Resilience Assessment

December 2017

Mt Messenger Alliance

Technical Report 3

NZ TRANSPORT AGENCY WAKA KOTAHI

Mt Messenger Bypass

New Zealand Government

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Contents

Executive summary

The NZ Transport Agency is to develop a new section of SH3, north of New Plymouth, to bypass the existing steep, narrow and winding section of highway at Mt Messenger. The Project comprises a new section of two lane highway, some 6km in length, located to the east of the existing SH3 alignment.

The existing alignment of SH3 at Mt Messenger is prone to natural hazards that can affect road safety and result in traffic restrictions, delays and/or road closures for the road users and surrounding communities. The Project will enhance the safety, resilience and journey time reliability of SH3.

Resilience is an important factor when considering the complex issues of improving the highway in a challenging environment. This report presents an assessment of the enhanced route resilience in relation to natural shocks and stresses (natural hazards) for the Project. This includes discussion on land instability, flooding/ storms, earthquake, weather, high winds, wildfire, volcanic activity and increasing extreme weather frequency/ intensity due to climate change (including flooding and drought).

SH3 maintenance records indicate disruptions along the existing route have not typically been the result of natural stresses or shocks, other than rare overslips and underslips. These types of natural events are not very frequent and do not significantly affect the overall performance of the existing route. Should a significant natural hazard occur on the existing route, however (for example impacts from the large scale landslide north of the existing Mt Messenger tunnel), there is potential for extended road closures and disruption to the roading network.

Once the Project is in place, the probability of disruption along the proposed Project route through natural stresses and shocks will be low, as resilience enhancements will mitigate the risk of potential land instability, earthquake vulnerabilities and potential flooding. These improvements will be managed through a sound engineering geological and geotechnical assessment of site conditions closely integrated with appropriate geotechnical investigations, followed by the application of current, more advanced engineering design practice.

The construction of the Project will thus result in a significant improvement in resilience over the existing SH3 route to the potential natural stresses and shock challenges in the region. It will achieve this through major improvements to grades and curves throughout the proposed route as well as design and construction of cuttings and embankments, engineered structures including retaining walls, stormwater culverts and a bridge and tunnel.

As discussed further in the Traffic and Transport Assessment (Technical report 2), the Project will improve the resilience of the Mt Messenger section of SH3, and therefore the robustness of the broader regional transport network. Overall, the Project will provide enhanced resilience through improved levels of service, fewer incidents, reduction in risk to road users and better reliability for businesses and the wider community.

1 Introduction

1.1 Purpose and scope of this report

This report forms part of a suite of technical reports prepared for the NZ Transport Agency's Mt Messenger Bypass project (the Project). Its purpose is to inform the Assessment of Effects on the Environment Report (AEE) and to support the resource consent applications and Notice of Requirement to alter the existing State Highway designation, which are required to enable the Project to proceed.

This report provides a resilience assessment for the operational phase of the Project Alignment as shown on the Project Drawings in Volume 2. Resilience is an important factor when considering the complex issues of improving the highway in a challenging environment; while recognising the importance of taking a long-term view in terms of servicing the regional community, and ongoing benefits for future generations.

The purpose of this report is to:

a Provide context of resilience in terms of the Project (Section 2);

b Identify and describe the existing resilience environment (Section 3.1);

c Describe the enhanced and improved resilience for the operation of the Project (Section 3.2);

d Present an overall conclusion on resilience in relation to the Project (Section 5), drawing on relevant aspects of the Traffic and Transport Assessment (Technical report 2).

The assessment is based on professional judgement and a desktop review of the design, and other relevant existing information (including geotechnical information).

1.2 Project description

The Project involves the construction and ongoing operation of a new section of SH3 between Uruti and Ahititi, to the north of New Plymouth. It comprises a two-lane highway, approximately 6km in length, located to the east of the existing SH3 alignment. This new section will bypass the existing steep, narrow, winding highway at Mt Messenger.

The Project will enhance the safety, resilience and journey time reliability of travel on SH3 and contribute to enhanced local and regional economic growth and productivity for people and freight.

A full description of the Project including its design, construction and operation is provided in Volume 1 of the AEE, and is shown on the Drawings in Volume 2.

2 Resilience context

Resilience is the ability of systems (including businesses, infrastructure, government and communities) to proactively resist, absorb, recover from, or adapt to, disruption within a timeframe that is tolerable from a social, economic, cultural and environmental perspective (Money et al., 2017). Disruptions may be a result of systemic or organisational stresses[1] and shocks[2], as well as natural stresses and shocks.

The Taranaki region sits within a complex landscape, with many natural hazards. The region and local communities are built within the influence of the Mt Taranaki and Taupo Volcanic Zone, earthquake fault lines and in areas prone to severe weather rolling off the Tasman Sea.

The region's reliance and critical dependence on lifeline infrastructure such as transport, water supply, drainage, energy generation and telecommunications distribution leaves communities vulnerable should such infrastructure be compromised. Additionally, the region's economic prosperity relies on dairy farming, transport of goods and services, tourism and oil and gas activities. These assets typically traverse and rely on transportation over large geographical areas, and are vulnerable to natural and systemic challenges.

In addition to the resilience of transport networks, resilience of the entire environmental, economic and social system that relies on those networks is also relevant to consider, but is beyond the scope of this assessment.

The Awakino Gorge to Mt Messenger section of the existing SH3 is exposed to a spectrum of stresses and shocks from both within the programme area and outside. In respect of this particular Project, the existing SH3 Mt Messenger road route has steep grades, a winding alignment and limited overtaking opportunities. This presents practical limitations and vulnerabilities of the route through natural and systemic shocks and stresses. In addition, the ability to respond is hampered by very poor mobile communications network coverage.

Relevant shocks and stresses include:

- **Natural shocks**: land instability, flooding/ storms, earthquake, weather, high winds, wildfire and volcanic activity;
- **Natural stresses**: increasing extreme weather frequency/ intensity due to climate change (including flooding and drought);
- **Systemic shocks**: service route disruption (including supply chains and other community centres), infrastructure failure (key services such as communications, gas-Maui pipeline) and poor road maintenance leading to road closures; and
- **Systemic stresses**: changing customer/ road user expectations of service level for route and reliability of the network to support continued regional and local economic growth.

[1] Stresses: Longer term challenges that weaken the fabric of a system.

[2] Shocks: Sudden, sharp events that threaten a system, such as earthquake, floods and crashes.

Disruptions due to systemic shocks and stresses are discussed in the other specialist assessment reports attached to the AEE (including Strategic Transport, Traffic and Transport, Economic Effects and Social Impact Assessments, being Technical reports 1, 2, 4 and 5 respectively in Volume 3 of the AEE).

There are four measures (Money et al., 2017) of resilience:

Robustness: The ability of systems to withstand disruption and continue to provide to an acceptable level of service.

Redundancy: Provision of functionally similar outcomes, to an acceptable standard, during lost or degraded levels of service.

Recovery: The ability to restore an acceptable level of service after disruption.

Leadership and governance: The ability to develop an organisational mind-set/ culture of enthusiasm for challenges, agility, flexibility, adaptive capacity, innovation and taking opportunity.

Natural hazard challenges are by their very nature, uncertain, dynamic, and exist in perpetuity. While assumptions can be made based on history and good science about the expected probability and magnitude of consequences of events, we ultimately do not know precisely when an event will occur and what the full impacts will be.

This report presents an assessment of the enhanced route resilience in relation to natural shocks and stresses (natural hazards) for the Project.[3]

[3] As noted above, the resilience of wider systems is also relevant to consider in an overall assessment of resilience, but this is beyond the scope of this report.

3 Resilience assessment

3.1 Existing route resilience

The existing SH3 alignment at Mt Messenger is characterised by a steep, narrow and winding road which requires improvements to enhance safety, resilience and journey time reliability.

Heading north from Uruti, the existing route follows the valley of the Mimi River at around 50m above sea level (mRL). The route rises steeply to an elevation of around 195mRL as it passes around the Mt Messenger peak (of 306mRL) through a short tunnel and then descends into the valley (elevation around 12mRL) towards Ahititi. The steep and rough terrain is prone to natural shocks that present a hazard and may result in delays or road closures for the road users and surrounding communities. With no suitable alternative route, significant delays put communities at risk in an emergency and have adverse economic effects. The lack of a suitable alternative route is discussed further in the Traffic and Transport Assessment (Technical report 2, Volume 3 of the AEE).

Overall, the recorded disruption history for the existing route is predominantly traffic related, with road accidents and breakdowns leading to closures and / or long delays (see Traffic and Transport Assessment, Technical report 2). Due to the relative remoteness of the site, any obstruction of the corridor introduces significant delays to road users, so all potential sources of road obstruction (such as the natural stress/ shocks) have a level of risk to the corridor and network.

Natural stress/ shock factors affecting current route resilience include:

Land instability (potential for landslides, rockfall, mudflows, road overslips and underslips): In 2002, Beca reported that land instability above and below the highway across the route is likely to occur and may be triggered by uncontrolled stormwater and high groundwater levels. Possible route closures due to underslips such as slumping, fill failure or inadequate retaining walls could affect the network through temporary closures for 1-2 days followed with reduced lane use while construction continued for 10-12 weeks (Beca, 2002).

There have, however, been safety and roading improvements over the past 15 years following the earlier assessment of the corridor by Beca (Beca, 2002). More recent observed performance of existing slopes, cut batters, fills and retaining walls indicates infrequent landslip events do not always affect the overall performance of the route. Overslips such as rockfall and soil instability are typically the result of the ad hoc nature of the progressive construction styles used along the route over the past several decades and also rainfall-induced instability. Debris is typically deposited at the base of existing cuts, but records show rarely significantly affects the carriageway (TREIS Report, 2017). It is worth noting that there are very few open drainage/ rockfall debris catch ditches along the existing road. Maintenance of the route is typically done by clearing debris from the road shoulders, drains and road berms. In the past four years, the NZ Transport Agency Network Outcomes Contract (NOC) maintenance contractor reported only very limited and infrequent maintenance has been required for drainage, landslip and rockfall issues (see Shortlist

Report, Volume 4 of the AEE). This indicates the route has a level of redundancy and robustness that allows the network to continue partial operation until recovery and clean up occurs.

A large scale, landslide exists north of the existing Mt Messenger tunnel. This landslide is approximately 1km wide by 0.5km long and is identified on the national QMap landslide register/map (Edbrooke, 2005), and has also been identified in the Beca (2002) report and the Opus (2016) report. The southern section of the landslide is actively moving, with recent tension cracking and graben formation having been observed and mapped, along with other engineering geological features (see Geotechnical Appraisal, Technical report 14, Volume 3 of the AEE). It is assumed that this landslide feature was triggered by a very large earthquake based on the observed features. Such an earthquake (return period of greater than 10,000 years) is likely to have been well above normal NZ Transport Agency/NZS design conditions. Further large scale movement of this feature could disrupt the route for a significant time period before access to an acceptable level can be reinstated.

Flooding/ storms: Intense rainfall due to storms presents a risk to land instability as discussed above. Limited information is presented on groundwater levels across the route. However, recent MMA and earlier Beca (2002) observations indicate the groundwater levels appear to be very shallow near the ground surface within the valleys and these areas are very susceptible to flooding. Surface flooding of low lying areas and failure of culverts resulting in damming or overtopping of the road are the main disruptions that could occur causing temporary road closures until the water and debris is cleared. With the steep road gradients heading up out of the valleys, there is little risk of surface flooding. However, the surrounding deeply dissected terrain and hill catchments are of limited size and respond rapidly to rainfall (rapid peak flows) with minimal surface infiltration due to steep slopes and low permeability rocks and soils. Debris (vegetation and soil) build-up is common and requires ongoing maintenance to keep drainage pathways clear. The low-lying and flood-prone areas at the northern and southern ends of the route rely on the performance of the drainage and culverts to minimise blockages.

Earthquake: North Taranaki is an area of low to moderate seismicity for New Zealand. The offshore Turi Fault is the closest known active fault in the area suggesting large scale shallow earthquakes have been rare in the recent geological past. Since circa 1840, records show eight shallow, M5.0 and greater earthquakes have originated from epicentres within or close to north Taranaki (Geotechnical Appraisal Report, Technical Report 14). This includes the estimated M6.5 New Plymouth earthquake in January 1853 (the largest earthquake recorded), and the M5.4 earthquake located close to Awakino in January 1962. Similar levels of seismicity may be expected to occur in the future. Local damage only has resulted from occasional moderate magnitude earthquakes at very shallow depths within or close to north Taranaki, and larger magnitude earthquakes further away.

The existing route will have been subjected to these 'Recent' (in a geological sense) earthquakes and despite reports of very minor damage to old masonry buildings at Awakino as a result of this earthquake, there are no records of disruption to the relatively distant Mt Messenger section of SH3 so its robustness to earthquake has had only ‘qualified’ testing. Potential low vulnerabilities include liquefaction and lateral spreading of possibly susceptible geological materials around the stream areas in the southern Mimi River valley and the northern alluvial valley affecting the road. Potential cyclic softening of soft plastic soil deposits in these areas appear to have very minor vulnerability to deformations by a loss of strength during seismic accelerations (Geotechnical Appraisal Report, Technical Report 14). Earthquakes of 1000 year to greater than 2500 year return periods of about M6.0 are likely to affect the large scale landslide (discussed above) and other existing landslips along the existing route.

Weather: While weather related conditions such as fog and frost occur seasonally through the wider area, snow events are very infrequent. No incidents have been recorded from these weather conditions that have resulted in road restrictions or closures in the vicinity of Mt Messenger.

It is noted that the (coastal) SH3 route between Wellington and Auckland has and will provide a move resilient alternative than SH1, SH2 and SH5, when heavy snow conditions cause closures on the SH1/Desert Rd, Waioeka Gorge and Taupo-Napier highway.

High winds: Storms and adverse weather conditions resulting in high winds that may bring down trees and large vegetation from high slopes are infrequent and no incidents have been recorded in the last five years from these conditions that have resulted in road restrictions or closures.

Wildfire: Rural fires affecting the route are rare with no records in the last five years indicating wildfire disruptions to the road or wider community network.

Volcanic activity: There is very low risk of adverse effects from volcanic activity from Mount Taranaki in the south or the Taupo Volcanic Zone towards the east. However the impact and consequences of the very large, explosive rhyolitic eruptions from this latter zone are very significant. Very large ash showers have been deposited at supersonic speed and the extent and depth of these deposits is largely related to prevailing winds at the time of eruption(s). However, given the distance between these Taupo Volcanic Zone centres and Mt Messenger, the SH3 route is likely to offer a more resilient alternative route to SH1 and SH2 between Wellington and Auckland.

Historically, disruptions along the existing route have not typically been the result of natural stresses or shocks, other than rare overslips and underslips. These types of natural events which typically include land instability, flooding and storms resulting in culvert blockage are not very frequent and do not generally affect the overall performance of the existing route. However, should any of the discussed natural hazards occur on the existing route which causes a significant road restriction or obstruction (for example impacts from the large scale landslide north of the existing Mt Messenger tunnel), there is potential for extended road closures and disruption to the roading network.

3.2 Proposed route resilience

The proposed route covers a total distance of 6km and is located to the east of the existing Mt Messenger SH3 highway. In the south, the new route diverges from the existing road and starts to climb out of the Mimi River valley from an elevation of approximately 50mRL. It then continues a short distance further east along the Mimi Valley floor within private farmland, along foothills west of the Mimi Stream (swamp maire) wetland before gradually climbing up through the steep terrain via a combination of earth embankments, rock cuttings and a bridge crossing a deep gully to a maximum elevation of approximately 115mRL. This maximum new highway elevation is approximately 85m lower than the crest of the existing SH3 route. The route then tunnels through a prominent ridgeline and descends via further high embankments and deep cuttings to the eastern side of the Mangapepeke Stream valley, before connecting back via low embankments into the existing SH3 highway at an elevation of about 12mRL.

The construction of the Project will result in an improvement in resilience over the existing SH3 alignment at Mt Messenger to some of the potential natural stresses and shock challenges in the region. The Project achieves this through design and construction of cuttings and embankments, and engineered structures to achieve major improvements to grades and curves throughout the proposed route.

The mitigation measures and associated resilience benefits of proposed route are as follows:

Land instability (potential for landslides, rockfall, mudflows, road overslips and underslips): Geotechnical designed cuts/ embankments/ retaining walls along the route will avoid or mitigate potential land instability through developing a robust alignment. Resilience mitigation/ risk avoidance measures for the Project include:

1 The proposed route avoids the known northern landslide area, which improves the long term resilience of the network.
2 Low to moderately high, steep rock cuts are designed for overall stability with appropriate batter slopes to minimise the impact of rockfall to the carriageway to an acceptable level from a maintenance and road user perspective. If rockfall occurs, debris will be collected within a catch ditch/barrier system for occasional clearance by the NZ Transport Agency maintenance contractor.
3 Landslides and rockfall causing road closure has a low potential impact due to designed stability and mitigation measures such as increased width and/or depth of energy absorbing catch ditch and/or through the inclusion of soil nail reinforcement, rockfall meshed drape, combined with a low wire rope/barrier a catch-fence adjacent to higher cut batters.
4 Embankment design will consider mitigation measures required where appropriate for ground deformations such as differential settlement for the different soil conditions across the Project.

Flooding/ storms: Low risk of flooding inundation due to road elevation being sufficiently above streams and waterways will provide a robustness to the system. Resilience to flooding and consequential land instability/ erosion will be achieved through stormwater and drainage design such as directing water/ runoff into catchment areas more quickly to limit impacts, using surface water diversion channels with appropriate discharge points or intercepted runoff to be discharged/ diverted via channels or pipework. The Project compared to the existing route provides:

1 Moderate improvements in stormwater/ hydrology control in main valleys.
2 Provision of erosion protection measures.

Given the Project alignment ties into the existing route at the northern and southern extents which are low-lying and flood prone, it is considered the Project will not worsen the existing resilience to surface flooding at these tie-in points.

Earthquake: There is a low to moderate risk of earthquakes affecting the region as previously discussed. A seismic hazard assessment is being prepared by GNS Science (in press, 2017). A draft of this assessment indicates seismic ground motions are similar to, but generally less that those indicated by the NZ Transport Agency Bridge Manual (NZTA, 2016) and New Zealand Standards NZS1170.5 - Earthquake actions (2004). The draft hazard spectra results represent a low level of hazard for the location.

The Project route will benefit from advanced, modern design, and lessons learnt from recent experiences from the Canterbury Earthquake Sequence (2010-2011) and Kaikoura Earthquake (2016). Mitigation of potential consequences will be achieved through robustness in the detailed design where site-specific seismic design parameters will be considered.

1 Liquefaction: Typically low risk. The Project is less exposed to damage from liquefaction and lateral spreading in an earthquake than the existing route due to current design practices. As noted previously, there is a low to moderate potential for ground-shaking for this site. Also, recent preliminary field testing of alluvial soils along the preferred route, combined with supplementary soils tests in the laboratory, indicate the general soil composition is unlikely to be significantly affected by liquefaction. Areas in the south around Mimi River and towards the north around Mangapepeke Stream could potentially be affected by discrete areas/zones of soft liquefiable ground associated with valley floor alluvium and high groundwater levels. However, these liquefaction effects on the new route will be addressed by current design practice to limit displacements under design earthquakes to tolerable levels.

2 Earthquake-induced instability: The Project area appears to have performed well under earthquake loadings over recent (geological) time (i.e. less than 10,000 years). The area is resilient to major instability or earthquake-induced instability (over the design life 100 years) based on the observed performance of the natural and cut landforms along the existing route. There are no known mapped large scale landslide features observed on the proposed route (compared with the partially active northern landslide on the existing route). The nature of the Mt Messenger Formation soft rock with relatively few joints, tight defects and sub-horizontal bedding also provides a natural overall stability for cut and natural slopes. Small to moderate failures, for example rockfall and overslips following significant earthquake shaking, along the route will likely be able to cleaned up quickly to restore service shortly after the disruption.

3 Earthquake-induced cyclic softening: Preliminary field and laboratory testing indicates there is a low risk of cyclic softening associated with soft plastic Recent alluvial deposits in the Mangapepeke Stream area of the Project. Further detailed geotechnical investigations and assessment of this natural shock is required. Mitigation measures for these soils include surcharge preloading to improve the strength of the foundation soils. These and other ground improvement measures will be designed to limit the

anticipated ground deformations to acceptable levels to enable redundancy of the route and therefore enhance resilience.

Weather: Weather related conditions such as fog and frost occur seasonally and snow infrequently. The Project alignment has a lower elevation than the existing route so is considered less susceptible to snow (although there are no reports of road closures due to snow on Mt Messenger). Fog conditions on the existing SH3 alignment are reported to occur from time to time to the north of the site, where the highway follows the Tongaporutu River flats. Fog conditions may occur infrequently along the Project alignment but as this risk already exists there is little change expected to the likely effects and risks. The 3D digital terrain model for the Project has capacity to predict shading and sun angle for every day of the year. The model was used along the Project alignment to consider potential issues with differing sun angles and subsequent shading. The Project alignment generally follows a north – south arrangement, and so receives sun through the day, regardless of season. Records from the NZ Transport Agency's maintenance contractor report that grit use for ice conditions has not occurred at Mt Messenger for the past four years (the length of the current contract). As the Project alignment will receive good levels of sun through the day, there is little change expected to the existing ice risks on SH3.

High winds: It is considered the Project route will be less exposed to general wind conditions compared to the existing route due to the route being at an overall lower elevation and with less exposed valleys in the south and north of the route.

Extreme weather (due to climate change): Due to the location of the Project (West coast – typically more rainfall), it is considered that drought conditions would be rare, and if there were more intense periods of extreme dry weather the impacts would be low. Groundwater levels within the valleys are inferred to be high (as discussed above). Should drought conditions exist during construction that would lower the permanent groundwater levels then this may encourage settlement along the route. This can be sufficiently designed for and mitigated by preloading of areas prone to groundwater fluctuations.

Engineering works and structures (tunnels, bridges, embankments, cuts, drainage culverts): Earthworks such as cuts through ridges and embankment fills in valleys will be designed and constructed to tread lightly on the land to reduce the amount of land required to be disturbed and any potential for natural defects or unfavourable hazard conditions. This will provide additional robustness and redundancy for the resilience of the route through avoidance or mitigation of land prone to instability. In addition, structures such as the tunnel and bridge will significantly reduce the impact on the land and the environment through innovation and robust design.

1. Design would be consistent with the principles of the NZ Transport Agency Bridge Manual (NZTA, 2016) with land instability, flooding and earthquake vulnerabilities in mind.
2. Earthquake resilient works and structures will be developed using good robust design practice.

3 Appropriately designed tunnels are particularly resilient to natural stresses which is evident by the good condition of the existing unlined Mt Messenger tunnel within the Mt Messenger Formation siltstone/sandstone (geological formation of the region).
4 Enhanced resilience to intense rainfall in adequately drained catchments using good design practices.

Overall the Project will provide a robust road corridor using design and mitigation measures to withstand disruptive events so the network is restored to an acceptable level of service quickly.

Generally in small to moderate earthquakes and storm events the Project route is expected to be robust with some redundancy, to remain open with the possibility of reduced capacity in extreme events. Restoration and recovery times for minor land instability are expected to be none to minor as the design provides for wider berms and catch mechanisms for overslip debris to enable traffic to keep moving.

4 Resilience summary

A summary is presented comparing the natural shock and stress resilience assessment of the proposed Project route compared to the existing SH3 route.

Table 4.1: Summary of resilience assessment

Natural shock/ stress challenges	Existing route	Proposed route	Assessment
Land instability	Moderate-high risk Infrequent events	Low risk (through design factors)	Improvement in resilience
Flooding/ storms	Moderate-high risk Infrequent events	Low risk (through design factors)	Improvement in resilience
Earthquake-induced instability	Low-moderate risk	Low risk (through design factors)	Improvement in resilience
Earthquake – liquefaction	Low-moderate risk	Low risk (through design factors)	Improvement in resilience
Weather (fog/ frost/ snow)	Low risk	Low risk (lower elevation)	No resilience change
High winds	Low risk	Low risk (lower elevation)	No resilience change
Wildfire	Low risk	Low risk	No resilience change
Volcanic activity	Very low risk	Very low risk	No resilience change
Extreme weather	Low risk	Low risk	No resilience change

The assessment identifies that the Project alignment is relatively well located in terms of the most critical natural hazards (land instability, flooding and earthquake related vulnerabilities).

Enhanced resilience is important for the overall delivery of the Project to enable the entire network functionality to be relied on for service benefits to the overall regional community. Along with the improved and enhanced resilience of the Project alignment, additional improvements across the whole SH3 programme of works will assist in providing an enhanced resilience for the wider Waikato and Taranaki regions. Businesses and communities rely on the land transport systems, therefore complex interdependencies exist that extend beyond the actual users of the network. Roads are also key lifeline utilities and are required to ensure functionality to the fullest extent possible after a natural hazard or other disruptive event.

5 Conclusions

The Project will improve the resilience of the Mt Messenger section of SH3, and therefore the robustness of the broader regional transport network. This improvement will result from various resilience enhancements over the existing SH3 route to natural stresses and shock challenges in the region.

The chosen route for the Project avoids a significant landslide affecting the existing SH3 route (and other known areas of instability).

Further, the Project will incorporate mitigation design measures to improve the natural hazards resilience of the new route, including:

- Enhanced resilience through design methodologies for cut slopes, embankments and culverts;
- Innovation and robust design of structures such as the tunnel and bridge which will significantly reduce the impact on the land and the environment through avoidance and mitigation of unfavourable ground conditions;
- Improved resilience and management of natural drainage patterns and integrated stormwater management of water quality and water quantity, including the use of structures for stream and gully crossings; and
- Construction methodologies that avoid and/or mitigate vulnerabilities associated with adverse natural shocks and stresses.

Other relevant matters to note, also addressed in the Traffic and Transport Assessment (Technical report 2), are:

- A shorter length of Project route than the existing route providing better route vertical and horizontal geometry, higher design speeds and significant improvements to travel time and road user reliability; and
- Increased performance of the transport network system with strengthened robustness and redundancies that lessen the risk of outages and extend the ability to withstand disruption.

The probability of disruption along the proposed Project route through natural stresses and shocks is low, because resilience related enhancements and improvements will mitigate the risk of potential land instability, earthquake vulnerabilities and potential flooding. These improvements will be implemented through targeted geotechnical investigation, a sound technical understanding of engineering geological and geotechnical site conditions along with the application of current, more advanced engineering design practice.

Overall, the Project will provide positive outcomes through improved levels of service, fewer incidents and reduction in risk to the road user. Road users will experience a safer, more resilient, well designed route and businesses and the wider community will benefit from the route's enhanced reliability.

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