University of Southern Queensland

Faculty of Engineering and Surveying

ANALYSIS OF HIGH-SPEED RURAL TRAFFIC CRASHES WITHIN THE SOUTH-WEST DISTRICT OF TOOWOOMBA REGIONAL COUNCIL

A dissertation submitted by

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in fulfilment of the requirements of

Courses ENG4111 and ENG4112 Research Project

towards the degree of

Bachelor of Engineering (Civil)

Submitted: October 2011

Abstract

This project aims to investigate road crashes on classified roads in the regional districts of Toowoomba Regional Council. This task was completed by undertaking analysis of crash data received from Transport and Main Roads Toowoomba, specifically identifying whether local trends followed those experienced elsewhere in Australia. Crash features analysed included crash time, day and month, severity as well as crash rates for each classified road. This process also aimed to find out which crash types are most common for the survey area.

In terms of fatal and injury crashes, the local data recorded an average lower than that of New South Wales and the Australian Capital Territory (ARRB, 2008). Contrary to this finding, fatal crash rates in the local region averaged over twice the results recorded for both Queensland and Australia for the corresponding period 2005-2010 (BITRE, 2011). Despite their higher traffic volumes, the National Highways recorded lower crash rates than the Other State Controlled Roads for the region when considering traffic volume and road length. The highest crash rates occurred on Murphy's Creek Road and Greenmount Connection Road.

Crash feature trends in the local data were similar to that in other areas of Australia; similar proportions between single and multiple vehicle crashes resulted, with non-collision crashes on straights and curves recording the highest frequencies. Research conducted as part of the literature review revealed the horizontal alignment has substantial influence on crash rates, particularly where sharp horizontal curves are present. Considering the common crash type results mentioned, three crash locations were selected from the data for detailed analysis of their geometric elements and road furniture considering relevant industry guidelines and standards.

The three sites selected were located on Clifton-Leyburn Road, Pittsworth-Felton Road and Toowoomba-Karara Road. All three sites failed to meet aspects of Austroads geometric design guidelines; generally, the operating speed, horizontal curve radius and superelevation values were insufficient. Conversely, road furniture standards for all sites were generally good.

Due to the likely financial constraints, recommendations for these sites include;

- improvement of the road surface, removing any significant depressions and ruts
- where operating speed is an issue, increase superelevation values to acceptable values
- upgrade and/or maintain the level of road furniture to the standards set out in TMR's MUTCD

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CERTIFICATION

I certify that the ideas, designs and experimental work, results, analyses and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

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23·10·2011

Date

Acknowledgements

I would like to thank the following people for their support, guidance and encouragement that has helped me through this project.

- Professor Ron Ayers (University of Southern Queensland)
- Mrs Nadia Ives (Toowoomba Regional Council)
- Mr Michael Castley (Transport and Main Roads, Toowoomba)
- Mrs Sheryl Zajacek (Transport and Main Roads, Toowoomba)

I would also like to thank my family for their support over the last six years in helping towards reaching my goal of successfully completing my Bachelor of Engineering.

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Acronyms

AADT – Average Annual Daily Traffic (measured in vehicles per day)

ABS – Australian Bureau of Statistics

ARMIS – Automated Reporting Management Information System

ARRB – Australian Roads Research Board

BITRE – Bureau of Infrastructure, Transport and Regional Economics

CAM – Chevron Alignment Marker

CV – Commercial Vehicles

DCA – Definitions for Coding Accidents

EDD – Extended Design Domain

EDROC – Eastern Downs Regional Organisation of Councils

GPS – Global Positioning System

LGA – Local Government Authority

LRRS – Local Roads of Regional Significance

MUTCD – Manual of Uniform Traffic Control Devices

NAASRA – National Association of Australian State Road Authorities

NH – National Highway

OSCR – Other State Controlled Road

OSD – Overtaking Sight Distance

PPE – Personal Protective Equipment

RMPC – Road Maintenance Performance Contract

RTA – Road Traffic Authority, New South Wales

SSD - Stopping Sight Distance

TARS – Traffic Analysis and Reporting System

TMR – Transport and Main Roads, Queensland

TRC - Toowoomba Regional Council

USQ – University of Southern Queensland

VPD – Vehicles per day

VKT – Vehicle Kilometres Travelled

WH&S – Workplace Health and Safety

WMS – Work Method Statement

1. Introduction

1.1. Project Background

In rural and regional Australia, road transport is the most heavily utilised and effective transport mode available. The Australian rural road network not only serves individuals' travel needs, but the economy relies greatly on the safe and efficient transport of goods and services between the urban and rural environments, across our vast nation. A safe road network not only gives the public a sense of security, but also aids in Australia competing economically on the international stage.

The growing trend over the last decade in Australia is a decrease in road fatalities; an approximate decrease of 2.2% per year over this period (BITRE 2011, p. 2). This may be attributed to safety improvements to vehicles, upgrades to the road network and greater user awareness of safety. Worryingly though, is the fact that the state of Queensland experienced an increase in road crash fatalities over the five year period from 2003 to 2008 (BITRE 2011, p. 5). A rising and ageing population of drivers and vehicles may have contributed to this increase, along with the poor state of a large number of Queensland's roads. This project will investigate road crashes that have occurred on State Controlled Roads in Toowoomba Regional Council (TRC) from the last five years. In the case where the geometric design of the road appears to contribute, a thorough investigation of the geometric aspects of the road will be conducted in order to determine likely causes

1.1.1.1. Toowoomba Regional Council

Toowoomba is Australia's second largest inland city after Canberra with an estimated population over 98,000 (Toowoomba.org, 2011). Located on the Darling Downs, approximately 120 km west of Queensland's capital city Brisbane, the region's economy relies heavily on the agricultural industry; crops such as sorghum, wheat, sunflowers and cotton, and livestock including beef, pork, chicken and lamb are common commodities. Manufacturing is another major industry for the region (Toowoomba.org, 2011).

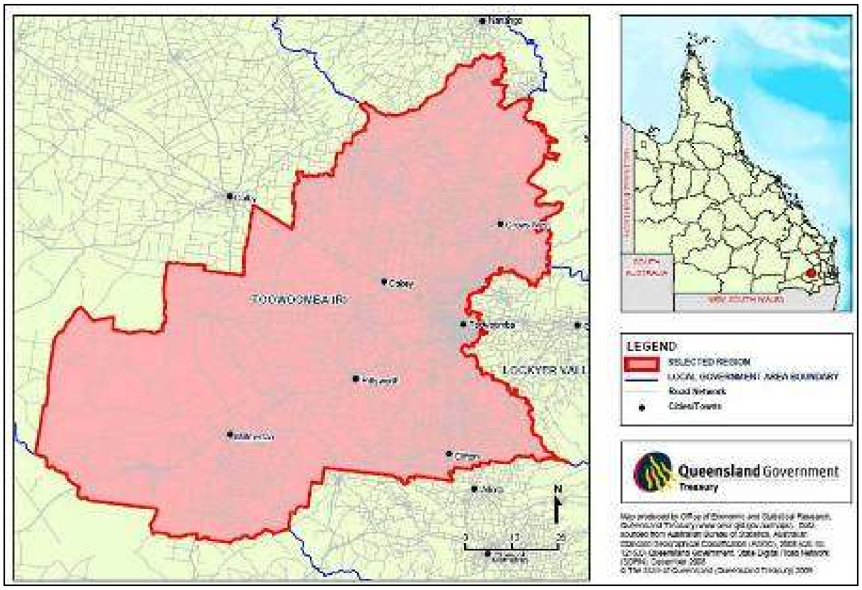


Figure 1.1: Queensland Local Government Areas, (Queensland Government Office of Economic and Statistical Research, 2010)

TRC is the local government authority encompassing the city of Toowoomba and a number of surrounding rural towns and villages. This local government authority was formed in 2008 following the Queensland Government decision to amalgamate smaller local councils into regional councils across the state, a move reportedly made to ensure financial security in local governments. In the case of TRC, the eight previous local councils of Cambooya Shire Council (Greenmount), Clifton Shire Council, Crows Nest Shire Council, Jondaryan Shire Council (Oakey), Millmerran Shire Council, Pittsworth Shire Council, Rosalie Shire Council (Goombungee) and Toowoomba City Council amalgamated. As a result, the new regional council serves a population over 150,000, making it the eighth most populous Local Government Authority in Queensland (Queensland Government Office of Economic and Statistical Research, 2011). Covering an area of approximately 13,000 km² requires TRC to maintain a total of 6194 km of sealed and unsealed roads, 1135 km of which are classified roads (Toowoomba Regional Council, 2011). Figure 1.2 below displays TRC, with district boundaries shown.

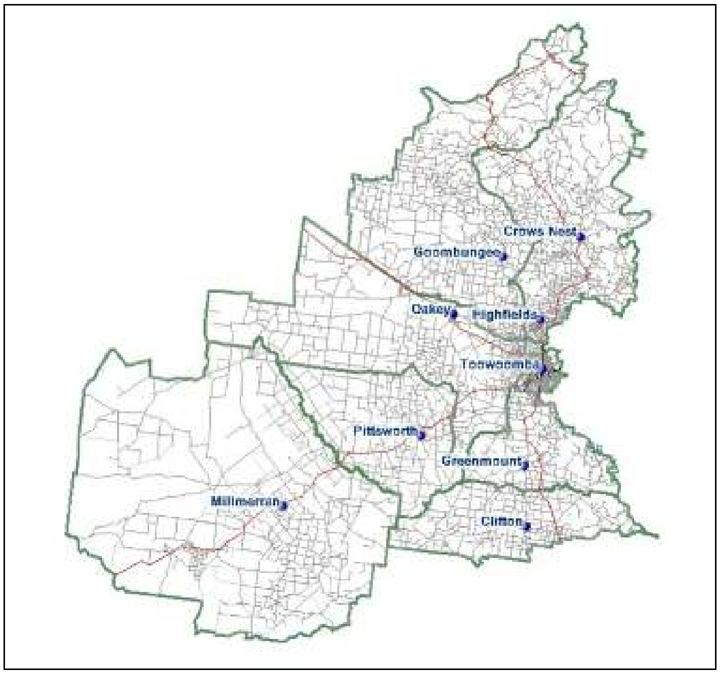


Figure 1.2: Map of Toowoomba Regional Council, (Toowoomba Regional Council, 2011)

1.2. Project Aim

The aim of this project is to examine the role road geometry has on the causes of road crashes in the south-west area of TRC and to identify remedial measures and treatments.

1.3. Project Objectives

1. Undertake background research on roads and road safety, in particular;
   a. The various standards and guides concerning the geometric design of high-speed rural roads, considering their differences and usage. Over the years in Queensland, there has been a number of differing geometric road design standards used and developed by a number of road authorities;
   b. Crash data acquisition and analysis procedures; and
   c. Road safety issues for high-speed rural roads.
2. Obtain crash data from the Queensland Government Department of Transport and Main Road (TMR) Automated Reporting Management Information System (ARMIS), for all State Controlled Roads within TRC.

3. Analyse the crash data for all crashes that have occurred on classified roads within TRC, considering a number of road, crash and general characteristics (e.g. road geometry, type of crash, time of day, etc).
4. For those crashes within the south-west area of TRC, where road geometry appears to be a significant factor, acquire geometric design plans from the relevant authority and analyse the designs against the recommendations of the relevant design standards.
5. Identify significant crash causal factors and provide recommendations to eliminate or alleviate future crashes.
6. If time permits, extend the area of interest to include non-classified roads within TRC, and compare and contrast crashes in the different road classifications.
7. Report findings in the required written format and through an oral presentation at the Project Conference.

2. Literature Review

For any research-based activity, it is important that appreciable background knowledge be known about the key components of the topic. This process clarifies the research component, while identifying other studies of a similar nature. Therefore a literature review of important topics related to this project will be undertaken and the results to follow.

2.1.1. Road Classification

Australia has an extensive road network, spanning a length over 800,000 km, (Australian Automobile Association, 2011). However, not all of the roads in Australia serve the same purpose. Between 1969-1974, the Commonwealth Bureau of Roads and the National Association of Australian State Road Authorities (NAASRA) jointly completed the Australian Roads Survey. This process saw roads with similar traffic volumes and physical conditions grouped, forming a road classification system. Nine classes were developed in the survey, five rural and four urban, ranging from the high traffic volume roads between major centres to those that provide for only one particular service or activity. The nine classes are cited below in Table 2.1 for reference.

Rural	
Class 1	For movement of people and goods between the major cities and regions
Class 2	For movements between major cities and towns and between towns
Class 3	For movement between important centres and between centres and towns and as feeder roads to the Class 1 and Class 2 roads
Class 4	For provision of road access to properties and houses
Class 5	For provision for one particular activity or function in rural areas
Urban	
Class 6	For large volume movement of people and goods
Class 7	For large volume movement of traffic for distribution to the local street systems and to supplement the Class 6 roads
Class 8	For provision of road access to abutting properties
Class 9	For provision for one particular activity or function in urban areas
Note: Classes 1, 2 and 3 roads comprise rural arterial roads, Class 6 roads are urban arterial roads and Class 7 roads are also known as urban sub-arterial roads	

Table 2.1: Australian Road Classification (Australian Bureau of Statistics, 1974)

In Queensland, and the other five states of Australia, the legal responsibility in terms of the management of roads is generally shared between the state road authorities and local government authorities. State authorities govern roads classified as 'freeways, state highways, tourist routes, developmental roads, other roads which were constructed for state or national purposes and all roads in unincorporated areas. The local government authorities are responsible for all unclassified roads', (Australian Bureau of Statistics, 1974). Generally in Queensland, and in TRC, State governed roads are split into National Highways and Other State Controlled Roads.

This study will investigate crashes on State Controlled Roads falling under Classes 2 and 3, located in TRC. Figure 2.1 below outlines the location of these classified roads within TRC, with details for each district's roads contained in Appendix 11.2.

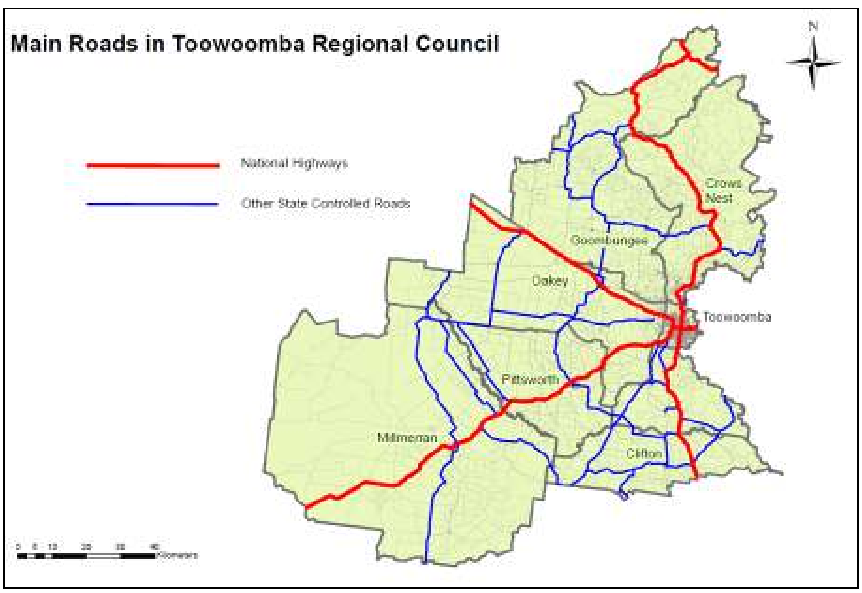


Figure 2.1: State Controlled Roads within Toowoomba Regional Council, (Toowoomba Regional Council, 2011)

2.1.2. Geometric Road Design and Standards

The safe design of all roads requires standards and guidelines to ensure uniformity. Road geometry and road furniture are two examples of the road environment requiring such governance, which form much of the analysis in the project.

Geometric road design refers to the 'design of the visible dimensions of the roadway', (Ayers 2010). Obviously, there are many components to the road environment that fall under this definition. A brief discussion of the key geometric elements, which shall be investigated as part of this project, follows.

2.1.2.1. Operating speed

In road design, there are a number of speed parameters required in the design of geometric elements. One such parameter is operating speed, that being the speed road users are anticipated to adopt at low traffic volumes. The operating speed relates to the 85th percentile speed, defined as 'the speed at which 85% of car drivers will travel slower and 15% will travel faster', (Ayers 2010, p. 8). Section operating speed is another variable, known as the stabilised speed of traffic through a road segment containing various curves and short tangents (Austroads 2010, p. 241). The charts contained in Figure 2.2 and Figure 2.3 are used in the determination of operating speed.

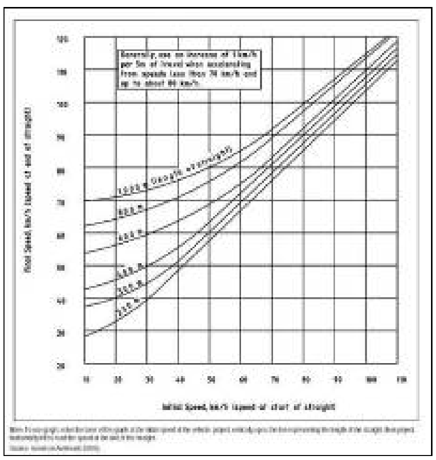


Figure 2.2: Acceleration on straights (Austroads 2010, p. 19)

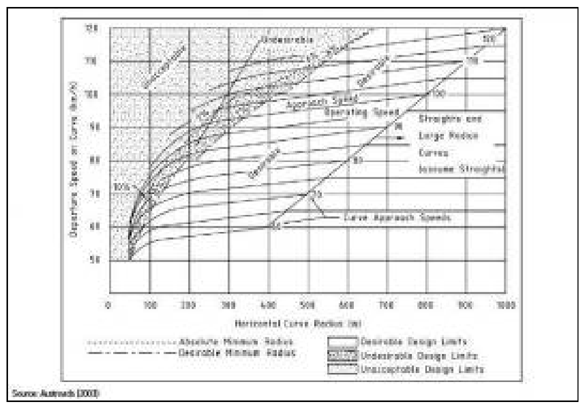


Figure 2.3: Deceleration on curves (Austroads 2010, p. 20)

An estimation of the operating speed is necessary to determine whether the continuity of a road segment is adequate, i.e. road users are not met with unexpected geometry, such as a tight horizontal curve in a high-speed environment. There are guidelines on changes to the operating speed provided in the various geometric road design standards, as exemplified below in Figure 2.4.

Geometric feature	Reverse curves Tangent to curves		Compound curves
	Desirable max	Absolute max (1)	
All roadways except downgrades in the hatched area of Figure 7.1	10 km/h	15 km/h (3,4)	5 km/h
Downgrades in the hatched area of Figure 7.1 between 6% and 8% slope	8 km/h	12 km/h (3)	4 km/h
Downgrades in the hatched area of Figure 7.1 above 8% slope	6 km/h	– (2)	3 km/h

1. When the decrease in operating speed exceeds the desirable maximum, it is desirable that the curve operating speed be less than the limiting curve speed so that there is still some margin for a driver who misjudges the curvature. The Operating Speed Model shows whether this will occur. The alignment must be refined where it is reasonable to do so.
2. Where the desirable maximum decrease cannot be achieved, alternative treatments to reduce vehicle speeds may be applied.
3. When the decrease in operating speed between successive geometric elements exceeds 10 km/h and it is not appropriate to revise the alignment, the design must include warning signs and chevron markers in accordance with road authority guidelines.
4. With interchange ramps and connecting roadways, larger decreases are possible. This is due to drivers expecting and being more willing to accept such a decrease when changing from one roadway to another.

Note: The maximum decrease in speed values given in this table are normally only applicable to low and intermediate speed rural roads and minor urban roads. Major roads such as freeways, major rural roads and major urban roads should use the same speed value for the design of each horizontal element (i.e. no decrease in speed between successive elements should be allowed.

Figure 2.4: Maximum decrease in speed value between geometric elements for low and intermediate speed rural roads (Austroads 2010, p. 134)

2.1.2.2. Traffic lane

The traffic lane is 'that part of the roadway set aside for one-way movement of a single stream of vehicles', (Austroads 2010, p. 30). The number and width of traffic lanes is dependent on a number of factors, including the traffic volume and composition, speed environment, location of road (i.e. urban or rural) and horizontal alignment (i.e. presence of curves). A commonly accepted lane width is 3.5 m; however, this value is often increased or decreased when the specifics of the site are considered. The number of traffic lanes is determined through a traffic study of the segment of interest.

2.1.2.3. Shoulders

The road shoulder is that part of the carriageway adjacent to the traffic lane. They fulfil two roles; shoulders provide structural support to the pavement and act as a clear, trafficable area suitable for errant or stopped vehicles and cyclists (Austroads, 2010). Similar to that of traffic lanes, the width of shoulders depends on a variety of factors including traffic volume and composition, speed environment and location. Depending on the situation, the width of a shoulder could be as little as 0.5 m, specifically for lateral support of the pavement, or up to 3.0 m, to accommodate the needs of cyclists and stopped vehicles (Austroads, 2010).

2.1.2.4. Traffic lane and shoulder crossfall

The road crossfall is defined as the slope, measured as a percentage, from the centreline of the road, i.e. the crown, to the edge of the traffic lane or shoulder. Crossfall is required for surface drainage and superelevation purposes (discussed in

Section 2.1.2.5), with a value of 3% recommended for drainage of bituminous sealed pavements (Austroads, 2010), present within the survey roads.

2.1.2.5. Superelevation

A variable in the determination of horizontal curve radius is superelevation, referring to the slope, measured as a percentage, between the edges of adjacent traffic lanes, i.e. one-way crossfall for the width of the pavement. Superelevation is required to maintain safe vehicle handling through a circular curve. The degree of superelevation takes into consideration a number of factors, including operating speed, curve radius and stability of high laden vehicles (Austroads, 2010). Austroads (2010) provides a graphical relationship between curve radius, superelevation and operating speeds, contained in Figure 2.5 below.

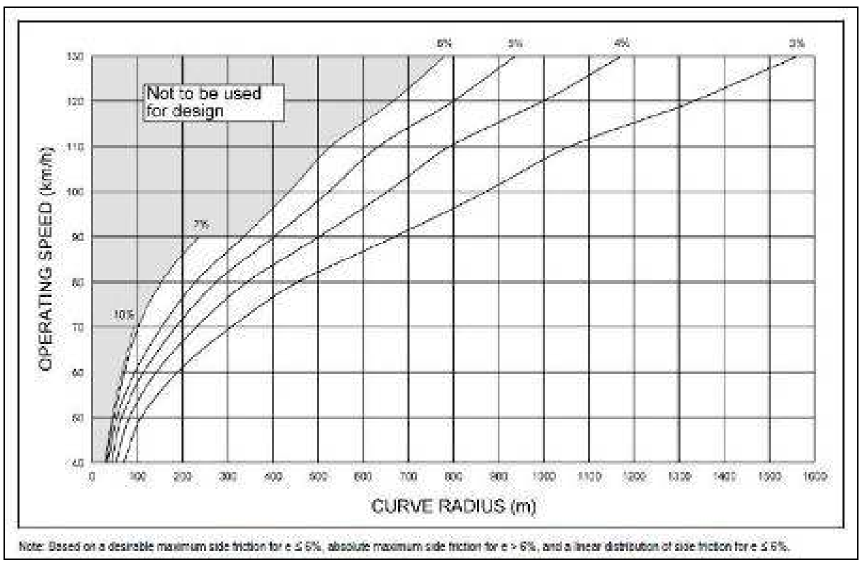


Figure 2.5: Rural roads relationship between speed, radius and superelevation (V>80 km/h), (Austroads 2010, p. 148**)**

This same information can be determined using Equation 2.1.

$$e_1 = \frac{V^2 e_{\max}}{127R(e_{\max} + f_{\max})}$$

where,

V = operating speed (km/h),

e_{max} = maximum superelevation (m/m),

R = curve radius (m),

f_{max} = side friction factor,

e_1 = required superelevation (m/m)

Equation 2.1: Required superelevation (linear method) (Austroads 2010, p. 147)

Superelevation is not required on all horizontal curves. If the radius is sufficiently large, the standard two-way crossfall can be maintained. This is known as adverse crossfall, and while not recommended by Austroads (2010), this crossfall method can be employed in geometric design.

2.1.2.6. Sight distance

Sight distance is an important factor in safe road design. It is defined as 'the distance, measured along the carriageway, over which visibility occurs between a driver and an object' (Austroads 2010, p. 99). The object can be anything from another vehicle, a stationary object on the road, such as an animal, or the road surface, depending on the application. The height of the vehicle and object, driver reaction time, longitudinal grades and condition of the road surface are used in determining the sight distance parameter. Stopping sight distance (SSD) and overtaking sight distance (OSD) are two examples.

SSD is most relevant for the purpose of this study. It is the distance required to 'enable a normally alert driver, travelling at the design speed on wet pavement, to perceive, react and brake to a stop' (Austroads 2010, p. 104). SSD, determined using the formula contained in Equation 2.2, is an important factor in determining horizontal and vertical alignment features.

$$SSD = \frac{R_T V}{3.6} + \frac{V^2}{254(d + 0.01a)}$$

where,

R_T = reaction time (s),

V = operating speed (km/h),

d = coefficient of deceleration,

a = longitudinal grade (%),

SSD = stopping sight distance (m)

Equation 2.2: Stopping sight distance (Austroads 2010, p. 104)

2.1.2.7. Horizontal alignment

The horizontal alignment is that which is viewed from above, i.e. the plan view of the road. It is made up of 'a series of straights (tangents) and circular curves that may or may not be connected by transition curves' (Austroads 2010, p. 133). Austroads (2010) also states that the horizontal alignment of a road segment influences a driver's operating speed more so than any other geometric design element. Therefore, the general practice in the design of the horizontal alignment is to minimise changes in operating speed of through traffic, by maximising the radii of horizontal curves. By providing a design with a relatively uniform operating speed, the road users are not confronted with sudden deceleration zones.

For a particular combination of speed and superelevation, a minimum curve radius can be determined using the formula contained in Equation 2.3 below.

$$R = \frac{v^2}{(e+f)g} = \frac{V^2}{127(e+f)}$$

where,

v = vehicle speed (m/s),

V = vehicle speed (km/h),

R = curve radius (m),

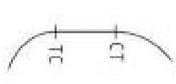
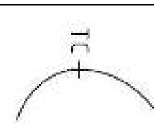
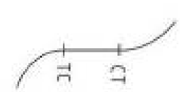
e = pavement superelevation (m/m),

f = side friction factor (between the tyre and the pavement),

g = acceleration due to gravity (9.81 m/s²)

Equation 2.3: Horizontal curve equation, (Austroads 2010, p. 136**)**

Horizontal curves can come in a variety of combinations, including reverse, broken back and compound. These curve forms are generally not recommended, however they can be incorporated by meeting guidelines proposed in geometric design standards. Figure 2.6 contains typical layouts for these horizontal curve types.

 Broken back curve	 Broken back curve	 Compound curve with	 Reverse curve

connected by tangent	connected by large radius curve	common tangent point	connected by tangent

Figure 2.6: Horizontal curve types (Austroads, 2010)

2.1.2.8. Curve widening

Widening of the traffic lanes on horizontal curves may be required due to the following;

- vehicles travelling on curves occupy a greater width of pavement than when travelling along straights (Austroads, 2010)
- vehicles travelling on curves tend to wander more than on straights due to the extra control required in steering (Ayers 2010, p. 17)

Figure 2.7 below exemplifies how large vehicles track towards the inside of a curve. The amount of curve widening depends mostly on the curve radius, with reference also made to the normal lane width, traffic composition and vehicle clearance (Austroads 2010, p. 159). At greater curve radii, Austroads provides recommended curve widening extents, however it is recommended that vehicle turning templates be utilized at smaller radii.

Figure 2.7: Heavy vehicle tracking on a horizontal curve (Ayers 2010, p. 17)

2.1.2.9. Vertical alignment

The vertical alignment is defined as 'the longitudinal profile along the centreline of the road' (Austroads 2010, p. 164). Similar to the horizontal alignment, the vertical alignment is made up of straights (grades) and curves. In determining the vertical alignment of a road section, a number of criteria must be satisfied or considered, including limiting cut and fill volumes during construction, drainage requirements (e.g. minimum grades), vehicle limitations (e.g. maximum grades), vertical clearances, sight distance, driver comfort and appearance.

2.1.2.10. Geometric road design standards

There are a number of recognised publications available, providing guidance on how road authorities design, construct and maintain roads. An important principle to consider is that these publications are termed guidelines, not standards. Austroads (2010) states that their publications are produced as a general guide and that their use is discretionary. Liability with geometric road design lies with the road designer and not with the producer of the publication.

As there are a number of industry-recognised guidelines available, the choice on which one to use results from a combination of experience, class of road, speed environment and traffic volumes, amongst other criteria. Austroads, the Association of Australian and New Zealand Road Transport and Traffic Authorities, has an aim of 'contributing to the achievement of improved Australian and New Zealand transport related outcomes', (Austroads, 2011). Along with producing guides, such as the Guide to Geometric Road Design, Austroads also undertakes strategic and technical research in the field of transport engineering. Table 2.2 below is an example from Austroads Guide to Geometric Road design, specifically recommended traffic lane and shoulder widths.

Table 4.5: Single carriageway rural road widths (m)

Element	Design AADT				
	1 – 150	150 – 500	500 – 1,000	1,000 – 3,000	> 3,000
Traffic lanes(1)	3.7 (1 x 3.7)	6.2 (2 x 3.1)	6.2 – 7.0 (2 x 3.1/3.5)	7.0 (2 x 3.5)	7.0 (2 x 3.5)
Total shoulder	2.5	1.5	1.5	2.0	2.5
Minimum shoulder seal (2),(3),(4),(5),(6)	0	0.5	0.5	1.0	1.5
Total carriageway	8.7	9.2	9.2 – 10.0	11.0	12.0

1. Traffic lane widths include centre-lines but are exclusive of edge-lines.
2. Where significant numbers of cyclists use the roadway, consideration should be given to fully sealing the shoulders. Suggest use of a maximum size 10mm seal within a 20 km radius of towns.
3. Wider shoulder seals may be appropriate depending on requirements for maintenance costs, soil and climatic conditions or to accommodate the tracked width requirements for Large Combination Vehicles.
4. Short lengths of wider shoulder seal or lay-bys to be provided at suitable locations to provide for discretionary stops.
5. Full width shoulder seals may be appropriate adjacent to safety barriers and on the high side of superelevation.
6. A minimum 7.0 m seal should be provided on designated heavy vehicle routes (or where the AADT contains more than 15% heavy vehicles).

Table 2.2: Single carriageway rural road widths (Austroads, 2010)

While Austroads published material is widely accepted throughout industry in Australia, in some circumstances more localised reference material may be required. Most state road authorities undertake their own research in compiling transport engineering standards and guidelines. Along with TMR in Queensland, New South Wales' Road Traffic Authority, VicRoads and Main Roads Western Australia all publish their own localised material. In Queensland, TMR's Road Planning and Design Manual is a source of information in regards to geometric road design. The material contained within these standards does not differ greatly to the Austroads publication; however, there is a greater focus on localised issues, such as design in western Queensland for TMR. Table 2.3 and Table 2.4 below contain TMR's standardised widths for traffic lanes and shoulders. Note the subtle differences between the TMR standard and that produced by Austroads, such as TMR's greater standard for lower traffic volumes (< 150 vpd).

Table 7.4 Guidelines for Traffic Lane Width (Two Lane Rural Roads)

Width of Traffic Lanes		Anticipated AADT at Opening		
		Low Future Growth (<3)%	Reasonable Future Growth (3-6)%	High Future Growth (>6)%
Two Lanes	(6.0)	up to 700	up to 500	up to 300
	(6.5)	700-1700	500-1200	300-900
	(7.0)*	over 1700	over 1200	over 900

* Where local conditions dictate, widths in excess of 7.0m may be considered.

If in using the table, volumes fall near the boundary of groups, consider carefully whether to use higher or lower value.

Table 2.3: Guidelines for Traffic Lane Width (Department of Transport and Main Roads, 2004)

Table 7.7 Guidelines for Shoulder Widths

Nominal Shoulder Width (m)	Situation
0.5-1.0*	Normally widths less than 1.0 m will be used only where overlaying is being carried out with full formation sealing, and widening of formation is not justified.
1.0*	Minimum shoulder width for general use (i.e. unless special reasons dictate otherwise). Appropriate also when shoulder seal is desired and material cost/properties dictate full normal paving material.
1.5*	Normal shoulder width with sealed or partly sealed shoulders. Depends on availability of suitable material.
2.0-2.5*	Suitable shoulder width on higher volume roads when periodic provision to stop completely clear of traffic lanes is difficult to provide.
3.0*	Special cases where local issues dictate (e.g. high speed high volume rural routes where incidence of stopped vehicles unable to exercise choice as to location of stop may be significant). Normally only occurs on arterial outlets to major urban areas, especially if recreational routes.

* Shoulders between 0.5 m and 1.5 m do not enable a vehicle to stop clear of traffic lanes. 2.0 m shoulders enable it to stop largely clear. A vehicle travelling 100 km would expect to encounter some 4 to 5 stopped vehicles for every 1000 vehicles/hour using the road. Of these something less than 5% would have little

Table 2.4: Guidelines for Shoulder Widths (Department of Transport and Main Roads, 2004)

A third source of standards is the local standards. An example of this for the Darling Downs is the Eastern Downs Regional Organisation of Councils (EDROC) Regional Standards. Similar to the State Road Authority standards, the purpose of local standards is generally to apply the knowledge obtained from local experience and other sources to suit a specific locality. This may involve an appropriate application of a reduced standard, where very low traffic volumes are present.

Commonly, all of the above standards will abide by the same general principles, with some minor differences. TRC will commonly use all of the aforementioned standards, depending on the application. For the case of this study, reference shall be made to Austroads Guide to Road Design Part 3: Geometric Design.

2.1.2.11. Extended Design Domain (EDD)

The aforementioned design standards apply to newly constructed roads. Austroads (2010) provides extended design domain values for use in geometric road design under constrained (i.e. existing) conditions, termed brownfield sites (Austroads 2010, p. 219). In some situations, it is not possible to apply the requirements of road design standards where existing infrastructure or constraints exist, such as the design of horizontal alignment where existing structures prevent resumptions, or where there are drainage limitations on vertical alignment.

EDD values are a reduced geometric standard and should only be used under the following circumstances;

- reviewing the geometry of existing roads,
- realignment of a few geometric elements on existing roads in constrained conditions
- improving the standard of existing roads in constrained locations, and
- building temporary roads (Austroads 2010, p. 219)

The use of EDD is generally not recommended unless other options are unavailable. As EDD is a reduction in the standard, documentation of design decisions and thorough understanding of consequences is important prior to their application. Figure 2.8 conveys the differing standards (EDD shown on top, normal standard underneath) for traffic lane and shoulder widths. As shown, the EDD dimensions are significantly less than that of the normal standard, particularly in regards to shoulder width.

Element	Design AADT			
	150 – 500	500 – 1000	1000 – 3000	> 3000
Traffic lanes (1)	6.2 (2 x 3.1)	6.2 – 7.0 (2 x 3.1/3.5)	7.0 (2 x 3.5)	7.0 (2 x 3.5)
Shoulders (2),(3)	0.85 [1.0]	0.85 [1.0]	1.25 [1.5]	1.75 [2.0]
Total carriageway (3)	7.9(4) [8.2]	7.9 [8.2] – 8.7 [9.0]	9.5 [10.0]	10.5 [11.0]

Element	Design AADT				
	1 – 150	150 – 500	500 – 1,000	1,000 – 3,000	> 3,000
Traffic lanes(1)	3.7 (1 x 3.7)	6.2 (2 x 3.1)	6.2 – 7.0 (2 x 3.1/3.5)	7.0 (2 x 3.5)	7.0 (2 x 3.5)
Total shoulder	2.5	1.5	1.5	2.0	2.5
Minimum shoulder seal (2),(3),(4),(5),(6)	0	0.5	0.5	1.0	1.5
Total carriageway	8.7	9.2	9.2 – 10.0	11.0	12.0

Figure 2.8: EDD (top) and normal (bottom) standard comparison of traffic lane and shoulder width (Austroads, 2010)

2.1.3. Road Furniture Standards

The geometric design of roads is only one of many components that make up the complete road design process. Correct implementation of road furniture is another important aspect. Road furniture is defined as "any roadside item or device including signs, guideposts, guardrails, barriers, fences and grids", (TMR, 2006), and is utilised to regulate, warn and guide road users on upcoming road features. As a result, signage is divided generally into Regulatory signs (R series), Warning signs (W series), Guide signs (G series) and Hazard markers (D series), (TMR 2011). The use and layout of road furniture in differing situations is crucial in its success; the Manual of Uniform Traffic Control Devices (MUTCD) sets out the accepted provisions in Queensland.

2.1.3.1. Regulatory signs

'Regulatory signs inform road users of traffic laws or regulations which it would be an offence to disregard' (TMR 2011, p. 15). Within this group of signs is a number of subgroups, known as series, including the Movement Series (e.g. R1-1 Stop, R1-2 Give Way), Direction Series (e.g. R2-2 One Way, R2-4 No Entry) and Speed Series (e.g. R4-1 Speed Restriction, R4-Q01 School Zone). The shape and colour of these signs varies, depending on the message. Typical Regulatory signs are contained below in Figure 2.9.

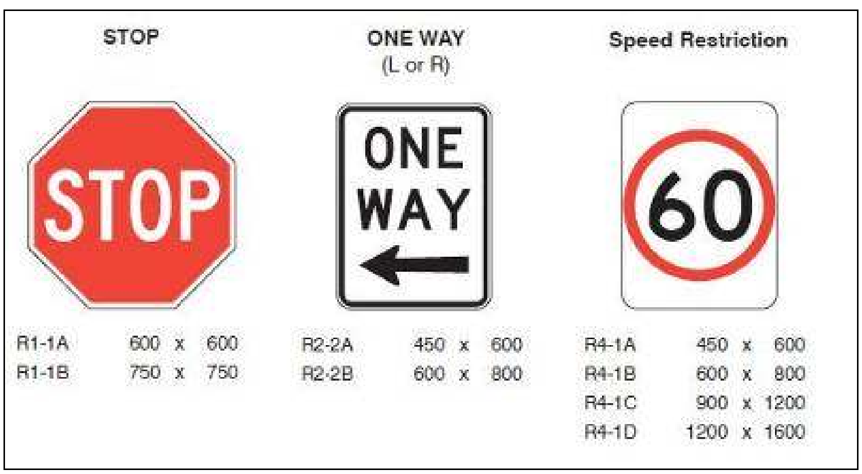


Figure 2.9: Typical Regulatory signs (TMR, 2011)

2.1.3.2. Warning signs

'Warning signs are used to warn traffic of potentially hazardous conditions, on or adjacent to the road', (TMR 2011, p. 41). Again, there are a number of series within the Warning sign type, including the Alignment Series (e.g. W1-1 Turn, W1-4 Reverse Curve), Intersection and Junction Series (e.g. W2-1 Cross Road, W2-4 Side Road Junction) and Road Width, Low and Narrow Clearance Series (e.g. W4-1

Narrow Bridge, W4-3 Road Narrows). Typically, the Warning type signs are yellow with a black message, printed on a diamond shape. In addition to the diamond shaped warning sign, the Auxiliary series can be used in conjunction to complement or confirm the warning message. The Advisory speed plate is such an example. Typical Warning signs are contained in Figure 2.10.

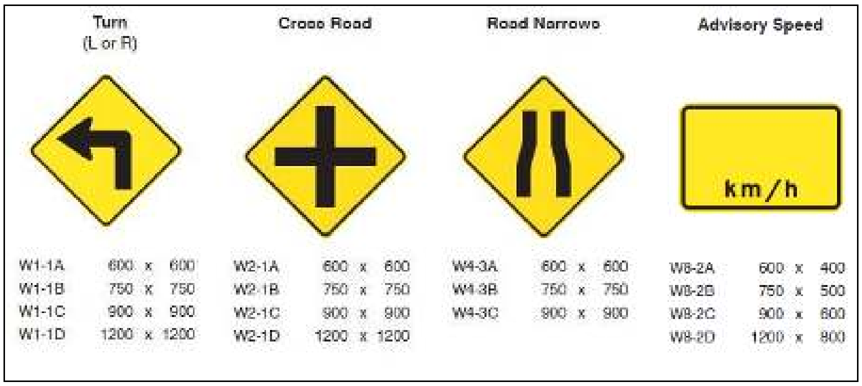


Figure 2.10: Typical Warning signs (TMR, 2011)

Warning signs are employed when the horizontal or vertical alignment is considered substandard. TMR defines this in the MUTCD as follows.

> Horizontal curves are regarded as substandard if the advisory speed of the curve is at least 10 km/h less than the 85th percentile speed on the immediate preceding section of road. The advisory speed is the maximum speed at which the curve may be comfortably negotiated under good road and whether conditions (TMR 2009, p. 41).

Treatment of substandard horizontal curves can include hazard markers, guideposts and linemarking, in addition to warning signs.

2.1.3.3. Guide signs

‘Guide signs inform and advise road users about the direction and distances of destinations on the route they are following, or along other roads which intersect their route’ (TMR 2011, p. 62). Typically, these signs are rectangular, with colour dependent on message (i.e. green for directional, blue for services and brown for tourist signs). Included within this group of signs are street name signs, route markers and tourist signs.

2.1.3.4. Hazard markers

'Hazard markers are used to emphasize to approaching traffic a marked change in the direction of travel and the presence and width of an obstruction', (TMR 2011, p. 121). These signs are rectangular in shape, constituting equally spaced stripes or arrows delineating the direction of travel. Three common examples of such signs are contained below in Figure 2.11.

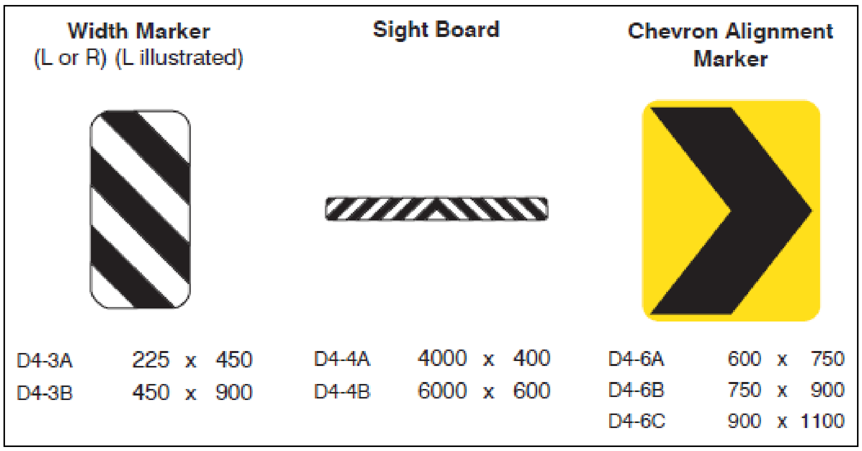


Figure 2.11: Typical hazard markers (TMR, 2011)

2.1.3.5. Substandard horizontal curve treatment

TMR's MUTCD provides guidance on the treatment of substandard horizontal curves; the horizontal geometry influences drivers operating speed more so than other geometric elements. This treatment can involve warning signs with advisory speeds, chevron alignment markers (CAM), guideposts and linemarking. In determining the type and size of warning signs and CAM, MUTCD provides the following two charts,

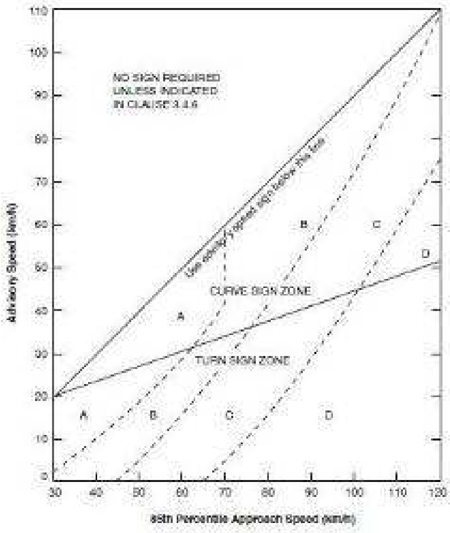


Figure 2.12: Signposting of substandard horizontal curves (TMR 2009, p. 43)

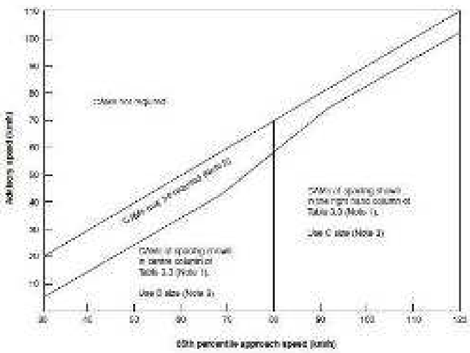


Figure 2.13: Guide for the use of Chevron Alignment Markers (TMR 2009, p. 44)

2.1.3.6. Determination of advisory speeds on horizontal curves

An advisory speed is required in determining the type of warning signs used at horizontal curvature. This value is a recommended speed that will enable traffic to safely traverse the geometry. The determination of this value requires a site inspection, using a device that measures 'the centripetal force exerted on a vehicle when travelling around the curve at a particular speed, and from that information, determine the travel speed at which the centripetal force would be at a predetermined acceptable level' (TMR 2009, p. 152).

There are currently two devices available for this investigation, the ball bank indicator and electronic accelerometer. The electronic accelerometer is preferred in industry, as its results are less likely to be influenced by human factors, however due to the unavailability of an electronic accelerometer, the ball bank indicator will be used in determining advisory speeds for this investigation. In the case of the ball bank indicator, incorrect survey speed, incorrect device setup and device reading errors are factors that can influence results obtained.

The ball bank indicator, depicted below in Figure 2.14, is a clear cylindrical tube, filled with a damping liquid and ball bearing. It is located laterally within a vehicle, generally around the dashboard, and levelled. The 'ball bank' angle is read from the graduated scale while the vehicle traverses a curve at constant speed.

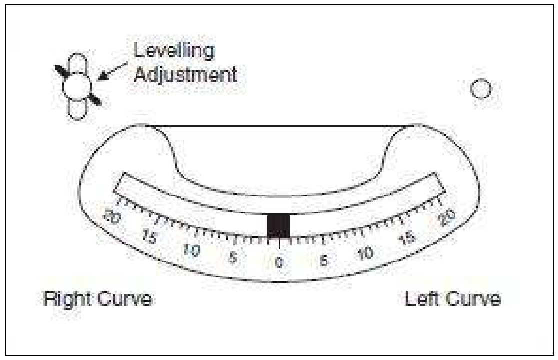
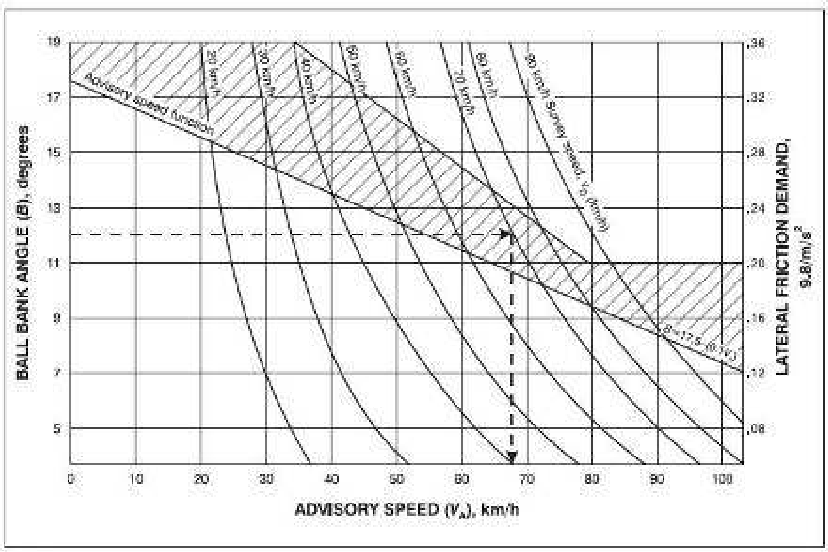


Figure 2.14: Ball bank indicator (TMR 2009, p. 152)

The ball bank angle and survey speed are combined with Figure 2.15 below to determine the appropriate advisory speed. For two-lane, two-way roads, the lowest advisory speed determined in either direction is that which is used in further analysis.



NOTES:

1 The example shows an observed reading of 12 degrees at a survey speed of 70 km/h. The advisory speed is 66 km/h.

2 The graph is based on the matching of ball bank angle to advisory speed as shown in the following Table:

Ball bank angle degrees	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0
Advisory speed km/h	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25

Figure 2.15: Determination of advisory speed on a horizontal curve (TMR 2009, p. 153)

2.1.4. Road Maintenance Practices and Intervention Levels

All road infrastructure has a specific lifespan; the continuous movement of vehicular traffic, along with general wear and tear, takes its toll. The design life is a value used to aid in determining the extent of a design, with consideration made to the expected growth of the project. For example, Austroads (2010) recommends a design life of 30 years for a new road and 100 years for a new bridge.

Although it is impossible to prevent road infrastructure from ageing, it is possible to retard the impact of time through appropriate maintenance schedules and techniques. For example, ensuring a road's seal is satisfactory helps prevent moisture ingress into the pavement, and hence reduces the possibility of pavement repairs in the future. For State Controlled Roads in Queensland, it is common for the Local Government Authority (LGA) to be responsible for the maintenance of these roads in a contract with State Road Authority known as the Road Maintenance Performance Contract (RMPC). The LGA is required to maintain the road based on the provisions advised in TMR's RMPC Manual. This manual provides guidance on inspection frequencies, defects, maintenance activities, standard procedures, intervention levels and response times. Appendix 11.3 contains this information for the sealed roadway defect of isolated depressions and bumps.

By complying with the RMPC Manual's guidelines, roads can be maintained in a safe state for longer, ultimately reducing long-term capital expenditure.

2.2. Crash Definition

Crashes of different severities occur continually throughout the state and region. However, for transport engineering and crash data purposes, it is crucial that a definition is made regarding what crashes should be included for analysis. A crash can be defined by the following;

> An apparently unpremeditated event which results in death or injury to a person or property damage and is attributable to the movement of a road vehicle on a public road (including vehicles entering or leaving a public road (Austroads 1997, p. 2).

For crash data purposes in Queensland, TMR's Data Analysis Road Crash Glossary 2010 identifies the following criteria that determine whether a crash is worthy of entering into their crash database. These criteria are;

- that the crash occurs on a public road, and

- a person is killed or injured, or
- the value of the property damage is:
    - $2500 to property other than the vehicles (after 1 December 1999)
    - $2500 damage to vehicle and property (after 1 December 1991 and prior to 1 December 1999)
    - value of property damage is greater than $1000 (prior to 1 December 1991), or
- at least one vehicle was towed away.

Austroads (1997, p. 2) define a fatal crash as 'one where a person is killed outright or dies within 30 days of the crash from injuries attributable from the crash.

These criteria ensure that only suitably severe traffic crashes are included in the database for future analysis. There are also factors that may prohibit a crash being reported on, for example, a crash involving deliberate intent or legal intervention (Queensland Government Department of TMR, 2010). Once these criteria have been met, data detailing the crash is reported.

The terms 'crash' and 'accident' are often used interchangeably, however in this text, the term crash will be used.

2.3. Crash Data Capture

At present, the states of Australia implement differing methods of crash data collection. A general practice, however, is that crashes are designated an injury severity code and a crash severity code. The following describes how these codes are determined and applied.

> The road crash data systems in each jurisdiction code both injury severity and accident severity. The injury severity variable describes the extent of injury to each person and is coded for each person in the crash. For each crash, the most severe injury severity among the persons in the crash is selected and coded as the accident severity variable. If one person was admitted to hospital and two persons were treated but not admitted in a crash, then the accident severity of that crash would be coded as "hospital admission", Ozanne-Smith and Haworth (1993).

This data may be collected by the road authority but more commonly by the Police service present at the crash scene. Examples of injury severity used for coding include killed, hospital admission, injured and not treated (Ozanne-Smith and Haworth 1993, p. 42).

The exact means of assigning severity codes differs between the states. For example in Tasmania, Police officers may seek advice from ambulance or hospital staff as to the severity of injuries sustained in a crash, whereas in Queensland this process does not tend to occur. It is on the Police reports completed after a crash that the injury severity is recorded. Generally, the road authority will assign the crash severity value later in their database, Ozanne-Smith and Haworth (1993). TMR store all crash data in an Automated Reporting Management Information System (ARMIS). Appendix 11.4 contains an example Crash Incident Report form, obtained through TMR's ARMIS database.

The Crash Incident Report form contains details on the crash, including time of day, prevailing weather conditions, location and possible causal factors. There is an accepted coding system used by Queensland Police and TMR to describe this information, contained in Appendix 11.5, known as the Definitions for Coding Accidents (DCA), (Queensland Government Department of TMR, 2010). This diagram describes possible combinations of vehicular crash, with the nature of the crash defined by the columns and the feature of the crash defined by the rows of the table.

This figure aids traffic engineers to classify crashes for analysis, specifically the movement of the units involved prior to the crash. There are ten crash-types; pedestrian, intersection, vehicles from opposing directions, vehicles from one direction, manoeuvring, overtaking, on path, off-path on straight, off-path on curve and passengers and miscellaneous. The crash is then further classified based on the specifics of the incident. For example, an off-path on straight crash-type is divided into nine subgroups relating to the vehicle movements; off carriageway to left, off carriageway to right, left off carriageway into object, right off carriageway into object, out of control on carriageway, left turn, right turn, mounting traffic island and other. This simple coding method allows attending Police officers to quickly identify the crash-type. The example Crash Incident Report form, Appendix 11.4, recorded a DCA code of 101, meaning an intersection crash-type, with involved parties both travelling through the intersection.

2.4. Crash Data Analysis

There are many ways crash data can be manipulated and analysed. It is common for data to initially be split in terms of a crash, as defined in Section 2.2. Most crash analysis reports are made based on the injury severity of the crash. For example, Road Deaths Australia Statistical Summary 2010 (BITRE, 2011) reports only fatal crashes in Australia, while the International Road Safety Comparisons 2009 (BITRE, 2010) reports both fatal and injury crashes. Commonly, crashes whereby only property damage is experienced are omitted from crash data analysis.

BITRE (2011) provides raw data of road fatalities in Australia, with some general breakdown. This breakdown includes generating trends in crash rates, separation by state, month, day, time and road user, and various combinations of each. The broad separation of data in this publication provides an overall view of road safety in Australia.

In order to compare crash data between various roads and jurisdictions, it is important that the results be reported in a common way. Obviously, factors of traffic volume and road length will impact on crash rates; it would be expected that roads with greater volumes or length would experience greater crashes rates. Therefore results are often published as crashes per vehicle kilometres travelled (VKT), defined as the 'the sum of the product of segment length and traffic volume' (Austroads 2009, p. 106). A graphical representation of VKT is shown below in Figure 2.16.

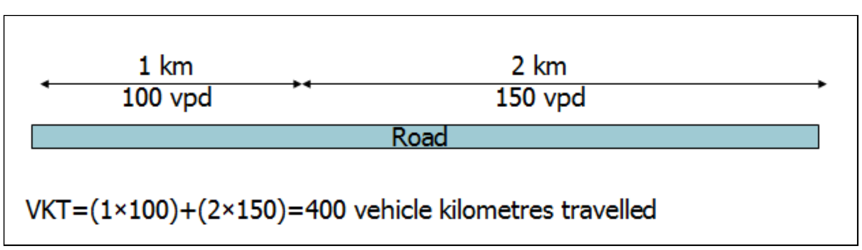


Figure 2.16: Vehicle kilometres travelled (VKT) explanation (Keleher, 2011)

Results of this calculation are often represented in terms of crashes per 100 million vehicle kilometres travelled.

2.5. Relationship between crash rates and external factors

Road crashes are caused by many different factors. Often it is difficult to ascertain these factors and identify reasonable conclusions. Many studies have been completed by various international organisations to quantify how different factors attribute to road crash statistics. A common practice in such analyses is to differentiate between human factors and road environment factors.

Symmons, Hayworth and Johnston (2004) conducted a high-level investigation on VicRoads crash data in rural Victoria. In their analysis, contributing factors were divided into those relating to the road user, such as vehicle type, driver age and gender and blood alcohol content, and those factors relating specifically to the physical aspects of the crash, including crash location, road alignment, roadside hazards and speed zone. The Australian Government Department of Infrastructure and Transport released an information sheet in 2011 detailing the crash types and contributing factors from 1990-2009. The most significant user-related crash factors were unintended driver error, excessive speed and alcohol or drug use. During this period, the number of single, run-off-road crashes increased by 10%, while the proportion of multi-vehicle fatal crashes remained steady at around 40%, (Australian Government, 2011).

In terms of road geometry, Symmons et al investigations revealed that, while more crashes occur at intersections, 37% for rural Victoria, more severe crashes occur on curved road sections. Single vehicle crashes accounted for 44% of the total, with crashes involving multiple vehicles attributing 50% of the data, aligning similarly to the Australian Government's finding.

Cairney and McGann (2001) found similar results in their investigation on the impact of geometric road features on crash statistics. In their analysis of nine highway routes in New South Wales, Victoria and Tasmania, crash rates did not vary greatly.

Substantial increases were found to occur at road segments containing extreme values of horizontal curvature and/or vertical gradient. Surprisingly, there was little variation in crash rates when compared to lane width. Three key findings from this investigation were;

- relatively little effect on crash risk for horizontal curvature until extreme values are reached;
- a much greater risk on crash risk for horizontal curvature than vertical curvature; and
- a tendency to higher crash rates with no sealed shoulder, but no consistent tendency for crash rates to diminish with wider seals

Conversely, it is widely accepted that monotonous driving conditions can result from road alignments consisting of long straights and short curves, with fatigue contributing to crash rates. Austroads recognises this and states, "the ideal alignment is a continuous curve with constant, gradual and smooth changes of direction" (Austroads 2010, p. 61).

In conflict with Cairney's and McGann's findings, Gross et al (2009) discovered "crash reductions for wider paved widths, lanes and shoulders, all else being equal". This American study looked keenly at the effects of lane and shoulder width for fixed pavement widths on two-way, two-lane undivided rural roads. Their conclusions found there to be no clear correlation between lane and shoulder widths and reduced crash rates. Broadly, the results of the Gross et al analysis identified the following relationship;

- for narrow pavement widths (7.32 m) with low AADTs (less than 1,000 vehicles per day), narrower lanes with wider shoulder are most effective;
- for narrow pavement widths (7.32 m) with high AADTs (greater than 1,000 vehicles per day), 3.66 m lanes with no shoulders are most effective; and
- for wider pavement widths (greater than 7.32 m), there were no clear results, with wider lanes and narrower shoulders effective in some locations, while the opposite occurred in others

Zegeer et al (1981) found similar results of reduced crash rates with wider traffic lanes, and identified that "run-off-road and opposite-direction crashes were the only crash types found to be associated with narrow lanes and shoulders".

The clear zone of a roadway is a major contributor to road crashes, particularly the run-off-road type, defined as the "area adjacent to the traffic lane that should be kept free from features that would be potentially hazardous to errant vehicles, (Austroads, 2008). Examples of such hazards include bridge and culvert structures, vegetation, embankments and any other rigid object. The proportion of clear zone is most important to run-off-road crash severity. Austroads recommend a number of actions for the treatment of hazards within the clear zone, as follows in order of priority;

- removal of the roadside hazard;
- redesign of the hazard so as to make it traversable;
- relocate the hazard to a location where it is less likely to be struck;
- replacement of the hazard so that it breaks away or is impact absorbing;
- shield the obstacle with an appropriate barrier and/or a crash cushion; or
- if none of the above is attainable, delineate the object.

As with the determination of standard traffic lane and shoulder widths, much research has gone into acceptable degrees of clear zone. Austroads uses the recommendation of the American Association of State Highway and Transportation Officials (AASHTO), contained in Table 2.5 below. There are many contributing factors to the determination of clear zone, with the data below based on "the probability of a vehicle leaving the road and encroaching into the roadside", (Jurewicz & Pyta, 2010). The data used was limited and therefore extrapolated to achieve results, reducing the figures to a general nature (Austroads, 2010).

Table 4.1: Clear zone distances from edge of through travelled way

Design speed (km/h)	Design ADT	Clear zone width (m)					
		Fill batter			Cut batter		
		6:1 to flat	4:1 to 5:1	3:1 and steeper[2]	6:1 to flat	4:1 to 5:1	3:1 and steeper[2]
≤ 60	< 750	3.0	3.0	[2]	3.0	3.0	3.0
	750 – 1500	3.5	4.5	[2]	3.5	3.5	3.5
	1501 – 6000	4.5	5.0	[2]	4.5	4.5	4.5
	> 6000	5.0	5.5	[2]	5.0	5.0	5.0
70 – 80	< 750	3.5	4.5	[2]	3.5	3.0	3.0
	750 – 1500	5.0	6.0	[2]	5.0	4.5	3.5
	1501 – 6000	5.5	8.0	[2]	5.5	5.0	4.5
	> 6000	6.5	8.5	[2]	6.5	6.0	5.0
90	< 750	4.5	5.5	[2]	3.5	3.5	3.0
	750 – 1500	5.5	7.5	[2]	5.5	5.0	3.5
	1501 – 6000	6.5	9.0	[2]	6.5	5.5	5.0
	> 6000	7.5	10.0[1]	[2]	7.5	6.5	5.5
100	< 750	5.5	7.5	[2]	5.0	4.5	3.5
	750 – 1500	7.5	10.0[1]	[2]	6.5	5.5	4.5
	1501 – 6000	9.0	12.0[1]	[2]	8.0	6.5	5.5
	> 6000	10.0[1]	13.5[1]	[2]	8.5	8.0	6.5
110	< 750	6.0	8.0	[2]	5.0	5.0	3.5
	750 – 1500	8.0	11.0[1]	[2]	6.5	6.0	5.0
	1501 – 6000	10.0[1]	13.0[1]	[2]	8.5	7.5	6.0
	> 6000	10.5[1]	14.0[1]	[2]	9.0	9.0	7.5

1. Where a site specific investigation indicates a high probability of continuing crashes, or such occurrences are indicated by crash history, the designer may provide clear zone distances greater than the clear zone shown in Table 4.1. A jurisdiction may limit clear zones to 9 m for practicality and to provide a consistent roadway template if previous experience with similar projects or designs indicates satisfactory performance.

2. Since recovery is less likely on the unshielded, traversable 3:1 slopes, fixed objects should not be present in the vicinity of the toe of these slopes. Recovery of high-speed vehicles that encroach beyond the edge of the shoulder may be expected to occur beyond the toe of the slope. Determination of the recovery area at the toe of the slope should take into consideration available road reservation, environmental concerns, economic factors, safety needs, and crash histories. Also, the distance between the edge of the travelled lane and the beginning of the 3:1 slope should influence the recovery area provided at the toe of the slope. While the application may be limited by several factors, the fill slope parameters which may enter into determining a maximum desirable recovery area are illustrated in Figure 4.4.

Notes:

The design ADT in the table is the average daily traffic volume in both directions and in all lanes, other than for divided roads where it is the total traffic in all lanes in one direction.

Where the road is curved the values in Table 4.1 should be adjusted by the curve correction factors in Table 4.2.

The RTA New South Wales uses a similar approach based on a hazard corridor and with curve adjustments included rather than ADT (Appendix C). For the same situation the RTA method results in greater clear zones than those shown in Table 4.1.

Source: Adapted from AASHTO (2006).

Table 2.5: Clear zone distances from edge of through travelled way (Austroads, 2010)

Jurewicz & Pyta, 2010 conducted a study on this topic, investigating 2,900 km of rural roads in Victoria. The study determined that where the clear zone exceeded 8 m, casualty crashes by run-off-road to the left decreased by approximately 21%, which agrees with the common standard of 9 m.

Road design is not a black and white exercise; experience, good judgement and commonsense are equally as valuable as figures presented in the various design guides. As a result, discrepancies can arise at particular road locations due to human factors. This project will look to identify where geometric road designs have strayed from accepted standards and guidelines, and whether this has had an impact on crash rates.

2.6. *Road Safety Audits*

A road safety audit is often employed in order to assess a proposed or existing road section's overall safety. Austroads (2002) provides the following definition;

> A road safety audit is a formal examination of a future road or traffic project or an existing road, in which an independent, qualified team reports on the project's crash potential and safety performance

This formal process is intended to assess a range of road characteristics and compare, with experience against relevant standards, the overall safety of a road. Austroads produces the Road Safety Audit publication which shall be referenced while undertaking onsite inspections of selected crash sites.

3. Methodology

The aim of this project is to examine the role road geometry has on causes of road crashes in the south-west area of TRC and to identify remedial measures and treatments.

3.1. Background research and literature review

It is necessary to conduct background research in the area of crash data capture and analysis, in order to fully understand and then examine a number of traffic crashes and locations. There are a number of sources for this information, from both the public and private sectors. This project has primarily utilised the USQ Library for books and other hardcopy information, in addition to online information sources and publication from Austroads, TRC, Queensland TMR and the Australian Bureau of Statistics

3.2. Data Sources

Queensland TMR's Automated Reporting Management System contains all crash data necessary for conducting this project. This data is in the form of Police Crash Incident Reports, containing date, time, location, weather, severity and nature and feature information, along with a brief description at the arrival time of Police at the crash scene.

Traffic count data for the State Controlled Roads, specifically data from the 2008 and 2010 traffic censuses, was obtained from the Traffic Analysis and Reporting System (TARS). A weighted average was calculated to obtain a mean AADT for each road, for those roads with multiple traffic counts.

Finally, road design plans for specific locations were obtained from Queensland TMR.

3.3. Crash and traffic count data retrieval

The project involves two stages to the crash data analysis; an overall investigation of all the State Controlled Roads within the regional districts of TRC, and a detailed analysis of specific crash sites within the south-west area of TRC.

The regional districts of Greenmount, Clifton, Crows Nest, Oakey, Millmerran, Pittsworth and Goombungee all have somewhat similar terrain and traffic densities to one another. The district of Toowoomba will be omitted due to the predominantly urban nature of the State Controlled Roads within its boundary. Data for the broad analysis, from 13 June 2005 to 11 December 2010, are to be divided with reference to the Definitions for Coding Accidents, and tallied accordingly. Charts of crashes per 10 km, crashes per 1000 vehicles and crashes per 10 km per 100 vehicles will be developed.

4. Risk Assessment

This project involves the investigation of road related issues, with a combination of office-based analysis and some onsite inspections.

The greatest risk will no doubt occur from onsite inspection of roads. As TRC is the sponsor of the project, and much of the onsite investigations will take place on TRC and TMR land and roads, appropriate workplace health and safety provisions must be made. TRC's Workplace Health and Safety Policy utilises Work Method Statements (WMS) to aid in recognising risks and hazards throughout its workplace. This project may require onsite road inspection as part of the analysis, therefore the relevant "Work on or Adjacent to a Road or Railway" WMS shall be incorporated. A copy of this WMS is included in Appendix 11.6. The key requirements from the WMS include correct Personal Protective Equipment (PPE), comprising high visibility safety garments in accordance with the MUTCD, steel cap safety boots, wide brim hat and sunscreen. As inspections can be completed during gaps in the traffic, and will generally take less than 5 minutes, temporary signage will not be compulsory. However, temporary signage may be installed in accordance with the MUTCD if determined necessary. During inspections, it may also be necessary to employ a 'spotter' to watch for oncoming traffic.

Office-based risks will include fatigue, strained eyes and possibly a repetitive strain injury. It will be important to take regular breaks during computer work, in order to minimise the risk of these injuries.

5. Broad Crash Analysis

The initial interpretation of the crash data encompasses all classified roads within TRC's regional districts, namely Greenmount, Clifton, Crows Nest, Oakey, Millmerran, Pittsworth and Goombungee. The urban district of Toowoomba was omitted from the analysis due to the urban traffic makeup on the State Controlled Roads within its boundaries.

5.1. Analysis Procedure

Crash data was obtained from TMR covering the State Controlled Roads within the districts identified. Details regarding the State Controlled Roads for these districts are included Appendix 11.1.

The analysis of total crashes for the survey area shall also include relationships between crashes and time of day, day of week, month and against the DCA classification. As the crash data obtained from TMR did not cover the same duration for each district (i.e. start and end dates differed for each district), the data was rationalised into an average annual crashes.

Comparisons of crash rates shall also be made against the segment length and by traffic volume. Traffic count data, sourced from TMR's 2008 and 2010 traffic censuses, is averaged for the road lengths of interest to provide a weighted AADT, with an example of this calculation is included in Appendix 11.8. This calculation will make allowance for roads, such as 324 Toowoomba-Cecil Plains Road, which have a high traffic count for a short length of urban passage and a much lower traffic volume for the remaining majority of their rural length. The traffic count data from TMR contains the predetermined road segments, which can be considered for analytical purposes as having the same traffic volume. This comparison of crash rates will be performed in the following manner;

- total crashes with respect to a typical 10 km segment of road, which shall balance the effect of varying road segment lengths within the area of interest, for example between Toowoomba-Cecil Plains Road and Charlton Connection Road with a lengths of 72.9 km and 1.6 km respectively,

- total crashes per 1000 vpd, which shall balance the effect of varying traffic counts of roads within the survey area, for example between the Warrego Highway and Millmerran-Cecil Plains Road with 6588 vpd and 122 vpd respectively, and
- total crashes with respect to 100 million vehicle kilometres travelled, as defined in Section 2.4, to balance the effect of both segment length and traffic volume, for an overall check on the crash rate of each road.

Comparison shall also be made against the results presented in other publications. In many cases, these analyses only include those crashes that result in either a fatality or injury/hospitalisation; however, the local data also contains those crashes whereby only property damage is experienced. Where comparison is to be made against other publications, the data included shall be altered to enable a direct comparison, i.e. only fatal crashes experienced in the survey area to be included.

5.2. Results

The Main Roads' crash data covered a period over the last five years. The Crash Detail Reports contain date and time information that can be separated and analysed individually, as shown below.

5.2.1. Crash Severity

As discussed in the literature review, the crash severity refers to the most severe injury severity experienced by those involved in the crash; for example if in an crash one person is killed and two others are hospitalised, the crash severity would be fatal.

An initial comparison will be made on the crash severity of the local data, to gauge whether the trends experienced locally compare to those experienced elsewhere. For simplicity, the crash severity will be separated into fatal, injury, (including hospitalisation, other medical treatment and injured) and property damage only. Results for the local data are contained in Figure 5.1 below.

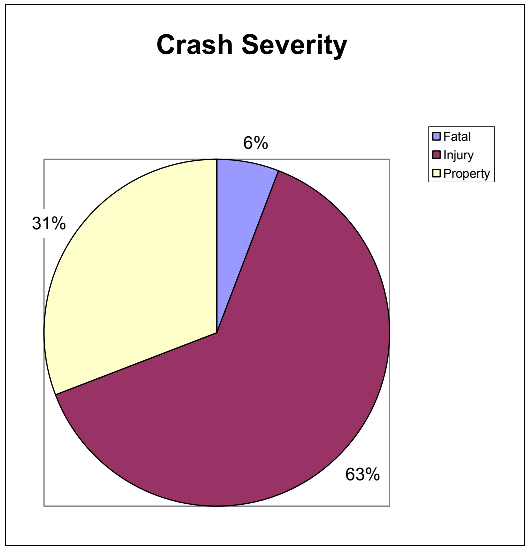


Figure 5.1: Crash severity

This brief comparison shows that the greatest proportion of crashes experienced in the local survey are of injury severity. The local data reveals a relatively low occurrence of fatal crashes at 6% of the total.

A study conducted by Symmons, Haworth and Johnston (2004) identified crash severities for rural local governments in Victoria, with results reproduced in Figure 5.2.

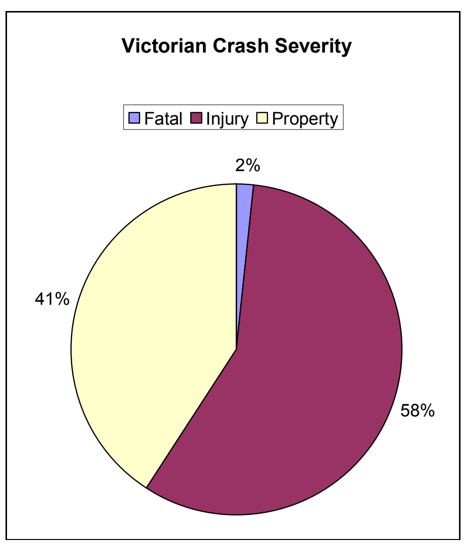


Figure 5.2: Victorian crash severity (Symmons, Haworth & Johnston 2004, p. 20)

These results convey the same trend as that experienced in the local data; that being the greater proportion of crashes classified as injury, with a relatively low fatal injury occurrence. However, the proportions of each injury category differ with the Victorian data, which experiences proportionally one third of fatal crashes.

It is this same differentiation of crash severity that is performed when comparing the local results with those obtained in other studies.

5.2.2. Crashes by time of day

The time of day has the potential to be highly influential in causing crashes. At night, vision is reduced significantly, making hazards within the road environment less visible. Dawn and dusk driving also present the issue of glare for motorists, however the majority of traffic movements occurs through the day.

The crash data received from TMR was separated by hour, with graphical results displayed in Figure 5.3.

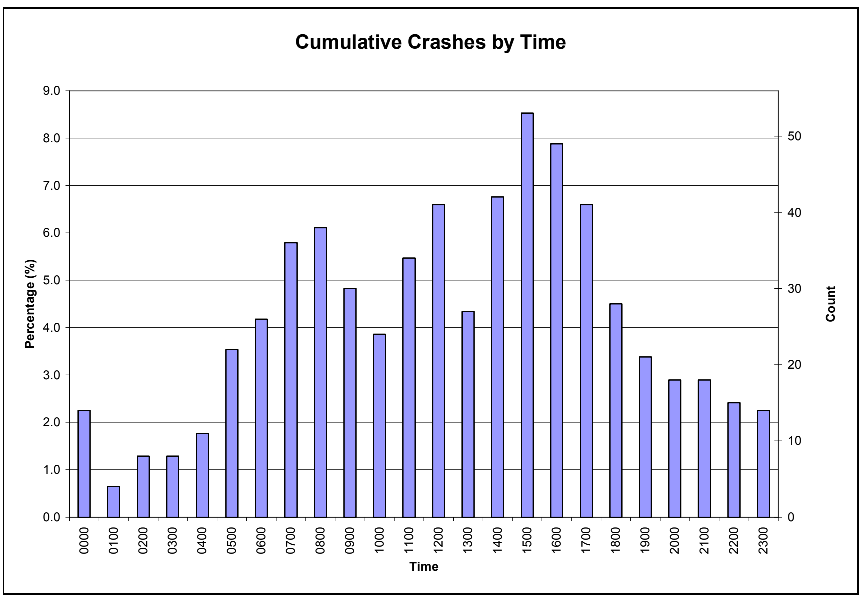


Figure 5.3: All crashes by time of day

There is a significant trend of crashes occurring towards the middle of the day, with a peak occurring around 3 pm. Looking closer at the results, there appears to be a significant increase in crashes between 4 am and 8 am, most likely the time when people are commuting to work and/or school. This initial peak is followed by a brief lull of approximately two hours, before a spike between 11 am and 12 pm, possibly lunchtime commuters. The daily peak is achieved at 3 pm, with a steady decline from this time until 6 pm, presumably the time when people are returning home from work and school. The low occurs during the hour of 1 am, predictably when the traffic volumes are around their lowest during a 24-hour period.

Another method of examining the data is to divide by day and night. BITRE released the Road Deaths Australia 2010 Statistical Summary, containing national data on road fatalities for 2010, with comparisons made to previous years. As a result, local data included in this comparison was only that involving a fatal injury; 37 fatal crashes were experienced during the survey period. Daytime 'refers to 6 am to 5.59 pm each day', (BITRE, 2011). Figure 5.4 contains the results of this analysis below.

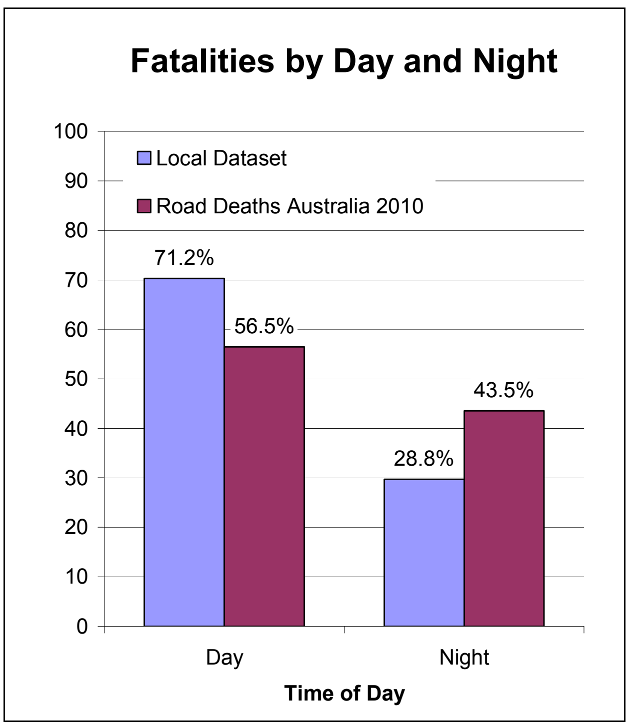


Figure 5.4: Fatal crashes by day and night (Australian Government Department of Infrastructure and Transport, 2011)

The trend is similar between the local and national data, in that more fatal crashes take place during the day. The local data does display a greater tendency toward daytime crashes when compared with the national data; however, a number of factors, including the smaller dataset and different local driver movements and behaviour, may explain this. A greater proportion of traffic travelling during daylight hours would explain the relationship shown.

5.2.3. Crashes by day of week

Crash rates for the local data may also vary between the days of the week. The crash data was therefore grouped accordingly, with results displayed below in Figure 5.5.

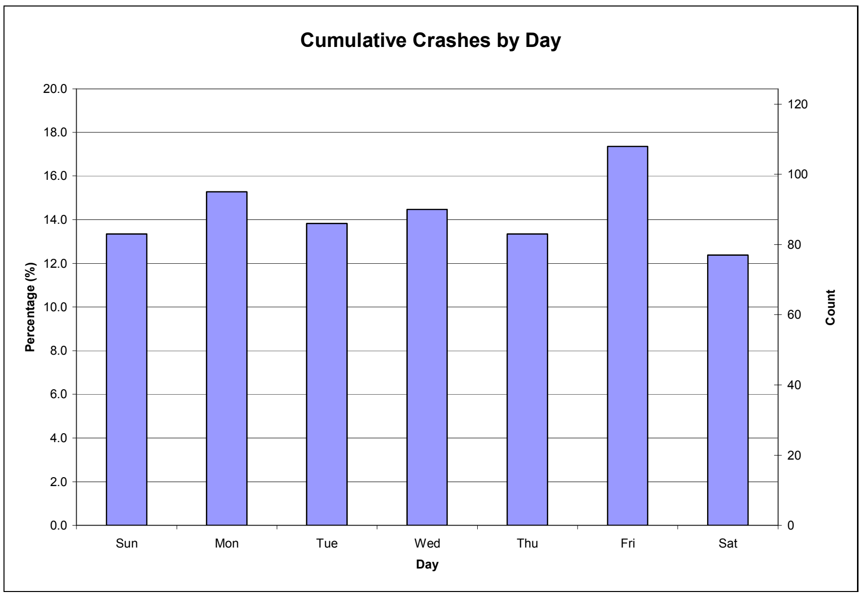


Figure 5.5: All crashes by day of week

The results show little difference between crash rates for each day of the week. The high is experienced on Friday with the low experienced on Saturday, however trends within the results cannot be made with confidence, as there is not sufficient difference between the days.

The Road Deaths Australia 2010 Statistical Summary also compares crashes against the days of the week, specifically between weekends and weekdays. Figure 5.6, below, contrasts between the national fatality data and that crash data obtained for the TRC area. Again, only fatal crashes from the local data were included for comparison.

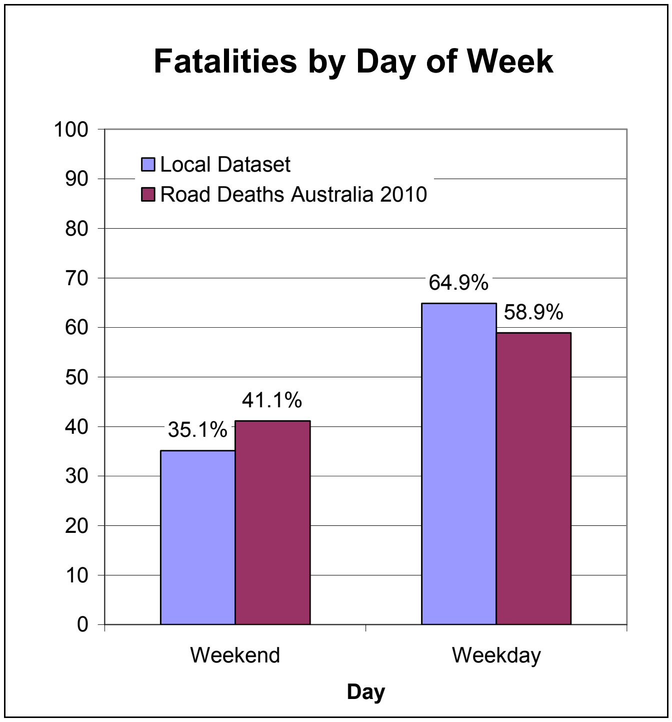


Figure 5.6: Fatal crashes by day of week (Australian Government Department of Infrastructure and Transport, 2011)

Figure 5.6 shows that for both datasets more fatal crashes within occur on a weekday than on a weekend. Similar to the comparison of time of crashes, the local data follows the same trend as that provided in the national data. This difference may again be the result of the relatively small data size for the local crash statistics, and differing local driver movements and behaviour.

5.2.4. Crashes by Month

In an attempt to identify whether a trend exists between fatal crashes and months of the year, the results were separated by month, and compared against the Road Deaths Australia 2010 Statistical Summary results. Figure 5.7, below, displays the results for all crashes in the local survey area.

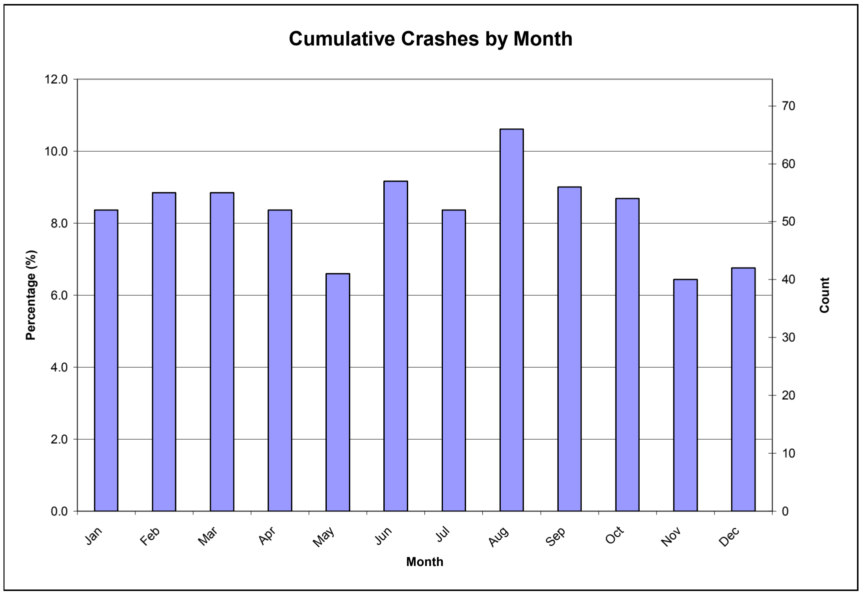


Figure 5.7: All crashes by month

There is a notable difference in crash rates for the months of the year. The peak in the data occurs during the month of August, with lows experienced during May and November. It is difficult to identify specific features that may have influenced this trend in crash rates; traffic variations, including holiday commuters and seasonal agricultural related traffic may have contributed to the variation.

Again, national fatal results obtained from BITRE shall be compared against the local results, contained in Figure 5.8.

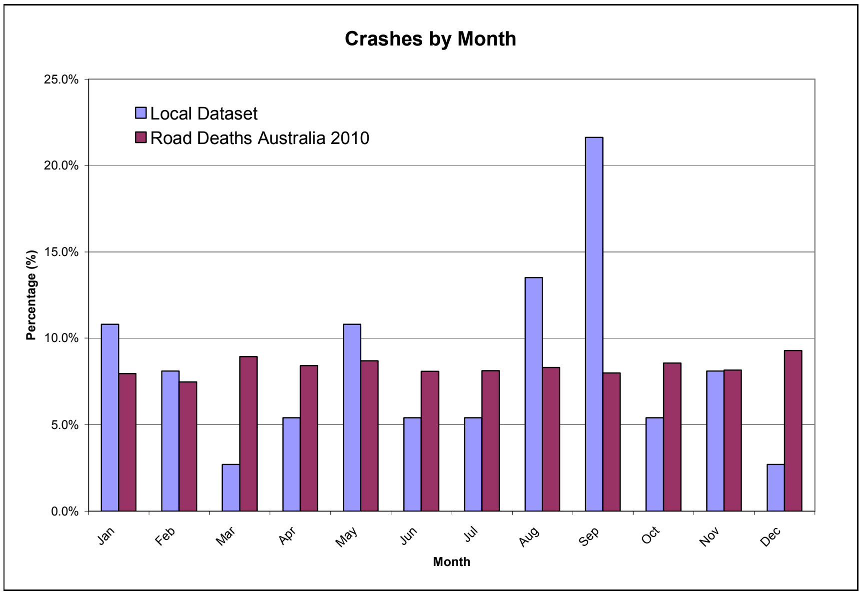


Figure 5.8: Fatal crashes by month (Australian Government Department of Infrastructure and Transport, 2011)

The results from the local data show significant variation between the months of the year for fatal crashes. A substantial maximum is reached in the month of September, with lows occurring in March and December. However, a trend for the local fatal crashes cannot be established due to the low number in the dataset. The national data conveys much more consistent results, with relatively little difference in crash rates between the months of the year, which emphasises the influence the smaller dataset may play on the results.

5.2.5. Crashes by DCA

As stated, the crash data was separated into the various DCA crash-types. The cumulative results for this process are contained in Appendix 11.7, with Figure 5.9 below conveying the number of each crash-type for each council district.

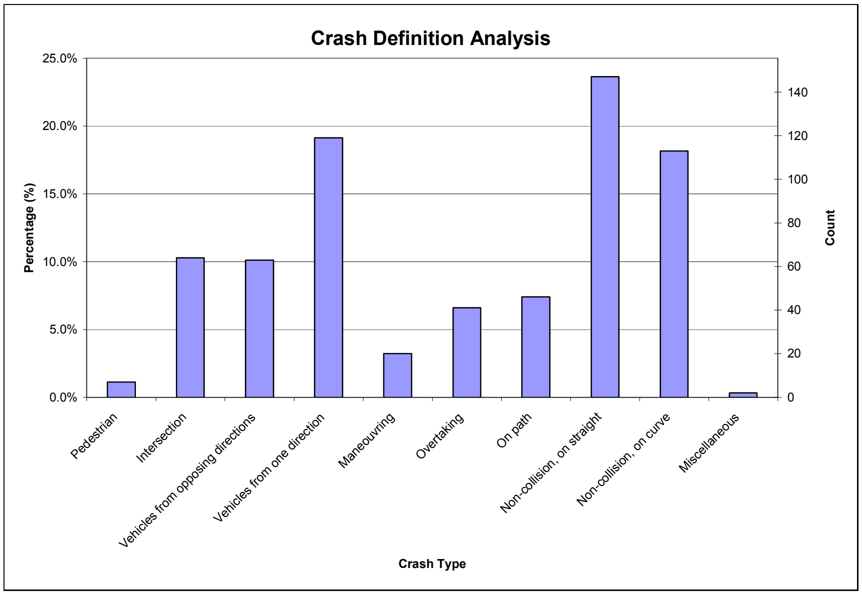


Figure 5.9: All crashes by DCA definitions

The results show that non-collision crashes, i.e. single vehicle, are most prevalent, along with crashes involving vehicles travelling in the same direction. Crash-types involving intersections, vehicles travelling in opposite directions, on path and overtaking were next most prevalent, with manoeuvring, pedestrian and miscellaneous crashes only accounting for 4% of the total.

An interesting result of this analysis is that of the number of non-collision crashes occurring on straights. Many of the classified roads in the local area include substantial lengths of straight, with high speed limits, however for such crashes to occur, other factors must be present. Fatigue is one possibility, whereby a driver loses concentration after long driving periods of low stimulation. Analysis as to whether fatigue may have played a role in these results is beyond the scope of this project, however should be considered when analysing these results.

By sorting the results in terms of single and multiple vehicle crashes, it is shown that the overall proportions between the two are quite similar. Figure 5.10 below displays this relationship.

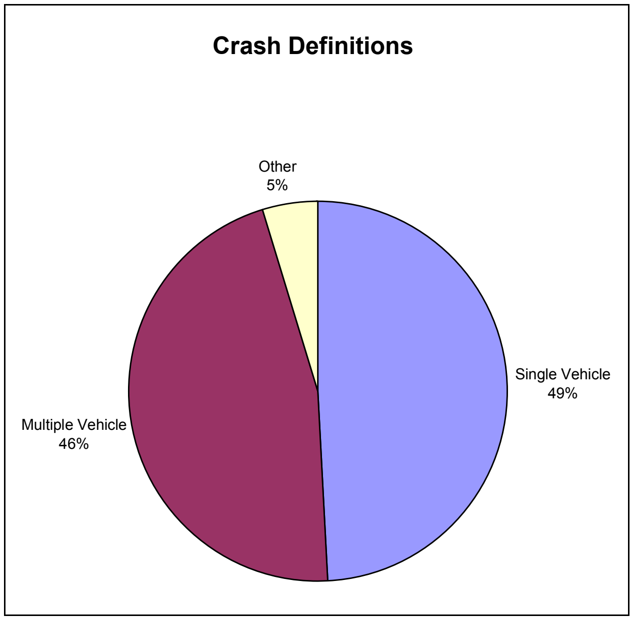


Figure 5.10: Summary of crash type

Symmons et al (2004) conducted a similar study on rural roads in Victoria. Trends obtained in their study align with those discovered locally; 44% were single vehicle, 50% multiple vehicle and 6% other.

There are a number of plausible factors for these results. However, broadly speaking, the following attributes would have some influence;

- The majority of roads in the survey area are high-speed rural roads, which may increase the chance of non-collision crashes.
- In general, sight distance is good throughout the majority of the survey area, due to the open nature of the rural landscape, reducing risk of crashes between oncoming vehicles.
- The majority of the roads pass through lowly populated regional areas, which would account for the fewer pedestrian related accidents.

5.2.6. Crashes by Road

The crash data was separated by road, with results conveyed in Figure 5.11 and Table 5.1.

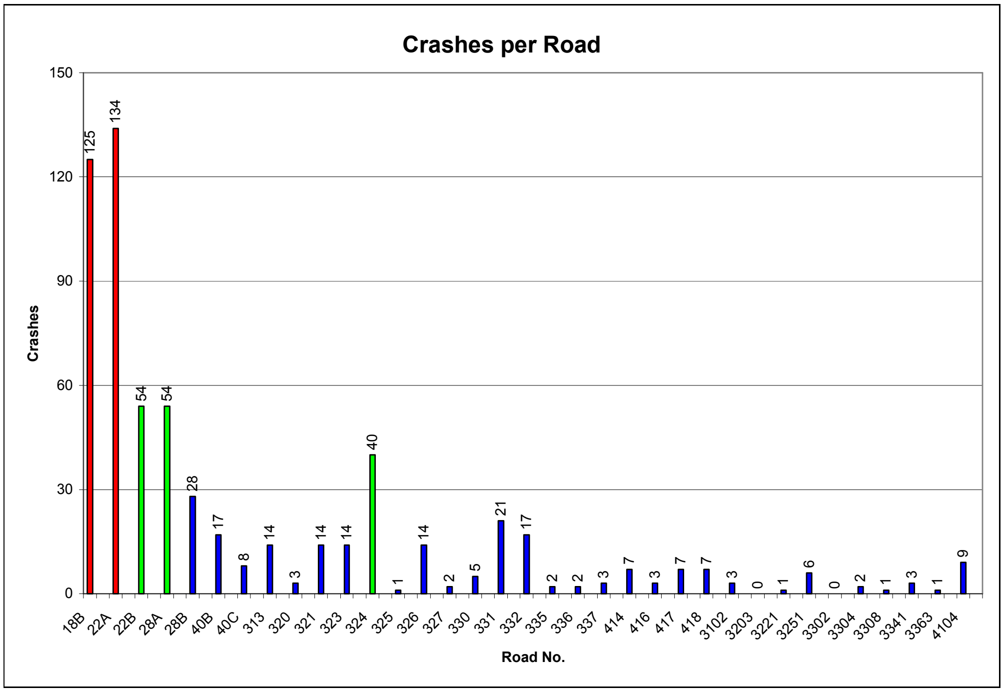


Figure 5.11: All crashes by road

Rank	Road No.	Road Name	Count
1	22A	New England Highway	134
2	18B	Warrego Highway	125
3	22B	New England Highway	54
3	28A	Gore Highway	54
5	324	Toowoomba-Cecil Plains Road	40
6	28B	Gore Highway	28
7	331	Toowoomba-Karara Road	21
8	40B	D'Aguilar Highway	17
8	332	Pittsworth-Felton Road	17
10	313	Gatton-Clifton Road	14
10	321	Drayton Connection Road	14
10	323	Oakey-Pittsworth Road	14
10	326	Oakey Connection Road	14
14	4104	Murphy's Creek Road	9
15	40C	D'Aguilar Highway	8
16	414	Esk-Hampton Road	7
16	417	Oakey-Cooyar Road	7
16	418	Pechey-Maclagan Road	7
19	3251	Millmerran-Cecil Plains Road	6
20	330	Felton-Clifton Road	5

21	320	Charlton Connection Road	3
21	337	Millmerran-Inglewood Road	3
21	416	Dalby-Cooyar Road	3
21	3102	Greenmount-Hirstvale Road	3
21	3341	Greenmount Connection Road	3
26	327	Pampas-Horrane Road	2
26	335	Millmerran-Leyburn Road	2
26	336	Clifton-Leyburn Road	2
26	3304	Cambooya Connection Road	2
30	325	Dalby-Cecil Plains Road	1
30	3221	Brookstead-Norwin Road	1
30	3308	Nobby Connection Road	1
30	3363	Ryeford-Pratten Road	1
34	3203	Bowenville-Norwin Road	0
34	3302	Dalrymple Creek Road	0
		AVERAGE CRASHES/ROAD	**17.8**

Table 5.1: Ranking of crashes per road

The results shown above plausibly show that a greater number of crashes occur on the more heavily trafficked national highways. Atop the list of total crashes are the major routes of the New England Highway, Warrego Highway and Gore Highway, presumably due to their high traffic volumes and long segment lengths. Figure 5.12 below splits the total crashes by National Highway, with a clear majority of 68%, and Other State Controlled Roads.

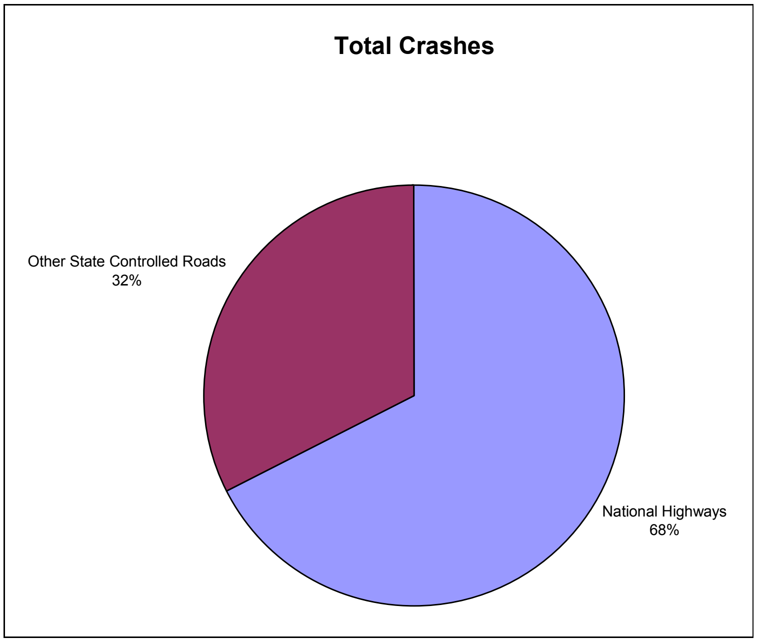


Figure 5.12: Total crashes split by NH and OSCR

Although interesting, the real world use of these results is limited, as traffic volume and length of road segment is not taken into consideration. An example of this is 40C D'Aguilar Highway; with an AADT over 3300, it would be expected that it would be ranked higher in the list of total crashes. However, with a segment length of only 4.7 km within TRC, this road ranked 15th overall with eight crashes recorded. By analysing the roads with respect to their segment lengths, the results shall be factored accordingly.

5.2.7. Crashes by Road Length

The analysis of crashes versus the length of road segment will help gain a better understanding of how prone each road is to accidents. The road segment length refers to the length of the Main Road within the boundaries of the regional TRC districts. The total crash counts were recalculated assuming all road segment lengths were 10 km. Figure 5.13 and Table 5.2 contain the results of this comparison.

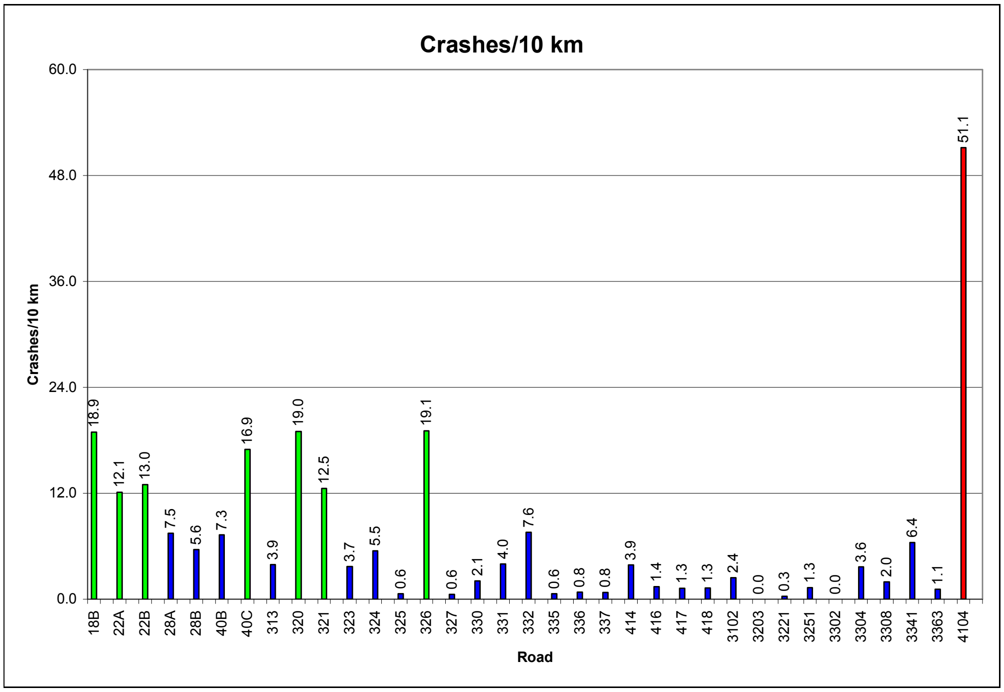


Figure 5.13: All crashes by road length

Rank	Road No.	Road Name	Crashes/10 km
1	4104	Murphy's Creek Road	51.1
2	326	Oakey Connection Road	19.1
3	320	Charlton Connection Road	19.0
4	18B	Warrego Highway	18.9
5	40C	D'Aguilar Highway	16.9
6	22B	New England Highway	13.0
7	321	Drayton Connection Road	12.5
8	22A	New England Highway	12.1
9	332	Pittsworth-Felton Road	7.6
10	28A	Gore Highway	7.5
11	40B	D'Aguilar Highway	7.3
12	3341	Greenmount-Connection Road	6.4
13	28B	Gore Highway	5.6
14	324	Toowoomba-Cecil Plains Road	5.5
15	331	Toowoomba-Karara Road	4.0
16	313	Gatton-Clifton Road	3.9
16	414	Esk-Hampton Road	3.9
18	323	Oakey-Pittsworth Road	3.7
19	3304	Cambooya Connection Road	3.6
20	3102	Greenmount-Hirstvale Road	2.4
21	330	Felton-Clifton Road	2.1

22	3308	Nobby Connection Road	2.0
23	416	Dalby-Cooyar Road	1.4
24	417	Oakey-Cooyar Road	1.3
24	418	Pechey-Maclagan Road	1.3
24	3251	Millmerran-Cecil Plains Road	1.3
27	3363	Ryeford-Pratten Road	1.1
28	336	Clifton-Leyburn Road	0.8
28	337	Millmerran-Inglewood Road	0.8
30	325	Dalby-Cecil Plains Road	0.6
30	327	Pampas-Horrane Road	0.6
30	335	Millmerran-Leyburn Road	0.6
33	3221	Brookstead-Norwin Road	0.3
34	3203	Bowenville-Norwin Road	0.0
34	3302	Dalrymple Creek Road	0.0
		AVERAGE CRASHES/10 KM/ROAD	**6.8**

Table 5.2: Ranking of crashes per road per 10 km

This comparison has significantly altered the order of roads in terms of their likelihood for crashes. Murphy's Creek Road is now atop the rankings, averaging 51.1 crashes per 10 km. National Highways are still among the higher ranked roads; however, the influence of their greater length is removed. Figure 5.14 below confirms this statement with OSCR now totalling 66% of total crashes.

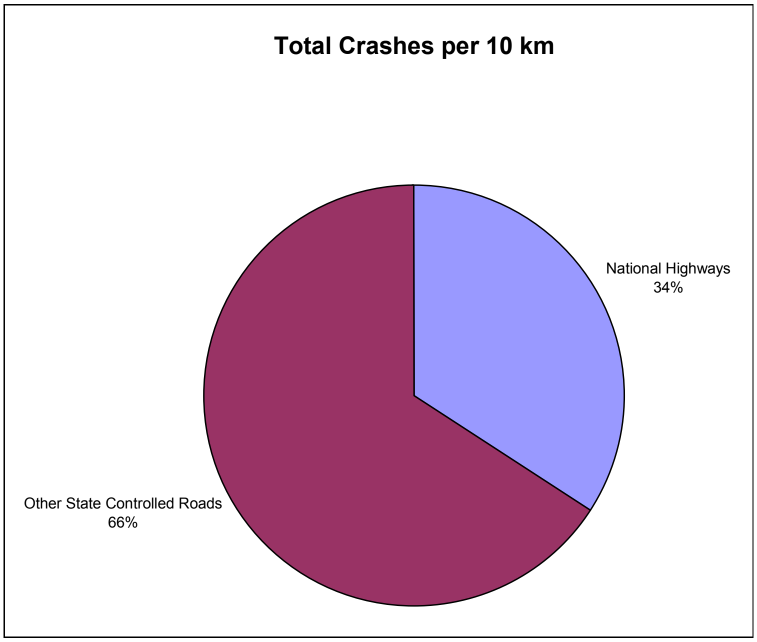


Figure 5.14: Total crashes per 10 km split by NH and OSCR

5.2.8. Crashes by Traffic Volume

A comparison with respect to traffic volume follows, based on the assumption of equal traffic volumes for each road, i.e. 1000 vehicles per day.

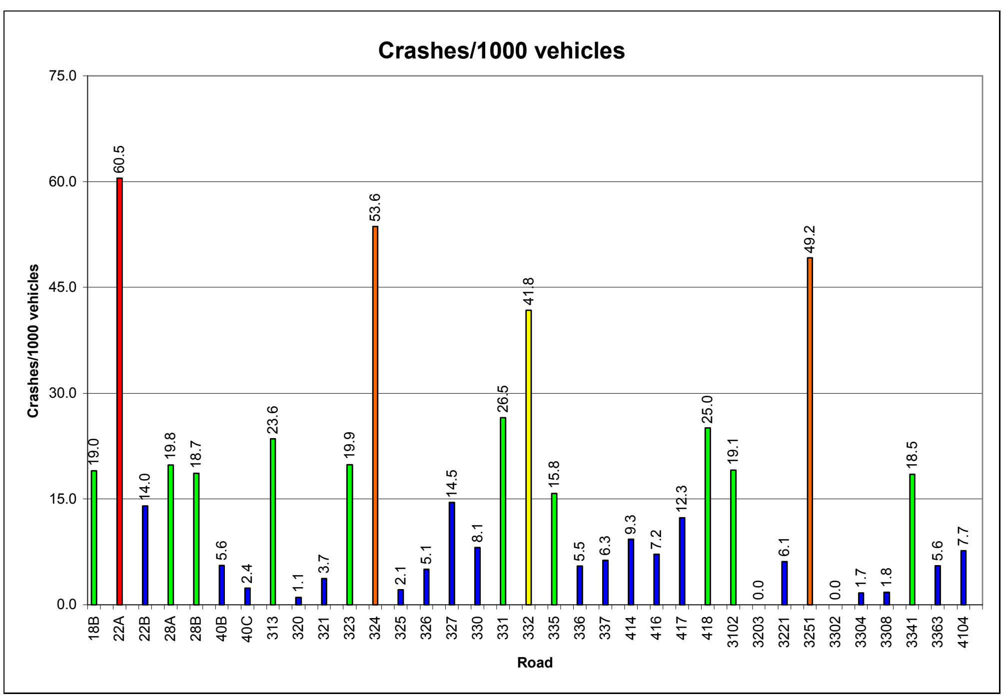


Figure 5.15: All crashes by road traffic volume

Rank	Road No.	Road Name	Crashes/1000 vehicles
1	22A	New England Highway	60.5
2	324	Toowoomba-Cecil Plains Road	53.6
3	3251	Millmerran-Cecil Plains Road	49.2
4	332	Pittsworth-Felton Road	41.8
5	331	Toowoomba-Karara Road	26.5
6	418	Pechey-Maclagan Road	25.0
7	313	Gatton-Clifton Road	23.6
8	323	Oakey-Pittsworth Road	19.9
9	28A	Gore Highway	19.8
10	3102	Greenmount-Hirstvale Road	19.1
11	18B	Warrego Highway	19.0
12	28B	Gore Highway	18.7
13	3341	Greenmount Connection Road	18.5
14	335	Millmerran-Leyburn Road	15.8
15	327	Pampas-Horrane Road	14.5
16	22B	New England Highway	14.0
17	417	Oakey-Cooyar Road	12.3
18	414	Esk-Hampton Road	9.3
19	330	Felton-Clifton Road	8.1
20	4104	Murphy's Creek Road	7.7
21	416	Dalby-Cooyar Road	7.2
22	337	Millmerran-Inglewood Road	6.3
23	3221	Brookstead-Norwin Road	6.1
24	40B	D'Aguilar Highway	5.6
24	3363	Ryeford-Pratten Road	5.6
26	336	Clifton-Leyburn Road	5.5
27	326	Oakey Connection Road	5.1
28	321	Drayton Connection Road	3.7
29	40C	D'Aguilar Highway	2.4
30	325	Dalby-Cecil Plains Road	2.1
31	3308	Nobby Connection Road	1.8
32	3304	Cambooya Connection Road	1.7
33	320	Charlton Connection Road	1.1
34	3203	Bowenville-Norwin Road	0.0
34	3302	Dalrymple Creek Road	0.0
		AVERAGE CRASHES/1000 VEHICLES/ROAD	**15.2**

Table 5.3: Ranking of crashes per 1000 vehicles

The effect of this computation is similar to that of referencing road segment length. The majority of the National Highways are no longer at the upper end of the ranking, due to their higher traffic volumes; 22B New England Highway is now ranked 16th overall with an average of 14.0 crashes per 1000 vehicles. On the other hand, 3251 Millmerran-Cecil Plains Road is ranked 3rd with an average of 49.2 crashes per 1000 vehicles, due to its low traffic volume of 122 vehicles per day (TMR, 2008).

An interesting result from this analysis is that the National Highway of 22A New England Highway is ranked highest, despite its high traffic volume of 2216 (TMR, 2008).

Once again, the balance towards Other State Controlled Roads' majority is evident in Figure 5.16, with these roads attributing to 74% of the total crashes per 1000 vehicles.

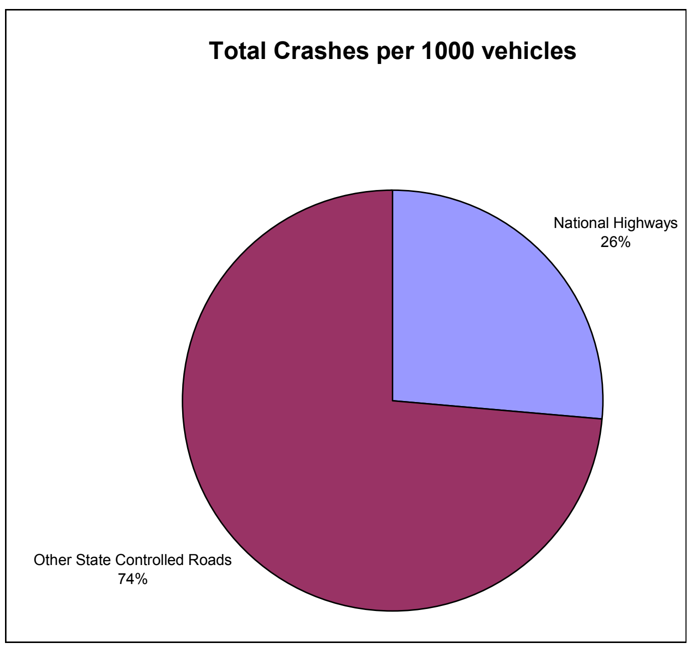


Figure 5.16: Total crashes per 1000 vehicles split by NH and OSCR

The results produced from this calculation are not completely representative, as 40C D'Aguilar Highway ranks 29th due to its short segment length. The final computation involves combining both the road segment length and traffic volume variables, as follows.

5.2.9. Crashes by Road Length and Traffic Volume

To gain a more complete understanding of the data, both the road segment length and traffic count data will be combined with the total crashes for each road. The factor of VKT, specifically crashes per 100 million VKT, forms this analysis, as described in Section 2.4. Results are contained below in Figure 5.17 and Table 5.4.

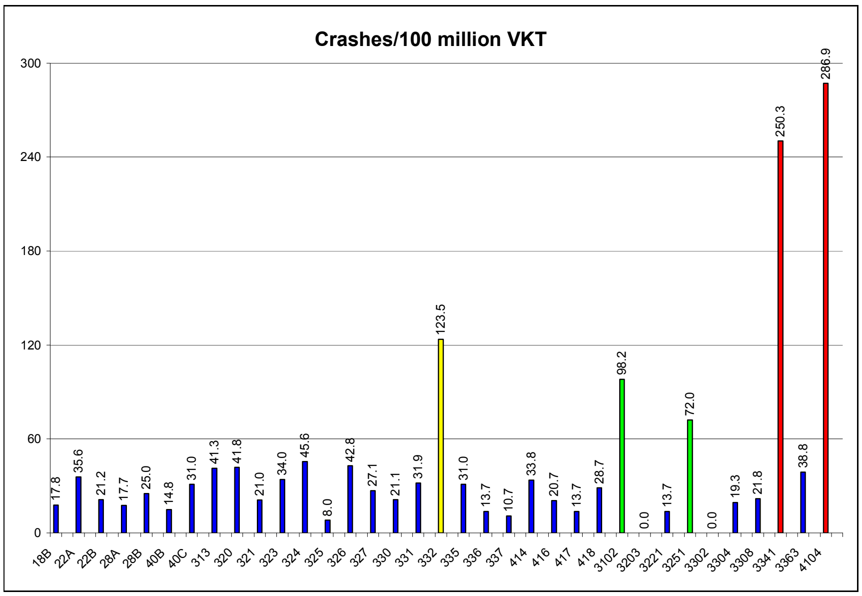


Figure 5.17: Crashes by road segment length and road traffic volume

Rank	Road No.	Road Name	Crashes/100 million VKT
1	4104	Murphy's Creek Road	286.9
2	3341	Greenmount Connection Road	250.3
3	332	Pittsworth-Felton Road	123.5
4	3102	Greenmount-Hirstvale Road	98.2
5	3251	Millmerran-Cecil Plains Road	72.0
6	324	Toowoomba-Cecil Plains Road	45.6
7	326	Oakey Connection Road	42.8
8	320	Charlton Connection Road	41.8
9	313	Gatton-Clifton Road	41.3
10	3363	Ryeford-Pratten Road	38.8
11	22A	New England Highway	35.6
12	323	Oakey-Pittsworth Road	34.0

13	414	Esk-Hampton Road	33.8
14	331	Toowoomba-Karara Road	31.9
15	40C	D'Aguilar Highway	31.0
16	335	Millmerran-Leyburn Road	31.0
17	418	Pechey-Maclagan Road	28.7
18	327	Pampas-Horrane Road	27.1
19	28B	Gore Highway	25.0
20	3308	Nobby Connection Road	21.8
21	22B	New England Highway	21.2
21	330	Felton-Clifton Road	21.1
23	321	Drayton Connection Road	21.0
24	416	Dalby-Cooyar Road	20.7
25	3304	Cambooya Connection Road	19.3
26	18B	Warrego Highway	17.8
27	28A	Gore Highway	17.7
28	40B	D'Aguilar Highway	14.8
29	417	Oakey-Cooyar Road	13.7
30	336	Clifton-Leyburn Road	13.7
31	3221	Brookstead-Norwin Road	13.7
32	337	Millmerran-Inglewood Road	10.7
33	325	Dalby-Cecil Plains Road	8.0
34	3203	Bowenville-Norwin Road	0.0
34	3302	Dalrymple Creek Road	0.0
		AVERAGE	**25.1**

Table 5.4: Ranking of crashes per 10 km per 1000 vehicles

This final analysis against segment length and traffic volume provides the most complete overview of each road and its susceptibility to crashes; 4104 Murphy's Creek Road (286.9), 3341 Greenmount Connection Road (250.3) and 332 Pittsworth-Felton Road (123.5) are now the three highest ranked road segments in terms of crashes. Each of these roads also have differing properties; traffic counts and segment lengths vary markedly, operating speed is different on each and general terrain on each road varies to some extent.

The National Highways have significantly lower crash rates in this analysis, averaging approximately 22.3 crashes per 100 million VKT in comparison to OSCR average of 34.0 crashes per 100 million VKT. This may be attributed to the fact National

Highways are designed and maintained at a higher standard than the lower trafficked OSCR, due to their generally higher traffic counts. Overall, the region experiences an average of 25.1 crashes per 100 million VKT.

As the data provided in Section 5.2.9 are provided in a recognised format, that being crashes per 100 million VKT, it is now possible to compare these factored local crash rates against those results reporting in other studies.

The Australian Road Research Board (ARRB) conducted a similar study for the period 1999-2003, looking at crash rates in New South Wales and the Australian Capital Territory (ACT). Their results found ACT experienced 18.2 fatal and injury crashes per 100 million VKT over this time, with New South Wales (NSW) recording 62 per 100 million VKT. Already the local average of 25.1 crashes per 100 million VKT is lower than that recorded in NSW, whilst including property only crashes. The local average reduces to 17.4 crashes per 100 million VKT when only fatal and injury crashes are considered. This result suggests that crash rates, and hence road safety, is superior in the local area when compared to ARRB's results.

However, when the local results are compared against the Road Deaths Australia 2010 Statistical Summary (BITRE 2011, p. 23), the opposite trend occurs. Results are contained in Table 5.5.

	Local dataset	**Queensland**	**Australia**
Average fatal crashes per 100 million VKT (2005-2010)	1.49	0.69	0.68

Table 5.5: Fatal crashes per 100 million VKT (BITRE 2011, p. 23)

The local fatal crash rates are over twice that experienced in Queensland and Australia. The results of these two comparisons reveal that although overall crash rates in the local area are lower than those experienced elsewhere, a greater majority of these are fatal in severity.

There are a number of plausible reasons for this trend, including the following;

- The general state of roads in this area is fair, and the physical environment of TRC's regions is generally open plains where visibility is good. This may contribute to lower overall crash rates.

- High operating speeds result from the open nature of roads in the region, which may contribute to a higher fatality rate in crashes.

- The majority of traffic movements in Queensland and Australia occur in urban areas where most of the population reside. Urban areas in general have higher traffic volumes are lower operating speeds than what would be experienced locally. Therefore it is understandable that while a greater number of crashes would occur in these regions, a lesser number of these would result in a fatality.

5.3. Crash Data Analysis Conclusions

This relatively brief analysis of crash data for the region has revealed some interesting results. The trends in the local data mostly follow those identified in other state and national studies; however, the comparatively small dataset for the local region makes identifying trends difficult, particularly when only considering fatal crashes.

The overall crash rates, in terms of crashes per 100 million VKT, are comparable to those experienced in Queensland and other parts of Australia. Interestingly, the overall local crash rates, (i.e. all injury and fatal crashes) are lower than results revealed in NSW and ACT (ARRB, 2008), however considering only fatal crashes, the local rate is over twice that recorded in Queensland and Australia over the same period (BITRE 2011, p. 23).

The literature review revealed research that found a greater proportion of road crashes occur on horizontal curvature, and it is this geometric feature that impacts driver behaviour more so than any other. Therefore, the second component of this study, which investigates specific crash sites in terms of their geometry and road furniture, shall be made up of crash site where horizontal geometry appeared to contribute. The proceeding sections identify such sites, and following onsite and desktop safety audits, discussing whether the geometric features, such as horizontal alignment, had an influence on crash rates at the location by comparing inspection results with industry standards and guidelines.

6. Detailed Crash Site Analysis

A more detailed look at specific crash locations will be required to aid in identifying causal crash factors. In terms of crash types, with reference to the Definitions for Coding Accidents, the actions relating to 7 – Non-collision, on straight and 8 – Non-collision, on curve are the most likely to have been impacted by the geometry of the road environment. In general, the other modes of crash are more likely to have resulted in driver error or misjudgement. The results determined in Section 5.2.5 identified that the majority of crashes within TRC are the single vehicle crashes mentioned.

6.1. Selection of Specific Locations

On completion of the broad crash data analysis, three sites were identified as being particularly prone to accidents that may have resulted from the geometric design of the road. With reference to the DCA, crash types 7: non-collision, on straight and 8: non-collision, on curve are more likely than other crash types to have been influenced by road geometry. The selection of sites also took into consideration the circumstances and contributing factors of the crash itself. For example, if the Crash Detail Report stated that the driver was under the influence of alcohol, then this crash would be omitted from consideration.

6.2. Method of Investigation

A key requirement in road safety auditing is to be consistent when conducting the investigation. A set routine of analysis technique is best employed to ensure reliable outcomes.

Austroads (2002) set out several road characteristics that are important to designing for road users, including design speed, horizontal and vertical curves, intersections, cross section, access control, parked vehicles, clear zone and signage. These properties shall be addressed during site inspections and compared against the relevant design standard. Chainages shall be determined using TMR GPS chainage system.

Although TMR have developed their own manuals for the geometric design of roads, the Austroads' Guide to Road Design series will be used in the comparison. In the analysis of road furniture standards, TMR's Manual for Uniform Traffic Control Devices will act as the benchmark.

TMR supplied construction issue plans for the crash sites identified. However, the level of detail, and therefore their use, was limited. As a result, geometric road features were measured, both on-site and through desktop analyses.

6.2.1. Length measurement

The measurement of lengths during site inspections will be done in one of two ways. All longitudinal measurements will be completed via the road chainage, referring to the distance along the road from a datum point, measured using TMR's GPS chainage program. This program utilises GPS technology in providing a road chainage for state-controlled roads, to the nearest metre. Figure 6.1 below conveys the TMR GPS chainage program, which shall be utilised in determining curve lengths and sight distances.

Figure 6.1: TMR's GPS Chainage program

For all cross-section length measurements, common devices such as measuring wheels and tapes shall be utilised.

6.2.2. Crossfall estimation

Although a typical cross section may be included in the TMR supplied geometric plans, the crossfalls provided may not be representative of what is apparent onsite. The crossfall may vary with length, thus an averaged value for the segment of interest will incorporate a number of measurements. The crossfall shall be measured using a digital level similar to that shown in Figure 6.2.

Figure 6.2: Digital level used in estimating road crossfall

This device was calibrated before use to ensure correct readings.

6.2.3. Horizontal curve radius estimation

Where horizontal curve radius is not provided in the TMR plans, an estimate shall be achieved by scaling TRC aerial photography in AutoCAD© software to approximate a suitable circular curve radius. This process shall be repeated three times and averaged. A typical screenshot of this process is contained below in Figure 6.3.

Figure 6.3: Typical AutoCAD screenshot in determining curve radius

6.2.4. Advisory Speed Determination

The method for determining the advisory speed will be that discussed in Section 2.1.3.6. This method requires use of actual vehicle speed, thus this was determined for the survey vehicle, a 2006 Ford Falcon utility. This process involved averaging the time taken to travel a 1 km straight at various speeds, to determine the actual travel speed. Results for this test are contained in Appendix 11.20. It is the actual travel speeds that are used in the determination of advisory speed limits.

As discussed in Section 2.1.3.6, the ball bank indicator device shall be used in determining advisory speeds on horizontal curves. The device is setup on the dashboard of the survey vehicle, as shown below in Figure 6.4, with readings recorded during the survey.

Figure 6.4: Ball bank indicator in survey vehicle

6.3. Site 1: 336 Clifton-Leyburn Road

6.3.1. Site Background

Clifton-Leyburn Road is a State Controlled Road linking the township of Clifton to the locality of Leyburn. In general, the topography of this area is that of open floodplains, with some rolling hills, prevalent with expansive black clay soils.

The crash site itself is located approximately 4.3 km west of Clifton, at the Kings Creek crossing of Aides Bridge and intersection with the council managed Terra Bella and Mount Molar Roads. This site is subject to approximately 700 vehicles per day of high-speed traffic (TMR, 2010). Approximately 18.1% of this traffic is that of commercial vehicles, with 23 m B-Doubles permitted access (TMR, 2011). The Crash Incident Report for this single-vehicle crash and an aerial photograph of the site, Figure 6.5, are contained below.

Unit 1 was travelling east from Ernst Rd, Back Plains to Clifton on the Clifton-Leyburn Rd. As unit 1 approached 408 Clifton-Leyburn Rd the vehicle lost control, swerved into the oncoming land and skidded sideways off the road into a tree (TMR, 2006)

Figure 6.5: Crash site 1 at Clifton-Leyburn Road (TRC, 2011)

6.3.2. Road Characteristics

A site inspection was conducted on 3 August 2011 to assess this section of Clifton-Leyburn Road. Presently, the site is a two-lane, two-way bitumen sealed road. A sweeping curve of approximately 300 m length leads to Aides Bridge when travelling east. Due to the nature of the expansive soils at this location, the road is very much out of shape; rutted outer wheel paths and large depressions are widespread. In an attempt to mitigate the issue, asphaltic concrete has been applied to these ruts and depressions. The road reserve is open, with only a few large trees present. Geometric plans obtained from TMR for the design of Crash Site 1 were limited, thus the geometric road characteristics were measured through onsite and desktop inspections. A summary of these findings are contained below in Table 6.1.

Road Characteristic		336 Clifton-Leyburn Road
Design Speed and traffic makeup		100 km/h speed limit, 714 vpd, 18.1% CV
Horizontal curves	Geometry	One horizontal curve; 480 m radius, 300 m length, right-hand curve
	Ball bank indicator readings (survey speed 86.7 km/h)	Travelling East: 6 Travelling West: 4

Vertical curves		There is a subtle grade of 0.8% leading into the bridge from the eastern side. The approach from the western end is relatively flat.
Intersections	Priority and layout	Terra Bella Road: very low traffic, gravel road, standard T intersection located on outside of horizontal curve eastern side of Kings Creek Mount Molar Road: low traffic, bitumen road, standard T intersection, located on western side of Kings Creek
	Visibility	Terra Bella Road: sight distance is approximately 298 m and 982 m looking east and west respectively Mount Molar Road: sight distance is approximately 377 m and 836 m looking east and west respectively
Cross section	General	Two-lane, two-way, bitumen sealed road
	Lane widths	3.4 m (curve) 3.0 m (bridge)
	Shoulder widths	0.5 m (curve) 0.5 m (bridge)
	Crossfall	approximately 1.5% (typical section) approximately 2.1% (superelevation, average)
Access control		N.A.
Parked vehicles		N.A.
Road furniture	Signage	- No warning signs installed regarding geometry of road - No warning signs installed regarding reduced width on bridge - No warning signs installed regarding side road junctions - D4-Q02 Guardrail Hazard Markers installed on exposed extremities of guardrail - G9-21 ROAD SUBJECT TO FLOODING Indicators show depth located approximately 200 m east of Kings Creek - No flood depth indicators present - Road name signs installed on Terra Bella Road and Mount Molar Road
	Guideposts	Spaced approximately 25 m on inside and outside of curve
	Guardrail/barriers	Installed on Kings Creek bridge, approaches recently repaired due to December/January flooding event
	Linemarking	Centreline marking is provided, however in poor condition; it is faded, and in places covered over by asphalt, thus in need of maintenance.
Miscellaneous issues		The road surface is significantly out of shape

Table 6.1: Summary of 336 Clifton-Leyburn Road site inspection

Sight distance and clear zone appear reasonable, as conveyed in Figure 6.6 and Figure 6.7. There are presently no warning signs for the impending horizontal curve and bridge from either approach, thus a check shall be made to ensure this is correct.

Figure 6.6: Crash site 1 Clifton-Leyburn Road looking north-west

Figure 6.7: Crash site 1 Clifton-Leyburn Road looking south-east

6.3.3. Comparison Against Standards

The geometric and road furniture features of Crash Site 1 shall be compared against Austroads' Guide to Road Design Part 3 and TMR's MUTCD respectively.

6.3.3.1. Operating Speed

Provisions within Austroads' Guide to Road Design enable road designers to estimate the operating speed of road segments. Crash Site 1 is regarded as a High Speed Rural Road (Austroads, 2010) by definition that it is being designed for an operating speed in excess of 90 km/h. A quick calculation using the Operating Speed Model (Austroads 2010, p. 17) will be conducted for Crash Site 1 to predict the operating speed. Appendices 11.11 and 11.12 contain the charts necessary to perform this estimation.

The straights leading into Crash Site 1 are both long enough (i.e. greater than 2.5 km) to ensure approaching traffic will be travelling at or close to the legal speed limit of 100 km/h. Reference to Appendix 11.13 shows that for a curve of radius 480 m, the estimated operation speed is approximately 105 km/h. Applying this knowledge to Figure 6.8 calculates the curve as being acceptable.

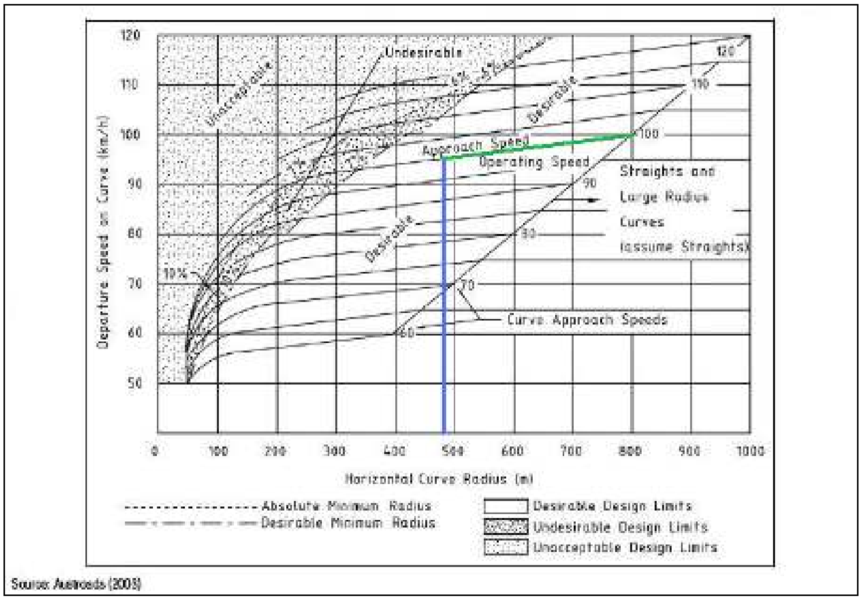


Figure 6.8: Clifton-Leyburn Road speed estimation on curve (Austroads 2010, p. 20)

6.3.3.2. Traffic Lane Widths

Austroads' guidelines recommend a total seal width of 7.2 m, for two-lane, two-way rural roads. There is no requirement for curve widening, due to the relatively large radius present. The width of Clifton-Leyburn Road at Crash Site 1 is significantly less than that recommended by Austroads at 6.8 m.

In terms of bridge lane widths, Austroads states 'traffic lane and shoulder widths provided on the bridge should not be less than the widths provided on the approach roadway' (Austroads 2010, p. 211). In the case of Crash Site 1, this recommendation is not met.

TMR also offer guidance in selecting bridge lane widths, with summarised results contained in Table 6.2. For the expected 20 year AADT, a total carriageway width of 8.5 m is recommended.

Bridge		Two Way								One Way			
		Two Lane				Single Lane				Two Lane			
Length	AADT	Shldr	Lanes	Shldr	Width	Shldr	Lane	Shldr	Width	Shldr	Lanes	Shldr	Width
Any	<100	1.0	6.0	1.0	8.0	0.6	3.0	0.6	4.2	-	-	-	
Any	100-500	1.0	6.0	1.0	8.0	2.0	3.0	1.0	6.0	-	-	-	
Any	500-1000	1.0	6.5	1.0	8.5	2.0	3.25	1.0	6.25	-	-	-	
<20	1000-2000	1.5	6.5	1.5	9.5	2.0	3.25	1.0	6.25	-	-	-	
>20	1000-2000	1.0	6.5	1.0	8.5	2.0	3.25	1.0	6.25	-	-	-	
<20	>2000	2.0	7.0	2.0	11.0	2.0	3.5	1.0	6.5	2.0	7.0	1.0	10.0
>20	>2000	1.0	7.0	1.0	9.0	2.0	3.5	1.0	6.5	1.0	7.0	1.0	9.0

NOTES:

1. Wherever possible, bridge carriageway widths should equal the approach carriageway widths.
2. Use 3.0m shoulders adjacent to a barrier centreline marking or consider further widening to provide for auxiliary lane/s.
3. Add appropriate lane widths to the two lane configurations to determine multi-lane bridge widths.
4. All culverts are to be designed for full width of formation.
5. AADT's are within 20 years.
6. If a bridge is part of cycle route and/or is in a built-up area, extra shoulder width will be required to allow adequate cyclist access, and pedestrian facilities will be required.

Table 6.2: Main Roads Bridge Carriageway Widths - Other Than National Highways, (Transport and Main Roads, 2004)

6.3.3.3. Sight Distance

The following Equation 6.1 is used in calculating the SSD for Crash Site 1.

$R_T = 2.5\ s$,

$V = 100\ km/h$,

$d = 0.36$,

$a = -0.8\%$,

$$SSD = \frac{R_T V}{3.6} + \frac{V^2}{254(d + 0.01a)} = \frac{2.5 \times 100}{3.6} + \frac{100^2}{254(0.36 - 0.01 \times 0.8)}$$

$$SSD = 181.3m$$

Equation 6.1: Crash Site 1 Stopping Site Distance

This value of 176 m is well within those distances determined from the site inspections.

6.3.3.4. Curve radius and superelevation

As the alignment of the horizontal curve is set and acceptable, the degree of superelevation shall be checked. Austroads provides the following formula to calculate the necessary superelevation for a horizontal curve of given radius.

$V = 100\ km/h$,

$e_{max} = 6\%$,

R = 480 m,

$f_{max} = 0.12$,

$$e_1 = \frac{V^2 e_{\max}}{127R(e_{\max} + f_{\max})} = \frac{100^2 \times 0.06}{127 \times 480(0.06 + 0.12)}$$

$$e_1 = 5.5\%$$

Equation 6.2: Crash Site 1 Required Superelevation (linear method)

This simple calculation has shown that the superelevation at Crash Site 1 is inadequate for the predicted operating speed. In fact, the superelevation value measured onsite of approximately 2.1%, and indeed the standard crossfall of 1.5% is less than the 3% required to provide adequate surface drainage on bituminous seals (Austroads 2010, p. 31).

The formula used above in Equation 6.2 can be rearranged in order to determine the operating speed for the combination of superelevation and curve radius present at Crash Site 1.

$$V = \sqrt{\frac{e_1 127\, R(e_{\max} + f_{\max})}{e_{\max}}} = \sqrt{\frac{0.021 \times 127 \times 480(0.06 + 0.12)}{0.06}}$$

$$V = 62.0 km / h$$

Equation 6.3: Crash Site 1 Superelevation Operational Speed (linear method)

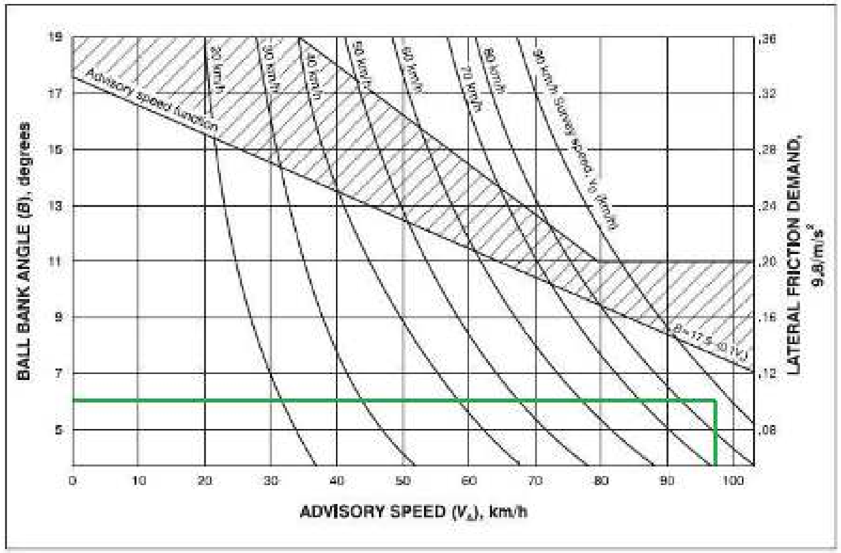
This result clearly demonstrates inadequacy of the current level of superelevation; the theoretical operating speed of the curve has been reduced by approximately 40 km/h, purely due to the inadequate superelevation.

6.3.3.5. Road Furniture

In its current state of low superelevation, the road furniture at Crash Site 1 may not be sufficient with reference to the MUTCD. Road furniture will be reviewed, including determination of curve advisory speed.

6.3.3.5.a. Advisory speed

The advisory speed for the horizontal curve at Crash Site 1 shall be determined using the method outlined in Section 2.1.3.6, requiring the ball bank indicator, with the result for Crash Site 1 contained in Table 6.1. As stated, a ball bank indicator reading of six was measured travelling east at a survey speed of 90 km/h.



NOTES:

1 The example shows an observed reading of 12 degrees at a survey speed of 70 km/h. The advisory speed is 66 km/h.

2 The graph is based on the matching of ball bank angle to advisory speed as shown in the following Table.

Ball bank angle degrees	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0
Advisory speed km/h	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25

Figure 6.9: Crash Site 1 advisory speed determination (TMR 2009, p. 153**)**

As shown, the ball bank indicator reading falls outside the limits established on the chart for the survey speed of 90 km/h. In order to achieve a reading within the limits, the survey speed would need to be increased. However this is not possible, as 90 km/h is the maximum survey speed available on this chart. Therefore, the advisory speed for this curve shall be taken as 100 km/h, the operating speed of the road.

6.3.3.5.b. Warning Signs (W Series) and Hazard Markers (D Series)

Three road characteristics may require advanced warning to motorists at the location of Crash site 1; the horizontal curve, bridge with reduced lane widths, and side road junctions of Terra Bella Road and Mount Molar Road. TMR's MUTCD provides advice on implementing these traffic management solutions.

The most common and visible traffic management solution is the use of warning signs. Appendix 11.15 contains the basic chart used to determine the type of sign required at horizontal curves. As the advisory speed of the curve is the same as that of the straight, determined from the ball bank indicator, warning signs and chevron alignment markers are not required for the horizontal curve (TMR 2009, p. 43).

The narrowing of the pavement leading into the Kings Creek crossing may also require treatment, with reference made to Clause 3.6 of the MUTCD. Although the traversable width of the bridge is not less than that of the approaches, the same treatment is advised due to the overall width of the bridge being less than 8.6 m. Therefore, edge lines and bridge width markers are necessary in accordance with Appendix 11.18. W4-1 Narrow Bridge and R6-2 No Overtaking on Bridge signs are not required in this instance.

The final geometric characteristic that may require warning sign delineation is the side road junctions of Terra Bella Road and Mount Molar Road. Section 2 of MUTCD deals with the applicable traffic management devices.

The governing variable in determining the need for intersection warning signs is the SSD. Referring to Appendix 11.19, to justify use of an intersection warning sign, the SSD must be 170 m or less. In the case of both Terra Bella Road and Mount Molar Road, the available sight distance is greater than 170 m, thus their use is not necessitated.

6.3.3.5.c. Guideposts

Guideposts are a relatively cheap method of providing delineation on road geometry. When located and spaced adequately, they provide road users with an indication of the horizontal and vertical alignment, and changes to pavement width.

The MUTCD contains guidelines on spacing guideposts on curves, attached in Appendix 11.14. With reference to the radius of 480 m present at Crash Site 1, MUTCD recommendation is 30 m spacing on the outside of the curve, and 60 m on the inside of the curve. The existing guideposts are within this recommended spacing, and therefore are adequate. Crash Site 1 regularly experiences fogs, therefore a spacing of 60 m or less is a requirement.

6.3.3.5.d. Linemarking

Longitudinal centreline marking is required throughout the length of Crash Site 1, as the AADT at this point is greater than 300 (TMR 2009, p. 117). Dividing lines and one and two direction barrier lines are required, depending on the overtaking site distance requirements. These are currently present, however are in need of re-marking.

The use of edge line marking is generally required in situations where additional delineation of the traffic lane is favoured, i.e. poor alignment or fog (TMR 2009, p. 122). The MUTCD states for pavements 6.8 m or wider, 'edge lines should be considered provided generally that a dividing line is also used' (TMR 2009, p. 35). At present, with the substandard superelevation and adjacent bridge structure, the use of an edge line would be beneficial to the safety of the road.

6.3.4. Crash Site 1 Conclusions on Causal Factors

Analysis of the geometry and road furniture of Crash Site 1 has revealed a number of deficiencies that may increase this road segment's susceptibility to crashes, specifically;

- Substandard superelevation on the horizontal curve, with respect to anticipated approach speeds;
- Generally poor state of the road surface, with ruts, depressions and bumps prominent leading up to and through the horizontal curve; and
- A lack of crossfall throughout the road segment.

Although Crash Site 1 does not currently meet geometric road design standards, it is not in an unacceptable condition from the perspective of a road user. Currently the horizontal and vertical alignments are satisfactory, with the main deficiency relating to the pavement crossfall, superelevation and general poor state of the road surface. As a result, it is difficult to identify geometric road features as being the major contributor to crashes at this location; human and vehicular factors would almost certainly play a significant role in crashes.

The superelevation is the major geometric deficiency; therefore, it would be possible to upgrade Crash Site 1 to an acceptable standard at relatively low cost.

6.3.5. Recommendations for Implementation

There is one main remedial solution for the road segment which would be to upgrade the surface of the road to the necessary degree of superelevation, while removing the ruts and depressions located on the curve.

This solution would either involve road reconstruction or application of an asphaltic overlay to the existing road segment, particularly through the horizontal curve. This action would have the combined impact of regaining suitable superelevation, as well as improving the state of the road surface for ride quality and drainage purposes.

6.4. Site 2: 332 Pittsworth-Felton Road

6.4.1. Site Background

Pittsworth-Felton Road is a two-lane, two-way, road linking the town of Pittsworth to Toowoomba-Karara Road, at the locality of Felton. The landscape that Pittsworth-Felton Road traverses is slightly more undulating than similar roads in the region. Traffic counts for this road reveal an AADT of 407 vpd, with approximately 17.6% being commercial vehicles (TMR, 2008). TMR (2011) allows multi-combination vehicles up to 25 m B-Doubles passage on Pittsworth-Felton Road. The analysis of crash rates determined previously revealed Pittsworth-Felton Road's annual crash rate of 123.5 crashes per 100 million VKT, ranking it third out of the classified roads in the survey area.

The crash location identified on Pittsworth-Felton Road is the intersection with Broxburn Road, a council maintained gravel road that acts as a shortcut from the Gore Highway. Although Broxburn Road itself is unsealed, the intersection is a large sealed area, designed to be suitable for large multi-combination vehicle movements. This intersection is located midway on a 400 m long sweeping curve on Pittsworth-Felton Road. An aerial photograph of the intersection is located in Figure 6.10 below.

Figure 6.10: Crash Site 2 at Pittsworth-Felton Road (TRC, 2011)

This location has been subject to a number of crashes over the years, including a motorcycle crash fatality in 2007, and a truck rollover in 2009 (TMR, 2011). Plans retrieved from TMR for this location are contained in Appendix 11.24, dated from 2001 when road widening was undertaken.

6.4.2. Existing Site Conditions

A site inspection was undertaken on 9 August 2011 to determine the state of existing features of interest for this intersection. A summary of findings from this inspection are contained below in Table 6.3.

Figure 6.11: Crash Site 2 Pittsworth-Felton Road, looking east toward Broxburn Road

Figure 6.12: Crash Site 2 Pittsworth-Felton Road, looking north towards Broxburn Road

Road Characteristic	332 Pittsworth-Felton Road
Design Speed and traffic makeup	100 km/h speed limit, 407 vpd, 17.6% CV

Horizontal curves	Geometry	There is a sweeping bend located within the section identified; approximately 200 m radius, 280 m length, right-hand curve
	Average ball bank indicator reading (survey speed 86.7 km/h)	Travelling east: 9 Travelling west: 11
Vertical curves		Leading into the right-hand curve is a downhill grade of approximately 2.8% for 540 m Leading out of the right-hand curve is an uphill grade of approximately 1.9% for 170 m
Intersections	Priority and layout	Broxburn Road: Ch 5.88, low-medium traffic, sealed road, standard T intersection located on outside of right-hand, horizontal curve
	Visibility	Broxburn Road: sight distance is good, approximated at 280 m to the west and 260 m to the east
Cross section	General	Two-lane, two-way, bitumen sealed road
	Lane widths	3.0 m (straight) 3.0 m (curve)
	Shoulder widths	1.0 m (straight) 1.0 m (curve)
	Crossfall	approximately -3.0% (typical section) approximately 3.0% (superelevation)
Access control		N.A.
Parked vehicles		N.A.
Road furniture	Signage	East bound lane; - W5-11 Crest, Ch 5.19 - W1-3(R) Curve 80 km/h, Ch 5.595 - W2-4(L) Side Road Junction, Ch 5.65 - D4-6 Chevron Alignment Markers, Ch 5.75-6.03 - D4-3 Width Markers located on extremities of box culvert West bound lane; - W2-4 (R) Side Road Junction, Ch 6.1 - W1-3 (L) Curve 80 km/h, Ch 6.16
	Guideposts	Spaced of approximately 30 m and 11 m on outside and inside of curve respectively
	Guardrail/barriers	N.A.
	Linemarking	Centreline marking is provided, however is quite faded, particularly at the intersection with Broxburn Road.

Miscellaneous issues	Large box culvert located mid-corner after Broxburn Road

Table 6.3: Summary of 332 Pittsworth-Felton Road site inspection

6.4.3. Comparison Against Standards

Crash Site 2 of Pittsworth-Felton Road shall also be compared against the relevant Austroads and TMR standards.

6.4.3.1. Operating speed

Once again, the Operating Speed Model defined by Austroads will be used in estimating the operating speed of this road segment. This process will be relatively simple as there is only one horizontal curve within the road section of interest.

Referring to Austroads Section Operating Speed, contained in Appendix 11.13, a single curve radius of 200 m has a potential section operating speed of approximately 80 km/h. Both approaches to this curve are straights over 2.5 km in length and can be assumed to have an operating speed of 100 km/h as a result. Applying this information to Figure 6.13 below reveals that this curve is unacceptable in relation to its operating speed.

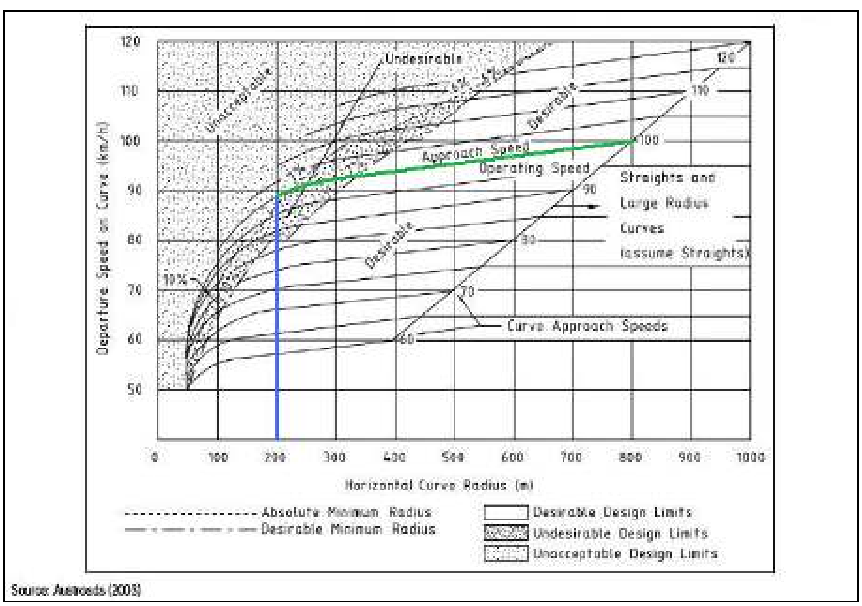


Figure 6.13: Crash Site 2 speed estimation on curve (Austroads 2010, p. 20)

The same Austroads chart can be used to determine the required curve radius to meet operating speed requirements for Crash Site 2. To remain within the desirable zone at approach speeds of 100 km/h, a horizontal curve radius of approximately 340 m is necessary. This value is significantly greater than that already existing.

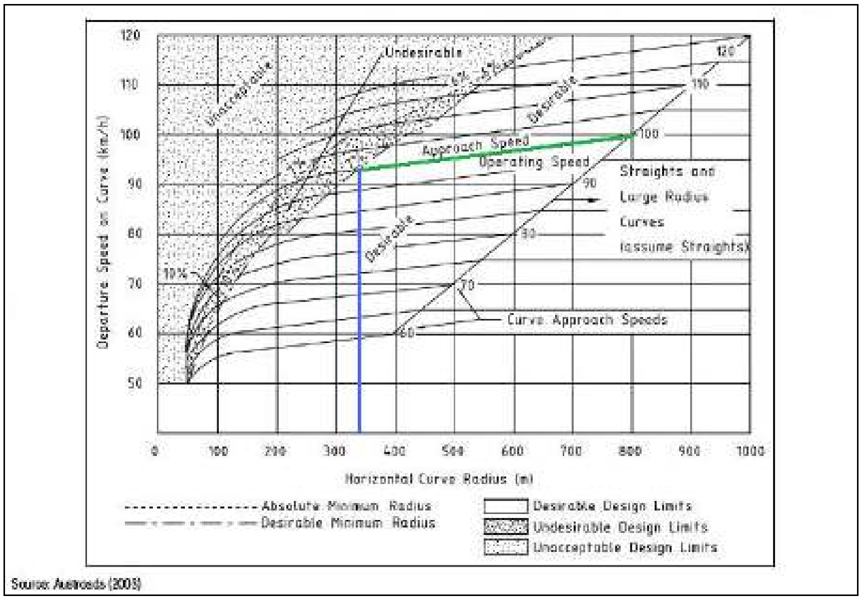


Figure 6.14: Crash Site 2 radius required to meet operating speed requirements (Austroads 2010, p. 20)

6.4.3.2. Traffic lane widths

The recommended traffic lane widths for the traffic volumes expected on Pittsworth-Felton Road is 2 × 3.1 m lanes, with 1.5 m shoulders (0.5 m sealed) either side. As B-Double trucks are allowed access through this segment, curve widening of 0.45 m must also be applied, totalling the sealed carriageway width to 7.65 m.

The existing lane and shoulder widths total 8.0 m through the straight and curves, and therefore are within the recommended values.

6.4.3.3. Sight distance

The SSD can be determined using the procedure outlined in Section 2.1.2.6, Equation 6.4.

$R_T = 2.5\ s$,

$V = 100\ km/h$,

$d = 0.36$,

$a = -2.8\%$,

$$SSD = \frac{R_T V}{3.6} + \frac{V^2}{254(d + 0.01a)} = \frac{2.5 \times 100}{3.6} + \frac{100^2}{254(0.36 - 0.01 \times 2.8)}$$

$$SSD = 188.0m$$

Equation 6.4: Crash Site 2 Stopping Site Distance

6.4.3.4. Curve radius and superelevation

The horizontal alignment of Pittsworth-Felton Road has been found to be unacceptable in terms of its operating speed, but a check on its relationship with superelevation and operating speed shall be conducted using Austroads' linear method.

The first check will determine the operating speed the current curve radius and superelevation combination is able to support, by rearranging the linear method equation, and using values reported in the TMR plans. The values of e_{max} and f_{max} are determined using an operational speed of 100 km/h, that of the approach tangents.

$e_1 = 3.0\%$,

$R = 200$ m,

$e_{max} = 6.0\%$,

$f_{max} = 0.12$,

$$V = \sqrt{\frac{e_1 127 R(e_{\max} + f_{\max})}{e_{\max}}} = \sqrt{\frac{0.03 \times 127 \times 200(0.06 + 0.12)}{0.06}}$$

$$V = 47.8 km/h$$

Equation 6.5: Crash Site 2 existing operational speed (linear method)

This operational speed is substantially below that of the approaches, and proves that the existing combination of curve radius and superelevation is not suitable for this application. This analysis will be repeated to determine the extent of superelevation required, if possible, to enable operation at 100 km/h, Equation 6.6.

$V = 100$ km/h,

$e_{max} = 6.0\%$,

$R = 200$ m,

f_{max} = 0.12,

$$e_1 = \frac{V^2 e_{\max}}{127R(e_{\max} + f_{\max})} = \frac{100^2 \times 0.06}{127 \times 200(0.06 + 0.12)}$$

$$e_1 = 13.1\%$$

Equation 6.6: Crash Site 2 superelevation requirement for 100 km/h operation (linear method)

These calculations have proven that 100 km/h operation around this curve is not possible within the confines of the Austroads guidelines, and that the current superelevation is not sufficient to meet the operational speed requirements. A check follows on the extent of superelevation required for 80 km/h operation, Equation 6.7, the speed identified in Section 6.4.3.1 capable of support from a 200 m radius curve.

V = 80 km/h,

e_{max} *= 7.0%,*

R = 200 m,

f_{max} *= 0.13 (desirable max for trucks)*

$$e_1 = \frac{V^2 e_{\max}}{127R(e_{\max} + f_{\max})} = \frac{80^2 \times 0.07}{127 \times 200(0.07 + 0.13)}$$

$$e_1 = 8.8\%$$

Equation 6.7: Crash Site 2 superelevation requirement for 80 km/h operation (linear method)

Equation 6.7 has again shown that the curve on Pittsworth-Felton Road is substandard, requiring 8.8% superelevation to maintain a safe operating speed of 80 km/h, which itself is not sufficient when compared against the Operating Speed Model in Section 6.4.3.1. This required superelevation value is also greater than the maximum allowable (7%) for this location.

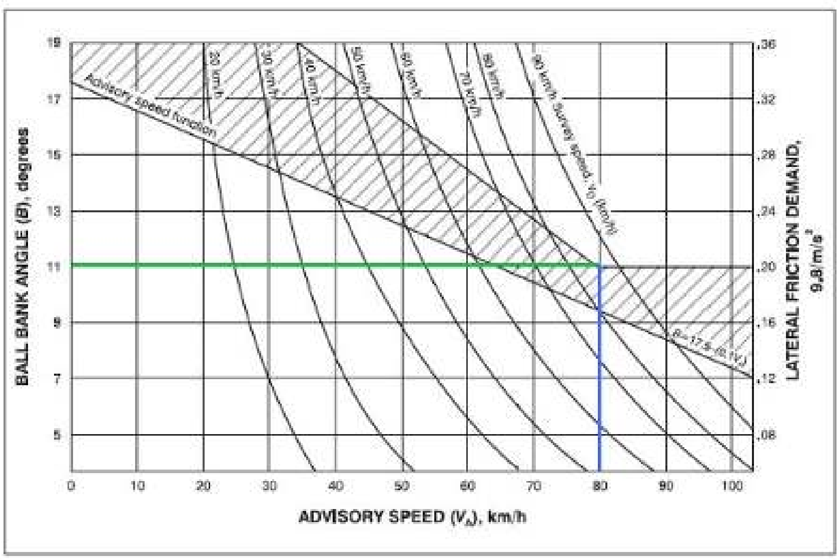
6.4.3.5. Road furniture

The preceding analysis of the geometric aspects of Crash Site 2 has revealed substandard design in a number of areas. As a result, the amount and type of road furniture must be sufficient to warn road users of unexpected road features.

6.4.3.5.a. Warning signs (W series) and Hazard markers (D series)

Warning signs may be necessary at Crash Site 2 for the horizontal curve and Broxburn Road intersection. As identified during the site inspections, there are currently Curve signs with an advisory speed of 80 km/h at either end of the horizontal curve, along with signs warning of the side road junction with Broxburn Road.

Firstly, the advisory speed for Crash Site 2 shall be determined, following the requirements of the MUTCD. The onsite inspection revealed a maximum ball bank indicator reading of 11 travelling west, at a survey speed of 86.7 km/h. By plotting these results onto TMR's advisory speed determination chart, Figure 6.15 below, results in an advisory speed of 80 km/h.



NOTES:

1 The example shows an observed reading of 12 degrees at a survey speed of 70 km/h. The advisory speed is 66 km/h.

2 The graph is based on the matching of ball bank angle to advisory speed as shown in the following Table:

Ball bank angle degrees	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0
Advisory speed km/h	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25

Figure 6.15: Crash Site 2 advisory speed determination (TMR 2009, p. 153)

For an advisory speed of 80 km/h, and with traffic approaching the curve at approximately 100 km/h, the MUTCD recommends use of a Curve warning sign. This finding supports the current curve warning signs located at Crash Site 2.

Side Road Junction warning signs are required where the SSD to the intersection is 170 m or less, when the approach speed is 91-100 km/h (TMR 2009, p. 23). Therefore, Side Road Junction warning signs are not required at Crash Site 2 when considering SSD, and it can only be assumed that the road authority considered the Broxburn Road intersection needing such warning for other reasons.

6.4.3.5.b. Guideposts

Guideposts are used to delineate horizontal curvature. TMR's MUTCD recommends spacing guideposts at 30 m and 15 m, on the inside and outside of the curve respectively, on a horizontal curve of radius 200 m (TMR 2009, p. 38). Presently, Crash Site 2 has guideposts spaced at or closer than the recommendations of the MUTCD, and therefore is deemed acceptable.

6.4.3.5.c. Linemarking

A dividing line is required through Crash Site 2 as the AADT is greater than 300 vpd, and the width of seal is greater than 5.5 m (TMR 2009, p. 117). This is currently the case at Crash Site 2, with the dividing line being of double barrier type, but is in need of re-marking.

Edge lines are employed to delineate the traffic lanes, particularly on narrow pavements and curves, making driving easier. There are currently no edge lines present at Crash Site 2, however these 'should be considered' (TMR 2009, p. 35).

6.4.4. Conclusions on Causal Factors

Analysis of the geometry and road furniture of Crash Site 2 has revealed a number of deficiencies that may increase this road segment's susceptibility to crashes, specifically;

- the operating speed of the horizontal curve is substandard when the approach speeds of the adjacent straights are considered
- the degree of superelevation is insufficient to enable safe operation at the desired speed
- the location of the Broxburn Road intersection mid-curve is not ideal for exiting traffic

It would appear that the insufficiencies in regard to the operating speed would influence this sites susceptibility to crashes. The main issue for a driver would be the unexpected reduction in speed required to traverse safely the horizontal curve. However, having driven this road segment a number of times it is important to note that the current alignment is not entirely insufficient, when considering the road furniture provided for an uninitiated driver. The road furniture, specifically the CAMs and linemarking, delineate the alignment of the curve satisfactorily, allowing a driver to make the necessary adjustments while traversing it. The current state of the pavement and road surface is good and there is good sight distance through the curve. These facts make it difficult to identify singularly the road geometry as contributing to the crashes identified, despite the site discrepancies with the Austroads guidelines.

Crash Site 2 does not meet these geometric constraints due mostly to the limited room within the road reserve for position of the horizontal alignment, the governing factor being operating speed. Therefore, to upgrade this segment to a standard that befits the desired operating speed would involve considerable cost associated with land resumptions and road construction.

6.4.5. Recommendations for Implementation

To upgrade this segment of Pittsworth-Felton Road to Austroads' recommendations (i.e. operating speed), requires realignment of the horizontal geometry. The radius of the curve needs to increase to a value of approximately 340 m in order to meet minimum operating speed requirements. To accomplish this would require substantial construction work, including some land resumptions, resulting in an expensive exercise; the centreline of Pittsworth-Felton Road at this location requires offsetting over 20 m for a 340 m radius.

Considering the number of crashes that have occurred at this location over the survey period, improving the horizontal geometry to this standard may not be justified by the road authorities. The state of the existing road surface and pavement are reasonable, and considering this segment was constructed approximately only 10 years ago, would further reduce the road authorities preference for a new construction. A more cost effective solution is to improve and maintain the road furniture present at the site to levels defined in the analysis, specifically;

- reapplying linemarking to the road segment, including a double barrier centreline and edge lines
- regular maintenance and replacement of warning signs, CAM and guideposts

Although this solution may not improve the state of the road, the application of a greater standard of road furniture will aid driver awareness prior to and through this road segment.

A further option may be to employ a reduced standard, provided by Austroads' EDD values. However, this is beyond the scope of this project.

6.5. Site 3: 331 Toowoomba-Karara Road

6.5.1. Site Background

Toowoomba-Karara Road is a major road link that heads south from the Gore Highway, Drayton, towards Karara, a small village located on the Cunningham Highway. It is a major route for traffic heading south into New South Wales from areas surrounding Toowoomba, and vice versa. The landscape around Toowoomba-Karara Road varies greatly along its length, from the small townships of Wyreema and Cambooya, rural residential areas and vast plains south of Leyburn. TMR's 2008 traffic census revealed approximately an AADT of 1,176 vehicles, 4.8% of which being commercial vehicles. Large multi-combination vehicles are not prohibited on this section of Toowoomba-Karara Road.

The crash site in question is located between the townships of Wyreema and Cambooya, where a series of horizontal curves exist. Figure 6.16, below, conveys an aerial photograph of the site in question. Seemingly, due to this geometry, a number of crashes have occurred at this site over recent years. Two such examples are included in Appendices 11.20 and 11.22. The attending Police officers at these crashes identified speed and slippery conditions as possible contributing factors; however, an investigation into whether road geometry may have played a part follows.

Figure 6.16: Crash Site 3 at Toowoomba-Karara Road (TRC, 2011)

6.5.2. Existing Site Conditions

A site inspection was conducted on 3 August 2011 to evaluate the existing standard of the road section, with a summary of findings included in Table 6.4 below. There are a series of varying radii horizontal curves, including both reverse and broken back types, for a length of approximately 3.7 km. While the overall vertical grades of the road are relatively minimal, there are a number of floodways present, that include dips and crests throughout, some of which occur mid-corner.

The series of corners are currently signed with W1-3 Curve, W1-4 Reverse Curve and W1-5 Winding Road signs, with an advisory speed limit of 70 km/h consistent throughout. Travelling through this road segment at this speed is comfortable, however judging by the speed of passing vehicles witnessed during the site inspection, road users may not abide by this advisory speed limit.

For the purpose of the investigation, each of the horizontal curves will be numbered in order of chainage.

Road Characteristic		331 Toowoomba-Karara Road
Design Speed and traffic makeup		100 km/h speed limit, 1,176 vpd, 4.8% CV
Horizontal curves	Geometry	Within the section identified there are seven curves, in order and relative to direction of chainage; 1) 215 m radius, 190 m length, left-hand curve

		60 m straight 2) 240 m radius, 360 m length, right-hand curve 350 m straight 3) 130 m radius, 120 m length, left-hand curve 230 m straight 4) 170 m radius, 90 m length, left-hand curve 170 m straight 5) 300 m radius, 380 m length, right-hand curve 170 m length 6) 390 m radius, 565 m length, left-hand curve 190 m straight 7) 870 m radius, 570 m length, right-hand curve
	Average ball bank indicator readings (survey speed as shown in km/h)	1, 77.7) Travelling south: 10, travelling north: 6 2, 86.7) Travelling south: 10, travelling north: 12 3, 77.7) Travelling south: 12, travelling north: 10 4, 77.7) Travelling south: 13, travelling north: 8 5, 86.7) Travelling south: 5, travelling north: 9 6, 86.7) Travelling south: 8, travelling north: 4 7, 86.7) Travelling south: 0, travelling north: 4
Vertical curves		Although the overall vertical grades of the road segment are relatively low, there are a number of minor sags and crests that may affect vehicle handling, specifically at chainages 8.007, 9.004 and 9.530.
Intersections	Priority and layout	Loves Road: Ch 8.25, low traffic, sealed road, standard T intersection located on outside of second (right-hand) horizontal curve Frank Road: Ch 9.693, low traffic, gravel road, standard T intersection, located on outside of fifth (right-hand) horizontal curve
	Visibility	Loves Road: sight distance is approximately 390 m and 160 m looking north and south respectively Frank Road: sight distance is approximately 613 m and 237 m looking north and south respectively
Cross section	General	Two-lane, two-way, bitumen sealed road
	Lane widths	3.5 m (straight) 3.7 m (curve)
	Shoulder widths	0.5 m (straight) 1.0 m (curves)
	Crossfall	approximately 3.0% (typical section) 1) approx. 5.4%

		2) approx. 4.7% 3) approx. 3.8% 4) approx. 5.8% 5) approx. 2.7% 6) approx. 3.6% 7) approx. 1.9%
Access control		N.A.
Parked vehicles		N.A.
Road furniture	Signage	Southbound lane; - W1-5 Winding Road, Ch 7.68 - W1-4 (L) Reverse Curve 70 km/h, Ch 7.78 - W5-7 Floodway, Ch 7.88 - W2-4 (L) Side Road Junction, Ch 8.14 (Loves Road) - W1-3 (R) Curve 70 km/h, Ch 8.745 - W5-7 Floodway, Ch 8.905 - W1-3 (L) Curve 70 km/h, Ch 9.185 - W5-7 Floodway, Ch 9.425 - W6-3 Children, W8-Q03 Bus Stop, Ch 9.45 - W1-3 (R) Curve, Ch 9.475 - W2-4 (L) Side Road Junction, Ch 9.58 (Frank Road) Northbound lane; - W1-3 (L) Curve, Ch 10.22 - W6-3 Children, W8-Q03 Bus Stop, Ch 9.9 - W2-4 (R) Side Road Junction, Ch 9.79 (Frank Road) - W5-7 Floodway, Ch 9.645 - W1-3 (R) Curve 70 km/h, Ch 9.51 - W1-3 (R) Curve 70 km/h, Ch 9.2 - W1-4 (L) Reverse Curve 70 km/h, Ch 8.755 - W2-4 (R) Side Road Junction, Ch 8.36 (Loves Road) - W5-7 Floodway, Ch 8.11 - R4-1 80 km/h, Ch 7.89
	Guideposts	Located at spacing of approximately 10-30 m and 10-20 m on outside and inside of curve respectively
	Guardrail/barriers	N.A.
	Linemarking	Centreline and edge line marking is provided, and in generally good, visible condition.
Miscellaneous issues		Floodways located mid-corner at Ch 8.007 and 9.004 could adversely affect car handling

Table 6.4: Summary of Crash Site 3 inspection

Figure 6.17: Crash Site 3 Toowoomba-Karara Road looking south, dip mid-corner

Figure 6.18: Crash Site 3 Toowoomba-Karara Road, crest leading into horizontal curves

6.5.3. Comparison Against Standards

Plans obtained from TMR Toowoomba contain a typical cross-section for a length of the segment of concern. A copy of this plan is attached in Appendix 11.23. All other geometric features were measured during site inspection.

6.5.3.1. Operating speed

An estimation of operating speed is again the first step in the analysis, using Austroads Operating Speed Model. Unlike the situation at Clifton-Leyburn Road and Pittsworth-Felton Road, Toowoomba-Karara Road has a series of curves between the straight sections, and therefore a more comprehensive calculation is required. Austroads (2010, p. 242) provides an example on such a calculation, which shall be followed in this analysis.

The first check is to determine the desired operating speed. Austroads (2010) makes provision for this, with the table of values repeated in Figure 6.19. Here it is seen that for a curve radius range of 150-500 m, applicable to this section of Toowoomba-Karara Road, the desired operating speed should be 110 km/h for flat terrain. This, however, is not possible, due to the constrictive nature of the road reserve at this location, and thus a thorough investigation follows, utilising the Operating Speed Model defined in Austroads (2010).

Approximate range of horizontal curve radii (m)[1]	Desired speed (km/h)[2,3] terrain type			
	Flat	Undulating	Hilly	Mountainous
Less than 75	–	–	75	70
75 – 300	–	90	85	80
150 – 500	110	100 – 110	95	90
over 300 – 500	110	110	–	–
over 600 – 700	110 – 120	–	–	–

1. Value selected as representative of the road section's general geometric standard. These are not to be used as design values.
2. Desired speed as a function of overall geometric standard and terrain type. It is the speed regarded as acceptable to most drivers in the particular environment, and represented by the 85th percentile speed on unconstrained sections, e.g. straights, curves with radii well above those listed.
3. On roads with a speed limit < 100 km/h, the desired speed is typically equal to the speed limit + 10 km/h.

Figure 6.19: Typical desired speed for rural roads (Austroads 2010, p. 16)

The Operating Speed Model requires the alignment be grouped according to curve radii range, as per Appendix 11.13. In the case of Toowoomba-Karara Road, the segment is divided into three sections, defined by Table 6.5 below. Austroads (2010) considers only straights greater than 200 m separate sections.

Section No.	Curve/ Straight No.	Radii (m)	Straight (m)	Radii Range (m)	Section Operating Speed (km/h)
1	C1, C2	215, 240	-	200-310	86
2	S1	-	350	-	-
3	C3	130	-	130	71
4	S2	-	230	-	-
5	C4	170	-	170	76
6	C5, C6	300, 390	-	295-415	96
7	C7	870	-	500+	110

Table 6.5: Separation of Crash Site 2 into sections

For this analysis, it shall be assumed that the pavement condition and crossfall remain constant throughout the road segment. The initial estimate of operating speed will run in numerical order of the sections, i.e. from north to south. The approach speeds at either end of the road segment are determined from Austroads (2010, p. 19) Acceleration on Straights chart. It is assumed that the exit speed from the previous low speed intersections is 40 km/h, with northern and southern approach lengths of 1 km and 1.3 km respectively. Results for the approach speed are contained in Figure 6.20 and Figure 6.21.

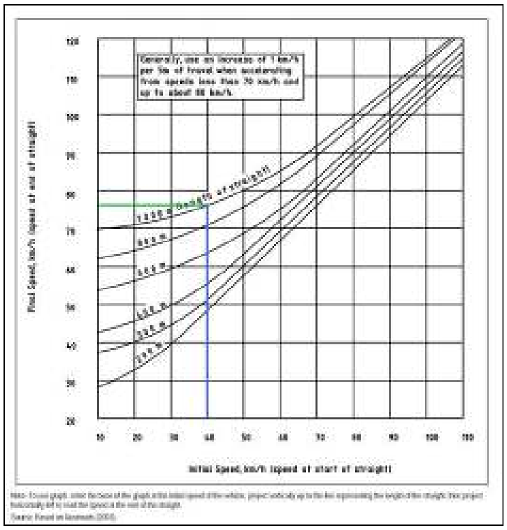


Figure 6.20: Northern approach speed (76 km/h)

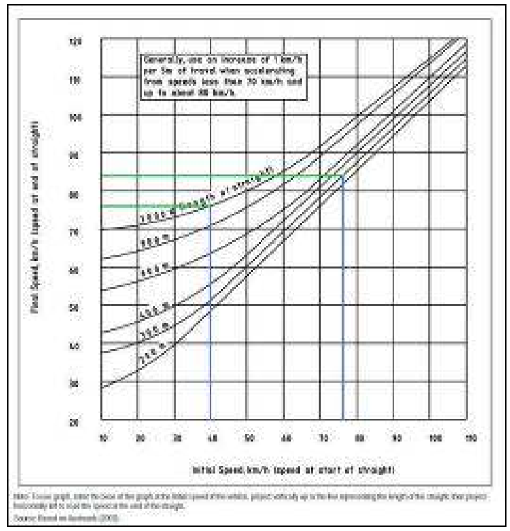


Figure 6.21: Southern approach speed (84 km/h)

The operating speed analysis now follows, with results shown in Figure 6.22 to Figure 6.26.

Where the approach speed to a section is less than the potential section operating speed, the Austroads Acceleration on Straights chart shall be used to determine the departure speed from these curves. The maximum allowable departure speed is the potential operating speed.

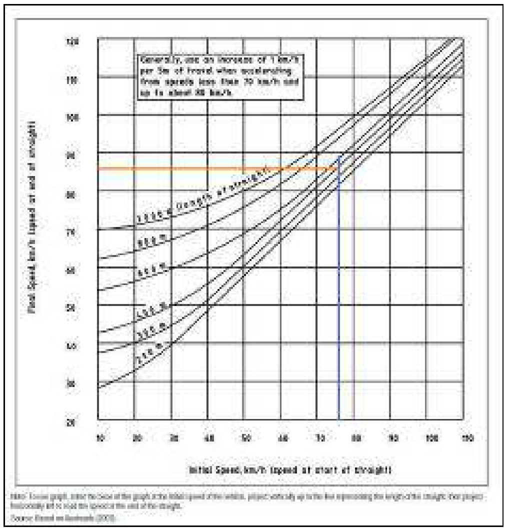


Figure 6.22: Curves 1 and 2 north-south departure speed (86 km/h)

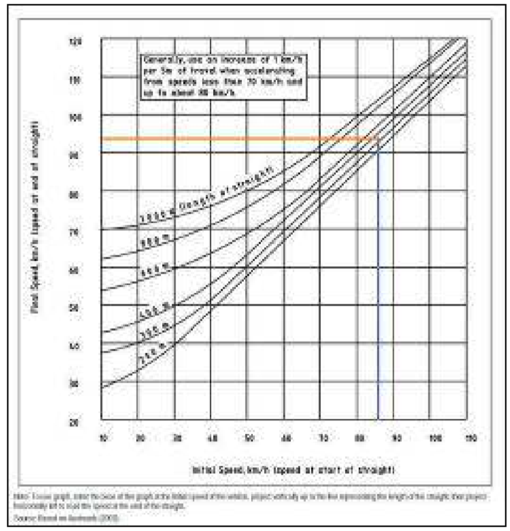


Figure 6.23: Straight 1 north-south departure speed (94 km/h)

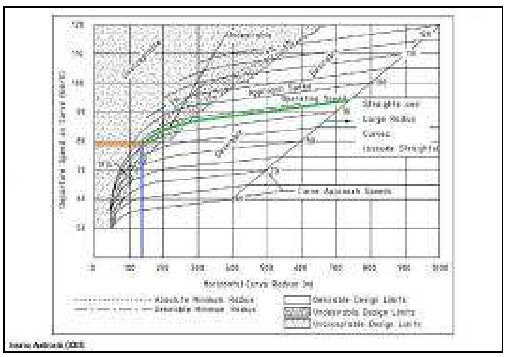


Figure 6.24: Curve 3 north-south departure speed (79 km/h): UNDESIRABLE

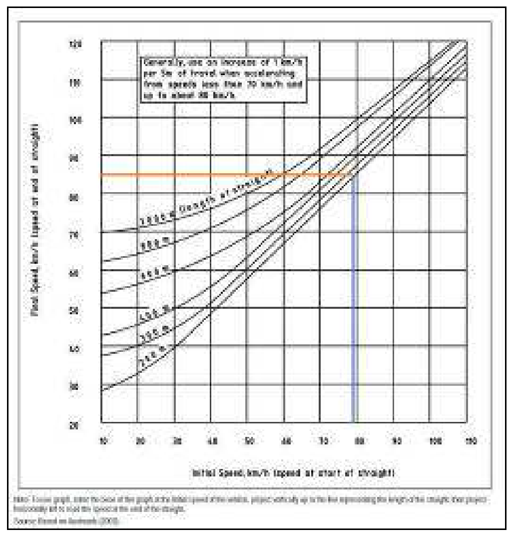


Figure 6.25: Straight 2 north-south departure speed (85 km/h)

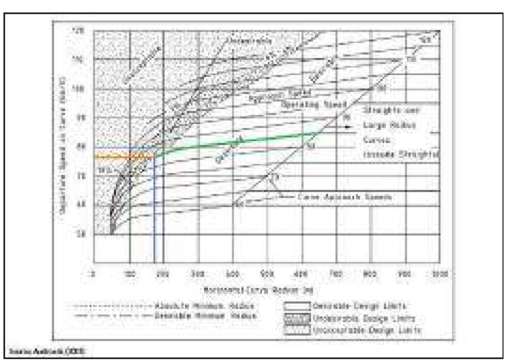


Figure 6.26: Curve 4 north-south departure speed (77 km/h): ACCEPTABLE

As Sections 5 and 6, containing Curves 5, 6 and 7, have potential operating speeds in excess of one another, operating speed will not be an issue, and hence has not been calculated.

The analysis of operating speed travelling north-south has revealed satisfactory results; only Curve 3 recorded an undesirable operating speed. Apart from Section 1, the potential operating speed of each section increases in turn, providing the satisfactory results.

The analysis procedure is repeated in the south-north direction, as follows.

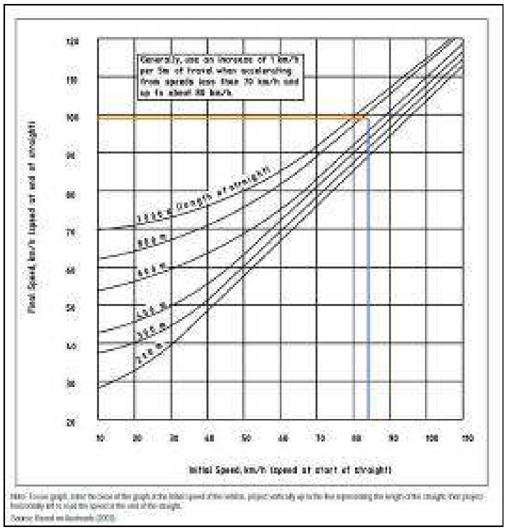


Figure 6.27: Curve 7 south-north departure speed (99 km/h)

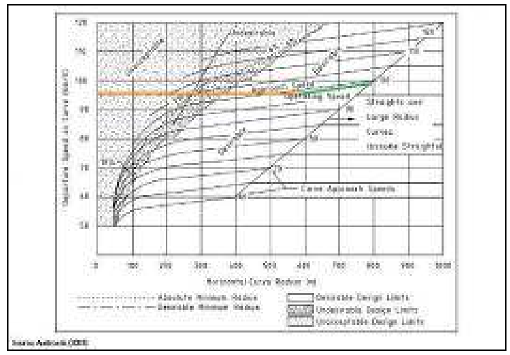


Figure 6.28: Curves 5 and 6 south-north departure speed (96 km/h): ACCEPTABLE

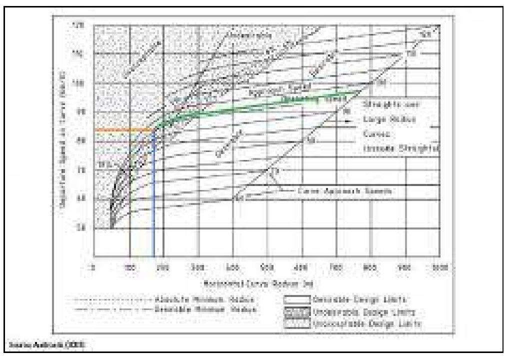


Figure 6.29: Curve 4 south-north departure speed (84 km/h): UNACCEPTABLE

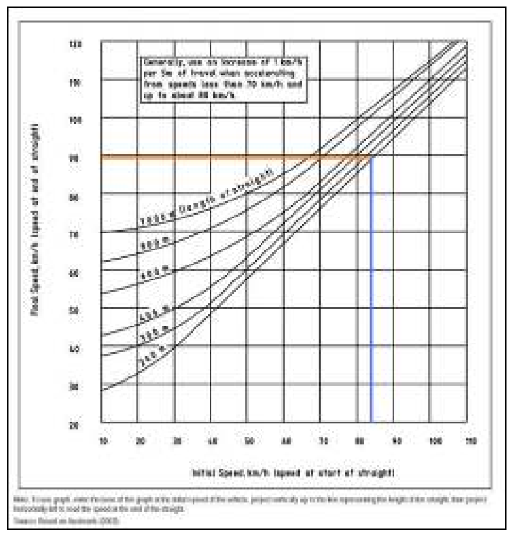


Figure 6.30: Straight 2 south-north departure speed (90 km/h)

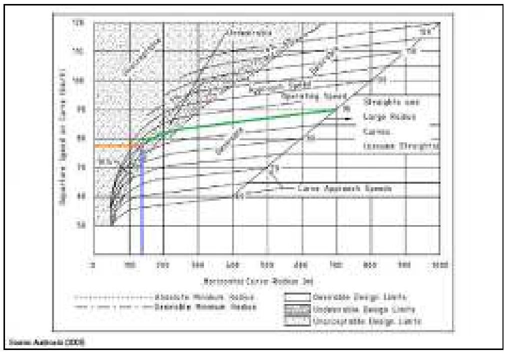


Figure 6.31: Curve 3 south-north departure speed (78 km/h): UNDESIRABLE

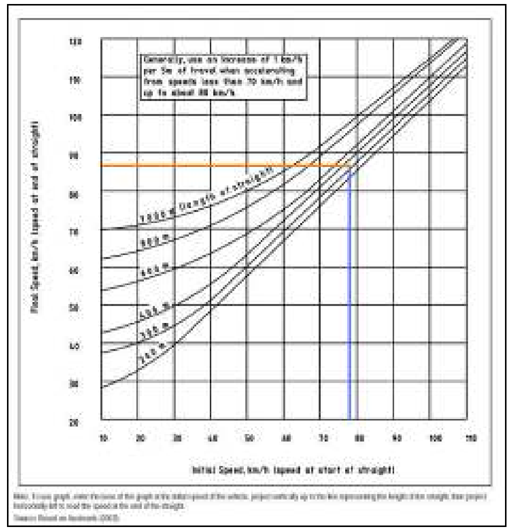


Figure 6.32: Straight 1 south-north departure speed (87 km/h)

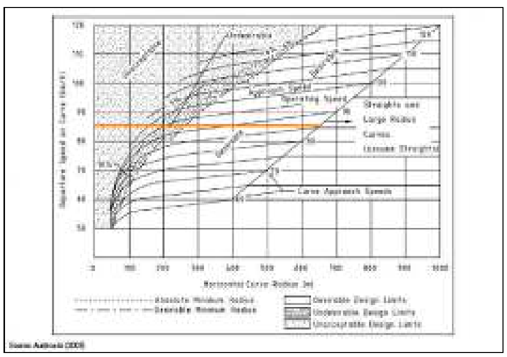


Figure 6.33: Curves 1 and 2 south-north departure speeds (86 km/h): ACCEPTABLE

The results achieved travelling south-north are significantly different to those obtained travelling north-south. In this instance Curve 4 is considered unacceptable and Curve 3 is considered undesirable. This outcome demonstrates the impact preceding road sections have on suitable operating speed, and that a consistent operating speed is desired.

Where curves are not considered satisfactory in terms of their operating speed, appropriate road furniture should be installed to warn motorists of the substandard conditions ahead. The requirements of this are discussed further in Section 6.5.3.5.

6.5.3.2. Traffic lane widths

The traffic volumes on Toowoomba-Karara Road at this location require 2 × 3.5 m traffic lanes, with 2.0 m shoulders, 1.0 m of which is sealed (Austroads 2010, p. 35). Curve radii ranging from 130 m to 870 m will require widening, as conveyed in Table 6.6. Curve widening values will be interpolated from Austroads' guidelines.

Curve No.	Radius (m)	Curve Widening (m)	Lane Width Required (m)	Existing Lane Width (m)	Pass/Fail
1	215	0.33	7.33	7.2	Fail
2	240	0.30	7.30	7.2	Fail
3	130	0.60	7.60	7.0	Fail
4	170	0.46	7.46	7.0	Fail
5	300	0.23	7.23	7.1	Fail
6	390	N.A.	7.00	7.2	Pass
7	870	N.A.	7.00	7.2	Pass

Table 6.6: Crash Site 3 curve widening requirement

This check has revealed most lane widths to be insufficient, with the exception of those in Curves 6 and 7. However, the additional lane width required is not significant, and the existing sealed shoulder width of approximately 0.5 m acts as sufficient curve widening.

6.5.3.3. Sight distance

The SSD can be determined using the procedure outlined in Section 2.1.2.6. An operating speed of 100 km/h was used in determining the SSD for Crash Site 2 to be applicable throughout, with the calculation presented in Equation 6.8.

$R_T = 2.5\ s,$

$V = 100\ km/h,$

$d = 0.36,$

$a = 0\%$

$$SSD = \frac{R_T V}{3.6} + \frac{V^2}{254(d + 0.01a)} = \frac{2.5 \times 100}{3.6} + \frac{100^2}{254(0.36 + 0.01 \times 0)}$$

$$SSD = 178.8m$$

Equation 6.8: Crash Site 3 site distance southern approach

6.5.3.4. Curve radius and superelevation

Each horizontal curve within the Toowoomba-Karara Road segment shall be analysed in terms of its combination of radius and superelevation, following Austroads linear method.

e_{exist} = 5.1%,

V = 86 km/h,

R = 215 m,

e_{max} = 7%,

f_{max} = 0.118,

$$e_1 = \frac{V^2 e_{\max}}{127R(e_{\max} + f_{\max})} = \frac{86^2 \times 0.07}{127 \times 215(0.07 + 0.118)}$$

$$e_1 = 10.1\%$$

Equation 6.9: Crash Site 3 Curve 1 required superelevation (linear method)

The required superelevation of 10.1% is significantly greater than that existing, at 5.1%. The required value is also greater than the maximum allowable, therefore this curve is not acceptable. It is also important to note that there is currently a floodway located at the midpoint of this curve, which is likely to upset vehicle handling.

e_{exist} = 4.7%,

V = 86 km/h,

R = 240 m,

e_{max} = 7%,

f_{max} = 0.118,

$$e_1 = \frac{V^2 e_{\max}}{127R(e_{\max} + f_{\max})} = \frac{86^2 \times 0.07}{127 \times 240(0.07 + 0.118)}$$

$$e_1 = 9.0\%$$

Equation 6.10: Crash Site 3 Curve 2 required superelevation (linear method)

Again, the required superelevation is greater than both the existing and allowable maximum, thus this curve is not acceptable.

$e_{exist} = 3.8\%,$

$V = 71\ km/h,$

$R = 130\ m,$

$e_{max} = 7\%,$

$f_{max} = 0.139,$

$$e_1 = \frac{V^2 e_{\max}}{127R(e_{\max} + f_{\max})} = \frac{71^2 \times 0.07}{127 \times 130(0.07 + 0.139)}$$

$$e_1 = 10.2\%$$

Equation 6.11: Crash Site 3 Curve 3 required superelevation (linear method)

The result for Curve 3 is the same as that of Curves 1 and 2; required superelevation is greater than both existing and maximum permissible, due mostly to the small curve radius. Also at this location is a floodway, crossing the curve midway through. Similar to Curve 1, this floodway would likely upset the handling and balance of a vehicle traversing the corner, and when combined with the significant substandard superelevation, could act to increase the risk of accidents.

$e_{exist} = 5.8\%,$

$V = 76\ km/h,$

$R = 170\ m,$

$e_{max} = 7\%,$

$f_{max} = 0.136,$

$$e_1 = \frac{V^2 e_{\max}}{127R(e_{\max} + f_{\max})} = \frac{76^2 \times 0.07}{127 \times 170(0.07 + 0.136)}$$

$$e_1 = 9.1\%$$

Equation 6.12: Crash Site 3 Curve 4 required superelevation (linear method)

The trend of unsatisfactory existing superelevation continues for Curve 4.

$e_1 = 2.7\%,$

$V = 96\ km/h,$

$R = 300\ m,$

$e_{max} = 6\%,$

$f_{max} = 0.116,$

$$e_1 = \frac{V^2 e_{\max}}{127R(e_{\max} + f_{\max})} = \frac{96^2 \times 0.06}{127 \times 300(0.06 + 0.116)}$$

$$e_1 = 8.2\%$$

Equation 6.13: Crash Site 3 Curve 5 required superelevation (linear method)

Again, despite the larger radius the substandard superelevation trend continues for Curve 5.

$e_1 = 3.6\%,$

$V = 96\ km/h,$

$R = 390\ m,$

$e_{max} = 6\%,$

$f_{max} = 0.116,$

$$e_1 = \frac{V^2 e_{\max}}{127R(e_{\max} + f_{\max})} = \frac{96^2 \times 0.06}{127 \times 390(0.06 + 0.116)}$$

$$e_1 = 6.3\%$$

Equation 6.14: Crash Site 3 Curve 6 required superelevation (linear method)

$e_{exist} = 1.9\%,$

$V = 101\ km/h,$

$R = 870\ m,$

$e_{max} = 6\%,$

$f_{max} = 0.12,$

$$e_1 = \frac{V^2 e_{\max}}{127R(e_{\max} + f_{\max})} = \frac{101^2 \times 0.06}{127 \times 870(0.06 + 0.12)}$$

$$e_1 = 3.1\%$$

Equation 6.15: Crash Site 3 Curve 7 required superelevation (linear method)

The final, large radius curve is the first in the series to require a superelevation value less than the maximum; however the required value remains greater than that existing. The existing minimal superelevation is at a value that may not provide sufficient surface drainage, 3% for bituminous sealed pavements (Austroads 2010, p. 31).

6.5.3.5. Road furniture

The horizontal alignment of this segment of Toowoomba-Karara Road is deficient in a number of respects in terms of its geometry. It is therefore important that the standard of road furniture is equal to that specified in the MUTCD. An assessment of road furniture follows.

6.5.3.5.a. Advisory speed

Advisory speeds for Crash Site 3 were determined using the ball bank indicator method. Due to the nature of the ball bank indicator device, the survey speed was varied between curves in order to produce correct results. In all cases, the maximum ball bank indicator reading was achieved when travelling on the inside of the curve, and is reported below in Table 6.7.

Curve no.	Survey speed (km/h)	Ball bank indicator reading	Advisory speed (km/h)
1	77.7	10	77
2	86.7	10	80
3	77.7	12	71
4	77.7	13	70
5	86.7	9	86
6	86.7	8	90
7	86.7	4	N.A.

Table 6.7: Crash Site 3 determination of advisory speeds

In accordance with MUTCD, for road segments that contain a number of substandard curves, the advisory speed of the slowest curve shall be used throughout. In the case of Crash Site 3, this advisory speed is 70 km/h, which is currently present.

6.5.3.5.b. Warning Signs (W series) and Hazard Markers (D series)

As stated, Crash Site 3 contains a series of horizontal curves, including reverse and broken back types. Referring to the MUTCD found that all curves can be signed as 'curves' as opposed to 'turns', considering the advisory speed of 70 km/h and an approach speed of 100 km/h. Currently, these curve signs are present, and positioned correctly; curves 6 and 7 do not require such signs. The MUTCD treats reverse curves as those adjoined by a tangent of 120 m or less. Crash Site 3 has only one instance where this is present, the reverse curves 1 and 2, and the correct 'reverse curve' signs are located here.

For an advisory speed of 70 km/m, chevron alignment markers are required where the approach speed is in excess of 88 km/h, and may be required for approach speeds between 80-88 km/h. Thus, for Crash Site 3, chevron alignment markers are recommended at Curves 2, 3 and 4.

6.5.3.5.c. Guideposts

The extent of guideposts through Crash Site 3 appears acceptable, with regularly spaced delineation installed at all horizontal curves. The requirements for guideposts according to the MUTCD for each horizontal curve are contained below in Table 6.8.

Curve No.	Radius	Spacing outside of curve (m)	Spacing inside of curve (m)
1	215	15	30
2	240	15	30
3	130	10	20
4	170	10	20
5	300	20	40
6	390	20	40
7	870	60	60

Table 6.8: Guidepost spacing (MUTCD 2009, p. 38)

On inspections, it appears the site currently meets the MUTCD standard, with correctly spaced, relatively new guideposts.

6.5.3.5.d. Linemarking

Currently the site contains centreline marking, in the form of dividing lines and one and both direction barrier lines, along with edge line marking throughout. All linemarking is in reasonable condition. The MUTCD recommends use of centre and edge line marking on roads containing frequent horizontal curves; hence their use on Toowoomba-Karara Road is acceptable.

Although the current state of the linemarking is acceptable during daylight, a night inspection may reveal the need to re-mark, if reflectivity is no longer acceptable.

6.5.4. Conclusions on Causal Factors

As with any crash location, there are a number of possible factors that may contribute to a higher accident rate. In the case of Toowoomba-Karara Road, it appears the horizontal geometry, in combination with limited superelevation, is the most influential factor. The operating speed of the corners is unacceptable in places and may become an issue, particularly for traffic travelling north.

The location of floodways may also contribute to crash potential. Austroads (2010, p. 135) states, "designers should avoid locating floodways or floodway approaches on curved sections of road". There are currently three floodways constructed in this road segment, two of which are located mid-curve.

There are two potential issues with these. Firstly, the floodways introduce changes in vertical grades, in the form of dips and crests. Located mid-curve, these floodways alter both the superelevation and ride quality. This combination has the capability to upset vehicle handling, particularly when vehicles are travelling above the designed operating speed.

The second cause for concern is the fact water crosses the road at these floodways after rain events. The mid-curve location is of greatest concern, as stopping sight distance requirements for floodways may not be satisfied during flooding events.

6.5.5. Recommendations for Implementation

The location of the adjacent railway and relatively narrow road reserve means it is difficult for this section of Toowoomba-Karara Road to be designed for high-speed (>90 km/h) travel. The operating speed currently does not satisfy the recommendations of Austroads Guide to Road Design Part 3 (2010).

Like most projects of this kind, the limiting factor may be financial; realignment of the horizontal geometry may not be deemed sufficiently poor to become a priority for the road authority. Therefore improving the shape of the pavement surface, to develop suitable crossfall and superelevation, would be deemed most beneficial. The inclusion of chevron alignment markers would also aid delineation for motorists traversing the substandard geometry, at a relatively low cost.

7. Site Inspection Conclusions

The three site inspections undertaken have revealed interesting results. All locations possess aspects of their geometry or road furniture that do not meet the recommendations of the respective guidelines. Operating speed, horizontal curvature and superelevation are three geometric features that were commonly substandard throughout the locations. In the case of Clifton-Leyburn Road and Toowoomba-Karara Road, the state of the road surface, with depressions and ruts, also contributed to potential crash concerns.

However, it is important to point out that, although the sites did not meet the geometric design recommendations set out in Austroads (2010), the overall state of each of the crash sites was not beyond that deemed acceptable. The current standard of road furniture at these sites is suitable, and therefore where an unexpected geometric element may be present, the road user is generally warned and directed appropriately.

The task of determining whether road geometry has significantly contributed to crash rates is difficult. As discussed throughout, human and vehicular factors can combine with the road environment in contributing to crashes, and it is therefore difficult to single out one of these factors. However, the various road design guidelines have been developed to provide motorists with a safe and trafficable road environment. Sites where these recommendations have not been met could be considered a failure in the system, and therefore can be considered as having a greater potential for crashes than those sites that have met the design recommendations.

The ideal recommendation for each site would include reconstruction to the requirements of the various guidelines. This may not be possible, with financial and geographic constraints likely to govern. Therefore the general, more cost effective recommendations for each site include:

- improvement of the road surface, removing any significant depressions and ruts

- where operating speed is an issue, increase superelevation values to acceptable values
- upgrade and/or maintain the level of road furniture to the standards set out in TMR's MUTCD

Although these recommendations may not fully address the geometric issues discussed, the affordability of the solutions in combination with relatively low crash rates suggest these options as being viable at these locations.

8. Future Work

There are further studies that could be undertaken to follow on from the work presented here. Firstly, more crash locations could undergo analysis. In some respects, Transport and Main Roads currently undertake this task. The ARMIS crash database software is capable of producing maps identifying locations with high crash rates. Sites where an unacceptable level of crashes have occurred are prioritised for inspection and possible upgrade.

From the perspective of TRC, it would be beneficial to undertake an analysis of crash data on unclassified roads under their management. However, this project may be set back by a lack of accurate crash data for these roads. This issue may be overcome by focusing on TRC's Local Roads of Regional Significance (LRRS), which may have experienced greater crash rates. If reasonable results could be obtained, identifying locations where unsuitable road geometry has contributed to crashes, TRC could prioritise such locations for upgrade.

Another related project may be to look at the actual role road furniture, such as warning signs, play in affecting local driver behaviour. As this project has identified, for financial or geographic reasons some roads may not be able to be constructed to the recommended geometric standard, and a higher road furniture standard may be employed. Such a study may determine the success of such road furniture, and whether its use is justified. This task could be undertaken through analysis of crash data before and after implementation of road furniture, or more simply by examining traffic speeds at specific sites.

9. Conclusions

This project has investigated traffic crashes on classified roads within rural TRC, revealing some interesting results throughout. Whilst the highly trafficked national highways understandably have higher overall crash rates, in terms of VKT, it was shown that some of the lower trafficked OSCR experienced the greater crash rates; Murphy's Creek Road and Greenmount Connection Road had the highest crash rates in this regard.

Comparison of fatal and injury crashes from the study area against those results reported by ARRB for NSW and ACT reveal a lower rate for the local area. However, consideration of only fatal crashes for the TRC roads revealed a substantially greater average than that recorded for the period 2005-2010 in both Queensland and Australia.

While the geometry of the crash sites investigated may not have met the recommendations of the various road design standards, it is difficult to be certain that this has increased crash rates. Human and vehicular factors can combine with the road environment in the cause of crashes.

It is important to note that the crash sites identified are not totally substandard, at least from the perspective of the road user. The sufficient standard of road furniture reduces unexpected road features, such as horizontal curvature, and allows the road user to traverse safely.

Ultimately, financial constraints play a large role in determining the extent of works undertaken at a particular site. The road authority must carefully allocate funds to ensure a safe road environment for everyone.

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11. Appendices

11.1. Project Specification

University of Southern Queensland

Faculty of Engineering and Surveying

ENG4111 / ENG4112 PROJECT SPECIFICATION

FOR: **Matthew KELEHER (Stud. No. 0050056535)**

TOPIC: ANALYSIS OF HIGH-SPEED RURAL TRAFFIC CRASHES WITHIN THE SOUTH-WEST DISTRICT OF TOOWOOMBA REGIONAL COUNCIL

SUPERVISORS: Professor Ron Ayers – University of Southern Queensland

Mrs Nadia Ives – Toowoomba Regional Council

SPONSORSHIP: Toowoomba Regional Council

PROJECT AIM: The aim of this project is to examine the causes of road crashes in the south-west district of Toowoomba Regional Council and to identify remedial measures and treatments.

PROGRAMME: **Issue A, 28 February 2011**

1. Undertake background research on roads and road safety, in particular;
   a. Geometric design of low-volume, high-speed rural roads, considering the various design standards, their differences and use;
   b. Road maintenance practices and intervention levels;
   c. Road furniture standards, usage and success;
   d. Crash data acquisition and analysis procedures; and
   e. Road safety issues for high-speed rural roads.
2. Obtain crash data from the Department of Transport and Main Roads for the south-west district of Toowoomba Regional Council, for the last 5 years.
3. Analyse the crash data for all crashes which have occurred on classified roads within the area, considering a number of road, crash and general characteristics (e.g. road geometry, type of crash, time of day, etc).
4. For those crashes where road geometry appears to be a significant factor, acquire geometric design plans and analyse the designs against the recommendations of the relevant road design standards.
5. Identify significant crash causal factors and provide recommendations to eliminate or alleviate future crashes.
6. Present information and results in required written and oral formats.

As time permits:

1. Extend the region of interest to include non-classified roads &/or another district within the Toowoomba Regional Council area.
2. Compare and contrast crashes in the different road classifications &/or districts.

AGREED:

Student: ________ 24/02/2011 Supervisor: ________ 1/3/2011

(Matthew Keleher) (Ron Ayers)

11.2. State Controlled Roads within Toowoomba Regional Council regional districts

Road Number	Road Name	Start Chainage	Start Location	End Chainage	End Location
Greenmount – National Highways					
22B	New England Highway	6.31	Hayden Street	34.45	Nobby Connection Road
28A	Gore Highway	7.315	Boundary Street	8.45	Westbrook Road
Greenmount – State Controlled Roads					
313	Gatton-Clifton Road	26.79	TRC Boundary	43.73	Kings Creek
321	Drayton Connection Road	3.33	Hanrahan Road	11.17	New England Highway
330	Felton-Clifton Road	0.000	Toowoomba-Karara Road	5.02	Mount Kent Boundary Road
331	Toowoomba-Karara Road	1.65	Hanrahan Road	31.09	Greenmount-Clifton Boundary
332	Pittsworth-Felton Road	19.54	Hodgson Creek	22.39	Toowoomba-Karara Road
3102	Greenmount-Hirstvale Road	0.000	New England Highway	12.29	Gatton-Clifton Road
3304	Cambooya Connection Road	0.000	New England Highway	5.49	Toowoomba-Karara Road
3308	Nobby Connection Road	0.000	New England Highway	3.28	Greenmount-Nobby Road
3341	Greenmount Connection Road	0.000	New England Highway	4.67	Greenmount-Nobby Road
Clifton – National Highways					
28A	New England Highway	34.45	Nobby Connection Road	47.92	Clarke Road
Clifton – Other State Controlled Roads					
313	Gatton-Clifton Road	43.74	Kings Creek	62.71	Clifton-Leyburn Road
330	Felton-Clifton Road	5.02	Mount Kent Boundary Road	24.16	Clifton-Leyburn Road
331	Toowoomba-Karara Road	31.09	Greenmount-Clifton Boundary	54.09	Delahaye Road
335	Millmerran-Leyburn Road	26.18	Elerby Road	32.99	MacQuarie Drive
336	Clifton-Leyburn Road	0.000	Gatton-Clifton Road	25.06	Toowoomba-Karara Road
3302	Dalrymple Creek Road	22.15	TRC Boundary	25.39	Ryeford-Pratten Road
3308	Nobby Connection Road	3.28	Greenmount-Nobby Road	5.08	Felton-Clifton Road
3363	Ryeford-Pratten Road	0.000	Clifton-Leyburn Road	8.96	Condamine River
Crows Nest – National Highways					
22A	New England Highway	36.1	Mitchell Creek Road	110.58	Murphy’s Creek Road

Crows Nest – Other State Controlled Roads					
414	Esk-Hampton Road	27.62	Horrex Road	45.76	New England Highway
418	Pechey-Maclagan Road	0.000	New England Highway	14.33	Douglas Plainby Road
4104	Murphy's Creek Road	22.82	TRC Boundary	24.58	New England Highway
Oakey – National Highways					
18B	Warrego Highway	8.54	Boundary Street	74.61	Griffiths Road
28A	Gore Highway	8.45	Westbrook Road	23.94	Harelmar Road
Oakey –Other State Controlled Roads					
320	Charlton Connection Road	0.000	Warrego Highway	1.58	Toowoomba-Cecil Plains Road
323	Oakey-Pittsworth Road	0.000	Warrego Highway	17.5	Moran Road
324	Toowoomba-Cecil Plains Road	5.86	Charlton Connection Road	72.1	Condamine River (North Branch)
325	Dalby-Cecil Plains Road	22.62	West Prairie Boundary Wambo Road	36.43	Boundary Road
326	Oakey Connection Road	0.000	Warrego Highway	7.34	Warrego Highway
417	Oakey-Cooyar Road	0.000	Oakey Connection Road	2.68	Devon Park Boundary Road
3203	Bowenville-Norwin Road	0.000	Warrego Highway	26.86	Toowoomba-Cecil Plains Road
3221	Brookstead-Norwin Road	29.36	Oakey-Pittsworth Boundary	29.56	Toowoomba-Cecil Plains Road
Millmerran – National Highways					
28A	Gore Highway	59.59	Condamine River North Branch	79.54	28B Gore Highway
28B	Gore Highway	0.000	28A Gore Highway	49.92	TRC Boundary
Millmerran – Other State Controlled Roads					
324	Toowoomba-Cecil Plains Road	72.1	Condamine River (North Branch)	78.78	Dalby-Cecil Plains Road
325	Dalby-Cecil Plains Road	36.43	Boundary Road	39.08	Toowoomba-Cecil Plains Road
327	Pampas-Horrane Road	0.000	Gore Highway	35.77	Toowoomba-Cecil Plains Road
335	Millmerran-Leyburn Road	0.000	Gore Highway	26.2	Elerby Road
337	Millmerran-Inglewood Road	0.000	Gore Highway	39.46	TRC Boundary
3251	Millmerran-Cecil Plains Road	0.000	Gore Highway	45.61	Dalby-Cecil Plains Road
Pittsworth – National Highways					
28A	Gore Highway	23.94	Harelmar Road	59.98	Condamine

					River North Branch
Pittsworth – Other State Controlled Roads					
323	Oakey-Pittsworth Road	17.5	Moran Road	37.883	Gore Highway
332	Pittsworth-Felton Road	0.000	Gore Highway	19.54	Hodgson Creek
3221	Brookstead-Norwin Road	0.000	Gore Highway	29.36	Toowoomba-Cecil Plains Road
Goombungee – National Highways					
22A	New England Highway	0.000	D'Aguilar Highway	36.1	Mitchell Creek Road
40B	D'Aguilar Highway	45.34	Nukku Boundary Road	68.72	New England Highway
40C	D'Aguilar Highway	0.000	New England Highway	4.72	TRC Boundary
Goombungee – Other State Controlled Roads					
416	Dalby-Cooyar Road	36.87	TRC Boundary	58.2	Oakey-Cooyar Road
417	Oakey-Cooyar Road	2.68	Devon Park Boundary Road	55.72	New England Highway
418	Pechey-Maclagan Road	14.33	Douglas Plainby Road	55.35	Dalby-Cooyar Road
4163	Bunya Mountains-Maclagan Road	5.77	Cooyar-Rangemore Road	16.36	Dalby-Cooyar Road

11.3. Example RMPC Defect/Activity Combination

RMPC Guidelines for Undertaking Routine Maintenance — 87.104.3 (February 2004)

DEFECT/ACTIVITY COMBINATIONS WITH DEFECT INTERVENTION LEVELS, RESPONSE TIMES AND PRIORITY GROUPS

Defect Classification/Type	Initial Intervention Level	General Intervention Level	Activity	Unit of Measurement for payment	Response Time	Priority Group
SEALED ROADWAY 01 Deformation and Potholes in Bituminous Surface.						
AA Isolated Depressions and Bumps	Isolated depression or bump which causes noticeable riding discomfort.	• Depth or height measured longitudinally using a 4 m string line of: 100 mm for AADT <500 75 mm for AADT 500 – 2500 50 mm for AADT >2500 (Note: 30 mm to apply for National Highways) or:	110 Surface Correction with Premix/Asphalt (Manual)	Tonnes	By General Intervention Level	3
			111 Surface Correction with Premix/Asphalt (Mechanical)	Tonnes	-	
			161 Profile Planning	m^2	-	
			155 Asphalt Overlay	Tonnes	-	
		• Ponding of water hazardous to traffic occurs or:	156 Replace Excavated Asphalt	Tonnes	-	
		• severity of defect exceeds 20 mm per metre.	157 Excavate and Replace Asphalt	Tonnes	-	
			169 Other Pavement Work	Dollars	-	
			143 Pavement Repairs (Mechanical) - Minor	m^2	-	
			144 Pavement Repairs (Mechanical) - Major	m^3	-	

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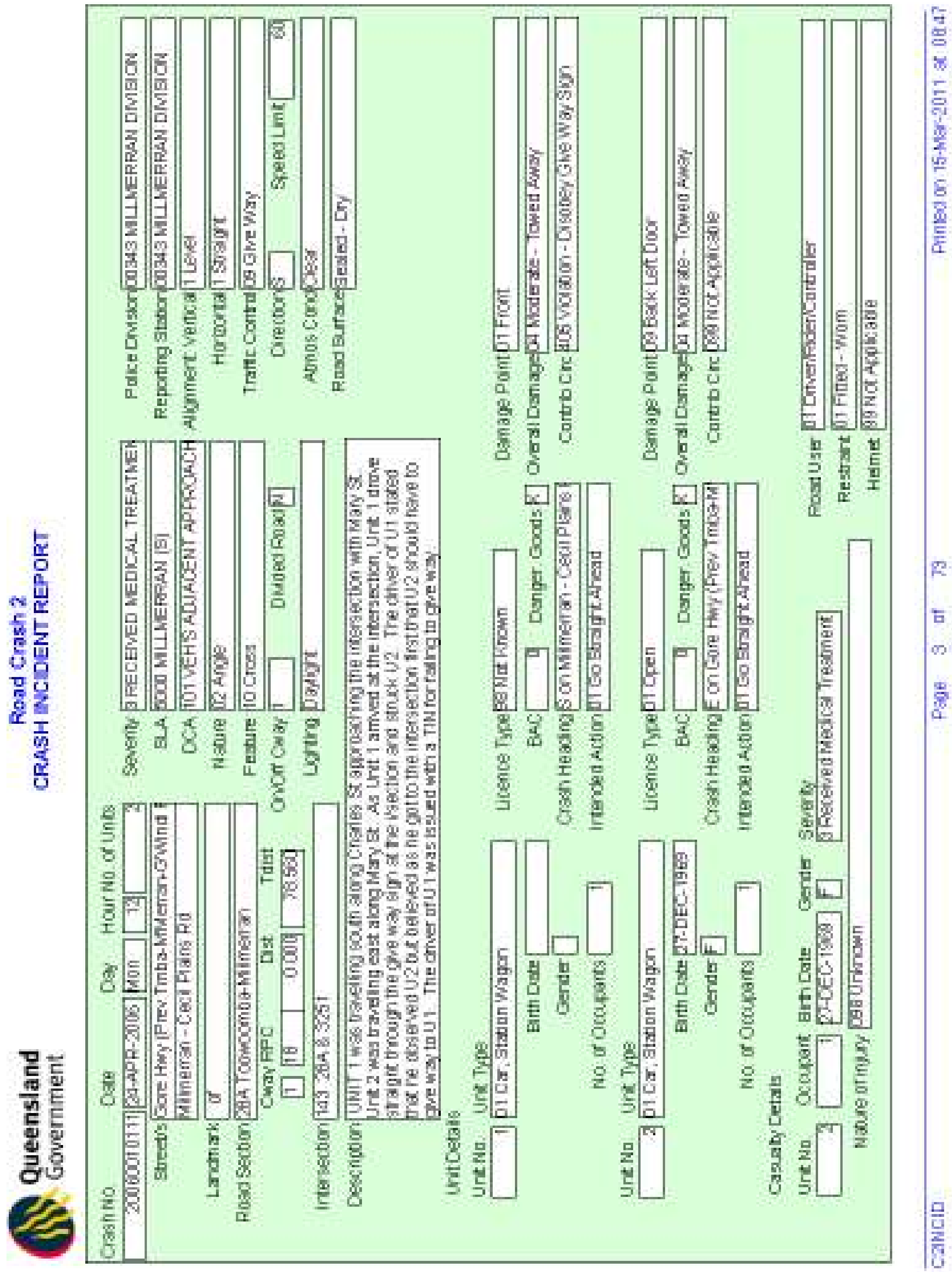
11.4. Example Crash Incident Report form



Queensland Government

Road Crash 2
CRASH INCIDENT REPORT

Crash No 200800010111 | Date 28-APR-2008 | Day Mon | Hour 13 | No. of Units 2 | Severity 3 RECEIVED MEDICAL TREATMEN | Police Division 00343 MILLMERRAN DIVISION

Streets Gore Hwy (Prev Tmba-Millmerran-G/Wind | BLA 5000 MILLMERRAN (S) | Reporting Station 00343 MILLMERRAN DIVISION

Millmerran - Cecil Plains Rd | DCA 101 VEH'S ADJACENT APPROACH | Alignment: Vertical 1 Level

Landmark 0 | Nature 02 Angle | Horizontal 1 Straight

Road Section 28A Toowoomba-Millmerran | Feature 10 Cross | Traffic Control 09 Give Way

Cway RPC 1 18 | Dist 0.000 | Tdist 76.960 | On/Off Cway 1 | Divided Road N | Direction S | Speed Limit 60

Intersection 103 28A & 3251 | Lighting Daylight | Atmos Cond Clear | Road Surface Sealed - Dry

Description: UNIT 1 was travelling south along Charles St approaching the intersection with Mary St. Unit 2 was travelling east along Mary St. As Unit 1 arrived at the intersection, Unit 1 drove straight through the give way sign at the i/section and struck U2. The driver of U1 stated that he observed U2 but believed as he got to the intersection first that U2 should have to give way to U1. The driver of U1 was issued with a TIN for failing to give way.

Unit Details

Unit No. 1 | Unit Type 01 Car, Station Wagon | Licence Type 88 Not Known | Damage Point 01 Front
Birth Date | BAC 0 | Danger Goods X | Overall Damage 04 Moderate - Towed Away
Gender | Crash Heading S on Millmerran - Cecil Plains | Contrib Circ 406 Violation - Disobey Give Way Sign
No. of Occupants 1 | Intended Action 01 Go Straight Ahead

Unit No 2 | Unit Type 01 Car, Station Wagon | Licence Type 01 Open | Damage Point 09 Back Left Door
Birth Date 27-DEC-1969 | BAC 0 | Danger Goods X | Overall Damage 04 Moderate - Towed Away
Gender F | Crash Heading E on Gore Hwy (Prev Tmba-M | Contrib Circ 099 Not Applicable
No. of Occupants 1 | Intended Action 01 Go Straight Ahead

Casualty Details

Unit No 2 | Occupant 1 | Birth Date 27-DEC-1969 | Gender F | Severity 3 Received Medical Treatment | Road User 01 Driver/Rider/Controller
Nature of Injury 098 Unknown | Restraint 01 Fitted - Worn
Helmet 99 Not Applicable

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Figure 11.1: Example Crash Incident Report form, Queensland Government Department of Transport and Main Roads (2011)

11.5. Definitions for Coding Crashes

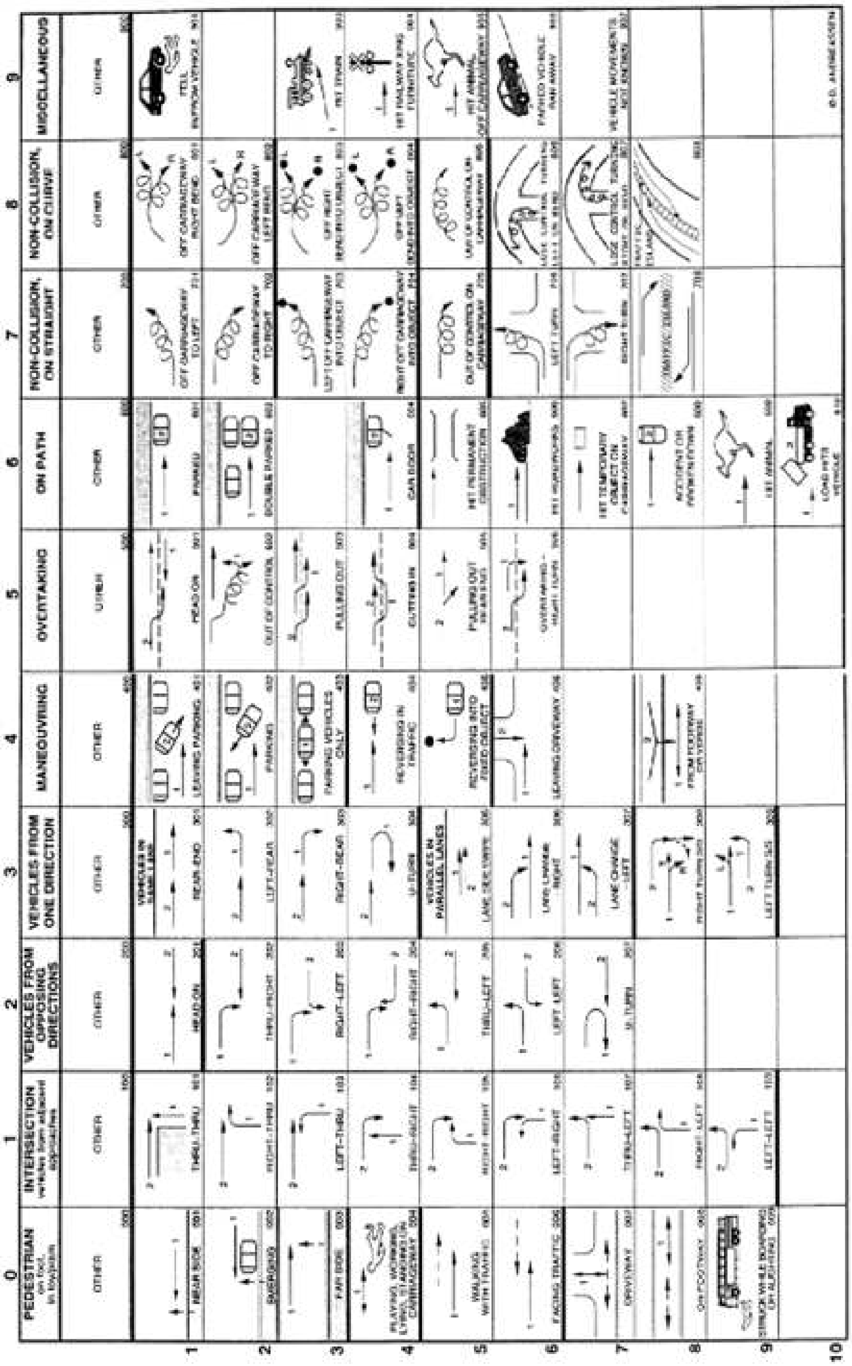

Figure 11.2: Definitions for Coding Accidents, Queensland Government Department of Transport and Main Roads (2010)

11.6. Work Method Statement

Toowoomba Regional Council

Work Method Statement

Work On Or Adjacent To A Road Or Railway

Approved by:	KEN GOULDTHORP	[signature]	21/5/09
	Name	Signature	Date

All personnel conducting this work MUST be made aware of these methods of control at toolbox meetings and / or pre start meetings before work commences, with on-site enforcement by the Site Supervisor.

Council Details	*Toowoomba Regional Council*
Council ABN	99788305360
Construction Site Address	
Planned high risk activity	Work on or adjacent to a road or railway...... Other......
Risk Assessment	**E=Immediate Action, H= Action Required, M= Action Desirable, L=Acceptable**

Assess the likelihood and consequences from the hazards or risks

Likelihood	Consequences: **Insignificant** *No injury, 0 - low $ loss*	**Minor** *First Aid injury, low - medium $ loss*	**Moderate** *Medical Treatment, medium - high $ loss*	**Major** *Serious injuries, major $ loss*	**Catastrophic** *Death, huge $ loss*
Almost Certain *is expected to occur at most times*	H	H	E	E	E
Likely *will probably occur at most times*	M	H	H	E	E
Possible *might occur at some time*	L	M	H	E	E
Unlikely *could occur at some time*	L	L	M	H	E
Rare *may occur in rare circumstances*	L	L	M	H	E

Controls & Implementation

Tick	TASK HAZARD / RISK	METHOD OF CONTROL
☑ ☐	**Pre-Start**	• Pre-start briefing to ensure all staff are fully aware of the scope of work before work commences.Ensure all workers have undertaken WH&S induction.
☐	**Motor vehicle traffic** **Compliance with the Manual of Uniform Traffic control Devices**	All work will comply with the Manual of Traffic Control Devices some of but not all are listed below • Ensure any control device applied does not become a potential hazard to workers or pedestrians or vehicles. • Correct signage will be identified and displayed before work begins. • Signage devices will be set up at correct distances. • Signage devices will be set up at correct heights. • Signage devices shall be clean and in good condition. • Local speed shall be reduced to an acceptable level. • Signage to be regularly checked and correctly recorded. Refer to TRC Signage Booklet

Page 1 of 3   Revision 1 (01/2009)

Tick	TASK HAZARD / RISK	METHOD OF CONTROL
☑	**Pedestrians**	• Install safety barriers where necessary. • Where required clearly marked alternative safe laneways shall be made available for pedestrians. Laneways crossing kerb and channelling shall have non-slip ramps suitable for wheelchairs, baby strollers, pedestrian scooters and aged or disabled persons.
☐	**Poor light, Long term works.**	• Where long-term works exist (more than one shift) correct suitable delineation (eg. Flashing lights or reflecting bollards) shall be installed and checked by a responsible person at the end of each shift. Workers operating in poor / low light conditions shall wear high visibility day / night garments.
☐	**Short term works. Mowing, Garbage Collection, Pothole Patching, Herbicide Spraying, Sign Repairs.**	• Signage to conform to Manual of Traffic Control devices. • Vehicles to have warning devices (e.g. flashing lights, vehicle signage e.g. vehicle frequently stopping.) • All workers to wear correct high visibility clothing. • Safety devices (eg witches hats) to be used around high risk work sites (e.g. traffic islands) • Mowers to be used with shut away from traffic. • Refer to TRC Signage Booklet. Signage to be regularly checked and correctly recorded.
☐	**Work near railway**	• Railway controlling authority shall be contacted before work begins within the authorities boundaries. • Work will not start until permission is granted from controlling authority. Work will conform to controlling authority's guidelines.
☐	**Correct clothing** P.P.E.	• All workers shall wear high visibility garments that comply with the Manual for Uniform Traffic Control devices. (Persons with faded garments shall wear reflective vests). • Vests shall be correctly secured when worn. P.P.E. shall be identified and worn
☐	**General**	• Only accredited traffic controllers shall be used for traffic control. • Traffic controllers shall have their tickets available on site. Only trained persons will be given responsibility for worksite signage.
☐	**Other** (please state)	• • • • • • • • • •
Monitoring of Site Controls		
Tick	TASK HAZARD / RISK	METHOD OF CONTROL
☐	**Inspections**	• Person in Control of Work Site to ensure that pre start checks are completed in log books or check sheets before work commences. • Exclusion zones and hazard warning signs (where required) be displayed before work commences. • Effective reliable communications available on site. Check barricading is in place each day.

☐	**Ongoing monitoring**	• Ongoing risk assessments are conducted during the project and discussed at toolbox meetings. • The Site Supervisor will hold regular Toolbox meetings to discuss changes to the workplace or identification of new hazards. Internal / External audits and inspections by Supervisor, WHSO and others.
☐	**Incidents / Near Misses**	• Ensure Safety of all Persons • Complete appropriate form • In the event of a Traffic Incident (either witnessed or reported) it is to be immediately reported to your Team Leader / Coordinator Detailed records to be kept
☐	**Review to Occur when**	• Incident Occurs • Conditions Change. (Plant, Weather, Staff etc). When directed. (Start of Shift, Daily, Weekly etc)

11.7. Cumulative DCA Results

	0 Pedestrian	1 Intersection	2 Vehicles from opposing directions	3 Vehicles from one direction	4 Maneouvring	5 Overtaking	6 On path	7 Non-collision, on straight	8 Non-collision, on curve	9 Miscellaneous	Totals
0	Other	Other	Other	Other	Other	Other	Other	Other	Other	Other	43
Count	2	1	3	Nil	2	7	1	16	10	1	
1	Near side	Thru-thru	Head on	Rear-end	Leaving parking	Head on	Parked	Off carriageway to left	Off carriageway right bend	Fell in/from vehicle	160
Count	3	21	41	49	Nil	3	1	22	20	Nil	
2	Emerging	Right-thru	Thru-right	Left-rear	Parking	Out of control	Double parked	Off carriageway to right	Off carriageway left bend		62
Count	Nil	8	18	5	Nil	12	Nil	8	11	Nil	
3	Far side	Left-thru	Right-left	Right-rear	Parking vehicles only	Pulling out		Left off carriageway into object	Off right bend into object	Hit train	114
Count	Nil	2	Nil	42	Nil	2	Nil	36	31	1	
4	On carriageway	Thru-right	Right-right	U-turn	Reversing in traffic	Cutting in	Car door	Right off carriageway into object	Off left bend into object	Hit railway x'ing furniture	77
Count	Nil	28	Nil	1	Nil	2	Nil	25	21	Nil	
5	Walking with traffic	Right-right	Thru-left	Lane side swipe	Reversing into fixed object	Pulling out rear end	Hit permanent obstruction	Out of control on carriageway	Out of control on carriageway	Hit animal off carriageway	54
Count	1	Nil	Nil	7	Nil	2	1	27	16	Nil	
6	Facing traffic	Left-right	Left-left	Lane change - right	Leaving driveway	Overtaking - right turn	Hit roadworks	Left turn	Lose control turning left on bend	Parked vehicle ran away	33
Count	Nil	Nil	Nil	5	8	13	Nil	5	2	Nil	
7	Driveway	Thru-left	U-turn	Lane change - left			Hit temp object	Right turn	Lose control turning right on bend	Vehicle movements not known	27
Count	Nil	4	1	2	Nil	Nil	17	1	2	Nil	
8	On footway	Right-Left		Right turn SS	From footway on verge		Accident or broken down	Traffic island	Traffic island		26
Count	1	Nil	Nil	6	10	Nil	2	7	Nil	Nil	
9	Struck while boarding	Left-left		Left turn SS			Hit animal				23
Count	Nil	Nil	Nil	2	Nil	Nil	21	Nil	Nil	Nil	
10							Load hits vehicle				3
Count	Nil	Nil	Nil	Nil	Nil	Nil	3	Nil	Nil	Nil	
Totals	7	64	63	119	20	41	46	147	113	2	622

11.8. Example Averaging of Traffic Count Data

TMR records traffic count results with respect to Road Segments. These road segments represent lengths of road that can be considered as having the same traffic count; the land use type

For the purpose of this study, an AADT value is required for the total length of each road. This value is a weighted average, that takes into consideration the length of each road segment. This value is simply expressed as the VKT divided by the total road length, Equation 11.1, where VKT is equal to the sum of the product of traffic volume and segment length.

$$AADT = \frac{VKT}{L}$$

where,

AADT = average annual daily traffic,

VKT = average annual daily vehicle kilometres travelled,

L = total length of road

Equation 11.1: AADT definition

Oakey-Pittsworth Road shall be used as an example of this calculation. Traffic count and road segment information is included below in Table 11.1.

Segment Start (Chainage in km)	Segment End (Chainage in km)	Length (km)	Volume
0.000	0.940	0.940	865
0.940	15.340	14.400	724
15.340	37.883	22.543	685

Table 11.1: Oakey-Pittsworth Road traffic count information (TMR 2008)

The first step is to determine the average annual daily VKT for Oakey-Pittsworth Road, Equation 11.2.

$$VKT = sum(traffic\ volume \times segment\ length)$$

$$VKT = (865 \times 0.940) + (724 \times 14.400) + (685 \times 22.543) =$$
$$VKT = 26680.7$$

Equation 11.2: Oakey-Pittsworth Road VKT calculation

The AADT for the road is simply equal to the VKT divided by the total road length, as shown in Equation 11.3.

$$AADT = \frac{VKT}{L}$$
$$AADT = \frac{26680.7}{37.883}$$
$$AADT = 704$$

Equation 11.3: Oakey-Pittsworth Road AADT calculation

This AADT value of 704 for Oakey-Pittsworth Road can now be used in analysis.

This procedure is the same for all roads in the survey area and is recognised method of rationalising traffic count data.

11.9. *Comprehensive Crash Results*

Road No.	Road Name	From	To	Crashes	Length (km)	Crashes/ 10km	AADT	Crashes/ 1000 veh.
National Highways								
18B	Warrego Highway	Ipswich	Toowoomba	125	84.2	14.8	6932	18.0
22A	New England Highway	Yarraman	Toowoomba	134	118.3	11.3	2938	45.6
22B	New England Highway	Toowoomba	Warwick	54	34.5	15.7	4834	11.2
28A	Gore Highway	Toowoomba	Millmerran	54	79.5	6.8	3347	16.1
28B	Gore Highway	Millmerran	Goondiwindi	28	49.9	5.6	1500	18.7
40B	D'Aguilar Highway	Kilcoy	Yarraman	17	58.2	2.9	3040	5.6
40C	D'Aguilar Highway	Yarraman	Kingaroy	8	45.7	1.8	3805	2.1
Other State Controlled Roads								
313	Gatton-Clifton Road	TRC Boundary	Clifton-Leyburn Road	14	43.7	3.2	655	21.4
320	Charlton Connection Road	Warrego Highway	Toowoomba-Cecil Plains Road	3	1.6	18.8	2822	1.1
321	Drayton Connection Road	Hanrahan Road	New England Highway	14	11.2	12.5	3763	3.7
323	Oakey-Pittsworth Road	Warrego Highway	Gore Highway	14	37.9	3.7	704	19.9
324	Toowoomba-Cecil Plains Road	Charlton Connection Road	Dalby-Cecil Plains Road	40	78.8	5.1	1281	31.2
325	Dalby-Cecil Plains Road	West Prairie Boundary Wambo Road	Toowoomba-Cecil Plains Road	1	39.1	0.3	470	2.1
326	Oakey Connection Road	Warrego Highway	Warrego Highway	14	7.3	19.2	2766	5.1
327	Pampas-Horrane Road	Gore Highway	Toowoomba-Cecil Plains Road	2	35.8	0.6	138	14.5
330	Felton-Clifton Road	Toowoomba-Karara Road	Clifton-Leyburn Road	5	4.5	11.1	289	17.3
331	Toowoomba-Karara Road	Hanrahan Road	Delahaye Road	21	31.1	6.8	1137	18.5
332	Pittsworth-Felton Road	Gore Highway	Toowoomba-Karara Road	17	22.4	7.6	407	41.8
335	Millmerran-Leyburn Road	Gore Highway	Macquarie Drive	2	26.2	0.8	113	17.7
336	Clifton-Leyburn Road	Gatton-Clifton Road	Toowoomba-Karara Road	2				
337	Millmerran-	Gore	TRC Boundary	3	39.5	0.8	474	6.3

	Inglewood Road	Highway						
414	Esk-Hampton Road	Horrex Road	New England Highway	7	45.8	1.5	753	9.3
416	Dalby-Cooyar Road	TRC Boundary	Oakey-Cooyar Road	3	58.2	0.5	574	5.2
417	Oakey-Cooyar Road	Oakey Connection Road	New England Highway	7	55.7	1.3	569	12.3
418	Pechey-Maclagan Road	New England Highway	Dalby-Cooyar Road	7	55.4	1.3	280	25.0
3102	Greenmount-Hirstvale Road	New England Highway	Gatton-Clifton Road	3	12.3	2.4	157	19.1
3221	Brookstead-Norwin Road	Gore Highway	Toowoomba-Cecil Plains Road	1	29.6	0.3	163	6.1
3251	Millmerran-Cecil Plains Road	Gore Highway	Dalby-Cecil Plains Road	6	45.6	1.3	122	49.2
3302	Dalrymple Creek Road	TRC Boundary	Ryeford-Pratten Road	0				
3304	Cambooya Connection Road	New England Highway	Toowoomba-Karara Road	2	5.5	3.6	1191	1.7
3308	Nobby Connection Road	New England Highway	Felton-Clifton Road	1	3.3	3	245	4.1
3341	Greenmount Connection Road	New England Highway	Greenmount-Nobby Road	3	4.7	6.4	162	18.5
3363	Ryeford-Pratten Road	Clifton-Leyburn Road	Condamine River	1				
4104	Murphys Creek Road	TRC Boundary	New England Highway	9	24.6	3.7	1387	6.5

11.10. Crash Site 1 Report

Queensland Government

Road Crash 2
CRASH DETAIL REPORT

Crash No	Date	Day	Hour	DCA	No. Units	Street/s
20600047595	12-AUG-2006	Sat	02	704 OFF PATH-	1	Clifton - Leyburn Rd

RSect: 336 Clifton - Leyburn Road
Cway: 1 Direction: E
Inter.:
Road Surface: Sealed - dry
RPC: 1
Dist from RPC: 4.080
Tdist: 4.080

Nature: 06 Hit fixed obstruction or temporai
Severity: 2 ADMITTED TO HOSPITAL
Alignment: Vertical: 1 Level
Horizontal: 1 Straight
Feature: 99 Not Applicable
Traffic Control: 99 No Traffic Control

Units	Age	Gender	Unit Type	Dim.	Intended Action	BAC
1			01 Car, Station Wagon	E	01 Go Straight Ahead	N/A

Description:
Unit 1 was travelling east from Ernst Rd, Back Plains to Clifton on the Clifton-Leyburn Rd. As unit 1 approached 408 Clifton-leyburn Rd the vehicle lost control, swerved into the oncoming lane and skidded sideways off the road into a tree. Unit 1 driver sustained facial injuries and transported to Warwick Hospital. Vehicle statained extensive damage. S.27'55.656 E'151.51.948

Contributing Circumstances:
1 VIOLATION - UNDUE CARE AND ATTENTION
1 DRIVER - FATIGUE RELATED BY DEFINITION

Crash No	Date	Day	Hour	DCA	No. Units	Street/s
20700244951	22-AUG-2007	Wed	14	705 OFF PATH-	1	Clifton - Leyburn Rd

RSect: 336 Clifton - Leyburn Road
Cway: 1 Direction: W
Inter.:
Road Surface: Sealed - dry
RPC: 2
Dist from RPC: 2.665
Tdist: 8.215

Nature: 07 Overturned
Severity: 5 PROPERTY DAMAGE ONLY
Alignment: Vertical: 1 Level
Horizontal: 1 Straight
Feature: 99 Not Applicable
Traffic Control: 99 No Traffic Control

Units	Age	Gender	Unit Type	Dim.	Intended Action	BAC
1			01 Car, Station Wagon	W	01 Go Straight Ahead	94

Description:
Unit 1 was travelling west along the Clifton Leyburn Road, Ryeford towing a caravan when a strong gust of wind has forced the caravan up on one wheel. The driver of Unit 1 attempted to control the caravan and vehicle however was unable to do so. As a result the caravan was totally destroyed. No one was injured. The vehicle and caravan was towed from the scene. No charges are to be laid. GPS COORDINATES B S27.93132 & E151.90552

Contributing Circumstances:
1 ATMOSPHERIC CONDITIONS - MISCELLANE(
1 DRIVER - AGE (LACK OF PERCEPTION; POW
1 DRIVER - FATIGUE RELATED BY DEFINITION

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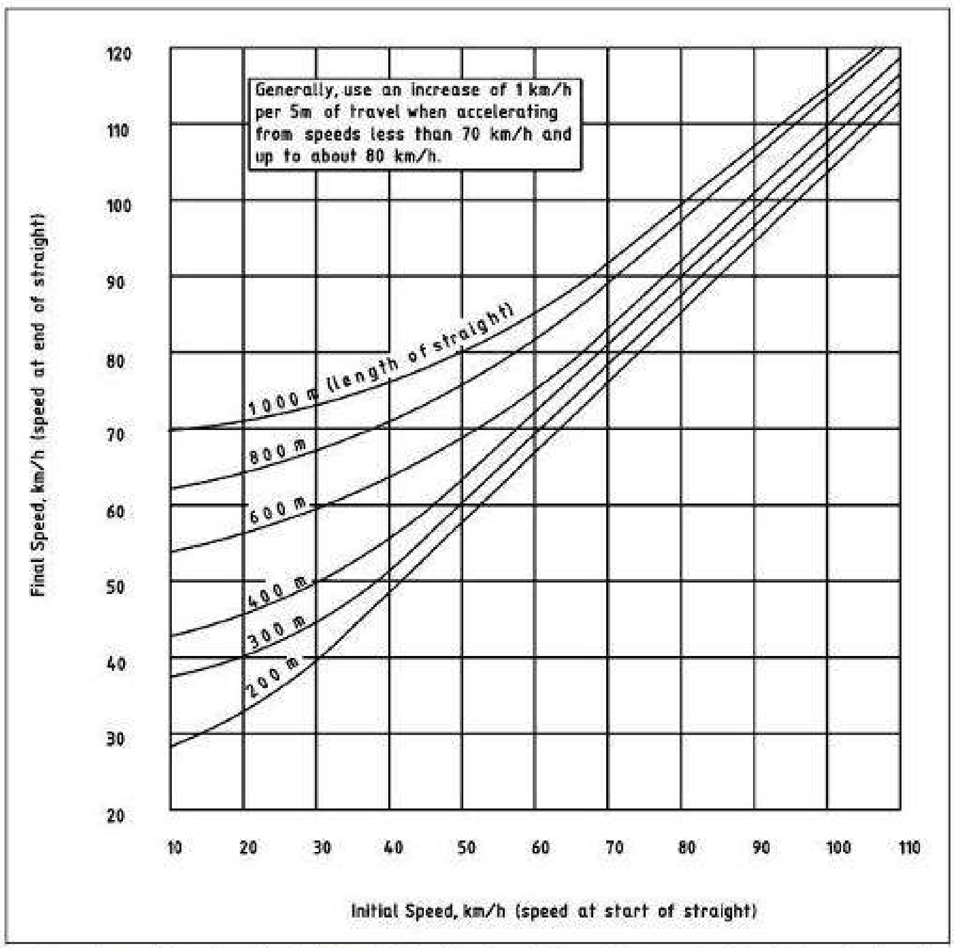
Crash Detail Report for Crash Number 20600047595

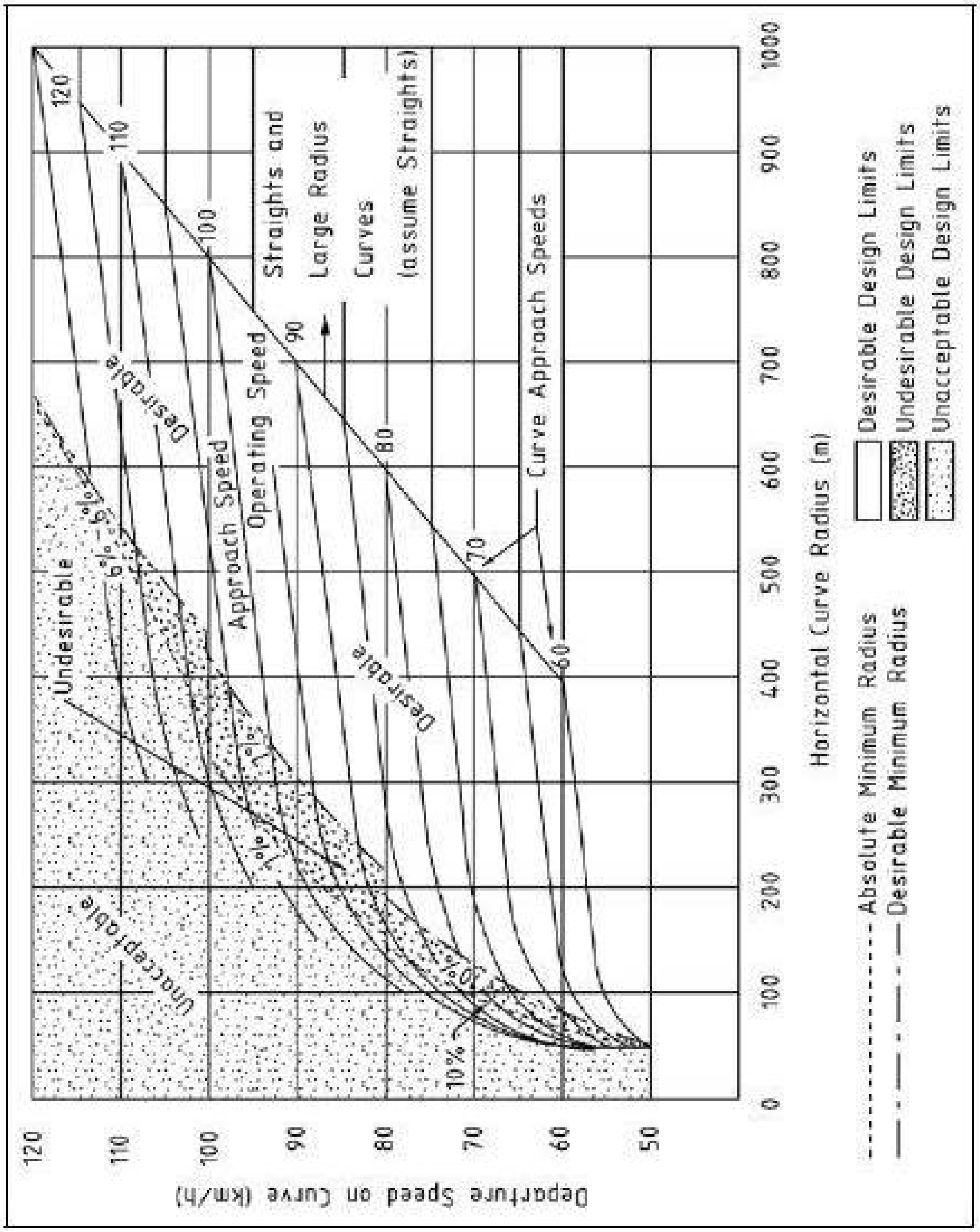
11.11. Austroads Car Acceleration on Straights Graph



Note: To use graph, enter the base of the graph at the initial speed of the vehicle, project vertically up to the line representing the length of the straight, then project horizontally left to read the speed at the end of the straight.

Source: Based on Austroads (2003).

11.12. Austroads Car Deceleration on Curves Graph



Source: Austroads (2003)

11.13. Austroads Section Operating Speed

Range of radii in section (m)	Single curve section radius (m)	Section operating speed (km/h)	Range of radii in section (m)	Single curve section radius (m)	Section operating speed (km/h)
45 – 65	55	50	180 – 285	235	84
50 – 70	60	52	200 – 310	260	86
55 – 75	65	54	225 – 335	280	89
60 – 85	70	56	245 – 360	305	91
70 – 90	80	58	270 – 390	330	93
75 – 100	85	60	295 – 415	355	96
80 – 105	95	62	320 – 445	385	98
85 – 115	100	64	350 – 475	410	100
90 – 125	110	66	370 – 500	440	103
100 – 140	120	68	400 – 530	465	105
105 – 150	130	71	425 – 560	490	106
110 – 170	140	73	450 – 585	520	107
120 – 190	160	75	480 – 610	545	108
130 – 215	175	77	500 – 640	570	109
145 – 240	190	79	530+	600	110
160 – 260	210	82			

Note: If the section operating speed shown in this table is greater than the desired speed, take the section operating speed to be the desired speed.

11.14. MUTCD Spacing of Guideposts on Curves

Curve radius (Note 1)	Spacing (Note 2) (metres)	
	On outside of curve	On inside of curve (Note 3)
<100	6	12
100 – 199	10	20
200 – 299	15	30
300 – 399	20	40
400 – 599	30	60
600 – 799	40	60
800 – 1 199	60	60
1 200 – 2 000	90 (Note 4)	90 (Note 4)
>2 000 incl. straights	150 (Note 4)	150 (Note 4)

NOTES:

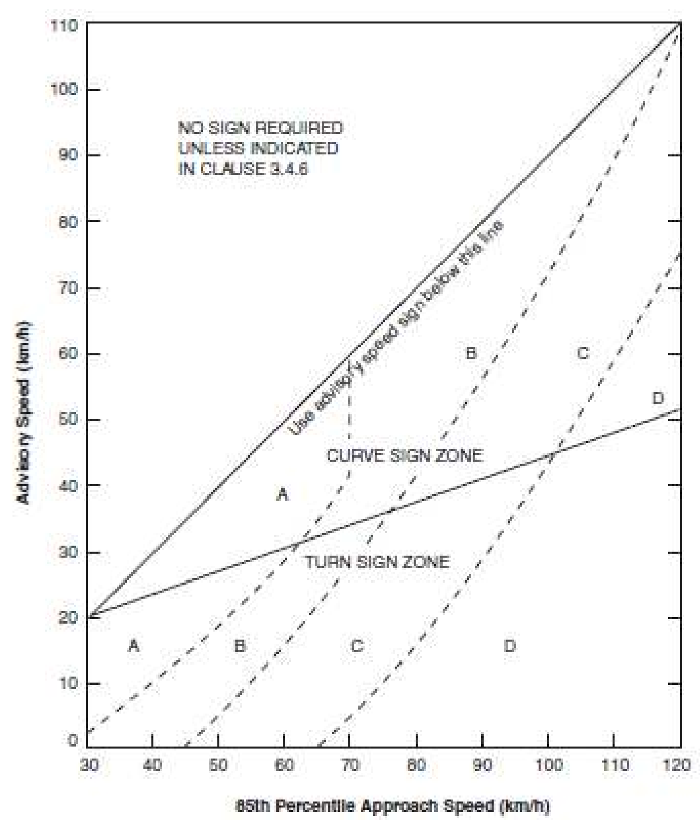
1 Where the radius of an existing curve is not available from records, it may be determined approximately by measuring the middle ordinate offset from a chord of known length using either the edge of pavement or a marked longitudinal line as a guide.

2 On guard fence, spacing should be adjusted, if necessary, to the nearest multiple of post spacing.

3 Each post on the inside of a curve is placed opposite a post on the outside of the curve wherever practicable.

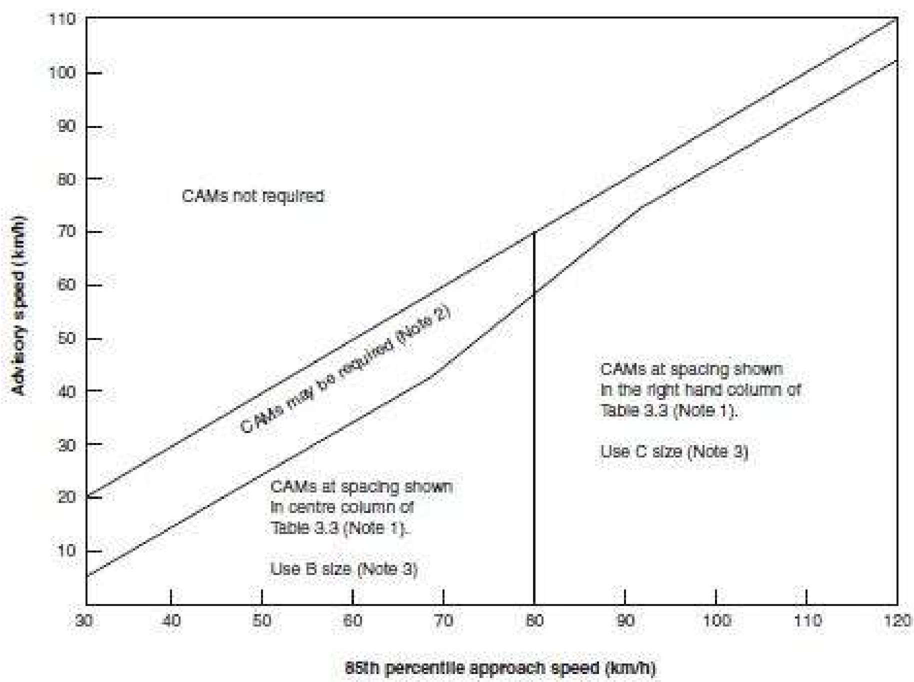
4 Spacing is reduced to 60 m in areas subject to fog. (See also Clause 3.2.4.4(a)).

11.15. MUTCD Guide to the Signposting of Substandard Horizontal Curves



NOTE: A, B, C and D indicate the size of the sign. B size is the minimum size recommended for arterial roads. Increase one size where either the sign is cantilevered over the roadway, there are two or more lanes in one direction or the sign is more than 6 m from edge of running lane.

11.16. MUTCD Guide for the use of Chevron Alignment Markers (CAMs)



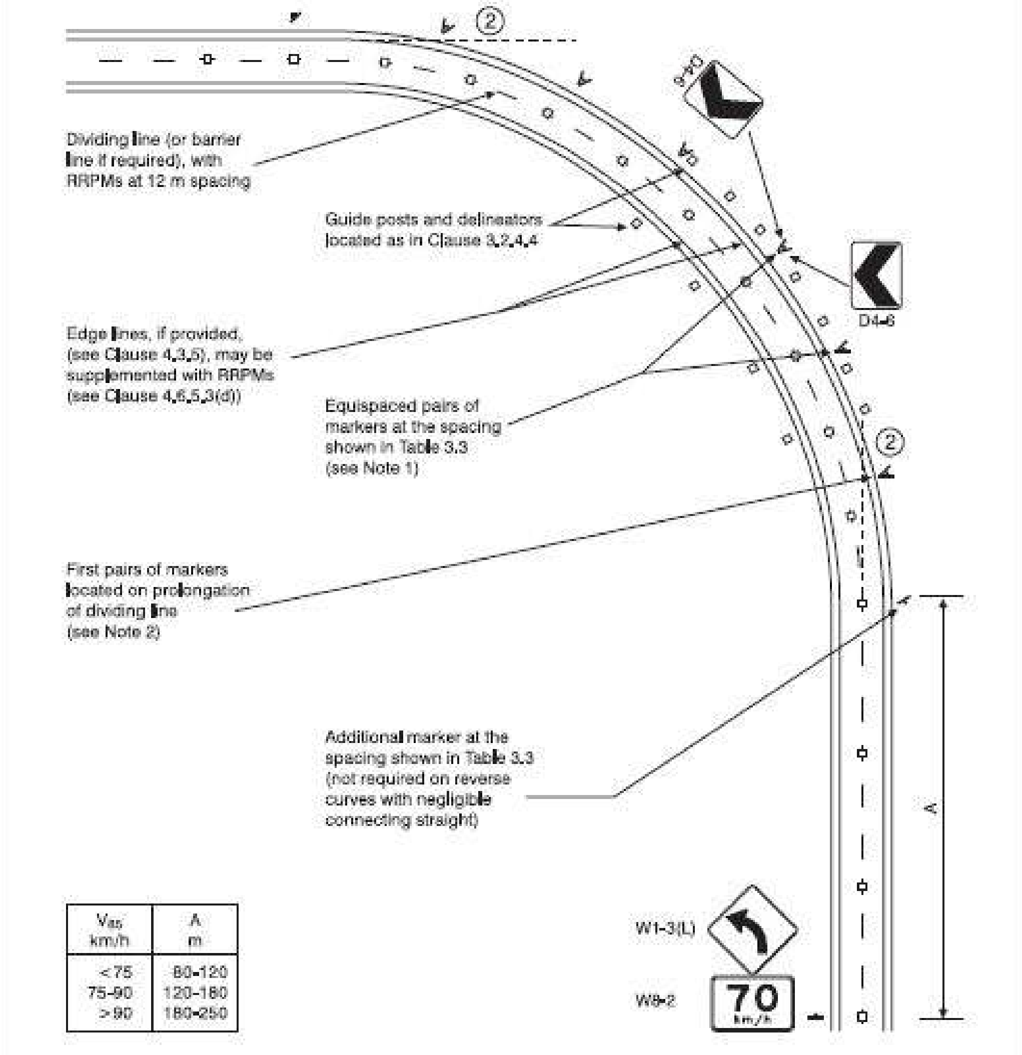
NOTES:

1 CAMs should be provided at curves in this region in accordance with Clause 3.4.9.

2 Curves in this region will not normally require CAMs, but may be required where the existence or direction of the curve may not be clear to approaching drivers, e.g. where the curve is just beyond a crest, or the locality is subject to frequent fogs or other adverse weather conditions.

3 B and C indicate the size of sign. On multilane roads and freeways, the sign size should be increased to C and D respectively.

11.17. MUTCD Substandard Horizontal Curve with Small Speed Deficiency



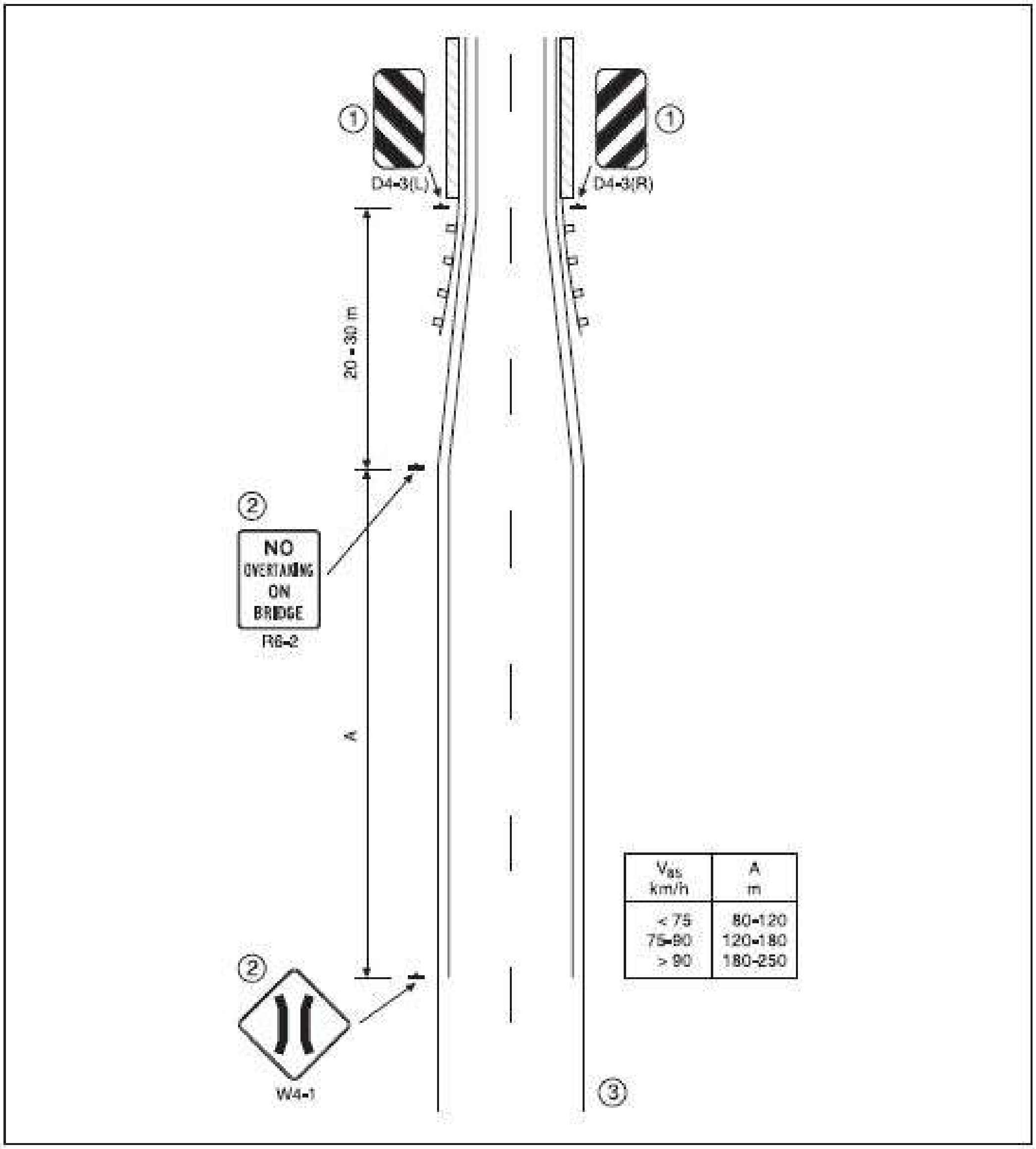
V_{85} km/h	A m
<75	80-120
75-90	120-180
>90	180-250

NOTES:

1 On short curves a minimum of three markers in each direction are required.

2 Location of first and last markers for each direction of travel is as given in Note 1 to Figure 3.7.

11.18. MUTCD Narrow Bridge



NOTES:

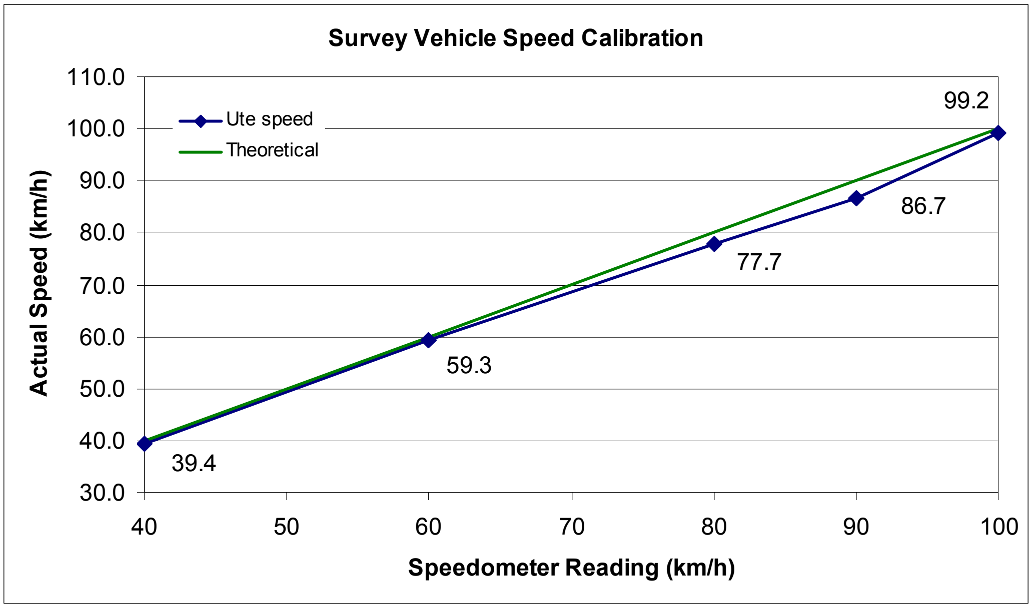
1. D4-3 width markers should be used where the horizontal clearance is less than that specified in Clause 3.6.7.2(c).
2. R6-2 or W4-1, or both, should be used where widths between kerbs are in the range specified in Clauses 3.6.6.1(c) and 3.6.6.3(a) respectively.
3. The arrangement for one lane bridges (Figure 3.11 or 3.12) should be used where the width between kerbs is less than 5.5 m and the conditions specified in Clause 3.6.2.2 occur.

11.19. MUTCD Stopping Sight Distances on Level Sealed Pavements

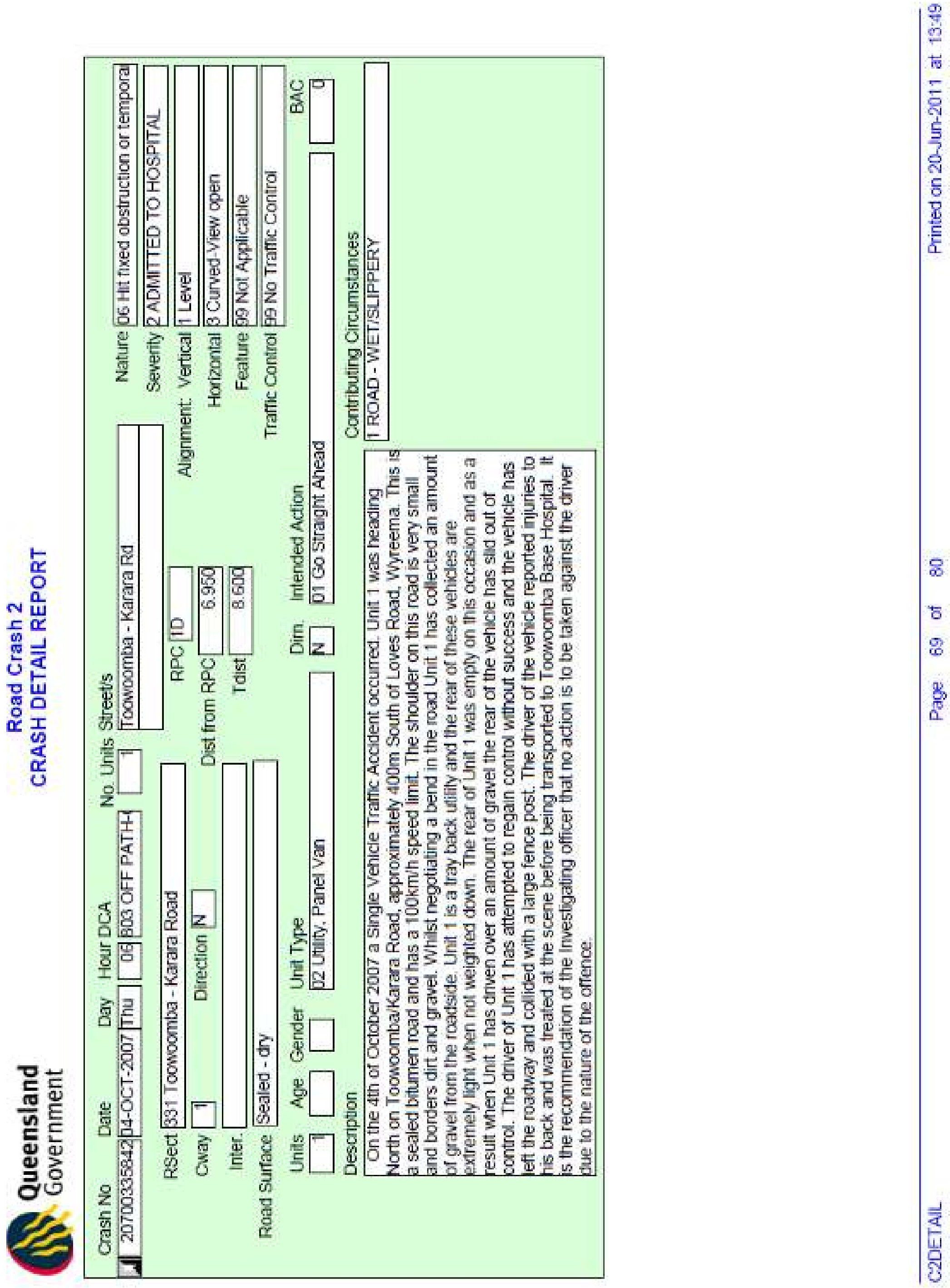
V_{85}, km/h	Stopping sight distance, m
31 – 40	35
41 – 50	45
51 – 60	65
61 – 70	85
71 – 80	115
81 – 90	140
91 – 100	170
101 – 110	210
111 – 120	250
121 – 130	300

NOTE: This Table has been adapted from *Rural Road Design*, Austroads, 1989. Values given for the speed ranges 70 km/h and below are based on a reaction time of 2.0 sec, and those above 70 km/h, 2.5 sec.

11.20. Survey Vehicle Speed Calibration



11.21. Crash Site 2 Report 1



Queensland Government

Road Crash 2
CRASH DETAIL REPORT

Crash No	Date	Day	Hour	DCA	No. Units	Street/s
20700335842	04-OCT-2007	Thu	06	803 OFF PATH-(	1	Toowoomba - Karara Rd

RSect: 331 Toowoomba - Karara Road
Cway: 1
Direction: N
Inter.:
Road Surface: Sealed - dry
RPC: ID
Dist from RPC: 6.950
Tdist: 8.600

Nature: 06 Hit fixed obstruction or tempora
Severity: 2 ADMITTED TO HOSPITAL
Alignment: Vertical: 1 Level
Horizontal: 3 Curved-View open
Feature: 99 Not Applicable
Traffic Control: 99 No Traffic Control

Units	Age	Gender	Unit Type	Dirn.	Intended Action	BAC
1			02 Utility, Panel Van	N	01 Go Straight Ahead	0

Description

On the 4th of October 2007 a Single Vehicle Traffic Accident occurred. Unit 1 was heading North on Toowoomba/Karara Road, approximately 400m South of Loves Road, Wyreema. This is a sealed bitumen road and has a 100km/h speed limit. The shoulder on this road is very small and borders dirt and gravel. Whilst negotiating a bend in the road Unit 1 has collected an amount of gravel from the roadside. Unit 1 is a tray back utility and the rear of these vehicles are extremely light when not weighted down. The rear of Unit 1 was empty on this occasion and as a result when Unit 1 has driven over an amount of gravel the rear of the vehicle has slid out of control. The driver of Unit 1 has attempted to regain control without success and the vehicle has left the roadway and collided with a large fence post. The driver of the vehicle reported injuries to his back and was treated at the scene before being transported to Toowoomba Base Hospital. It is the recommendation of the Investigating officer that no action is to be taken against the driver due to the nature of the offence.

Contributing Circumstances

1 ROAD - WET/SLIPPERY

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Crash Detail Report for Crash Number 20700335842

11.22. Crash Site 2 Report 2

Queensland Government

Road Crash 2
CRASH DETAIL REPORT

Crash No	Date	Day	Hour	DCA	No. Units	Street/s
20700419005	10-NOV-2007	Sat	17	803 OFF PATH-(	1	Toowoomba - Karara Rd

RSect: 331 Toowoomba - Karara Road
Cway: 1 Direction: N
Inter.:
Road Surface: Sealed - dry
RPC: 1D
Dist from RPC: 7.290
Tdist: 8.940

Nature: 06 Hit fixed obstruction or temporal
Severity: 2 ADMITTED TO HOSPITAL
Alignment: Vertical: 1 Level
Horizontal: 3 Curved-View open
Feature: 99 Not Applicable
Traffic Control: 99 No Traffic Control

Units	Age	Gender	Unit Type	Dirn.	Intended Action	BAC
1			06 Motor Cycle	N	01 Go Straight Ahead	N/A

Description:
Unit 1 has been ridden in a Northerly direction from Cambooya towards Wyreema. Upon a wide left to right sweeping bend the Unit has lost control on the sealed carriageway and over corrected from left to right for at least 100m before leaving the carriageway and striking railway sleeper fencing posts and overturning. QFS, QAS attended. Major leg injuries to rider. Nil RBT possible due to late attendance at scene and driver already removed from scene by QAS. Driver admitted to TBH. ALLEGATIONS OF DRUG USE, ALCOHOL CONSUMPTION AND 160KMH SPEED AT TIME OF CRASH. NIL EVIDENCE

Contributing Circumstances:
1 VIOLATION - EXCEEDING SPEED LIMIT
1 CONDITION - UNDER INFLUENCE OF LIQOUR

Crash No	Date	Day	Hour	DCA	No. Units	Street/s
20700069808	11-APR-2007	Wed	19	502 VEH'S OVER	1	Franks Rd; Toowoomba-Karara Rd (Code To 74767

RSect: 331 Toowoomba - Karara Road
Cway: 1 Direction: S
Inter.:
Road Surface: Sealed - dry
RPC: 1D
Dist from RPC: 7.990
Tdist: 9.640

Nature: 06 Hit fixed obstruction or temporal
Severity: 5 PROPERTY DAMAGE ONLY
Alignment: Vertical: 1 Level
Horizontal: 3 Curved-View open
Feature: 11 T junction
Traffic Control: 99 No Traffic Control

Units	Age	Gender	Unit Type	Dirn.	Intended Action	BAC
1			01 Car, Station Wagon	S	02 Overtake	94

Description:
Unit 1 has overtook a vehicle travelling South. Upon overtake he has clipped the edge of the sealed carriageway by golbng to wide and thne through a series of over-corrections has spun across the carriageway and spun out of control over grassy verge, into fence and then rolled several times before resting on roof. Non injury. Neg RBT and vehicle towed.

Contributing Circumstances:
1 VIOLATION - UNDUE CARE AND ATTENTION
1 DRIVER - INEXPERIENCE/LACK OF EXPERTIS
1 EXCESSIVE SPEED FOR CIRCUMSTANCES

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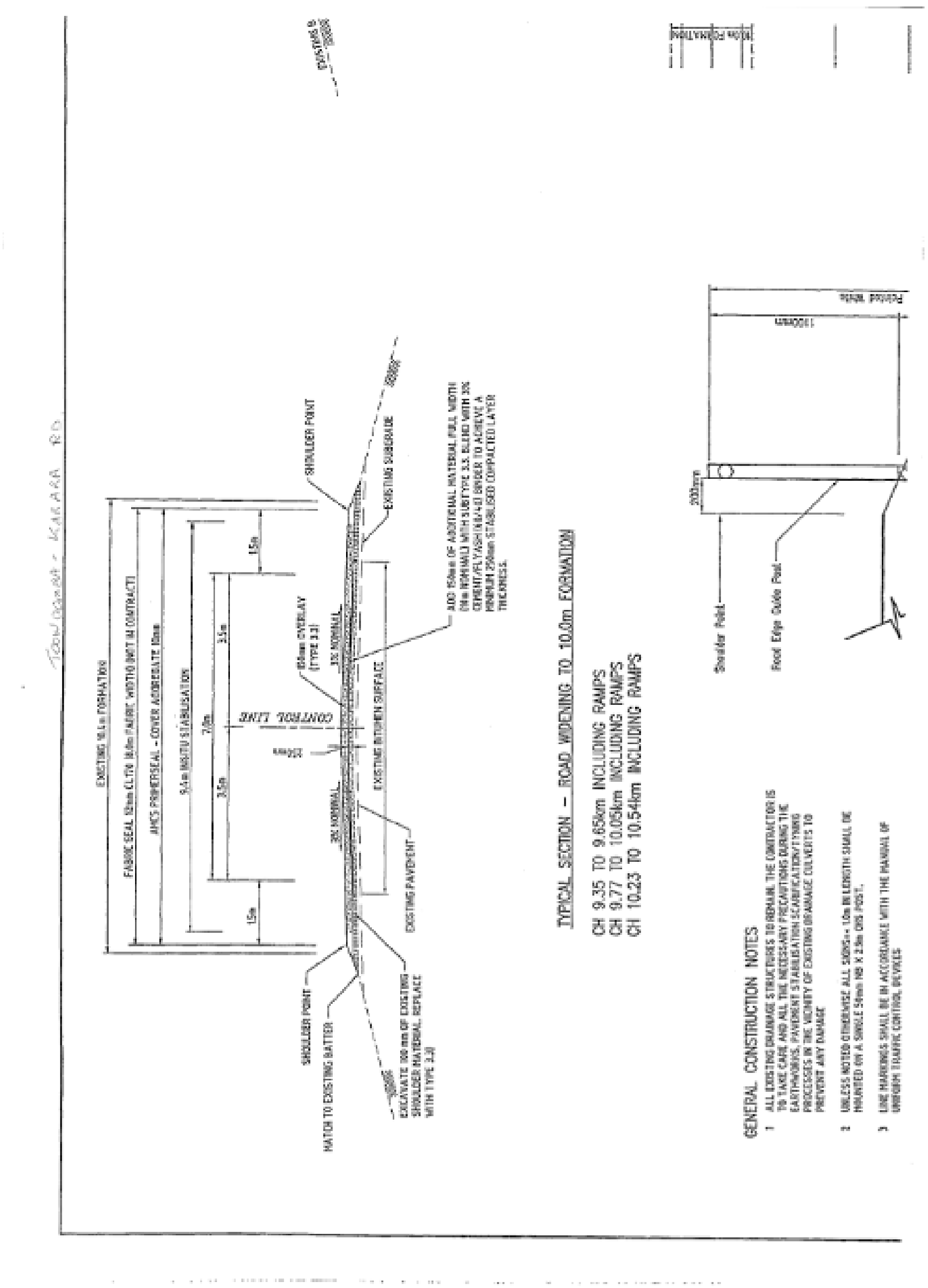
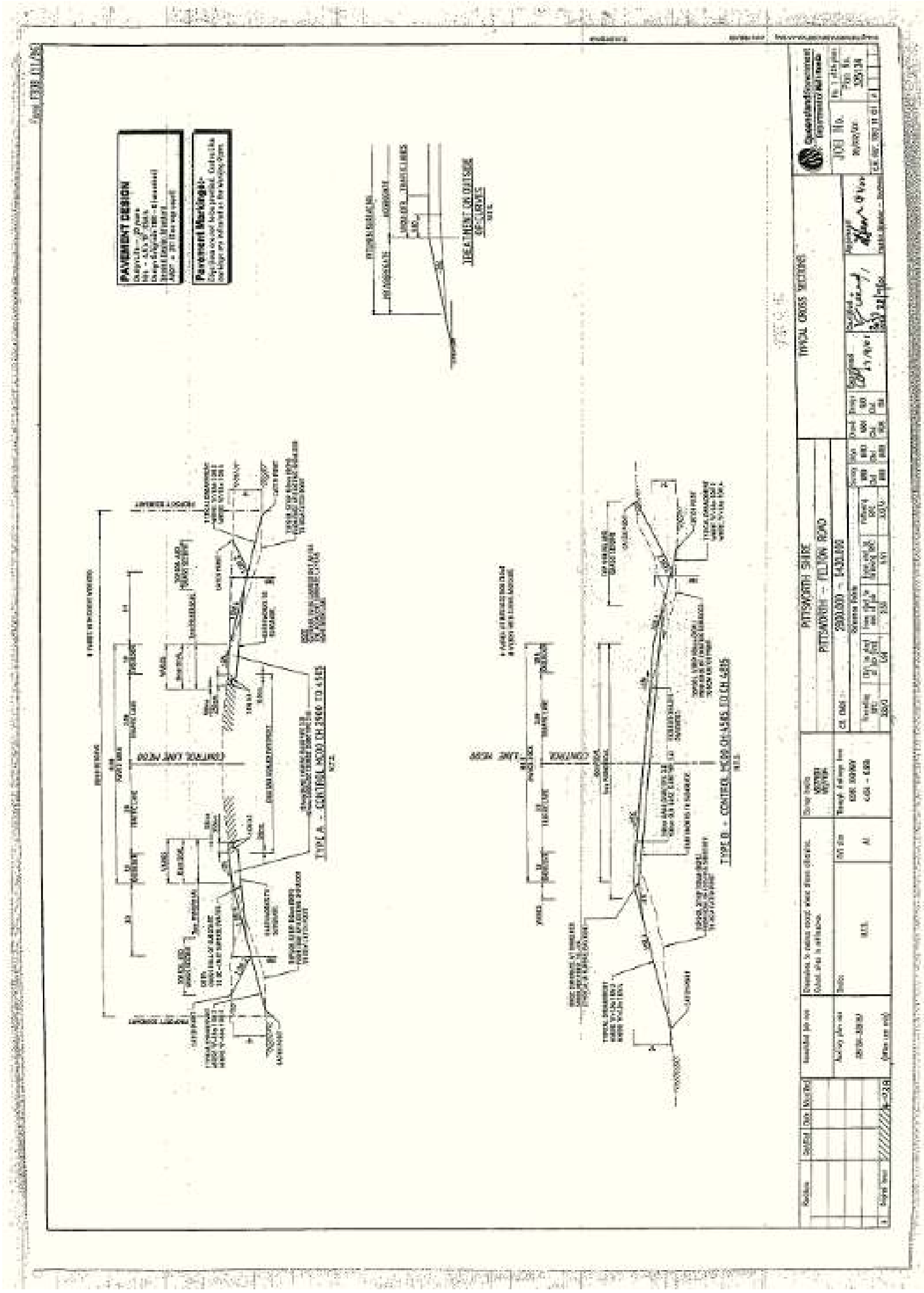
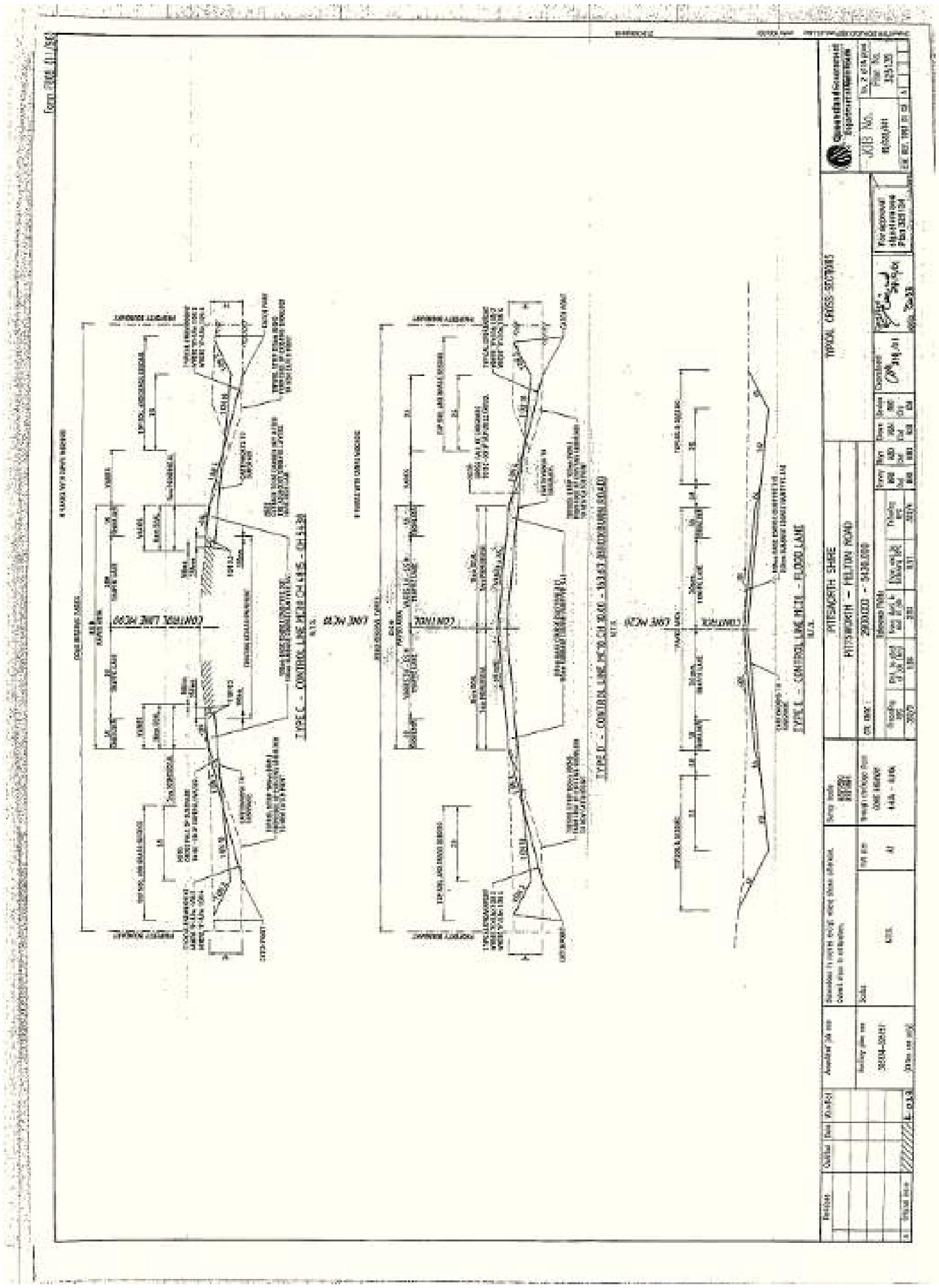
Crash Detail Report for Crash Number 20700419005

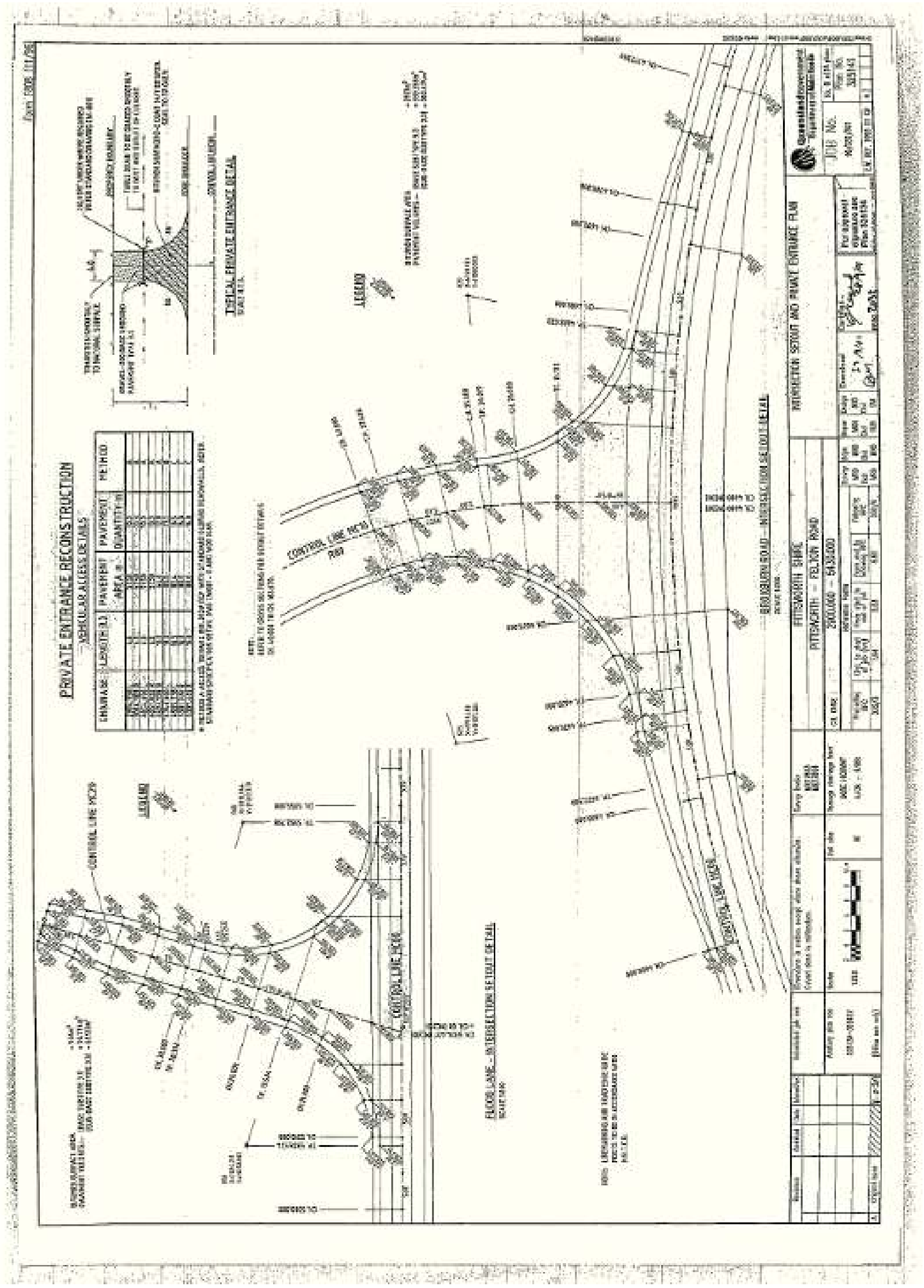
11.23. 331 Toowoomba-Karara Road Plans



11.24. 332 Pittsworth-Felton Road Plans




TYPICAL CROSS-SECTIONS
PITTSWORTH SHIRE


PRIVATE ENTRANCE RECONSTRUCTION
VEHICULAR ACCESS DETAILS
TYPICAL PRIVATE ENTRANCE DETAIL
LEGEND
CONTROL LINE MC10
BROOKBURN ROAD - INTERSECTION SETOUT DETAIL
FLOOD LANE - INTERSECTION SETOUT DETAIL
INTERSECTION SETOUT AND PRIVATE ENTRANCE PLAN
PITTSWORTH SHIRE
PITTSWORTH - FELTON ROAD