vehicles affected by closures shows how we are performing at maintaining access to the state highways for our customers. The chart below shows the number of unplanned road closures greater than two hours in the 2016/17 year (data extracted from RAMM and TREIS).

Unplanned road closures 2016/17



In addition, the Transport Agency undertakes a variety of planned works across the state highway network. Where possible we endeavour to carry out these works in quieter periods or overnight, however this is not always an option. Therefore, the number of planned road closures or restrictions and the number of vehicles affected by these also demonstrates how we are performing at maintaining access to the state highways for our customers.

Pavement and surface condition

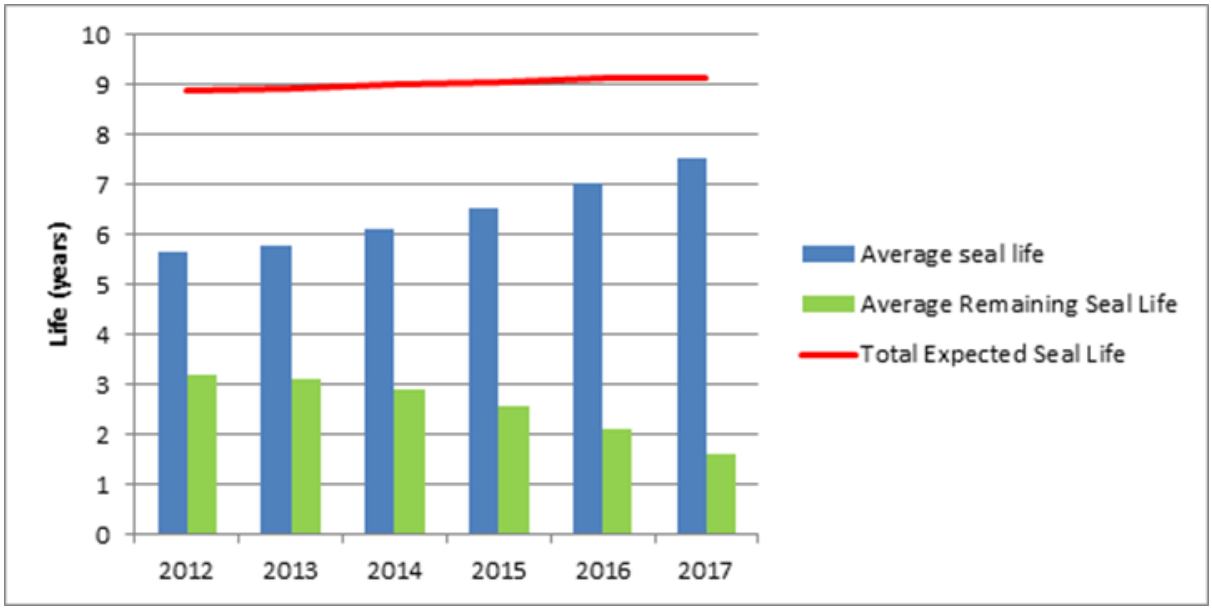
There are two principal aspects of pavement condition with regard to maintenance activities which we have considered. Firstly, the service life of the surface leading up to renewal as a means to obtaining the best value from our investment to appropriately balance level of service and risk and secondly the surface condition index.

Service life

Recent pavement and surface renewal programmes (which have been smaller compared to historical levels) have led to increased seal lives achieved and reduced average remaining seal lives. However, the overall total expected seal age has been increasing over the past five years as shown below, taken from the *One Network Road Classification Performance Measures Reporting Tool*[8]. This shows that we are increasingly allowing our surfaces to achieve their service life without early renewal intervention; the result of a move toward driving optimisation of renewals and risk across various road classifications to achieve maximum life from the asset.

[8] https://www.nzta.govt.nz/roads-and-rail/road-efficiency-group/onrc/

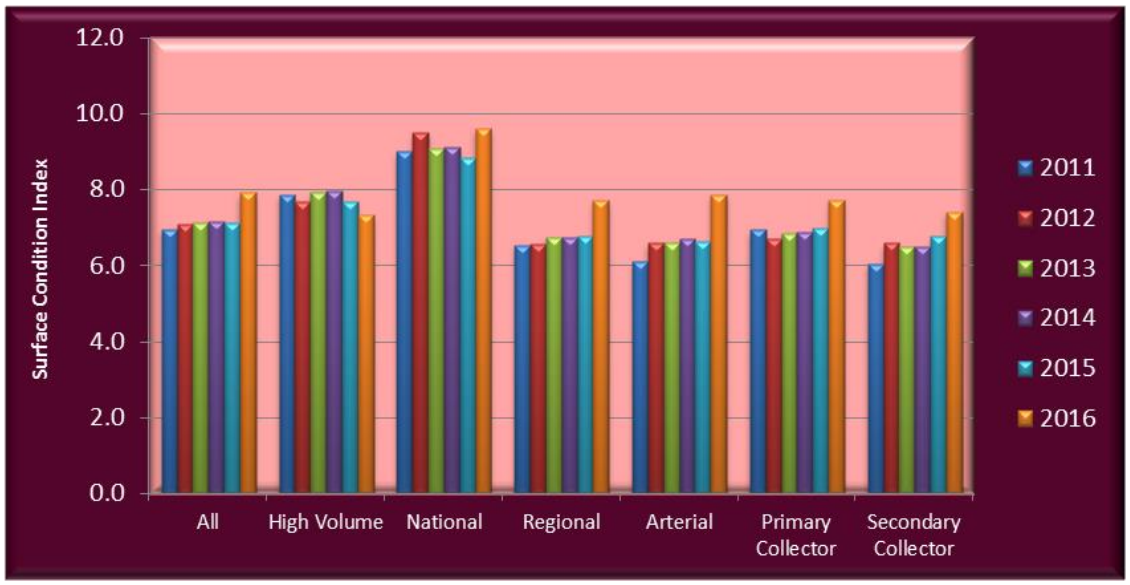
Average seal life and average remaining seal life



Recent pavement and surface renewal programmes have led to increased expected seal life, with the average seal life increasing and average remaining seal life reducing. This indicates a higher level of consumption of the asset and increased risk as a growing proportion is at or near its expected service life. The investment in pavement and surface renewals has been below the long run stretch sustainable level and is confirmed by the surface condition index.

As can be seen below, the surface condition index[9] has increased (i.e. worsened) across the State Highway network over the last five years signifying a deterioration of the State Highway surface condition. In general, all the classifications for the surface condition index for each One Network Road Classification have seen increases over the last five years, with a noticeable increase in 2016. With the exception of the surface condition index for High Volume roads, which have improved in 2016.[10]

Surface Condition Index by One Network Road Classification

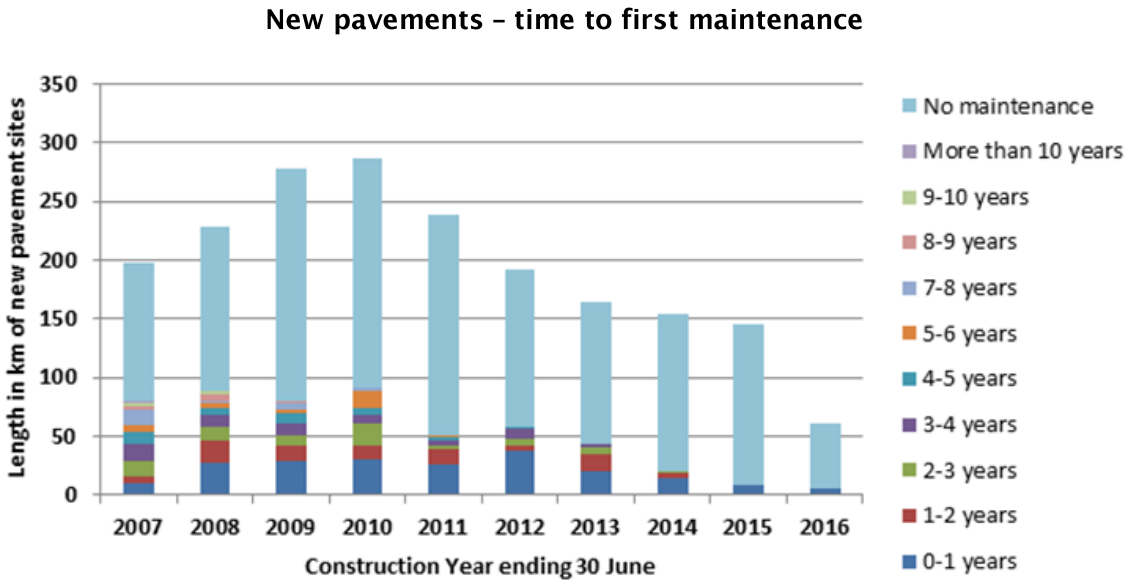


[9] https://www.nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/performance-management/state-highway-reports

[10] 2017 data is not yet available for use.

Pavement construction quality

If new pavements (new construction and rehabilitations) are not constructed to the necessary quality standards it can lead to an additional early burden on the maintenance programme. An analysis of the level of maintenance required for pavements less than two years old has been undertaken as part of a look back review. This shows that the quality of new construction has been steadily improving and so the risk of reduced performance decreasing.



Methodologies

This section sets out the methods adopted to develop our recommended programme of access and resilience activities.

Pavements and surfacing

Programme development process

The Transport Agency forecasts long term state highway pavement renewal needs using the New Zealand standard performance modelling framework maintained by IDS Ltd for use across all road networks in New Zealand. This model utilises a methodology based on the World Bank HDM approach with significant enhancements based on calibration for New Zealand pavement and surfacing asset performance. The model is underpinned by 20 years' development experience in New Zealand for local conditions.

The model is implemented using Deighton's Total Infrastructure Asset Management System (dTIMS). The dTIMS lifecycle modelling tool uses an internationally recognised methodology to optimise maintenance interventions.

In 2013 the state highway network needs were forecast as a forerunner to setting the renewal investment quantities that would underpin the new Network Outcomes Contracts. The recommended quantities from this analysis are lower than historic levels.

In 2016 following significant enhancement to the model to address issues arising from the 2013 modelling, the network needs were reanalysed to verify the investment needs for the NLTP. Both modelling projects produced similar results. The outputs of the 2016 modelling work are summarised in the 2016 report *NLTP Pavement and Surfacing Business Case*[11] with the detailed analysis results presented in the more detailed report *2016 NZ Transport Agency Strategic Maintenance Investment Model*[12] July 2016.

The optimisation objective in both modelling assignments was focussed on assessing the minimum sustainable investment profile for the various road classes across the state highway network. The 2016 analysis incorporated a more robust methodology to take into account the differentiation of outcomes by ONRC, and included assessment to quantify the safety impacts of slippery road surfaces.

This modelling work establishes the network level investment need and proposes a suggested programme of works. The agency has implemented comprehensive processes that are focussed on ensuring that final programmes are tested rigorously before implementation:

1. *A field review of the baseline plan:*

   A candidate programme targeting the recommended quantities from the modelling work was field validated to create the baseline plan for the NOC contracts. The renewals quantities finalised through this process are specified in the contract and form the basis for pricing the lump sum for routine maintenance.

2. *A review of these outcomes by contractors during the tendering process:*

[11] https://nzta.govt.nz/assets/Planning-and-investment/State-highway-investment-proposal/Technical-documents-supporting-maintenance/NLTP-Pavement-and-Surfacing-Business-Case-Oct-2016.pdf
[12] https://nzta.govt.nz/assets/Planning-and-investment/State-highway-investment-proposal/Technical-documents-supporting-maintenance/2016-NZ-Transport-Agency-Strategic-Maintenance-Investment-Model.pdf

The contractors for each Network Outcome Contract have reviewed the baseline plan and the specified quantities during the tender process. This further validation tests the proposed investment programme against commercial drivers.

All of our contracts have been successfully awarded based on the specified renewal investment quantities and the tendered lump sums for routine maintenance. The routine maintenance need is lump sum priced and is highly sensitive to the specified renewal quantities. We received no indication that the specified quantities are considered inappropriate based on pricing the lump sum. In most cases tenderers confirmed in their tender submission that the outcome level of service could be maintained for the specified quantities.

Contractors have created a more detailed version of the programme based on the specified quantities and initially guided by the baseline plan provided by the agency. This programme distributes the quantities to suit the most efficient commercial drivers and then forms the basis for their annual submission for funding.

3. *Renewals justification process*

   The NOC contracts incentivise the supplier to minimise renewal inputs. An emphasis is put on implementing preventive maintenance to maximise the life of existing assets and take any planned renewals through a formal renewal justification process. This includes the need to demonstrate that:

   - Preventive maintenance opportunities have been exhausted
   - Other forms of maintenance and renewal are no longer viable, and
   - The type and timing of the proposed option provides the least whole of life cost based on Net Present Value over a 30 year analysis period. The agency has implemented the use of the economic indicator as a check on the robustness of the NPV assessment.

4. *The RAPT (review and prioritisation team) process:*

   Renewal projects submitted through the annual plan process are reviewed through the agencies RAPT (review and prioritisation team) process. The RAPT process is testing the effectiveness of the programming effort and checking that programming development processes have been followed. Each proposed treatment is reviewed in the field, and the supporting documentation tested against the on-site conditions.

5. *The "Looking Back Review" process:*

   To help ensure the investment in the maintenance and operations of the state highway is effective and efficient, the Transport Agency reviews the programme that was delivered for the previous year.

   This review is characterised by a series of investigative and analysis tasks intended to confirm the appropriateness of our existing processes and procedures and to identify any deficiencies that need to be addressed. This informs lessons learnt improvement opportunities and our approach to continual improvement.

   For the *2015/16 NZTA Maintenance and Operations Looking Back review* identified some areas for improvement with the NOCs and makes recommendations for improvement across the maintenance and operation programme. These recommendations are being implemented.[13]

[13] https://infohub.nzta.govt.nz/otcs/cs.dll?func=ll&objaction=overview&objid=27420452

Outcomes

Key outcomes of the process outlined are:

- Confidence in long term renewal need

  We are confident that we have a reliable long term forecast for the level of pavement and surfacing renewal necessary to sustain the asset within the ONRC level of service.

- Forming the basis for a tensioned short and medium term programme expectation

  The short and medium term programmes are tensioned by the level of renewals output from the long term investment programme.

  The current programmes match very well the long term forecast need for surfacing renewals over the NLTP period. The first year of pavement renewals match closely the modelled forecast need, but are below it for years 2 and 3. Differences result from:

  - An ambitious outlook of the extent to which the use of preventive and heavy maintenance will defer renewal needs
  - The field validation not being able to see in the current pavement performance the justification of medium term needs and an ambitious assumption that deterioration rates will not accelerate, and
  - Suppliers taking risks particularly on lower classification networks in anticipation that the agency will approve additions to the programme should this be necessary.

  The recent history of programme adjustments to advance future treatments indicates that it is prudent to forecast the medium term programme based on the robust modelling work. The case studies presented in the *Demonstrating Customer Impacts that may arise from a reduced programme*[14] document and demonstrate the outcomes that result in programme adjustments.

The processes explained ensure that regardless of funding levels and forecast renewal needs, only treatments that are genuinely necessary will proceed to construction.

The NLTP funding request is based on the recommended renewal levels forecast in the 2016 modelling work. We have confidence in the outputs of the modelling work and anticipate that it will be necessary to advance some of the pavement treatments that are currently being ambitiously deferred in the short term programme.

Confidence in forecasts derived from the modelling work

The recommended investment level for pavement and surfacing relies on the robustness of the modelling work. In this section, the reasons why the modelling work is robust are presented.

Close alignment with 2013 analysis forecasts

The contractors and the Transport Agency engineering assessments have shown the modelling outputs in 2013 have a high degree of alignment with subsequent pavement treatments undertaken. This result provides some confidence in the forecast outputs. However, the 2013 analysis preceded the publishing the ONRC performance expectations,

[14] https://infohub.nzta.govt.nz/otcs/cs.dll?func=ll&objaction=overview&objid=27420130

and disclosed some opportunities to improve further the model. In 2016, significant improvements have been made to:

- Implementing a new crack initiation model for asphalt surfaces.
- A new optimisation technique was adopted in order to cater specifically for the One Network Road Classification.
- A separate treatment category was created for a heavy maintenance option (Heavy maintenance is patching renewal treatments that do not extend over the full length or width of the road and / or will slow significantly increasing maintenance costs).
- Developing and incorporating a new safety model into the overall investment planning
- A stronger focus on the validation of the modelling results.

Sensitivity analysis

- The modelling has assessed a number of investment levels to determine the optimum level. Sensitivity analysis was undertaken to assess the impact of reduced or lowered levels of investment.

The analysis work and development of the recommended investment levels has taken into account these sensitivities.

Testing model outputs

- **Comparing models** – Used alternative model form to predict investment need from totally different viewpoint. The outcomes of the IDS maintained deterministic model compared favourably with the outputs of a probabilistic model developed by the Transport Agency.
- **Sample networks** – Analysed historical data on three sample networks, resetting back 5 years including condition and treatments to determine predicted condition. This was then tested against current condition and the model calibrated to achieve a high degree of compatibility.
- **Untreated sections** – Analysed historical data (5 years past) for key condition models nationally for all untreated sections to confirm rate of deterioration and model accuracy.
- **Data Quality** – The State Highway data is of a high quality, particularly from a modelling perspective. The high speed condition data is consistent and high quality, and the agency has spent a considerable effort in improving the inventory. The forecasting is based on reliable data.
- **Peer review** – A peer review of the Technical Report by Greenwood Associates Infrastructure Consultants found "the report and supporting materials to be comprehensive and well structured".
- **Experienced team** – The Transport Agency utilised leading consultants and Transport Agency staff to working together to undertake the model improvement and analysis. The modelling team included Elke Beca (Opus), Theuns Henning (IDS), Peter Cenek (Opus) and Luca de Marco (Jacobs). The steering team for the project included Gordon Hart (The Transport Agency), Roger Bailey (The Transport Agency), Samuel Grave (The Transport Agency), Kym Neaylon (Opus) and David Jeffrey (Just Add Lime).

Pavement modelling limitations

The pavement modelling methodology has identified the following limitations:

- Asphalt – An increasing quantum of New Zealand's Roads of National Significance (RONS) are being surfaced in asphalt, which costs about ten times as much as chip seal treatment. This resurfacing has been included in the modelling. Most of this

length of new asphalt will require its first renewal from about year 8, contributing to the predicted long-term increase in investment. Future growth in asphaltic surfaces has not been included in the modelling.

- Targets for low volume roads – The technical performance targets used in the modelling have been set to align with the intent of One Network Road Classification levels of service for differing classes of road, but the targets used are untested. There is a risk the target set for low volume roads are overly optimistic, allowing too much deterioration with the potential for pavements to deteriorate beyond acceptable levels. Currently low volume road treatments are triggered by maintenance costs and the cost effective whole of life impacts rather than by technical performance issues. It is expected the technical targets used will be reviewed within the next 3 years to assess the accuracy and may need to be adjusted accordingly. No provision is made to cover this risk in our NLTP submission.
- Maintenance – the current model uses a coarse assignment of routine maintenance input. This is adequate for modelling pavement and surfacing renewal needs but a more accurate assessment of the routine maintenance need is the assessment carried out from first principles based on the outcome renewal quantities. The maintenance budgets used in the NLTP are based on a commercial assessment of these needs that has been carried out by the NOC contractors in tendering the lump sum necessary to match the renewal quantities. Collectively this lump sum and the renewal inputs deliver the outcome level of service expected.

Structures

Principal structures inspections are carried out every six years and general inspections every two years in line with international practice and are the primary mechanism to identify structural defects and maintenance requirements. The frequency can be increased or reduced through risk analysis. It is not possible to accurately predict future defects and maintenance requirements in advance – the actual programme is developed based on the outcomes of the inspections as they occur. In addition, there are often significant investigations and evaluations required post inspection to determine the optimum option and timing of remedial works in order to achieve the best value for money.

Maintenance work is prioritised as high, medium or low priority on the basis of a documented risk approach. All high priority works are put forward for funding each year with some medium priorities. A fundamental premise of this work is the achievement of a least whole of life cost to achieve the best value for money outcome.

In order to improve forward planning, regional lifecycle management plans are prepared. These plans document key structures issues from the bottom up based on individual structures needs. They also document the justification for the funding requests. Appropriate investigations and assessments are programmed in advance to facilitate more informed planning particularly for major maintenance works and bridge renewals. In summary, the structures maintenance forecasts are based on:

- Specific known defects or maintenance requirements that have already been identified, investigated and planned. These are documented in the regional lifecycle management plans.
- A best assessment of other high priority works that will arise during the budget period (based on history and professional knowledge and experience).
- An independent review of the Lifecycle Management Plans and budget forecasts by the National Structures team.

The justification for the funding request also takes due consideration of other factors as follows:

- The first New Zealand state highway structures asset management plan identified international research that indicated the low end of the range for maintenance of a bridge network, such as the New Zealand state highway network, to be in the order of 0.45 percent of the replacement value of the asset. This is not a target but provides some context for gross budget levels. The NCHRP Synthesis 227 Collecting

and Managing Cost Data for Bride Management systems provided an average bridge maintenance cost of 1.5 percent over 35 states in the USA. This applies to bridges but not necessarily other structures. Historically, the 0.45 percent has proven to be a robust indicator.

- Historical regional expenditure has generally been well recorded and is used as a guide. Different regions have different expenditure ratios reflecting specific environmental, traffic and topographical factors amongst others. These specific regional factors are reflected in the funding requests together with natural variations over time.
- Inventory changes (e.g. new and revoked highways) can be significant and are accounted for in the request.
- Maintenance backlog is evaluated and recorded each year. Backlog in this sense is defined as any unfunded H and M priority works. The backlog trend and absolute value is monitored at a regional and national level. This is a key indicator which guides any funding request. It is also a pseudo 'condition indicator' because it is directly based on the observed structure defects.
- Significant projects (e.g. major bridge repaint) can be high value and heavily skew regional funding requests. These projects receive significant scrutiny at a national level.

Historically structures risk management has focussed on seismic and scour performance with longstanding retrofit programmes in place that are now reaching maturity. Scour issues are reviewed as part of the inspection process and mitigation works agreed where proven necessary. However, this is a relatively small proportion of maintenance works but it is critical in maintaining reduced risk levels. The seismic retrofit programme is also virtually complete.

Regional Bridges and Major Culverts Life Cycle Management Plans and Other Significant Highway Structures Preliminary Life Cycle Management Plans have been used to support the funding proposal.

As outlined above, we take a longer-term view of our maintenance activities, ensuring that forecast expenditure is within the minimum whole of life cost for an asset and that the asset continues to be required.

The backlog of structural maintenance and structural component replacement works has been identified by priority in the funding schedules. The trend of the backlog has been considered and its significance with respect to risk and whole of life costs shall be discussed in the three and 10-year plan submission. Possible steps to reduce the backlog have also been discussed.

Drainage

Our programme of drainage works remains relatively low. Our investment in drainage maintenance, operations and renewals is targeted to:

- Remove water efficiently from the pavement surface to ensure roads are as safe as possible in all weather conditions and can operate, with minimal traffic flow disruptions
- Minimise the likelihood of water entering the pavement base layers to ensure the long-term sustainability of our pavement and base layers, thereby protecting the legacy investment made
- Remove the build-up of water that may lead to flooding or washout events to reduce the risk of events interrupting the access provided by our state highways and improves the resilience of our network.

Our current programme is planned to ensure the best possible timing of drainage works, however further investigation is required to better understand the optimum timing and quantity of drainage works and we will continue to improve our programme accordingly.

The need to invest more in drainage is recognised and a number of projects are underway in order to assess and quantify the benefits of improved moisture measurement and define intervention triggers for drainage works. This would allow us to better target our work.

We have started modelling possible benefits from increasing the drainage improvement programme to extend pavement life by looking at the differential progression of rutting in the inside and outside wheel tracks. The impact on pavement lives is estimated by looking at how moisture affects pavement deterioration. Networks were inspected to validate this approach and there was found to be a good relationship between differential rutting and sites with poor drainage.

Resilience

Our maintenance and operations resilience programme is intended to maintain access to the State Highway network and minimise travel disruptions as much as possible. We undertake this though our management of winter services activities, removal or small slips and supply of Calcium Magnesium Acetate – an effective, environmentally-friendly chemical de-icing solution for New Zealand's roads which does not compromise protection of nearby soils, vegetation and waterways.

Our resilience programme also includes the removal of specific trees assessed as being a high risk of falling and affecting the access of the neighbouring State Highway. Each network has identified and assessed trees likely to create a risk to the State Highways. These trees are assessed in their request for funding and approved / declined accordingly.

Access and resilience core programme

Overview

We have adopted standardised levels of service in keeping with the ONRC framework. This means we have not considered an access and resilience programme with alternative level of service targets however, in developing the core programme we have considered alternative programmes that:

- either cost less but expose the Transport Agency and our customers to greater risk, or cost more and reduce the risk to us and our customers and/or
- incur more costs now for later savings, or defer costs now with anticipated increased costs at a later time.

In general, it is cheaper (particularly when considering the whole of life costs) to intervene before our assets fail to deliver access because of rapid deterioration under load. In addition to this cost efficiency trigger, we are also mindful of the inconvenience to our customers when access is lost through asset failure. Our intervention approach is therefore based on always intervening before the asset fails.

The funding request for our core access and resilience programme differs from our previous proposals due to the following:

- General and heavy vehicle traffic growth
- An increased reseal and rehabilitation programme
- Asset growth (large capital projects), which has resulted in a significant increase in the number of assets and associated maintenance activities for those assets.

The overall access and resilience maintenance and operations three and 10 year investment is outline in the table below

Access and resilience proposed investment

Work Category	Forecast funding ($ m)	
	2018-21	2018-27
WC 111	$67.0	$249.4
WC 112	$0.5	$2.0
WC 113	$24.6	$91.7
WC 114	$103.4	$385.0
WC 121	$72.3	$269.2
WC 122	$1.8	$6.7
WC 123	$0.0	$0.0
WC 124	$1.5	$5.5
WC 141	Not Incl.	Not Incl.
WC 151	$100.0	$372.3
WC 161	$24.4	$91.0
WC 211	$1.6	$5.8
WC 212	$333.4	$1,241.7
WC 213	$23.6	$87.8
WC 214	$157.0	$584.8
WC 215	$79.3	$295.5
WC 221	$0.0	$0.0

WC 222	$4.7	$17.5
Total	**$995.1**	**$3,705.9**

Pavements and surfacing

The proposed work programme forecasts an increase in renewal works in response to the deteriorating condition of pavements overall as confirmed by field validation of proposed works. This is to ensure the long-term sustainability of the State Highway network.

Our proposed investment in pavements and surfacing will enable us to undertake the following lengths of resurfacing and pavement rehabilitation:

Proposed investment in pavements and surfacing

	ANNUAL AVERAGE	TOTAL 2018/21
Sealed Road Resurfacing (lane km)	1,840	**5,521**
Pavement Rehabilitation (lane km)	160	**479**
Total (lane km)	**2,000**	**6,000**

The pavement modelling undertaken by the Transport Agency indicates that the proposed level of investment will maintain the state highway network to the necessary levels of service in accordance with the One Network Road Classification aspirations.

Through the core programme we will continue to shift renewal and maintenance priority towards higher volume roads, while allowing lower volume roads to deteriorate to an acceptable minimum level over time.

Further details of the proposed programme of works making up these programmes can be found in the annual plan submissions for each Network Operations Contract.

The 2016 modelling was undertaken at numerous budget levels to determine the least cost sustainable long-term investment required to prevent the pavements from reaching the tipping point beyond which is considered unsustainable and would require large investment to reinstate the pavement. In modelling terms, the tipping point is the point at which deterioration accelerates to an unacceptable level or at an unacceptable rate.

Options to reduce long term costs discounted

There are opportunities to improve levels of service and value for money not reflected in the core programme. Not all state highways can be economically converted to HPMV routes in the short term because the forecast numbers of HPMV trips are small and/or the required works are extensive because of poor strength in current pavements. However, where there is sufficient potential demand for HPMV capacity, it could be advantageous to select HPMV-capable treatments whenever pavements are rehabilitated as part of normal periodic renewal processes. This would deliver HPMV capacity over a longer timeframe for less cost than a current retrofit. The estimated cost of this is between $5-10m per year.

On high volume routes, where resurfacing or pavement rehabilitation works have significant impact on customers, there is potentially an economic advantage by using higher strength, more durable treatments that extend service life and reduce customer impact. However, these cost more and require greater renewal expenditure in order to deliver subsequent savings in maintenance and renewal costs. Some examples are:

- The use of Epoxy OGPA, a high strength road surface material on high volume rigid pavements to extend surface lives from about seven to eight years to potentially 50 years.
- The use of bound structural pavements on higher volume routes to extend the service life of pavements and reduce the impact on traffic.

We will continue to explore with our sector partners and investors the business case for investment in this level of service improvements with whole-of-life economic benefits.

Whole of life considerations

The Transport Agency is aiming to deliver a network that fulfils the customer level of service expectations over the long term, at the least sustainable cost.

It is known that our visibility of required pavement rehabilitation works is reasonably short (generally around one to two years). We therefore consider that the proposed programme quantities of works will be below that actually required to sustainably maintain the condition of the State Highway network. We have therefore raised future years' pavement rehabilitation quantities to align with the pavement modelling undertaken by the Transport Agency.

To maximise the life of the State Highway pavements, a separate treatment category has been created for a heavy maintenance option. This is best described as patching renewal treatments that do not extend over the full length or width of the road and / or will slow significantly increasing maintenance costs. By enabling these patching treatments, we are able to efficiently target failing pavements, whilst extracting the full life out of the neighbouring sections of State Highway.

Structures

Through the prioritisation of structures work as described prior, only those structures component replacements classes high priority work and a proportion of the medium priority work are undertaken. This process ensures that a sustainable core programme is completed.

Drainage

Our programme of drainage works remains relatively low. Modelling identified the length of network requiring drainage renewal ranged from 3 percent to 5.2 percent. Our proposed programme of drainage works is at the lower end of this range. The need to invest more in drainage is recognised and a number of projects are underway in order to assess and quantify the benefits of improved moisture measurement and define intervention triggers for drainage works.

Resilience

Resilience preventative works are generally delivered through capital projects (outside this high-level business case). However, the day to day resilience of the State Highway network, during the winter for example, is covered by the Maintenance, Operations and Renewals budget.

An alternative identified for resilience in the maintenance programme is to reduce the number of specific trees removed. This increases the risk of a closure or partial closure of a State Highway due to a fallen tree and may also lead to increased costs to reopen State Highways when one of these trees falls.

Investment opportunities to enhance customer outcomes

The main opportunity for access is to improve the life and performance of pavement assets by providing effective drainage – the work programme and funding need for this has yet to be quantified. It is proposed that, once investigations into optimum interventions are

completed, the business case will be developed and approved. It is envisaged that funding for the 2018/21 period could come from savings realised during the 18/21 NLTP (through efficiency gains for example).

Access and resilience programme risks

Service level risks

The greatest risks to the delivery of the access and resilience core programme are:

- Sudden unexpected failures of surfaces or pavements
- Loss of integrity of the road formation arising from, for example:
    - Scour by nearby rivers
    - Coastal erosion
    - Under slips on the downhill side of the road.
- Blockage of the carriageway by, for example:
    - Events or incidents, e.g. crashes, broken down vehicles, lost cargo
    - Over slips depositing material on the road
    - Rainfall and floods making the road impassable.
    - Other weather-related events, e.g. winter conditions
    - The alternative route is unavailable
- The impact of major unplanned events:
    - Earthquakes
    - Major slips blocking state highways

The risks to the serviceability and integrity of road surfaces, pavements and formation from deterioration are generally low due to the sophisticated maintenance and renewal processes employed. Risk nonetheless exists, as the programmes have been tensioned. A small nationwide contingency is held and managed nationally to cover this.

At a local level, Emergency Procedures and Preparedness Plan (EPPP) is prepared and updated by the Network Outcomes Contract contractors. Network Managers are responsible for the coordination of emergency response within the network, including bridges and major structures. The EPPPs include specific requirements for structures (usually within site specific Operations and Emergency Management Plans).

Each regional Structures Management Contract includes emergency response provisions. Essentially, the Regional Structures Management Consultant is required to be available at short notice to provide technical support in the event of an emergency. In addition, any issues which have the potential to cause an emergency event are to be identified by the Structures Management Consultant and advised to The Transport Agency to allow appropriate mitigation action to be taken.

For lesser scale events affecting structures, but not involving declaration of an emergency, the Structures Management Consultant is required to liaise with the Network Managers and Network Outcomes Contract contractors to develop appropriate responses which ensure the safety of the public, while minimising disruption to the network.

Quantities, cost, and effectiveness

In addition to the above service level risks, the programme's expenditure profile over the next 10 years depends on the following key factors:

- Efficiency and effectiveness gains compared to past practice.
- Increased demand which causes greater deterioration than before.
- The growing scope and complexity of the network requiring more extensive or advanced maintenance and renewal works to sustain service levels.
- Continued increases in input prices.
- Availability of key materials and resources (e.g. chips).
- Ability to deliver much larger reseal programmes, with minimal disruption to our customers, is a challenge due to the current New Zealand contractor capacity to deliver.

The greatest risks to the value for money of service levels arise from:

- Deferred renewal works beyond the optimum intervention point.
- Inadequately addressing the causes of failure or deterioration, in part, when maintaining or renewing road surfaces and pavements.

Any such event would lead to a greater amount of maintenance works than normal to restore and maintain service:

- A prolonged reduction in road resurfacing and pavement renewal works, below the long term sustainable level, that requires abnormal amounts of maintenance to maintain service and allows the condition of surfaces and pavements to deteriorate to such an extent that they require rebuilding rather than the cheaper renewal to maintain service levels.
- Our contractors have reported difficulty in delivering quantities of pavement rehabilitations and renewals. Should this continue it may affect our long-term ability to provide durable road surfaces capable of delivering the required capacity and travel time reliability in any weather.

This risk arises either by prolonged under-investment, or an underestimate of pavement and surface deterioration.

While these are risks, the Transport Agency has the necessary systems and processes in place to mitigate, manage and reduce the likelihood of these risks and factor significantly effecting the programme.

Part D – Travel time reliability

Consistent, reliable travel times for daily journeys contribute to an efficient and enjoyable travel experience. Predictable journeys (including the travel time reliability of the route) are a key priority for the Transport Agency. Our investment in predictable journeys is intended to ensure that:

Reliability: the consistency of travel times that road users can expect.

Maintaining travel time reliability is critical to the quality of experience for customers, the cost of travel (for people and goods) and therefore the New Zealand economy. The ability for people and commercial organisations to be able to predict travel times is vital to them. Our customers care about time travel reliability because:

- They are extremely busy and their time is becoming increasingly valuable to them.
- They want to be able to plan and complete their journeys as expected.
- They want to be able to make informed decisions about their journeys.
- For businesses, travel time reliability can be a vital component of their viability.

The delivery of the proposed programme of works to enable network journey predictability is aligned with a number of One Network Road Classification performance measures including:

- Customer Outcome: The number of journeys affected by unplanned events
- Customer Outcome: The number of instances where road access is lost
- Customer Outcome: Throughput at indicator sites
- Cost Efficiency: Overall network cost and cost by work category.

Because these measures are being developed, we have developed measures that are applied to the NOCs to track travel time reliability performance. These measures are used in the interim until the customer outcome and cost efficiency measures are developed.

Maintenance and operations activities

Our proposed programme of works to deliver travel time reliability for our customers is made up of a number of core service aspects as outlined below.

Proposed programme of works

	Service aspects	Access and resilience	Travel time and reliability	Safety	Amenity
Travel Time Reliability	Provide travel information	✓✓✓	✓✓✓	✓✓	
	Event and incident management and response	✓✓✓	✓✓✓	✓✓	
	Network optimisation through TOCs	✓✓✓	✓✓✓	✓	

Our investment in traffic management is targeted to:

- Optimise traffic flows throughout the day (for planned events and congestion management).
- Monitoring and managing minor to major incidents that occur as ‘business as usual’.

- Managing information systems such as variable message boards and public. information channels for drivers.

Traffic management

Our investment in traffic management includes the operational running of the four Transport Operations Centres across the country (Auckland, Wellington and Christchurch). While each region is slightly different, the Transport Operations Centres contribute positively and directly to customer journeys through four key services.

The table below provides a description of the service area, the tasks and the benefit to our customers.

SERVICE AREA	DESCRIPTION	TASKS	BENEFIT TO CUSTOMERS
Optimisation (Supply/capacity management)	This is achieved through the use of technology and data to facilitate the management of demand from travellers within the road network and enables vehicles to make the most efficient use of the urban and rural road networks. The data collected aids the implement of demand management strategies that aim to re-distribute traveller demand between nodes in the road network and ideally to other modes of transport.	• Monitor, collect and store traffic data • Develop demand management strategies • Use Intelligent Transport Systems assets to influence traffic flow • Provide advice on where infrastructure / systems should be implemented (e.g. traffic signals and passing lanes) • Work with contractors (e.g. tunnel operators) to maintain and enhance network capacity • Support Councils with public transport initiatives	Supports the efficient movement of people and goods through the transport system by improving customer journey time reliability.
Real Time Travel Information (Demand management)	The provision of real time information to travellers about traffic conditions, including other available routes and times.	• Monitor traffic, events and weather information • Provide up-to-date traffic information to customers through electronic mediums such as Twitter and Facebook • Plan special routes for emergency and goods vehicles • Use roadside assets to inform customer journeys	Influences travellers' choices about their mode, route and time of travel.
Unplanned	Manage the response to	• Collect, filter and	Minimises the

SERVICE AREA	DESCRIPTION	TASKS	BENEFIT TO CUSTOMERS
Incident Management	and minimise the impact on customer journeys from unplanned incidents. This activity relies upon coordinated incident management. Specifically, the identification and classification of incidents, and planning intervention that minimises the impact of unplanned incidents on customers' ability to efficiently navigate the road network.	classify incident notifications from a variety of sources • Initiate, plan and implement appropriate responses to incidents • Manage contracts with external contractors • Coordinate response teams, including emergency services • Redirect traffic to minimise disruption and further incidents	impact of unplanned incidents on customer journeys and customer journey time reliability.
Planned Event Management	Prepare the road network to effectively and efficiently cope with planned events to minimise the disruption to road users' journeys.	• Work with Councils to plan the road network for planned events • Plan and implement alternative routes • Communicate event information to customers (in real time) • Liaise with contractors to support roadwork activities	Minimises the impact of planned events on customer journeys and customer journey time reliability.

Intelligent Transport Systems are critical for the monitoring and operation of the network. Intelligent Transport Systems apply information and communication technologies that support and optimise all modes of transport by cost-effectively improving how they work, both individually and in cooperation with each other. Intelligent Transport Systems capabilities influence the smart choices our customers make, help us manage the one network, support safer journeys, deliver more effective freight supply chains and enable more enjoyable user experiences.

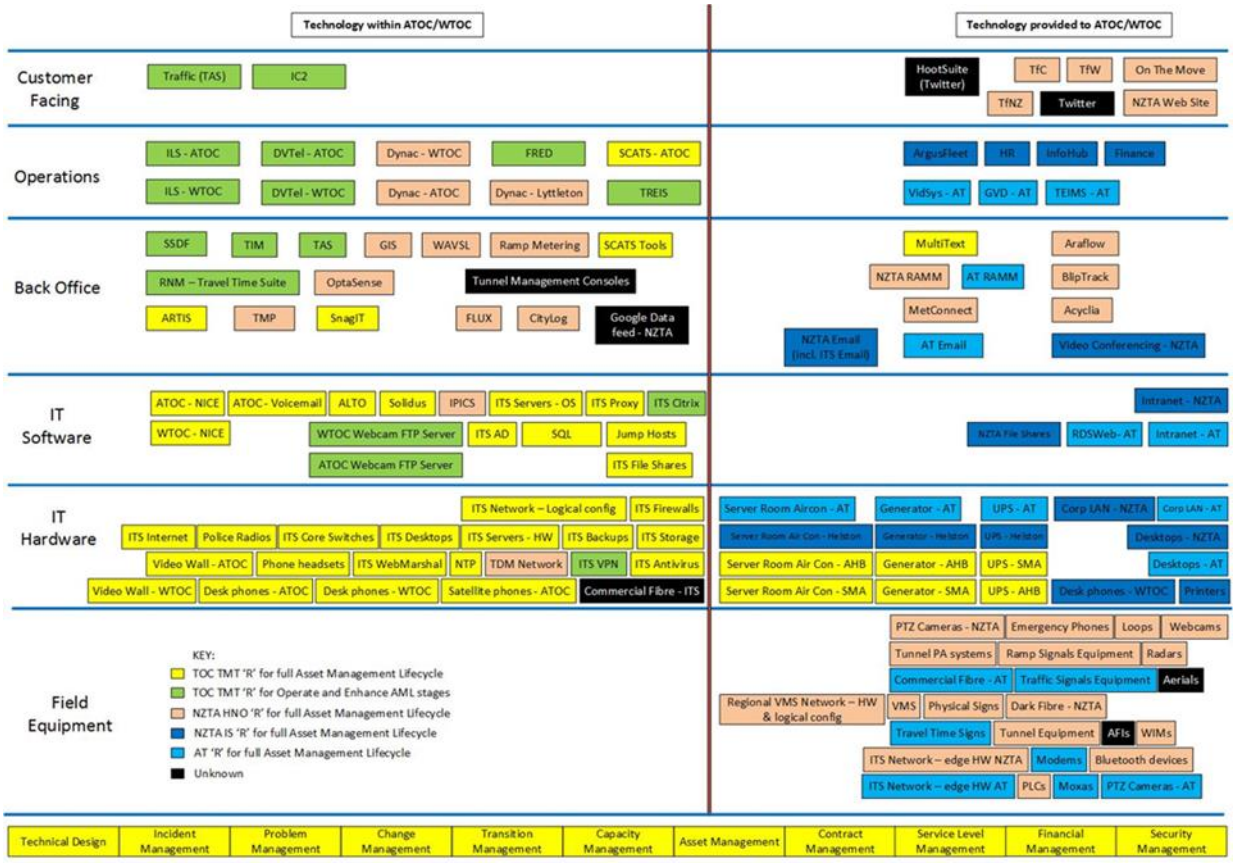
Intelligent Transport Systems allow the Transport Operations Centres deliver services to customers by:

- Our ability to protect people from their and others' mistakes: active vehicle safety features and real-time safe speed messaging to drivers to help reduce the occurrence and severity of crashes.
- Our ability to resolve operational issues: intelligent transport systems enable us to respond quickly to changing traffic conditions through interventions such as adjustments to traffic signals, variable speed and messaging signs, and ramp metering.
- The amount and quality of data: having comprehensive, in-depth data is invaluable for our planning, investment and operational activities at local, regional and national levels, and for managing the risks and costs of network ownership and operation.

- The way we gather and use data about traffic flows and the state of the network: smartphones and GPS-compatible devices, advanced roadside equipment (signs, gantries and sensors) and innovations that are turning vehicles into data-gathering machines are enabling us to see who's using the network, how they're using it, and whether it's performing optimally. This informs Transport Operations Centre staff so that appropriate interventions can be made to improve customer journeys.
- Our ability to communicate with travellers: Intelligent Transport Systems enable us to provide real-time travel information to customers (via roadside signs, smart devices etc.) on network conditions, safe speeds, incidents and alternate journey choices – with flow on benefits in safety, convenience and journey efficiency.

The Transport Operations Centres are reliant on both Intelligent Transport Systems and Information Services to deliver its outputs. Intelligent Transport Systems support is provided through the Transport Operations Centres Technology Team, Transport Agency Information Services teams, third party vendors and suppliers. The diagram below outlines the core Information Services / Intelligent Transport Systems technology required to deliver Transport Operations Centre services.

Illustration of technology within and provided to Transport Operation Centres



The technology is split into six areas as follows:

1. Intelligent Transport Systems Field Equipment – devices on the road or roadside such as cameras, loops and detectors and variable message signs. These devices are used to provide situational awareness of network performance and issues (cameras), alert Transport Operations Centres staff to unusual performance (loops and detectors) and provide real time information to travelling customers (electronic signs).
2. Hardware – physical technology which provides the foundation systems that the operational systems and services operate from i.e. server rooms, desktops and storage.

3. Software – software technology which provides the foundation systems that the operational systems and services operate from i.e. communication systems, webcam operating systems.
4. Back office – systems that run in the background and are essential to enable operation of the technology used by operations staff/ customers, and/or systems that provide data and information that is required to enable operation of the network or which is provide directly to the customer.
5. Operations – technology directly utilised by Transport Operations Centres staff to operate the network.
6. Customer facing – technology provided directly to the customer for their consumption / use.

Signalling

We invest in maintaining and renewing signalling to manage traffic flow onto and along the state highways during peak periods and other busy times. This has been included under our traffic management programme due to the interrelated nature of these assets.

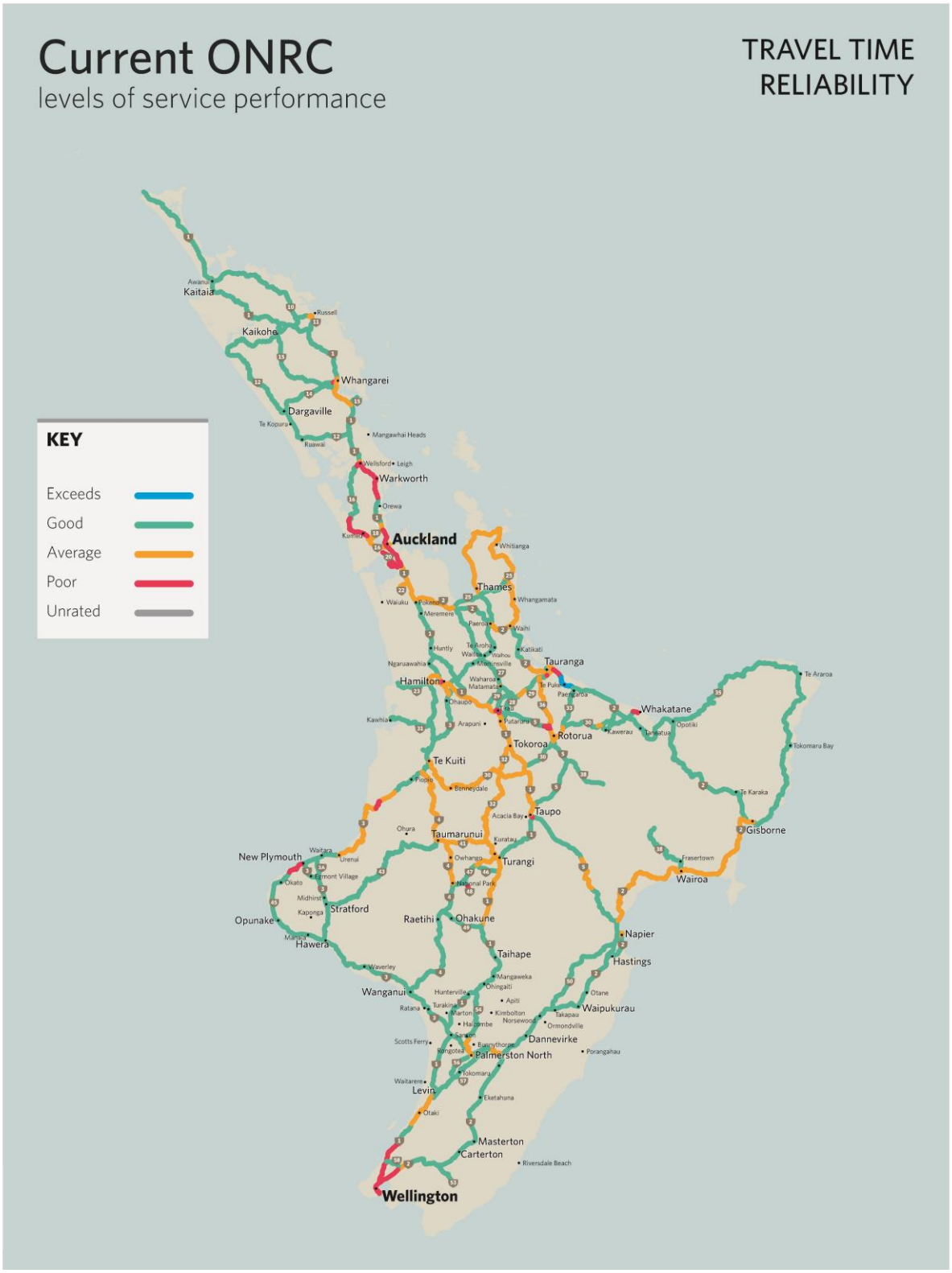
Signage

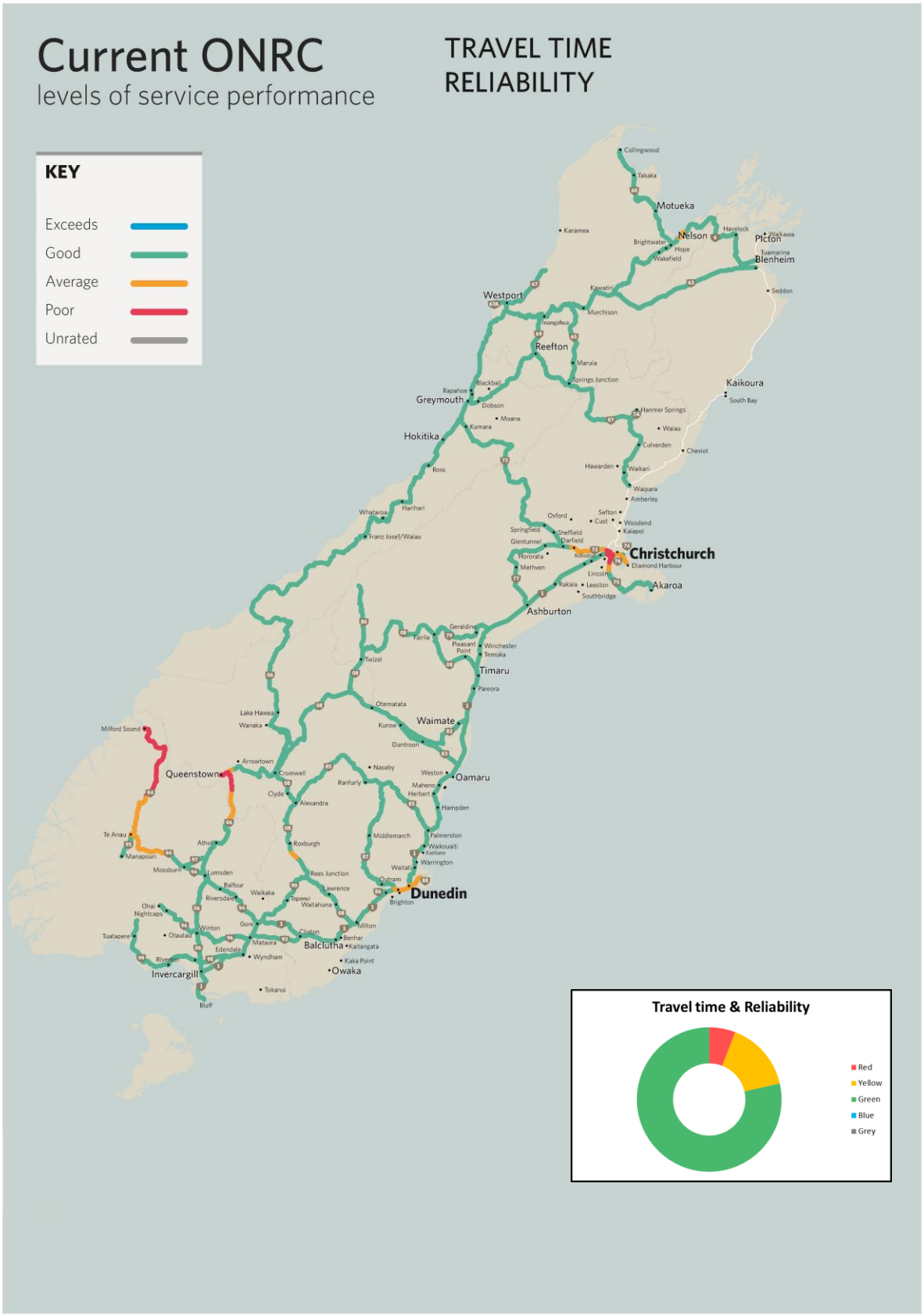
We operate and maintain traveller information systems which allow information about the road network and public transport systems to be distributed to travellers. The use of this allows travellers to make informed route, time and mode choices, which reduces traffic congestion through distributing traffic more evenly over a network.

Current state

The figure below shows the travel time reliability levels of service for the defined corridor sections. it shows that generally, there are service gaps in urban areas, where growth, congestion and access pressure are creating level of service challenges.

Current ONRC performance – Travel time reliability




Current ONRC
levels of service performance
TRAVEL TIME RELIABILITY
KEY
Exceeds
Good
Average
Poor
Unrated
Motueka
Nelson
Picton
Blenheim
Westport
Reefton
Greymouth
Kaikoura
Hokitika
Christchurch
Akaroa
Ashburton
Timaru
Waimate
Oamaru
Queenstown
Dunedin
Balclutha
Owaka
Invercargill
Travel time & Reliability
Red
Yellow
Green
Blue
Grey

Journey length

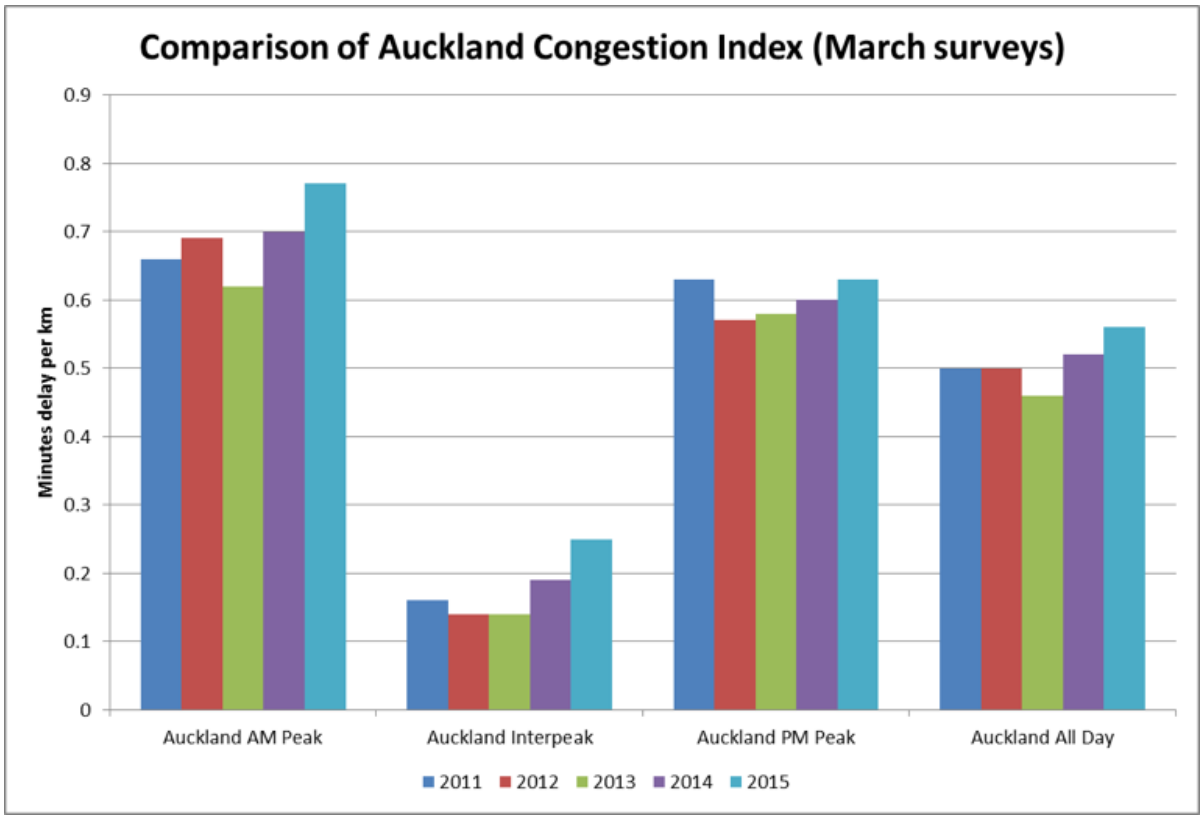
Twice a year we undertake research[15] to find out how long it takes road users at key locations in the country's main cities to get from journey start to journey end. The aim is to identify areas where journeys are taking longer, for example because of increasing congestion, to determine whether the longer journey is acceptable, and if not, develop solutions to reduce the congestion.

The Transport Agency has the aim of improving journey predictability. We track and demonstrate our progress against this outcome by measuring:

- Minutes delay per km, compared to travel at the speed limit in the surveyed area for Auckland, Wellington, Christchurch and Hamilton.
- The number of planned and unplanned road closures and the number of vehicles affected by these closures.

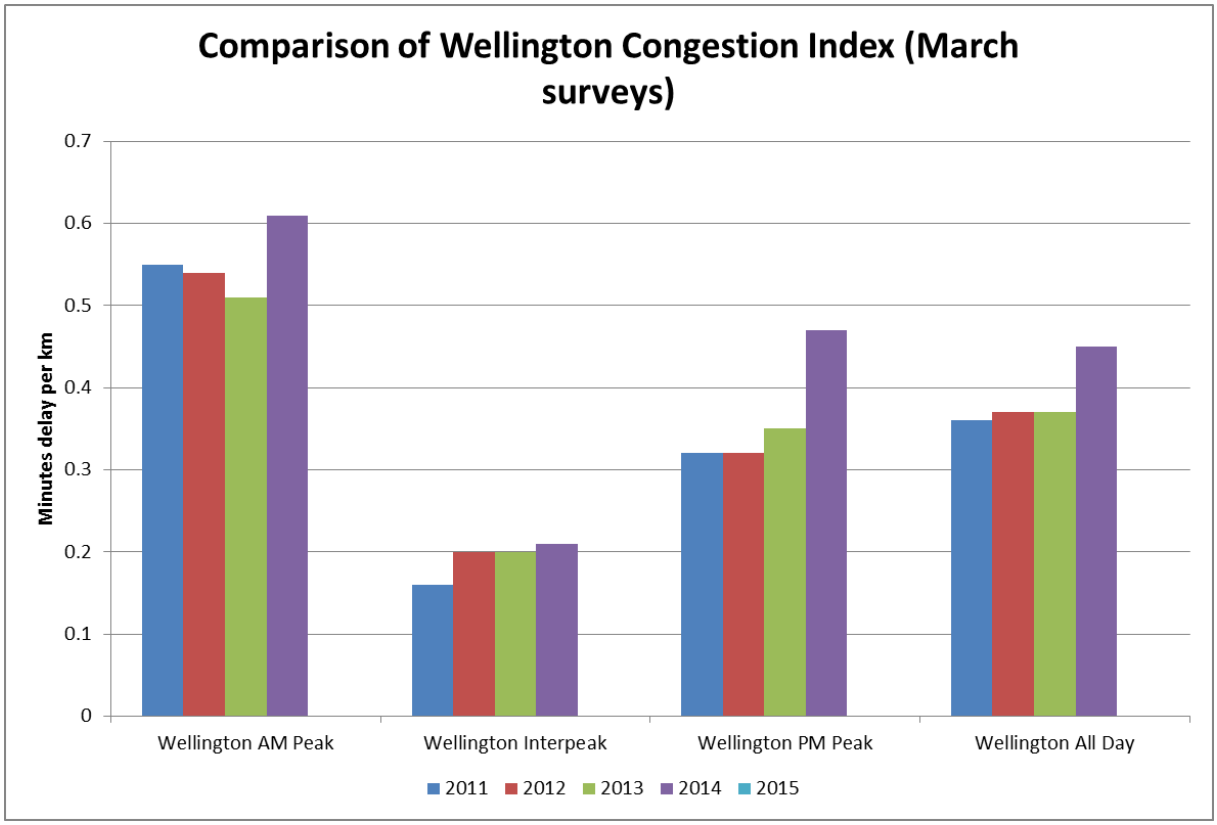
The graphs below show our performance for minutes' delay per km[16], compared to travel at the speed limit in the surveyed area for Auckland, Wellington[17] and Hamilton.[18] It shows that since 2011, the minutes delay per km has been rising across all travel time periods in the four major centres.

Auckland Congestion Index

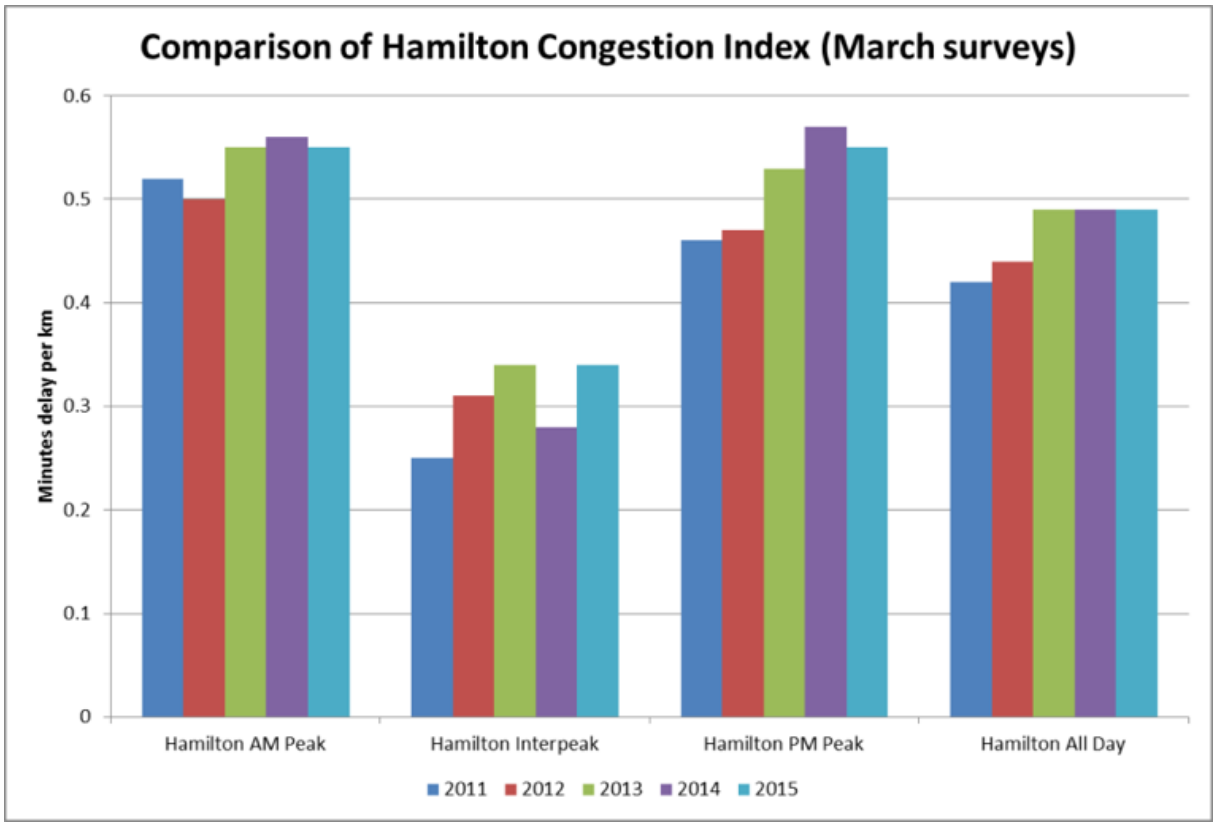


[15] Via travel time surveys.
[16] Data sourced from Ministry of Transport website.
[17] Note that the Wellington 2015 results are still under analysis.
[18] Note that no reliable data is available for Christchurch since 2011 as the survey results have been influenced by substantial disruption caused by roading activities related to post-earthquake rebuilding.

Wellington Congestion Index



Hamilton Congestion Index



Road closures

The Transport Agency measures the number of unplanned road closures and the number of vehicles affected by closures. This shows how we are performing at maintaining minimising disruption for our customers and the resilience of the network. The Transport Agency undertakes a variety of planned works across the state highway network. To minimise the number of vehicles affected, where possible we endeavour to carry out these works in quieter periods or overnight, however this is not always an option.

The table below shows the number of unplanned road closures that were greater than two hours and the approximate total number of vehicles affected by these in the 2015/16 year.[19][20]

Unplanned road closures greater than two-hours

	NUMBER OF INSTANCES WHERE ROAD ACCESS WAS LOST 2015/16	
	No. of closures	**Approximate no. of vehicles affected**
High Volume	48	168,700
National	55	103,200
Regional	105	195,100
Arterial	68	88,900
Primary Collector	62	46,200
Secondary Collector	4	300

In the 2015/16 year the Transport Agency identified over 600 planned road closures greater than 2 hours affecting approximately 5.6 million vehicles.

The cost efficiency measures provide an indication of the relative costs and efficiency of works related to sealed road surfacing and pavements, unsealed roads and National Land Transport Programme funded maintenance and renewal costs. These measures allow us to review how efficiently we provide predictable journeys and should be considered alongside the other relevant One Network Road Classification performance measures, as they provide a richer picture in combination than when considered individually.

Other performance initiatives

The Transport Agency continues to undertake predictable journeys initiatives across the network, this includes intelligent transport systems, toll roads, smart motorways, ramp signalling and traffic management.

Traffic management

Traffic management involves using technology to provide road users with a safe and efficient state highway network.

[19] This is based on the One Network Road Classification performance measures.
[20] Note, this only reflects the time the state highway is closed and may not accurately reflect built up congestion, which can take a significant time to fully clear, thereby affecting additional vehicles.

Our state highway traffic management centres in Auckland, Wellington and Christchurch use a network of remote cameras and sensors to enable us to monitor traffic flow and respond rapidly to conditions or to incidents that are stopping or slowing traffic.

New technology is constantly being developed and we work closely with our partners in the public and private sectors to improve the scope and extent of our traffic management techniques and tools. We currently apply several technological tools to help keep traffic flowing smoothly, as and when traffic volumes and conditions require, including:

- Linked traffic signals which ensure the most efficient movement of traffic across a network of intersections.
- Electronically changeable signs (also known as 'variable message signs') that provide messages about what's happening ahead and enable drivers to make early decisions on their travel options.
- 'Variable mandatory speed control' signs, which aim to reduce traffic speeds before queues start to form. The signs can legally reduce traffic speeds from 100km/h to 60 or 50km/h.
- Closed-circuit television cameras that enable us, the police and emergency services to respond quickly to incidents and events on the state highway network.
- The road conditions website that provide up-to-date information[21] on conditions on the state highway network.
- Underground sensors that detect the presence and speed of vehicles and activate traffic management tools.
- The lane-control system on the Auckland Harbour Bridge.

The customer experience within each Transport Operations Centre's operational area differs significantly depending on where and when travel is undertaken, especially as the areas spans wide ranges of population densities, vast and varied terrain, and is prone to extreme weather events.

Keeping road users up to date with travel information regarding incidents, delays, and road closures, is one of the Transport Operations Centres' biggest challenges and our Intelligent Transport Systems infrastructure plays a vital role in this.

Outside of the major metropolitan areas, towns can be separated by large distances, with some areas being particularly remote. This poses a significant challenge for contractors and emergency services responding to incidents. The Transport Operations Centres are increasingly working with local authorities, contractors and emergency services, to provide customers with more efficient journeys 'one network' across the transport system.

Ramp signalling

Ramp signals are essentially traffic lights that manage traffic flow from two-lane on-ramps onto the motorway. The signals operate only when they are needed to improve traffic flows, for example during peak periods and other busy times. Widely used internationally, ramp signals have been shown to reduce congestion and improve traffic flows resulting in more consistent travel times, safer merging and fewer accidents.

Ramp signalling is one initiative we've introduced to help manage the increasing traffic volumes on Auckland's motorway network. We've worked closely with Auckland's local and regional councils and Auckland Transport to install 61 ramp signals on the Southern, Northern and Northwestern motorways.

Wellington Smart Motorway

Smart motorways improve safety and reduce congestion by carefully controlling the flow of vehicles. The key is smoothing the flow of traffic and reducing sudden braking which causes a domino effect on following traffic.

[21] The site is updated every two minutes, providing a useful tool for journey planning.

Smart motorways reduce congestion by carefully controlling the flow of vehicles. The most critical time when the system can influence the severity of congestion is as the traffic volume begins to build i.e. before the road becomes congested. Detectors under the road and radars mounted on lighting poles and gantries count the number of vehicles in each lane, as well as the speed they're travelling.

The section of State Highway 1 between Ngauranga and the Terrace Tunnel is Wellington's busiest section of road, used by around 90,000 vehicles a day. Wellington's new smart motorway opened on 22 June 2016 and started operating southbound on 8 July 2016.

The smart system calculates the rate at which the road is getting congested, factors in what's likely to happen based on traffic records that are continually updated and monitored, and automatically adjusts the speed limit to pace the traffic and delay queues being formed.

Toll roads

The Transport Agency currently has three toll roads: the Northern Gateway Toll Road north of Auckland, and the Tauranga Eastern Link Toll Road and the Takitimu Drive Toll Road, both in Tauranga.

The toll is collected through an electronic tolling system. This system uses cameras and sensors with optical character recognition technology to capture an image of a vehicle's registration plate and assign the correct toll price, based on the size of the vehicle.

Intelligent transport systems

We've already made significant investments in intelligent transport systems over several years including:

- Installation of sensor technologies in roads and integrated them with roadside infrastructure to gather information about traffic volumes and flows.
- Provision of roadside and web-based journey information, including estimated journey time, speed and weather advisories.
- Installation of joint traffic operations centres that allow us to see in real-time what's happening on the network and adjust settings remotely in response to traffic and changing conditions e.g. variable speeds and ramp signals in Auckland.
- Introduction of electronic road user charging and electronic log books.
- Installation of systems that automatically recognise number plates to support free-flow toll roads.

Methodology

Most intelligent transport system equipment has a manufactured working life of 7 to 10 years. For most intelligent transport system assets, the equipment becomes obsolete as the equipment ages with an unavailability of replacement parts or unsupported service from the manufacturer. For a large proportion of the intelligent transport system the equipment was installed in the last 10 years. It is expected that this equipment will require replacement as the parts required for maintenance will not be available in the future.

The expected life of intelligent transport systems assets is often complex to estimate as the assets do not operationally deteriorate in a manner that can be monitored and will often have an “go” or “no go” status, where the asset is either working or has simply died due to an unpredictable electronic failure. Significant failures are often beyond economical repair and the sub board or entire asset needs renewal.

Signalling maintenance and replacement is based on the expected lives for the assets. Signalling assets are inspected regularly to identify condition or performance deterioration requiring attention (particularly visibility). Where signals have been damaged and renewed, these are excluded from the list requiring maintenance activities unless further issues are identified.

The Transport Agency manages the renewal programme based on performance and loss of level of service rather than age. Some assets can be run to failure based on an assessment of operational risk, availability and readiness to replace with a new unit or temporary unit until a new standard unit is sourced. Others need to be replaced when it is no longer able to deliver the required level of service.

This business case has considered the current range of services and benefits delivered by the Traffic Operations Centres.

The Transport Agency has developed an approach based on six key principles to guide all our intelligent transport systems related operational and investment decisions, these are:

1. We invest in and support intelligent transport systems solutions that demonstrably contribute to our strategic objectives. This enables us to focus our limited resources where they’ll add most value.
2. We prefer a traveller-centric (rather than mode or road) approach, with customers at the heart of our business.
3. We consider intelligent transport systems from multi-modal perspectives, integrating information and customer experience across modes.
4. We encourage sector-led intelligent transport systems development and investment. This prevents us unnecessarily investing in or overregulating technologies, unless the investment is in an asset for which we’re accountable.
5. We’re solution neutral and prefer to be a service provider of last resort.
6. We value traveller choice over administrative convenience.

Travel time reliability core programme

Overview

We have adopted standardised levels of service under the One Network Road Classification framework. This means we have not considered programmes with alternative level of service targets. We have considered alternative programmes that:

- Either cost less and expose the Transport Agency and our customers to greater risk, or cost more and reduce the risk to us and our customers and/or
- incur more costs now for later savings, or defer costs now with anticipated increased costs at a later time.

The funding request for our core travel time reliability programme differs from our previous proposals due to the following:

- Ensuring we deliver connected journeys and improved customer experience across the transport system, on a busier and more complex network.
- Focusing Traffic Operations Centre activity on key outcomes such as achieving improved freight efficiency.
- Addressing the highest priority areas identified in the Auckland, Wellington and Christchurch network operating plans, through operational improvements.
- Improving the use of information from existing Intelligent Transport Systems to understand how the network is operating, where its performance gaps are and implementing new technology where this improves service.
- Improving the quality of travel information provided to customers.
- Asset growth (large capital projects and safety improvement programme), results in a significant increase in the number of assets and associated maintenance activities for those assets.

A summary of the programme cost is provided in the table below.

Travel time reliability funding

Work Category	Forecast funding ($ m)	
	2018–21	2018–27
WC 111	$0.0	$0.0
WC 112	$0.0	$0.0
WC 113	$0.0	$0.0
WC 114	$0.0	$0.0
WC 121	$47.0	$174.9
WC 122	$0.0	$0.0
WC 123	$131.0	$487.9
WC 124	$0.0	$0.0
WC 141	Not Incl.	Not Incl.
WC 151	$37.4	$139.1
WC 161	$4.5	$16.7
WC 211	$0.0	$0.0
WC 212	$0.0	$0.0
WC 213	$0.0	$0.0
WC 214	$0.0	$0.0
WC 215	$0.0	$0.0

WC 221	$0.0	$0.0
WC 222	$22.1	$82.5
Total	**$241.9**	**$901.0**

The increase for traffic signal maintenance activities[22] is based on the age and condition of the asset (and associated higher level of maintenance expected) as well as an estimate for the number of new assets being added to the network.

Traffic management

The various operating systems and applications outlined earlier in this business case are integrated both within and across the six areas and failure to maintain one of the individual applications or systems could adversely impact many. The complexity of the Transport Operations Centre environment is further exacerbated by the reliance on technology that supports the joint venture in Auckland / Wellington, and the consequential requirement to integrate systems and applications from separate organisations.

There is significant skill and experience required to support this environment, and this requires close management of third party suppliers to ensure levels of service are maintained.

The core programme supports a rigorous programme of work to ensure on-going operational resilience, business as usual for Transport Operations Centres and additional work required to respond to civil defence emergencies, improve congestion and customer journeys for each area of operation.

Intelligent transport system benefits will be influenced by evolving technologies and market demands. The Transport Agency will continually monitor the global transport sector to ensure that our intelligent transport systems efforts and investment practices are maximising returns for New Zealand.

Our proposed programme of works in tandem with our CAPEX plan ensure suitable journey predictability across the State Highway network in a manner consistent with the One Network Road Classification.

The NZ Transport Agency has undertaken a number of reviews of the benefits of Network Operations[23][24] and overall, the proposed travel time reliability core programme is a very strong value for money proposition. The benefit cost analysis and literature review undertaken in the 2017 Deloitte report 'Traffic Operations Centres'[25] identified:

- Typically, there were high values for transport management activities.
- The cost of congestion, variable trip times and crashes is significant to road users and the public sector.
- Management activities such as incident management reducing congestion and related crashes, real time information or optimisation reducing congestion, crashes and improving reliability are found to have a high benefit when quantified.
- The Traffic Operation Centres managers identified there was limited renewals and maintenance planning undertaken related to intelligent transport systems infrastructure and software systems.

[22] Traffic signal maintenance for is undertaken through a contract split across each contract area. The preventative maintenance programme is outlined in the contract; however, the Transport Agency has limited opportunities to reduce the preventative maintenance costs due to contractual obligations.

[23] http://www.nzta.govt.nz/resources/research/reports/548
[24] http://www.nzta.govt.nz/resources/research/reports/584
[25] https://nzta.govt.nz/assets/Planning-and-investment/State-highway-investment-proposal/Technical-documents-supporting-maintenance/NZTA-Traffic-Operations-Centres-2016.pdf

- This puts the Traffic Operation Centres functional activities at risk when intelligent transport systems infrastructure fails (for example, a CCTV camera failing), as it limits the centre's ability to identify and respond to changes in the road network.

This core programme for intelligent transport systems infrastructure is intended to close this gap and ensure that the valuable service provided by these assets remains operational, minimising the risk associated with an unplanned failure.

The June 2016 Transport Agency research report *Demonstrating the benefits of network operations activities*[26] identified that key elements of the day-to-day traffic operations centre and journey manager work (optimisation, planned and unplanned events, and provision of traveller information) have an economic impact on the transport system. It also found that generally operations activities generate high benefit cost ratios, indicating they are highly cost-effective treatments.

The 2017 Deloitte report 'Traffic Operations Centres' identified the following benefits provided by the Traffic Operations Centres travel time savings, reliability savings, congestion cost savings, vehicle operating costs savings, crash cost savings and emissions cost savings. A benefit cost ratio analyses carried out indicated a range of BCRs for the 3 Traffic Operations Centres ranging from 4.5 to 10.8. The lower bound was derived conservatively because we had little information on vehicle occupancy, but where we did the ratio rose to 10.

Opportunities / enhanced programme

The Transport Agency is currently reviewing how the Traffic Operations Centres operate and is developing a national strategy for these. This document will look to align operational processes and ensure consistent systems / technology is utilised to allow us to capture available efficiencies.

Travel time reliability programme risks

Risk to levels of service and desired outcomes

The greatest risks to predictable journeys are:

- Impact of road incidents and planned works
  - From damage occurred due to increased numbers of crashes/incidents.
- The impact of weather related events, including:
  - Winter conditions.
  - Rainfall and flooding.
  - Slips blocking the state highway
- Loss of integrity of assets (including traffic management systems) arising from, for example:
  - Poor inspection / maintenance regime.
  - Erosion / under scour by rivers or coast.
  - Damage from collisions, particularly unreported ones.
  - Under slips on the downhill side of the road.
- Increasing traffic volumes across the State Highway network
  - These volumes lead to congestion during peak periods and can impact travel time reliability at other times.

Roadworks cause a reduction of capacity which results in travel time delays and can all negatively impact on the reputation of the Transport Agency. Maintenance and other scheduled activities provide the opportunity to positively or negatively influence the

[26] http://www.nzta.govt.nz/resources/research/reports/594

experience of road users when driving on the state highway network. Management of works in the state highway corridor is a key element in meeting road user expectations and network efficiency. Traffic management plans must demonstrate that the effects and impacts of proposed work on road users and the community have been assessed, and actions taken to mitigate any identified risks and minimise potential disruptions.

In developing our approach to assessing the benefits and opportunities of intelligent transport systems we have made a number of assumptions:

- Pressure on our urban networks will increase over the next 25 years, with a rising aggregate demand for travel and greater personalisation, and a requirement for us to get more out of the existing network while minimising the costs.
- An unforeseen technological game changer will not emerge in the next decade and render our investment decisions moot.
- Privacy concerns won't significantly impede progress towards realising some intelligent transport systems benefits, especially those that depend on knowing a traveller's or a vehicle's immediate location.
- While it's highly desirable to introduce common standards for certain aspects of intelligent transport systems, it's unlikely that these will be retrofitted to existing investments – so we'll need to accommodate diversity in the short to medium term.
- Having to compete with other initiatives for limited resources will not unduly limit investment in intelligent transport systems.
- The pace at which technology is advancing and the uncertainty around the future of traffic signal systems could see the current technology replaced or significantly changed
- Intelligent Transport Systems assets can fail with no prior indication of degradation

These issues introduce a number of risks. For example, New Zealand's transport sector might invest in outmoded solutions, incur additional costs if we adopt early-generation technologies too soon, or end up with overlapping and incompatible solutions, potentially responding to the same challenge.

Risk related to quantities, cost and effectiveness

The programme's expenditure profile over the next 10 years depends on the following key factors:

- Efficiency and effectiveness gains compared to past practice
- Increased demand which causes greater congestion than previously.
- The growing size, scope and complexity of the network (particularly in and around the large urban centres) requiring more extensive or advanced maintenance and renewal works to sustain service levels.
- New technology meaning existing technology becomes obsolete earlier than expected. Additionally, our customers' expectations are also changing – they are expecting us to deliver a wider range of services or service via alternative means as technology evolves and improves.
- Continued capital investment, increasing the quantity of assets requiring ongoing operations, maintenance and renewal.
- Continued increases in input prices.
- The commencement of a new contract in future years creates uncertainty around the future costs and the potential for insufficient funding to undertake the desired activities

The greatest risks to the value for money of service levels arise from:

- deferred renewal works beyond the optimum intervention point
- inadequately addressing the causes of failure or deterioration, in part, when maintaining or renewing assets.

Any such event would lead to a greater amount of maintenance works than normal to restore and maintain service:

- A prolonged reduction in renewal works, below a long term sustainable level, would mean a significant increased maintenance programme to catch up to return to ONCR levels of service. This would require rebuilding rather than the cheaper renewal to maintain service levels.

This risk arises either by prolonged under-investment, or an underestimate of asset deterioration.

Part E – Safety

The Transport Agency is committed to maintaining a safe road system. Our investment in a safe road system is intended to ensure that:

Our customers can travel safely on our network

Ultimately, our customers need to be able to travel safely, at all times (day and night), in almost all conditions (including during severe weather events, albeit at lower speeds), and have the confidence that that they are able to do so. The key levels of service that we deliver to our customers are:

- Road surfaces are safe to drive on (even when wet), at the appropriate speed.
- Drivers are adequately warned of hazards.
- Barriers and lines help drivers stay on the road.

We deliver these service levels consistently across the entire state highway network, independently of future safety improvement projects. The delivery of the proposed programme of works to enable network safety is aligned with the One Network Road Classification performance measures including:

- Customer Outcome: The number of fatal and serious injuries on the network.
- Customer Outcome: Collective risk (fatal and serious injury rate per kilometre).
- Customer Outcome: Personal risk (fatal and serious injury rate by traffic volume).
- Technical Outputs: Covering hazards, faults, obstructions, loss or control and vulnerable users.
- Cost Efficiency: Overall network cost and cost by work category.

Maintenance activities

Our proposed programme of works to deliver a safe network for our customers is made up of core service aspects as outlined below.

Proposed programme of works to deliver a safe network

	Service aspects	Access and resilience	Travel time and reliability	Safety	Amenity
Safety	Skid resistant surfaces	✓		✓✓✓	
	Delineation and hazard warnings		✓	✓✓✓	
	Vegetation control to maintain sightlines		✓	✓✓✓	✓
	Operating and maintaining tunnel ventilation and fire safety systems			✓✓✓	
	Lighting			✓✓✓	✓
	Cycle path maintenance			✓✓✓	✓✓

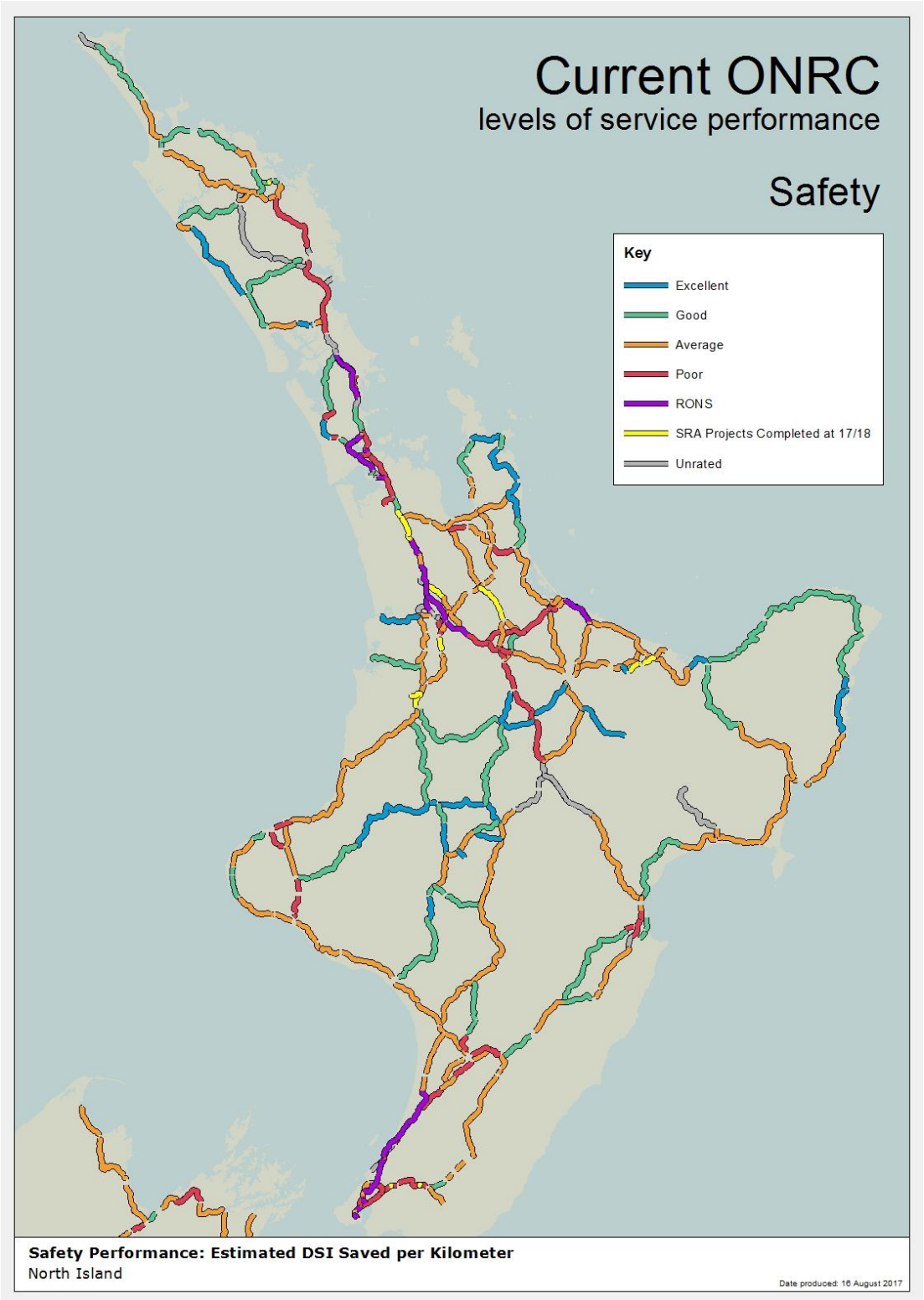
Maintaining road safety requires that we maintain current infrastructure and monitor and address emerging hazards by:

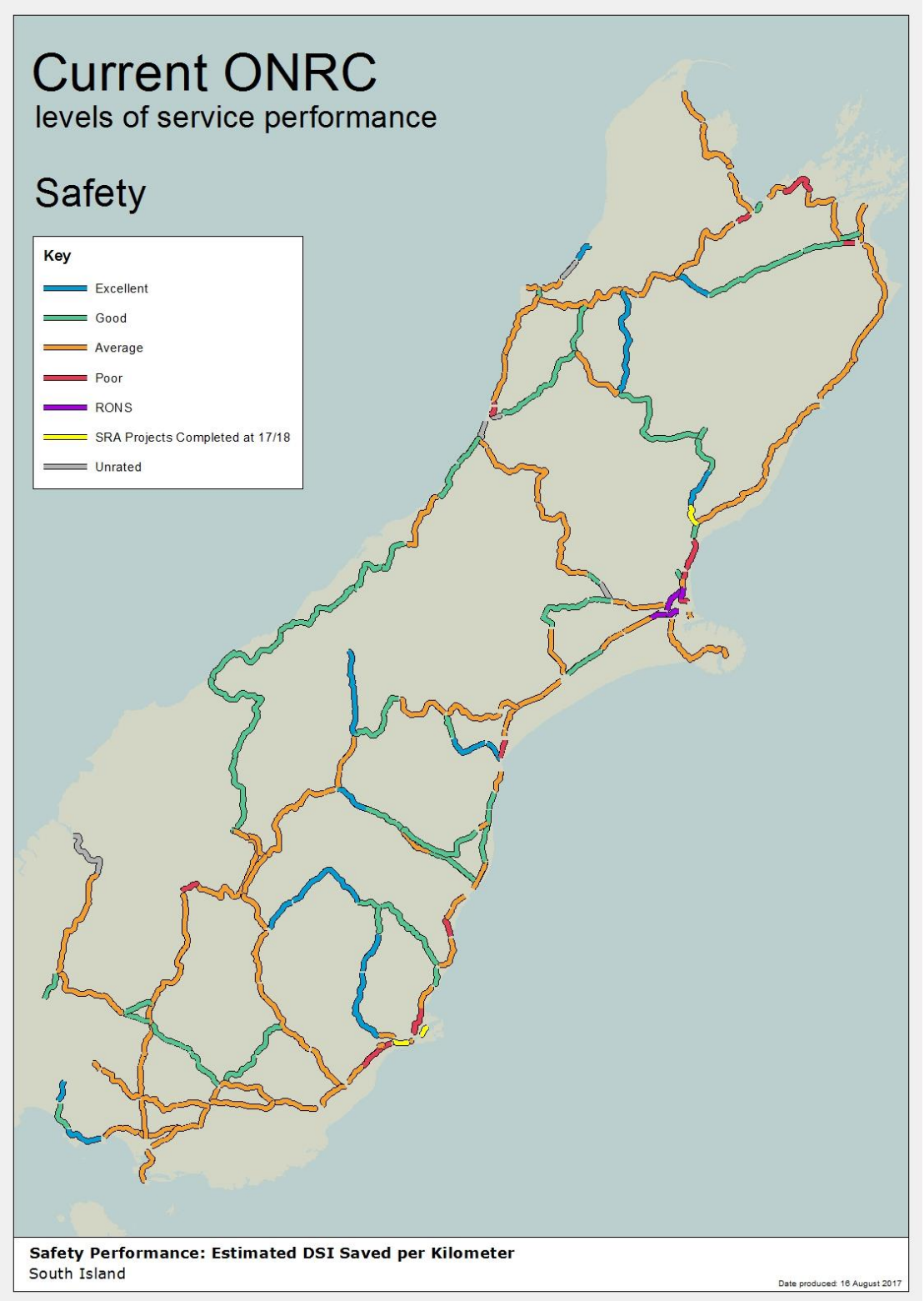
- Monitoring safety hazards on the network.
- Making priority hazards safe.
- Providing guidance so customers can navigate the network and hazards safely.
- Ensuring the road and roadside infrastructure is in a fit for purpose, safe condition.

Current state

From the gap analysis completed we know that the majority of the state highway network (80 percent) has a better or average performance for safety (refer to maps below).

Current network alignment to ONRC safety customer levels of service





The state highways below the expected safety customer levels of service are dispersed throughout New Zealand and across all road classifications from high volume national routes to collector roads. Many of the state highways with safety gaps also provide the main access to our regions and rural hinterland.

In the North Island the more significant safety gaps extend from Northland down through the Bay of Plenty and Waikato areas, with pockets of gaps elsewhere across the state highway network.

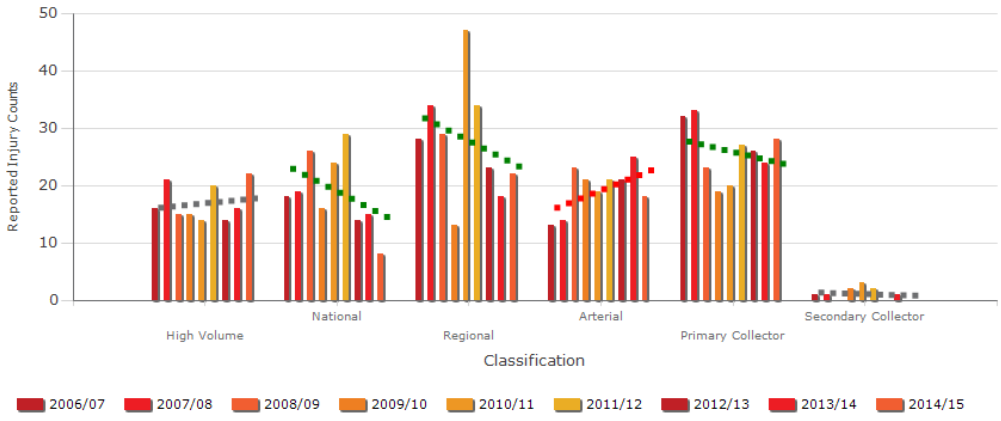
In the South Island the safety levels of service gaps tend to be on key tourism and freight routes including SH 94 Te Anau to Milford Sound, SH1 Timaru to Dunedin, in and around Christchurch, Greymouth (SH 6 and 7) and the at the top of the South Island on SH 6 and 60.

Fatal and serious injuries

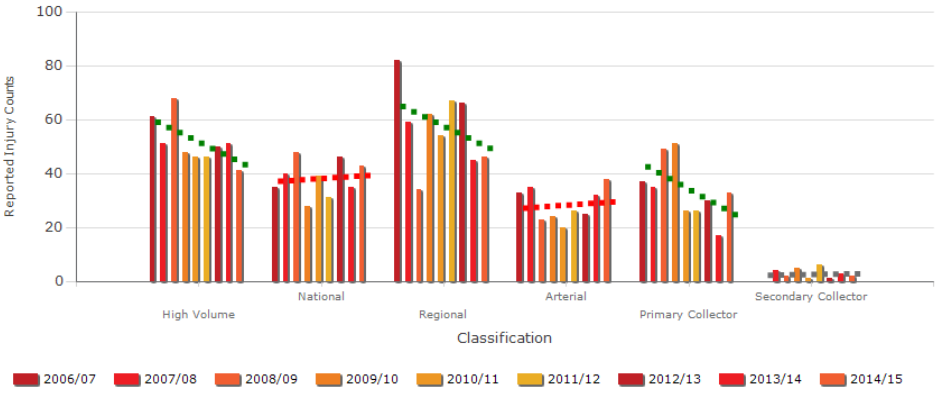
To ensure the road and roadside is safer for road users, the Transport Agency track and demonstrate progress by measuring the total number of fatal and serious injuries each year on the network; per kilometre; and by traffic volume. As we move to integrate the One Network Road Classification, we will assess the number of fatal and serious injuries per kilometre and by traffic volume for each road classification. This will help us to better understand our performance and where we need to focus our attention.

The graphs below present the number of Death and Serious Injuries (DSI) by road classification due to loss of control at night, at intersections and involving cyclists and pedestrians.

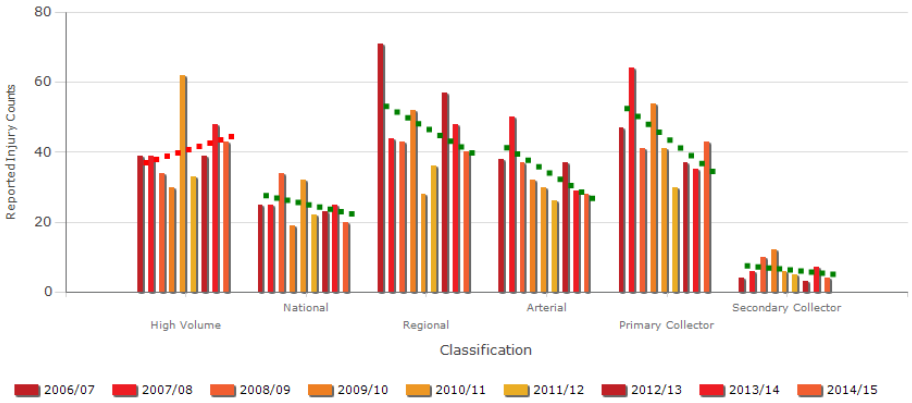
DSI as a result of loss of control at night



DSIs at intersections



DSIs involving cyclists and pedestrians



The table below presents the injury counts by road classification. While the overall number of fatal and serious injuries on the network have dropped since 2009/10, we have not seen consistent year on year improvements. This is partly due to injury counts reflecting a number of factors including driver behaviour, other road safety initiatives (e.g. police speeding drives, Transport Agency campaigns etc.) and vehicle safety ratings as well as our ongoing work to maintain and improve the safety of the state highway network.

Injury count by road classification

Injury counts – Fatal & Serious[27]	High Volume	National	Regional	Arterial	Primary Collector	Secondary Collector	Total
2009/10	171	176	241	131	219	26	964
2010/11	181	148	237	126	180	18	890
2011/12	170	152	262	141	157	20	902
2012/13	151	124	243	143	172	11	844
2013/14	172	151	218	151	167	27	886
2014/15	172	151	237	151	177	18	906

Collective risk and personal risk

The Transport Agency collates data on collective risk and personal risk. The table below presents the risk rating and collective risk within the road classifications. This has been calculated by dividing the number of rural crashes occurring on network within each classification by the number of years of data to get the number of crashes per year. This is then divided by the length of network within the classification to calculate the Collective Risk.[28]

[27] Note: 2015/16 data is incomplete, so has not been included.
[28] As outlined in the One Network Road Classification performance measures reporting tool.

Risk rating and collective risk by road classification

Classification	Risk rating	Collective Risk
High Volume	Medium	0.118
National	Low	0.095
Regional	Low	0.082
Arterial	Low	0.047
Primary Collector	Low	0.045
Secondary Collector	Low	0.022

Our highways with the greatest volumes of traffic have the highest collective risk. This is due to the increased risk of head on collisions compared to other classifications and the increased likelihood of a fatal and severe injury crash occurring. Over time, we would expect this to drop as we improve the safety of our highest classifications of highway, through capital improvement projects and upgrades to the state highway network (e.g. the RONS programme).

The table below presents the risk rating and personal risk per vehicle kilometres travelled (VKT) within the road classifications. This has been calculated by dividing the number of rural crashes occurring on network within each classification by the number of years of data[29] to get the number of crashes per year. This is then divided by the VKT and multiplied by 100,000,000 to get the numbers within range.

Risk rating and personal risk rating

Classification	Risk rating	Personal Risk per 100M Vehicle Kilometres Travelled
High Volume	Low	2
National	Low	4
Regional	Low	4
Arterial	Low	5
Primary Collector	Medium	6
Secondary Collector	Medium	8

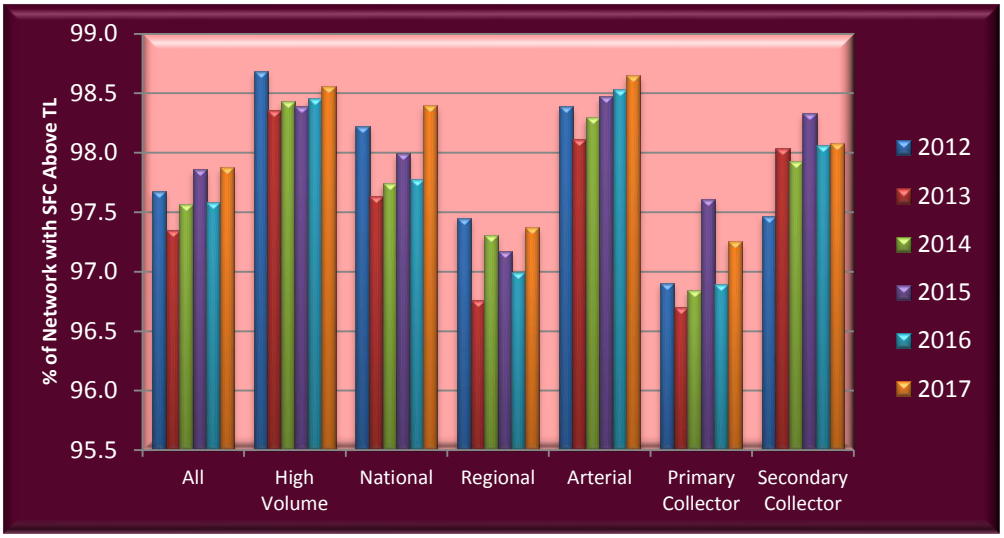
Our highways with lower classifications have a higher personal risk rating. This is as anticipated, as although our higher classification highways experience a greater number of fatal and severe injury crashes, the volume of vehicles mean that these are far lower per 100 million vehicle kilometres travelled.

[29] The difference between the first crash in the classification and the last up to a maximum of 10 years.

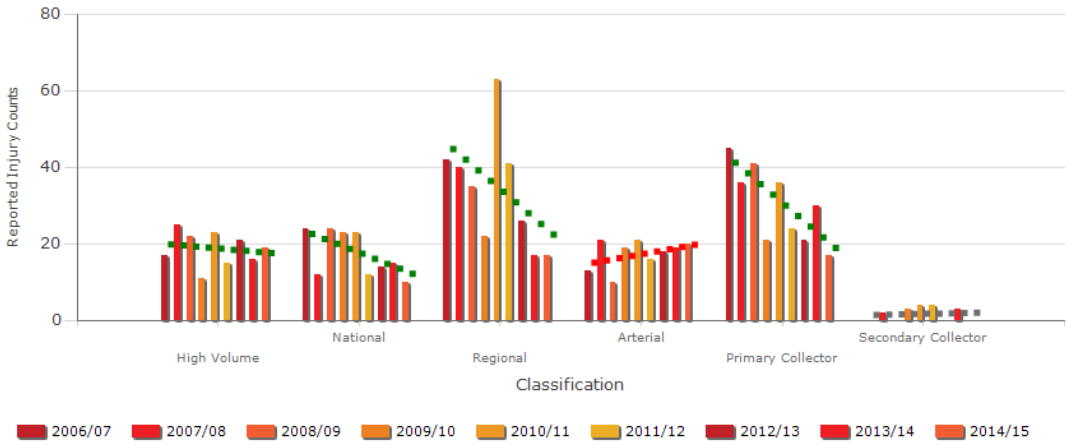
Skid resistant surfaces

Ongoing pavement and surface renewal programmes and provision of skid resistant surfaces along the network has led to an overall improvement in the good skid exposure. As presented in the figure below, loss of control crashes in the wet have been reducing as a result of the skid resistance work, although improvements have not been consistent year on year.

Skid exposure (% of network with Skid Friction Coefficient above Threshold Level)



Loss of control on wet roads by road classification



Wire rope safety barriers

In 2005, the Transport Agency installed a 3.5km-long wire rope median barrier on State Highway 1 Centennial Highway, just north of Wellington. This stretch of road was a particularly treacherous – from 1996 to 2000 it recorded eight fatalities, two serious injuries and seven minor accidents. Between 2001 and 2004, the passing lanes were removed and

road markings, reflectors and signs were increased, however four fatalities, two serious injuries and two minor injury accidents were recorded.

From 2005 to 2009, following the installation of the wire rope median barrier and lowering the speed limit to 80km/hr, there were no fatal and no major injury accidents, and just three3 minor injuries recorded.

Between 2005 and October 2015, the Centennial Highway barrier has been hit over 100 times without a single death. Each event has required operational support to clear the state highway lane affected and to reinstate the wire rope barrier.

Traffic sign supports

Large traffic signs represent a significant roadside hazard. To mitigate the risks associated with these necessary roadside objects, the Transport Agency has developed technical advice in consultation with the industry regarding the selection, installation and maintenance of passively safe (or frangible) traffic sign supports.

Methodologies

Pavements and surfacing

The Transport Agency has developed a new model to quantify how much of the renewal work is driven by safety needs and how much is required to maintain a safe network. When undertaking the modelling we aimed to provide answers to the following questions:

- What safety is needed to improve the skid resistance of high risk sites on the network?
- How much of this safety need is actually treated by asset preservation prior to manifesting as a safety concern?
- What is the predicted network skid resistance profile following the combined asset preservation and surface safety program?

Current Transport Agency policy is to improve sites with a high traffic volume, low skid resistance, low road surface texture and a history of two or more wet weather crashes over the past five years. The safety modelling uses the same policy intervention thresholds for skid resistance and road surface texture to determine the annual need for safety related pavement rehabilitation. The modelling focuses on high risk sites as presented in the table below.

NZTA Safety Risk Categories

NZTA Safety Risk Categories		
Risk	**Site Category**	**Skid Site Descriptions**
High	1	Approaches to railway level crossings, traffic signals, pedestrian crossings, controlled intersections, roundabouts and one lane bridges.
	2	Urban curves <250m radius, rural curves <400m radius, down gradients >10 percent and on-ramps with ramp metering.
Medium	3	State highway approach to a local road junction, down gradients 5 percent to 10 percent, motorway junction area including on/off ramps and roundabouts, circular section only.
Low	4	Undivided carriageways (event-free)
	5	Divided carriageways (event-free)

Skid resistance

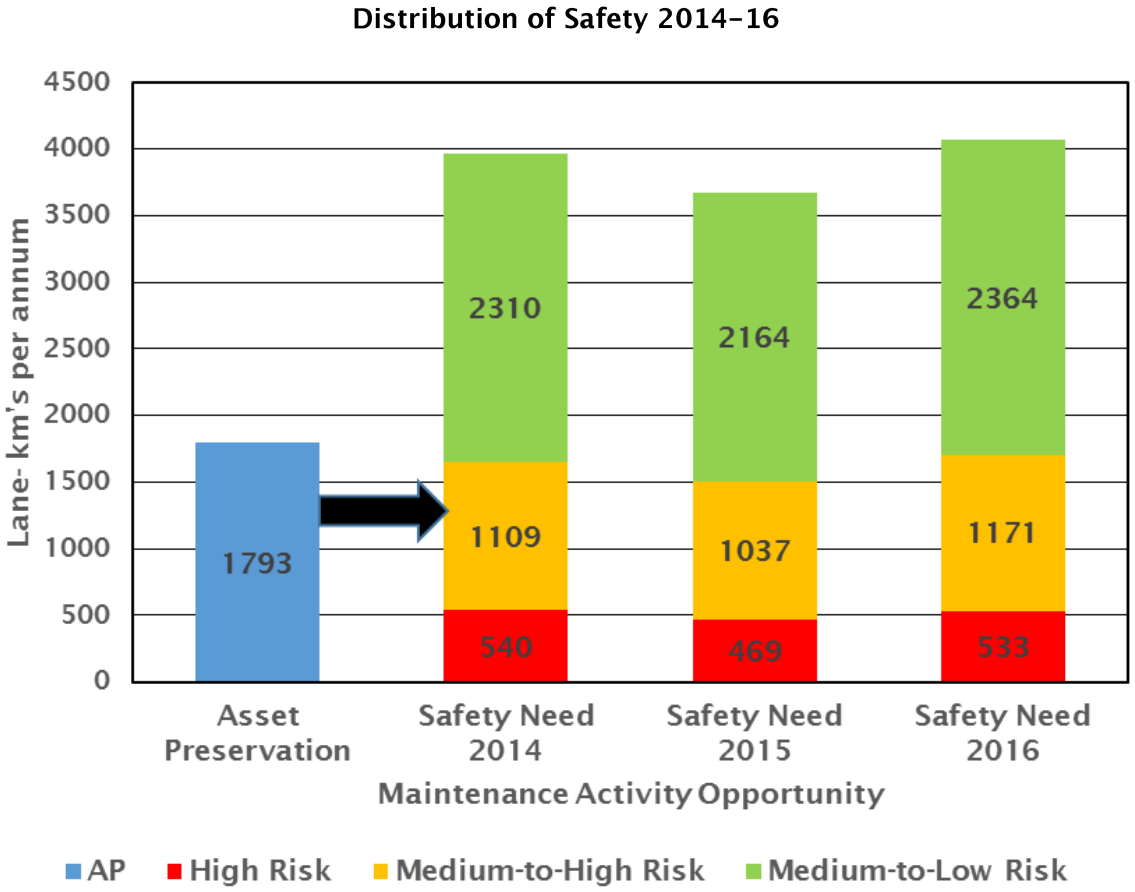
As chip seal surfaces age, the exposed surface reduces in texture and can reach a condition described as flushed. Flushing can lead to a dramatic lowering of the skid resistance available to vehicles because the tyre rubber is not supported on the low skid resistant bitumen. Premature flushing indicates a potential asset preservation issue and represents one of the expected end-of life conditions of a chip seal surface.

Treating sites with a high risk of wet crashes is shown to be very cost effective. It results in an annual expenditure on safety works of $5.95m, returning $30.5m in benefit from 42 fewer wet injury crashes per annum.

The graph shows the distribution of safety need over the past three years, in terms of the lengths of state highway that are high risk of a wet skidding crash (i.e. below the skid

resistance threshold level) and medium risk (i.e. between the skid resistance investigatory and threshold levels).

On average, about 3,370 lane kilometres per year (about 15 percent of the state highway network) is medium risk and may deteriorate into high risk. The orange bars show in the chart show that about a third of this length (approximately 1,106 lane kilometres per annum) is very close to becoming high risk (reaching the threshold level). The maintenance treatment of these lane kilometres was shown to have a benefit cost ratio of one, which is fiscally neutral with every $1 spent on resurfacing yielding $1 in crash cost saving. However, by identifying the lengths of state highway where lower skid resistance and texture are contributing to wet road crashes, treatments can achieve benefit cost ratios in excess of four.



The above graph also highlights that there is considerable opportunity for asset preservation surfacing to contribute to safety by impacting on the amount of the state highway that is close to breaching skid resistance and texture thresholds, thereby allowing safety works to remain at manageable levels and reducing crashes wherever asset preservation surfacing coincides with sections of state highway with a history of surfacing related crashes.

Safety and asset prevention

Considering the safety programme alongside the pavement and surface renewal and rehabilitation (asset preservation) programme means that there are some lengths that would be treated both for safety and asset preservation reasons. By combining and optimising the asset preservation and safety programmes, the Transport Agency is able to ensure we do not duplicate work and ensure the programme we put forward minimises expenditure (otherwise we would expect to see roughly an additional $5.2m per annum). By combining and optimising the programmes we aim to achieve:

- A reduction of 39 percent over the year period of safety treatments as resurfacing under asset preservation will address some of the length of state highway that breaches skid resistance and texture safety thresholds. On a per annum basis, this corresponds to 114 lane kilometres.
- More funding diverted to pavement related work, resulting in a 97 lane kilometres reduction in the forecast annual asset preservation resurfacing need, corresponding to a 5.1 percent reduction.

Pavement renewal

In addition to the pavements programme for access and reliability outcomes, there is also a substantial contribution made to safety outcomes. In addition to the methodologies described in Part C the safety element of the pavements programme has been validated on two levels as follows:

- Retrospective application to establish how well it replicated historical trending of state highway condition with regard to skid resistance and road surface texture over the 5-year period 2011 to 2015.
- Forward application to determine for 2015/16 how well predictions of "high" safety risk sections of state highway agreed with those actually observed

The high level of agreement achieved in both cases provides confidence in the safety model with economic evaluations of the T10 skid resistance policy undertaken in 2008 and 2011 concluded the benefit cost ratio of the policy was between 13 and 35.

Barriers

Barrier replacement and maintenance is based on design lives for the barriers, this includes allowances for the expected numbers of barrier strikes each year (using the barrier strike model) and nuisance barrier strikes for which we are unable to recover our costs. Barriers are inspected annually to identify condition deterioration requiring attention and to confirm the need to renew barriers. Barriers that have been struck and renewed are excluded from the list unless further strikes are identified.

Over the past few years the Transport Agency has invested in safety features across the network. These investments have included extensive lengths of barriers and guardrails that has increased the number of assets that require ongoing maintenance and renewal and increased the quantity of works undertaken on these assets.

The 2013 Transport Agency research paper "Optimising expenditure on roadside safety barriers"[30], reviewed if and when it is more appropriate to rectify or replace existing roadside crash barriers that do not conform to the installation specifications – particularly in terms of height and condition, or to install new roadside crash barriers at locations with significant hazards where there are currently no barriers.

It found that there was an effect on increasing crash severity with barrier heights that were lower than specifications. However, this was not generally found to be severe, even for height differences thought to exceed those expected to occur on the state highway network. The research suggested that in many cases (especially for wire-rope barriers) it would be much more cost effective to install new barriers at previously untreated locations than to raise existing barriers to the correct heights.

Signage

Road signage provides a range of safety benefits to road users, this includes a reduction in crash statistics and a reduced severity. Signage provides road users with directions and advanced warning of the road environment, allowing for users to be pre-warned of

[30] http://www.nzta.govt.nz/resources/research/reports/536

upcoming alignments, conditions or hazards. Signage requires maintenance to retain them at a level of service that ensures the greatest benefits are gained.

Signage is prone to general wearing as they become faded by sunlight, dust and dirt cover the face reducing reflectivity and product deterioration as a result of ageing. Maintenance and replacement of signage is based on the expected lives for the signs. The Transport Agency regularly inspect signs to identify condition deterioration requiring attention, in particular, visibility and reflectivity.

Electronic signs also deteriorate over time as they become less luminescent and technology changes make older signs incompatible. The Transport Agency pre-programme electronic sign renewal based on their expected lifecycle and cost benefits.

Regulatory warning signage must be maintained to ensure they are able to provide the documented safety benefits. The Road Assessment and Maintenance Management (RAMM) database identifies the current costs associated with sign maintenance are:

Sign Maintenance Current Costs per year

SIGNAGE	TOTAL
Sign maintenance	$3,347,113
Signpost and fitting maintenance	$87,877
Total annual sign maintenance cost	$3,434,991

Warning signage can influence crash reduction factors[31] such as a:

- 25 percent reduction in curve related crashes for curve warning chevrons.
- 35 percent reduction for bridge related crashes for bridge signage.
- 7 percent reduction in all crashes where static advance warning of rural intersections is deemed necessary.
- 15 percent reduction in (relevant) crashes is applicable for direction signage.[32]

The role of advisory signage for curves proposing an advisory speed of less than 80km/h can influence crash reduction and create a total social cost of $99m for 2015, when applying the Ministry of Transport social cost for crashes. Presented in the table below are the annual average costs for the 5 years 2011 to 2015 inclusive.

Annual average costs 2011-15

NUMBER	COST/CRASH	TOTAL
11 Fatal Crashes	$4,709,000	$51,799,000
42 Serious Crashes	$900,000	$37,800,000
1014 Minor Crashes	$95,000	$9,633,000
Total		**$99,232,000**

Appropriate curve warning signage is expected to reduce curve crashes by 15 percent to 25 percent. If the signage was not maintained to an effective level, we expect the social cost to be around 17 percent to 33 percent higher and an equivalent estimate social cost of $17.5m to $33m per annum. The benefits of maintaining curve signage are 5.1 to 9.6 times the

[31] As outlined in the Compendium to Appendix A6 of the Economic Evaluation Manual.
[32] As outlined in the Austroads Road Safety Engineering Toolkit.

costs of maintaining all signage i.e. the benefit cost ratio to maintain signage is in the range of at least 5.1 to 9.6.

The Transport Agency works with our suppliers to ensure the signs we use are durable and provide us with the optimum whole of life costs available. Signs are maintained and replaced for a variety of reasons: cleaning, crash damage, graffiti, being missing, to remove non-standard signs, realignment, removing signs no longer required and vandalism.

We annually spend around 10 percent of our budget replacing signs for these reasons.

For our small signs, we have limited opportunities to extend their life, without incurring excessive additional costs. This is both due to available technology and the restricted number of signs that are not replaced or maintained prematurely.

Line markings

Pavement lines and markings provide a range of safety benefits road users including a reduction of crash statistics or reduced severity. As a direct result of installing such assets they require maintenance to retain them at a defined level of service to ensure the greatest benefits are gained.

When combined with additional delineation devices line markings assist drivers in assessing changes in alignment, particularly at night with lines, pavement reflectors and edge marking posts assisting in defining the road. The following line markings benefit road users:

- Centre lines indicate an initial separation point for opposing traffic.
- Edge lines indicate where a shoulder area may start and indicates the limits of the surfaced carriageway.
- Yellow lines are used to indicate unsafe vertical sight distances, known as no overtaking lines.
- Markings provide alignments to improve night visibility for horizontal alignment.
- Raised markings assist in wet weather conditions raising the alignment to indicate wet surfaces.

Line markings become faded and worn from a range of sources, such as traffic and weather. The reoccurrence of line marking depends on the location, for example lines in areas affected by snow and ice are remarked after each winter as the grit wear off the paint sooner whereas areas with raised markers and long-life materials have longer durations between maintenance and use the higher priced materials as it is cost efficient.

It is more economical to remark painted lines before they are fully deteriorated and assessments are undertaken to determine the frequency of the remarking. In some situations, it becomes more economical to use long life or profiled marking to extend the life and reduce significant costs of maintenance works.

Line markings are undertaken on a cyclic basis to ensure they remain visible all year round. The Transport Agency reviews the condition of lines to prioritise remarking efforts, however the expectation is that all lines are renewed each year. Audio Tactile Profile markings, long-life Cold Applied Plastic markings and electronic warning signs all increase the quantity of renewals required and are network specific. Maintenance criteria are specified in the Network Outcome Contracts based on Land Transport Rules, and Transport Agency performance based specification and manuals. When adjustment is required from variations in weather patterns, wearing and product properties, the network contractors present additional plans on the remarking quantities to ensure compliance.

Assumptions underpinning the safety benefits of markings are outlined in the table below.

Assumptions underpinning benefits from road markings

ASSUMPTIONS	VALUE	NOTES
Rural injury crashes average cost ($)	$539,000	From Ministry of Transport 2015 all injury crashes for open roads
Discount rate (percent)	6%	Economic Evaluation Manual
Evaluation Time Period (yr.)	10	
Crash Modifying Factor	1	CMF changes for non-standard road widths, but assume 1 for graphs

Road markings provide significant benefits to the higher category roads, with higher traffic volumes.

On lower category roads, road markings do not provide a benefit cost ratio of 1 until traffic volumes reach approximately 600 vehicles of average daily traffic per year.[33] Long life and profiled markings can lead to fluctuating costs being attributed to a networks renewals programme but are also directed towards overall customer safety over the entire state highway network.

The Transport Agency engages with our suppliers to ensure we are aware of the most appropriate and durable marking solutions to minimise the whole of life costs. High durability products are used where appropriate to ensure traffic disruptions are minimised for the reapplication of road markings and to ensure maximum durability in areas of high traffic or extreme environmental conditions. Product selection is made carefully to minimise whole of life costs.

High performance marking (e.g. Audio Tactile Profile and Cold Applied Plastic) are considered under renewals due to the expected longevity of the product and the deterioration being location specific. The range of products available can include coloured or plain white and may even include glass beads to improve reflectivity.

Lighting

Lighting the state highways improves safety through increasing visibility of the highway features and hazard identification leading to a reduction of crash statistics or reduced severity. Street lighting benefits road users by:

- Improving visibility beyond vehicle headlights.
- Assisting in intersection identification and illumination.
- Improving visibility of pedestrians and cyclists.
- Improving visibility in lower light situations, poor weather and during dusk and dawn.

The Transport Agency commissioned a report in 2012 called 'Strategic Road Lighting Opportunities for New Zealand'[34] that outlines public space lighting, crash severity and public benefits. Key findings from the report include:

[33] However, the Transport Agency recognises the contribution of road markings to the safety rating (Kiwirap) of New Zealand state highways and prioritises the installation and maintenance of standard road markings.

[34] https://www.nzta.govt.nz/assets/resources/rmtf-report/docs-interim/strategic-road-lighting-opportunities.pdf

- Of the 14,388 road accidents (including deaths) that cost an estimated $3.8b in 2010, 31.3 percent of them occurred in relative darkness which suggests a cost of about $1.2b per year. This justifies a separate road lighting strategy to reduce these numbers.
- Research has shown that white light sources improve driver peripheral vision and reduce driver brake reaction time by at least nine percent at night. It is therefore likely, but not confirmed by this study, that replacing yellow lighting with white lighting could lead to reduced accident rates during twilight and darkness.

The Transport Agency has significant investment in lighting assets and on-going maintenance to ensure the level of service is maintained at current levels and projects aim to reach the compliance specified in AS/NZS 1158, lighting for roads and public spaces.

Overall there are 21,269 poles directly related to Transport Agency asset ownership and over 28,467 pole records in RAMM associated to street lighting. NZ Transport Agency owns a range of lights, with over 45 different types, produced by at least 16 manufacturers, and a complete count of 29,506 light fittings within the RAMM database.[35]

Each network has developed a carriageway lighting renewals programme, based on ensuring the desired lighting of the state highway is maintained, with additional maintenance undertaken as necessary (e.g. replacing bulbs).

Lighting maintenance is aligned to ensure they remain functional and damages are repaired within suitable time frames. Where lighting is limited, the requirements would increase while motorway or express way situations will have greater flexibility due to the number of fittings illuminating the area but also the complexity to undertake maintenance.

Being an electrical asset these duties are typically undertaken by an energy network provider who has the ability to undertake maintenance safely. Electrical assets are typically replaced on a programmed cycle based on efficiency and compatibility and modern lights are updated to lower energy consumption and longer life with LED style fittings.

LED street lights come on instantly, last up to six times longer than high pressure-sodium and are shock and vibration-proof, making them perfect for windy locations. LED street lights contain no harmful substances and provide better colour differentiation and visibility making them more economical[36] and safer for vehicles, drivers, pedestrians and cyclists.

A considerable proportion of the savings from LED lighting is due to a 50 percent lower energy consumption and 70 percent lower maintenance costs.[37] The Transport Agency General Circular Investment: No 15/01[38] – Accelerated renewal road lighting LED conversion programmes, addresses the proposal to upgrade street lighting to LED technology siting an expected 'all cost' analysis to demonstrate a payback of less than 10 years.

We are exploring how to implement LED lighting across maintained networks and how this is best coordinated with adjacent network partners when they replace their lights. A 2015 rule change by the Transport Agency means that local authorities can replace existing road lights with LED immediately, rather than wait until they reach the end of their useful life.

[35] Note, this is not a complete list of assets. A range of additional lighting assets are managed by local councils including bracket structures and the power supply network, some of which is also documented by the supplier of the service and not fully recorded within the RAMM system.
[36] An Energy Efficiency and Conservation Authority –commissioned report estimates that switching to LED could save the country $10m in operational costs each year. In particular, urban areas will benefit from lower electricity and maintenance costs.
[37] PWC, Assessing the potential cost savings from accelerating the roll out of LED road lights, October 2014.
[38] http://www.nzta.govt.nz/assets/resources/general-circulars/docs/15-01.pdf

Safety core Programme

Overview

We have adopted standardised levels of service under the One Network Road Classification framework. This means we have not considered programmes with alternative level of service targets. We have considered alternative programmes that:

- Either cost less and expose the Transport Agency and our customers to greater risk, or cost more and reduce the risk to us and our customers and/or
- incur more costs now for later savings, or defer costs now with anticipated increased costs at a later time.

The funding request for our core safety is greater than the 15/18 period largely due to asset growth, in particular large capital projects and safety improvement programmes. This results in a significant increase in the number of assets and associated maintenance activities for those assets – especially in the areas of safety and amenity.

A summary of the programme cost is provided in the table below.

Safety spend

Work Category	Forecast funding ($ m) 2018-21	2018-27
WC 111	$75.4	$280.9
WC 112	$0.5	$1.8
WC 113	$14.0	$52.2
WC 114	$16.0	$59.5
WC 121	$9.2	$34.1
WC 122	$119.9	$446.5
WC 123	$0.0	$0.0
WC 124	$0.2	$0.8
WC 141	Not Incl.	Not Incl.
WC 151	$78.7	$293.1
WC 161	$10.5	$38.9
WC 211	$0.0	$0.0
WC 212	$56.6	$210.8
WC 213	$0.0	$0.0
WC 214	$3.9	$14.5
WC 215	$17.1	$63.7
WC 221	$0.0	$0.0
WC 222	$45.3	$168.7
Total	**$447.2**	**$1,665.6**

Our proposed core safety programme of works, in tandem with our improvements programme, will support delivery of services aligned to the One Network Road Classification.

Key aspects of signs, delineation and lighting have sufficient underlying studies and data to enable cost benefit analysis to demonstrate there is an overall gain to the New Zealand

public, for both road safety and reducing crash severity or statistics but also by being financially beneficial for the works undertaken, hence they provide value for money.

Within our core programme we are proposing to reduce the risk of skid related accidents by increasing the SCRIM programme by a moderate amount, approximately $3m per annum. Increasing the amount of skid resistance works will deliver a better customer safety outcome. This requires us to focus the works carefully, and be very deliberate about the use of smelter aggregate, so we get most benefit from this scarce premium product.

Core safety programme risk

Risks to service levels and desired outcomes

The greatest risks to the safety programme are:

- Reduction in grip on carriageway
- Water ponding on the road surface
- Loss of integrity / operability of safety assets arising from, for example:
    - Poor inspection / maintenance regime
    - Erosion / underscour by rivers or coast
    - Damage from collisions, particularly unreported ones
    - Underslips on the downhill side of the road.

The risks to the serviceability and integrity of road surfaces and other safety assets from deterioration are generally low due to the sophisticated inspection, maintenance and renewal processes employed.

Risk related to quantities, cost and effectiveness

The programme's expenditure profile over the next 10 years depends on the following key factors:

- Efficiency and effectiveness gains compared to past practice
- Increased demand which causes greater deterioration than before
- Continued supply of quality materials for the skid resistance programme
- The growing scope and complexity of the network requiring more extensive or advanced maintenance and renewal works to sustain service levels
- Continued increases in input prices.

It is difficult to determine the overall expected growth on the network relating to significant projects currently throughout New Zealand. The Roads of National Significance are progressing and it is reasonable to accept additional maintenance will occur and require funding. Pavement markings should remain functional for this three-year investment request; likewise, electronic signage should remain operational with little additional maintenance or operational funding requests. Street light energy or maintenance costs have still to be finally assessed and this would be reflected in variances in annual plan requests as they become commissioned and energy supplies are evaluated.

The greatest risks to the value for money of service levels arise from:

- The potential to defer renewal works beyond the optimum intervention point.
- The potential to inadequately address the causes of failure or deterioration, in part, when maintaining or renewing safety assets.

Any such event would lead to a greater amount of maintenance works than normal to restore and maintain service:

- A prolonged reduction in safety renewal works, below a long term sustainable level, which requires abnormal amounts of maintenance to maintain service and allows the condition of assets to deteriorate to such an extent that they require rebuilding rather than the cheaper renewal to maintain service levels.

This risk arises either by prolonged under-investment, or an underestimate of asset deterioration.

Part F – Amenity

The Transport Agency is committed to creating a smooth road surface and managing the appearance of the road corridor to ensure an enjoyable travel experience for road users. Amenity is a priority for the Transport Agency, our investment in our road system is intended to ensure:

Travel quality and aesthetics: the road environment means our customers experience comfortable and pleasant journeys across the State Highway network

Our road users expect that we will keep state highways free from visual nuisances such as graffiti or litter and make the drive as pleasant as possible. Although spend on amenity is relatively small compared to other areas of maintenance expenditure, it is often the factor that has the greatest influence on how our customers view the Transport Agency. Additionally, our work around vegetation control can have a major impact on fire safety in rural areas.

Maintenance activities

Our proposed programme of works to deliver amenity to our customers is made up of a number of core service aspects as outlined below.

Programme of works to deliver amenity

	Service aspects	Access and resilience	Travel time and reliability	Safety	Amenity
Amenity	Road roughness treatment				✓✓✓
	Litter, graffiti, rest area maintenance				✓✓✓
	Pest plant, bio-diversity management, maintenance water quality devices				✓✓✓

Maintaining amenity is critical to the quality of experience for customers, including an increasing number of tourists. Our customers appreciate a comfortable journey in a visually pleasing environment – this means that the state highway corridor and its immediate surroundings should remain tidy and clean with a smooth surface providing an enjoyable drive. We deliver the levels of service to our customer through:

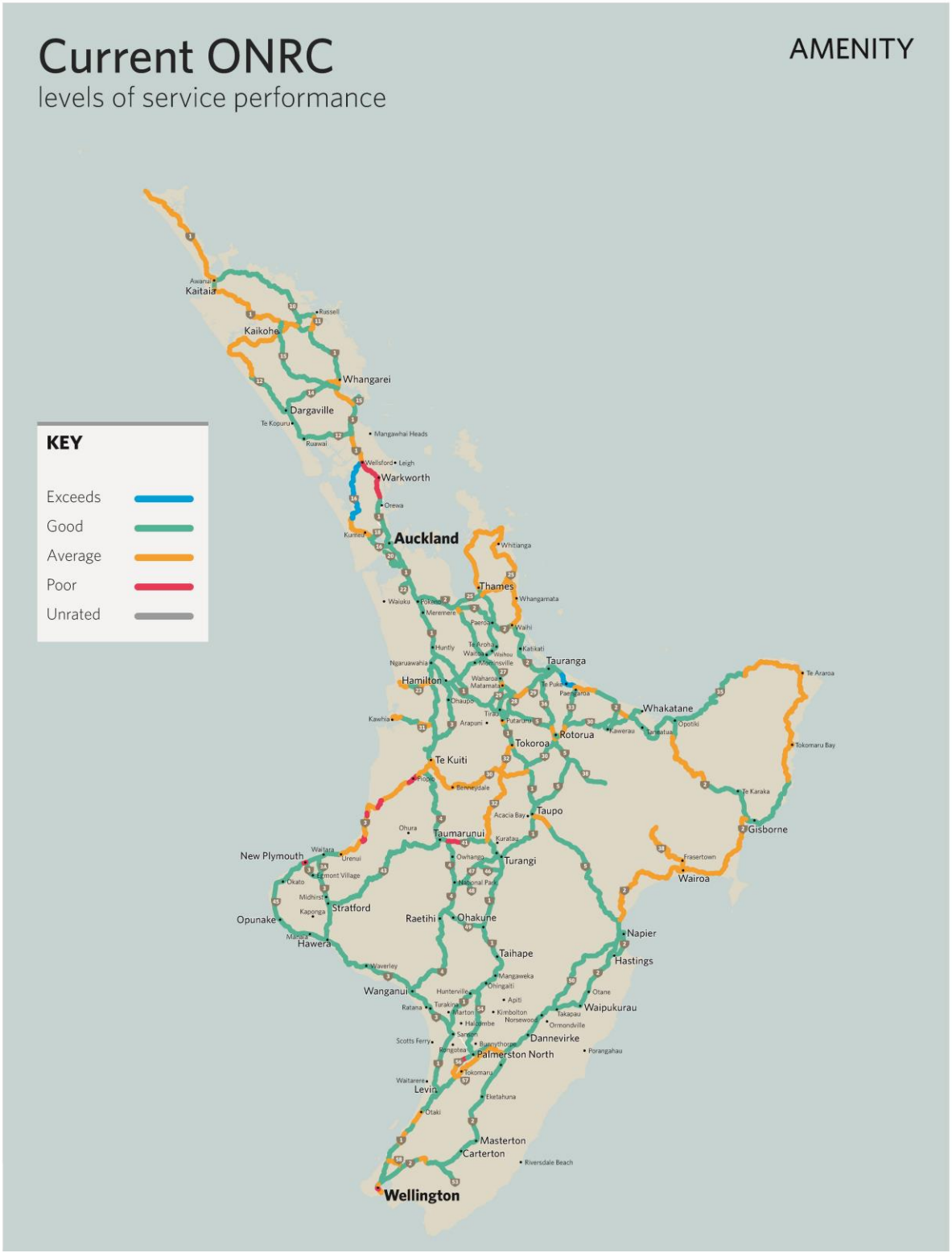
- Removal of litter, detritus and graffiti along the state highway corridor.
- Maintenance of roadside vegetation, landscaped areas and rest areas.
- Maintaining roughness levels to a level appropriate the road classification, to ensure a comfortable ride.

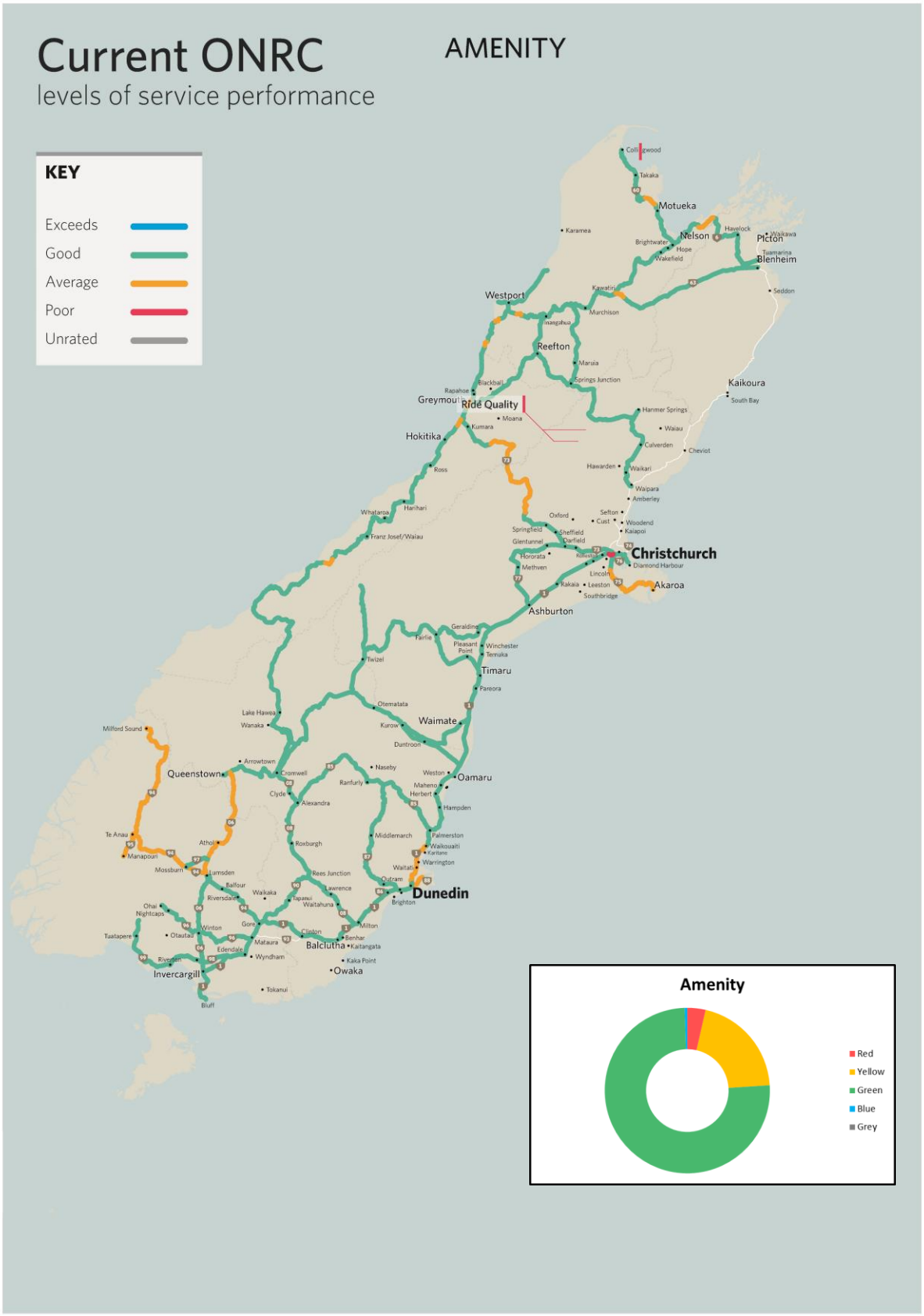
There is an increased focus on amenity because of the implementation of the One Road Network Classification. In particular, the capital programme is increasing the size of the network and changing the characteristics of the network, especially in and around the large urban centres. We have listened and responded to our customers – as they are particularly concerned about amenity issues and are more likely to complain about poor amenity levels of service.

Current state

Many of the key activities that are visible to our customers such as litter, detritus and graffiti can be intermittent and unpredictable. This causes dual issues in terms of responding to issues in a timely manner and planning of budgets to enable us to respond without necessitating excessive budgets.

Current ONRC performance – Amenity




Current ONRC
levels of service performance
AMENITY
KEY
Exceeds
Good
Average
Poor
Unrated
Ride Quality
Motueka
Nelson
Picton
Blenheim
Westport
Reefton
Greymouth
Hokitika
Kaikoura
Christchurch
Akaroa
Ashburton
Timaru
Waimate
Oamaru
Queenstown
Dunedin
Balclutha
Owaka
Invercargill
Amenity
Red
Yellow
Green
Blue
Grey

Ride comfort

The Transport Agency aims to maintain an appropriate level of ride comfort. We track and demonstrate our progress against this outcome by measuring:

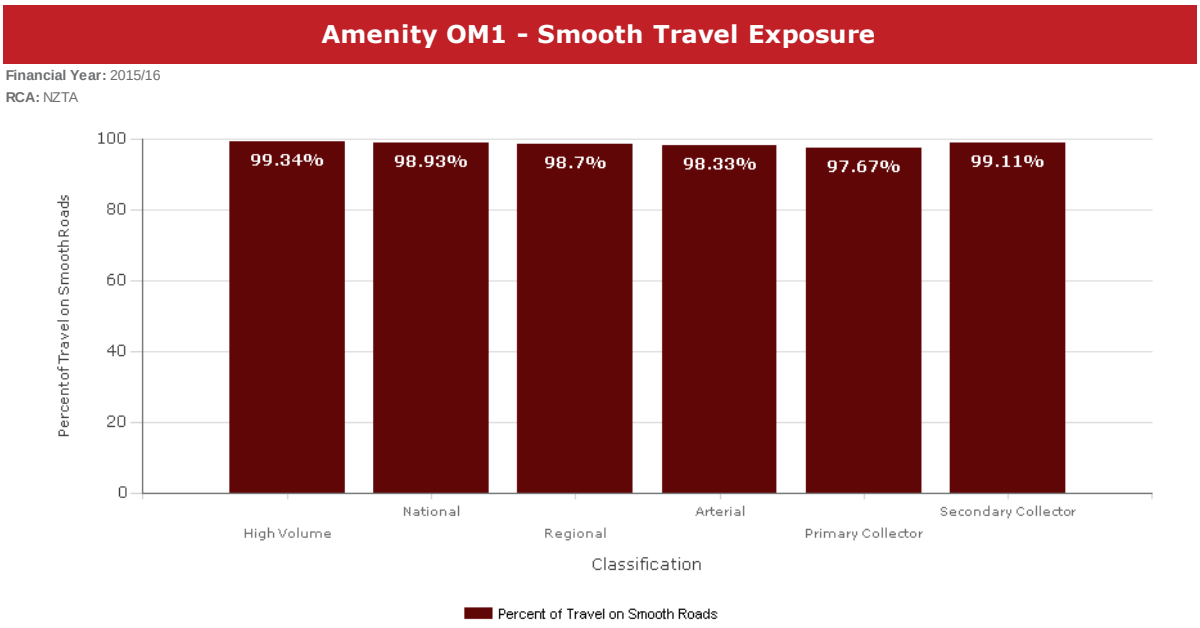
- Smooth Travel Exposure
- Peak Roughness Sealed roads
- Average Roughness (NAASRA)
- Median Roughness (NAASRA)

Between October and March each year, the Transport Agency collects condition information including roughness using a vehicle called 'SCRIM+'. Using the reliable, timely and accurate data collected we can respond to road-condition issues promptly and cost effectively.

Smooth Travel Exposure

Smooth Travel Exposure measures the proportion (percentage) of vehicle kilometres travelled (VKT) in a year that occurs on 'smooth' sealed roads. We aim for our highest usage (by traffic volume) and urban state highways to have the smoothest ride. The graph below shows our performance for Smooth Travel Exposure across the entire NZTA network for 2015-16.[39]

Smooth Travel Exposure 2015-16



Peak Roughness Sealed roads

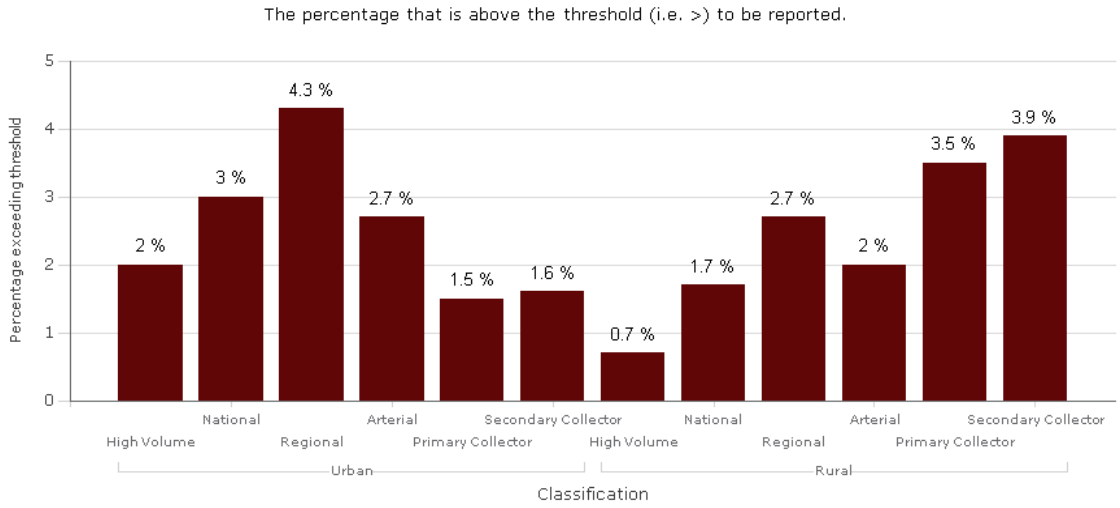
Our network has relatively short distances of state highway above the threshold roughness however, these roads generally have higher than proportionate traffic volumes, thereby impacting more road users. Our performance for peak roughness across the entire network for 2015-16 can be seen in the graph below.

[39] Taken from the One Network Road Classification performance measures reporting tool.

Peak roughness 2015–16

Amenity PM1 - Peak Roughness Sealed roads

Financial Year: 2015/16
RCA: NZTA



Average and Median Roughness

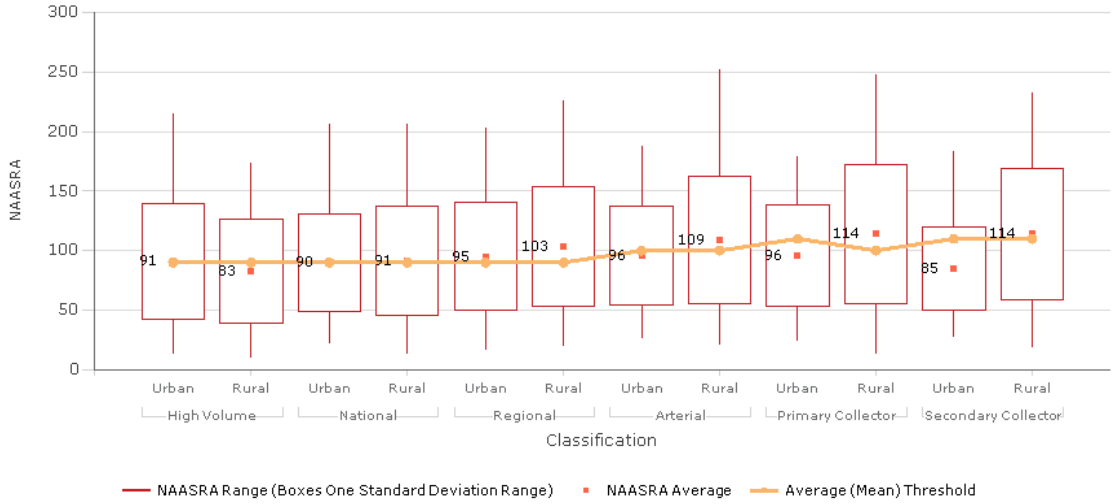
The graphs below show our performance for average and median roughness across the entire NZTA network for 2015–16. The threshold values were developed in the One Network Road Classification Framework. Across the network, our average roughness figures for the following road classifications are above (i.e. worse than) our threshold figures:

- Urban High Volume
- Rural National
- Urban and Rural Regional
- Rural Arterial
- Rural Primary Collector
- Rural Secondary Collector

Average roughness 2015–16

Amenity OM2 - Average Roughness (NAASRA)

Financial Year: 2015/16
RCA: NZTA



Classification		Threshold (NAASRA value)	Average	Min	Max	Standard Deviation	
						Lower	Upper
High Volume	Urban	90	91	14	215	42	140
	Rural	90	83	10	174	39	127
National	Urban	90	90	23	206	49	131
	Rural	90	91	14	206	45	137
Regional	Urban	90	95	17	203	49	141
	Rural	90	103	20	226	53	153
Arterial	Urban	100	96	27	188	55	137
	Rural	100	109	21	252	55	163
Primary Collector	Urban	110	96	25	179	54	138
	Rural	100	114	14	248	56	172
Secondary Collector	Urban	110	85	28	183	50	120
	Rural	110	114	19	233	58	170

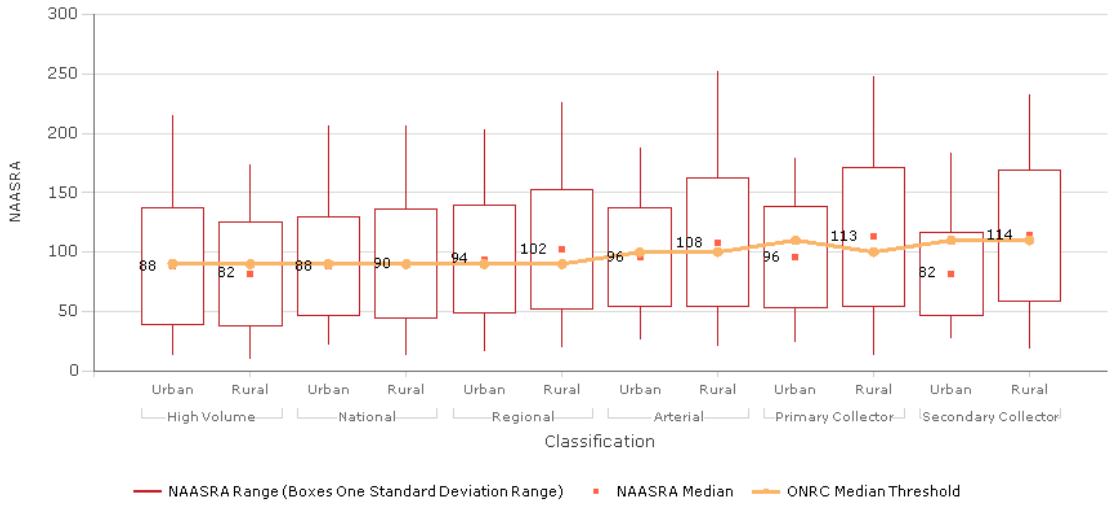
When compared to the graph below showing our performance for median roughness across the entire NZTA network for 2015/16, it can be seen that the following road classifications are higher (i.e. worse than) our threshold figures:

- Urban and Rural Regional
- Rural Arterial
- Rural Primary Collector
- Rural Secondary Collector

Median roughness 2015-16

Amenity OM2 - Median Roughness (NAASRA)

Financial Year: 2015/16
RCA: NZTA



Classification		Threshold (NAASRA value)	Median	Min	Max	Standard Deviation	
						Lower	Upper
High Volume	Urban	90	88	14	215	40	137
	Rural	90	82	10	174	39	126
National	Urban	90	88	23	206	47	130
	Rural	90	90	14	206	45	136
Regional	Urban	90	94	17	203	49	140
	Rural	90	102	20	226	52	153
Arterial	Urban	100	96	27	188	54	137
	Rural	100	108	21	252	53	162
Primary Collector	Urban	110	96	25	179	54	139
	Rural	100	113	14	248	55	171
Secondary Collector	Urban	110	82	28	183	48	117
	Rural	110	114	19	233	58	169

In drawing conclusions on any condition measure, it is important to take account of several key factors:

- Foundation and pavement materials in highway construction vary considerably throughout the country.
- Different regions experience varying climatic conditions, such as different temperature ranges and rates of rainfall.
- Improvements to technology and measuring techniques mean that a measured parameter might be reported differently over time, even though the underlying condition might be constant.
- Reliability of the associated data inputs, for example surfacing and traffic volumes.
- Varying network condition targets or standards.
- Conditions vary over the year and reported results represent only a snapshot of network condition (the high speed data survey is carried out over the summer months).

In addition to such technical issues above, broader external factors also have an impact, including:

- Changes in traffic volumes and loadings.
- Our state highway network is dynamic, in so far as from time to time we revoke, take on and build new highways.

The reporting of aesthetic faults through the One Network Road Classification reporting tool was not available at the time of developing this business case. We will continue to monitor and develop this reporting in future years. In the meantime we are using the NOC operational performance measures that provides useful proxy measures to the ONRC.

Other performance initiatives

The Transport Agency continues to undertake amenity initiatives across the network.

Native plant partnership in Northland

In 2014, the Transport Agency embarked on a program to address the large number of pest plants that were creating ecological, stormwater, safety and visual problems at the Whangarei entrances to State Highway One. The highway road reserve was designed to enhance biodiversity, reduce and suppress pest plants, minimise erosion and reduce tagging and vandalism, through the use of mass plantings of inland and coastal native rare and endangered species to create self-sustaining green spaces. This work was undertaken alongside the local community, Northland Regional Council and Whangarei District Council.

One plant in particular, *Tecomanthe speciosa*, has proved very valuable at reducing the amount of graffiti and vandalism along fence lines between Transport Agency land and homes. The species was planted at regular intervals.

Low growth grass

Low growth grass has been planted along the verges of State Highway 1, between Pokeno and Rangiriri, to reduce the cost of road maintenance and traffic management. It requires less road side mowing and associated road works and keeps the highway verges looking tidier for longer. It also reduces the impact to the surrounding environment by reducing chemical discharges from pesticides and mower emissions, whilst improving the visual quality of vegetation on the state highway network.

Methodologies

Pavements and surfacing

Roughness is indication of pavement deterioration and is uncomfortable for our road users. Our pavement deterioration modelling sets the least cost sustainable long term investment required to prevent the pavements from reaching the tipping point, beyond which is considered unsustainable and would require large investment to reinstate the pavement.

Our programme of works is targeted to manage roughness associated with pavement deterioration and other causes. This is to ensure that our target threshold levels of roughness are met across the network for all road classifications and to minimise discomfort to road users.

Forecast work quantities have been developed. These are based on the most recent high speed data, assessed roughness progression, One Network Road Classification investment strategies and compliance trigger for the percentage of networks above threshold levels for each classification.

Environmental maintenance and renewals

The primary purpose of our environmental maintenance is to manage the appearance of the road corridor. Our contractors undertake regular inspections of the state highways and we also respond to customers complaints about issues on the network, for instance litter or graffiti. We are also responsible for the maintenance and renewal of roadside facilities including rest areas and look outs that enhance the travel experience for road users.

Our programme of works is directed to ensure we meet our targets for inspecting and clearing aesthetic issues from the state highways and renew our assets before they fall below the desired ONCR level of service.

Vegetation control

We undertake vegetation control to maintain safe clear zones along the length of our highways, to ensure adequate visibility and appearance.

Our programme of works ensures that we meet our targets for mowing, removal of vegetation and clearing aesthetic issues from the state highways.

Core amenity programme

Overview

The funding request for our proposed core amenity programme is higher than the 2015/18 NLTP. The significant difference in amenity funding is due to the asset growth (large capital projects and safety improvement programme), resulting in an increase in the number of assets and associated maintenance activities for those.

Overall, we believe this remains a strong value for money proposition. The increase in funding request is low when considering the ongoing increases in network size, asset growth and customer expectations.

The programme is summarised below.

Amenity spend by Work Category

Work Category	Forecast funding ($ m)	
	2018-21	2018-27
WC 111	$8.3	$30.9
WC 112	$0.0	$0.0
WC 113	$0.0	$0.0
WC 114	$0.0	$0.0
WC 121	$80.4	$299.3
WC 122	$0.0	$0.0
WC 123	$0.0	$0.0
WC 124	$0.0	$0.0
WC 141	Not Incl.	Not Incl.
WC 151	$10.6	$39.5
WC 161	$2.6	$9.7
WC 211	$0.0	$0.0
WC 212	$0.0	$0.0
WC 213	$0.0	$0.0
WC 214	$0.0	$0.0
WC 215	$0.0	$0.0
WC 221	$10.0	$37.1
WC 222	$0.0	$0.0
Total	**$111.8**	**$416.5**

The delivery of the proposed programme of works to enable network amenity is aligned with a number of One Network Road Classification performance measures including:

- Customer Outcome: Smooth travel exposure – roughness of the road (the percentage of travel on sealed roads which are smoother than the defined threshold)
- Customer Outcome: Peak roughness
- Technical output: Roughness of the road (peak and average)
- Technical output: Aesthetic faults

A 'do nothing' core programme has not been deemed appropriate, as we undertake vegetation control to manage roadside vegetation for aesthetic and safety reasons. The

programme presented is the minimum quantity based on our Network Outcomes Contracts lump sum amounts and to maintain our minimum level of service.

Whenever practical we have considered the whole of lifecycle costs when developing our programme of works. For instance, low growth grass has been planted along the verges of State Highway 1, between Pokeno and Rangiriri, to reduce the cost of road maintenance and traffic management. Low growth grass requires less road side mowing and associated road works and keeps the highway verges looking tidier for longer. Although the grass mix may cost slightly more to install than a normal grass, the maintenance savings generated will easily pay for this.

Environmental maintenance and renewals

A 'do nothing' core programme has not been considered applicable, as we undertake environmental maintenance and renewals to manage the appearance of the road corridor in line with the expectations of road users. The programme presented is the minimum quantity based on our Network Outcomes Contracts lump sum amounts and to maintain our minimum level of service.

Vegetation control

A 'do nothing' core programme has not been deemed appropriate, as we undertake vegetation control to manage roadside vegetation for aesthetic and safety reasons. The programme presented is the minimum quantity based on our Network Outcomes Contracts lump sum amounts and to maintain our minimum level of service.

Opportunities

The main opportunity for amenity is to target the performance of pavement assets by actively reducing peak roughness locations. As outlined above, we will not be able to remedy all of these without significantly increasing our programme targeting localised peak roughness.

Our expenditure on rest areas and amenity features for tourists could be increased. This would better meet the growing expectations of tourists and assist in improving safety outcomes by giving road users more opportunities to break up journeys and rest.

Another option is to look to reduce some of our amenity vegetation works. However, this option is likely to only provide small savings and increase the risk through reduced sightlines or raised fire danger in the summer periods.

Risks

Service level risks

The greatest risks to amenity are:

- Loss of integrity of assets arising from, for example:
  - Poor inspection / maintenance regime
  - Differential settlement between structures and pavements causing localised roughness such as at bridge abutments
- Localised persistent litter or graffiti
- Contractor failure to control vegetation
- New pests or vegetation that require management

The risks to the serviceability and integrity of road surfaces and other assets from deterioration are generally very low due to the sophisticated inspection, maintenance and renewal processes employed.

Cost and effectiveness risk

The programme's expenditure profile over the next 10 years depends on the following key factors:

- Efficiency and effectiveness gains compared to past practice.
- Increased demand (such as increased tourists) which causes greater deterioration than before.
- The growing scope and complexity of the network requiring more extensive or advanced maintenance and renewal works to sustain service levels.
- Continued increases in input prices eg pest control, particularly around renewal of Network Outcomes Contracts in the 10-year period, potentially meaning significant increase in lump sum costs for particular activities.

The greatest risks to the value for money of service levels arise from:

- Deferring renewal works beyond the optimum intervention point.
- The potential to inadequately address the causes of failure or deterioration, in part, when maintaining or renewing amenity assets (including the State Highway pavement).

Any such event would lead to a greater amount of maintenance works than normal to restore and maintain service:

- A prolonged reduction in amenity works, below a long term sustainable level, which requires abnormal amounts of maintenance to maintain service and allows the condition of assets to deteriorate to such an extent that they require rebuilding rather than the cheaper renewal to maintain service levels.

This risk arises either by prolonged under-investment, or an underestimate of asset deterioration.

Part G – Core programme and alternatives

In Parts C–F of this business case the components of the core programme have been discussed from a customer outcome perspective. The methodologies and risks associated with key asset management elements have been outlined.

In this Part of the business case, the overall core programme is summarised along with a discussion on a number of alternative programmes which have been discounted.

Core programme

The core programme has been built bottom up on a first principles basis with an over-riding intent of achieving targeted outcomes.

The recommended core programme is as presented in the tables below.

Recommended core maintenance and operations programme by WC ($ m)

Work Category	Forecast funding ($ m) for 2018–21			
	Access & Resilience	Travel Time Reliability	Safety	Amenity
WC 111	$67.0	$0.0	$75.4	$8.3
WC 112	$0.5	$0.0	$0.5	$0.0
WC 113	$24.6	$0.0	$14.0	$0.0
WC 114	$103.4	$0.0	$16.0	$0.0
WC 121	$72.3	$47.0	$9.2	$80.4
WC 122	$1.8	$0.0	$119.9	$0.0
WC 123	$0.0	$131.0	$0.0	$0.0
WC 124	$1.5	$0.0	$0.2	$0.0
WC 141	Not Incl.	Not Incl.	Not Incl.	Not Incl.
WC 151	$100.0	$37.4	$78.7	$10.6
WC 161	$24.4	$4.5	$10.5	$2.6
WC 211	$1.6	$0.0	$0.0	$0.0
WC 212	$333.4	$0.0	$56.6	$0.0
WC 213	$23.6	$0.0	$0.0	$0.0
WC 214	$157.0	$0.0	$3.9	$0.0
WC 215	$79.3	$0.0	$17.1	$0.0
WC 221	$0.0	$0.0	$0.0	$10.0
WC 222	$4.7	$22.1	$45.3	$0.0
Total	**$995.1**	**$241.9**	**$447.2**	**$111.8**

Recommended core maintenance programmes: 3-year and 10-year ($ m)

	2018/21	2018/27
Access and resilience	995	3,705
Travel time reliability	241	901
Safety	447	1,665
Amenity	112	416
Total	**1,796**	**6,687**

We prioritise our operations and maintenance programmes to ensure services are delivered for the best balance of risk, expenditure and required service level for each category of road. We have optimised these interventions by considering:

- Targeting the most important issues.
- Identifying where we can make the greatest difference (generally the most trafficked and highest category roads).
- Identifying the best actions we can implement to resolve current and approaching problems.
- Balancing interventions across the programmes and combining works where practical to reduce costs.
- Optimising this suite of responses to make changes that will make the biggest difference for the lowest cost.
- Integrating our programme with other Approved Organisations and taking an internal optimisation approach to investment through amalgamating individual regional programmes into a nationally moderated programme.
- The funding request for 2018/21 National Land Transport Programme is higher than the 2015/18 programme but inside the funding range provided in the Government Policy Statement. The significant difference is due to the following:
- Much larger reseal and rehabilitation programme (translating into an additional $140m).
- Significant increase in travel time reliability funding request to meet the increasing needs of our customers, on a busier and more complex network.
- Asset growth (large capital projects and safety improvement programme), resulting in a significant increase in the number of assets and associated maintenance activities for those assets – especially in the areas of safety and amenity.

Within the core programme however, we continue to drive tension in the programme and on ourselves to deliver value for money. Within the total bid of $1,796n over three years we have assumed we will achieve two percent year on year cost savings through value money initiatives. This adds up to $80m of savings over 3 years.

Overall, therefore we believe the proposed core programme offers very strong value for money. The increase in funding is sensible when considering the increase in network size, complexity, traffic volume and freight volume, and asset growth.

Emergency works

Our core programme does not include an allowance for emergency works which are carried out following a weather event or natural disaster to rectify damage to the State Highway network and regain access, safety, travel predictability or amenity customer levels of service.

These works have not been allocated to a part of the country or to any groups of assets, however, we propose to request approximately $53m per year in addition to our core programme.

Alternatives considered

A number of alternative programmes were developed through the production of this business case. These included:

- **Unconstrained:** This $1.93b programme contained no tension at all nor did it seek to provide further value for money savings
- **Unconstrained with savings:** This $1.86b programme, whilst providing 2 percent savings year on year, had little tension in service delivery with increases in pavement renewals and maintenance as well as structures replacements and traffic services renewals.
- **Tensioned:** The tensioned programme is described further below.
- **Overly Tensioned:** This $1.68b option is based on our core programme but significantly reduces our already optimised programme. The proposal reduces our Network Outcome Contract investment by $30m per annum with no compensatory increase in transferable renewals which creates a significant level of service risk. The SCRIM programme is reduced by $5m per annum undermining our safety levels of service and we have made no allowance for maintenance impacts of freight growth.

Both of the unconstrained programmes and the overly tensioned programme have been discounted as they either offer poor value for money (in the case of the untensioned programmes) or, as is the case in the overly tensioned programme, place significant LoS risk on the NZ Transport Agency.

The overly tensioned programme in particularly, has significant consequence for the Transport Agency, including:

- More sudden failures of pavements and surfaces, resulting in prolonged loss of access and longer travel times as a result of a reduced reseals/renewals programme – with really limited ability to react due to minimal contingencies
- General reduction across all Customer Levels of Service
- Significantly increased safety risk due to reduced SCRIM funding
- Reduced level of service from our Traffic Operations Centres (impacting our Travel Time Reliability Customer LOS)
- Reduction in our ability to pro-actively and efficiently manage our assets, activities and IP as National Office funding is significantly reduced, which will also impact on our ability to lead the sector in terms of asset management
- Large flagship projects such as BIM will need to be deferred
- Real risk of deterioration of relationships with our local partners (e.g. RCAs) as we can no longer afford to collaborate and share costs (as is currently the case through various agreements)
- Overall, the customer level of satisfaction is expected to significantly decrease and the number of complaints to increase sharply, leading to a deterioration of the image of the Transport Agency in the public eye.

Tensioned programme

The tensioned programme is based on our optimised core programme but reduces our Network Outcome Contract totals by $30m per annum with some compensation through an increase of $5m per annum in transferable renewals. The programme also reduces SCRIM by $3m per annum. We have removed allowances for freight growth and assumed no further savings can be achieved.

The savings offered over the core programme are presented in the table below.

Tensioned programme reductions as compared to core programme by WC ($ k)

Work Category	Reduction Per Annum
111 Sealed pavement maintenance	-$4,000
112 Unsealed pavement maintenance	$-
113 Routine drainage maintenance	-$500
114 Structures maintenance	-$2,500
121 Environmental maintenance	-$4,000
122 Traffic services maintenance	-$1,000
123 Operational traffic management	-$700
124 Cycle path maintenance	$-
151 Network and asset management	-$12,054
161 Property management	-$840
211 Unsealed and metalling	$-
212 Sealed road resurfacing	-$10,000
213 Drainage renewals	$-
214 Sealed road pavement rehabilitation	-$5,000
215 Structures component replacements	-$3,000
221 Environmental renewals	$-
222 Traffic services renewals	-$150
Total ($ k)	**-$43,744**

To out some context to the above figures, a reduction of $10m in sealed road resurfacing (work category 212) is the equivalent of reducing the programme by approximately 300 lane kilometres.

The tensioned programme was subsequently discounted as, again, it was felt that the overall impact on customer service levels undermined the One Network Road Classification and introduced unacceptable levels of risk including potentially more sudden failures of pavements and surfaces resulting in reduced access and resilience; increased safety risk through reduced SCRIM; impacted travel time reliability through reduced investment in our Traffic Operations Centres.

Part H – Assessment of core programme

We have self-assessed how well the proposed programme will deliver the desired results, while considering integration, whether the solution has been correctly scoped, is affordable, timely and manages risk.

The table below sets out the effectiveness assessment of our core programme. The assessment considers all criteria. The overall effectiveness assessment is reported as the lowest rating for any criterion, i.e. an overall M rating will be given when all criteria and parts have either an M or H rating.

COMPONENT	EXPLANATION	RATING
Outcomes focused	• All works are aligned in a consistent manner nationwide with the One Network Road Classification	H
Integrated	• The proposed programme is aligned with The Transport Agency strategic goals and future transport plans. Further ongoing dialogue will be required with our AO partners to ensure we are fully integrated when it comes to delivery to ensure we are obtaining system wide value for money.	M
Correctly scoped	• A robust option selection process has been followed nationwide to ensure the programme of works is sized appropriately, with a range of options considered where sensible	H
Value for money	• Where appropriate we have made appropriate trade-offs to achieve the best whole of life cost • We have investigated alternative delivery arrangements to ensure we achieve our objectives in as economic manner as possible	H
Timely	• The proposed programme has been assessed as timely as we will ensure interventions are timed to ensure our customers' expectations are met	H
Confidence	• We have confidence our proposed programme will deliver the desired outcomes over a range of future scenarios – it therefore appears robust	H
Overall		**M**

Part I – Delivering the programme

The Transport Agency has a number of systems and processes to help ensure that maintenance and operations programme delivers the necessary outcomes and achieves value for money. This section outlines some of the key system and process in place.

Smart procurement

The Transport Agency outsources the majority of works and services for our asset improvement and asset management projects on the state highway network. Our approach to procurement uses a range of delivery models. These models have been developed based on international best practice and adapted to the New Zealand context, this includes:

- Selecting the best procurement models to deliver optimal value for money based on specific project and market characteristics
- Avoiding the potential for supplier manipulation of a single process
- Maintaining strong, collaborative supplier relationships
- Maintaining a strong procurement skill base and understanding of the supplier market, including competitive rates, capabilities and commercial processes

The policies and processes fundamental to state highway procurement are detailed in the following Transport Agency documents:

- Procurement manual[40]
- State highway procurement strategy[41]
- Contract procedures manual (SM021)[42]

The maintenance and operations space has moved from the existing traditional, hybrid and performance specified maintenance contracts to a primary supplier model. This model brings professional services and physical works components into one contract, called the network outcomes contract (NOCs).

NOCs are a single contract model (inclusive of physical works and network management functions) and are a combination of outcome and output performance based measures. The NOCs provide for collaboration between the Transport Agency and suppliers to achieve positive network outcomes. The performance framework, contract risk profile and basis of payment have been designed to bring the contractor's practices and decision-making processes into line with the Transport Agency goals and objectives for state highways.

The core maintenance activities covered by the NOCs include:

- Network management – asset management, network controls and safety management.
- Physical works – maintenance of sealed pavement, drainage and structures and environmental maintenance, traffic services and operational traffic services.
- Other network specific maintenance activities (e.g. tunnels) and local roads can be included as required.

[40] http://www.nzta.govt.nz/resources/procurement-manual/procurement-manual/
[41] http://www.nzta.govt.nz/resources/state-highway-portfolio-procurement-strategy/
[42] http://www.nzta.govt.nz/resources/contract-procedures-manual/

Programme governance

The Network Outcomes Contract Management Team is responsible for the day-to-day management and leadership of the Contract teams to ensure that the Contract outcomes, including Outcome Performance Measures, KRAs and KPIs, are being considered.

The relationships within the team (and externally) are effective and contract risks are being appropriately managed. The Contract Management Team is also responsible for overseeing cost-effective, innovative practices.

The Contract Board, as a key agent of good governance, adds value through performing four critical functions:

- Determination of Purpose – The Board leads the development of the organisation's purpose goals and its strategy to achieve those goals.
- Governance Culture – The Board works well as a team to deal effectively with the right issues at the right time and in the right manner. It operates within a high performance culture that celebrates debate, thoughtful challenge and dissent, commitment, candour and trust characterised by effective relationships within the Board and with management, customers and key stakeholders.
- Holding to account – The Board holds management strictly and continuously to account through informed, astute, effective and professional oversight. It does not do management activities, but it ensures the purpose and strategy is understood by management and implemented with a clear plan with proper resource deployment, task allocation and performance management.
- Compliance – The Board ensures the organisation is and remains financially viable. It will ensure the probity of financial reports and process and the accuracy of compliance with regulatory environments. It ensures that all risks, existing and prospective, affecting the entity's ability to fulfil its fundamental purpose are identified and managed. The two key obligations of Board Members are the fiduciary duty of good faith and the duty of care and skill. Governance is a high level overview of the entity's operations, monitoring and ensuring performance and achievements of its objectives and goals.

The Transport Agency has developed its own project management practice over recent years. The guidance included in this section attempts to document lessons learnt as we have developed and delivered projects and to provide advice on the best way to progress through various mandatory processes while avoiding pitfalls along the way. Comprehensive project management guidance can be found in the 'Project management manual' (SM011).

Effectiveness and efficiency gains

One of the key recommendations of the Road Maintenance Task Force was that feedback loops between past performance, lessons learnt and future planning and action should be strengthened. Systemising this in a continual improvement process implements this recommendation, and also provides a method for 'tuning' asset management approaches for each network.

Through analysis of our asset and service data and information, the performance management team is helping increase the effectiveness and efficiency of the Transport Agency's maintenance and operations programme and the value for money we provide to our customers.

A key aspect of this is increasing our understanding of the different performance (direct and comparatively) of networks and contracts over time. The evidence provided by the pavement condition report and network expenditure trends and comparisons per work category provided valuable evidence when developing the proposed programme. Over time the

Transport Agency is expecting to become more sophisticated in its use of data and analytics to better optimise the land transport system.

Some of the analysis now being undertake is outlined in the table below. The table shows that since 2010 both average seal age and the total expected seal life have risen year on year. The date demonstrates we are intervening later to maximise the investment in pavement surfacing and also acting to raise the overall pavement durability as evidenced by the longer overall pavement cycle time. In addition, ongoing improvements to drainage are supporting the raising of pavement lives

Average expected seal life

	2010	2011	2012	2013	2014	2015	2016
Average seal age	5.34	5.43	5.68	5.82	6.14	6.66	7.08
Average remaining seal life	3.41	3.33	3.18	3.1	2.85	2.42	2.07
Average expected seal life	**8.75**	**8.76**	**8.86**	**8.92**	**8.99**	**9.08**	**9.15**

Looking back reviews

To help ensure the investment in the maintenance and operations of the state highway is effective and efficient, the Transport Agency reviews the programme on a regular basis.

This review is characterised by a series of investigative and analysis tasks intended to identify, describe and discuss the existing conditions, trends, and known challenges that face the Agency and the infrastructure it is custodian for. This informs lessons learnt improvement opportunities and our approach to continual improvement.

For the 2015/16 review identified some areas for improvement with the NOCs and makes recommendations for improvement across the maintenance and operation programme. These recommendations are being implemented.

Maintenance and operations research

Through the Transport Agency's research programme, we invest in innovative and relevant research that plays a critical role at the forefront of land transport thinking and contributes to achieving the government's goals for transport.

Part J – Risk management

The risk management process, to be applied to aspects of the Transport Agency's business, is governed by either the 'Risk management process manual' (for contracts awarded prior to 2013) or the Z44 Risk Management Minimum Standard.[43]

Risk to Levels of Service and desired outcomes

There are many State Highway asset risks that are common across the entire State Highway network, however, regions / networks may and will have specific risks that require specialist evaluation and mitigation.

There are a number of key risks to maintaining the integrity of the State Highway network in order to deliver the associated service levels to our customers, for example:

Business risks:

- Risk of a lack of or deferred funding
- Risk of schedule slippage
- Risk of overspend
- Risk of failure to gain property access
- Risk of poor contract execution
- Risk of sole supplier insolvency

Network risks:

- Risk of catastrophic failure of a network structure
- Risk of premature deterioration of the asset
- Risk of failure of integration of new projects with existing asset

Natural risks:

- Risk of unanticipated occurrence of a natural event – e.g. flood, earthquake, landslip, avalanche, bush fire, adverse weather

Stakeholder risks:

- Risk of sub optimal design and/or construction practises or materials
- Risk of damage to the asset
- Risk of pollution and/or negative impacts on flora and fauna

Cost fluctuations are additional to this funding investment case. Fluctuations are included annually on a consistent scale set by external factors.

[43] http://www.nzta.govt.nz/resources/minimum-standard-z-44-risk-management/

Part K – Performance and review

The Network Outcomes Contract Contractor's performance is demonstrated by:

- Monthly Contractor reports (Outcome Performance Measures)
- Four-monthly KRA performance evaluations
- KRA annual performance evaluations
- Annual performance workshops.

To serve the best needs of national network prioritisation and to take account of the funding capabilities of the Principal, the Base Renewal Preservation Quantities may still vary from the quantities nominated within the Contract. If this occurs, the Baseline Plans will become a reference point during each year of the Contract Period, to quantify the impacts of any interference with the previously developed investment levels.

The Contractor and Maintenance Contract Manager review the pavement rehabilitation and resurfacing renewal quantities to:

- Monitor the renewal investment levels applied to the network
- Carry out an Annual Reconciliation with respect to the Contractor's tendered Baseline Plan
- Manage change in risk as a result of investment under the baseline plan quantities

Outcome performance measures

Contractor performance is to be reported monthly against the Network Outcomes Contract Outcome Performance Measures. Contractors have their own system (tools) to manage the Outcome Performance Measure process. The Maintenance Contract Manager must be comfortable with the integrity of the Contractor's assessment.

Transparency around the outcome of any challenges involves the following:

- The Maintenance Contract Manager may compare the results from spot checks completed within one day of the Contractor's audit from the previous month
- The Maintenance Contract Manager may complete spot checks on the audit results on the same audit sections
- Elevating misalignment of Contract standard interpretations or intent to the Maintenance Contract Manager's Knowledge Community for a nationally consistent interpretation
- Reporting to the Maintenance Contract Manager's Knowledge Community.

The Maintenance Contract Manager regularly reviews the manner in which the Contractor carries out activities in terms of consistency with their approved plans and the Contractor's compliance levels with the Contract specification requirements such as materials and design standards.

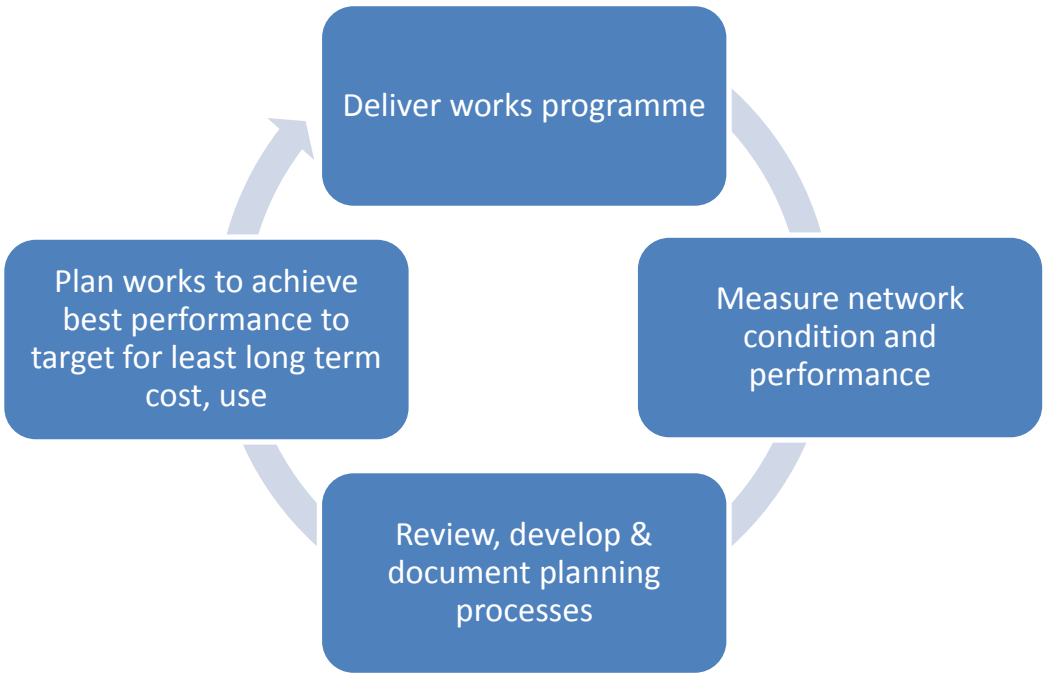
One Network Road Classification reporting

Whilst there are similarities between the Outcome Performance Measures and the One Network Road Classification performance measures, the latter are generally pitched at a higher 'output' level. The final performance measures are available to assist network managers to understand their network and tell their investment story within their business case for the Regional Land Transport Plan.

The performance measures will allow for the monitoring and measurement of roads using consistent tools and standards to ensure investment is targeted at customer levels of service. The three types of One Network Road Classification performance measures (customer outcomes, technical outputs and cost efficiency) together measure our efficiency and effectiveness at meeting the customer levels of service.

Part L – Continual improvement

Our general approach to improving our asset management processes is outlined as follows:



This approach:

- Uses learnings from both the state highway network and works programmes and from external sources including peers and research
- Implements a key recommendation of the Road Maintenance Task Force to better use feedback loops.

Changes to process will be reflected in:

- Annual plan instructions
- Lifecycle Asset Management Plans.

Programmes developed using updated processes will embed the new approach, subject to contractual arrangements.

Improvement projects

Improvement projects have been identified through the development of this business case and are being prioritised as part of the NZ Transport Agency's business planning process. The provisional list is shown below.

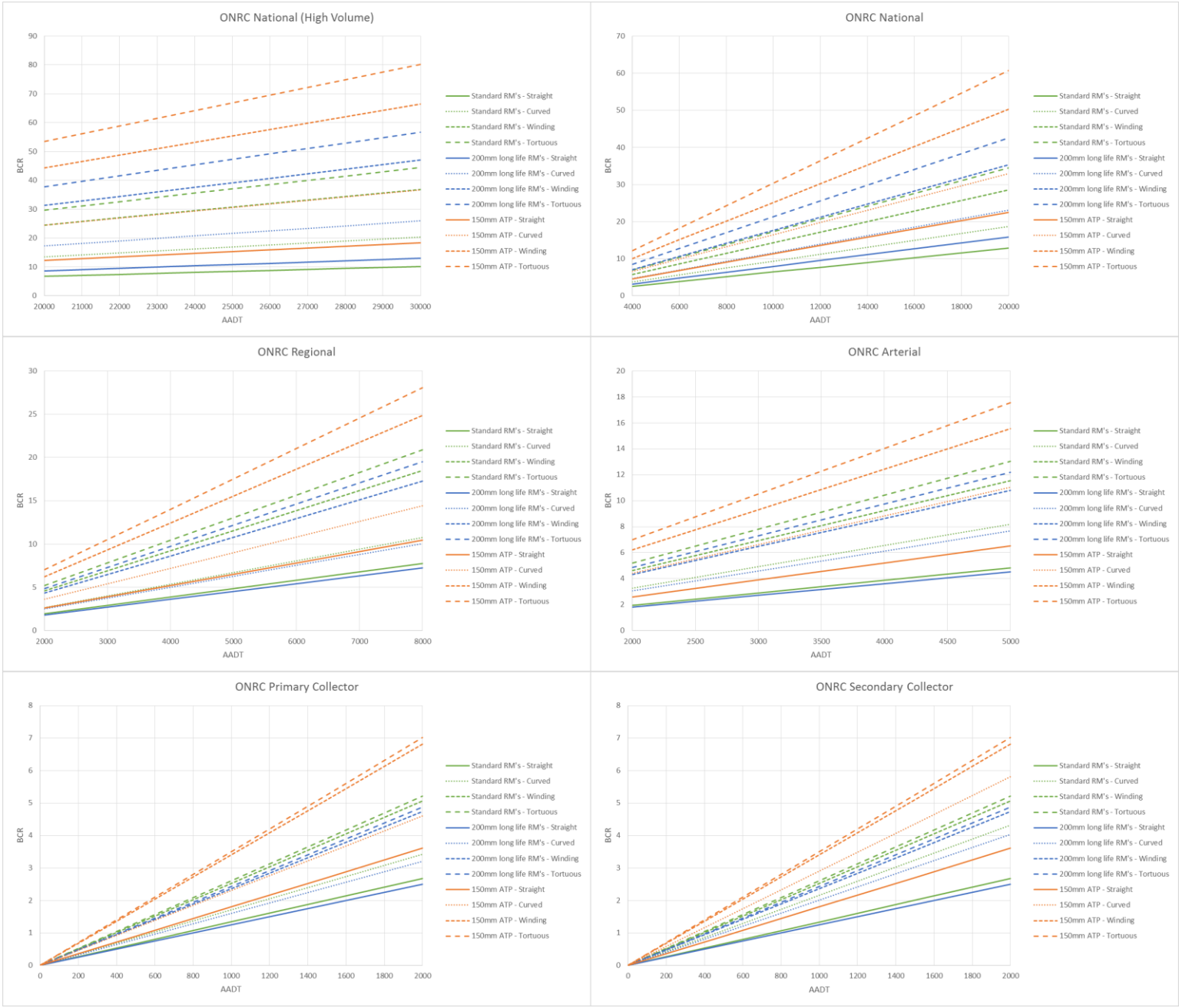
Customer level of service	Asset groups	Improvement
Access	Drainage	Undertake projects to assess and quantify benefits from measurement tools, to define intervention triggers for drainage works and apply these to the network to better understand the required programme investment.
	Pavement modelling	Impact of the future growth in asphaltic surfaces in the modelling
	Pavement modelling	A more accurate assessment of the routine maintenance need, based on the assessment to be carried out using the output renewal quantities from the model
	Pavement modelling	Targets for low volume roads – The technical performance targets used in the modelling have been set to align with the intent of One Network Road Classification levels of service for differing classes of road, but the targets used are untested
	Pavement and surfaces	Continue to investigate the use of new materials to deliver longer lives
	Delivering works	Further improve our ability to schedule the delivery of works to minimise disruption to our customers
Safety	All	Assess the number of fatal and serious injuries per kilometre and by traffic volume for each road classification to better understand our performance and where we need to focus our attention.
Predictable journeys (Travel time reliability)	Traffic management	Improve the measurement of Traffic Operations Centre costs and benefits, so these can be compared and understood in a consistent manner.
	Traffic management	Develop a national Traffic Operations Centre strategy to align operational processes and ensure consistent systems / technology is utilised.
	Traffic management	Develop and implement common standards for intelligent transport systems were possible.
	Traffic management	Developing a single technology solutions

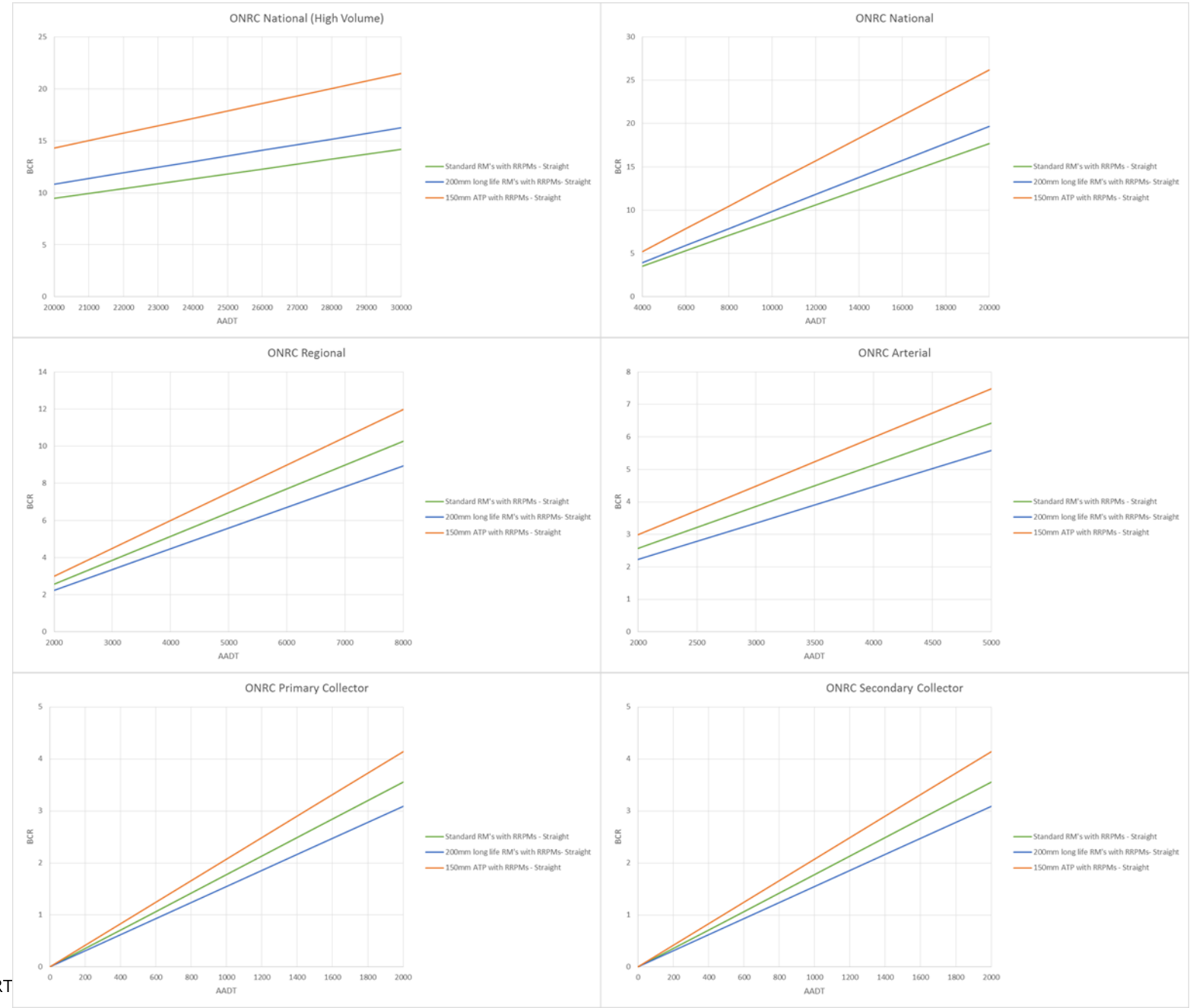
		roadmap for Auckland.
	Traffic management	Moving our travel information to a single digital platform.
	Traffic management	Migrating key systems to the cloud.
	Traffic management	Enabling emerging technologies (including connected and automated vehicles).
	Pro-active winter maintenance	Make use of new technology to enable pro-active winter maintenance activities to ensure that key routes remain opened during winter
All	All	Continue to explore the business case for investment in level of service improvements with whole-of-life economic benefits.
	All	Continue to improve automated data collection – for assets and for activities
	All	Develop and introduce Building Information Management (BIM)

Appendix A – Pavement marking and RRPM BCRs

The graphs below show how pavement markings and RRPMs provide a varying level of benefit cost ratio depending on the:

- One Network Road Classification
- Traffic volumes
- Geometrical perspective


ONRC National (High Volume)
BCR
AADT
ONRC National
BCR
AADT
ONRC Regional
BCR
AADT
ONRC Arterial
BCR
AADT
ONRC Primary Collector
BCR
AADT
ONRC Secondary Collector
BCR
AADT
Standard RM's - Straight
Standard RM's - Curved
Standard RM's - Winding
Standard RM's - Tortuous
200mm long life RM's - Straight
200mm long life RM's - Curved
200mm long life RM's - Winding
200mm long life RM's - Tortuous
150mm ATP - Straight
150mm ATP - Curved
150mm ATP - Winding
150mm ATP - Tortuous


ONRC National (High Volume)
BCR
AADT
Standard RM's with RRPMs - Straight
200mm long life RM's with RRPMs- Straight
150mm ATP with RRPMs - Straight
ONRC National
ONRC Regional
ONRC Arterial
ONRC Primary Collector
ONRC Secondary Collector