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Review of methods to determine criticality of roading networks

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Table of Contents

Executive Summary

This report is prepared for the New Zealand Transport Agency (NZTA) and contains a desktop review of methods to assess the criticality of roading networks. It is understood that this project will contribute to the growing body of knowledge around criticality, risk and resilience - with a goal to better understand areas of high risk in order to assist with prioritisation of risk reduction efforts (including investment in improving network resilience) and improved response and recovery planning.

Critical assets can be defined as those that *are especially significant to societal wellbeing and that therefore merit priority attention by utilities in emergency response and recovery.* They are also defined as those which have a *high consequence of failure*. For example, a transport route may be critical because it carries high volumes of traffic, or if it is the only access route to a hospital.

The scope of the project involved a literature review of a range of approaches for measuring road hierarchy and criticality, including NZTA's One Network Road Classification (ONRC) system. The intent of the review was not to recommend changes to the ONRC itself. Instead, any additional (and relevant) 'criticality' criteria were to be captured and justified, alongside existing criteria.

As a result of the literature review and analysis undertaken, a criticality framework has been proposed which incorporates three elements:

1. ONRC classification.
2. Access to lifeline utilities or a lifeline evacuation route.
3. Access to essential services.

A scoring system has been developed as summarised below.

Table ES1 Proposed criteria, scoring and data sources

Criteria	Comment / Rationale	Scoring	Potential data source
ONRC	The ONRC provides an established functional classification covering traffic volumes, economic criteria, accessibility, connectivity etc.	4 – National or high volume 3 – Regional or arterial 2 – Primary or secondary collector 1 – Local or access	ONRC assessment
Access to Lifeline utilities, or a lifeline evacuation route.	In order for a region to recover from any natural hazard event it is important for the various key utilities such as water, wastewater, power and telecoms to be able to access their assets to inspect and undertake repairs. This category includes physical utility assets such as sub-stations that require access to maintain continuity of service to the public and also access to critical transport hubs such as ports and airports. This also includes any routes which are considered themselves as essential for evacuation.	Based on the total number of utilities on a route, criticality of utility. 4 – More than 5 locally-significant utility assets, more than 3 regionally-significant assets, or 1 or more nationally-significant assets. 3 – Three or four locally-significant utility assets, 1 or more regionally-significant assets, or an essential evacuation route. 2 – One or two locally-significant utility assets. 1 – No access for utilities.	Utility asset information
Access to essential services	These are essential services which would be required for response and recovery during a natural hazard event. There are 6 priority areas proposed including: hospitals and large age-care facilities,	Based on the total 'priority score' calculated based on all the priority services accessed by a given route. Refer body of the main report for	Essential service asset information

Criteria	Comment / Rationale	Scoring	Potential data source
	ambulance, fire, police and emergency ops centres, major utility control centres, welfare centres, key retail outlets – hardware stores, construction resources and supermarkets, schools and sector posts and major industry.	details. 4 – Score of more than 5 3 – Score of three or four 2 – Score of one or two 1 – Less than 1	

It is proposed that each criteria be weighted equally and aggregated to provide an overall criticality score from 1 (vital) to 4 (local).

In terms of next steps, the following points are made:

a. In order to undertake an assessment, the criteria would need to be evaluated based on existing 'routes' or 'road segment' databases. It is understood that NZTA currently do not have this type of formal delineation (although, some information is available in RAMM), and, as such, further work is required in this regard. The following is suggested as a starting point for segmentation:

   - Base segments initially on ONRC classifications. Then further refine the segments by dividing between major intersections. A potential further division could be achieved if considered necessary (eg by dividing into segments of a maximum given length), however this level of resolution is not deemed to be necessary. Note that the length and extent of route lengths may also influence scores, and should be carefully considered when implementing and testing the framework.

b. The framework is proposed as a draft for discussion, and it is suggested this be circulated for comment and further discussion to confirm assumptions, criticality scores, priority scores, lifeline utility scores, weightings etc.

c. It is recommended the framework be tested within a region and refined where appropriate.

d. More broadly, it is recommended that a nationally consistent set of criticality definitions be developed to ensure improved consistency in both terminology and application both within and across sectors.

1.0 Introduction and background

1.1 Introduction

This report is prepared for the New Zealand Transport Agency (NZTA) and contains a desktop review of methods to assess the criticality of roading networks. It is understood that this project will contribute to the growing body of knowledge around criticality, risk and resilience - with a goal to better understand areas of high risk in order to assist with prioritisation of risk reduction efforts (including investment in improving network resilience) and improved response and recovery planning.

1.2 Background

Critical assets are defined as those that *are especially significant to societal wellbeing and that therefore merit priority attention by utilities in emergency response and recovery* (Lifelines Glossary, 2015). They are also defined as those which have a *high consequence of failure* (IIMM, 2015). For example, a transport route may be critical because it carries high volumes of traffic, or if it is the only access route to a hospital.

Generally, critical assets are ranked into different 'levels' to represent their relative importance. An example is shown below (State of Victoria, 2015).

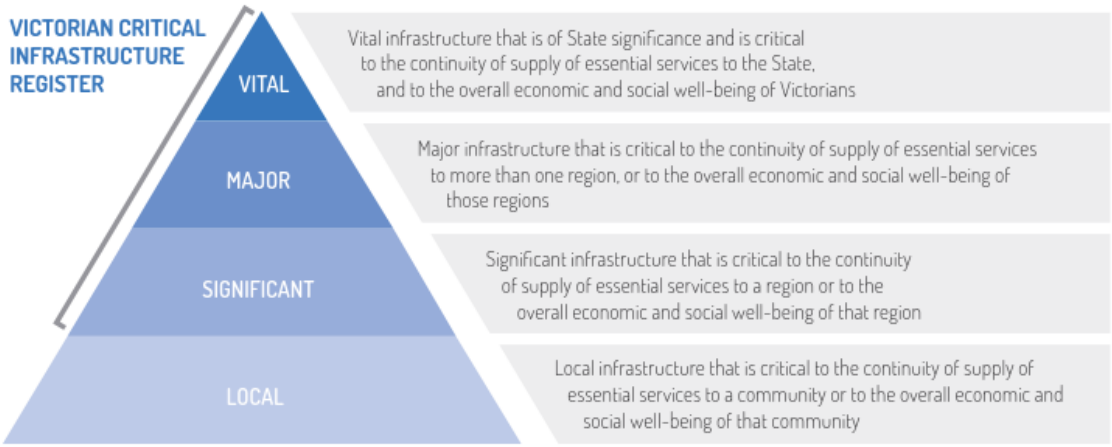

Figure 1 Victorian Critical Infrastructure Model (State of Victoria, 2015).

Understanding and managing critical assets involves an understanding of lifeline infrastructure requirements as defined by the Civil Defence and Emergency Management (CDEM) Act 2002, the principles and practices of asset management, including principles of risk management, services of importance to customers and the interdependencies with other utilities' critical infrastructure.

The fundamental first step in managing risk in infrastructure systems (including roading networks) is to understand the *criticality* of the system itself and the various elements within the system, so efforts can be prioritised.

To be clear, in the context of this study, the term 'criticality' is assumed to be informed (defined) by the *consequence* of the asset failing. That is if there is an *unacceptable consequence* should a particular asset fail, then that asset would be classed as *highly critical.*

Risk can then be estimated as the likelihood of failure (or hazard impact) multiplied by the consequence (criticality[1]) as illustrated in Figure 1.

1

Figure 2 Risk equation

While there are clear high-level definitions for critical infrastructure in New Zealand, there are no consistent frameworks for establishing criticality within and across sectors. Most utilities and Councils will have their own methods for determining criticality and may use different criteria for this.

Often these methods are based on the *consequence* of the asset failing, and may relate to factors such as customer impact, financial loss, environmental damage, corporate image etc. There is potential for some of these to outweigh others depending on the business priorities.

In the context of roading networks, many roading authorities develop hierarchies/classifications of asset types to describe the *function* that different types of road provide. Generally these help guide the management, operation and use of the road corridors in order to improve safety and efficiency – and to provide a consistent level of service for road users.

The NZ Transport Agency has developed the One Network Road Classification (ONRC) which categorises all roads into seven functional classifications (National High Volume through to Access Roads), according to a range of criteria as follows:

- Movement of people and goods – 4 criteria: Annual Average Daily Traffic (AADT), Heavy Commercial Vehicles (HCV), Buses, Active modes.
- Economic and Social – 6 criteria: Linking places, connectivity, ports, airports, tourism, hospitals.

The ONRC guidelines provide comprehensive definitions regarding each of these criteria and how they are interpreted and measured. Refer Section 2.0 for further detail.

These common systems of hierarchy for different level roads generally infer a level of 'criticality' – as per the example in Figure 1. This study aims to review a variety of different hierarchy and criticality systems in order to better capture an appropriate range of factors which may determine more accurately the criticality of a particular road or route.

In the sections which follow, we firstly summarise the current ONRC approach utilised by NZTA. Then we present a range of alternative approaches used in determining criticality based on a literature review, and suggest a framework which could be used to more accurately determine criticality for NZTA.

It is not the intention that the proposed framework replaces the ONRC. Instead it seeks to align where appropriate and provide any additional criteria required for improved risk-based decision making.

2.0 ONRC approach summary

The ONRC framework establishes six functional road categories and 10 criteria for determining these. These criteria are summarised below:

Table 1 ONRC Criteria (NZTA, 2013)

ONRC Criteria	Description
Typical daily traffic (average annual daily traffic):	A proxy for economic activity based on the movement of people. Also a proxy for traffic generators with both economic and social/place dimensions such as employment locations, shopping areas and schools/tertiary institutions.
Heavy commercial vehicles (daily vehicle flows):	A proxy for economic productivity through connecting major industrial/commercial and distribution centres to markets.
Buses (buses per hour and/or bus passengers per hour – during urban peak):	Based on the number of buses per peak hour using a particular route.
Active modes (significant numbers of pedestrians and cyclists (urban peak) or part of identified cycling or walking network):	Based on the number of pedestrians and cyclists using a route.
Linking places (centres of population):	This captures the principal links between major centres based on population size. Major urban areas also have the highest concentration of economic activity in terms of employment and businesses / industry
Critical connectivity (remote regions/sole connectivity in urban areas or access to significant critical infrastructure):	A further important function of routes/roads is linking remote regions or providing sole connectivity in urban areas and providing critical connectivity (lifeline connections) where there are no alternative routes[2], particularly in rural areas.
Freight tonnes and values at ports and inland ports (per annum):	Key economic criteria and provides a useful indicator of the significance of a route/road in economic terms.
Airport passenger numbers (annual):	This captures the number of passenger numbers, which relates to the scale and importance of the airport relevant to tourism, as well as social and economic outcomes.
Significant tourism destinations and significant scenic routes:	Proxy for the significance of tourism to the New Zealand economy in rural and urban areas alike.
Access to tertiary or regional hospitals:	Proxy for an important social place function.

It is also noted that the ONRC also includes a range of customer levels of service (outcome) measures – which include 'resilience'. It is noted that this is a desired outcome to be delivered, not a criteria able to be used to evaluate a particular route.

In the following section we review a range of hierarchy and criticality methods used by other authorities and organisations, locally and internationally.

[2] Alternative routes are a key criticality consideration. This is included within the ONRC currently to a certain degree and is discussed further in Section 4.2.

3.0 Review of methods to determine hierarchy and criticality

Internationally, most authorities utilise the concept of roading 'hierarchy'. Typically this breaks roads into a range of categories / hierarchies which allow prioritisation for functional operational and asset management purposes. For example, categories may include: highways, arterials, collectors and local roads.

These levels are typically used to guide levels of service, design practice, design speeds, accessibility, amenity, safety etc.

Some authorities have developed separate sets of hierarchies for different focus areas – for example, South Australia has developed functional hierarchies for areas including public transport, cycling routes, pedestrian access, freight routes etc.

Other authorities have developed more comprehensive approaches which combine a range of criteria into a single measure (such as the ONRC).

The hierarchy criteria can influence a broad range of factors such as:

- Road condition, road defects and repair prioritisation
- Road marking and road asset maintenance frequency (e.g. including drainage assets)
- Requirements for types of signage
- Guidelines for types and timing of roadworks
- Design of roads and standards for shoulders, pavement types etc
- Width and height restrictions
- Type of incident response required during a hazard or accident event
- Approach to risk mitigation, etc.

A number of examples are discussed in more detail below.

3.1 South Australia Functional Hierarchy

The Government of South Australia's Department of Planning, Transport and Infrastructure has developed a functional hierarchy framework for their land transport network (Govt of South Australia, 2013). This framework was developed "*to describe a functional hierarchy that identifies which corridors are important for different modes of transport. It will guide the use of road and rail space to improve safety and efficiency for users of the transport network."* The framework applies to the road, cycling and rail networks, and importantly, identifies the importance of integrating transport hierarchy with land use and urban design considerations.

The framework is applied across seven distinct functional areas:

Table 2 South Australia functional hierarchy

Functional Area	Comment
Public transport corridors	These are divided into four levels, specifically: Dedicated corridors, Priority Corridors, High Frequency Corridors, and Standard Frequency Corridors.
Cycling routes	These are divided into metropolitan, regional, local and greenway cycle routes.
Pedestrian access areas	These are divided into priority routes (located along and across arterial roads), high activity routes and local routes.
Major traffic routes	Routes with high traffic volumes (in the order of 20,000+ vehicles per day in the metropolitan area and 2000 - 3000+ vehicles per day in regional areas), and all forms of long distance traffic. Given their importance, major traffic routes would typically be the focus of major investment and highly responsive maintenance. These routes would typically have minimal direct side road or property access (potentially using service roads).
Freight routes	Major freight routes are identified as these provide an indication of economic productivity within the region

Functional Area	Comment
Peak hour routes	Peak hour routes are defined as those that link residential and employment areas and cater particularly for private vehicle travel during peak periods.
Tourist routes	These are divided into: Direct/Scenic Tourist Routes (those which provide a direct link to/from key regional activity centres or key tourist destinations, and through major tourist regions), and Outback/Adventure Tourist Routes (those which are scenic routes on unsealed roads through major tourist regions.

It is noted that this method did not look to aggregate a hierarchy 'score' across measures, rather it provided different hierarchies for the different functional areas.

3.2 Transport Scotland Asset Management Hierarchy

Transport Scotland (2009) has developed a comprehensive framework for their trunk road network, based on a series of subjective and objective assessment criteria. In total there are fourteen criteria spread across the three general areas of Economic, Social and Integrated Transport. The criteria are:

Table 3 Transport Scotland hierarchy criteria and rationale (Source: Transport Scotland, 2009)

Area	Criteria	Comment / Rationale
Economic	Commercial Vehicle Flow	The level of commercial vehicle flow is an indicator of the link's usage in relation to the movement of freight and goods throughout Scotland.
	Strategic Rural Roads	Any trunk road, in particular within the central belt and in and around the main cities of Scotland, plays a high over-arching strategic role for the movement of people and goods. However, it is recognised that within rural areas the trunk road network has more diverse roles. Several rural industries (i.e. farming, forestry, fishing) are dependent on key trunk roads and accordingly links serving these industries have been classed as Strategic Rural Roads.
	Non-commercial vehicle flow (commuter)	It is recognised that within any trunk road link, the composition of car traffic comprises cars-in-work and cars-not-in-work. The cars-not-in-work values can be subdivided into cars-leisure and cars-commuter which have an effect on the economic importance of each link. Therefore each link has been assessed in relation to its commuting traffic flow.
	Non-commercial vehicle flow (in work)	The level of non-commercial vehicle flow considered to be travelling in-work is an indicator of the link's importance in relation to the movement of people for business purposes during working time.
	Supporting Tourism	Tourism plays an important role in the economic vitality of Scotland. The movement of people to and from the major tourist attractions is vital in maintaining this economic benefit. Therefore each link has been assessed against its function in relation to the tourist industry.
	Trans-European Route	A subset of trunk roads has been classified as having a strategic role at a European level for the movement of freight and goods between countries. Accordingly each link has been assessed in relation to its role at the European level.
Social	Rural community accessibility	The level of community accessibility is measured taking cognisance of the trunk road's role in providing access to rural areas. Due to its importance, Health has been given its own scoring value (see below).
	Populations served (>20,000)	Given that the trunk road network's main function is the transportation of people and goods in a safe and efficient manner, road links which connect the largest settlements play an important role in determining its strategic importance. Any link serving a population centre of over

Area	Criteria	Comment / Rationale
		20,000 people was considered of medium or higher importance.
	Health	Direct access to health facilities is important for all communities but in particular, the trunk road has a more important role for rural communities. In rural Scotland, the trunk road network is often the only viable route to/from local health care facilities. Therefore each link has been assessed against its function in relation to access to healthcare.
	Non-commercial vehicle flow (non-commuter)	Non-commuter vehicle flow is an indicator of the link's importance in relation to the movement of people in a social and non-business manner. It is therefore considered that, the level of non-commercial vehicle flow is an important factor in this regard.
	Defence	The trunk road network is key to the safe and speedy transportation of personnel, equipment and vehicles related to the defence of the nation. It is considered that due to the nature of this type of activity, each link forming part of a defined 'defence route' should be ranked equally.
Integrated transport	Coach routes	The trunk road is essential for the provision of fast inter-city road-based public transport.
	Airports	The location of an airport is a vital component in assessing the strategic importance of a trunk road as it serves economic, tourist, social and political needs.
	Ports	The location of ferry ports are also vital components in assessing the strategic importance of a trunk road as they also serve economic, tourist, social and political needs.

The above framework was developed in close consultation with industry and, based on the research undertaken for this report, is one of the more comprehensive. Transport Scotland also chose *not* to include a number of criteria - including those relating to safety, environment and quality of diversion routes as these were deemed to be covered by other mechanisms.

This last factor, 'quality of diversion route' is interesting in the context of risk and resilience management. It was considered by Transport Scotland, that the functional hierarchy of a main route should not *be influenced by* the availability or quality of the diversion route, instead the hierarchy of the main route should be one of the factors which influences the quality of the diversion (that is its level of service) provided.

3.3 Lifelines

In a New Zealand context, lifelines infrastructure has been defined as part of the CDEM Act 2002. This Act sets out which sectors are considered as critical lifeline infrastructure (utilities) and includes: transport, water, wastewater, stormwater, energy and telecommunications services. These organisations provide essential community functions and the Act enables them to respond and provide for the wellbeing of their residents when hazards occur.

The CDEM Act requires lifeline utilities to:

- Function to the fullest possible extent during and after an emergency,
- Have plans for such functioning (continuity) that can be made available to the Director of the Ministry of Civil Defence & Emergency Management,
- Participate in CDEM planning at national and regional levels where requested,
- Provide technical advice on CDEM issues where reasonably required.

Critical lifelines infrastructure has been identified in a number of New Zealand regions by the relevant regional lifelines group in coordination with lifeline utilities – using risk management approaches and 'levels of criticality'.

These lifelines groups focus on 'enhancing the connectivity of lifeline utility organisations across agency and sector boundaries in order to improve infrastructure resilience'.

To achieve this, organisations within lifeline groups have identified infrastructure which is critical to the provision of services during emergency events. Three levels of criticality have been developed as shown in Figure 3, however there are no established criteria for the individual sectors in order to consistently determine criticality.

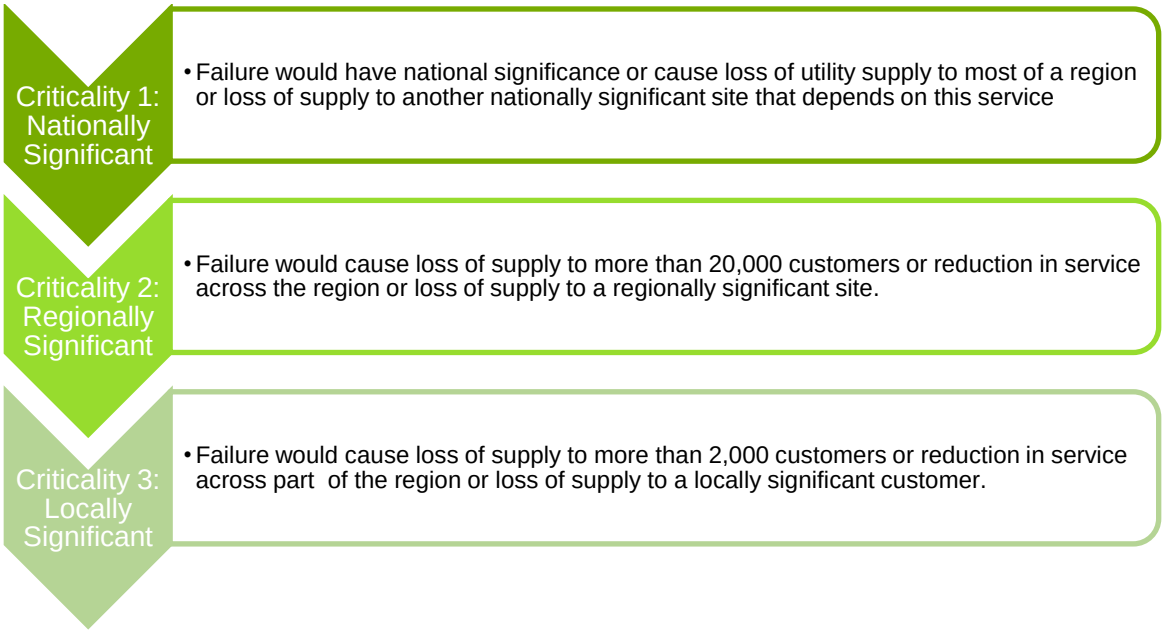

Figure 3 Defining critical lifelines infrastructure assets (Auckland Engineering Lifelines Group, 2014)

Recent lifelines analysis reports have identified priority transport routes based not only on their existing function within the roading network, but also in relation to; a) the connectivity they provide to critical lifelines and emergency services sites (e.g. power, water, gas, telecom, fuel, hospital, first responder etc) that have been identified, and b) the need to provide a core system of functioning routes connecting townships and key services during an emergency event. An example is provided in Section 3.4.

3.4 Waimakariri Lifelines Resilience Study

The Waimakariri Lifelines Resilience Study (AECOM, 2009) involved a detailed assessment of hazard impacts on various lifelines for the Waimakariri District. The roading component of the study developed criticality scores based on four criteria: traffic volume, road function, access to lifeline utility assets, and access to essential services.

Of particular interest are the processes used to develop the lifelines score and the essential services score.

Lifelines score: was based on the *number* of lifeline utility assets on a route (with all given equal importance).

Essential services score: was based on assigned priorities for a range of essential services. These were developed via consultation with stakeholders. These included hospitals and large aged-care facilities, ambulance, fire, police and emergency operations centres, major utility control centres, welfare centres, key retail outlets (hardware stores, construction resources and supermarkets), schools and sector posts and major industry.

For both of the above, the scores are added together based on either the number of lifeline assets, or the number of essential services.

Figure 4 provides a schematic of the approach taken to scoring the relevant criteria.

The other criteria used were traffic volume and road function, which are typical of most hierarchy classification systems.

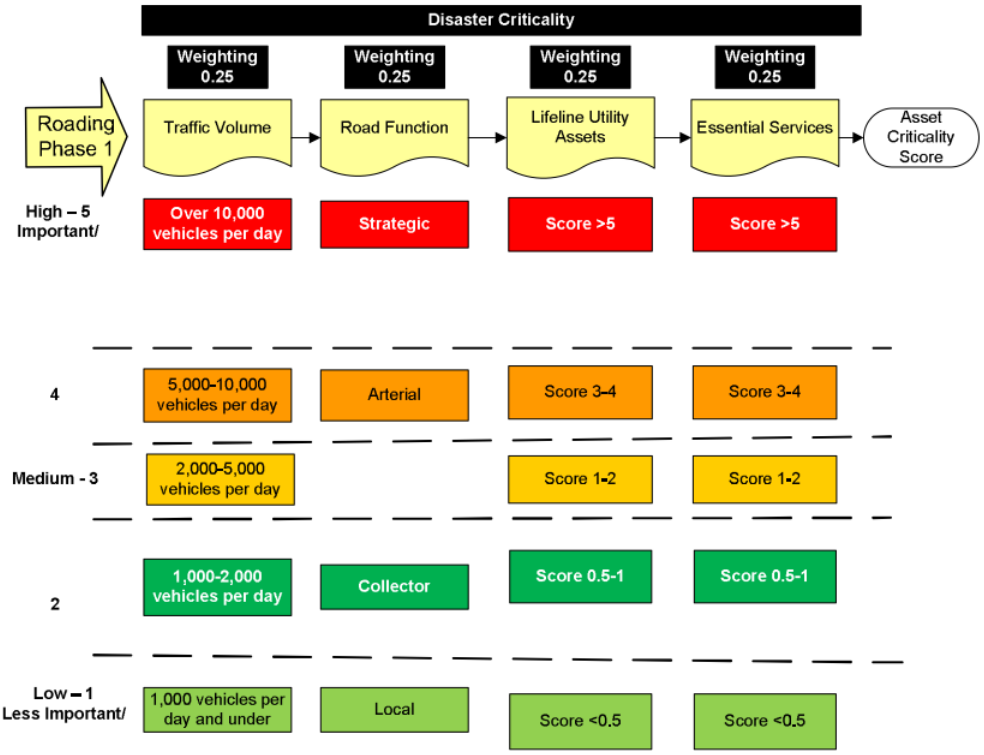

Figure 4 Criticality assessment for roading (AECOM, 2009)

3.5 Other studies and reports

The following two studies were reviewed and suggest some general criteria to consider when determining criticality of transport corridors.

3.5.1 Critical land transport infrastructure risk management review (URS, 2005)

This study summarised interviews with a range of key transport sector organisations and noted the following as factors which affect or determine the 'criticality' of transport assets. Assets which were considered critical included those that:

- Carry high volumes of traffic or freight (this would include most rail routes and major highways, port access).
- Are vital to social/economic wellbeing.
- Have no other alternate route.
- Provide access to other critical infrastructure.
- Provide linkages between transport modes (eg the link span between road and rail as part of the inter-island ferry service).
- Are sections of the network that are critical to commercial imperatives for operators or users.
- Are critical to maintaining law and order, or national security.

3.5.2 Victorian Transport Policy Institute (VTPI, 2010)

The VPTI provides additional thinking, and suggests critical road networks provide for:

- Emergency response (police, fire, medical services, disaster relief, etc.)
- Public services (utility repair and maintenance, garbage collection, etc.)
- Freight and package delivery.
- Commercial and business travel.
- High value personal errands (medical appointments, basic shopping, etc.)
- Commuting (travel to work and school).
- Lower-value personal errands (social trips, recreational shopping, etc.)
- Other low-value travel (leisure travel, cruising).

The above list is presented in order of approximate importance, with the most important functions towards the top. The inclusion of some of these (or otherwise) is discussed in Section 3.6.

3.6 Best practice criteria summary

Based on our review of the above examples a number of observations are made in regard to best practice criteria for determining criticality – as follows:

- The majority of existing systems used by roading authorities around the world are *hierarchy* frameworks which aim to facilitate management of roads to deliver related levels of service. Few include criteria which specifically relate to criticality and the ability to provide a level of service during an unforeseen hazard event.
- Most frameworks include elements such as traffic volumes (commuter, non-commuter, commercial, freight etc).
- Most frameworks have criteria which consider public transport, cycling provision, pedestrian access, and tourist traffic.
- A number of frameworks consider accessibility criteria for centres of large population, or remote centres where there are few (or no) alternate routes.
- Only two frameworks (Scotland and ONRC) include criteria for access to healthcare and hospitals.
- Transport Scotland includes criteria for access to other modes of transport, including ports and airports, which is supported by the studies undertaken by URS (2005) and VTPI (2010).
- Transport Scotland includes a criteria specifically related to defence purposes. This is also supported by URS (2005). Our view is, however, that defence uses are should not be included specifically at this stage, as this may be more related to jurisdictions with more imminent threats,
- Only a few frameworks consider criteria relating to economic criteria – or that are critical for economic activity. This may be related to freight volumes, but also may be more specific to certain sectors (eg forestry etc).
- Only the Waimakariri Lifelines framework includes specific criteria which relate to access to a range of priority lifelines sites. The ONRC framework does include an assessment for critical connectivity (lifelines) where there are no alternate routes, and makes reference to connections to critical infrastructure, however there is little definition around what constitutes critical infrastructure and no range of 'scores' suggested.
- URS (2005) and VTPI (2010) suggest a range of more specific and detailed measures that could be included within a criticality assessment (e.g. for maintaining law and order, commercial and business travel etc). It is our view that a number of these are too detailed and would add additional burden to an assessment without necessarily providing more useful results. This also applies to the defence criteria as discussed above.

3.7 Comparing best practice criteria to the ONRC

The ONRC appears to contain a large number of criteria common to the other hierarchy frameworks reviewed. In addition, it includes less-common criteria such as access to healthcare and economic criteria.

While the ONRC does makes reference to connections to critical infrastructure, it does not provide sufficient detail to enable a robust assessment (other than for hospitals and ports / airports).

4.0 A proposed framework for the roading network

4.1 Overview

Based on the above literature review, a framework is proposed below which will enable a better understanding of 'criticality', which, in turn, will allow improved management of risk.

A single aggregated 'criticality' score is proposed, rather than a range of individual scores relating to criteria, as this is deemed to offer a simpler method of application.

Figure 5 shows a simple schematic framework (decision tree), including weightings which are proposed for each criteria. The weightings are shown as 'W1, W2, W3'. An alternative to weightings could be to use a 'worst-case' assessment. This can be experimented with during testing and through discussions with NZTA staff.

This decision tree links criteria and, where appropriate, sub-criteria to provide an overall Criticality Score. The scores for each criterion are weighted when combined to generate the overall score. This score is then used to assign the route / asset to a criticality category. This may be a simple criticality numerical scale (e.g. 1 to 4), or a more descriptive 'local' through to 'vital' scale as per Figure 1.

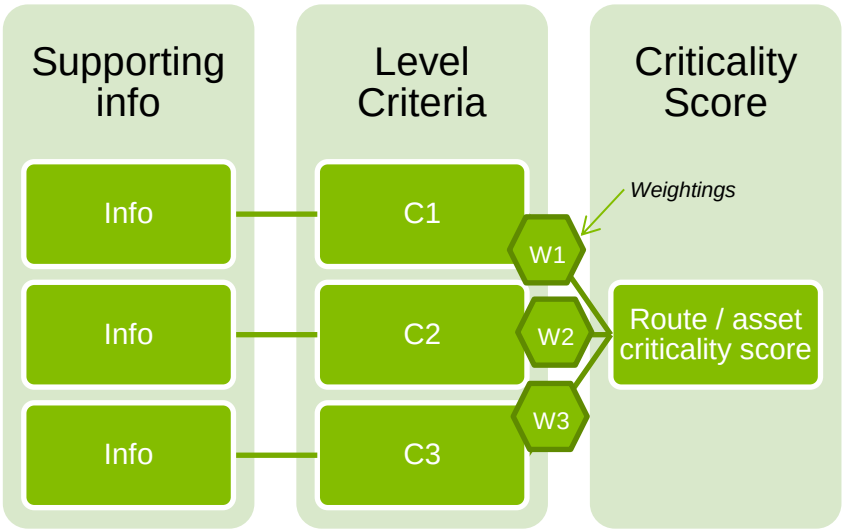

Figure 5 Schematic framework for criticality

The following 1-4 scale shown in Table 4 is proposed for the roading network. A scale of four has the advantage of avoiding a middle 'average' score.

Table 4 Proposed criticality scale

Criticality scale	Description
Criticality 1 (Vital)	A vital route or section of road whose failure would have a nationally significant economic or social impact, or is a nationally significant lifeline, ensuring access or continuity of supply of essential services during an unforeseen event.
Criticality 2 (Major)	A major route or section of road whose failure would have a significant economic or social impact to more than one region, or is a regionally significant lifeline, ensuring access or continuity of supply of essential services during an unforeseen event.
Criticality 3 (Significant)	An important route or section of road whose failure would have a significant economic or social impact to a region, or is a significant lifeline, ensuring access or continuity of supply of essential services during an unforeseen event.
Criticality 4 (Local)	A local route or section of road whose failure would have a serious local economic or social impact, or is a locally important lifeline, ensuring access or continuity of supply of essential services during an unforeseen event.

Note: A score of 'zero criticality' has not been suggested as this would be implicit in those routes that would have no score.

In applying the methodology to a road network, the following must also be considered:

a. Identification of the criteria that should be used to classify a given route or asset,

b. Potential data sources, and avoidance of duplication of effort (e.g. with ONRC), and;

c. Determination of the relative weightings of the criteria.

Incorporating ONRC

There are two potential methods for developing the criticality framework, the first being a complete set of relevant (and standalone) criteria covering traffic volumes, economic factors, accessibility, connectivity, and lifelines etc. The second is to utilise the existing ONRC classification as a proxy for many of these factors, and to aggregate this with the relevant additional lifelines criteria.

This second approach has been chosen as it is deemed more practical and implementable. This will avoid duplication of work, and will, ideally, be simpler to develop and test, building on the existing, established ONRC hierarchy.

Limitations of a criticality rating

As with any similar rating tool there is a trade-off between accuracy of results, and the ease / simplicity of application (including the effort to gather and analyse data). Imperfect outcomes will always occur, as well as conflicts between some of the criteria. An example is that of alternative routes. A detailed analysis would perhaps consider the likelihood of the alternative route being affected by the same hazard, the capacity of the alternative route to take additional vehicles, and the additional duration of travel along the alternative route etc. While this may generated more accurate results, the depth of analysis required would make the assessment time-consuming, bearing in mind that this is only *one* of the considerations in relation to criticality. In this case, we would recommend, therefore that a simpler assessment of alternative routes is preferable (and as currently included within the ONRC).

4.2 Proposed criteria for criticality

Based on the literature review undertaken, it is proposed that criteria be chosen to relate to the following criteria. A relatively simple set of criteria is proposed which draws on ONRC classifications to avoid duplication.

- **ONRC Classification:** This captures a wide range of factors that are important in determining criticality, namely traffic volumes (including freight), economic factors, accessibility, connectivity etc.
- **Access to Lifeline utilities:** This would explicitly cover routes which are priority lifeline routes, or provide access to major lifeline facilities. It would also include links to major intermodal hubs such as ports and airports, as well as routes which are themselves considered as vital evacuation routes.
- **Access to essential services:** This would explicitly cover routes which provide access to essential services as identified by a given community or region. These may include hospitals and large age-care facilities, ambulance, fire, police and emergency ops centres, major utility control centres, welfare centres, key retail outlets – hardware stores, construction resources and supermarkets, schools and sector posts and major industry.

Further detail is provided below regarding rationale, scoring and data sources.

As discussed in Section 2.0, the lack of alternative routes is currently covered within the ONRC. It is suggested that no additional criteria be required to capture ‘alternative routes’ at this stage, however this can be revisited during testing of the framework.

Table 5 Proposed criteria, scoring and data sources

Criteria	Comment / Rationale	Scoring	Potential data source
ONRC	The ONRC provides an established functional classification covering traffic volumes, economic criteria, accessibility, connectivity etc.	4 – National or high volume 3 – Regional or arterial 2 – Primary or secondary collector 1 – Local or access	ONRC assessment
Access to Lifeline utilities, or a lifeline evacuation route.	In order for a region to recover from any natural hazard event it is important for the various key utilities such as water, wastewater, power and telecoms to be able to access their assets to inspect and undertake repairs. This category includes physical utility assets such as sub-stations that require access to maintain continuity of service to the public and also access to critical transport hubs such as ports and airports.[3] This also includes any routes which are considered themselves as essential for evacuation.	Based on the total number of utilities on a route, and criticality of utility. 4 – More than 5 locally-significant utility assets, more than 3 regionally-significant assets, or 1 or more nationally-significant assets. 3 – Three or four locally-significant utility assets, 1 or more regionally-significant assets, or an essential evacuation route. 2 – One or two locally-significant utility assets. 1 – No access for utilities. Refer Section 4.2.1 for further discussion.	Utility asset information
Access to essential services	These are essential services which would be required for response and recovery during a natural hazard event. There are 6 priority areas proposed as discussed in 4.2.2 below.	Based on the total 'priority score' calculated based on all the priority services accessed by a given route. Refer 4.2.2 below. 4 – Score of more than 5 3 – Score of three or four 2 – Score of one or two 1 – Less than 1	Essential service asset information

[3] Road function is likely to be dependent on other utility organisations in order to restore asset serviceability. Should power lines come down in the vicinity of the road, the area will be closed until the power company can make the area safe. This makes the power and the roading functions heavily reliant on each other; the power company will be unable to access damaged asset without some degree of road access.

4.2.1 Lifelines scores

The lifelines score is proposed to be based on the number of utilities able to be accessed from a particular route, and the *criticality* of the utility itself. A simple scoring system has been proposed as shown in Table 5, however it is acknowledged that some refinement will be required based on discussions with NZTA staff and other stakeholders.

Currently it is proposed that the criticality of the utility being accessed is based on its lifelines criticality level – that is whether it is *nationally*, *regionally* or *locally* significant (refer Section 3.3). This information should be available from regional lifelines groups. In the absence of this information, a separate assessment would need to be undertaken.

Also it is noted that fuel stations are often identified as critical lifeline sites. At this stage, no specific importance is proposed to be given to fuel distribution points as service stations tend to be located on major access routes and will therefore already be captured as critical. The separate issue of fuel priority during an event should be addressed by CDEM and lifelines groups - and may impact response and recovery planning for NZTA.

4.2.2 Priority scores for essential services

The following priority scores are proposed for the *essential services* criteria. These have been adapted from (AECOM, 2009). Where there are multiple essential services on a particular route, the scores are to be added and the total score used to get a rating as per Table 5.

Table 6 Priorities for essential services

Priority scale	Category	Comment
Priority 1 (Score = 3)	Hospitals and large aged-care facilities	Hospitals and large aged-care facilities are considered to be the highest priority of all the essential customers due to the large numbers of dependent individuals with limited mobility. People at these locations are expected to lack self-sufficiency and are therefore unable to travel to collect water from bowsers or distribution points and may have difficulty using alternative sanitary arrangements. These groups would also have increased susceptibility to the spread of disease in the event of failure of basic health requirements.
Priority 2 (Score = 2)	Ambulance, fire, police and emergency ops centres (& dialysis)	Ambulance, police, fire and emergency operations centres would have similar needs for access during an emergency event. It is noted that the emergency operations centres could be relocated if necessary.
Priority 3 (Score = 0.5)	Major utility control centres – Council, Telecom and Power	Restoration of services to power utility control centres (especially power to their own control centres) is considered a high priority. Once the essential utilities are able to function restoration efforts can be expedited.
Priority 4 (Score = 0.25)	Welfare centres	Access to designated welfare centres is important during an emergency event, and these locations form the priority 4 group. Welfare centres are generally designated at a regional level by the local CDEM group and Council.
Priority 5 (Score = 0.2)	Key retail outlets – hardware stores, construction resources (contractors) and supermarkets	A range of retail outlets are considered necessary to enable the community to make repairs and resume normal function self-sufficiently. These organisations include hardware stores and supermarkets. Experience has shown that supermarkets and hardware stores can play an important role in emergency management beyond the consumer goods available at these locations. For example, in the distribution of bottled water facilitated by large parking areas. Contract resources providing services to the Council and public are detailed as they provide necessary resource

Priority scale	Category	Comment
		(skills, manpower and plant and equipment) that are vital to a large scale response.
Priority 6 (Score = 0.15)	Priority 6 Schools and sector posts, major industry	Sector posts, schools and major industry are all considered priority customers of lesser importance, in terms of restoration of supplies than the above mentioned groups. Sector posts are communication points that gather information on the impact of an emergency on the local area. Limited equipment is kept at these locations and they provide lower levels of welfare support such as shelter, limited catering and registration. In the event of interruption to a schools water supply exceeding two hours the school is required to close. The normal operation of schools is important to help a community re-build following an event. Once schools are re-opened routine can return and the absence of full time child care duties for parents will aid recovery.

It is noted that a regular review of the essential customers list is required to ensure the information remains current.

4.3 Proposed weightings

As discussed previously, weightings are proposed in order to aggregate the 3 criteria. An alternative approach would be to take the 'worst case' score from each criteria. It is suggested that this be tested as well once the framework is implemented.

Notionally, there would not appear to be any reason to weight criteria differently as the lifelines elements play an equally (if not more) important role during an emergency event as the ONRC criteria.

As a result, weightings of 0.33 across each of the 3 criteria are considered appropriate. Further consultation with NZTA staff is recommended to confirm this.

5.0 Summary and next steps

As a result of the literature review and analysis undertaken, a criticality framework has been proposed which incorporates three elements:

1. ONRC classification.
2. Access to lifeline utilities, or a lifeline evacuation route.
3. Access to essential services.

Based on the literature review undertaken it is clear that the existing ONRC framework incorporates a large number of those factors which influence criticality, with those relating to lifeline and essential services being the two that were outstanding (missing).

In terms of next steps, the following points are made:

a. In order to undertake an assessment, the criteria would need to be evaluated based on existing 'routes' or 'road segment' databases. It is understood that NZTA currently do not have this type of formal delineation (although, some information is available in RAMM), and, as such, further work is required in this regard. The following is suggested as a starting point for segmentation:

   - Base segments initially on ONRC classifications. Then further refine the segments by dividing between major intersections. A potential further division could be achieved if deemed necessary (eg by dividing into segments of a maximum given length), however this level of resolution is not deemed to be necessary. Note that the length and extent of route lengths may also influence scores, and should be carefully considered when implementing and testing the framework.

b. The framework is proposed as a draft for discussion, and it is suggested this be circulated for comment and further discussion to confirm assumptions, criticality scores, priority scores, lifeline utility scores, weightings etc.

c. It is recommended the framework be tested within a region and refined where appropriate.

d. More broadly, it is recommended that a nationally consistent set of criticality definitions be developed to ensure improved consistency in both terminology and application both within and across sectors.

6.0 References

AECOM (2009) *Waimakariri Lifelines Resilience Assessment* (Report for Waimakariri District Council)

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